WATER QUALITY – BLACKSTONE RIVER

Final Report 2: Field Investigations

Submitted to:

**Rhode Island
Department of
Environmental Management**

February 2008

Submitted by:

The Louis Berger Group, Inc.

in association with

**University of Rhode Island
University of Massachusetts - School of Marine Science
and Technology**

Rhode Island Department of Environmental Management

WATER QUALITY - BLACKSTONE RIVER

FINAL REPORT 2: FIELD INVESTIGATIONS

Submitted to:
Rhode Island Department of Environmental Management
Office of Water Resources
235 Promenade Street
Providence, Rhode Island 02908

Submitted by:
The Louis Berger Group, Inc.
295 Promenade Street
Providence, RI 02908

in association with:
University of Rhode Island
University of Massachusetts - School of Marine Science and Technology

February 2008

EXECUTIVE SUMMARY

This study ('BTMDL study') was performed as part of the development of Total Daily Maximum Loads (TMDL). Waterbodies included in the BTMDL study consisted of the Rhode Island portion of the Blackstone River (impaired for biodiversity, pathogens, copper, lead), Mill River (lead), Peters Rivers (pathogens, copper, lead), Valley Falls Pond (biodiversity impacts, pathogens, phosphorus, low dissolved oxygen, excess algal growth, lead), and Scott Pond (excess algal growth, chlorophyll *a*, low dissolved oxygen, phosphorus). In addition, nutrient data were collected in the Blackstone River to better understand nutrient contributions from Massachusetts, and the loading from the Blackstone River to Narragansett Bay.

Field investigations were conducted in the impaired waterbodies consisting primarily of dry and wet weather water sampling, outfall reconnaissance surveys, and biodiversity assessment. In addition, studies of the sediment, bathymetry, phytoplankton, and wetlands were conducted in the two ponds.

Pathogens

Pathogens are contributed from Massachusetts for the Blackstone River, Mill River, and Peters River during dry and wet weather. Additional loading to these rivers occurs in Rhode Island in the urban areas of Woonsocket (defined in the report as 'Reach 1': MA/RI State line to Manville) and Central Falls and Pawtucket (Reach 3: Lonsdale to mouth of the Blackstone River). The Branch River as well as several of the outfalls and small brooks contained high fecal coliform concentrations, particularly during wet weather. There are no major pathogen sources in the mid-section of the Blackstone River (Reach 2: Manville to Lonsdale) between the two urban centers. The Woonsocket Wastewater Treatment Facility as well as Abbott Run Brook were not a source.

Compared to the 1991 Blackstone River Initiative (BRI) study, the pattern of fecal coliform concentrations was very similar during both wet and dry weather. This suggests that there were neither significant reductions in the discharge of fecal coliform nor new sources in this time frame.

Dissolved Copper

During dry weather there were three minor acute dissolved copper exceedances in any of the rivers, two of which occurred at the MA/RI State line. The largest number of dry weather chronic exceedances also occurred at the MA/RI State line (W-01), where 60% of the surveys had concentrations that exceeded the standards. The exceedances of dissolved copper at the lower Blackstone River stations were a direct result of the high concentrations at the State line that carried through to the mouth of the river. Copper concentrations in the Branch River, Mill River, Peters River, and Abbott Run Brook met chronic criteria. These four tributaries contributed copper on average at less than 4.7%, 1.7%, 0.4%, and 4.6% respectively, at their points of confluence with the Blackstone River. Most of the sampled outfalls also met regulatory standards.

During wet weather, the acute criteria were exceeded approximately half of the time at the State line; chronic criteria were exceeded during each storm. Most of the copper load measured in Manville (downstream end of Reach 1) was attributable to loading from Massachusetts. However, copper concentrations in the Branch River also exceeded the acute and chronic criteria. The Peters River only exceeded the regulatory standards slightly during the second sampled storm. The Mill River exceeded the acute criteria once. Load analysis for Reach 1 did not suggest additional significant sources of copper in addition to the sources that were monitored. There were no significant sources within Reaches 2 and 3. Some of the sampled outfalls in all three reaches exceeded the regulatory criteria for copper.

The dry weather profile for the 1991 BRI was similar to that observed in the BTMDL study. In general, concentrations during the BTMDL study were lower and the ranges between maximum and minimum were smaller than the BRI study. There appears to be a measurable reduction in copper from Massachusetts over the 14 years. This change can also be seen in the downstream stations.

Dissolved Lead

During dry weather there were no acute dissolved lead exceedances in any of the rivers. Chronic criteria in the Blackstone River were exceeded only during one sampling event at all Blackstone River stations, suggesting that the source during that event was in Massachusetts. The Branch River exceeded the chronic criteria during three of out of four dry weather events, in part due to its low hardness. The chronic criteria were exceeded twice in the Mill River out of six sampling events, although one sample was likely affected by elevated lead concentrations in the Blackstone River. Lead concentrations in the Peters River and Abbott Run Brook met chronic criteria. These four tributaries contributed lead on average at 45% (Branch River), 11% (Mill River), 1% (Peters River), and 16% (Abbott Run Brook) at their respective points of confluence with the Blackstone River. All but one of the sampled outfalls met regulatory standards.

During wet weather there were no acute dissolved lead exceedances in any of the rivers. The chronic criteria were exceeded only once at a Woonsocket station in the Blackstone River, and once for the Branch River. The Mill and Peters Rivers did not exceed the criteria. Load analysis for Reach 1 did not suggest additional significant sources of lead in addition to the sources that were monitored. There were no significant sources within Reaches 2 and 3. Some of the sampled outfalls exceeded the regulatory criteria for lead during wet weather.

The dry weather concentrations reported in the BTMDL are considerably lower than those reported in the BRI in 1991. This may be a direct result of the improved technology being used in the laboratory now as compared with 14 years ago. The available lead data do not support listing the Blackstone River, Mill River, and Peters River on the 303(d) list.

Nutrients

During dry weather, the total phosphorus concentrations along the Blackstone River did not vary significantly, with the highest concentration at the State line (0.38 mg/l) and the lowest concentration at the mouth of the river at Slater Mill (0.27 mg/l). On an annual basis, the majority of the nutrient load at the Manville station (downstream end of Reach 1) was contributed by Massachusetts sources, specifically 71% of nitrates, 68% of ammonia, and 58% of total phosphorus; within Rhode Island, the most significant nutrient sources are the Woonsocket WWTF and the Branch River. The Mill River and Peters River contributed less than 2% each to the nutrient loads in the Blackstone River.

During wet weather, much of the nutrient load at the Manville station (downstream end of Reach 1) was contributed by Massachusetts sources, specifically 74% of nitrate, 84% of ammonia, and 84% of total phosphorus. The remaining load was largely contributed by the major tributaries (Branch, Mill and Peters River) and the Woonsocket WWTF. In Reaches 2 and 3, there were no major changes in nutrient loads on balance.

The BTMDL dry weather concentrations for ammonia and nitrate concentrations were in general similar to the 1991 BRI concentrations. The most obvious differences were observed at the State line where the mean ammonia concentration was approximately 4 times higher during the BTMDL than for the BRI. This is not unexpected since two of the three surveys completed for the BRI were taken when the Upper

Blackstone Water Pollution Abatement District provided nitrification. The BTMDL study captured data that included the period between October and May when nitrification at the UBWPAD was not occurring. Nevertheless, despite the 14 years difference between surveys, the pattern of nitrate and ammonia concentrations was very similar. This suggests that there were neither significant reductions in the discharge of nitrate and ammonia nor new source additions within this time frame.

Biodiversity

Based on 2004 and 2005 results and historic data, the Blackstone River benthic community at the Millville (MA) and Manville (RI) stations were slightly to moderately impaired. This finding reflects a very slight overall decrease in impairment over the last two decades. Comparing the Biotic Index over the last 10 years, the level of impairment at the Manville station is slightly higher than at the Millville station. This finding suggests that organic loading is added in the Woonsocket reach of the river between the MA/RI State line and Manville, as was observed during the water quality surveys. However, local conditions at the Manville station could also be a reason for the slightly impaired conditions.

The main stressor appears to be organic loading and not metal toxicity. This conclusion is supported by the data collected in 2004 and 2005 at Station M-02 where the taxa that are known to be sensitive to organic enrichment were not as common at Manville station as compared to the Wood River reference station.

Valley Falls Pond

Valley Falls Pond is eutrophic. It is influenced by the Blackstone River, but at the same time it functions as a semi-separate system. The pond is flushed primarily as a result of fluctuations in the water elevation in the river. It accumulates fine-grained sediments and organic matter derived from the Blackstone River as well as high level of algae and phytoplankton growth associated with its eutrophic status, and detritus from the surrounding wetlands. The consequence of this deposition is the accumulation of nitrogen and phosphorus and the accumulation of 0.5 to 2.0 m (1.5 to 7 feet) of unconsolidated material. It is likely that the high rate of organic matter deposition results in a high rate of sediment oxygen demand that is causing the periodic oxygen depletion within the pond. However, it also appears that the water within the pond is sufficiently shallow to have adequate ventilation to prevent anoxia.

Pathogen concentrations were generally low but can increase as a result of flooding of the pond by the Blackstone River. Dissolved copper concentrations were generally similar in Valley Falls Pond and the Blackstone River station. However, the dissolved lead concentration was always higher than in the river, although only one sample violated the chronic criterion for lead. The available metals data do not support listing the pond on the 303(d) list.

It is clear that management options for removing Valley Falls Pond from the 303(d) list for impairments related to phosphorus enrichment must include both improvements of the Blackstone River waters which dominate the loading to the pond and an acknowledgement that the pond is operating not as a "classic" freshwater pond or lake, but as an open water basin within a significant wetland system. The observations of the healthy status of the Valley Falls Marsh and the relatively modest oxygen depletions and the status of fish habitats in the pond under its currently high rates of organic matter inputs, supports the contention that wetland ponds are less sensitive to nutrient enrichment than "classic" ponds and lakes.

Scott Pond

Scott Pond is an eutrophic freshwater pond at the terminus of a remnant of the Blackstone Canal and its local watershed. The pond operates as a depositional basin, which is enriched in phosphorus and which shows classic symptoms of eutrophication: high total phosphorus levels, high chlorophyll *a* levels, low transparency and high phytoplankton biovolumes. In addition, the bottom waters of both the northern and southern basins of Scott Pond become seasonally anoxic. Management will be required for the restoration of this impaired aquatic resource.

The hydrologic balance of Scott Pond is dominated by inflow from the Blackstone Canal (85%), with the watershed and direct atmospheric deposition accounting for 11% and 4%, respectively. Freshwater outflow appears to be through the subsurface most likely to the Moshassuck River and possibly Valley Falls Pond. The Blackstone Canal is a source of nutrients to Scott Pond. The watershed to Scott Pond is likely an important, though secondary, source of phosphorus to pond waters. Scott Pond likely has a significant amount of phosphorus release from the bottom sediments due to the periodic anoxia of the bottom waters.

At present, management of eutrophic conditions within Scott Pond merely addresses turbidity and has short-term effects. Periodic summer time water treatment with copper sulfate is the current management method. However, the current treatment results in high dissolved copper concentrations in pond waters, well above the regulatory limits. Further, this treatment does not address the fundamental problem of excess phosphorus, and therefore reductions in phosphorus loadings are needed. It is recommended to develop a phosphorus management plan for Scott Pond. The management plan should address the phosphorus loading of the pond by the Blackstone Canal which is estimated to be over 90% on an annual basis. The remainder of the phosphorus loading is contributed by the watershed of Scott Pond (surface water runoff, groundwater). Appropriate load reduction measures should be developed. The plan should further consider release of phosphorus from the pond sediments and discuss effective in-pond management approaches (e.g., treatment with alum).

Both the oxygenated surface waters and anoxic bottom waters of Scott Pond met the standards for dissolved lead. The standards for dissolved copper were greatly exceeded in the surface waters of Scott Pond due to treatment of the water with copper sulfate. The bottom water met the standard for dissolved copper. Scott Pond also generally met the standard for pathogens during dry weather. During wet weather, the pond received high pathogen loads from the Blackstone Canal. Only the northern basin of Scott Pond exceeded the regulatory standard during wet weather, but the inflowing canal water likely also affects the southern basin of Scott Pond during large rainstorms.

Table of Content

List of Figures

Notes: Given the large number of figures and tables, they were all placed at the end of each main section of the report. In addition, all Tables in the main part of the report were labeled as Figures to simplify locating them. Figures that represent tables are flagged in the list below as *'Table'*.

List of Appendices

List of File Folders on CD

Folder 1	Report
Folder 2	Laboratory data
Folder 3	Storm Line Plans, City of Woonsocket, 2004

List of Abbreviations

ac	acres
AS	Artificial substrate
BAC	Blackstone Army Corps study (Wright et al, 2004)
BI	Biotic Index
BLK	Station prefix for BRI stations (1991)
BRI	Blackstone River Initiative
BTMDL	Blackstone River Total Maximum Daily Load study (this study)
DW-	Dry weather sampling event
cfs	cubic feet per second
EMC	Event mean concentration
EPT	Ephemeroptera, plecoptera, and trichoptera
FC	Fecal coliform
km^2	square kilometer
M-	Macroinvertebrate sampling station
MA/RI	Massachusetts/Rhode Island State line
NBC	Narragansett Bay Commission
OF-	Point source station
OUTFALL-	Reconnaissance sampling event for outfalls
P-	Pond sampling station
POND-	Sampling event for Valley Falls Pond and Scott Pond
RIDEM	Rhode Island Department of Environmental Management
RBP	Rapid Bioassessment Protocol
RS	River segment
TKN	Total Kjeldahl Nitrogen
TOT	Time of travel
TSI	Trophic State Index
TSS	Total suspended solids
UBWPAD	Upper Blackstone Water Pollution Abatement District
USGS	United States Geological Survey
VFP	Valley Falls Pond
VSS	Volatile suspended solids
W-	Water quality sampling station
WL-	Water level monitoring station
WW-	Wet weather sampling event (i.e., Storm event)

Acknowledgements

We thank the cities and towns in the study area for their information and cooperation in this study, providing maps, insights, and other information. Specifically, we thank the Town of North Smithfield (Michael Philips, Town Planner), the City of Woonsocket (Michael Delrossi, City Engineer; Scott Sanford, Engineering Division); the Town of Cumberland (Dennis Szwec, Public Works Engineering Aide), the Town of Lincoln (Kim Wiegand, Town Engineer; John Faile, Water Superintendent); Mike Gagnon, Highway Superintendent), the City of Central Falls (Joseph Nield, Public Works Director), and the City of Pawtucket (Ross Adrain, Town Engineering Office). We also thank the Rhode Island Department of Transportation (Don Soares, Plan Room) providing available plans and information for major highways in the study area.

We thank David Newton from EPA Region 1 for his information on Superfund sites including the Peterson Puritan site. We also thank staff from departments outside the Water Resources Department at RIDEM providing information of fish tissue sampling and hazardous waste sites.

We thank various residents who kindly provided historic information and access to sites through their property, namely Mr. and Ms. Len and Madeleine Nadeau (Central Falls), and Mr. James Burgess (Lincoln). We thank Linda Green for permission to include the URI Watershed Watch data from Valley Falls Pond that have been collected by Michael Montagne for many years. The field assistance of the following staff is also acknowledged: Michael Bartlett and Athena Hay.

Further, we thank Adel Banoub of the Woonsocket Wastewater Treatment Facility for collecting the composite sample for this site. We also appreciate the flexibility and cooperation by the participating laboratories (Mitkem, Severn Trent Laboratories (STL), Microinorganics, and the Coastal System Analytical Lab of the University of Massachusetts in Dartmouth. Their cooperation allowed for sampling during evenings and on weekends.

Finally, we thank Elizabeth Scott, Cindy Hannus, Connie Carey, and Skip Viator from the Rhode Island Department of Environmental Management to provide us with the flexibility in our efforts toward achieving the objective of our field investigations and data analyses.

1.0 INTRODUCTION

1.1 Project Overview

The primary goal of the Blackstone River water quality project for the development of Total Daily Maximum Loads (the project is referred to herein as 'BTMDL') was designed to obtain information needed to address identified water quality impairments within the Rhode Island portion of the watershed of the Blackstone River, Mill River, Peters River, Valley Falls Pond and Scott Pond. A secondary goal was to collect nutrient data as input for assessments of nitrogen loads from both the Massachusetts and Rhode Island portions of the Blackstone River into the Seekonk/Providence Rivers and Upper Narragansett Bay while also evaluating current phosphorus loads and concentrations in the Blackstone River itself.

Name	**Area/Length** (*)	**Class**	**Cause of Impairment** (**)
Blackstone River	25.3 km (15.7 mi)	B1 / B1{a}	biodiversity impacts, pathogens, copper, lead
Mill River	0.13 km (0.082 mi)	B	Lead
Peters River	0.75 km (0.469 mi)	B	pathogens, copper, lead
Valley Falls Pond	0.17 km^2 (42.7 ac)	B1 (E)	biodiversity impacts, pathogens, phosphorus, low dissolved oxygen, excess algal growth, lead
Scott Pond	0.18 km^2 (45.6 ac)	B	excess algal growth, chlorophyll *a*, low dissolved oxygen, phosphorus

(*) Lengths pertain to the RI portion of the river.

(**) For lead and copper, the impairment pertains to the dissolved phase.

TMDLs are required under Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130). The purpose of TMDLs is to reduce the pollutant loading to waterbodies from point and nonpoint sources in order to achieve water quality goals set for the waterbody.

1.2 Project Tasks

The BTMDL project has been conducted in two phases up to this point. Phase 1 consisted of a synthesis of the existing data and information; findings were presented in a report (Berger, 2004). The goal of Phase 2 (this report) was to investigate data gaps identified during Phase 1. Specifically, Phase 2 consisted of the following tasks:

- *Task 1:* *Development of Work Plan and QAPP:* The QAPP was submitted and approved by the U.S. Environmental Protection Agency prior to commencement of sampling.
- *Task 2:* *Inventory of Major Discharges of Stormwater Runoff*: Reconnaissance investigations of point sources entering the project waterbodies. See Section 5 below.
- *Task 3:* *Dry Weather Water Quality Monitoring:* Characterization of the water quality at significant boundaries and locations in the Blackstone River and its major tributaries. See Section 3 below.

- *Task 4:* *Wet Weather Water Quality Monitoring:* Assessment of the effect of stormwater discharges on the water quality of the Blackstone River and its major tributaries. See Section 4 below.
- *Task 5:* *In-situ Monitoring:* This task was optional and ultimately not requested by RIDEM.
- *Task 6:* *Impoundments:* This task was also optional and ultimately not requested by RIDEM.
- *Task 7:* *Biodiversity:* Investigation in the Blackstone River, expanding existing records. See Section 6 below.
- *Task 8:* *Time of Travel:* For flows along the entire Blackstone River. See Section 2.2 below.
- *Task 9:* *Valley Falls Pond:* Development of an understanding of the general hydraulic and nutrient dynamics as a step toward the goal of a management plan for the pond. See Section 7 below.
- *Task 10:* *Scott Pond:* Same goal as for Valley Falls Pond. See Section 8 below.
- *Task 11:* *Fish Tissue Analysis:* This task will be performed by RIDEM and is therefore not addressed in this report.
- *Task 12:* *Determination of Loads:* Load determinations and analysis of the water quality data to define management strategies to reduce pollutant loadings and obtain program goals. Also, determination of nutrient contributions from Massachusetts and from the mouth of the Blackstone River. Dry weather load analyses were incorporated in Section 3; wet weather load analyses were incorporated in Section 4.
- *Task 13:* *Preparation of Final Report*
- *Task 14:* *Meetings*

2.0 BLACKSTONE RIVER WATERSHED

2.1 Overview

The Blackstone River is an important natural, recreational, and cultural resource to both Rhode Island and Massachusetts. In 1986, the Blackstone River Valley National Heritage Corridor was established by Congress to preserve and interpret the significant historic and cultural lands, waterways, and structures within the watershed. Following is a brief summary of the key aspects of the watershed. A detailed description of the watershed was provided Final Report 1 (Existing Data; Berger, 2004).

The Blackstone River has a total drainage area of 1,180 km^2 (454 square miles) with a total length of 77 km (48 miles) (Figure 2-1). The drainage area is located in south-central Massachusetts. The river flows from Worcester, MA, to the Main Street Dam in Pawtucket, RI, where it enters the Seekonk River. The Seekonk River is a tidal estuary that extends for approximately 11 km (7 miles) to the south before combining with the Providence River at India Point. The Blackstone River is the second largest source of freshwater to Narragansett Bay.

Approximately 75% of the Blackstone River watershed is located within Massachusetts with the remainder located in Rhode Island. The Massachusetts portion of the watershed encompasses Worcester County and small sections of Middlesex, Norfolk, and Bristol Counties. It encompasses a total of thirty cities and towns including Worcester and Attleboro. In Rhode Island, the watershed encompasses a portion of the following cities and towns: Burrillville, Glocester, North Smithfield, Smithfield, Woonsocket, Cumberland, Lincoln, Central Falls, and Pawtucket.

Primary tributaries to the Blackstone River in Rhode Island are the Branch River, Mill River, Peters River, and Abbot Run Brook. The Mill River has a drainage area of approximately 88 km^2 (35 mi^2), located primarily in Massachusetts. The drainage area is characterized by open land and low-density residential development, with limited areas of high-density urban development. The headwater of the Mill River is North Pond, located in Hopkinton, MA. The Peters River has a smaller drainage area than the Mill River. Its headwaters are located in Bellingham, Massachusetts. The river flows for approximately 5.6 km (3.5 miles) to the State line and continues for an additional 1.5 km (1 mile) where it combines with the Blackstone River. The drainage area is characterized by medium to medium high residential development with high-density urban development in the City of Woonsocket.

The Rhode Island section of the Blackstone River can be separated into three river reaches based on contaminant loading identified during the Blackstone River Initiative (BRI; Wright et al., 2001). Water quality sampling stations (BLK__) of the watershed-wide BRI are presented in Figure 2-2. Water quality sampling of the BTMDL study was focused on the Rhode Island portion of the Blackstone River. The BTMDL stations (W-__) reoccupied many of the BRI stations in Rhode Island to allow for comparisons (Figure 2-3). A more detailed description of the BTMDL stations is presented in Section 3 below. The three river reaches are as follows:

- **Reach 1: Woonsocket Area** *(MA/RI State line [Stations W-01; near Station BLK13] to Manville Dam [Stations W-02; BLK18]).* Reach 1 brackets the largest urban area (Woonsocket) along the Blackstone River, as well as three of the four largest tributaries (Branch, Mill, and Peters Rivers) and the only municipal wastewater treatment facility. This reach was one of the reaches highlighted in the BRI (Stations BLK13 to BLK18) as a significant contributor of contaminants.

- **Reach 2: Lincoln/Cumberland** *(Manville Dam [Stations W-02; BLK18] to Lonsdale Ave [Stations W-04; BLK20]):* Reach 2 covers the area between Reaches 1 and 3. The area surrounding Reach 2 is more rural than the areas surrounding Reaches 1 and 3. As a result, the pollutant loads contributed in this reach are smaller, as also reflected in the data of the BRI.

- **Reach 3: Central Falls/Pawtucket Area** *(from Lonsdale [Stations W-04; BLK20] to the end of Blackstone River at Slater Mill [Stations W-05; BLK21]):* Reach 3 brackets the second largest urban area along the Blackstone River in Rhode Island, as well as the fourth largest tributary (Abbott Run Brook) and the only CSOs along the river. Aside from Reach 1, this reach was also identified in the BRI as a reach of concern. Stormwater discharges downstream of the Valley Falls Dam are currently in the process of being mitigated by the Narragansett Bay Commission as part of the CSO abatement program.

The monthly mean flows in the Blackstone River (USGS gage in Woonsocket) range from a low of approximately 300 cfs in August to a high of 1,500 cfs in March. The flows during the study period of 2004 to 2006 reached a peak of over 13,000 in October July (Figure 2-4).

Average annual rainfall in Woonsocket is approximately 50 inches per year, ranging from 27 to 65 inches (Table A-1 in Appendix A).

2.2 Time of Travel

Time of travel (TOT) represents the length of time for water to flow a certain distance along the river. It is in part a function of the total water volume in the river at any given time and the variability in flow velocity along the various stretches of the river. The TOT is particularly relevant for the assessment of wet weather events in Rhode Island, as stormwater discharges entering the Blackstone River in the City of Worcester typically reach the Rhode Island border only approximately a day later.

2.2.1 Methodology

Time of travel for the Blackstone River was first assessed by the USEPA in 1964 and 1970 (USEPA, 1970). Additional TOT information was obtained by the Department for Civil and Environmental Engineering at URI (Wright, unpublished data) in the 1980s. Equations describing time of travel on the Blackstone River have been used in recent modeling efforts (Wright et al., 2001; Wright et al., 2004). All of this work was done under dry weather, steady-state conditions.

The goal of the evaluation in this BTMDL study was to analyze available information to provide an understanding of the TOT for wet weather conditions. Estimates were obtained for Blackstone River water between Worcester (MA), the MA/RI State line, and Slater Mill at the river's mouth in Pawtucket (RI). Specifically, TOT estimates were determined for six Blackstone River segments (RS), listed below. The RS end points correspond to water quality stations (BLK__) used by the Blackstone River Initiative (Wright et al., 2001), and/or stations used for the present BTMDL study (W-__) (Figures 2-2 and 2-3).

Blackstone River Segments in Rhode Island

RS-1 MA/RI State line (W-01; near BLK13) to the mouth of the Blackstone River at Slater Mill in Pawtucket (BLK21; W-05). This river segment corresponds to the combined Reaches 1, 2, and 3. Length of RS-1: 31.2 km (19.4 miles).

RS-2 MA/RI State line (W-01; near BLK13) to Manville Dam (W-02; BLK18). This river segment corresponds to Reach 1. Length of RS-2: 15.1 km (9.4 miles).

Blackstone River Segments in Massachusetts

RS-3 City of Worcester (near BLK01) to MA/RI State line (W-01; near BLK13). Length of RS-3: 42.5 km (26.4 miles).

RS-4 Upper Blackstone Water Pollution Abatement District (UBWPAD) discharge point (between BLK1 and BLK2) to MA/RI State line (W-01; near BLK13). Length of RS-4: 40.2 km (25.0 miles).

RS-5 Fisherville Pond (near BLK06) to MA/RI State line (W-01; near BLK13). Length of RS-5: 29.9 km (18.6 miles).

RS-6 Rice City Pond (near BLK08) to MA/RI State line (W-01; near BLK13). Length of RS-6: 15.8 km (9.8 miles).

Continuous flow data for the Blackstone River were obtained from four USGS gages for the period between 2002 and 2004. These gages are located in Millbury (West Main Street bridge), Northbridge (Sutton Street bridge), Woonsocket (at Peters River confluence), and Roosevelt Avenue in Pawtucket (Figure 2-2). The distance between the MA/RI State line (Station W-01) and the Woonsocket gaging station was estimated as 10 km (6.2 miles).

Two examples of the storm signals used in the evaluation are presented in Figure 2-5. For the storm of October 26, 2002 the Millbury, Northbridge and Woonsocket gages were active. For the storm of July 24, 2004 the Millbury, Woonsocket, and Roosevelt Ave gages were active. Beside the peak flows at these gages, this figure also identifies the localized runoff from the City of Woonsocket.

2.2.2 Results

The peak flows at Millbury (M-Q_{peak}) and Woonsocket (W-Q_{peak}) were plotted against the estimated time of travel (Figures 2-6 and 2-7). The following equations resulted from the regressions:

? t (Millbury to Northbridge) = $71.767(\text{M-}Q_{peak})^{-0.3442}$ 9 Storms $R^2 = 0.660$

? t (Millbury to Woonsocket) = $46.395(\text{M-}Q_{peak})^{-0.1253}$ 17 Storms $R^2 = 0.698$

? t (Millbury to Woonsocket) = $37.591(\text{W-}Q_{peak})^{-0.0949}$ 17 Storms $R^2 = 0.760$

? t (Woonsocket to Pawtucket) = $48.767(\text{W-}Q_{peak})^{-0.3011}$ 5 Storms $R^2 = 0.933$

Peak flows ranged from 216 to 3,453 cfs between Millbury and Northbridge, and between 145 and 6,934 cfs between Millbury and Woonsocket (Figure 2-8). The TOT for the peak flow ranged from 4.5 to 10.5 hours between Millbury and Northbridge, 16.5 to 24 hours between Millbury and Woonsocket, and 3.3 to 7.3 hours between Woonsocket and Roosevelt Avenue in Pawtucket.

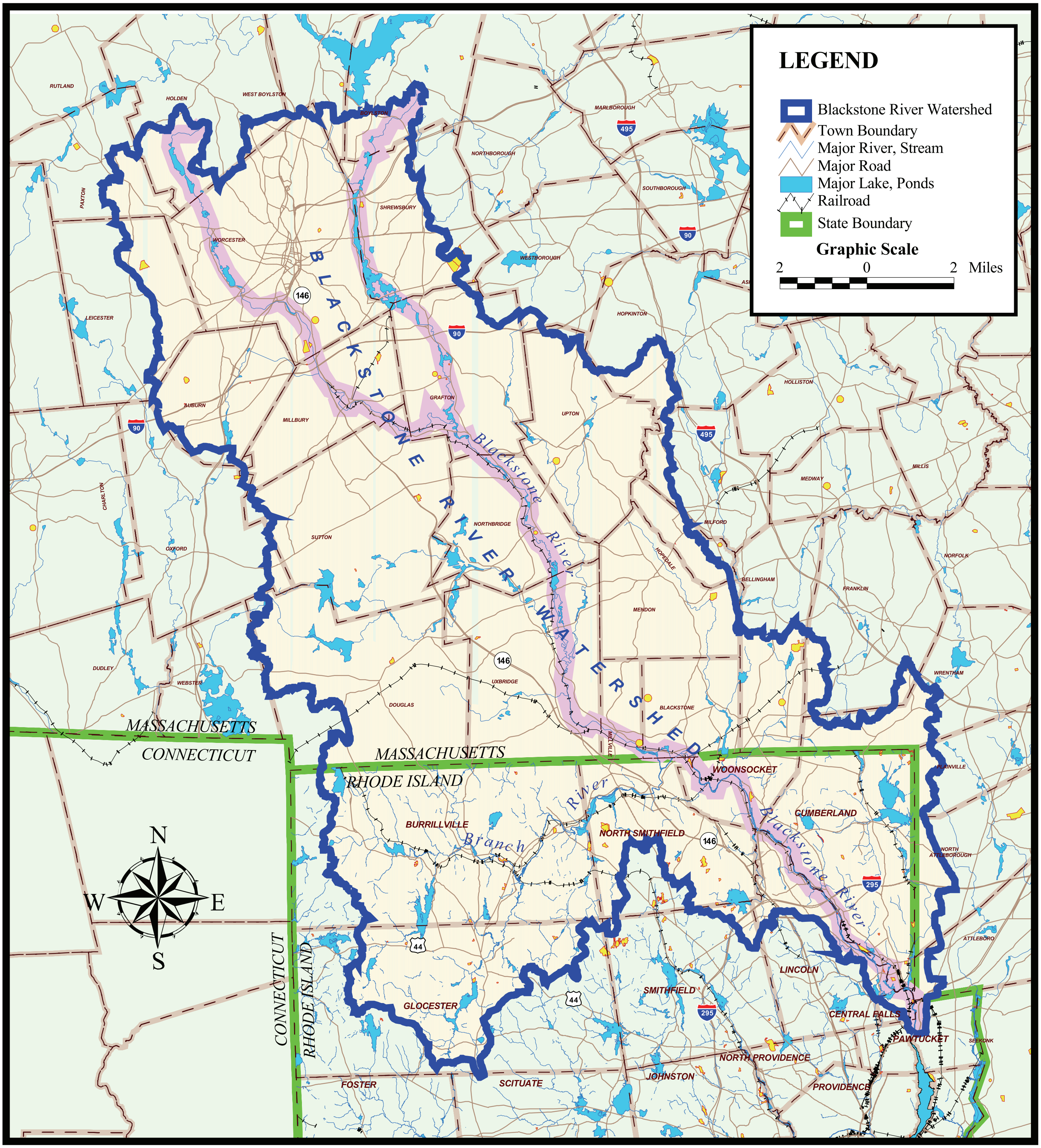
Predictions for the storms used to generate the regression equations were plotted against the observations (Figure 2-9a). The regression equations were used to estimate the time of travel for storms WW-01, WW-03, and WW-04, sampled in this study (Section 4). These results are presented in Figure 2-10 and superimposed on the earlier predictions (Figure 2-9b). The observed and predicted results were close.

Using these results, the TOTs for the observed range of peak flows at the Millbury and Woonsocket gages and the associated average velocities for those reaches were determined (Figure 2-11). The velocities presented in Figure 2-11 were then used to estimate the TOTs for the other river segments. TOTs for the Rhode Island river segments RS-1 and RS-2 are presented in Figure 2-12. These TOTs used velocities for the M-W relationship between the MA/RI State line (Station W-01) and the Woonsocket gage, and velocities for the W-R relationship between the Woonsocket gage and Slater Mill (Station W-05); both sets of velocities were based on W-Q_{peak}. TOTs for the Massachusetts river segments RS-3 to RS-6 are presented in Figure 2-13. These TOTs used velocities for the M-W relationship based on M-Q_{peak}.

Two events on the opposite end of the flow range provide examples of the peak flow TOTs for the Blackstone River:

- On August 5, 2002 the peak flows at the Millbury and Woonsocket USGS gages were the lowest observed for this review: 387 cfs and 145 cfs, respectively. Rainfall amounts recorded by the National Weather Service stations on that day were 0.53 inches in Worcester and trace amounts in Providence. Based on procedures used for Figures 2-12 and 2-13, the TOT for the peak flow from Worcester (Station BLK01) to Slater's Mill (Stations W-05; BRI-21) was estimated at 38 hours.

- On April 13, 2004 the peak flows at the Millbury and Woonsocket USGS gages were the highest observed for this assessment: 3,453 cfs and 6,934 cfs, respectively. The high flow was caused by 2.18 inches of rainfall recorded in Worcester and 0.40 inches recorded in Providence. The TOT for the peak flow from Worcester to Slater Mill for that event was estimated at 23 hours.



The Louis Berger Group, Inc.

Rhode Island DEM

Source: RIGIS, MASSGIS

File: bw-report-07.apr

Blackstone River TMDL

Figure 2-1

BLACKSTONE RIVER WATERSHED

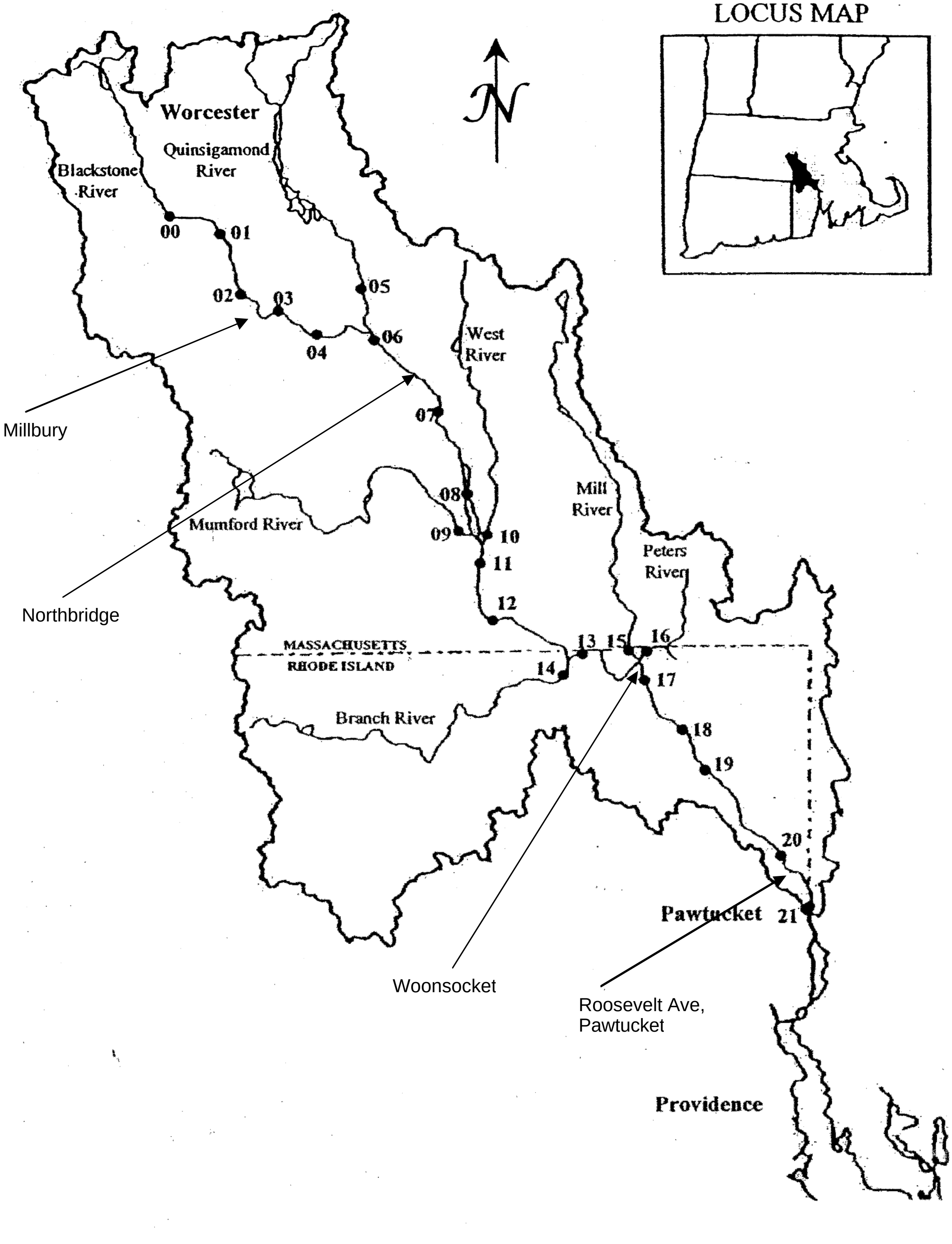
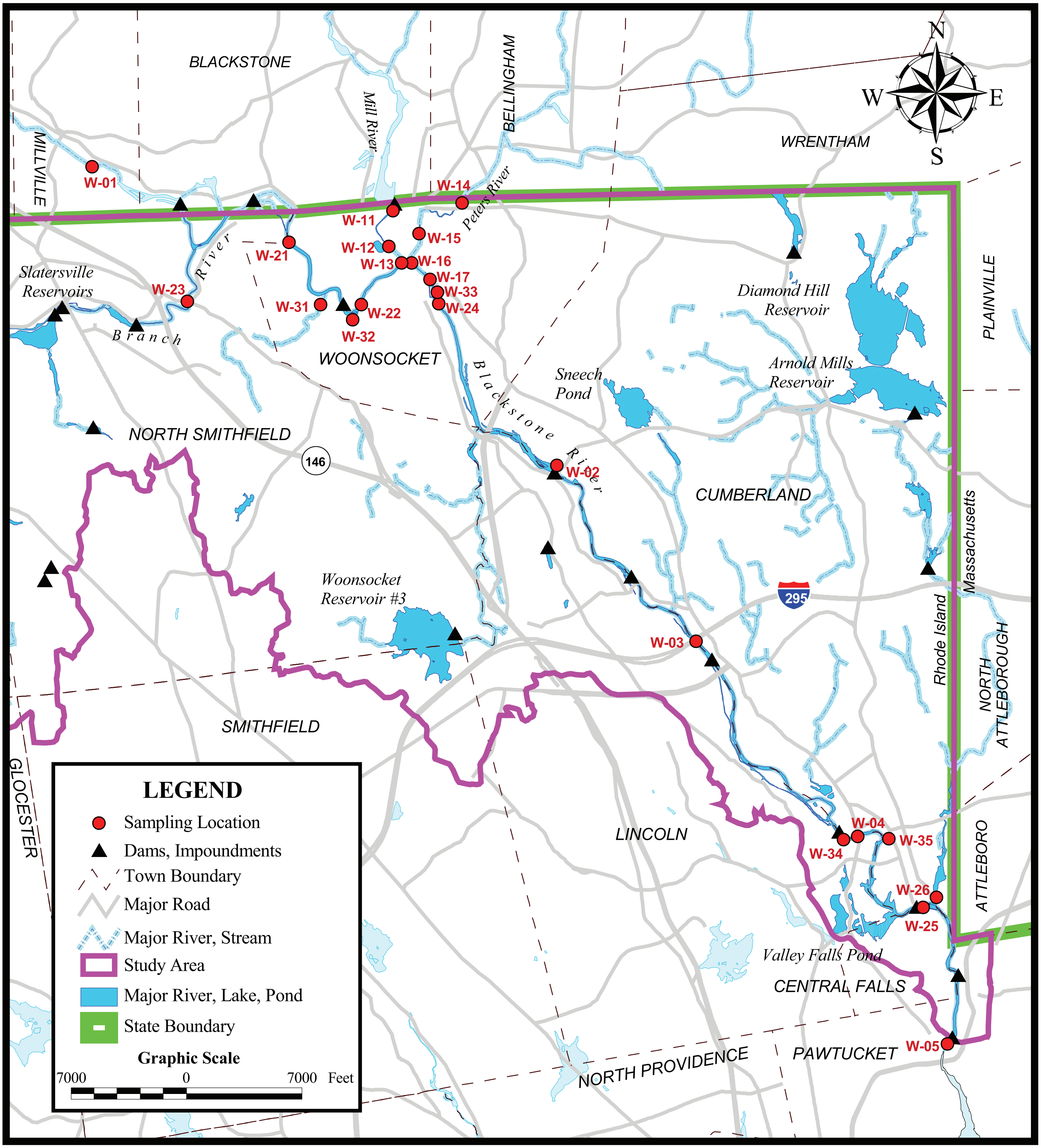


Figure 2-2: Blackstone River Initiative (1991) Sampling Locations (full circles with numbers; Wright et al., 2001) and USGS Gaging Stations used for the Time of Travel Assessment (arrows).



The Louis Berger Group, Inc.

Rhode Island DEM

Source: RIGIS, MASSGIS

File: bw-report-07.apr

Blackstone River Water Quality

Figure 2-3

WATER QUALITY SAMPLING STATION LOCATIONS

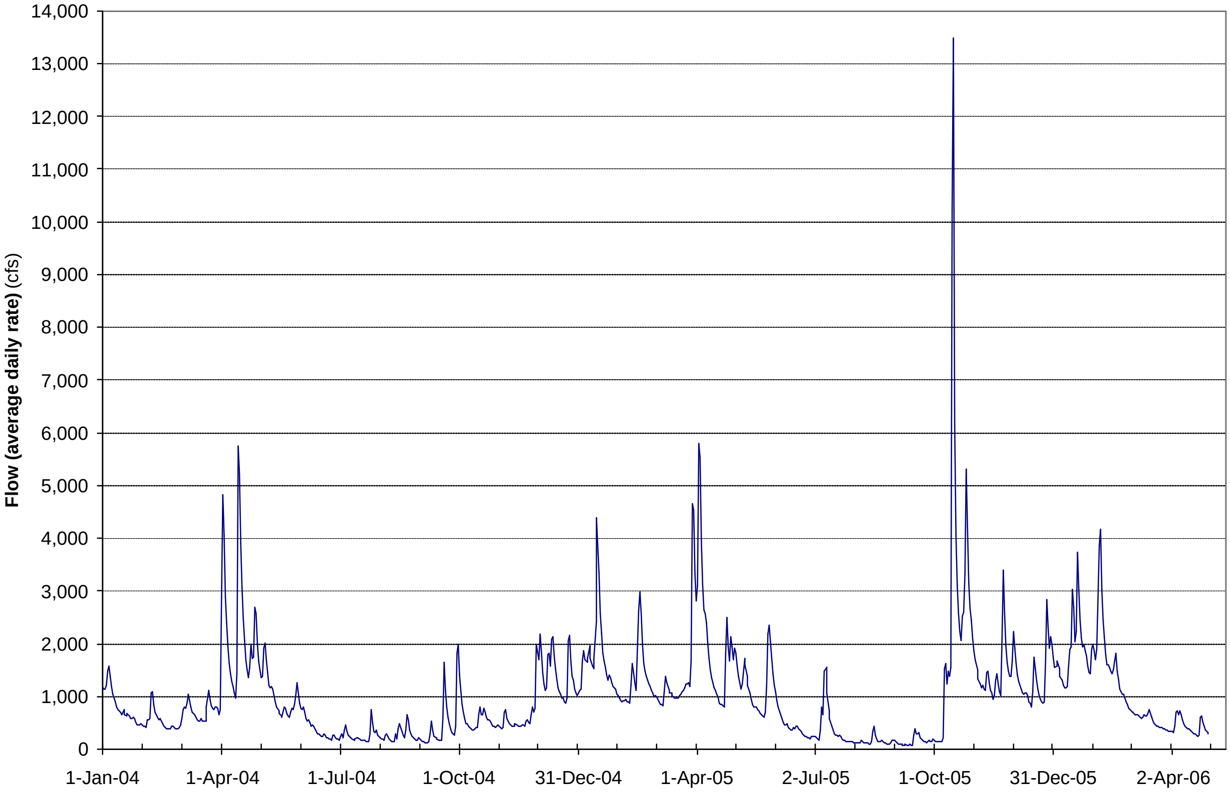
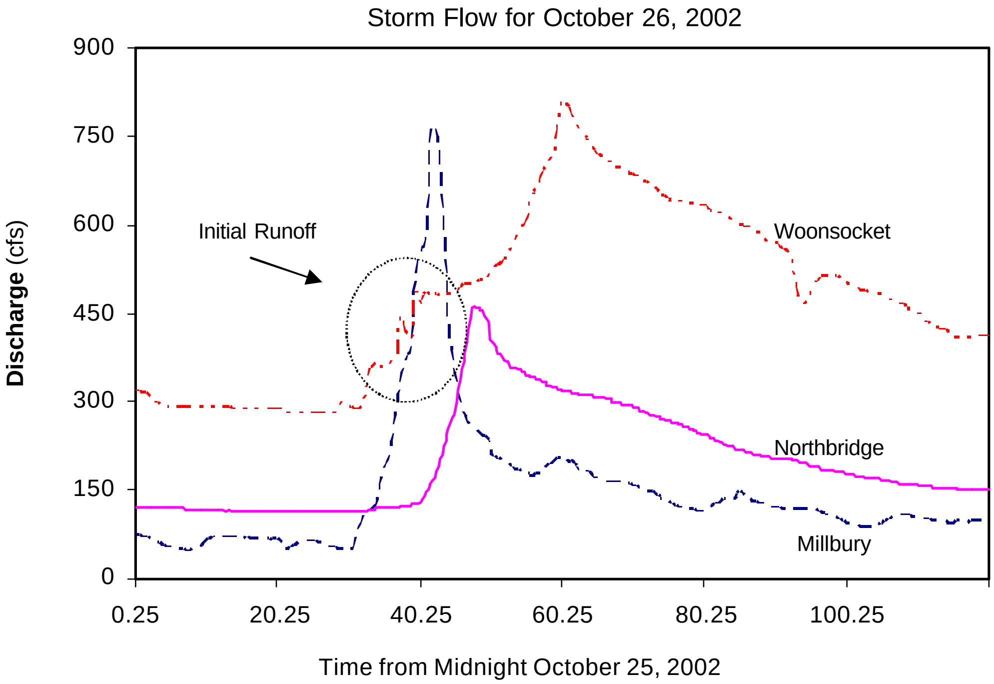


Figure 2-4: Flow of the Blackstone River at the USGS Woonsocket gage (Jan. 2004 to April 2006)



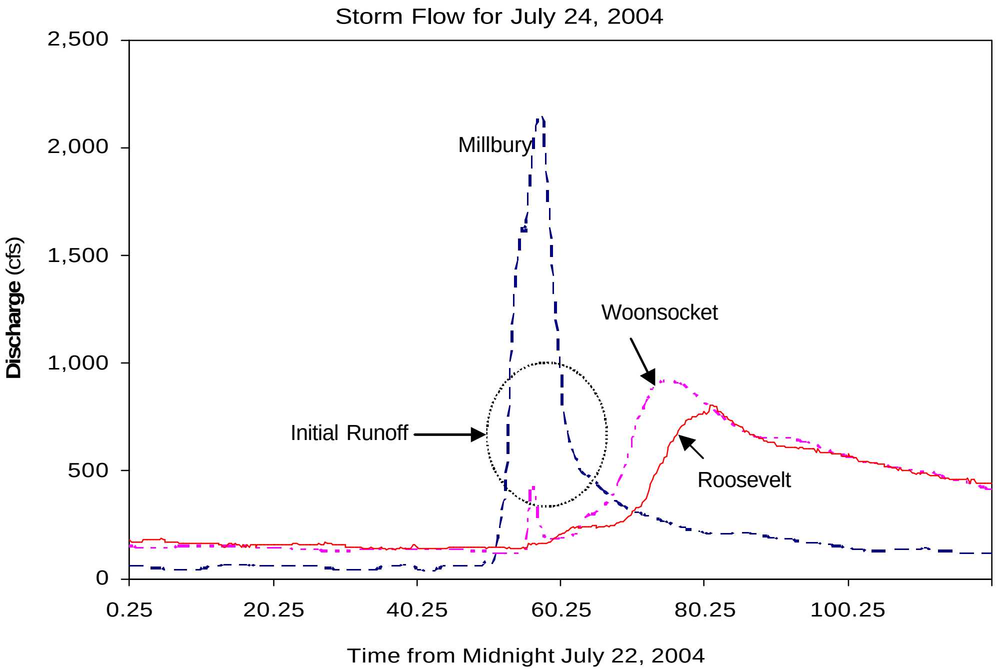
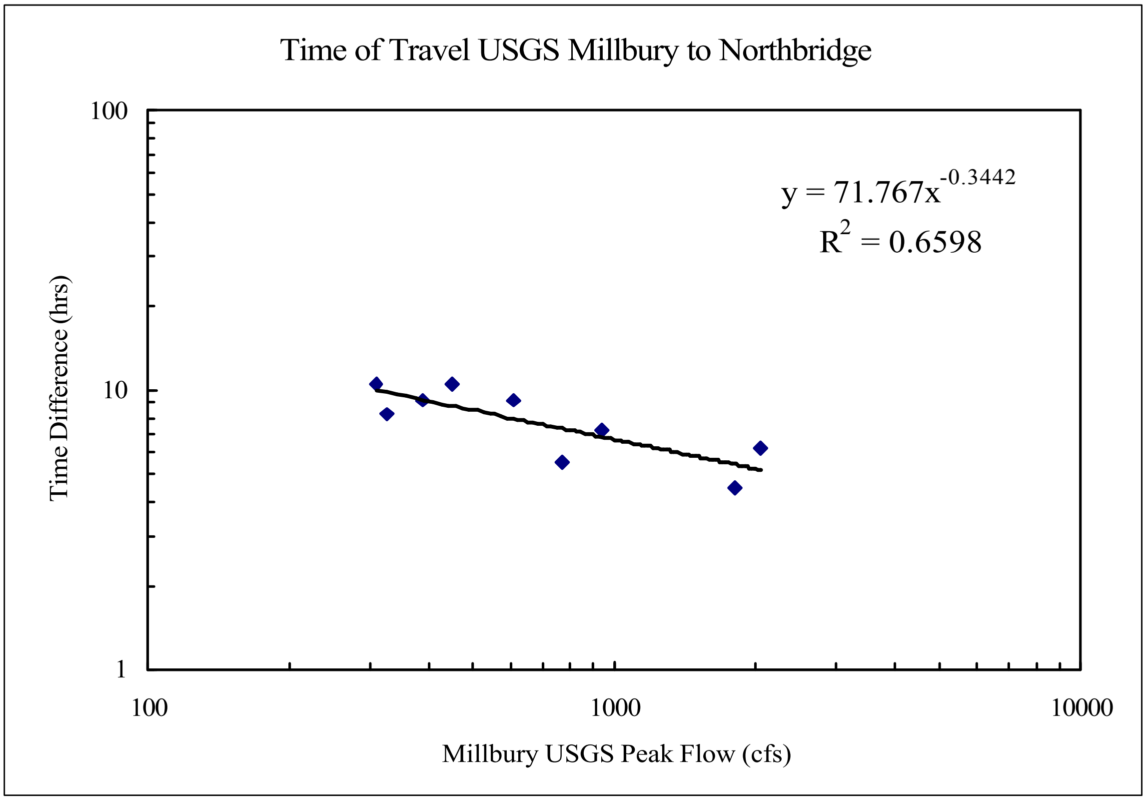


Figure 2-5: Storm Flows for October 26, 2002 and July 24, 2004 at several USGS gaging stations



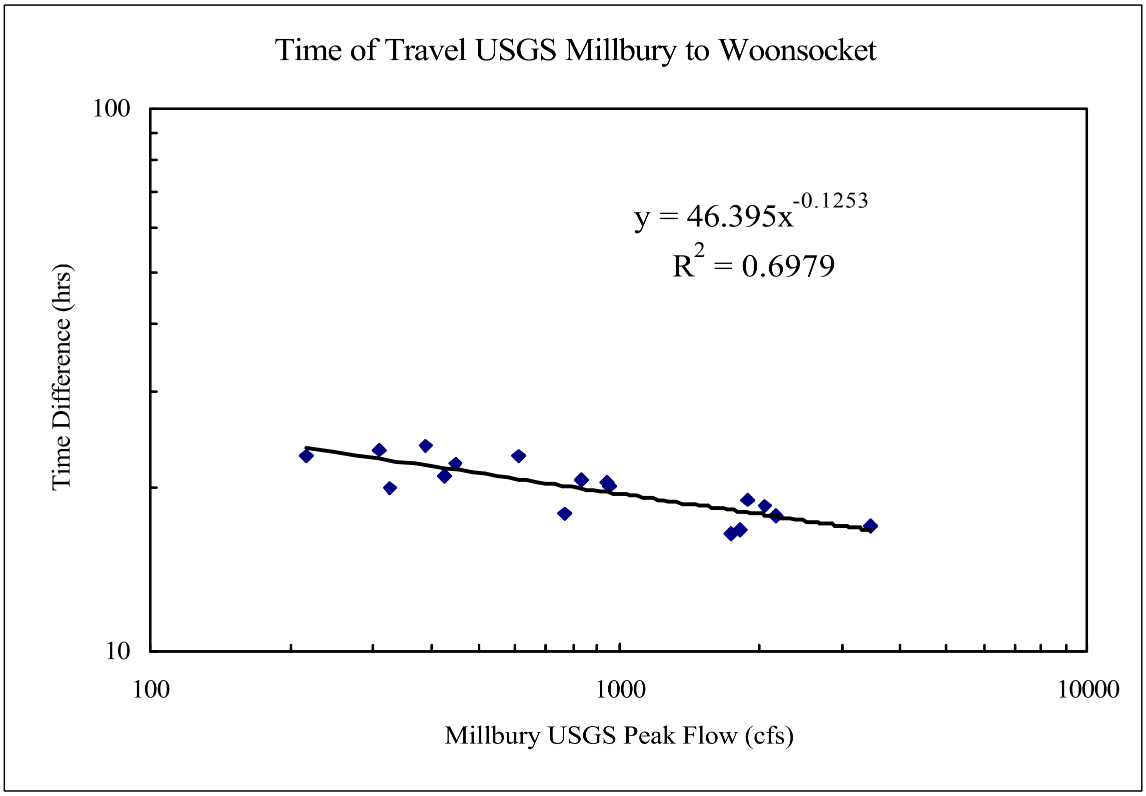
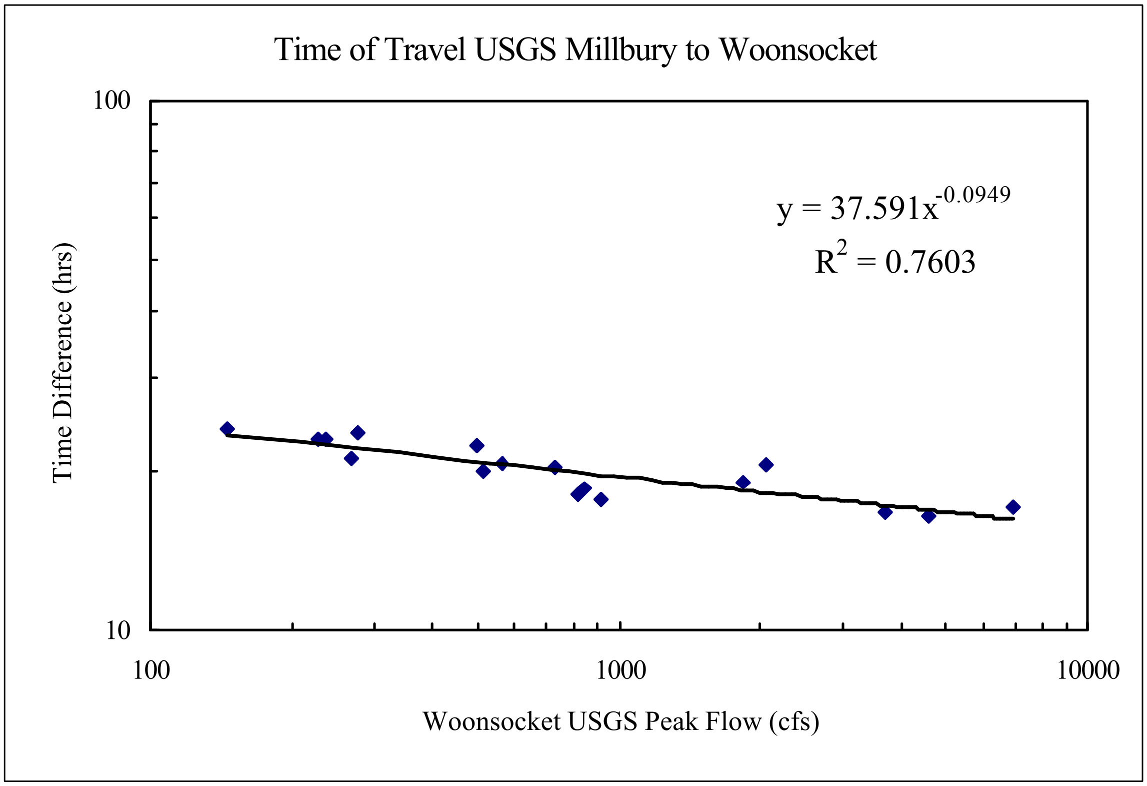


Figure 2-6: Time of Travel Relationships using Millbury USGS Peak Flow



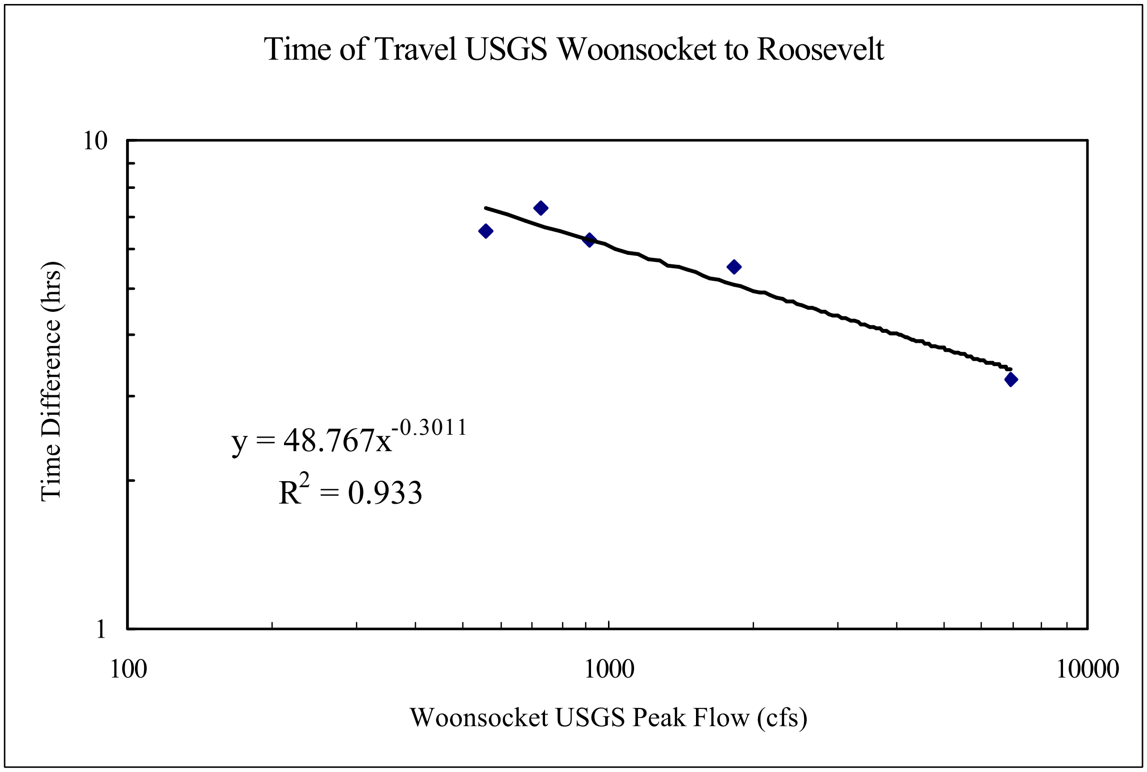


Figure 2-7: Time of Travel Relationships using Woonsocket USGS Peak Flow

Figure 2-8: Hydrograph Characteristics (2002-2004) used to develop Regression Equations

Millbury to Northbridge			Millbury to Woonsocket				Woonsocket to Roosevelt		
Storm Date	**M-Q_{peak} USGS**	**?t (hrs)**	**Storm Date**	**M-Q_{peak} USGS**	**W-Q_{peak} USGS**	**?t (hrs)**	**Storm Date**	**W-Q_{peak} USGS**	**?t (hrs)**
8/5/02	387	9.25	8/5/02	387	145	24.00	4/13/04	6,934	3.25
9/16/02	609	9.25	8/29/02	424	269	21.00	7/24/04	916	6.25
10/11-12/02	309	10.50	9/2/02	216	227	23.00	8/21/04	725	7.25
10/16/02	450	10.50	9/16/02	609	237	23.00	9/9/04	559	6.50
10/26/02	771	5.50	10/11-12/02	309	277	23.50	9/18/04	1,833	5.50
5/26/03	1,807	4.50	10/16/02	450	498	22.25			
6/7/03	940	7.25	10/26/02	771	814	18.00			
9/19/03	326	8.25	5/26/03	1,807	3,689	16.75			
9/23/03	2,062	6.25	6/7/03	940	2,060	20.50			
			6/22/03	1,744	4,570	16.50			
			9/19/03	326	511	20.00			
			9/23/03	2,062	846	18.50			
			4/13/04	3,453	6,934	17.00			
			7/24/04	2,156	916	17.75			
			8/21/04	958	958	20.25			
			9/9/04	836	836	20.75			
			9/18/04	1,892	1,892	19.00			

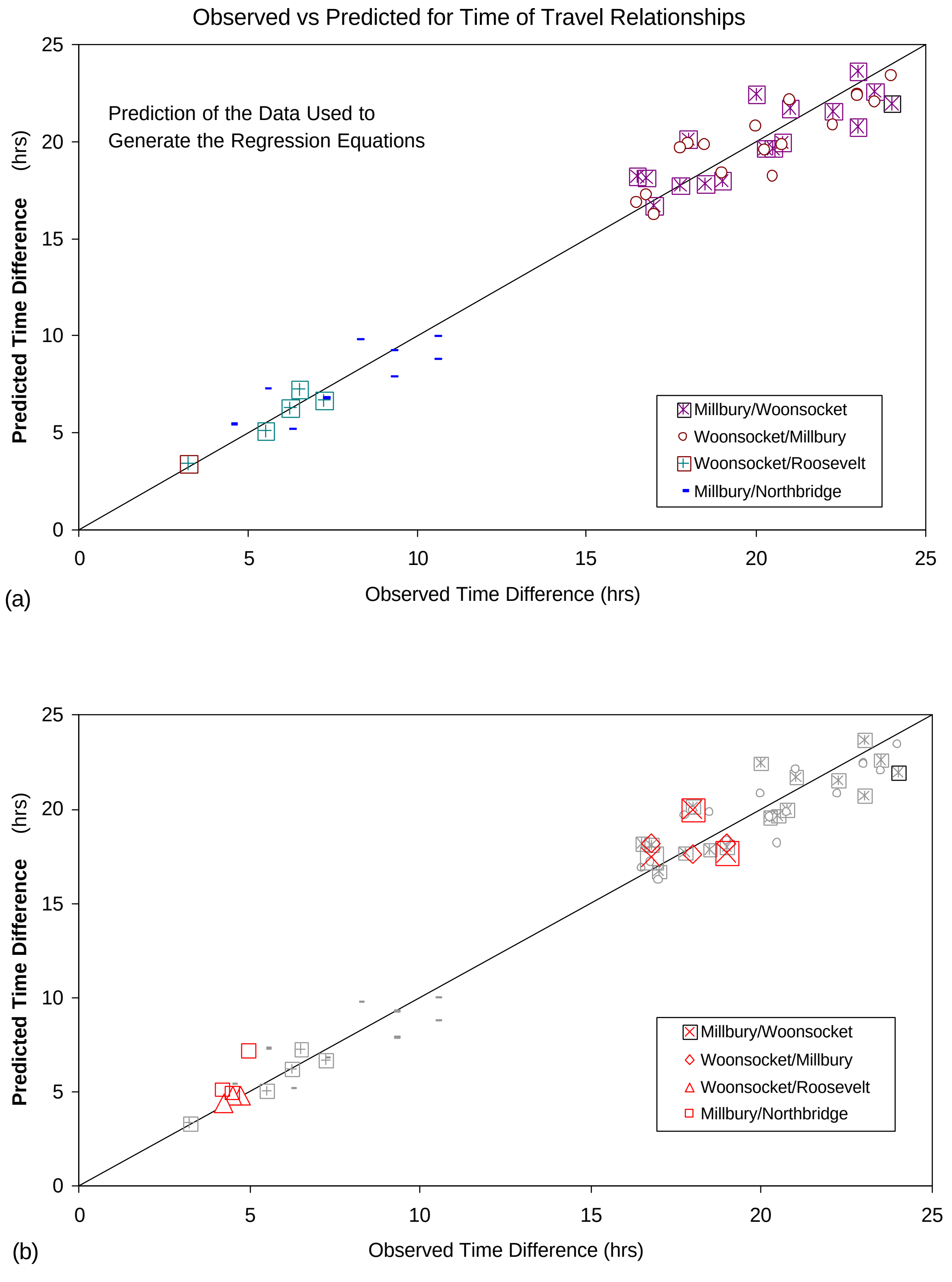


Figure 2-9: Prediction of Time of Travel using the Regression Equations

Figure 2-10: Prediction of Time of Travel for WW-01, WW-03 and WW-04 from Regression Equations

Storm	**Flow**		**Observed Time Difference**		
	USGS Millbury Q_{peak} (cfs)	USGS Woonsocket Q_{peak} (cfs)	Time Difference Millbury to Woonsocket (hours)	Time Difference Woonsocket to Roosevelt (hours)	Time Difference Millbury to Northbridge (hours)
	Observed	Observed	Observed	Observed	Observed
WW-1	2,450	2,098	16.75	4.75	4.50
WW-3	2,196	2,096	19.00	4.50	4.25
WW-4	820	2,864	18.00	4.25	5.00

Storm	**Flow**		**Prediction of the Time Difference from Millbury to Woonsocket based on Millbury Q_{peak}**		
	USGS Millbury Q_{peak}		?t (Millbury to Woonsocket USGS Gages) = 46.395(Millbury Qpeak)-0.1253		
			?t (Millbury to Northbridge USGS Gages) = 71.767(Millbury Qpeak)-0.3442		
	Observed		Predicted		Predicted
WW-1	2,450		17.45		4.89
WW-3	2,196		17.69		5.08
WW-4	820		20.02		7.13

Storm	**Flow**		**Prediction of the Time Difference from Millbury to Woonsocket based on Woonsocket Qpeak**		
		USGS Woonsocket Q_{peak}	?t (Millbury to Woonsocket USGS Gages) = 37.591(Woonsocket Qpeak)-0.0949		
			?t (Woonsocket to Roosevelt USGS Gages) = 48.767(Woonsocket Qpeak)-0.3011		
		Observed	Predicted	Predicted	
WW-1		2,098	18.19	4.87	
WW-3		2,096	18.19	4.88	
WW-4		2,864	17.66	4.44	

Figure 2-11: Evaluation of Time of Travel and Water Velocity for Observed Flow Range

M-Q_{peak}	M-N	Velocity M-N	M-W	Velocity M-W
cfs	hours	fps	hours	fps
100	14.7	0.55	26.1	1.56
200	11.6	0.70	23.9	1.70
300	10.1	0.80	22.7	1.79
400	9.1	0.88	21.9	1.86
500	8.5	0.95	21.3	1.91
600	7.9	1.02	20.8	1.95
700	7.5	1.07	20.4	1.99
800	7.2	1.12	20.1	2.02
900	6.9	1.17	19.8	2.05
1,000	6.7	1.21	19.5	2.08
1,100	6.4	1.25	19.3	2.11
1,200	6.3	1.29	19.1	2.13
1,300	6.1	1.33	18.9	2.15
1,400	5.9	1.36	18.7	2.17
1,500	5.8	1.39	18.6	2.19
1,600	5.7	1.42	18.4	2.21
1,700	5.5	1.45	18.3	2.22
1,800	5.4	1.48	18.1	2.24
1,900	5.3	1.51	18.0	2.26
2,000	5.2	1.54	17.9	2.27
2,100	5.2	1.56	17.8	2.28
2,200	5.1	1.59	17.7	2.30
2,300	5.0	1.61	17.6	2.31
2,400	4.9	1.64	17.5	2.32
2,500	4.9	1.66	17.4	2.33
2,600	4.8	1.68	17.3	2.35
2,700	4.7	1.71	17.2	2.36
2,800	4.7	1.73	17.2	2.37
2,900	4.6	1.75	17.1	2.38
3,000	4.6	1.77	17.0	2.39
3,100	4.5	1.79	16.9	2.40
3,200	4.5	1.81	16.9	2.41
3,300	4.4	1.83	16.8	2.42
3,400	4.4	1.85	16.7	2.43
3,500	4.3	1.87	16.7	2.44

W-Q_{peak}	M-W	Velocity M-W	W-R	Velocity W-R
cfs	hours	fps	hours	fps
200	22.7	1.79	9.9	1.82
400	21.3	1.91	8.0	2.25
600	20.5	1.98	7.1	2.54
800	19.9	2.04	6.5	2.77
1,000	19.5	2.08	6.1	2.96
1,200	19.2	2.12	5.8	3.13
1,400	18.9	2.15	5.5	3.28
1,600	18.7	2.18	5.3	3.41
1,800	18.5	2.20	5.1	3.53
2,000	18.3	2.22	4.9	3.65
2,200	18.1	2.24	4.8	3.76
2,400	18.0	2.26	4.7	3.85
2,600	17.8	2.28	4.6	3.95
2,800	17.7	2.30	4.5	4.04
3,000	17.6	2.31	4.4	4.12
3,200	17.5	2.33	4.3	4.20
3,400	17.4	2.34	4.2	4.28
3,600	17.3	2.35	4.1	4.36
3,800	17.2	2.36	4.1	4.43
4,000	17.1	2.37	4.0	4.50
4,200	17.0	2.39	4.0	4.56
4,400	17.0	2.40	3.9	4.63
4,600	16.9	2.41	3.8	4.69
4,800	16.8	2.42	3.8	4.75
5,000	16.8	2.43	3.8	4.81
5,200	16.7	2.43	3.7	4.87
5,400	16.6	2.44	3.7	4.92
5,600	16.6	2.45	3.6	4.97
5,800	16.5	2.46	3.6	5.03
6,000	16.5	2.47	3.6	5.08
6,200	16.4	2.48	3.5	5.13
6,400	16.4	2.48	3.5	5.18
6,600	16.3	2.49	3.5	5.23
6,800	16.3	2.50	3.4	5.27
7,000	16.2	2.50	3.4	5.32

Gaging Stations: M = Millbury; N = Northbridge; W = Woonsocket; R = Roosevelt Ave

Distance between Millbury and Northbridge USGS gages estimated as 8.9 km (5.5 miles)

Distance between Millbury and Woonsocket USGS gages estimated as 44.6 km (27.7 miles)

Distance between Woonsocket and Roosevelt USGS gages estimated as 19.8 km (12.3 miles)

fps = feet per second

cfs = cubic feet per second

Figure 2-12: Estimation of Woonsocket Peak Flow Time of Travel for Segments RS-1 and RS-2

W-Q_{peak}	**Velocity M-W**	**Velocity W-R**	**Segment RS-1**	**Segment RS-2**
cfs	fps	fps	hours	hours
200	1.79	1.82	15.7	7.7
400	1.91	2.25	13.4	6.9
600	1.98	2.54	12.2	6.4
800	2.04	2.77	11.5	6.2
1,000	2.08	2.96	10.9	6.0
1,200	2.12	3.13	10.5	5.8
1,400	2.15	3.28	10.1	5.7
1,600	2.18	3.41	9.9	5.6
1,800	2.20	3.53	9.6	5.5
2,000	2.22	3.65	9.4	5.4
2,200	2.24	3.76	9.2	5.3
2,400	2.26	3.85	9.0	5.2
2,600	2.28	3.95	8.9	5.2
2,800	2.30	4.04	8.8	5.1
3,000	2.31	4.12	8.6	5.1
3,200	2.33	4.20	8.5	5.0
3,400	2.34	4.28	8.4	5.0
3,600	2.35	4.36	8.3	4.9
3,800	2.36	4.43	8.2	4.9
4,000	2.37	4.50	8.1	4.9
4,200	2.39	4.56	8.1	4.8
4,400	2.40	4.63	8.0	4.8
4,600	2.41	4.69	7.9	4.8
4,800	2.42	4.75	7.8	4.8
5,000	2.43	4.81	7.8	4.7
5,200	2.43	4.87	7.7	4.7
5,400	2.44	4.92	7.7	4.7
5,600	2.45	4.97	7.6	4.7
5,800	2.46	5.03	7.5	4.6
6,000	2.47	5.08	7.5	4.6
6,200	2.48	5.13	7.4	4.6
6,400	2.48	5.18	7.4	4.6
6,600	2.49	5.23	7.4	4.5
6,800	2.50	5.27	7.3	4.5
7,000	2.50	5.32	7.3	4.5

RS-1: MA/RI state line (represented by W-01) to Slater's Mill (W-05)

RS-2: MA/RI state line (represented by W-01) to Manville Dam (W-02)

Distance between Station W-01 to Woonsocket USGS gage: Approx. 10 km (6.2 miles)

Lengths: RS-1 = 31.2 km (19.4 miles); RS-2 = 15.1 km (9.4 miles)

Figure 2-13: Estimation of Millbury Peak Flow Time of Travel for Segments RS-3 to RS-6

M-Q_{peak}	Velocity M-W	Segment RS-3	Segment RS-4	Segment RS-5	Segment RS-6
cfs	fps	hours	hours	hours	hours
100	1.56	24.8	23.5	17.5	9.2
200	1.70	22.8	21.6	16.0	8.5
300	1.79	21.6	20.5	15.2	8.0
400	1.86	20.9	19.8	14.7	7.7
500	1.91	20.3	19.2	14.3	7.5
600	1.95	19.8	18.8	14.0	7.4
700	1.99	19.5	18.4	13.7	7.2
800	2.02	19.1	18.1	13.5	7.1
900	2.05	18.9	17.9	13.3	7.0
1,000	2.08	18.6	17.6	13.1	6.9
1,100	2.11	18.4	17.4	13.0	6.8
1,200	2.13	18.2	17.2	12.8	6.8
1,300	2.15	18.0	17.1	12.7	6.7
1,400	2.17	17.8	16.9	12.6	6.6
1,500	2.19	17.7	16.7	12.5	6.6
1,600	2.21	17.5	16.6	12.4	6.5
1,700	2.22	17.4	16.5	12.3	6.5
1,800	2.24	17.3	16.4	12.2	6.4
1,900	2.26	17.2	16.3	12.1	6.4
2,000	2.27	17.1	16.2	12.0	6.3
2,100	2.28	17.0	16.1	11.9	6.3
2,200	2.30	16.9	16.0	11.9	6.3
2,300	2.31	16.8	15.9	11.8	6.2
2,400	2.32	16.7	15.8	11.7	6.2
2,500	2.33	16.6	15.7	11.7	6.2
2,600	2.35	16.5	15.6	11.6	6.1
2,700	2.36	16.4	15.6	11.6	6.1
2,800	2.37	16.4	15.5	11.5	6.1
2,900	2.38	16.3	15.4	11.5	6.0
3,000	2.39	16.2	15.4	11.4	6.0
3,100	2.40	16.1	15.3	11.4	6.0
3,200	2.41	16.1	15.2	11.3	6.0
3,300	2.42	16.0	15.2	11.3	5.9
3,400	2.43	16.0	15.1	11.2	5.9
3,500	2.44	15.9	15.1	11.2	5.9

M-Qpeak = Millbury USGS Peak Flow
M-W = Millbury to Woonsocket

RS = River Segments;
RS-3: Worcester (near BLK01) to MA/RI State Line (represented by W-01)
RS-4: UBWPAD discharge to MA/RI State Line (represented by W-01)
RS-5: Fisherville Pond (near BLK06) to MA/RI State Line (represented by W-01)
RS-6: Rice City Pond (near BLK08) to MA/RI State Line (represented by W-01)

Lengths: RS-3 = 42.5 km (26.4 miles); RS-4 = 40.2 km (25.0 miles);
RS-5 = 29.9 km (18.6 miles); RS-6 = 15.8 km (9.8 miles).

3.0 BLACKSTONE RIVER WATER QUALITY - DRY WEATHER

A dry weather water quality survey was conducted along the Blackstone River and its larger tributaries over a one-year period. Dry weather was defined as total rainfall in the Blackstone River watershed of less than 0.1 inches per day for 3 days prior to sampling.

3.1 Methodology

3.1.1 Stations

Dry weather samples were collected from March 2005 to February 2006 at a total of 23 stations (Figures 2-3 and 3-1). Station locations are also included on aerial photographs of the project area in Figures 5-1 to 5-13 in Section 5.

The BTMDL water quality stations were grouped into primary, secondary and tertiary stations based on sampling frequency:

- **Primary Stations:** Biweekly sample collection from May to October and once a month from November to April. This frequency covered the entire year with more frequent sampling at the more critical water quality period from late spring to fall.
- **Secondary Stations:** Sample collection three times over the summer (once in July, August and September). In addition, these stations were sampled in December, March, and June. Samples were collected in conjunction with the samples at the primary stations. Three secondary stations each were located along the Mill River (W-11 to W-13) and Peters River (W-14 to W-16). An additional station was located along the Blackstone River (W-17).
- **Tertiary Stations:** Sampling was conducted three times over the summer (once in July, August and September) along with the sampling for the primary and secondary stations. Stations were located along the Blackstone River (W-21, W-22, W-25), near the mouths of the Branch River (W-23) and Abbott Run Brook (W-26), and in the outflow from the Woonsocket WWTF (W-24). In addition, three small tributaries were sampled: Cherry Brook (W-31), unnamed brook at Front Street (W-32), Sylvestre Pond Outflow (W-33), and Blackstone Canal overflow in Lonsdale (W-34). The unnamed brook near Ann&Hope in Cumberland (W-35) was added later to the survey, based on water quality concerns during the outfall reconnaissance survey.

The field program was slightly modified from the originally proposed program based on field conditions and findings during the course of the program (Figure 3-2). Generally, the sampling frequency varied in order to assist in the data analysis. Specifically, the Blackstone River watershed in Rhode Island was divided into three reaches to bracket specific segments of the river.

- **Reach 1 (Woonsocket):** Reach 1 covered the urban area of the City of Woonsocket and is bracketed by Stations W-01 and W-02. Station W-01 represented the water quality of the Blackstone River at the MA/RI State line. Station W-02 was located just above the Manville Dam downstream from the City of Woonsocket. It was also located downstream of the Woonsocket WWTF. Larger tributaries entering the Blackstone River within Reach 1 consisted of the Branch River, Mill River, and Peters River.

- **Reach 2 (Lincoln/Cumberland):** Reach 2 covered the more rural Towns of Lincoln and Cumberland) and was bracketed by Stations W-02 and W-04. Station W-04 was located at the Lonsdale Avenue bridge. An additional station (W-03) was located at the Ashton Dam in the middle of Reach 2. There are no CSOs entering this reach. Discharges from the Town of Lincoln entering the long section of the Blackstone Canal from the Ashton Dam to the Lonsdale Bleachery overflow into the Blackstone River near the Lonsdale Bleachery within Reach 2. There are only a few small tributaries entering the Blackstone River within Reach 2.

- **Reach 3: (Central Falls/Pawtucket):** Reach 3 covered the urban area of the Cities of Central Falls and Pawtucket. The reach was bracketed by Stations W-04 and W-05. Station W-05 was located at Slater Mill dam, near the mouth of the Blackstone River. Reach 1 contained most of the CSOs that enter the Blackstone River from the two cities. Abbott Run Brook was the only larger tributary entering the Blackstone River within Reach 3. There has been considerable work done recently in the evaluation of the CSOs in these two cities. The abatement of the CSOs is scheduled to be completed by approximately year 2019. Since the current contaminant sources to this reach will change substantially, no outfalls within the city limits were sampled. Instead, the tertiary stations within this reach focused on Abbott Run Brook and Valley Falls Pond area contributions to the Blackstone River.

3.1.2 Parameters

Samples were analyzed by laboratories for the following parameters: pathogens (fecal coliform, enterococci), metals (dissolved copper and lead), hardness, total and volatile suspended solids, nutrients (total phosphorus, total Kjeldahl nitrogen, nitrate, and ammonia). Chlorophyll *a* was also analyzed at the primary stations. In-situ measurements in the field were conducted for dissolved oxygen, temperature, specific conductance, turbidity, pH, and chloride.

The laboratory reports of analytical data are included on the enclosed CD. Laboratory analyses for nutrients and pathogens were performed by Mitkem. Dissolved copper and lead analyses were carried out by three laboratories at various stages of the project for reasons of quality control. Initially, the primary laboratory was Mitkem that used the ICP method 200.7. At the beginning of the study, samples were analyzed simultaneously by Microinorganics for data verification purposes; Microinorganics used the (considerably more costly) method EPA 1637, designed for the detection of metals at very low concentrations. After dry weather event DW-06, it was decided to replace the ICP method 200.7 (Mitkem) by ICP-MS method 200.8 (performed by the Severn Trent Laboratory [STL]) as it became apparent that the data obtained with ICP method 200.7 were somewhat erratic at the low concentrations found in the Blackstone River. Figure 3-3 compares the reporting limits and method detection limits for metals by all three laboratories. A comparison of duplicate dry weather metals analyses by the three laboratories are presented in Tables B-1 and B-2 in Appendix B. Following are the key observations from this comparison:

- **Dissolved copper:** Dissolved copper concentrations analyzed by the EPA 1637 method (Microinorganics) were consistently lower by a factor of approximately two as compared to the ICP 200.7 method (Mitkem). Dissolved copper concentrations measured by the ICP-MS 200.8 method (STL) were also lower than the data obtained with the ICP 200.7 method, and more closely resembled the data from the EPA 1637 method. The precision for each analysis was generally high for both the lab and field duplicates.

- **Dissolved lead:** During Events DW-02 and DW-03, dissolved lead concentrations analyzed by the EPA 1637 method were lower by a factor of approximately two to five as compared to concentrations obtained with the ICP 200.7 method. During subsequent events, lead concentrations were largely below the MDL of 0.23 ug/l. Dissolved copper concentrations measured by the ICP-MS 200.8 method were generally close to the concentrations measured with the EPA 1637 method.

Given the uncertainty in the reliability of the dissolved copper and lead data by the ICP 200.7 method, data were not reported in the data tables in Section 3. Only data obtained with the ICP-MS 200.8 and EPA 1637 methods are provided. The removed dissolved copper and lead concentrations obtained by Mitkem are only provided in the QA/QC section of the report (Table B-5 in Appendix B).

In summary, the following dry weather concentration data are provided in the data tables in Section 3, as agreed with RIDEM in September 2007:

- Nutrients (nitrate, phosphorus, ammonia, total Kjeldahl nitrogen): Data are reported to the RL. Values below the RL but above the MDL are reported as <(RL). For mathematical calculations of means and loads, we utilized 50% of the RL for values below the respective RL.
- Dissolved Copper and Lead: Data are reported to the RL. Values below the RL but above the MDL are reported as <(RL). In the case of duplicate analyses by these two labs (STL, Microinorganics), the mean concentration by the two analyses was reported. For calculations of means and loads, concentrations below the RL were excluded.
- Bacteria: Values above and below the detection limits are flagged in italics and with '>' and '<', respectively. For mathematical calculations, fecal coliform and enterococci concentrations that exceeded the upper or lower detection limits were assumed at the detection limit, plus or minus one significant number (out of two reported numbers). For example, we assumed a value of 17,000 MPN/100 ml for concentrations of >16,000 MPN/100 ml. Similarly, we assumed a value of 1.9 MPN/100 ml for concentrations of <2 MPN/100 ml.
- Hardness: Values are reported to the RL.
- Pigments, Solids, Chloride: These analyses were run by UMASS (pigments) and URI (solids, chloride) and are reported to the MDL. RL's were not available. Values below the MDL were flagged in italics, which was only required for some of the pheopigment data.

3.1.3 Evaluation of Data for Compliance

As instructed by RIDEM, compliance of the pathogen and metals data with the standard was conducted with the understanding that load calculations will be developed for the TMDL.

Dissolved Copper and Lead

The determination of compliance for metals used average hardness values in a manner that reflected their distribution during both dry weather conditions (see Section 3.2.6) and wet weather conditions (see Section 4.3.4).

- **Dry Weather:** For dry weather, *acute and chronic criteria* calculations used the average hardness of all stations by survey for each waterbody. Accordingly, for the Blackstone River, the average of the mainstem stations (W-01 to W-05, W-21, W-22, W-17, and W-25) was calculated for each survey date. For the Mill River, Stations W-11 to W-13 were averaged for each survey date that samples were taken. Similarly, for the Peters River, data from Stations W-14 to W-16 were averaged. For the Branch River, Abbott Run and Cherry Brook, the hardness for each sample was used, since there was only one station along each waterbody. For the evaluation of the metals data for exceedances of regulatory standards, the value of each sample was compared against the calculated acute and chronic criteria.

- **Wet Weather:** For wet weather, the hardness for calculating acute and chronic criteria differed. For the calculation of the *acute criteria*, the average hardness of all stations on a waterbody for each run was used. For the Blackstone River, Stations W-01 to W-05, W-21, W-22, W-17, and W-25 along the mainstem were used (i.e., same stations as for dry weather data evaluation). Similarly, for the Mill River and Peters River, the average of the three respective stations for each run was used. As with the dry weather hardness, the individual hardness values for each sample for the Branch River, Abbott Run and Cherry Brook was used. For the evaluation of the metals data for exceedances, the value of each sample was compared against the calculated acute criteria.

  The wet weather *chronic criteria* were calculated by station using the average hardness for each wet weather event. For the evaluation of the metals data for exceedances, the metals value for each storm for each sample location was averaged and compared against the calculated chronic criteria.

- **Small Tributaries and Outfalls:** For the evaluation of the data from outfalls, we used the hardness for a station along the receiving waterbody closest to the discharge point of the outfall, utilizing the hardness appropriate to either the chronic or acute criteria.

- **Exceedances of Metals Criteria:** A waterbody does not comply with the standards when there is more than one exceedance of the criteria in three years. However, in some instances, a single exceedance of the criteria may be viewed as non-compliance with the standards if there is strong evidence that the criteria could be exceeded again within a three-year period. (See documents for draft Woonasquatucket River metals and pathogen TMDL [RIDEM, 2006] for further explanation of the approach.)

Pathogens

Compliance with pathogen standards was evaluated on a station-by-station basis. For the calculation of geometric means and percentile values, we used all available data for each individual station, unlike the approach commonly used for assessing baseline water quality data reported in the state's 305b report and serving as the basis for 303(d) listings, TMDL assessments do not typically average the data from several stations within a reach. Both dry and weather statistics were run to identify exceedances and to assist in evaluating possible pollution sources.

To establish necessary reductions to meet TMDL water quality targets, the RIDEM TMDL Program has adopted an approach that calculates a single mean value for each station by combining all data in the form of a "weighted average" based on the percentage of wet and dry weather days that occur annually in the watershed. RIDEM believes that this approach works well in establishing the representative year-round mean condition of a waterbody, particularly because the data used to characterize the average condition are typically not collected on a random basis. Data for nearly all areas of the state are biased toward dry weather conditions; however, it is recognized that this may not necessarily be the case for the Blackstone River, given the comprehensive sampling program completed. The weighting approach corrects the representative mean to reflect the overwhelming influence of weather conditions. (See documents for draft Woonasquatucket River metals and pathogen TMDL [RIDEM, 2006] for further explanation of the approach.)

3.1.4 Rainfall

Dry weather surveys required at least three dry days prior to the sampling date of no more the 0.1 inches of rainfall in any one day. Figure 3-4 is a summary of the rainfall prior to each survey. Daily and monthly rainfall data for Worcester and Woonsocket are presented in Appendix A. The three stations presented consist of the National Weather Service stations at the Worcester (MA) airport, Providence (RI) airport, and the weather underground station in either Cumberland (RI) or Bellingham (MA), both central to the Blackstone River watershed. All stations are within the Blackstone River watershed with the exception of the Providence station which is located to the south of the watershed.

- *DW-03, 06, 08, 11, 12, 14, 15, and 16:* These 8 of the 18 dry weather sampling events met the antecedent dry weather period requirements without qualification.

- *DW-02, 10, 13, and 18:* Minor rainfall (0.12 to 0.25 inches) occurred in Worcester for these 4 of the 18 events either on the day before or the day of sampling. There was no observed impact on the downstream flows in Rhode Island.

- *DW-09:* There was 0.21 inches of rain recorded in Providence 48 hours in advance of DW-09. No rainfall was recorded at the other stations within the Blackstone watershed. There was no observed impact on the downstream flows.

Five surveys violated the pre-sampling antecedent dry days set for this study. Each survey is discussed below.

- *DW-01 (March):* Rainfall was recorded in Worcester (0.24 inches) three days prior to sampling and in Cumberland (0.30 inches) within 48 hours of sampling. No rainfall was recorded at the Providence station.

- *DW-04 (May #2):* Rainfall was recorded in Worcester (0.13 inches) and in Cumberland (0.27 inches) the day before sampling. No rainfall was recorded at the Providence station.

- *DW-05 (June):* Rainfall was recorded in Worcester (0.69 inches) approximately 24 hours in advance of the sampling. No rainfall was recorded at either the Cumberland or Providence station.

- *DW-07 (July #2):* Rainfall was recorded in Worcester (0.28 inches) and in Cumberland (0.58 inches) approximately 48 hours in advance of the sampling. No rainfall was recorded at the Providence station.

- *DW-17 (January):* Rainfall was recorded in Cumberland (0.17 inches) and in Providence (0.08 inches) approximately 48 hours in advance of the sampling. No rainfall was recorded at the Worcester station.

In each case, the flows from the USGS gages on the Blackstone River at Woonsocket and Roosevelt and on the Peters River provided insight into the impact of these rainfall totals on the receiving river flows (Figure 3-5). For Events DW-01, DW-04, and DW-17, average daily flows along the Blackstone River continued to decrease; along the Peters River, flows were essentially constant in the days leading up to sampling. There was no obvious impact on the receiving rivers from these rainfalls.

DW-05 and DW-07 required further investigation. Average daily flows from the Millbury (just below Worcester), Woonsocket and Roosevelt USGS gages were plotted for the week leading up to and for several days after sampling (Figure 3-6).

- *DW-05 (June):* At the Millbury gaging station, flows essentially doubled between the day before (June 8) and the day of sampling (103 to 198 cfs). This reflected the rainfall recorded in Worcester on June 8. The peak at Millbury arrived in Woonsocket on June 10, one day after the sampling. The flow at Woonsocket remained constant (467 to 469 cfs) between June 8 and 9, mostly due to the late arrival of the flow from Worcester on June 9. Flows at Roosevelt continued to decrease between June 8 and 9 (533 to 519 cfs) and rose the day after sampling to 552 cfs. The impact of the storm would have been strongest on June 10. Results from DW-05 were used in the data analysis.

- *DW-07 (July):* At the Millbury gaging station, flows increased by 12 cfs between July 18 and 19 (84 to 96 cfs). The peak from Millbury reached Woonsocket on June 20. The increase was 23 cfs (230 cfs on June 19 to 253 cfs on June 20). By the next day, flow had returned to prestorm conditions (i.e., 235 cfs). The average daily flow on June 19 was 230 cfs. Flows at Roosevelt continued to decrease between June 19 and 21 (304 to 286 cfs). Any impact from the storm would have occurred on June 20 and would have passed through the system by the sampling on June 21. Results from DW-07 were used in the subsequent analysis.

3.1.5 Flow at the Time of Sampling

Aside from the continuous USGS stations at Millbury or Northbridge, Quinsigamond, Woonsocket and the Branch River, the following temporary USGS stations were available:

- Mill River at Harris Street, Woonsocket
- Peters River at Route 114 bridge, Woonsocket
- Blackstone River at Roosevelt Avenue, Pawtucket
- Abbott Run Brook, Valley Falls

USGS stations provided direct flow estimates at several locations (W-11, W-14, W-17, W-23, W-26). Other flows were developed for each station by one of several methods listed in Figure 3-7. The flow estimates at each station for each survey are presented in Figure 3-8.

Flows were modeled for Blackstone River stations for which nearby gaging information did not exist (W-02, W-03, W-04, W-05, W-22, W-23, W-25). The procedures used in the BRI and BAC studies were applied (Wright et al., 2001; Wright et al., 2004) using the USGS gage information along with the Woonsocket WWTF flows to develop incremental inflows in cfs/square mile. The additional temporary stations listed above were used to support and validate this procedure.

Incremental inflow was calculated for both the Mill and Peters Rivers from the USGS flow estimates and applied to downstream stations (W-12, W-13, W-15, W-16). Toward the end of the study, the USGS discontinued the Mill River gaging station. Flows for the remaining dry weather surveys were estimated from a regression equation developed for available data between the Mill and Peters Rivers.

Several of the small tributaries were directly measured at the time of sampling. The Woonsocket WWTF flow information was obtained from the facility for the time of sampling.

3.2 Results

3.2.1 Pathogens

Pathogen Concentrations

The dry weather concentrations of fecal coliform and enterococci are presented in Figures 3-9 and 3-10. Respective mass loadings are presented in Figures 3-11 and 3-12. The geometric mean fecal coliform concentrations for the entire study area are provided in Figure 3-13. The following observations are made from these data:

- *Blackstone River:* Two stations along the Blackstone River exceeded the 200 MPN/100 ml geometric mean criteria for fecal coliform: W-01 at 211 MPN/100 ml (17 observations) and W-17 at 454 MPN/100 ml (6 observations).

- *Mill River:* For the Mill River, concentrations were the lowest at the State line (W-11) and highest at the middle station (W-12). Stations W-12 and W-13 exceeded the 200 MPN/100 ml geometric mean criteria (8 observations at 436 and 215 MPN/100 ml, respectively).

- *Peters River:* For the Peters River, concentrations were highest in the mid and lower sections (W-15 and W-16), although the geometric mean remained below 200 MPN/100 ml criteria.

- *Branch River:* The Branch River (W-23) exceeded the 200 MPN/100 ml geometric mean criteria with a geometric mean of 269 MPN/100 ml (4 observations).

- *Small Tributaries:* Three of the small tributaries (W-35, W-31 and W-34) had values exceeding the 200 MPN/100 ml geometric mean criteria: 7,559 MPN/100 ml (W-35), 1,260 MPN/100 ml (W-31), and 427 MPN/100 ml (W-34) for only 4, 3, and 2 observations, respectively.

All stations were ranked according to their geometric means (Figures 3-14 and 3-15). Major observations are listed below:

- The brook near Ann&Hope (Station W-35) had the highest concentrations of fecal coliform and enterococci. The concentrations (7,559 and 966 MPN/100 ml) were approximately five times higher than the concentrations at the next highest station. This difference was significant. There were only four sampling events (DW-15 to DW-18) since this station was added toward the end of the study. The brook flows underground. Samples were collected at its point of discharge. As the brook emerges from the ground it flows through an old, well-constructed granite channel. On low-flow days there is a septic odor in the channel (see also discussion in Section 5).

- Cherry Brook (W-31) had the second highest pathogen concentrations. During mid to late summer, flow rates in the brook were very low. Low flow rates may have added to the high pathogen concentrations. The brook appears to drain an impounded area that fills in with macrophytes in the hot, highly productive months.

- There is evidence both in the rankings and in the bar charts shown in Figure 3-16 that pathogen profiles along the RI portion of the Mill and Peters Rivers fit the following generalized pattern. The aerial photograph of the Rhode Island section of these two rivers shows the respective portions of the rivers that are below ground (Figure 5-6 in Section 5).

- Mill River Stations W-11 and W-12 had geometric mean fecal coliform concentrations of 38 and 436 MPN/100 ml and enterococci concentrations of 7 and 157 col/100 ml. Either there were no pathogen sources upstream in Massachusetts, or pathogens entering Mill River in Massachusetts largely decayed in Harris Pond just upstream of Station W-11. Increases in the pathogen concentrations at Station W-12 suggest the presence of a significant dry weather source between W-11 and W-12. Potential sources are discussed in Section 5.2.3.2. The concentrations at W-13 are lower than at W-12 for fecal coliform and enterococci (215 MPN/100 ml and 72 col/100 ml) and do not indicate a significant source between W-12 and W-13.

- In the Peters River, geometric means for Stations W-14, W-15, and W-16 for fecal coliform and enterococci were 121, 176, 180 MPN/100 ml and 42, 51 and 15 col/100 ml, respectively. The concentrations at the MA/RI State line are important with respect to the rest of the river and should be considered if pathogen concentrations are to be reduced on the Peters River. The increase of fecal coliform and enterococci concentrations between W-14 and W-15 is consistent and indicates a small source(s). Potential sources are discussed in Section 5.2.3.3. There is no obvious source of pathogens between W-15 and W-16.

Pathogen Loads

- Fecal coliform and enterococci loads were very variable between individual stations for individual events (Figures 3-11 and 3-12). However, averaging all primary stations for the 18 sampling events shows comparatively uniform loads. In Reach 1, mean fecal coliform and enterococci loads at Station W-02 were approximately 10% higher at Station W-02 than at the State line (Station W-01), despite bacteria die-off. In Reach 2, between Stations W-02 and W-04, bacteria loads decreased by 20% due to die-off and lack of bacteria sources. In Reach 3, between Stations W-04 and W-05, mean fecal coliform and enterococci loads increased by 57% and 73%, respectively.

- The increase in bacteria in Reach 1 is in part a result of contributions from Mill River. High fecal coliform concentrations in Mill River resulted in comparatively high loads. The Mill River loads possibly contributed to the high ranking for fecal coliform at Station W-17 (Hamlet Street) (Figure 3-14).

- The second highest mean fecal coliform load was at Station W-05 (Slater Mill) indicating that bacteria are also added in Reach 3, i.e., the Central Falls/Pawtucket section of the Blackstone River.

Comparison between 1991 BRI and 2005 BTMDL Studies

There are nine stations used in the historic comparison between the 1991 BRI study (Wright et al., 2001) and this 2005 BTMDL study. The location of seven of these stations was the same (W-23, 11, 14, 17, 02, 04, 05); two stations were in close proximity (W-01 and W-03). The geometric means with maximums and minimums are presented on Figure 3-17. The BRI study included only 3 observations and covered only 3 surveys from the early to late summer. The higher variability of the concentrations of this study reflects the year long sampling program. Nevertheless, the pattern of fecal coliform concentrations was similar to the pattern in the 1991 study, despite the 14-year time difference. This suggests that there were neither significant reductions in the discharge of fecal coliform nor major new sources during this period.

3.2.2 Nutrients

Dry weather nutrient concentrations (total phosphorus, ammonia, and nitrate, and TKN) for each station are presented in Figures 3-18 to 3-21. Respective mass loadings are presented in Figures 3-22 to 3-25. For these mass loading estimates, all concentrations below the reporting limit were taken as one-half of the reporting limit. The number of samples per station ranged from 18 at the primary stations to 3 at some of the tertiary stations. In order to obtain a watershed-wide understanding including relative contributions from tributaries and main sampled outfalls, mean concentrations and loads were calculated for Events DW-07, 09, and 11 for which all stations in the watershed were sampled. The mean concentrations for total phosphorus, ammonia, and nitrate are presented in Figures 3-26 to 3-28. The following observations are made from these data:

Total Phosphorus Concentrations

- There were no obvious sources on either the Mill River or Peters River. Average concentrations ranged from 0.15 to 0.19 mg/l.
- The highest concentration occurred at the Woonsocket WWTF (1.21 mg/l was the average of only two measurements). This was followed by the Branch River (0.97 mg/l – mean of four measurements).
- The concentrations for the primary stations along the Blackstone River did not vary significantly with the highest concentration at the State line (0.38 mg/l at W-01) and the lowest concentration at the end of the river (0.27 mg/l at W-05).
- Small tributary stations W-31 to W-34 were not obvious phosphorus sources. However, at W-35 (brook near Ann&Hope), the mean total phosphorus concentration of 0.47 mg/l was higher than at all stations except for the Branch River and the Woonsocket WWTF.

Ammonia Concentrations

- The mean concentration at the State line was 0.48 mg/l (W-01) for all 18 sampling events. The mean concentrations at Station W-17 was 0.40 mg/l (six sampling events). The comparable mean concentrations for W-01 for the same six sampling events was 0.59 mg/l, suggesting that ammonia in the Blackstone River decreased as it flowed through the City of Woonsocket.
- The mean ammonia concentration in the effluent from the Woonsocket WWTF (W-24) was 5.35 mg/l (two sampling events). The mean ammonia concentration at W-02 was 0.49 mg/l. This concentration was similar to the concentration at the State line (W-01) and, in part, a result of any additions from the WWTF.
- Downstream of the WWTF, the ammonia concentrations decreased as expected between Stations W-02 and W-04 due to instream nitrification.
- The mean ammonia concentrations in the Peters River (0.26 to 0.33 mg/l) were slightly higher than in the Mill River (0.16 to 0.23 mg/l). These concentrations were higher than the background concentration represented by the lowest concentrations in the watershed at Station W-25 (all three values were below the reporting limit and to calculate averages these values and others were set as one-half of the reporting limit, i.e., at 0.10 mg/l).

- The small tributary stations W-33 and W-35 had relatively high ammonia concentrations (0.92 and 0.51 mg/l, respectively.

Nitrate Concentrations

- The highest nitrate concentration in the watershed was at W-35 (4.9 mg/l), which was even higher than the concentration from the WWTF (3.6 mg/l; Station W-24).

- The average concentration at W-32 (Front Street drain) was 2.7 mg/l, third highest in the watershed.

- For the primary stations along the Blackstone River, nitrate concentrations decreased from a high at the State line of 1.8 mg/l to 1.1 mg/l at Slater Mill (W-05).

- The nitrate concentrations in Peters River (0.71 to 0.87 mg/l) were slightly higher than in the Mill River (0.46 to 0.53 mg/l). Both rivers had higher concentrations than the lowest (background) concentrations measured in the watershed, i.e., in the Branch River with a mean of 0.29 mg/l, but concentrations were lower than at all stations along the Blackstone River.

All stations were ranked according to their concentrations and their mass loadings (Figures 3-29 to 3-31). Major observations are listed below:

Total Phosphorus Loads

- With the exception of the Branch River, nine out of the top 10 total phosphorus mass loading positions were taken up by the Blackstone River stations.

- Total phosphorus observations at the Branch River station were not consistent. The two surveys in the summer were very high at 1.9 mg/l; in contrast, the two surveys in the fall were below or near the reporting limit of 0.05 mg/l. The higher values for the summer surveys were not supported by a mass balance between W-01, W-23, and W-21 or W-22. The mass balance for the September fall survey was reasonable.

- The Mill River and Peters River provided only about 1-2% of the total phosphorus to the Blackstone River. This load was not significant.

- All small tributary stations monitored during the survey contributed less than 0.5% of the total phosphorus in the Blackstone River.

Ammonia Loads

- With the exception of the Woonsocket WWTF, nine out of the top 10 ammonia mass loading positions were taken up by the Blackstone River stations.

- The Mill River and Peters River provided only about 1-2% of the ammonia to the Blackstone River. This load was not significant.

- The Branch River contributed on average 14% of the ammonia at its confluence with the Blackstone River. Specifically, the mean load at Station W-23 was 36 lbs/day; the mean load at Station W-01 was 252 lbs/day. The contribution from the Branch River was consistent and significant.

- The Abbott Run Brook contributed about 14% of ammonia at its confluence with the Blackstone River. Specifically, the mean load at Station W-26 was 31 lbs/day; the mean load at Station W-04 was 216 lbs/day. However, concentrations were not consistent. Two of the three observations from Abbott Run were below the reporting limit and should not be considered significant.

- Although small tributary stations W-33 and W-35 had high concentrations, their ammonia load to the Blackstone River was not significant (less than 1%).

Nitrate Loads

- The top nine mass loading positions for nitrate were taken up by the Blackstone River stations.

- The Mill River and Peters River provided only about 1-3% of the nitrate to the Blackstone River. This load was not significant.

- The Branch River and Abbott Run Brook contributed nitrate at about 2% (30 vs. 1,400 lbs/day at W-23 and W-01) and 8% (105 vs. 1,261 lbs/day at W-26 and W-04) on average at their confluence with the Blackstone River. These contributions were not significant.

- Although small tributary stations W-35 and W-32 have high concentrations, their nitrate load to the Blackstone River was not significant (less than 1%).

Comparison between 1991 BRI and 2005 BTMDL Studies

Nine stations were used in the historic comparison between the 1991 BRI study and this study conducted in 2005. The location of seven of these stations was the same (W-23, 11, 14, 17, 02, 04, 05); two stations were in close proximity (W-01 and W-03). The concentrations with maximums and minimums are presented in Figures 3-32 and 3-33. Only nitrate and ammonia were common for the two studies.

The BRI study included three surveys with four samples analyzed for each survey. Therefore, the BRI average is based on 12 observations. The BRI surveys covered the early to late summer. For many of the stations there was a higher variability in the BTMDL (2005) study which reflects the year-long sampling program. The most obvious impact was at W-01 where the average ammonia concentration at the State line was approximately 4 times higher than for the BRI. This is not unexpected since two of the three surveys completed for the BRI were taken when the UBWPAD provided nitrification. The BTMDL study captured data that included the period between October and May when nitrification at the UBWPAD was not occurring.

Nevertheless, despite the 14 years difference between surveys, the pattern of nitrate and ammonia concentrations was very similar. This suggests that there were neither significant reductions in the discharge of nitrate and ammonia nor new source additions within this time frame.

3.2.3 Pigments

Pigment concentrations are presented in Figure 3-34 (chlorophyll *a*) and Figure 3-35 (pheophytin *a*). Chlorophyll *a* is the active compound in active phytoplankton cells. Pheophytin *a* is the first breakdown product of chlorophyll *a*. It is formed when phytoplankton senesence, die or are eaten. The sum of chlorophyll *a* and pheophytin *a* is typically used to assess the level of euthrophication. Otherwise, if sampling occurs after the peak of the phytoplankton bloom and part of the chlorophyll has degraded to pheophytin *a*, then sampling for chlorophyll *a* only would underestimate the phytoplankton concentration and thereby potentially the trophic level in the waterbody.

As expected, pigment (chlorophyll *a* + pheophytin *a*) concentrations were highest in the summer and lowest during the winter months. The average concentrations of the total pigments at individual stations ranged from 15 to 23 ug/l, reflecting mesotrophic conditions.

While it is the sum of chlorophyll *a* and pheophytin *a* that give the best indication of the level of eutrophication, the ratio of chlorophyll *a* to the combined pigment level can be used to gauge the status of a bloom. For example, ratios approaching 1.0 (generally >0.7) generally indicate an "active" phytoplankton bloom, where most of the cells contain non-degraded chlorophyll *a*. In contrast, ratios of <0.5 typically indicate blooms that are senescent, or that are declining due to grazing by phytoplankton. In general, the ratio between chlorophyll *a* and total pigment (chlorophyll *a* + pheophytin *a)* reflected healthy growth conditions for phytoplankton populations (Figure 3-36). It appears the phytoplankton blooms captured by the sampling program were most active in the summer and winter, with September-November pigments indicating either a period of poor phytoplankton "quality", due to resuspension or input of degraded material, or pure chance related to "missing" the peak of blooms (Figure 3-36). This latter alternative seems unlikely as the "fall" samplings had 19 of 30 samples with a ratio of <0.5, while there was only 1 of 80 samples with a ratio <0.5 during other times of the year.

3.2.4 Solids

Concentrations and Loads

Dry weather total suspended solids (TSS) and volatile suspended solids (VSS) for each station are presented in Figures 3-37 and 3-38. Mass loadings are presented in Figures 3-39 and 3-40. The number of samples per station ranged from 18 at the primary stations to 3 at some of the tertiary stations. The mean solids concentrations are presented in Figures 3-41 and 3-42. Mass loadings for TSS and VSS are ranked in Figures 3-43 and 3-44. The following observations are made:

- The top 9 mass loading positions for solids were from the Blackstone River stations.
- The Mill River and Peters River provided only about 1-2% of the TSS to the Blackstone River. This load was not significant.
- The Branch River contributed approximately 4% (174 vs. 4,461 lbs/day at Stations W-23 and W-01) on average at its confluence with the Blackstone River. This contribution was not significant.
- Abbott Run Brook contributed approximately 10% (627 vs. 6,228 lbs/day at Stations W-26 and W-04) on average at its confluence with the Blackstone River. This contribution was significant.
- Although small tributary stations W-31 and W-33 had high concentrations, their contribution of TSS mass to the Blackstone was not significant (less than 1%).

Comparison between 1991 BRI and 2005 BTMDL Studies

The TSS concentrations of the BTMDL and BRI studies were compared for overlapping stations. The concentrations with maximums and minimums are presented on Figure 3-45. Despite the 14 years difference between surveys, the pattern of TSS is very similar. This suggests that there were neither significant reductions in the discharge of TSS nor significant new sources in this period.

3.2.5 Dissolved Copper and Lead

In evaluating the trace metal data for dry weather conditions, acute and chronic criteria must be determined for average hardness for all stations on a waterbody by survey date. This includes:

- All Blackstone River stations including the primary stations (W-01 to W-05), secondary stations (W-17), and tertiary stations (W-21, 22, 25).

- Mill River stations (W-11 to W-13).

- Peters River stations (W-14, to W-16).

- Individual stations
    - Branch River (W-23)
    - Abbott Run Brook (W-26)
    - Cherry Brook (W-31)
    - Front Street Drain (W-32)
    - Sylvestre Pond Outflow (W-33)
    - Blackstone Canal overflow in Lonsdale (W-34)
    - Brook near Ann&Hope in Cumberland (W-35)

Dissolved Copper Concentrations

The dissolved copper data for both the STL and Microinorganics laboratories are presented in Figure 3-46. Figure 3-47 is a summary of the average hardness by waterbody and the calculated acute and chronic criteria for dissolved copper. These criteria were compared to individual station concentrations. Examples are given for two surveys (July 21 [DW-07] and October 22, 2005 [DW14]) for acute copper criteria (Figures 3-48 and 3-49) and chronic copper criteria (Figures 3-50 and 3-51).

Exceedances of the criteria at each station for all dry weather events are flagged in Figure 3-46 are summarized in Figure 3-52. The following was observed:

- There were three slight exceedances of the acute copper criteria within the watershed. Two exceedances occurred at the MA/RI border (Events DW-11 and DW-14); one exceedance occurred during Event DW-13 at Station W-03.

- All observed exceedances of the chronic copper criteria occurred on the mainstem of the Blackstone River.
    - The largest number of exceedances occurred at the State line (W-01). Approximately 60% of the events had values that exceeded the standard.

  - Exceedances also occurred at the other primary stations along the Blackstone River: W-02 (3 exceedances), W-03 (3 exceedances), W-04 (3 exceedances), and W-05 (1 exceedance). The October 22 survey had exceedances of the chronic criteria at all five primary stations (Figure 3-51).
  - There were no other exceedances of the chronic criteria during any of the surveys at any of the other stations, including the Mill River, Branch River, and the small tributaries.

Dissolved Lead Concentrations

The dissolved lead data for both the STL and Microinorganics laboratories are presented in Figure 3-53. Figure 3-54 is a summary of the average hardness by waterbody and the calculated acute and chronic criteria for lead. These criteria were compared to individual station concentrations. Examples are given for two surveys (July 21 [DW-07] and October 22, 2005 [DW-14]) for acute lead criteria (Figures 3-55 and 3-56) and chronic lead criteria (Figures 3-57 and 3-58).

Exceedances of the lead criteria at each station for all dry weather events are flagged in Figure 3-53 and summarized in Figure 3-57. The following was observed:

- There were no exceedances of the acute lead criteria within the watershed.
- There were a total of 13 exceedances of the chronic criteria in the watershed.
  - There was one exceedance at each station along the Blackstone River that occurred during the October 22, 2005 event (DW-14). The chronic criterion for dissolved copper was violated during the same event.
  - The Branch River's exceedances (3 of the 4 surveys) were a result of the lowest hardness values (17 to 23 mg/l) in the river. The low hardness resulted in very low chronic lead criteria.
  - The three stations along the Mill River violated the chronic criteria once during the study at Stations W-11 and W-12, and twice at Station W-13. However, one of the samples at Station W-13 was likely affected by entrained water from the Blackstone River which contained elevated concentrations at the time.
  - The only other exceedance in the watershed occurred at Cherry Brook (W-31) during the July 21, 2005 event (DW-07).

Dissolved Copper Loads

Mass loadings for both metals were developed for each station (Figures 3-60 and 3-61). All concentrations that were below the reporting limit were not included for mass loading estimates. The number of available samples per station ranged from 15 to 1. Both metals were ranked by concentration and mass loading (Figure 3-62 and 3-63). The following observations are made from these tables:

- There was little variation in the copper load for the primary stations: W-01 (4.47 lbs/day); W-02 (4.29 lbs/day); W-03 (4.54 lbs/day); W-04 (4.12 lbs/day); W-05 (4.87 lbs/day). The largest change was a gain of about 20% between W-04 and W-05.

- The Branch River contributed on average 4.7% to the copper load in the Blackstone River (0.21/4.47 lbs/day at W-23/W-01) at its confluence. The contribution from the Branch River was not significant.

- The Mill River and Peters River contributed only approximately 1.7 to 0.4%, respectively, to the copper load in the Blackstone River. This load was not significant. Loads between the State line stations (W-11 and W-14) and the confluence with the Blackstone River (W-13 and W-16) did not change. There was no obvious increase or decrease in the copper load in either the Mill River or Peters River within the Rhode Island section of the rivers.

- The Abbott Run Brook contributed 4.6% to the copper load in the Blackstone River (0.19/4.12 lbs/day at W-26/W-04) at its confluence. The contribution from Abbott Run Brook is considered small.

Dissolved Lead Loads

- There was little variation in the lead load for the primary stations: W-01 (0.16 lbs/day); W-02 (0.25 lbs/day); W-03 (0.16 lbs/day); W-04 (0.17 lbs/day); W-05 (0.23 lbs/day). There was a net increase in the lead load between Stations W-01 and W-02, and between W-04 and W-05 (0.17 to 0.23 lbs/day), suggesting contributions of lead within Reaches 1 and 3.

- The Branch River contributed on average 45% to the lead load in the Blackstone River (0.07/0.16 lbs/day at W-23/W-01) at its confluence. The contributions from the Branch River were consistent (concentrations observed 0.67, 0.62, 0.29, 0.40 µg/l) and significant. However, lead loads in the Branch River did not result in significantly higher concentrations at the downstream Blackstone River station (W-21 at Singleton Street), suggesting that the high load may in part be a result of variability of lead concentrations in the Branch River.

- The Mill River contributed on average 0.02 lbs/day to the Blackstone River (0.25 lbs/day at W-02), while the Peters River contributed on average 0.002 lbs/day to the Blackstone. Their impact on the Blackstone River load was considered small. Nevertheless, the concentrations in the Mill River and Peters River were among the highest reported anywhere in the watershed. (Caution should be taken in interpreting the apparent loss between W-15 and W-16. Samples at W-16 were restricted to three surveys and those happened to have the lowest concentrations of the six surveys sampled.)

- Small tributary stations W-31 (Cherry Brook) and W-34 (Blackstone Canal) had high lead concentrations, but their mass loads to the Blackstone River were not significant.

Comparison between 1991 BRI and 2005 BTMDL Studies

Nine stations were used in the historic comparison between the 1991 BRI study and this BTMDL study conducted in 2005. The location of seven of these stations was the same (W-23, 11, 14, 17, 02, 04, 05) and 2 stations were in close proximity (W-01 and W-03). The concentrations with maximums and minimums are presented on Figures 3-64 and 3-65. The BRI study included 3 surveys with 4 samples analyzed for each survey. Therefore, the BRI average, as reported, was based on 12 measurements. The BRI surveys covered the early to late summer. The following observations are made:

- *Copper:* The profile of the copper concentrations for the BRI study was similar to that observed in the BTMDL study. In general, concentrations during the BTMDL study were lower and the ranges between maximum and minimum values were smaller than during the BRI study. There appears to be a measurable reduction in the copper concentration upstream of Station W-01 over the 14 years period. This change can also be seen in the downstream stations.

- *Lead:* For lead, the concentrations reported in the BTMDL study are considerably lower than those reported in the BRI study. This may be a direct result of the change in technology being used presently in the laboratory as compared to 14 years ago.

3.2.6 Other Parameters

Other parameters consisted of dissolved oxygen, temperature, specific conductance, hardness, turbidity, chloride, and pH. Data are presented in Figures 3-66 to 3-72. All stations were ranked according to their measured values (Figure 3-73 and 3-74), with the exception of pH. Following are observations for dissolved oxygen and hardness.

Dissolved Oxygen

Dissolved oxygen was a field measurement completed at the time of sampling. All measurements were taken during the day under dry weather conditions.

All values taken at all stations were above 5.0 mg/l, with the exception of Station W-14. Concentrations at Station W-14 were 4.7, 4.9 and 4.8 mg/l during the August, September and October 2005 dry weather surveys.

Stations W-14 and W-26 had the lowest study averages of all primary and secondary stations (7.7 and 7.5 mg/l, respectively).

- At Station W-14, in the summer and early fall, low flow rates and velocities at this site contributed to the low dissolved oxygen values (low reaeration, high sedimentation and potential benthic demand). It is not obvious that any immediate contaminant source was the cause.

- At Station W-26, flow comes from a relatively large water supply reservoir. The measurements were made immediately downstream of the dam. The oxygen concentrations recorded would have benefited from the dam reaeration and the turbulence directly below the dam. It would have been interesting to have sampled the reservoir directly; however, the reservoir was secured and could not be accessed.

Some of the lowest oxygen values of the study were also seen at small tributary stations W-31, 33, and 34.

- Station W-31 (Cherry Brook) drains a wetland area that was heavily overgrown in the late summer and early fall.

- Station W-33 is the outlet of Sylvestre Pond. The pond outlet flows underground before emerging downstream of the Woonsocket WWTF administrative building. The combination of the pond (low velocity, low reaeration) and the underground flow (low reaeration) would have contributed to the lower oxygen concentrations.

- Station W-34 is along the Blackstone Canal. The low flow and velocity of the canal would have contributed to low oxygen concentrations.

Hardness

The hardness varied between the Blackstone River and the tributaries, although was fairly consistent within each waterbody for individual dry weather sampling events. In the Blackstone River (Stations W-01 to W-05, W-21, W-22, W-17, and W-25), the mean hardness was 53 mg/l, ranging from 37 to 72 mg/l for individual dry weather surveys. In the Branch River (Station W-23), the mean hardness was 21 mg/l, ranging from 17 to 26 mg/l. In the Mill River (Stations W-11 to 13), the mean hardness was 37 mg/l, ranging from 27 to 48 mg/l for each survey. In the Peters River (Stations W-14 to 16), the mean hardness was 58 mg/l, ranging from 45 to 76 mg/l for each survey. The mean hardness in Cherry Brook and Abbot Brook Run was 71 and 45 mg/l, respectively. The differences in hardness between the Blackstone River and the tributaries were considered in the approach used for the determination of acute and chronic criteria for metals (see Section 3.1.3).

3.3 Dry Weather Loading by Reach

Dry weather loads for each of the three reaches were determined using an approach similar to the approach used for wet weather load analyses (Section 4.4). Three sets of tables were prepared from the available data:

- **Weighted mean annual loads for each primary station and % change in loads between reaches** (Figure 3-75): These loads were determined by first adding the loads for each month over the 12-month sampling period for each parameter. For months with 2 or 3 sampling events, the mean load for that month was used in the calculation. The relative changes in loads between the three reaches were calculated.

- **Changes in loads for each primary station for each sampling event:** Loads relative to primary stations were computed for each parameter and reach for each of the 18 dry weather sampling events (Figure 3-76).

- **Mass loading for each reach for dry weather events with complete station coverage** (i.e., DW-7, 9, 11; Figures 3-77 to 3-80): This calculation accounted for loads entering the river between primary stations along the Blackstone River. All three events occurred during the summer. In addition, mass loads were compared for the Mill and Peters Rivers for a total of 8 events, including Events DW-7, 9, and 11.

Several constraints need to be considered in the analysis of these dry weather data:

- Flows in the river for individual sampling events over the 12-month period are variable, ranging from approximately 80 to 2,200 cfs (Woonsocket gage). Consequently, the time of travel of the river water was variable by up to a factor of two for these flow rates. The three complete events (DW-7, 9, 11) were all sampled during the summer when flows at the Woonsocket USGS station were low, ranging between approximately 100 and 200 cfs. On the other hand, the weighted mean annual loads are biased by high flow events.

- Variable flow rates affect processes such as decay rates of bacteria, settling of solids, adsorption of metals, and photosynthetic processes. This is particularly relevant as there are numerous impoundments along the course of the river.

- Waters are more biologically active during warmer months, resulting in higher rates of biological activity and greater uptake of inorganic nitrogen species by phytoplankton and bacteria. For that reason, we also computed the total nitrogen loads for the dry weather events by adding the nitrate and Total Kjeldahl Nitrogen (TKN) loads. TKN is the sum of organic nitrogen and ammonia nitrogen.

- The dry weather loads are based on a single sample at each station (unlike the wet weather load analysis which averages between 7 and 11 samples per station for each storm event; see Section 4.4). This increases the variability in the dry weather data, especially for parameters that are affected by "patchiness" in the environment such as bacteria and nutrients. As a result, individual data points need to be interpreted cautiously and placed into the context of other observations and measurements.

For the entire Blackstone River watershed within Rhode Island, the loads for all measured constituents increased on an annual basis between Stations W-01 (MA/RI State line) and W-05 (Slater Mill) (Figure 3-75). Loads at Station W-05 were between 121% and 171% higher for the chloride, hardness, nutrients and metals compared to Station W-01 at the MA/RI state line. For TSS and VSS, the loads at W-05 were 178% and 238%, respectively, compared to W-01; for fecal coliform the load at W-05 was 300% by comparison. Following is a discussion of changes in loads for each reach within Rhode Island.

3.3.1 Blackstone River Reach 1 *(Woonsocket)*

Generally, annual loads between Stations W-01 and W-02 increased for all constituents (Figure 3-75). With the exception of fecal coliform, more than 50% of the loads for individual constituents were contributed by Massachusetts.

For chloride and hardness, the additions per sampling event were comparatively consistent (Figure 3-76). On average, the mass balance accounted for most of the additions in Reach 1 with the primary sources being the Woonsocket WWTF and Branch River (Figure 3-77).

On an annual basis, 69% of the total nitrogen in Reach 1 was contributed by Massachusetts (Figure 3-75). The highest increases by event occurred in the spring and summer although there was no consistent pattern (Figure 3-76). During the three complete events in the summer, the main contributing Rhode Island sources were the Woonsocket WWTF and the Branch River (12.6% and 3.2%, respectively; Figure 3-77).

For total phosphorus at Station W-02, 58% of the annual load was from Massachusetts. As for total nitrogen, the change in load varied considerably between individual sampling events. The loading during the complete events (DW-7, 9, 11) indicated that Rhode Island's contributions were primarily from the Branch River and the WWTF. The mass balance further suggests that there was a net loss of total phosphorus within this reach, potentially due to uptake by phytoplankton. This assumption is supported by the mass loading of solids. On average 30% of the solids loads measured at Station W-02 remained unaccounted for, potentially reflecting phytoplankton that formed in Reach 1.

Only 41% of the annual dry weather fecal coliform load measured at Station W-02 was contributed by Massachusetts (without considering bacterial decay). For individual events, the change in fecal coliform loads between Stations W-01 and W-02 ranged widely. Within Rhode Island, the largest fecal coliform sources to the Blackstone River were the Branch River and Mill River, as shown by the data from the 3 complete events.

Massachusetts contributed 83% of the dissolved copper load to Reach 1 on an annual basis. For individual sampling events, the range was 66% to 112%. The largest load during the three complete events was contributed by Woonsocket WWTF, followed by the Branch River.

For dissolved lead, 67% of the annual load was contributed by Massachusetts. For individual sampling events, the contributions were more variable than for copper, ranging from 49% to 210%. The largest load during the three summer events was contributed by the Branch River (specifically during Event DW-07), followed by the Mill River.

3.3.2 Blackstone River Reach 2 *(Lincoln/Cumberland)*

On an annual basis, the weighted mean loads indicate that there were only comparatively minor additions or losses of the measured constituents within Reach 2. Average loads at Station W-04 ranged from 82% to 116% for the various compounds compared to loads at Station W-02 (Figure 3-75). Ammonia and TKN loads decreased (82% and 95%, respectively) while nitrate loads increased (108%), possibly reflecting nitrification within the reach as there was almost no net increase in total nitrogen within this reach (101%). The loads of TSS and VSS also decreased (82% and 88%, respectively), possibly due to settling within the impoundments and absence of additions from new sources within this reach..

For individual dry weather sampling events, the variability of changes in loads between Stations W-02 and W-04 was also comparatively small for chloride, hardness, total nitrogen, and dissolved copper. The variability was greater for fecal coliform, solids, dissolved lead, total phosphorus, and the various nitrogen species.

The variability within this reach was in part a function of the effect of the impoundments within this reach, and the absence of major tributaries or anthropogenic sources. As measured during the three complete summer events, the loads contributed by the Blackstone Canal were insignificant for all compounds (Figure 3-78).

3.3.3 Blackstone River Reach 3 *(Central Falls/Pawtucket)*

On an annual basis, the weighted mean loads indicate that there were no major additions of most measured constituents within Reach 3 (99% to 115%), with the exception of TSS and VSS which increased considerably (141% and 167%, respectively) (Figure 3-75).

As in Reach 2, the changes in loads for individual events between Stations W-04 and W-05 were comparatively narrow for chloride, hardness, total nitrogen, and dissolved copper. The variability for the other compounds was higher. For fecal coliform the variability was particularly high, ranging from a reduction of 13% (December 22, 2005) to an increase of 880% (August 25, 2005). This large variability was likely a function of factors such as inputs from sources like the Brook near Ann&Hope (Station W-35), potential dry weather flows from CSOs and/or other dry weather point sources, decay of bacteria, patchiness, and the fact that there was only a single sample at each station per event.

The main contributing source to the Blackstone River within Reach 3 was Abbott Run Brook, which contributed between 10% and 18% of the loads for most constituents (Figure 3-79). For dissolved copper and lead the additions in loads were 3% and 26%, respectively, although data from only 1 and 2 sampling events, respectively, were available, as opposed to 3 sampling events for the other constituents.

3.3.4 Mill River and Peters River

A total of 8 sampling events were available for load comparisons within the reaches of these tributaries to the Blackstone River. Means were computed for Events DW-7, 9, and 11 for direct comparisons for Reaches 1 to 3 along the Blackstone River, as well as means for all available events (Figure 3-80).

Loads for chloride and hardness varied little for both the Mill and Peters River during the different events.

Fecal coliform loads in Mill River increased sharply between Station W-11 and W-12, reflecting the low coliform concentrations in the water flowing out of Harris Pond (W-11) and the point where the Mill River goes underground (W-12). The source for bacteria in this comparatively short stretch along the Mill River is not known and should be investigated further. There were no further increases in fecal coliform load in the tunnel section of the river (i.e., between W-12 and W-13). In the Peters River, fecal coliform loads doubled on average between Stations W-14 and W-15 and increased by another 50% between Stations W-15 and W-16.

On average, total nitrogen and phosphorus loads as well as loads of solids and dissolved copper increased slightly in the Mill and Peters Rivers in Rhode Island. Loads of dissolved lead generally increased in the Mill River, but decreased in the Peters River between Stations W-14 and W-16. This decrease may have been a result of the fact that only two samples were collected at Station W-16; the change in load between just Stations W-14 to Station W-15 was 95% based on five sampling events which indicates that there were no additions of lead to the Peters River between the MA/RI state line and its entry into the tunneled section.

Figure 3-1: Water Quality Station Locations

					Type			Coordinates		
Station No. *(1)*	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location**	**Primary**	**Secondary**	**Tertiary**	**Latitude** *(…… N)*	**Longitude** *(….. W)*	**Description**
W-01	●			Millville, MA	●			42º 01' 22.49"	71º 34' 19.86"	Located in Millville, MA, off the railroad bridge, upstream of the state line. This is the last crossing on the Blackstone River before the river divides between the gorge and Tupperware impoundment and enters RI. This station represented the beginning of the first reach and the water quality of the Blackstone River as it leaves Massachusetts. During the 1991/92 BRI in low flow summer conditions, there was no flow going through the gorge. Samples were collected at BLK13, which was in the Tupperware impoundment. This is no longer the case. In the 1990s, there was an agreement to maintain flow through the gorge at all times. In the more recent 2001/02 BAC study (Wright et al., 2004), samples were taken at the gorge.
W-23		●		Branch River			●	41º 59' 59.94"	71º 33' 09.85"	Off the RTE 146A Bridge, approximately 800 m (1/2 mile) upstream from the confluence with the Blackstone River. This station was monitored as BLK-14 in the BRI and is the last crossing of the Branch River before the confluence.
W-21	●			Singleton Street			●	42º 00' 35.75"	71º 31' 45.67"	Off the Singleton Street bridge.
W-22	●			Below Thundermist Dam			●	42º 00' 00.44"	71º 30' 48.50"	Just below the River Island Park, approximately 600 m (2/5 mile) downstream of the Thundermist dam off the Bernon St Bridge.
W-11		●		Mill River (MA/RI border)		●		42º 00' 54.87"	71º 30' 25.55"	Located at the MA/RI border, approximately 100 m (300 feet) downstream of the Harris Pond dam. This station was monitored as BLK-15 in the BRI.
W-12		●		Mill River (pre-culvert entry)		●		42º 00' 34.18"	71º 30' 24.70"	Located before entry into a covered culvert, approximately 400 feet to the north of Social Street.
W-13		●		Mill River (confluence w/ Blackstone River)		●		42º 00' 24.56"	71º 30' 17.20"	Located at the confluence of Mill River with the Blackstone River, approximately 300 feet to the south of Clinton Street. This station can be sampled only at low stage height of the Blackstone River.
W-14		●		Peters River (MA/RI border)		●		42º 00' 56.13"	71º 29' 35.10"	Located at the Diamond Hill Road bridge, approximately 500 feet to the south of the MA/RI border. This station was monitored as BLK-16 in the BRI.
W-15		●		Peters River (pre-culvert entry)		●		42º 00' 34.72"	71º 30' 02.11"	Located before entry into a covered culvert, approximately 40 feet to the north of Elm Street.
W-16		●		Peters River (confluence w/ BR)		●		42º 00' 24.66"	71º 30' 10.03"	Located at the confluence of Peters River and Blackstone River, approximately 300 feet to the southwest of Cumberland Street. This station can be sampled only at low stage height of the Blackstone River.
W-17	●			Hamlet Avenue		●		42º 00' 10.73"	71º 29' 53.28"	Off Hamlet Ave bridge, located downstream of the confluence of the Mill and Peters Rivers and upstream of the Woonsocket WWTF outfall. This station was monitored in the BRI as BLK17.

Figure 3-1 *(cont.)*: Water Quality Station Locations

					Type			Coordinates		
Station No. *(1)*	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location**	**Primary**	**Secondary**	**Tertiary**	**Latitude** *(...... N)*	**Longitude** *(..... W)*	**Description**
W-24			●	Woonsocket WWTF			●	41º 59' 56.32"	71º 29" 44.11"	Daily composites were provided by the Woonsocket WWTF personnal. Composites included 24 hourly samples whose volume was weighted by flow. This station was monitored as BLK24 in the BRI.
W-02	●			Manville Dam	●			41º 58' 18.54"	71º 28' 14.11"	Approximately 2 m (5 feet) upstream of Manville Dam, off the shoreline on the eastern (Cumberland) side of the Blackstone River. This station was monitored as BLK-18 in the BRI.
W-03	●			George Washington Hwy Bridge	●			41º 56' 17.11"	71º 26' 01.57"	Located in Ashton off the bike path bridge below the RTE 116 George Washington Highway bridge.
W-04	●			Lonsdale Ave	●			41º 54' 40.59"	71º 24' 10.22"	Off the RTE 122 bridge, upstream of Valley Falls Pond. This station was monitored in the BRI as BLK20.
W-25	●			Broad Street			●	41º 53' 57.30"	71º 23' 24.74"	Off the RTE 114 Broad Street bridge just below the marina of the Blackstone River Tourism Council.
W-26		●		Abbott Run Brook			●	41º 54' 02.40"	71º 23' 08.33"	At the south side of the Mill Street bridge, approximately 200 feet upstream of the confluence with the Blackstone River.
W-05	●			Slaters Mill Dam	●			41º 52' 36.86"	71º 22' 55.71"	Located approximately 15 m (50 feet) upstream of the Slaters Mill Dam off the eastern shore. This station represented the mouth of the Blackstone River, just before it enters the Seekonk River. This station was monitored in the BRI as BLK21. This station is located downstream of the CSOs of Central Falls and Pawtucket.
W-31			●	Cherry Brook			●	41º 59' 57.03"	71º 31' 23.00"	At the Olo St. bridge, approx.130 m (400 feet) upstream of the confluence with the Blackstone River.
W-32			●	Front Street Drain			●	41º 59' 53.73"	71º 31' 02.97"	At the outflow from the pipe to the Blackstone River. The drain always had considerable dry weather flow, suggesting that is is a channelized small brook.
W-33			●	Sylvestre Pond Outflow			●	42º 00' 02.66"	71º 29' 49.81"	At the Woonsocket WWTF, approximately 10 m (30 feet) upstream of the confluence with the Blackstone River.
W-34			●	Blackstone Canal at Lonsdale			●	41º 54' 41.85"	71º 24' 28.10"	At the overflow weir just to othe north of the Lonsdale Bleachery.
W-35			●	Brook near Ann&Hope			●	41º 54' 39.65"	71º 23' 47.73"	At the eastern end of the Ann&Hope parking lot, along Ann and Hope Way in the Town of Cumberland. The outfall point is located in a small woodedn area between the Providence-Worcester rail line and the Blackstone River streambed.

(1) River and major tributary stations (W-1 to W-26) are listed from upstream to downstream.
Small tributaries and outfalls (W-31 to W-35) are listed at end of table.

Figure 3-2: Dry Weather Sampling Program - Blackstone TMDL Study

Event No.	Date	Primary Station		Secondary Station		Tertiary Station					
		W-01 to W-05		W-11 to W-17		W-21 to W-26		W-31 to W-34		W-35	
		Proposed	Actual	Proposed	Actual	Proposed	Actual	Proposed	Actual	Proposed	Actual
DW- 01	March 16	5	5	7	7						
DW- 02	April 20	5	5								
DW- 03	May 11	5	5								
DW- 04	May 23	5	5								
DW- 05	June 9	5	5	7	6[a]						
DW- 06	June 27	5	5								
DW- 07	July 21	5	5	7	6[a]	6	6	4	4		
DW- 08	August 3	5	5								
DW- 09	August 11	5	5	7	7	6	6	4	4		
DW- 10	August 25	5	5								
DW- 11	September 14	5	5	7	7	6	6	4[e]	3[e]		
DW- 12	September 26	5	5								
DW- 13	October 7	5	5	0	6[a,b]						
DW- 14	October 22	5	5	0	6[a,b]						
DW- 15	November 29	5	5							0	1
DW- 16	December 22	5	5	7	6[a]					0	1
DW- 17	January 27	5	5							0	1
DW- 18	February 17	5	5							0	1
Totals		90	90	42	51	18	18	12	11	0	4

[a] Stage greater than 0.4 m (1.4 feet) at Woonsocket. W-16 not sampled.

[b] Prestorm sampling for Storms WW-03 (Oct. 7, 2005) and WW-04 (Oct. 22, 2005).

[c] Station W-34 was not sampled. The Blackstone Canal was drawn down.

Proposed Total:	162
Actual Total:	174

Figure 3-3: Analytical Limits for Dissolved Copper and Lead

Parameter	Laboratory	Method	Reporting Limit (ug/l)	Method Detection Limit (ug/l)
Dissolved copper	Mitkem	ICP (Method 200.7)	15	3.2
	STL	ICP-MS (Method 200.8)	1	0.4
	Microinorganics	EPA 1637	1	0.4
Dissolved lead	Mitkem	ICP (Method 200.7)	5	0.23
	STL	ICP-MS (Method 200.8)	0.1	0.04
	Microinorganics	EPA 1637	0.2	0.092

Figure 3-4: Daily Precipitation leading to the Dry Weather Sampling Event (DW-_)

DW-01	Precipitation (inch)		
March #1	Worc.	Cumb.	Prov.
13-Mar-05	**0.24**	**0.65**	T
14-Mar-05	--	**0.30**	--
15-Mar-05	--	0.01	--
16-Mar-05	--	--	--

DW-02	Precipitation (inch)		
April #1	Worc.	Cumb.	Prov.
17-Apr-05	--	--	--
18-Apr-05	--	--	--
19-Apr-05	--	--	--
20-Apr-05	**0.15**	--	T

DW-03	Precipitation (inch)		
May #1	Worc.	Cumb.	Prov.
8-May-05	T	0.01	0.01
9-May-05	--	0.01	T
10-May-05	--	0.01	--
11-May-05	--	0.01	--

DW-04	Precipitation (inch)		
May #2	Worc.	Cumb.	Prov.
20-May-05	--	--	--
21-May-05	T	--	--
22-May-05	**0.13**	**0.27**	T
23-May-05	**0.24**	**0.13**	**0.15**

DW-05	Precipitation (inch)		
June #1	Worc.	Cumb.	Prov.
6-Jun-05	--	--	--
7-Jun-05	--	--	T
8-Jun-05	**0.69**	--	--
9-Jun-05	--	--	--

DW-06	Precipitation (inch)		
June #2	Worc.	Cumb.	Prov.
24-Jun-05	--	--	--
25-Jun-05	--	--	--
26-Jun-05	T	--	--
27-Jun-05	0.00	--	T

DW-07	Precipitation (inch)		
July #1	Worc.	Cumb.	Prov.
18-Jul-05	--	**0.33**	0.09
19-Jul-05	**0.28**	**0.58**	0.09
20-Jul-05	--	--	--
21-Jul-05	--	--	--

DW-08	Precipitation (inch)		
July #2	Worc.	Cumb.	Prov.
31-Jul-05	0.03	--	--
1-Aug-05	0.03	--	T
2-Aug-05	0.04	--	T
3-Aug-05	--	--	--

DW-09	Precipitation (inch)		
Aug #1	Worc.	Cumb.	Prov.
8-Aug-05	0.00	0.01	T
9-Aug-05	0.02	0.01	**0.21**
10-Aug-05	--	--	T
11-Aug-05	--	--	--

DW-10	Precipitation (inch)		
Aug #2	Worc.	Cumb.	Prov.
22-Aug-05	--	--	--
23-Aug-05	--	--	--
24-Aug-05	**0.12**	--	T
25-Aug-05	--	--	--

DW-11	Precipitation (inch)		
Sept #2	Worc.	Cumb.	Prov.
11-Sep-05	--	--	--
12-Sep-05	--	--	--
13-Sep-05	0.00	0.03	--
14-Sep-05	--	--	--

DW-12	Precipitation (inch)		
Sept #2	Worc.	Cumb.	Prov.
22-Sep-05	--	--	--
23-Sep-05	--	--	--
24-Sep-05	--	--	--
25-Sep-05	--	--	--

DW-13	Precipitation (inch)		
Oct #1	Worc.	Cumb.	Prov.
4-Oct-05	--	0.01	--
5-Oct-05	--	--	--
6-Oct-05	--	--	T
7-Oct-05	**0.25**	--	**0.17**

DW-14	Precipitation (inch)		
Oct #2	Worc.	Cumb.	Prov.
18-Oct-05	0.06	0.01	0.01
19-Oct-05	--	--	--
20-Oct-05	--	--	--
21-Oct-05	--	--	--

DW-15	Precipitation (inch)		
Nov #1	Worc.	Cumb.	Prov.
26-Nov-05	T	--	T
27-Nov-05	T	--	T
28-Nov-05	T	--	0.01
29-Nov-05	0.05	--	0.01

DW-16	Precipitation (inch)		
Dec #1	Worc.	Cumb.	Prov.
19-Dec-05	T	--	--
20-Dec-05	--	--	--
21-Dec-05	--	--	--
22-Dec-05	--	--	--

DW-17	Precipitation (inch)		
Jan #1	Worc.	Cumb.	Prov.
24-Jan-06	T	--	--
25-Jan-06	0.07	**0.17**	0.08
26-Jan-06	T	--	T
27-Jan-06	--	--	--

DW-18	Precipitation (inch)		
Feb #1	Worc.	Cumb.	Prov.
14-Feb-06	--	--	T
15-Feb-06	--	--	--
16-Feb-06	--	--	--
17-Feb-06	**0.12**	0.04	0.02

Figure 3-5: River Flows for Dry Weather Events in selected Months

Date	Flows at USGS Gaging Stations		
	Woonsocket (01112500)	**Peters River** (01112382)	**Roosevelt Ave** (01113895)
	cfs		
March 2005			
13	1,060	28	1,080
14	1,020	26	1,040
15	978	25	994
16	975	26	982
May 2005			
20	687	15	741
21	659	14	717
22	630	14	689
23	608	14	663
June 2005			
6	569	13	634
7	510	12	582
8	**467**	**12**	533
9	**469**	**19**	519
July 2005			
18	255	5.3	315
19	230	5.1	304
20	**253**	4.9	298
21	**235**	3.9	286
January 2006			
24	1,990	No data available.	
25	1,870		
26	1,780		
27	1,580		

Note: All flows were approved for publication; processing and review was completed

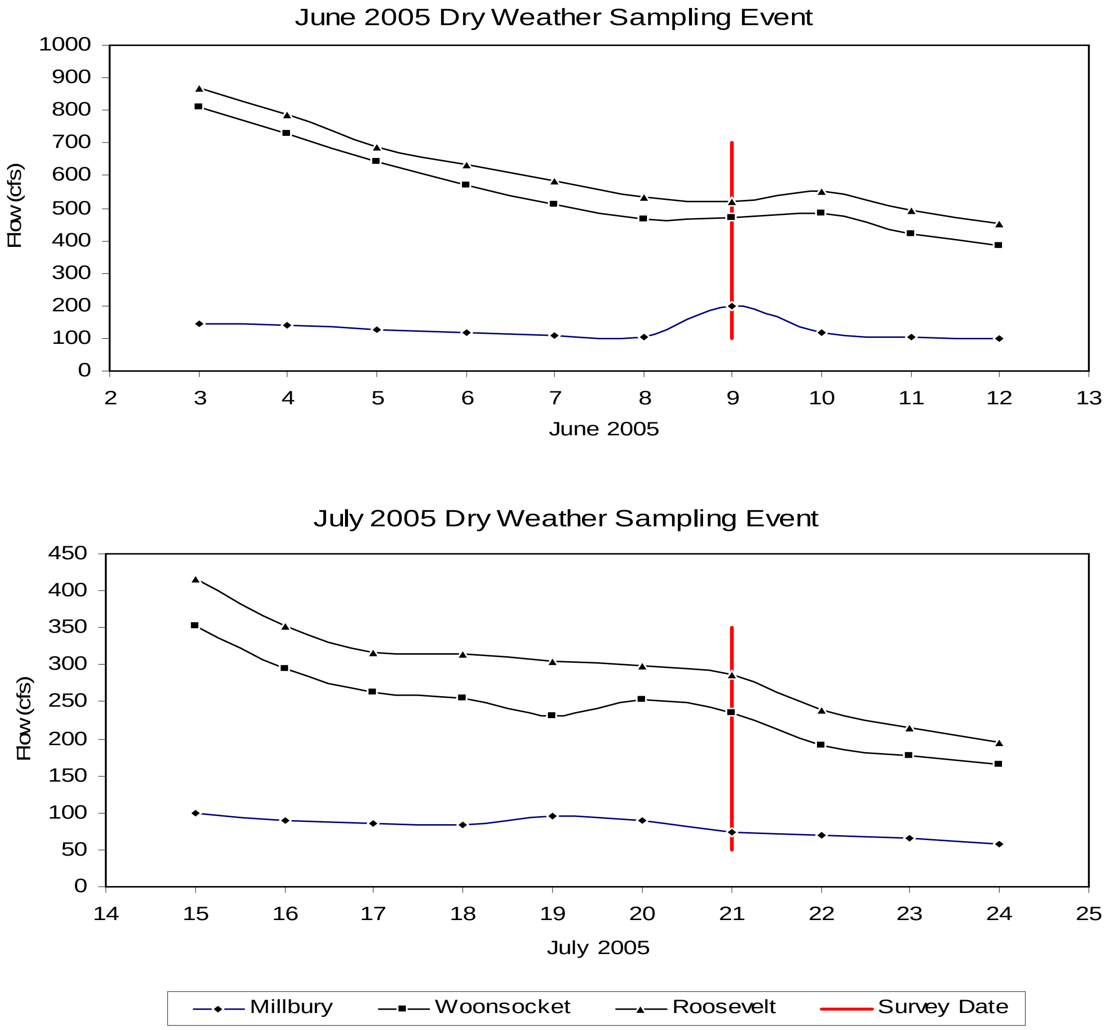


Figure 3-6: River Flows prior to June and July Dry Weather Sampling Events

Figure 3-7: Procedure followed to determine River Dry Weather Flows

WQ Station	**Procedure used**
W-01, W-02, W-03, W-04, W-05, W-12, W13, W-15, W-16, W-21, W-22	USGS gage flows were used to develop incremental inflow rates.
W-11	When USGS flows were reported, these were used. For the months that did not have published flows, a relationship between Mill and Peters Rivers was determined and the Peters River flow was used to estimate the W-11.
W-14, W-17, W-23, W-26	USGS flows were used for all surveys.
W-24	Flows were received from WWTF personnel.
W-25	USGS flows at Roosevelt minus Abbott Run estimated flows at W-25.
W-31, W-32	Direct measurement or from incremental inflow rates determined from USGS gages.
W-33, W-34, W-35	Direct measurement.

Figure 3-8: Flows during Dry Weather Sampling Events

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Location	Flows at each Water Quality Station (cfs)																		Statistics				
						16-Mar-05	**20-Apr-05**	**11-May-05**	**23-May-05**	**9-Jun-05**	**27-Jun-05**	**21-Jul-05**	**3-Aug-05**	**11-Aug-05**	**25-Aug-05**	**14-Sep-05**	**26-Sep-05**	**7-Oct-05**	**22-Oct-05**	**29-Nov-05**	**22-Dec-05**	**27-Jan-06**	**17-Feb-06**	**Mean** *(DW-7,9, and 11)*	**Mean** *(all Events)*	**Minimum** *(all Events)*	**Maximum** *(all Events)*	**Count**
					Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18					
W-01	Reach 1	●			Millville *(**MA/RI** border)*	625	582	784	428	332	148	167	93	93	92	61	109	106	1,600	859	632	972	1,019	**107.0**	483.3	61.4	1,600	18
W-23			●		Branch River	191	143	246	104	83	43	44	17	13	15	10	13	13	403	319	179	306	322	**22.1**	136.9	9.8	403	18
W-21		●			Singleton Street	849	751	1,069	549	417	194	216	111	107	108	71	123	121	2,057	1,216	841	1,319	1,383	**131.6**	639.0	71.4	2,057	18
W-22		●			Below Thundermist Dam	859	759	1,081	555	418	195	218	111	108	108	71	124	122	2,074	1,228	851	1,332	1,396	**132.4**	645.1	71.5	2,074	18
W-11			●		Mill River *(**MA/RI** border)*	74.0	54.0	75.0	31.0	30.0	11.0	11.0	6.4	5.3	5.1	3.8	4.2	11.0	87.0	76.2	53.8	87.1	91.1	**6.7**	39.8	3.8	91	18
W-12			●		Mill River (pre-culvert entry)	75.2	54.9	76.2	31.5	30.5	11.2	11.2	6.5	5.4	5.2	3.9	4.3	11.2	88.4	77.4	54.7	88.4	92.6	**6.8**	40.5	3.9	93	18
W-13			●		Mill River (confluence w/ BR)	75.9	55.4	76.9	31.8	30.8	11.3	11.3	6.6	5.4	5.2	3.9	4.3	11.3	89.3	78.2	55.2	89.3	93.5	**6.9**	40.9	3.9	93	18
W-14			●		Peters River *(**MA/RI** border)*	25.9	22.0	28.4	14.0	18.6	4.2	3.9	1.1	0.8	0.8	2.5	2.4	3.8	48.5	38.5	26.6	44.3	46.5	**2.4**	18.5	0.8	49	18
W-15			●		Peters River (pre-culvert entry)	26.6	22.6	29.2	14.4	19.1	4.3	4.0	1.1	0.8	0.9	2.6	2.5	3.9	49.9	39.6	27.4	45.6	47.8	**2.5**	19.0	0.8	50	18
W-16			●		Peters River (confluence w/ BR)	26.9	22.9	29.6	14.6	19.4	4.4	4.0	1.2	0.9	0.9	2.7	2.5	3.9	50.5	40.1	27.7	46.2	48.4	**2.5**	19.3	0.9	51	18
W-17		●			Hamlet Avenue	975	848	1,204	608	469	211	235	120	115	115	76	131	138	2,236	1,370	938	1,580	1,658	**142.1**	723.7	76.4	2,236	18
W-24				●	Woonsocket WWTF	11.3	12.8	13.9	13.9	12.2	12.2	11.4	10.3	10.3	10.3	9.8	9.8	17.6	17.6	15.5	14.7	17.4	16.1	**10.5**	13.2	9.8	18	18
W-02	Reach 2	●			Manville Dam	1,027	893	1,264	641	484	226	253	132	129	129	88	144	151	2,315	1,429	988	1,643	1,723	**156.3**	758.8	87.7	2,315	18
W-03		●			George Washington Hwy Bridge	1,063	921	1,306	659	487	228	258	134	131	130	88	146	153	2,372	1,470	1,021	1,688	1,768	**159.0**	779.0	88.0	2,372	18
W-04	Reach 3	●			Lonsdale Ave	1,074	930	1,320	665	488	229	260	134	132	131	88	146	154	2,391	1,483	1,031	1,702	1,782	**159.8**	785.5	88.0	2,391	18
W-25		●			Broad Street	1,075	931	1,322	666	488	230	260	134	132	131	88	146	154	2,394	1,485	1,033	1,704	1,784	**160.0**	786.5	88.1	2,394	18
W-26			●		Abbott Run Brook	76.0	70.0	85.0	46.0	47.0	38.0	27.0	40.0	36.0	46.0	31.0	30.0	28.0	41.0	90.7	71.5	100.0	103.4	**31.3**	55.9	27.0	103	18
W-05		●			Slaters Mill Dam	1,155	1,004	1,411	714	535	268	288	175	168	177	119	176	182	2,440	1,580	1,108	1,808	1,892	**191.6**	844.4	119.1	2,440	18
W-31	1			●	Cherry Brook							0.62		0.24		0.03								**0.29**	0.29	0.03	0.62	3
W-32				●	Front Street Drain							0.97		0.37		0.04								**0.46**	0.46	0.04	0.97	3
W-33				●	Sylvestre Pond Outflow							0.70		0.27		0.03								**0.33**	0.33	0.03	0.70	3
W-34	2			●	Blackstone Canal at Lonsdale							0.14		0.08		0.01								**0.08**	0.08	0.01	0.14	3
W-35	3			●	Brook near Ann&Hope															0.75	0.22	0.34	0.33		0.41	0.22	0.75	4

Figure 3-9: Dry Weather Concentrations - Fecal Coliform

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Location	Concentration (MPN/100 ml)																		Statistics				
						16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05	3-Aug-05	11-Aug-05	25-Aug-05	14-Sep-05	26-Sep-05	7-Oct-05	22-Oct-05 *(1)*	29-Nov-05	22-Dec-05	27-Jan-06	17-Feb-06	Geometric Mean	90^{th} Percentile	Minimum	Maximum	Count
					Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18					
W-01	Reach 1	●			Millville *(**MA/RI** border)*	500	22	70	280	130	170	130	40	130	140	40	170	500	170	1,700	1,300	700	1,700	**211**	1,420	22	1,700	18
W-23			●		Branch River							70		300		500		500						**269**	500	70	500	4
W-21		●			Singleton Street							130		130		70								**106**	130	70	130	3
W-22		●			Below Thundermist Dam							170		230		40								**116**	218	40	230	3
W-11			●		Mill River *(**MA/RI** border)*	4				23		170		20		230		80	*<20*		40			**38**	188	4	230	8
W-12			●		Mill River (pre-culvert entry)	300				500		2,400		1,700		300		500	130		110			**436**	1,910	110	2,400	8
W-13			●		Mill River (confluence w/ BR)	80						3,000		800		300		230	40		40			**215**	1,680	40	3,000	7
W-14			●		Peters River *(**MA/RI** border)*	13				500		900		270		40		130	70		80			**121**	620	13	900	8
W-15			●		Peters River (pre-culvert entry)	50				>1,600		300		230		70		410	270		20			**176**	797	20	>1,600	8
W-16			●		Peters River (confluence w/ BR)	90								230		170		300						**180**	279	90	300	4
W-17		●			Hamlet Avenue	500				130		300		700		800					800			**454**	800	130	800	6
W-24				●	Woonsocket WWTF							<20				20								**19**	20	<20	20	2
W-02	Reach 2	●			Manville Dam	50	50	110	140	110	110	130	170	80	80	20	230	80	130	1,300	500	230	3,000	**150**	740	20	3,000	18
W-03		●			George Washington Hwy Bridge	140	50	30	80	30	240	130	<20	<20	40	<20	60	80	70	1,700	500	210	2,400	**97**	860	<20	2,400	18
W-04	Reach 3	●			Lonsdale Ave	23	23	23	50	50	220	230	110	<20	20	260	130	20	70	800	2,400	800	1,300	**107**	950	<20	2,400	18
W-25		●			Broad Street							220		<20		20								**44**	180	<20	220	3
W-26			●		Abbott Run Brook							<20		<20		<20								**19**	19	<20	<20	2
W-05		●			Slaters Mill Dam	110	80	90	280	240	170	700	270	80	130	40	70	40	20	700	300	300	800	**153**	700	20	800	18
W-31	1			●	Cherry Brook							5,000		800		500								**1,260**	4,160	500	5,000	3
W-32				●	Front Street Drain							<20		170		500								**117**	434	<20	500	3
W-33				●	Sylvestre Pond Outflow							270		90		<20								**77**	252	<20	270	3
W-34	2			●	Blackstone Canal at Lonsdale							1,300		140										**427**	1,184	140	1,300	2
W-35	3			●	Brook near Ann&Hope															16,000	2,400	>16,000	5,000	**7,559**	16,700	2,400	>16,000	4
W-02	1 2	(=W-02)			Duplicate		26	30	26		500																	
W-05	3	(=W-05)			Duplicate	300																						
W-01	1	(=W-01)			Duplicate	500																						
W-41		(=W-11)			Duplicate							110		80		400			<20									
W-42		(=W-14)			Duplicate							500		300		300		500	120									
W-43	2 3	(=W-04)			Duplicate							230	130	40	300	<20	300	80	80	1,300	1,300	80	1,700					

(1) *Event DW-14 (10/22/05), sample W-11:* The original sample was accidentally not analyzed by lab. Thus, the duplicate sample W-41 was used (<20 MPN/100 ml) as data input for W-11.

300 Value exceeding the standard of 200 MPN/100 ml.

Detection Limits: <20 to >16,000 MPN/100 ml, except Event DW-05 where the upper limit was >1,600 MPN/100 ml.

Water Quality Criteria (Class B and B1): Not to exceed a geometric mean of 200 MPN/100 ml and not more than 20% of the samples shall exceed a value of 500 MPN/100 ml.

Figure 3-10: Dry Weather Concentrations - Enterococci

Station No.	Reach			Blackstone River	Tributary	WWTF/outfall/other	Location	Concentration (col/100 ml)																		Statistics				
								16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05	3-Aug-05	11-Aug-05	25-Aug-05	14-Sep-05	26-Sep-05	7-Oct-05	22-Oct-05	29-Nov-05	22-Dec-05	27-Jan-06	17-Feb-06	Geometric Mean	Standard Deviation	Minimum	Maximum	Count
							Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18					
W-01	Reach 1			●			Millville *(**MA/RI** border)*	27	6	23	3	2	8	8	<10	<10	20	10	10	10	<10	84	97	51	41	**14.0**	28	2	97	18
W-23					●		Branch River									<10										**<10**				1
W-21				●			Singleton Street									<10										**<10**				1
W-22				●			Below Thundermist Dam									<10										**<10**				1
W-11					●		Mill River *(**MA/RI** border)*	3				<1		13		<10		41					<10			**7.3**	15	<1	41	6
W-12					●		Mill River (pre-culvert entry)	160				30		330		280		160					210			**156.9**	105	30	330	6
W-13					●		Mill River (confluence w/ BR)	16						96		220		110					52			**72.0**	77	16	220	5
W-14					●		Peters River *(**MA/RI** border)*	8				120		360		75		20					<10			**41.5**	135	8	360	6
W-15					●		Peters River (pre-culvert entry)	11				150		180		110		52					10			**50.7**	72	10	180	6
W-16					●		Peters River (confluence w/ BR)	17								20		10								**15.0**	5	10	20	3
W-17				●			Hamlet Avenue	34				5		11		<10		10					30			**13.3**	12	5	34	6
W-24						●	Woonsocket WWTF																							
W-02		Reach 2		●			Manville Dam	2	4	5	7	6	8	9	<10	<10	<10	<10	10	10	41	74	41	<10	10	**10.2**	19	2	74	17
W-03				●			George Washington Hwy Bridge	2	2		<1	1	5	7	<10	<10	<10	<10	<10	10	10	150	30	10	10	**7.4**	36	<1	150	16
W-04			Reach 3	●			Lonsdale Ave	2	2	2	2	2	34	7	<10	<10	<10	10	10	<10	10	73	31	<10	10	**8.0**	18	2	73	17
W-25				●			Broad Street									<10										**<10**				1
W-26					●		Abbott Run Brook									<10										**<10**				1
W-05				●			Slaters Mill Dam	5	3	12	12	8	22	11	<10	<10	<10	<10	10	<10	10	63	63	20	<10	**12.1**	18	3	63	17
W-31	1					●	Cherry Brook									200										**200.0**				1
W-32						●	Front Street Drain									20										**20.0**				1
W-33						●	Sylvestre Pond Outflow									20										**20.0**				1
W-34		2				●	Blackstone Canal at Lonsdale									<10										**<10**				1
W-35			3			●	Brook near Ann&Hope															310	30	3,600	>25,000	**965.9**	12,449	30	>25,000	4
W-02	1	2		(=W-02)			Duplicate		<1	9	5		16																	
W-05			3	(=W-05)			Duplicate	2																						
W-01				(=W-01)			Duplicate	30																						
W-41	1			(=W-11)			Duplicate							15		<10		52					<10							
W-42				(=W-14)			Duplicate							240		96		20												
W-43		2	3	(=W-04)			Duplicate							6	<10	<10	<10	<10	20	<10	20	460	31	31	10					

120 Value exceeding the standard of 54 col/100 ml.

Detection Limits: <1 to >1,600 col/100 ml for Events DW-01 to DW-07; <10 to >1,600 col/100 ml for Events DW-09 to DW-18. For Station W-35, the upper limit was >25,000 col/100 ml.

Water Quality Criteria (Class B and B1): The proposed criteria is 54 col/100 ml (geometric mean).

Figure 3-11: Dry Weather Loads – Fecal Coliform

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Location	**Loads** (MPN x 10^9 / day)																		**Statistics**			
						16-Mar-05	**20-Apr-05**	**11-May-05**	**23-May-05**	**9-Jun-05**	**27-Jun-05**	**21-Jul-05**	**3-Aug-05**	**11-Aug-05**	**25-Aug-05**	**14-Sep-05**	**26-Sep-05**	**7-Oct-05**	**22-Oct-05**	**29-Nov-05**	**22-Dec-05**	**27-Jan-06**	**17-Feb-06**	**Geometric Mean** *Events DW-7,9,11)*	**Count**	**Geometric Mean** *(all Events - Primary Stations)*	**Count**
					Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18				
W-01	Reach 1	●			Millville (***MA/RI*** *border)*	7,642	313	1,342	2,932	1,055	616	532	91	295	314	60	452	1,296	6,656	35,715	20,085	16,640	42,390	**211**	3	**1,566**	18
W-23			●		Branch River							75		94		120		163						**94**	3		
W-21		●			Singleton Street							687		342		122								**306**	3		
W-22		●			Below Thundermist Dam							905		608		70								**338**	3		
W-11			●		Mill River (***MA/RI*** *border)*	7				17		46		3		21		22	40		53			**14**	3		
W-12			●		Mill River (pre-culvert entry)	552				373		656		224		28		137	281		147			**161**	3		
W-13			●		Mill River (confluence w/ BR)	149						828		106		29		63	87		54			**136**	3		
W-14			●		Peters River (***MA/RI*** *border)*	8				228		85		5		2		12	83		52			**10**	3		
W-15			●		Peters River (pre-culvert entry)	32				795		29		5		4		39	329		13			**8.5**	3		
W-16			●		Peters River (confluence w/ BR)	59								5		11		29						**7.3**	2		
W-17		●			Hamlet Avenue	11,926				1,490		1,724		1,971		1,495					18,367			**1,719**	3		
W-24				●	Woonsocket WWTF							5				5								**5**	3		
W-02	Reach 2	●			Manville Dam	1,257	1,092	3,403	2,195	1,301	607	803	551	252	252	43	811	296	7,362	45,461	12,089	9,248	126,445	**206**	3	**1,677**	18
W-03		●			George Washington Hwy Bridge	3,639	1,126	959	1,290	357	1,342	821	62	61	128	41	214	300	4,063	61,137	12,489	8,671	103,797	**127**	3	**1,115**	18
W-04	Reach 3	●			Lonsdale Ave	604	523	743	814	597	1,235	1,463	362	61	64	560	465	75	4,094	29,025	60,562	33,309	56,682	**369**	3	**1,274**	18
W-25		●			Broad Street							1,401		61		43								**155**	3		
W-26			●		Abbott Run Brook							13		17		14								**14**	3		
W-05		●			Slaters Mill Dam	3,108	1,965	3,107	4,890	3,144	1,114	4,928	1,154	329	564	117	302	178	1,194	27,051	8,130	13,272	37,033	**574**	3	**2,006**	18
W-31	1			●	Cherry Brook							75.5		4.6		0.3								**4.8**	3		
W-32				●	Front Street Drain							0.5		1.6		0.5								**0.7**	3		
W-33				●	Sylvestre Pond Outflow							4.7		0.6		0.0								**0.3**	3		
W-34	2			●	Blackstone Canal at Lonsdale							4.5		0.3										**1.1**	2		
W-35	3			●	Brook near Ann&Hope															293.59	12.96	142.60	40.03				

▨ Sampling events used for statistical analyses.

Figure 3-12: Dry Weather Loads - Enterococci

Station No.	Reach			Blackstone River	Tributary	WWTF/outfall/other	Location	**Loads** (col x 10^9 / day)																		**Statistics**			
								16-Mar-05	**20-Apr-05**	**11-May-05**	**23-May-05**	**9-Jun-05**	**27-Jun-05**	**21-Jul-05**	**3-Aug-05**	**11-Aug-05**	**25-Aug-05**	**14-Sep-05**	**26-Sep-05**	**7-Oct-05**	**22-Oct-05**	**29-Nov-05**	**22-Dec-05**	**27-Jan-06**	**17-Feb-06**	**Geometric Mean** *Events DW-7,9,11)*	**Count**	**Geometric Mean** *(all Events - Primary Stations)*	**Count**
							Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18				
W-01	**Reach 1**			●			Millville *(**MA/RI** border)*	413	85	441	31	16	29	31	22	22	45	15	27	26	388	1,765	1,499	1,212	1,022	**22**	3	**104**	18
W-23					●		Branch River									3.1										**3**	1		
W-21				●			Singleton Street									26										**26**	1		
W-22				●			Below Thundermist Dam									26										**26**	1		
W-11					●		Mill River *(**MA/RI** border)*	5.4				0.7		3.5		1.3		3.8					13			**3**	3		
W-12					●		Mill River (pre-culvert entry)	294				22		90		37		15					281			**37**	3		
W-13					●		Mill River (confluence w/ BR)	30						26		29		10					70			**20**	3		
W-14					●		Peters River *(**MA/RI** border)*	5				55		34		1.5		1.2					6.4			**4**	3		
W-15					●		Peters River (pre-culvert entry)	7				70		17		2.3		3.3					6.7			**5.1**	3		
W-16					●		Peters River (confluence w/ BR)	11								0.4		0.6								**0.5**	2		
W-17				●			Hamlet Avenue	811				57		63		28		19					689			**32**	3		
W-24						●	Woonsocket WWTF																						
W-02		**Reach 2**		●			Manville Dam	50	87	161	114	71	44	53	32	31	31	21	35	37	2,322	2,588	991	398	421	**33**	3	**115**	18
W-03				●			George Washington Hwy Bridge	52	45		16	12	28	47	32	32	32	21	35	37	580	5,394	749	413	432	**32**	3	**80**	17
W-04			**Reach 3**	●			Lonsdale Ave	53	46	65	33	24	191	47	33	32	32	22	36	37	585	2,648	782	412	436	**32**	3	**92**	18
W-25				●			Broad Street									32										**32**	1		
W-26					●		Abbott Run Brook									8.7										**9**	1		
W-05				●			Slaters Mill Dam	141	74	414	210	105	144	77	42	41	43	29	43	44	597	2,435	1,707	885	458	**45**	3	**159**	18
W-31	1					●	Cherry Brook									1.16										**1.2**	1		
W-32						●	Front Street Drain									0.18										**0.2**	1		
W-33						●	Sylvestre Pond Outflow									0.13										**0.1**	1		
W-34		2				●	Blackstone Canal at Lonsdale									0.02										**0.0**	1		
W-35			3			●	Brook near Ann&Hope															5.7	0.2	30	208				

▨ Sampling events used for statistical analyses.

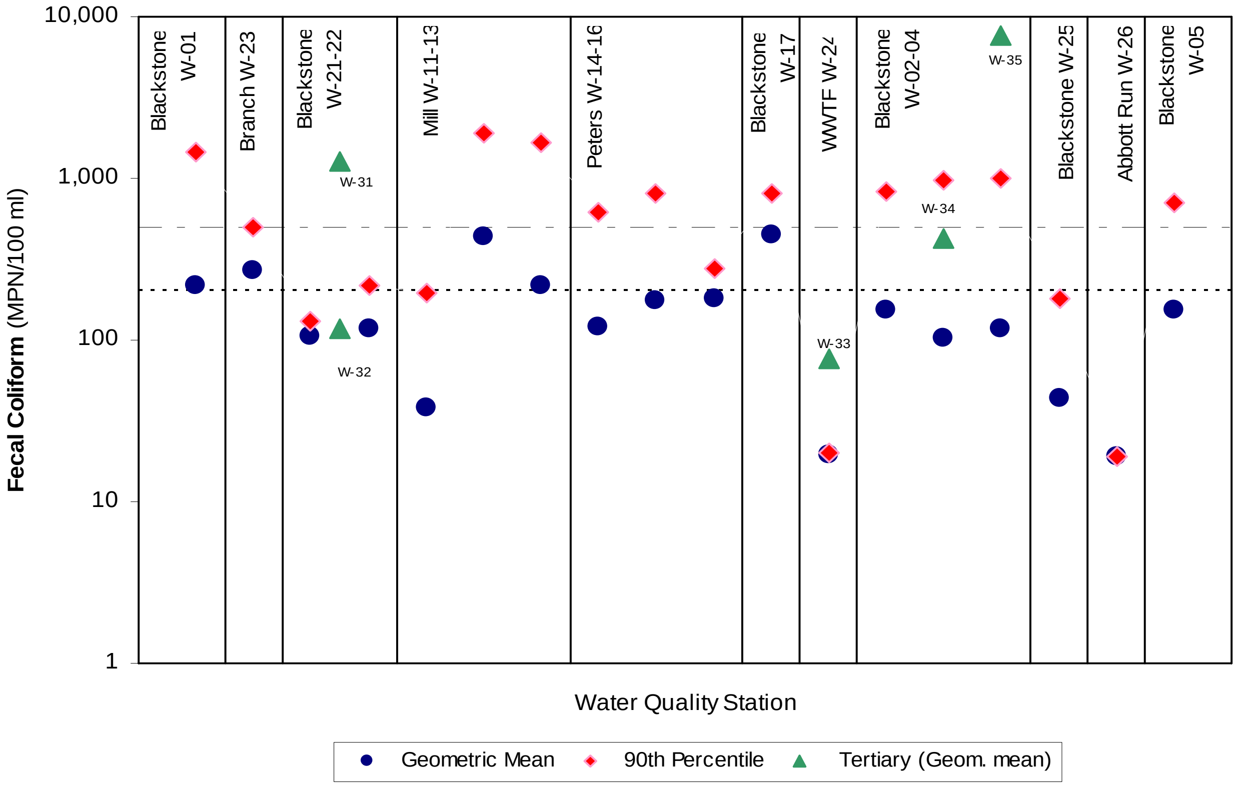


Figure 3-13: Dry Weather - Mean Fecal Coliform Concentrations (upstream to downstream)

Figure 3-14: Dry Weather Concentrations and Loads - Rankings for Fecal Coliform

Concentration					
Station No.	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location**	**Geometric Mean** (MPN/100 ml)
W-35			●	Brook near Ann&Hope	7,559
W-31			●	Cherry Brook	1,260
W-17	●			Hamlet Avenue	454
W-12		●		Mill River (pre-culvert entry)	436
W-34			●	Blackstone Canal at Lonsdale	427
W-23		●		Branch River	269
W-13		●		Mill River (confluence w/ BR)	215
W-01	●			Millville *(**MA/RI** border)*	211
W-16		●		Peters River (confluence w/ BR)	180
W-15		●		Peters River (pre-culvert entry)	176
W-05	●			Slaters Mill Dam	153
W-02	●			Manville Dam	150
W-14		●		Peters River *(**MA/RI** border)*	121
W-32			●	Front Street Drain	117
W-22	●			Below Thundermist Dam	116
W-04	●			Lonsdale Ave	107
W-21	●			Singleton Street	106
W-03	●			George Washington Hwy Bridge	97
W-33			●	Sylvestre Pond Outflow	77
W-25	●			Broad Street	44
W-11		●		Mill River *(**MA/RI** border)*	38
W-24			●	Woonsocket WWTF	20
W-26		●		Abbott Run Brook	19

Mass Loading *(Events DW-7, 9, 11)*					
Station No.	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location**	**Geometric Mean** (MPN x 10^9 / day)
W-17	●			Hamlet Avenue	1,719
W-05	●			Slaters Mill Dam	574
W-04	●			Lonsdale Ave	369
W-22	●			Below Thundermist Dam	338
W-21	●			Singleton Street	306
W-01	●			Millville (MA/RI border)	211
W-02	●			Manville Dam	206
W-12		●		Mill River (pre-culvert entry)	161
W-25	●			Broad Street	155
W-13		●		Mill River (confluence w/ BR)	136
W-03	●			George Washington Hwy Bridge	127
W-23		●		Branch River	94
W-26		●		Abbott Run Brook	14
W-11		●		Mill River (MA/RI border)	14
W-14		●		Peters River (MA/RI border)	10
W-15		●		Peters River (pre-culvert entry)	8.5
W-16		●		Peters River (confluence w/ BR)	7.3
W-24			●	Woonsocket WWTF	5.1
W-31			●	Cherry Brook	4.8
W-34			●	Blackstone Canal at Lonsdale	1.1
W-32			●	Front Street Drain	0.7
W-33			●	Sylvestre Pond Outflow	0.3
W-35			●	Brook near Ann&Hope	*n/a*

Figure 3-15: Dry Weather Concentrations and Loads - Rankings for Enterococci

Concentration

Station No.	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location**	**Geometric Mean** (col/100 ml)
W-35			●	Brook near Ann&Hope	966
W-31			●	Cherry Brook	200
W-12		●		Mill River (pre-culvert entry)	157
W-13		●		Mill River (confluence w/ BR)	72.0
W-15		●		Peters River (pre-culvert entry)	50.7
W-14		●		Peters River (***MA/RI*** *border)*	41.5
W-32			●	Front Street Drain	20.0
W-33			●	Sylvestre Pond Outflow	20.0
W-16		●		Peters River (confluence w/ BR)	15.0
W-01	●			Millville (***MA/RI*** *border)*	14.0
W-17	●			Hamlet Avenue	13.3
W-05	●			Slaters Mill Dam	12.1
W-02	●			Manville Dam	10.2
W-23		●		Branch River	<10
W-21	●			Singleton Street	<10
W-22	●			Below Thundermist Dam	<10
W-25	●			Broad Street	<10
W-34			●	Blackstone Canal at Lonsdale	<10
W-26		●		Abbott Run Brook	<10
W-04	●			Lonsdale Ave	8.0
W-03	●			George Washington Hwy Bridge	7.4
W-11		●		Mill River (***MA/RI*** *border)*	7.3
W-24			●	Woonsocket WWTF	*n/a*

Mass Loading *(Events DW-7, 9, 11)*

Station No.	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location**	**Geometric Mean** (col x 10^9 / day)
W-05	●			Slaters Mill Dam	44.9
W-12		●		Mill River (pre-culvert entry)	36.9
W-02	●			Manville Dam	32.8
W-17	●			Hamlet Avenue	32.1
W-25	●			Broad Street	31.9
W-04	●			Lonsdale Ave	31.8
W-03	●			George Washington Hwy Bridge	31.6
W-22	●			Below Thundermist Dam	26.2
W-21	●			Singleton Street	26.0
W-01	●			Millville (MA/RI border)	21.8
W-13		●		Mill River (confluence w/ BR)	20.1
W-26		●		Abbott Run Brook	8.7
W-15		●		Peters River (pre-culvert entry)	5.1
W-14		●		Peters River (MA/RI border)	4.0
W-23		●		Branch River	3.1
W-11		●		Mill River (MA/RI border)	2.6
W-31			●	Cherry Brook	1.2
W-16		●		Peters River (confluence w/ BR)	0.52
W-32			●	Front Street Drain	0.18
W-33			●	Sylvestre Pond Outflow	0.13
W-34			●	Blackstone Canal at Lonsdale	0.02
W-35			●	Brook near Ann&Hope	*n/a*
W-24			●	Woonsocket WWTF	*n/a*

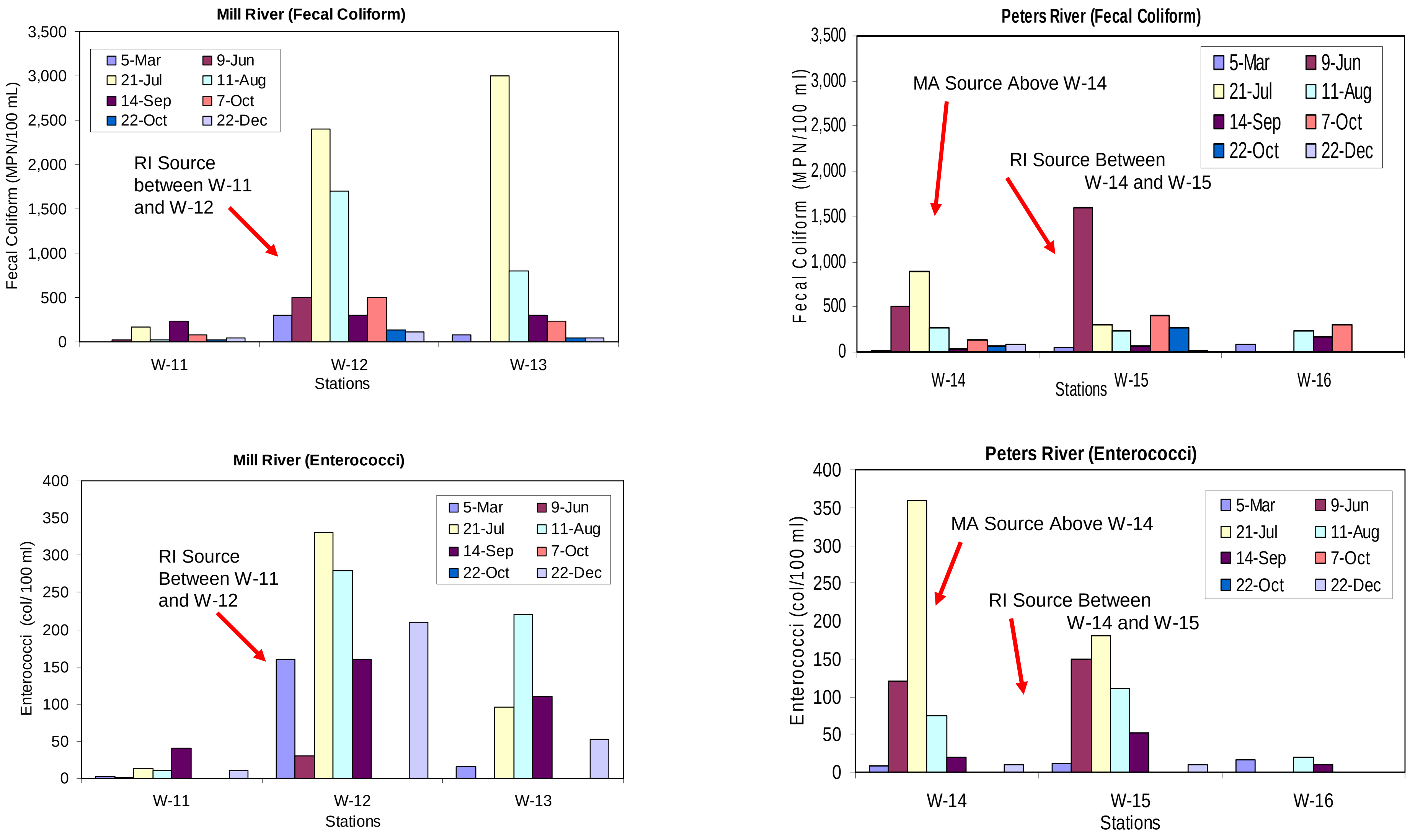


Figure 3-16: Comparison between States for Fecal Coliform & Enterococci in the Mill River and Peters River

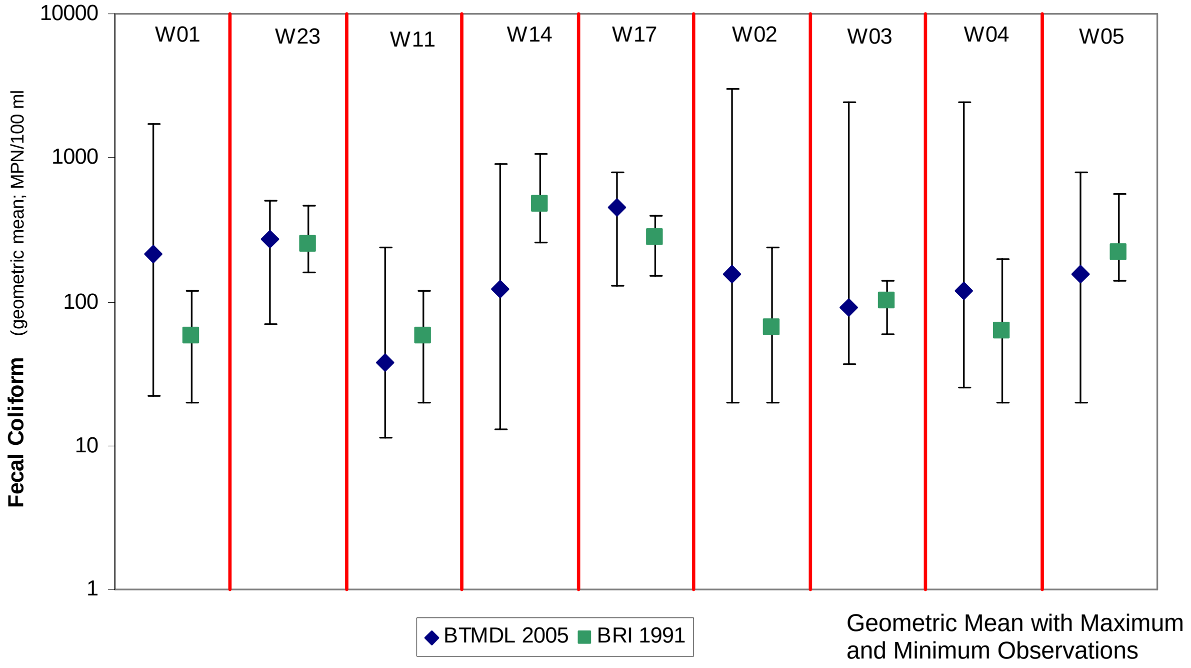


Figure 3-17: Dry Weather Fecal Coliform Concentrations - Comparison between BTMDL (2005) and BRI (1991) (geometric means)

Figure 3-18: Dry Weather Concentrations - Total Phosphorus

Station No.	Reach			Blackstone River	Tributary	WWTF/outfall/other	Location	**Concentration** (mg/l P)																		**Statistics**				
								16-Mar-05	**20-Apr-05**	**11-May-05**	**23-May-05**	**9-Jun-05**	**27-Jun-05**	**21-Jul-05**	**3-Aug-05**	**11-Aug-05**	**25-Aug-05**	**14-Sep-05**	**26-Sep-05**	**7-Oct-05**	**22-Oct-05** *(1)*	**29-Nov-05**	**22-Dec-05**	**27-Jan-06**	**17-Feb-06**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Count**
							Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18					
W-01	Reach 1			●			Millville *(**MA/RI** border)*	0.19	0.17	0.22	0.33	0.32	0.34	0.39	0.43	0.52	0.27	0.60	0.61	0.46	*0.13*	0.20	0.70	0.42	0.59	**0.38**	0.17	0.13	0.70	18
W-23					●		Branch River							1.9		1.9		<0.05		0.06						**0.97**	1.07	<0.05	1.90	4
W-21				●			Singleton Street							0.21		0.36		0.28								**0.28**	0.08	0.21	0.36	3
W-22				●			Below Thundermist Dam							0.22		0.66		0.36								**0.41**	0.22	0.22	0.66	3
W-11					●		Mill River *(**MA/RI** border)*	0.14				0.10		0.18		0.20		0.07		<0.05	*0.09*		0.42			**0.15**	0.12	<0.05	0.42	8
W-12					●		Mill River (pre-culvert entry)	0.16				0.14		0.11		0.11		<0.05		0.10	*0.11*		0.55			**0.16**	0.16	<0.05	0.55	8
W-13					●		Mill River (confluence w/ BR)	0.14						0.07		0.32		<0.05		<0.05	*0.11*		0.47			**0.17**	0.17	<0.05	0.47	7
W-14					●		Peters River *(**MA/RI** border)*	0.26				0.14		0.09		0.19		0.06		<0.05	*0.14*		0.59			**0.19**	0.18	<0.05	0.59	8
W-15					●		Peters River (pre-culvert entry)	0.09				0.11		0.14		0.33		0.08		<0.05	*0.19*		0.57			**0.19**	0.18	<0.05	0.57	8
W-16					●		Peters River (confluence w/ BR)	0.29								0.20		<0.05		0.08						**0.15**	0.12	<0.05	0.29	4
W-17				●			Hamlet Avenue	0.27				0.25		0.24		0.22		0.32					0.61			**0.32**	0.15	0.22	0.61	6
W-24						●	Woonsocket WWTF							0.22				**2.2**								**1.21**	1.40	0.22	2.20	2
W-02		Reach 2		●			Manville Dam	0.32	0.12	0.22	0.21	0.42	0.37	0.26	0.62	0.34	0.16	0.46	0.47	<0.05	*0.13*	0.32	0.61	0.42	0.69	**0.34**	0.18	<0.05	0.69	18
W-03				●			George Washington Hwy Bridge	0.20	0.15	0.22	0.20	0.50	0.26	0.27	0.60	0.58	0.07	0.25	0.31	<0.05	*0.13*	0.23	0.60	0.46	0.64	**0.32**	0.20	<0.05	0.64	18
W-04			Reach 3	●			Lonsdale Ave	0.19	0.13	0.20	0.15	0.44	0.22	0.20	0.59	0.26	0.23	0.20	0.25	0.38	*0.12*	0.18	0.66	0.41	0.45	**0.29**	0.16	0.12	0.66	18
W-25				●			Broad Street							0.09		0.11		<0.05								**0.07**	0.04	<0.05	0.11	3
W-26					●		Abbott Run Brook							0.18		0.24		<0.05								**0.15**	0.11	<0.05	0.24	3
W-05				●			Slaters Mill Dam	0.18	0.14	0.14	0.23	0.32	0.20	0.19	0.23	0.47	0.26	<0.05	0.21	0.33	*0.17*	0.20	0.63	0.45	0.44	**0.27**	0.15	<0.05	0.63	18
W-31	1					●	Cherry Brook							0.09		0.20		0.13								**0.14**	0.05	0.09	0.20	3
W-32						●	Front Street Drain							0.10		0.04		0.11								**0.08**	0.04	0.04	0.11	3
W-33						●	Sylvestre Pond Outflow							0.10		0.05		<0.05								**0.06**	0.04	<0.05	0.10	3
W-34		2				●	Blackstone Canal at Lonsdale							0.14		0.18										**0.16**	0.03	0.14	0.18	2
W-35			3			●	Brook near Ann&Hope															0.11	0.83	0.45	0.50	**0.47**	0.29	0.11	0.83	4
W-02	1	2		(=W-02)			Duplicate		0.14	0.23	0.26		0.41																	
W-05			3	(=W-05)			Duplicate	0.24																						
W-01	1			(=W-01)			Duplicate	0.29																						
W-41				(=W-11)			Duplicate							0.14		0.03		<0.05			*0.09*		0.64							
W-42				(=W-14)			Duplicate							0.07		0.25		0.09		0.22	*0.13*									
W-43		2	3	(=W-04)			Duplicate							0.10	0.36	0.20	0.18	0.23	0.33	0.37	*0.12*	0.16	0.85	0.53	0.49					

(1) *Event DW-14 (10/22/05):* All samples (in italics) had analyte detected in the associated Method Blank (0.03633 mg/l). Data were included in statistics, however.

Water Quality Criteria (Class B and B1): Criteria related to impact to the waterbody.

Reporting Limit: 0.033 mg/l (exceptions: DW-1 and DW-8 (0.066 mg/l); DW-11 and DW-13 (0.05 mg/l), and DW-16 to DW-18 (0.17 mg/l).

Figure 3-19: Dry Weather Concentrations - Ammonia

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Location	Concentration (mg/l N)																		Statistics				
						16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05	3-Aug-05	11-Aug-05	25-Aug-05	14-Sep-05 *(1)*	26-Sep-05	7-Oct-05	22-Oct-05	29-Nov-05	22-Dec-05	27-Jan-06	17-Feb-06	Mean	Standard Deviation	Minimum	Maximum	Count
					Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18					
W-01	Reach 1	●			Millville (***MA/RI*** *border)*	0.82	0.56	0.51	<0.2	0.66	0.71	0.48	<0.20	0.42	0.24	0.35	<0.20	<0.20	0.41	0.86	0.80	0.23	1.10	**0.48**	0.3	<0.20	1.10	18
W-23			●		Branch River							0.23		0.32		0.58		0.52						**0.41**	0.2	0.2	0.58	4
W-21		●			Singleton Street							<0.20		<0.20		0.30								**0.17**	0.1	<0.20	0.30	3
W-22		●			Below Thundermist Dam							0.23		<0.20		0.47								**0.27**	0.2	<0.20	0.47	3
W-11			●		Mill River (***MA/RI*** *border)*	<0.20				0.39		<0.20		0.20		0.22		<0.20	<0.20		0.28			**0.19**	0.1	<0.20	0.39	8
W-12			●		Mill River (pre-culvert entry)	<0.20				0.35		0.24		<0.20		0.22		<0.20	0.31		0.42			**0.23**	0.1	<0.20	0.42	8
W-13			●		Mill River (confluence w/ BR)	<0.20						<0.20		<0.20		<0.20		<0.20	<0.20		0.44			**0.16**	0.1	<0.20	0.44	6
W-14			●		Peters River (***MA/RI*** *border)*	0.25				0.43		0.40		0.40		0.26		0.34	<0.20		0.31			**0.31**	0.1	<0.20	0.43	8
W-15			●		Peters River (pre-culvert entry)	0.32				0.60		0.26		<0.20		<0.20		0.36	<0.20		0.25			**0.26**	0.2	<0.20	0.60	8
W-16			●		Peters River (confluence w/ BR)	<0.20								0.28		0.34		0.37						**0.33**	0.0	0.3	0.37	3
W-17		●			Hamlet Avenue	0.66				0.52		0.21		<0.20		0.38					0.53			**0.40**	0.2	<0.20	0.66	6
W-24				●	Woonsocket WWTF							2.30				**8.4**								**5.35**	4.3	2.3	8.40	2
W-02	Reach 2	●			Manville Dam	0.70	0.53	0.35	0.38	0.56	0.87	0.55	<0.20	0.47	0.30	0.53	0.28	0.21	0.40	0.84	0.61	0.36	0.79	**0.49**	0.2	<0.20	0.87	18
W-03		●			George Washington Hwy Bridge	<0.20	0.85	0.27	0.35	0.61	0.39	0.43	<0.20	0.37	0.35	0.31	0.36	<0.20	0.28	0.36	0.63	0.46	0.75	**0.39**	0.2	<0.20	0.85	18
W-04	Reach 3	●			Lonsdale Ave	0.41	0.78	0.33	0.32	0.40	0.41	0.20	0.22	0.36	0.47	0.24	0.25	<0.20	0.42	0.41	0.61	<0.20	0.81	**0.38**	0.2	<0.20	0.81	18
W-25		●			Broad Street							<0.20		<0.20		<0.20								**0.10**	0.0	<0.20	<0.20	3
W-26			●		Abbott Run Brook							<0.20		0.32		<0.20								**0.17**	0.1	<0.20	0.32	3
W-05		●			Slaters Mill Dam	0.49	0.50	0.21	0.22	0.34	0.43	0.22	<0.20	0.21	0.79	0.21	<0.20	<0.20	0.58	0.40	0.63	<0.20	0.70	**0.35**	0.2	<0.20	0.79	18
W-31	1			●	Cherry Brook							0.23		<0.20		<0.20								**0.14**	0.08	<0.20	0.23	3
W-32				●	Front Street Drain							0.25		<0.20		<0.20								**0.15**	0.09	<0.20	0.25	3
W-33				●	Sylvestre Pond Outflow							1.90		0.38		*0.47*								**0.92**	0.85	0.38	1.90	3
W-34	2			●	Blackstone Canal at Lonsdale							<0.20		0.22										**0.16**	0.08	<0.20	0.22	2
W-35	3			●	Brook near Ann&Hope															0.33	0.20	<0.20	1.40	**0.51**	0.60	<0.20	1.40	4
W-02	1 2	(=W-02)			Duplicate		0.21	0.42	0.45		0.51																	
W-05	3	(=W-05)			Duplicate	0.42																						
W-01	1	(=W-01)			Duplicate	0.91																						
W-41		(=W-11)			Duplicate							<0.20		0.28		*0.22*			0.25		0.22							
W-42		(=W-14)			Duplicate							<0.20		0.23		*0.36*		0.50	0.28									
W-43	2 3	(=W-04)			Duplicate							<0.20	<0.20	<0.20		<0.20	<0.20	0.63	0.36	0.53	0.60	<0.20	0.65					

(1) *Event DW-11 (9/14/05); samples W-33, W-41, W-42:* Samples (in italics) had analyte detected in the associated Method Blank. Data were included in statistics. however.

Reporting Limit: 0.20 mg/l

pH	**Acute Criteria** (mg/ N)	**Chronic Criteria** (mg/l N)		
		10ºC	*15ºC*	*20ºC*
6.5	48.8	8.9	6.5	4.7
7.0	36.1	7.9	5.7	4.2
7.5	19.9	5.8	4.2	3.1

Figure 3-20: Dry Weather Concentrations - Nitrate

Station No.	Reach			Blackstone River	Tributary	WWTF/outfall/other	Location	Concentration (mg/l N)																		Statistics				
								16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05 *(1)*	27-Jun-05	21-Jul-05 *(2)*	3-Aug-05	11-Aug-05	25-Aug-05 *(3)*	14-Sep-05	26-Sep-05	7-Oct-05	22-Oct-05	29-Nov-05 *(4)*	22-Dec-05	27-Jan-06	17-Feb-06 *(3)*	Mean	Standard Deviation	Minimum	Maximum	Count
							Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18					
W-01	Reach 1			●			Millville *(**MA/RI** border)*	0.90	0.92	0.82	1.3	*ed*	3.2	*1.8*	2.1	1.8	*2.5*	5.1	3.8	2.5	0.64	*0.77*	0.26	0.76	*1.1*	**1.78**	1.30	0.26	5.10	17
W-23					●		Branch River							0.23		0.29		0.32		0.33						**0.29**	0.04	0.23	0.33	4
W-21				●			Singleton Street							1.4		1.1		2.9								**1.80**	0.96	1.10	2.90	3
W-22				●			Below Thundermist Dam							1.3		0.9		2.8								**1.65**	1.02	0.85	2.80	3
W-11					●		Mill River *(**MA/RI** border)*	0.65				*ed*		0.27		0.20		0.13		0.49	0.36		1.6			**0.53**	0.50	0.13	1.60	7
W-12					●		Mill River (pre-culvert entry)	0.67				*ed*		0.44		0.46		0.89		0.29	0.40		<0.13			**0.46**	0.26	<0.13	0.89	7
W-13					●		Mill River (confluence w/ BR)	0.69						0.45		0.47		0.86		0.27	0.42		<0.13			**0.46**	0.26	<0.13	0.86	7
W-14					●		Peters River *(**MA/RI** border)*	0.86				*ed*		0.70		0.83		1.1		0.65	0.54		0.28			**0.71**	0.26	0.28	1.10	7
W-15					●		Peters River (pre-culvert entry)	0.85				*ed*		0.76		0.70		1.1		0.64	0.55		1.5			**0.87**	0.33	0.55	1.50	7
W-16					●		Peters River (confluence w/ BR)	0.75								0.72		1.1		0.64						**0.80**	0.20	0.64	1.10	4
W-17				●			Hamlet Avenue	0.81				*ed*		1.3		0.88		2.7					0.72			**1.28**	0.82	0.72	2.70	5
W-24						●	Woonsocket WWTF							*4.1*				3.1								**3.60**	0.71	3.10	4.10	2
W-02		Reach 2		●			Manville Dam	0.84	1.1	0.68	1.1	*ed*	2.4	1.3	1.5	1.2	*2.0*	2.8	2.9	2.0	0.62	*0.54*	0.38	0.59	*1.1*	**1.36**	0.79	0.38	2.90	17
W-03				●			George Washington Hwy Bridge	0.81	1.2	0.71	1.2	*ed*	2.2	1.1	1.5	1.1	*1.5*	2.2	2.9	1.7	0.66	*0.59*	0.32	0.58	*1.2*	**1.26**	0.68	0.32	2.90	17
W-04			Reach 3	●			Lonsdale Ave	0.83	1.1	0.74	1.1	*ed*	2.2	1.1	1.5	1.3	*1.9*	2.8	2.9	1.7	0.68	*0.64*	0.30	0.59	*1.3*	**1.33**	0.76	0.30	2.90	17
W-25				●			Broad Street							1.0		0.16		1.4								**0.85**	0.63	0.16	1.40	3
W-26					●		Abbott Run Brook							0.45		1.0		0.33								**0.59**	0.36	0.33	1.00	3
W-05				●			Slaters Mill Dam	0.82	1.0	0.77	1.1	*ed*	2.0	1.1	1.2	1.0	*1.6*	1.6	2.2	1.6	0.62	*0.72*	0.34	0.60	*1.0*	**1.13**	0.51	0.34	2.20	17
W-31	1					●	Cherry Brook							0.43		1.6		1.3								**1.11**	0.61	0.43	1.60	3
W-32						●	Front Street Drain							*2.6*		2.9		2.6								**2.70**	0.17	2.60	2.90	3
W-33						●	Sylvestre Pond Outflow							0.44		0.43		0.18								**0.35**	0.15	0.18	0.44	3
W-34		2				●	Blackstone Canal at Lonsdale							0.61		0.52										**0.57**	0.06	0.52	0.61	2
W-35			3			●	Brook near Ann&Hope															*3.9*	4.6	4.3	*6.8*	**4.90**	1.30	3.90	6.80	4
W-02	1	2		(=W-02)			Duplicate		1.0	0.71	1.1		2.3																	
W-05			3	(=W-05)			Duplicate	0.87																						
W-01	1			(=W-01)			Duplicate	0.89																						
W-41				(=W-11)			Duplicate							0.28		0.18		<0.05			0.37		1.1							
W-42				(=W-14)			Duplicate							0.67		0.79		<0.50		0.66	0.51									
W-43		2	3	(=W-04)			Duplicate							1.1	1.5	1.20	*1.9*	1.8	2.9	1.7	0.64	*0.56*	0.79	0.70	*1.3*					

(1) Event DW-5 (6/9/05); all samples: Analyte detected in associated Method Blank. Values above quantitation range. Values edited (ed).

(2) Event DW-7 (7/21/05); W-01, W-24, W-32: Values (in italics) were above the quantification range. Data were included in statistics, however.

(3) Events DW-10 (8/25/05) & DW-18 (2/17/06); all samples: Data of the initial run were higher but had calibration problems. Samples were rerun two days later, slightly beyond holding time, and used for reporting instead.

(4) Events DW-15 (11/29/05): All samples (in italics) had analyte detected in the associated Method Blank (MB; 0.031 mg/l). The MB value was not subtracted from the data for this event; the data were included in statistics.

Water Quality Criteria (Class B and B1): Criteria related to impact to the waterbody.

Reporting Limit: 0.025 mg/l (exceptions: DW-1,2,3,7: 0.05 mg/l; DW-4,6,13: 0.25 mg/l; DW-8: 0.1 mg/l; DW-9,10,16: 0.13 mg/l; DW-11,12: 0.5 mg/l).

Figure 3-21: Dry Weather Concentrations - Total Kjeldahl Nitrogen

Station No.	Reach			Blackstone River	Tributary	WWTF/outfall/other	Location	Concentration (mg/l N)																		Statistics				
								16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05	3-Aug-05	11-Aug-05 *(1)*	25-Aug-05	14-Sep-05	26-Sep-05	7-Oct-05	22-Oct-05	29-Nov-05	22-Dec-05	27-Jan-06	17-Feb-06	Mean	Standard Deviation	Minimum	Maximum	Count
							Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18					
W-01	Reach 1			●			Millville *(**MA/RI** border)*	1.2	1.0	0.65	0.85	0.73	1.1	0.33	1.2	0.58	0.94	0.67	0.72	0.62	0.92	0.76	1.0	1.5	1.3	**0.89**	0.29	0.33	1.50	18
W-23					●		Branch River							0.42		0.32		0.40		0.46						**0.40**	0.06	0.32	0.46	4
W-21				●			Singleton Street							0.78		0.68		0.80								**0.75**	0.06	0.68	0.80	3
W-22				●			Below Thundermist Dam							0.73		0.72		0.80								**0.75**	0.04	0.72	0.80	3
W-11					●		Mill River *(**MA/RI** border)*	0.58				0.51		0.52		0.36		0.50		0.46	0.51		0.56			**0.50**	0.07	0.36	0.58	8
W-12					●		Mill River (pre-culvert entry)	0.75				0.46		0.49		0.30		0.66		0.48	0.51		0.31			**0.50**	0.15	0.30	0.75	8
W-13					●		Mill River (confluence w/ BR)	0.48						0.53		0.40		0.59		0.84	0.56		0.61			**0.57**	0.14	0.40	0.84	7
W-14					●		Peters River *(**MA/RI** border)*	0.57				0.63		0.66		0.56		0.85		0.44	0.42		0.46			**0.57**	0.14	0.42	0.85	8
W-15					●		Peters River (pre-culvert entry)	0.42				0.69		0.50		0.30		0.51		0.44	0.47		0.29			**0.45**	0.13	0.29	0.69	8
W-16					●		Peters River (confluence w/ BR)	0.56								0.28		0.42		0.34						**0.40**	0.12	0.28	0.56	4
W-17				●			Hamlet Avenue	1.5				0.59		0.70		0.60		0.90					1.0			**0.88**	0.34	0.59	1.50	6
W-24						●	Woonsocket WWTF							**3.5**				**9.8**								**6.65**	4.45	3.50	9.80	2
W-02		Reach 2		●			Manville Dam	1.5	1.3	1.0	0.43	1.0	0.96	1.4	1.5	0.74	0.95	0.91	0.78	0.86	0.62	0.72	0.90	0.95	1.0	**0.97**	0.29	0.43	1.50	18
W-03				●			George Washington Hwy Bridge	1.0	0.98	0.58	0.32	0.79	0.87	0.99	1.5	0.90	0.87	0.68	0.84	1.00	0.76	0.90	0.74	0.78	1.2	**0.87**	0.25	0.32	1.50	18
W-04			Reach 3	●			Lonsdale Ave	0.97	1.7	0.76	0.44	0.84	0.85	0.81	2.2	0.70	0.82	0.67	0.80	0.64	0.64	0.70	0.90	0.77	1.0	**0.90**	0.41	0.44	2.20	18
W-25				●			Broad Street							0.82		0.36		1.00								**0.73**	0.33	0.36	1.00	3
W-26					●		Abbott Run Brook							0.35		0.66		0.34								**0.45**	0.18	0.34	0.66	3
W-05				●			Slaters Mill Dam	0.93	1.0	0.29	0.16	0.70	0.95	0.76	1.3	1.1	0.86	0.73	0.60	0.60	0.62	0.80	1.2	0.77	1.0	**0.80**	0.29	0.16	1.30	18
W-31	1					●	Cherry Brook							0.76		0.36		0.40								**0.51**	0.22	0.36	0.76	3
W-32						●	Front Street Drain							0.30		0.20		0.23								**0.24**	0.05	0.20	0.30	3
W-33						●	Sylvestre Pond Outflow							0.86		0.68		0.63								**0.72**	0.12	0.63	0.86	3
W-34		2				●	Blackstone Canal at Lonsdale							1.1		*0.88*										**0.99**	0.16	0.88	1.10	2
W-35			3			●	Brook near Ann&Hope															0.51	0.54	0.87	0.68	**0.65**	0.16	0.51	0.87	4
W-02	1	2		(=W-02)			Duplicate		0.91	0.88	0.50		0.90																	
W-05			3	(=W-05)			Duplicate	1.1																						
W-01	1			(=W-01)			Duplicate	1.4																						
W-41				(=W-11)			Duplicate							0.98		*0.62*		0.53			0.54		1.3							
W-42				(=W-14)			Duplicate							1.0		*0.65*		0.63		0.42	0.52									
W-43		2	3	(=W-04)			Duplicate							1.4	1.6	*0.87*	0.79	0.77	0.80	0.68	0.68	0.68	1.2	0.82	1.0					

(1) Event DW-9 (8/11/05); samples W-34, W-41, W-42, W-43: Samples (in italics) were in a batch that contained 0.246 mg/l of TKN in the method blank. The MB was not subtracted from affected samples of this event.

Water Quality Criteria (Class B and B1): Criteria related to impact to the waterbody.

Reporting Limit: 0.1 mg/l

Figure 3-22: Dry Weather Loads - Total Phosphorus

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Location	Load (lbs/day P)																		Statistics	
						16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05	3-Aug-05	11-Aug-05	25-Aug-05	14-Sep-05	26-Sep-05	7-Oct-05	22-0ct-05	29-Nov-05	22-Dec-05	27-Jan-06	17-Feb-06	Mean *(DW-7, 9, and 11)*	Count
					Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
W-01	Reach 1	●			Millville (MA/RI border)	638.6	531.8	927.4	759.9	571.1	270.7	350.6	214.2	259.1	132.9	198.2	357.1	262.1	1,119	924.0	2,378	2,195	3,235	269.3	3
W-23			●		Branch River							445.7		130.8		2.6		4.3						193.1	3
W-21		●			Singleton Street							243.9		208.0		107.6								186.5	3
W-22		●			Below Thundermist Dam							257.6		383.5		138.5								259.8	3
W-11			●		Mill River (MA/RI border)	55.7				15.3		10.7		5.7		1.4		1.5	42.1		121.6			5.9	3
W-12			●		Mill River (pre-culvert entry)	64.7				23.0		6.6		3.2		0.5		6.0	52.3		161.9			3.4	3
W-13			●		Mill River (confluence w/ BR)	57.2						4.3		9.3		0.5		1.5	52.3		138.3			4.7	3
W-14			●		Peters River (MA/RI border)	36.2				14.0		1.9		0.8		0.8		0.5	36.5		84.4			1.2	3
W-15			●		Peters River (pre-culvert entry)	12.9				11.5		3.0		1.6		1.1		0.5	50.9		84.0			1.9	3
W-16			●		Peters River (confluence w/ BR)	42.0								1.0		0.4		1.7						0.7	3
W-17		●			Hamlet Avenue	1,416				630.1		303.3		127.8		131.5					3079.6			187.6	3
W-24				●	Woonsocket WWTF							13.5				121.4								67.5	3
W-02	Reach 2	●			Manville Dam	1,769	576.3	1497	723.9	1093	449.1	353.3	441.6	235.4	110.6	217.0	364.4	20.3	1,619	2,461	3,243	3,713	6,395	268.6	3
W-03		●			George Washington Hwy Bridge	1,143	743.1	1546	709.3	1310	319.6	375.1	432.2	408.5	48.4	118.4	242.8	20.6	1,659	1,819	3,295	4,176	6,087	300.6	3
W-04	Reach 3	●			Lonsdale Ave	1,098	650.4	1420	536.7	1155	271.5	279.7	426.6	183.9	162.1	94.7	196.5	314.4	1,543	1,436	3,662	3,754	4,314	186.1	3
W-25		●			Broad Street							126.2		78.0		11.9								72.0	3
W-26			●		Abbott Run Brook							26.2		46.6		4.18								25.6	3
W-05		●			Slaters Mill Dam	1,118	756.2	1063	883.3	921.9	288.2	294.2	216.1	424.6	248.0	16.0	199.2	323.3	2,232	1,700	3,754	4,378	4,479	244.9	3
W-31	1			●	Cherry Brook							0.30		0.22		0.02								0.18	3
W-32				●	Front Street Drain							0.53		0.08		0.02								0.21	3
W-33				●	Sylvestre Pond Outflow							0.37		0.08		0.00								0.15	3
W-34	2			●	Blackstone Canal at Lonsdale							0.11		0.03										0.07	2
W-35	3			●	Brook near Ann&Hope															0.44	0.98	0.82	0.89	0.78	4

▨ Sampling events used for statistical analyses.

Figure 3-23: Dry Weather Loads - Ammonia

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Location	Load (lbs/day N)																		Statistics	
						16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05	3-Aug-05	11-Aug-05	25-Aug-05	14-Sep-05	26-Sep-05	7-Oct-05	22-Oct-05	29-Nov-05	22-Dec-05	27-Jan-06	17-Feb-06	Mean (DW-7, 9, and 11)	Count
					Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
W-01	Reach 1	●			Millville *(MA/RI border)*	2,756	1,752	2,150	230	1,178	565.3	431.5	49.8	209.2	118.1	115.6	58.5	57.0	3,530	3,973	2,718	1,202	6,032	252.1	3
W-23			●		Branch River							54.0		22.0		30.6		37.2						35.5	3
W-21		●			Singleton Street							232.3		115.6		115.2								154.4	3
W-22		●			Below Thundermist Dam							269.3		57.8		180.5								169.2	3
W-11			●		Mill River *(MA/RI border)*	39.8				62.9		5.9		5.7		4.5		5.9	46.8		81.0			5.4	3
W-12			●		Mill River (pre-culvert entry)	40.5				57.4		14.5		2.9		4.6		6.0	147.4		123.6			7.3	3
W-13			●		Mill River (confluence w/ BR)	40.8						6.1		2.9		2.1		6.0	47.6		129.5			3.7	3
W-14			●		Peters River *(MA/RI border)*	34.8				43.0		8.4		1.7		3.5		7.0	26.1		44.4			4.5	3
W-15			●		Peters River (pre-culvert entry)	143.1				62.6		5.6		0.5		1.4		7.6	26.8		36.9			2.5	3
W-16			●		Peters River (confluence w/ BR)	14.5								1.4		4.9		7.8						3.1	3
W-17		●			Hamlet Avenue	3462				1311		265.4		61.9		156.2					2676			161.2	3
W-24				●	Woonsocket WWTF							141.2				444.2								292.7	3
W-02	Reach 2	●			Manville Dam	3,870	2,545	2,381	1,310	1,457	1,056	747.4	71.2	325.4	207.4	250.1	217.1	170.6	4,981	6,459	3,243	3,183	7,322	441.0	3
W-03		●			George Washington Hwy Bridge	572	4,211	1,898	1,241	1,598	479.4	597.3	72.0	260.6	245.5	146.8	282.0	82.4	3,574	2,847	3,460	4,176	7,133	334.9	3
W-04	Reach 3	●			Lonsdale Ave	2,369	3,902	2,343	1,145	1,050	506.0	279.7	159.1	254.7	331.2	113.6	196.5	82.7	5,402	3,271	3,385	916	7,766	216.0	3
W-25		●			Broad Street							140.2		70.9		47.5								86.2	3
W-26			●		Abbott Run Brook							14.6		62.1		16.7								31.1	3
W-05		●			Slaters Mill Dam	3045	2701	1594	844.9	979.5	619.5	340.6	93.9	189.7	753.6	134.6	94.8	98.0	7,614	3,399	3,754	973	7,126	221.6	3
W-31	1			●	Cherry Brook							0.74		0.11		0.02								0.29	3
W-32				●	Front Street Drain							1.35		0.22		0.02								0.53	3
W-33				●	Sylvestre Pond Outflow							7.16		0.61		0.08								2.61	3
W-34	2			●	Blackstone Canal at Lonsdale							0.08		0.09										0.09	3
W-35	3			●	Brook near Ann&Hope															1.33	0.24	0.18	2.49	0.87	4

▨ Sampling events used for statistical analyses.

Figure 3-24: Dry Weather Loads – Nitrate

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Location	Load (lbs/day N)																		Statistics	
						16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05	3-Aug-05	11-Aug-05	25-Aug-05	14-Sep-05	26-Sep-05	7-Oct-05	22-Oct-05	29-Nov-05	22-Dec-05	27-Jan-06	17-Feb-06	**Mean** *(DW-7, 9, and 11)*	**Count**
					Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
W-01	Reach 1	●			Millville (***MA/RI*** *border)*	3,025	2,878	3,456	2,993	ed	2,548	1,618	1,046	897	1,231	1,685	2,224	1,424	5,510	3,557	883	3,973	6,032	1,400	3
W-23			●		Branch River							54.0		20.0		16.9		23.6						30.3	3
W-21		●			Singleton Street							1626		635.6		1114								1,125	3
W-22		●			Below Thundermist Dam							1522		493.9		1077								1,031	3
W-11			●		Mill River (***MA/RI*** *border)*	258.8				ed		16.0		5.7		2.7		29.0	168.5		463.1			8.1	3
W-12			●		Mill River (pre-culvert entry)	271.1				ed		26.5		13.4		18.7		17.5	190.2		19.1			19.5	3
W-13			●		Mill River (confluence w/ BR)	281.8						27.4		13.7		18.0		16.3	199.7		19.1			19.7	3
W-14			●		Peters River (***MA/RI*** *border)*	119.8				ed		14.7		3.6		14.8		13.3	140.9		40.1			11.0	3
W-15			●		Peters River (pre-culvert entry)	121.6				ed		16.4		3.4		15.4		13.4	147.4		221.1			11.7	3
W-16			●		Peters River (confluence w/ BR)	108.5								3.5		16.0		13.4						9.7	3
W-17		●			Hamlet Avenue	4248				ed		1643		544.9		1110					3635			1,099	3
W-24				●	Woonsocket WWTF							251.7				163.9								207.8	3
W-02	Reach 2	●			Manville Dam	4,643	5,282	4,626	3,792	ed	2,913	1,767	1,068	831	1,383	1,321	2,248	1,625	7,721	4,152	2,020	5,216	10,195	1,306	3
W-03		●			George Washington Hwy Bridge	4,630	5,945	4,990	4,256	ed	2,705	1,528	1,081	775	1,052	1,042	2,272	1,400	8,424	4,666	1,758	5,266	11,412	1,115	3
W-04	Reach 3	●			Lonsdale Ave	4,795	5,503	5,254	3,936	ed	2,715	1,538	1,085	920	1,339	1,326	2,279	1,407	8,746	5,106	1,665	5,402	12,464	1,261	3
W-25		●			Broad Street							1402		113.5		664.8								726.9	3
W-26			●		Abbott Run Brook							65.5		194.0		55.1								104.9	3
W-05		●			Slaters Mill Dam	5,095	5,402	5,845	4,224	ed	2,882	1,703	1,127	903	1,526	1,025	2,087	1,568	8,139	6,118	2,026	5,837	10,179	1,211	3
W-31	1			●	Cherry Brook							1.39		1.7		0.2								1.11	3
W-32				●	Front Street Drain							14.0		6.2		0.6								6.93	3
W-33				●	Sylvestre Pond Outflow							1.66		0.69		0.03								0.79	3
W-34	2			●	Blackstone Canal at Lonsdale							0.46		0.22										0.34	2
W-35	3			●	Brook near Ann&Hope															15.7	5.4	7.9	12.1	10.3	4

▨ Sampling events used for statistical analyses.

Figure 3-25: Dry Weather Loads - Total Kjeldahl Nitrogen

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Location	Load (lbs/day N)																		Statistics	
						16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05	3-Aug-05	11-Aug-05	25-Aug-05	14-Sep-05	26-Sep-05	7-Oct-05	22-Oct-05	29-Nov-05	22-Dec-05	27-Jan-06	17-Feb-06	Mean *(DW-7, 9, and 11)*	Count
					Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
W-01	Reach 1	●			Millville (MA/RI border)	4,033	3,128	2,740	1,957	1,303	875.9	296.7	597.8	288.9	462.7	221.3	421.4	353.2	7,920	3,511	3,397	7,841	7,128	269.0	3
W-23			●		Branch River							98.5		22.0		21.1		32.9						47.2	3
W-21		●			Singleton Street							906.0		392.9		307.3								535.4	3
W-22		●			Below Thundermist Dam							854.6		418.3		307.7								526.9	3
W-11			●		Mill River (MA/RI border)	230.9				82.3		31.4		10.3		10.2		27.2	238.7		162.1			17.3	3
W-12			●		Mill River (pre-culvert entry)	303.4				75.5		29.5		8.7		13.8		28.9	242.6		91.2			17.4	3
W-13			●		Mill River (confluence w/ BR)	196.0						32.2		11.6		12.4		50.6	266.3		179.5			18.7	3
W-14			●		Peters River (MA/RI border)	79.4				63.0		13.8		2.4		11.4		9.0	109.6		65.8			9.2	3
W-15			●		Peters River (pre-culvert entry)	60.1				72.0		10.8		1.5		7.1		9.2	125.9		42.7			6.4	3
W-16			●		Peters River (confluence w/ BR)	81.0								1.4		6.1		7.1						3.7	3
W-17		●			Hamlet Avenue	7,867				1487		884.6		371.5		369.9					5049			542.0	3
W-24				●	Woonsocket WWTF							214.9				52.9								133.9	3
W-02	Reach 2	●			Manville Dam	8,292	6,243	6,802	1,482	2,602	1,165	1,903	1,068	512.4	656.8	429.4	604.7	698.6	7,721	5,537	4,785	8,399	9,268	948.1	3
W-03		●			George Washington Hwy Bridge	5,716	4,855	4,076	1,135	2,069	1,070	1,375	1,081	633.8	610.4	321.9	658.0	823.7	9,700	7,117	4,064	7,082	11,412	777.0	3
W-04	Reach 3	●			Lonsdale Ave	5,604	8,505	5,396	1,574	2,205	1,049	1,133	1,591	495.2	577.9	317.2	628.8	529.6	8,232	5,585	4,994	7,050	9,588	648.3	3
W-25		●			Broad Street							1,150		255.4		474.9								626.7	3
W-26			●		Abbott Run Brook							50.9		128.1		56.8								78.6	3
W-05		●			Slaters Mill Dam	5,778	5402	2201	614.4	2017	1369	1177	1,221	993.6	820.3	467.8	569.1	587.8	8,139	6,798	7,151	7,491	10,179	879.4	3
W-31	1			●	Cherry Brook							2.5		0.4		0.1								0.97	3
W-32				●	Front Street Drain							1.6		0.4		0.0								0.70	3
W-33				●	Sylvestre Pond Outflow							3.2		1.1		0.1								1.48	3
W-34	2			●	Blackstone Canal at Lonsdale							0.8		0.4										0.60	2
W-35	3			●	Brook near Ann&Hope															2.1	0.6	1.6	1.2	1.4	4

▨ Sampling events used for statistical analyses.

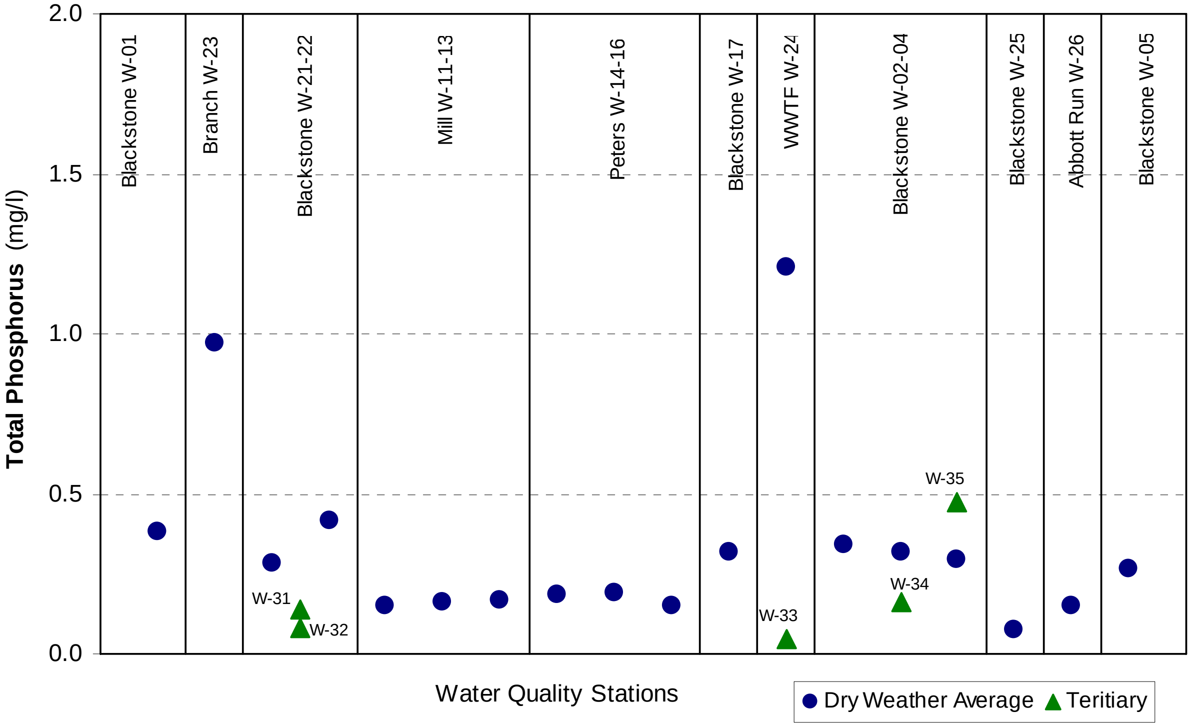


Figure 3-26: Dry Weather - Mean Total Phosphorus Concentrations (upstream to downstream)

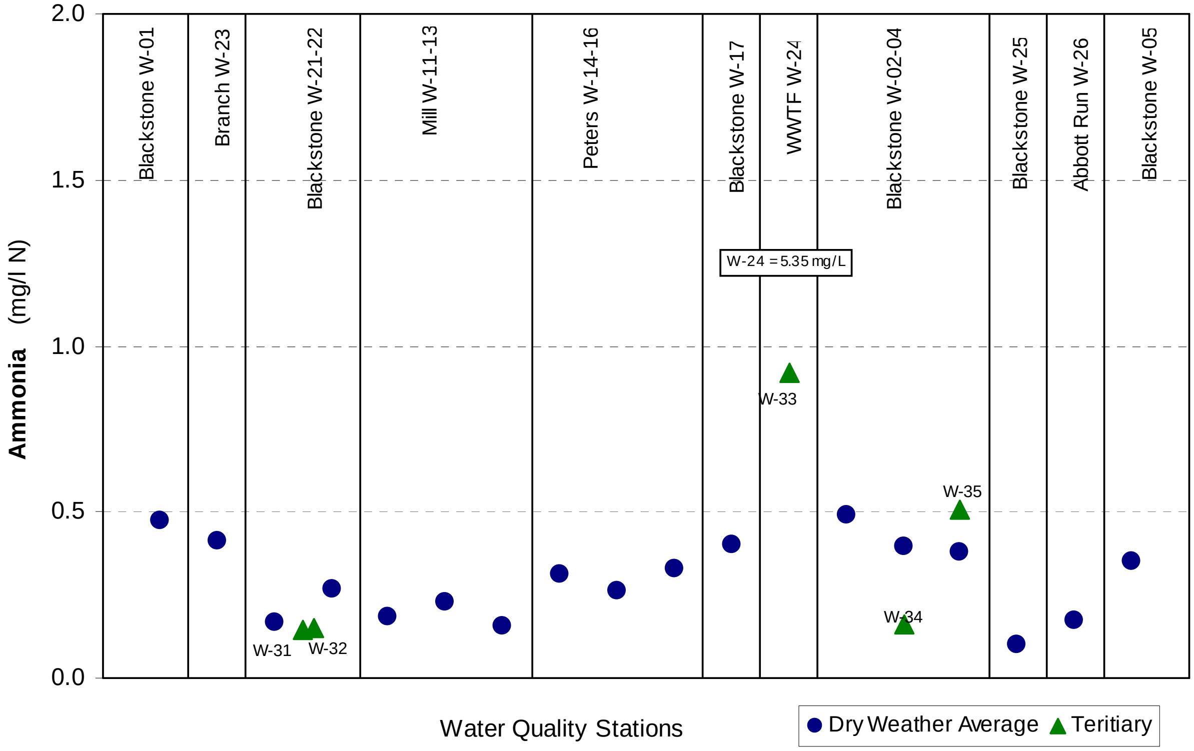


Figure 3-27: Dry Weather - Mean Ammonia Concentrations (upstream to downstream)

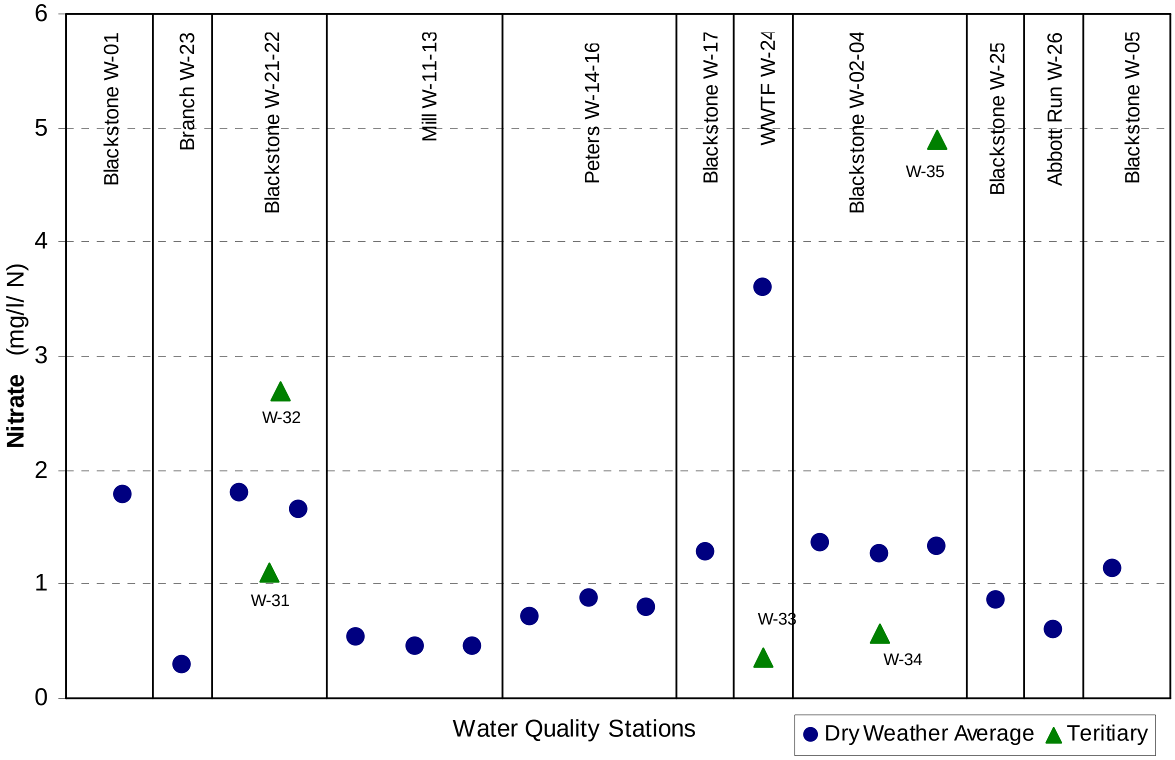


Figure 3-28: Dry Weather - Mean Nitrate Concentrations (upstream to downstream)

Figure 3-29: Dry Weather Concentrations and Mass Loads - Rankings for Total Phosphorus

Concentration

Station No.	Blackstone River	Tributary	WWTF/outfall/other	Location	Mean mg/l P
W-24			●	Woonsocket WWTF	1.21
W-23		●		Branch River	0.97
W-35			●	Brook near Ann&Hope	0.47
W-22	●			Below Thundermist Dam	0.41
W-01	●			Millville *(**MA/RI** border)*	0.38
W-02	●			Manville Dam	0.34
W-17	●			Hamlet Avenue	0.32
W-03	●			George Washington Hwy Bridge	0.32
W-04	●			Lonsdale Ave	0.29
W-21	●			Singleton Street	0.28
W-05	●			Slaters Mill Dam	0.27
W-15		●		Peters River (pre-culvert entry)	0.19
W-14		●		Peters River *(**MA/RI** border)*	0.19
W-13		●		Mill River (confluence w/ BR)	0.17
W-12		●		Mill River (pre-culvert entry)	0.16
W-34			●	Blackstone Canal at Lonsdale	0.16
W-11		●		Mill River *(**MA/RI** border)*	0.15
W-16		●		Peters River (confluence w/ BR)	0.15
W-26		●		Abbott Run Brook	0.15
W-31			●	Cherry Brook	0.14
W-32			●	Front Street Drain	0.08
W-25	●			Broad Street	0.07
W-33			●	Sylvestre Pond Outflow	0.06

Mass Loading *(Events DW-7, 9, 11)*

Station No.	Blackstone River	Tributary	WWTF/outfall/other	Location	Mean lbs/day P
W-03	●			George Washington Hwy Bridge	301
W-01	●			Millville *(**MA/RI** border)*	269
W-02	●			Manville Dam	269
W-22	●			Below Thundermist Dam	260
W-05	●			Slaters Mill Dam	245
W-23		●		Branch River	193
W-17	●			Hamlet Avenue	188
W-21	●			Singleton Street	186
W-04	●			Lonsdale Ave	186
W-25	●			Broad Street	72
W-24			●	Woonsocket WWTF	67
W-26		●		Abbott Run Brook	26
W-11		●		Mill River *(**MA/RI** border)*	5.9
W-13		●		Mill River (confluence w/ BR)	4.7
W-12		●		Mill River (pre-culvert entry)	3.4
W-15		●		Peters River (pre-culvert entry)	1.9
W-14		●		Peters River *(**MA/RI** border)*	1.2
W-35			●	Brook near Ann&Hope	0.8
W-16		●		Peters River (confluence w/ BR)	0.7
W-32			●	Front Street Drain	0.2
W-31			●	Cherry Brook	0.2
W-33			●	Sylvestre Pond Outflow	0.2
W-34			●	Blackstone Canal at Lonsdale	0.1

Figure 3-30: Dry Weather Concentrations and Mass Loads - Rankings for Ammonia

Concentration					
Station No.	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location**	**Mean** mg/l N
W-24			●	Woonsocket WWTF	5.35
W-33			●	Sylvestre Pond Outflow	0.92
W-35			●	Brook near Ann&Hope	0.51
W-02	●			Manville Dam	0.49
W-01	●			Millville (*MA/RI* border)	0.48
W-23		●		Branch River	0.41
W-17	●			Hamlet Avenue	0.40
W-03	●			George Washington Hwy Bridge	0.39
W-04	●			Lonsdale Ave	0.38
W-05	●			Slaters Mill Dam	0.35
W-16		●		Peters River (confluence w/ BR)	0.33
W-14		●		Peters River (*MA/RI* border)	0.31
W-22	●			Below Thundermist Dam	0.27
W-15		●		Peters River (pre-culvert entry)	0.26
W-12		●		Mill River (pre-culvert entry)	0.23
W-11		●		Mill River (*MA/RI* border)	0.19
W-26		●		Abbott Run Brook	0.17
W-21	●			Singleton Street	0.17
W-34			●	Blackstone Canal at Lonsdale	0.16
W-13		●		Mill River (confluence w/ BR)	0.16
W-32			●	Front Street Drain	0.15
W-31			●	Cherry Brook	0.14
W-25	●			Broad Street	0.10

Mass Loading *(Events DW-7, 9, 11)*					
Station No.	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location**	**Mean** lbs/day N
W-02	●			Manville Dam	441
W-03	●			George Washington Hwy Bridge	335
W-24			●	Woonsocket WWTF	293
W-01	●			Millville *(MA/RI border)*	252
W-05	●			Slaters Mill Dam	222
W-04	●			Lonsdale Ave	216
W-22	●			Below Thundermist Dam	169
W-17	●			Hamlet Avenue	161
W-21	●			Singleton Street	96
W-25	●			Broad Street	86
W-23		●		Branch River	36
W-26		●		Abbott Run Brook	31
W-12		●		Mill River (pre-culvert entry)	7.3
W-11		●		Mill River *(MA/RI border)*	5.4
W-14		●		Peters River *(MA/RI border)*	4.5
W-13		●		Mill River (confluence w/ BR)	3.7
W-16		●		Peters River (confluence w/ BR)	3.1
W-33			●	Sylvestre Pond Outflow	2.6
W-15		●		Peters River (pre-culvert entry)	2.5
W-35			●	Brook near Ann&Hope	0.9
W-32			●	Front Street Drain	0.5
W-31			●	Cherry Brook	0.3
W-34			●	Blackstone Canal at Lonsdale	0.1

Figure 3-31: Dry Weather Concentrations and Mass Loads - Rankings for Nitrate

Concentration					
Station No.	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location**	**Mean** mg/l N
W-35			●	Brook near Ann&Hope	4.90
W-24			●	Woonsocket WWTF	3.60
W-32			●	Front Street Drain	2.70
W-21	●			Singleton Street	1.80
W-01	●			Millville *(**MA/RI** border)*	1.78
W-22	●			Below Thundermist Dam	1.65
W-02	●			Manville Dam	1.36
W-04	●			Lonsdale Ave	1.33
W-17	●			Hamlet Avenue	1.28
W-03	●			George Washington Hwy Bridge	1.26
W-05	●			Slaters Mill Dam	1.13
W-31			●	Cherry Brook	1.11
W-15		●		Peters River (pre-culvert entry)	0.87
W-25	●			Broad Street	0.85
W-16		●		Peters River (confluence w/ BR)	0.80
W-14		●		Peters River *(**MA/RI** border)*	0.71
W-26		●		Abbott Run Brook	0.59
W-34			●	Blackstone Canal at Lonsdale	0.57
W-11		●		Mill River *(**MA/RI** border)*	0.53
W-13		●		Mill River (confluence w/ BR)	0.46
W-12		●		Mill River (pre-culvert entry)	0.46
W-33			●	Sylvestre Pond Outflow	0.35
W-23		●		Branch River	0.29

Mass Loading *(Events DW-7, 9, 11)*					
Station No.	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location**	**Mean** lbs/day N
W-01	●			Millville *(**MA/RI** border)*	1,400
W-02	●			Manville Dam	1,306
W-04	●			Lonsdale Ave	1,261
W-05	●			Slaters Mill Dam	1,211
W-21	●			Singleton Street	1,125
W-03	●			George Washington Hwy Bridge	1,115
W-17	●			Hamlet Avenue	1,099
W-22	●			Below Thundermist Dam	1,031
W-25	●			Broad Street	727
W-24			●	Woonsocket WWTF	208
W-26		●		Abbott Run Brook	105
W-23		●		Branch River	30
W-13		●		Mill River (confluence w/ BR)	20
W-12		●		Mill River (pre-culvert entry)	20
W-15		●		Peters River (pre-culvert entry)	12
W-14		●		Peters River *(**MA/RI** border)*	11
W-35			●	Brook near Ann&Hope	10
W-16		●		Peters River (confluence w/ BR)	10
W-11		●		Mill River *(**MA/RI** border)*	8.1
W-32			●	Front Street Drain	6.9
W-31			●	Cherry Brook	1.1
W-33			●	Sylvestre Pond Outflow	0.8
W-34			●	Blackstone Canal at Lonsdale	0.3

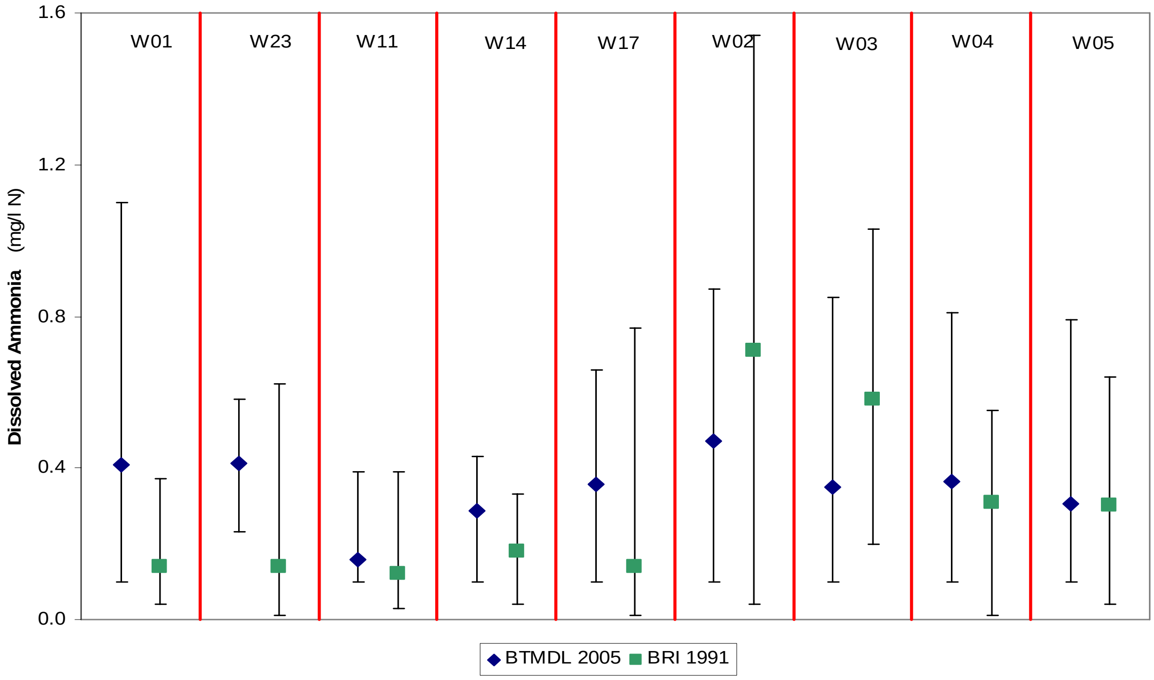


Figure 3-32: Dry Weather Ammonia Concentrations - Comparison between BTMDL (2005) and BRI (1991)

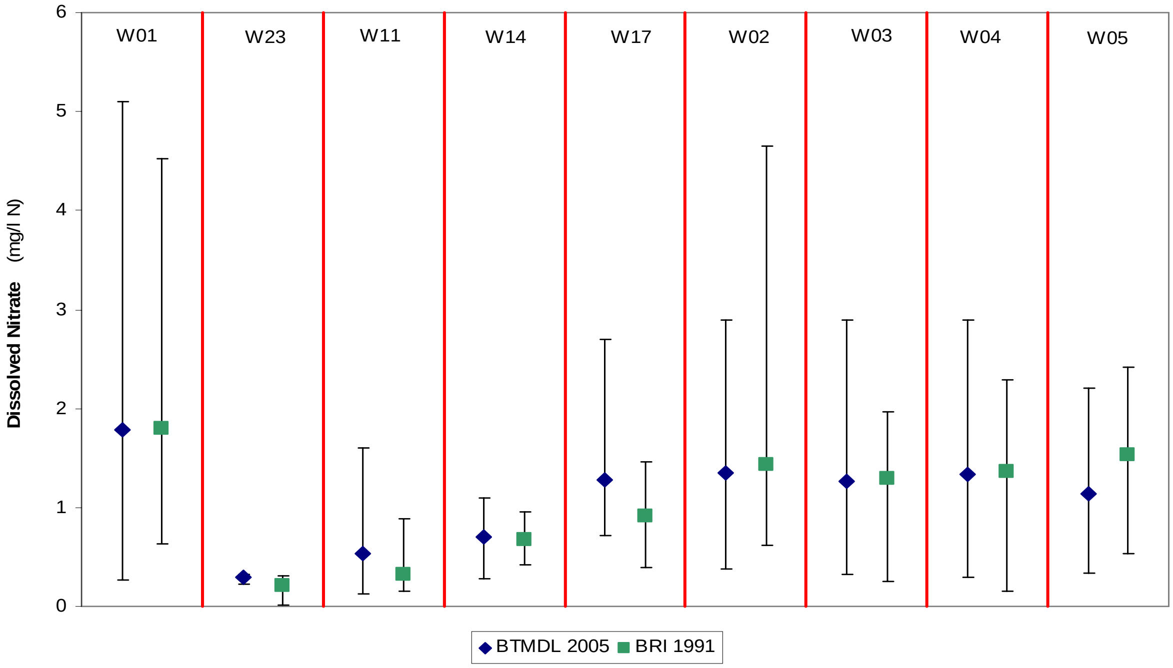


Figure 3-33: Dry Weather Nitrate Concentrations - Comparison between BTMDL (2005) and BRI (1991)

Figure 3-34: Dry Weather Concentrations - Chlorophyll *a*

Station No.	Reach			Blackstone River	Tributary	WWTF/outfall/other	Location	Concentration (ug/l)																		Statistics				
								16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05	3-Aug-05	11-Aug-05	25-Aug-05	14-Sep-05	26-Sep-05	7-Oct-05	22-Oct-05	29-Nov-05	22-Dec-05	27-Jan-06	17-Feb-06	Mean	Standard Deviation	Minimum	Maximum	Count
							Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18					
W-01	Reach 1			●			Millville (***MA/RI*** *border)*	7.41	10.89	5.07	6.40	3.02	66.66	68.85	16.26	23.30	16.73	0.43	0.53	7.20	0.47	1.00	1.50	30.79	1.58	**14.89**	21.05	0.43	68.85	18
W-23					●		Branch River																							
W-21				●			Singleton Street																							
W-22				●			Below Thundermist Dam																							
W-11					●		Mill River (***MA/RI*** *border)*																							
W-12					●		Mill River (pre-culvert entry)																							
W-13					●		Mill River (confluence w/ BR)																							
W-14					●		Peters River (***MA/RI*** *border)*																							
W-15					●		Peters River (pre-culvert entry)																							
W-16					●		Peters River (confluence w/ BR)																							
W-17				●			Hamlet Avenue																							
W-24						●	Woonsocket WWTF																							
W-02		Reach 2		●			Manville Dam	5.5	10.1	4.5	3.9	4.3	44.1	37.4	108.9	135.2	24.6	0.4	0.7	5.3	0.5	0.8	8.2	1.6	1.0	**22.0**	38.8	0.36	135.2	18
W-03				●			George Washington Hwy Bridge	6.4	7.4	4.7	4.9	7.6	37.8	20.6	111.7	61.1	10.1	0.3	0.2	5.8	0.5	0.9	2.1	1.5	1.3	**15.8**	28.6	0.20	111.7	18
W-04			Reach 3	●			Lonsdale Ave	8.5	8.7	5.2	6.5	9.3	40.9	46.0	137.0	40.6	9.0	0.5	0.4	3.4	0.5	1.5	1.5	1.5	1.2	**17.9**	33.3	0.40	137.0	18
W-25				●			Broad Street																							
W-26					●		Abbott Run Brook																							
W-05				●			Slaters Mill Dam	8.8	9.0	4.8	7.4	10.5	1.8	45.3	106.9	43.2	10.9	0.7	1.1	4.3	0.4	0.8	1.4	2.5	1.9	**14.5**	26.6	0.36	106.9	18
W-31	1					●	Cherry Brook																							
W-32						●	Front Street Drain																							
W-33						●	Sylvestre Pond Outflow																							
W-34		2				●	Blackstone Canal at Lonsdale																							
W-35			3			●	Brook near Ann&Hope																							
W-02	1	2		(=W-02)			Duplicate		10.3	5.2	3.4	4.8	41.4																	
W-05			3	(=W-05)			Duplicate	7.7				10.5																		
W-01	1			(=W-01)			Duplicate	8.5																						
W-41				(=W-11)			Duplicate																							
W-42				(=W-14)			Duplicate																							
W-43		2	3	(=W-04)			Duplicate							45.2	114.5	40.7	8.1	0.6	1.0	7.5	0.6	1.1	1.0	1.5	1.8					

Water Quality Criteria (Class B and B1): None.
Reporting Limit: n/a; Method Detection Limit: 0.05 mg/l

Figure 3-35: Dry Weather Concentrations - Pheophytin a

Station No.	Reach			Blackstone River	Tributary	WWTF/outfall/other	Location	Concentration (ug/l)																		Statistics				
								16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05	3-Aug-05	11-Aug-05	25-Aug-05	14-Sep-05	26-Sep-05	7-Oct-05	22-Oct-05	29-Nov-05	22-Dec-05	27-Jan-06	17-Feb-06	Mean	Standard Deviation	Minimum	Maximum	Count
							Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18					
W-01	Reach 1			●			Millville (***MA/RI*** *border)*	<0.05	<0.05	1.50	2.87	0.96	<0.05	<0.05	28.53	0.14	5.29	2.61	2.30	3.48	1.21	0.88	0.29	11.47	0.63	**4.44**	7.52	<0.05	28.53	14
W-23					●		Branch River																							
W-21				●			Singleton Street																							
W-22				●			Below Thundermist Dam																							
W-11					●		Mill River (***MA/RI*** *border)*																							
W-12					●		Mill River (pre-culvert entry)																							
W-13					●		Mill River (confluence w/ BR)																							
W-14					●		Peters River (***MA/RI*** *border)*																							
W-15					●		Peters River (pre-culvert entry)																							
W-16					●		Peters River (confluence w/ BR)																							
W-17				●			Hamlet Avenue																							
W-24						●	Woonsocket WWTF																							
W-02		Reach 2		●			Manville Dam	<0.05	<0.05	1.50	0.76	1.50	<0.05	<0.05	2.40	<0.05	3.99	4.63	1.75	1.51	0.98	1.04	<0.05	0.17	0.78	**1.75**	1.33	<0.05	4.63	12
W-03				●			George Washington Hwy Bridge	<0.05	0.92	1.68	1.72	0.74	6.73	3.00	<0.05	8.35	3.14	4.09	2.76	3.94	1.77	0.47	0.28	0.13	0.57	**2.52**	2.36	<0.05	8.35	16
W-04			Reach 3	●			Lonsdale Ave	<0.05	0.47	0.50	2.50	0.88	<0.05	<0.05	<0.05	5.84	4.30	3.83	2.28	1.43	1.14	0.95	0.30	0.29	0.33	**1.79**	1.75	<0.05	5.84	14
W-25				●			Broad Street																							
W-26					●		Abbott Run Brook																							
W-05				●			Slaters Mill Dam	<0.05	0.49	1.61	2.01	0.37	0.39	<0.05	0.41	0.24	4.46	6.10	2.87	2.02	1.09	0.67	0.31	<0.05	0.69	**1.58**	1.72	0.24	6.10	15
W-31	1					●	Cherry Brook																							
W-32						●	Front Street Drain																							
W-33						●	Sylvestre Pond Outflow																							
W-34		2				●	Blackstone Canal at Lonsdale																							
W-35			3			●	Brook near Ann&Hope																							
W-02	1	2		(=W-02)			Duplicate		<0.05	0.94	1.37	1.09	<0.05																	
W-05			3	(=W-05)			Duplicate	<0.05				1.27																		
W-01	1			(=W-01)			Duplicate																							
W-41				(=W-11)			Duplicate																							
W-42				(=W-14)			Duplicate																							
W-43		2	3	(=W-04)			Duplicate							<0.05	2.88	3.42	2.30	3.50	2.72	2.73	1.40	0.63	0.23	0.15	0.12					

Water Quality Criteria (Class B and B1): None.

Reporting Limit: n/a; Method Detection Limit: 0.05 mg/l

Figure 3-36: Dry Weather Concentrations - Ratio Chlorophyll a / (Chlorophyll a + Pheophytin a)

Station No.	Reach			Blackstone River	Tributary	WWTF/outfall/other	Location	Ratio Chlorophyll a / (Chlorophyll a + Pheophytin a)																		Statistics				
								16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05	3-Aug-05	11-Aug-05	25-Aug-05	14-Sep-05	26-Sep-05	7-Oct-05	22-Oct-05	29-Nov-05	22-Dec-05	27-Jan-06	17-Feb-06	Mean	Standard Deviation	Minimum	Maximum	Count
							Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18					
W-01	Reach 1			●			Millville (***MA/RI*** *border)*	1.00	1.00	0.77	0.69	0.76	1.00	1.00	0.36	0.99	0.76	0.14	0.19	0.67	0.28	0.53	0.84	0.73	0.71	**0.69**	0.28	0.14	1.00	18
W-23					●		Branch River																							
W-21				●			Singleton Street																							
W-22				●			Below Thundermist Dam																							
W-11					●		Mill River (***MA/RI*** *border)*																							
W-12					●		Mill River (pre-culvert entry)																							
W-13					●		Mill River (confluence w/ BR)																							
W-14					●		Peters River (***MA/RI*** *border)*																							
W-15					●		Peters River (pre-culvert entry)																							
W-16					●		Peters River (confluence w/ BR)																							
W-17				●			Hamlet Avenue																							
W-24						●	Woonsocket WWTF																							
W-02		Reach 2		●			Manville Dam	1.00	1.00	0.75	0.84	0.74	1.00	1.00	0.98	1.00	0.86	0.07	0.29	0.78	0.33	0.42	1.00	0.90	0.56	**0.75**	0.29	0.07	1.00	18
W-03				●			George Washington Hwy Bridge	1.00	0.89	0.74	0.74	0.91	0.85	0.87	1.00	0.88	0.76	0.06	0.07	0.59	0.23	0.66	0.88	0.92	0.69	**0.71**	0.29	0.06	1.00	18
W-04			Reach 3	●			Lonsdale Ave	1.00	0.95	0.91	0.72	0.91	1.00	1.00	1.00	0.87	0.68	0.12	0.15	0.70	0.28	0.60	0.83	0.84	0.79	**0.74**	0.29	0.12	1.00	18
W-25				●			Broad Street																							
W-26					●		Abbott Run Brook																							
W-05				●			Slaters Mill Dam	1.00	0.95	0.75	0.79	0.97	0.82	1.00	1.00	0.99	0.71	0.11	0.28	0.68	0.25	0.55	0.82	0.99	0.74	**0.74**	0.28	0.11	1.00	18
W-31	1					●	Cherry Brook																							
W-32						●	Front Street Drain																							
W-33						●	Sylvestre Pond Outflow																							
W-34		2				●	Blackstone Canal at Lonsdale																							
W-35			3			●	Brook near Ann&Hope																							
W-02	1	2		(=W-02)			Duplicate		1.00	0.85	0.71	0.82	1.00																	
W-05			3	(=W-05)			Duplicate	1.00				0.89																		
W-01	1			(=W-01)			Duplicate	1.00																						
W-41				(=W-11)			Duplicate																							
W-42				(=W-14)			Duplicate																							
W-43		2	3	(=W-04)			Duplicate							1.00	0.98	0.92	0.78	0.14	0.27	0.73	0.28	0.63	0.82	0.91	0.94					

Figure 3-37: Dry Weather Concentrations - Total Suspended Solids

Station No.	Reach			Blackstone River	Tributary	WWTF/outfall/other	Location	Concentration (mg/l)																		Statistics				
								16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05	3-Aug-05	11-Aug-05	25-Aug-05	14-Sep-05	26-Sep-05	7-Oct-05	22-Oct-05	29-Nov-05	22-Dec-05	27-Jan-06	17-Feb-06	Mean	Standard Deviation	Minimum	Maximum	Count
							Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18					
W-01	Reach 1			●			Millville *(**MA/RI** border)*	3.3	3.1	5.9	5.5	7.8	3.9	11.1	5.5	4.4	8.3	3.5	5.0	3.6	8.3	3.8	3.1	2.7	3.4	**5.1**	2.4	2.7	11.1	18
W-23					●		Branch River							1.4		1.3		2.0		1.2						**1.5**	0.4	1.2	2.0	4
W-21				●			Singleton Street							9.9		6.6		4.2								**6.9**	2.9	4.2	9.9	3
W-22				●			Below Thundermist Dam							7.6		7.8		4.4								**6.6**	1.9	4.4	7.8	3
W-11					●		Mill River *(**MA/RI** border)*	2.0				3.1		2.3		3.6		3.3		1.6	2.5		1.9			**2.5**	0.7	1.6	3.6	8
W-12					●		Mill River (pre-culvert entry)	2.0				3.2		5.1		3.2		8.7		2.2	2.6		2.3			**3.7**	2.3	2.0	8.7	8
W-13					●		Mill River (confluence w/ BR)	2.4						2.9		3.9		2.6		2.1	5.1		1.9			**3.0**	1.1	1.9	5.1	7
W-14					●		Peters River *(**MA/RI** border)*	2.4				5.2		3.2		5.2		5.0		2.2	1.9		1.4			**3.3**	1.6	1.4	5.2	8
W-15					●		Peters River (pre-culvert entry)	6.4				4.1		4.5		2.4		7.3		0.8	2.0		1.5			**3.6**	2.3	0.8	7.3	8
W-16					●		Peters River (confluence w/ BR)	2.2						6.4		6.2		3.3		1.4						**3.9**	2.3	1.4	6.4	5
W-17				●			Hamlet Avenue	4.3				3.8				8.7		4.7								**5.4**	2.2	3.8	8.7	4
W-24						●	Woonsocket WWTF							3.8				8.1					2.6			**4.8**	2.9	2.6	8.1	3
W-02		Reach 2		●			Manville Dam	1.7	2.0	4.6	5.8	7.1	4.3	7.9	14.3	13.4	6.5	4.9	5.6	2.4	6.2	3.5	8.3	3.0	3.6	**5.8**	3.5	1.7	14.3	18
W-03				●			George Washington Hwy Bridge	2.6	2.1	3.0	4.6	5.7	4.1	7.8	12.8	5.6	3.6	3.4	9.9	3.9	7.1	2.2	2.3	2.8	3.0	**4.8**	2.9	2.1	12.8	18
W-04			Reach 3	●			Lonsdale Ave	1.4	1.9	2.5	4.4	5.4	4.2	8.8	14.9	6.8	5.0	3.5	4.5	2.8	7.0	3.1	2.9	2.9	2.6	**4.7**	3.2	1.4	14.9	18
W-25				●			Broad Street							9.2		1.1		8.1								**6.1**	4.4	1.1	9.2	3
W-26					●		Abbott Run Brook							2.2		6.7		1.5								**3.5**	2.8	1.5	6.7	3
W-05				●			Slaters Mill Dam	3.1	2.3	4.5	4.3	6.0	4.5	6.6	11.5	6.0	4.3	6.5	4.7	2.7	6.1	6.8	2.1	4.3	4.1	**5.0**	2.2	2.1	11.5	18
W-31	1					●	Cherry Brook							6.10		12.07		18.57								**12.2**	6.2	6.1	18.6	3
W-32						●	Front Street Drain							9.80		0.43		1.03								**3.8**	5.2	0.4	9.8	3
W-33						●	Sylvestre Pond Outflow							6.60		6.57		13.03								**8.7**	3.7	6.6	13.0	3
W-34		2				●	Blackstone Canal at Lonsdale							1.00		7.00										**4.0**	4.2	1.0	7.0	2
W-35			3			●	Brook near Ann&Hope															1.7	1.4	1.4	11.8	**4.1**	5.1	1.4	11.8	4
W-02	1	2		(=W-02)			Duplicate		2.6	2.1	4.7	7.1	4.8																	
W-05			3	(=W-05)			Duplicate	2.2				6.2																		
W-01	1			(=W-01)			Duplicate	2.0																						
W-41				(=W-11)			Duplicate							2.4		3.4		4.1			3.4		1.9							
W-42				(=W-14)			Duplicate							3.3		3.7		4.1		1.9	2.2									
W-43		2	3	(=W-04)			Duplicate							6.9	14.8	7.6	3.3	4.1	5.8	2.3	6.8	3.0	2.5	2.9	3.4					

Water Quality Criteria (Class B and B1): None.

Figure 3-38: Dry Weather Concentrations - Volatile Suspended Solids

Station No.	Reach			Blackstone River	Tributary	WWTF/outfall/other	Location	Concentration (mg/l)																		Statistics				
								16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05	3-Aug-05	11-Aug-05	25-Aug-05	14-Sep-05	26-Sep-05	7-Oct-05	22-Oct-05	29-Nov-05	22-Dec-05	27-Jan-06	17-Feb-06	Mean	Standard Deviation	Minimum	Maximum	Count
							Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18					
W-01	Reach 1			●			Millville *(**MA/RI** border)*	1.1	1.4	3.1	2.6	3.4	2.4	5.2	3.3	2.5	3.5	1.5	1.6	1.6	2.7	1.8	1.0	1.1	1.7	**2.3**	1.1	1.0	5.2	18
W-23					●		Branch River							0.7		0.7		1.4		0.5						**0.8**	0.4	0.5	1.4	4
W-21				●			Singleton Street							4.6		3.6		2.1								**3.4**	1.3	2.1	4.6	3
W-22				●			Below Thundermist Dam							3.5		4.3		2.2								**3.3**	1.1	2.2	4.3	3
W-11					●		Mill River *(**MA/RI** border)*	0.8				0.6		1.3		2.0		2.3		1.3	1.3		0.6			**1.3**	0.6	0.6	2.3	8
W-12					●		Mill River (pre-culvert entry)	0.9				2.1		3.4		1.8		3.4		1.2	1.5		0.9			**1.9**	1.0	0.9	3.4	8
W-13					●		Mill River (confluence w/ BR)	0.8						1.2		2.3		1.4		1.4	2.7		0.6			**1.5**	0.8	0.6	2.7	7
W-14					●		Peters River *(**MA/RI** border)*	0.8				2.8		1.2		1.6		3.0		1.6	1.0		0.4			**1.6**	0.9	0.4	3.0	8
W-15					●		Peters River (pre-culvert entry)	2.5				2.3		1.7		1.3		1.4		1.4	1.1		0.2			**1.5**	0.7	0.2	2.5	8
W-16					●		Peters River (confluence w/ BR)	0.8						2.7		2.8		1.2		0.3						**1.6**	1.1	0.3	2.8	5
W-17				●			Hamlet Avenue	1.7				2.3				4.4		2.2		1.1			0.7			**2.1**	1.3	0.7	4.4	6
W-24						●	Woonsocket WWTF							1.3				3.0								**2.2**	1.2	1.3	3.0	2
W-02		Reach 2		●			Manville Dam	0.7	1.5	2.5	2.8	3.3	2.9	3.7	8.2	6.4	3.2	2.3	1.7	1.1	2.4	1.5	2.7	1.4	1.5	**2.8**	1.9	0.7	8.2	18
W-03				●			George Washington Hwy Bridge	1.0	1.3	2.1	2.6	3.2	2.7	3.6	8.1	3.2	1.9	1.4	5.9	1.8	2.4	1.3	0.9	1.5	1.4	**2.6**	1.8	0.9	8.1	18
W-04			Reach 3	●			Lonsdale Ave	0.7	1.0	1.8	2.6	2.8	2.4	3.8	8.5	3.7	2.1	1.3	1.3	1.6	2.5	1.6	0.9	1.4	1.4	**2.3**	1.8	0.7	8.5	18
W-25				●			Broad Street							3.5		0.4		5.0								**2.9**	2.3	0.4	5.0	3
W-26					●		Abbott Run Brook							1.1		3.7		0.9								**1.9**	1.6	0.9	3.7	3
W-05				●			Slaters Mill Dam	1.0	1.2	2.7	2.6	3.5	2.5	2.8	7.0	3.2	2.4	3.0	1.5	1.3	2.6	6.8	0.5	1.7	2.0	**2.7**	1.7	0.5	7.0	18
W-31	1					●	Cherry Brook							2.5		3.8		5.4								**3.9**	1.4	2.5	5.4	3
W-32						●	Front Street Drain							3.8		0.2		0.7								**1.6**	2.0	0.2	3.8	3
W-33						●	Sylvestre Pond Outflow							2.5		3.6		5.4								**3.8**	1.5	2.5	5.4	3
W-34		2				●	Blackstone Canal at Lonsdale							0.1		3.2										**1.7**	2.2	0.1	3.2	2
W-35			3			●	Brook near Ann&Hope															0.8	0.3	1.2	3.4	**1.4**	1.4	0.3	3.4	4
W-02	1	2		(=W-02)			Duplicate		1.3	1.7	2.8	3.2	3.0																	
W-05			3	(=W-05)			Duplicate	0.3				3.5																		
W-01	1			(=W-01)			Duplicate	0.5																						
W-41				(=W-11)			Duplicate							0.9		2.2		3.5			1.7		0.1							
W-42				(=W-14)			Duplicate							1.1		2.2		2.4		1.4	1.1									
W-43		2	3	(=W-04)			Duplicate							2.6	8.5	4.0	1.7	2.3	1.5	1.7	2.6	1.3	1.0	1.7	1.5					

Water Quality Criteria (Class B and B1): None.

Figure 3-39: Dry Weather Loads - Total Suspended Solids

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Location	Load (lbs/day)																		Statistics	
						16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05	3-Aug-05	11-Aug-05	25-Aug-05	14-Sep-05	26-Sep-05	7-Oct-05	22-0ct-05	29-Nov-05	22-Dec-05	27-Jan-06	17-Feb-06	Mean (DW-7, 9, and 11)	Count
					Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
W-01	Reach 1	●			Millville (MA/RI border)	10,977	9,573	24,727	12,586	13,978	3,078	10,009	2,740	2,208	4,101	1,167	2,907	2,032	71,455	17,555	10,532	13,904	18,643	4,461	3
W-23			●		Branch River							328		90		105		86						174	3
W-21		●			Singleton Street							11,538		3,794		1,613								5,648	3
W-22		●			Below Thundermist Dam							8,857		4,512		1,692								5,021	3
W-11			●		Mill River (MA/RI border)	783				506		134		104		67		93	1,186		550			101	3
W-12			●		Mill River (pre-culvert entry)	809				531		307		94		182		131	1,220		686			194	3
W-13			●		Mill River (confluence w/ BR)	966						178		112		55		124	2,409		549			115	3
W-14			●		Peters River (MA/RI border)	339				517		67		22		67		45	496		200			52	3
W-15			●		Peters River (pre-culvert entry)	911				428		96		12		102		16	545		226			70	3
W-16			●		Peters River (confluence w/ BR)	323						138		30		47		29						72	3
W-17		●			Hamlet Avenue	22,548				9,661				5,363		1,915								3,639	3
W-24				●	Woonsocket WWTF							231				428					3			330	3
W-02	Reach 2	●			Manville Dam	9,398	9,700	31,291	19,875	18,384	5,178	10,781	10,162	9,255	4,494	2,311	4,315	1,922	77,623	26,652	44,287	26,523	33,671	7,449	3
W-03		●			George Washington Hwy Bridge	14,862	10,403	21,015	16,193	14,929	4,998	10,788	9,196	3,967	2,502	1,594	7,755	3,212	90,613	17,398	12,797	25,722	28,845	5,449	3
W-04	Reach 3	●			Lonsdale Ave	8,088	9,405	17,751	15,862	14,264	5,224	12,257	10,798	4,787	3,524	1,641	3,510	2,316	89,905	24,732	16,092	26,542	24,602	6,228	3
W-25		●			Broad Street							12,856		780		3,846								5,828	3
W-26			●		Abbott Run Brook							325		1,300		256								627	3
W-05		●			Slaters Mill Dam	19,261	12,532	34,153	16,382	17,381	6,531	10,218	10,802	5,450	4,130	4,143	4,489	2,644	80,066	58,065	12,711	41,831	41,390	6,603	3
W-31	1			●	Cherry Brook							19.7		13.0		3.0								11.9	3
W-32				●	Front Street Drain							52.7		0.9		0.2								18.0	3
W-33				●	Sylvestre Pond Outflow							24.9		10.6		21.0								18.8	3
W-34	2			●	Blackstone Canal at Lonsdale							0.7		3.0										1.9	2
W-35	3			●	Brook near Ann&Hope															6.9	1.7	2.6	20.9	8.0	4

▨ Sampling events used for statistics.

Figure 3-40: Dry Weather Loads - Volatile Suspended Solids

						Load (lbs/day)																		**Statistics**	
Station No.	**Reach**	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location**	**16-Mar-05**	**20-Apr-05**	**11-May-05**	**23-May-05**	**9-Jun-05**	**27-Jun-05**	**21-Jul-05**	**3-Aug-05**	**11-Aug-05**	**25-Aug-05**	**14-Sep-05**	**26-Sep-05**	**7-Oct-05**	**22-Oct-05**	**29-Nov-05**	**22-Dec-05**	**27-Jan-06**	**17-Feb-06**	**Mean** *(DW-7, 9, and 11)*	**Count**
					Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
W-01	Reach 1	●			Millville *(MA/RI border)*	3,808	4,255	13,206	5,909	6,126	1,911	4,675	1,659	1,229	1,706	484	917	930	23,245	8,159	3,363	5,922	9,322	2,129	3
W-23			●		Branch River							164		50		76		36						97	3
W-21		●			Singleton Street							5,342		2,099		806								2,749	3
W-22		●			Below Thundermist Dam							4,058		2,479		833								2,457	3
W-11			●		Mill River *(MA/RI border)*	332				102		79		58		48		75	608		173			61	3
W-12			●		Mill River (pre-culvert entry)	350				339		205		53		72		70	713		265			110	3
W-13			●		Mill River (confluence w/ BR)	340						71		68		29		84	1,284		167			56	3
W-14			●		Peters River *(MA/RI border)*	116				283		24		7		42		32	252		57			24	3
W-15			●		Peters River (pre-culvert entry)	358				240		37		6		20		29	294		29			21	3
W-16			●		Peters River (confluence w/ BR)	111						58		13		17		7						30	3
W-17		●			Hamlet Avenue	8,707				5,712				5,602		1,383		466			3,701			3,493	3
W-24				●	Woonsocket WWTF							82				159								120	3
W-02	Reach 2	●			Manville Dam	4,052	7,107	17,006	9,648	8,497	3,479	5,073	5,841	4,454	2,235	1,085	1,287	920	29,465	11,788	14,355	12,670	14,208	3,537	3
W-03		●			George Washington Hwy Bridge	5,522	6,539	14,753	9,221	8,293	3,270	4,999	5,811	2,277	1,309	678	4,622	1,455	31,052	10,280	4,938	13,919	13,628	2,652	3
W-04	Reach 3	●			Lonsdale Ave	4,235	5,003	12,540	9,422	7,438	3,003	5,313	6,170	2,589	1,456	615	1,045	1,296	31,718	12,765	5,177	12,809	13,739	2,839	3
W-25		●			Broad Street							4,862		284		2,358								2,501	3
W-26			●		Abbott Run Brook							165		718		145								343	3
W-05		●			Slaters Mill Dam	6,418	6,482	20,747	10,111	10,179	3,649	4,334	6,566	2,860	2,257	1,900	1,422	1,240	33,686	58,065	2,777	16,859	20,257	3,031	3
W-31	1			●	Cherry Brook							8.1		4.1		0.9								4.3	3
W-32				●	Front Street Drain							20.6		0.5		0.2								7.1	3
W-33				●	Sylvestre Pond Outflow							9.4		5.8		0.9								5.4	3
W-34	2			●	Blackstone Canal at Lonsdale							0.1		1.4										0.7	2
W-35	3			●	Brook near Ann&Hope															3.1	0.4	2.3	6.1	2.9	4

▨ Sampling events used for statistics.

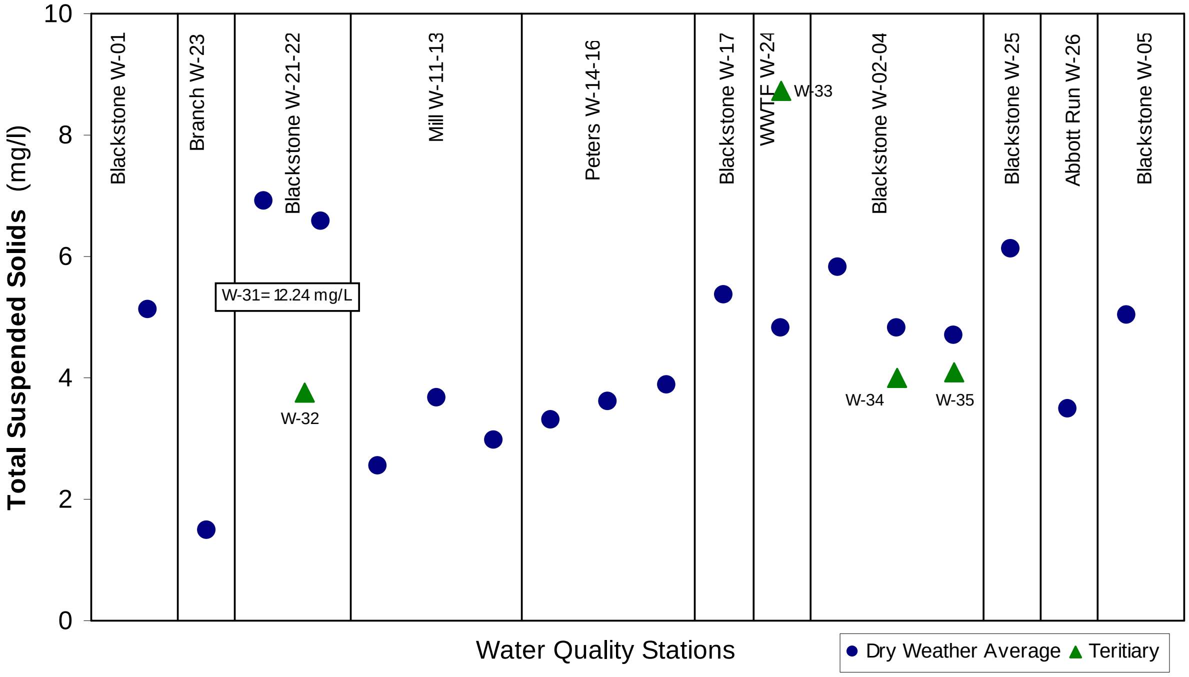


Figure 3-41: Dry Weather - Mean Total Suspended Solids Concentrations (upstream to downstream)

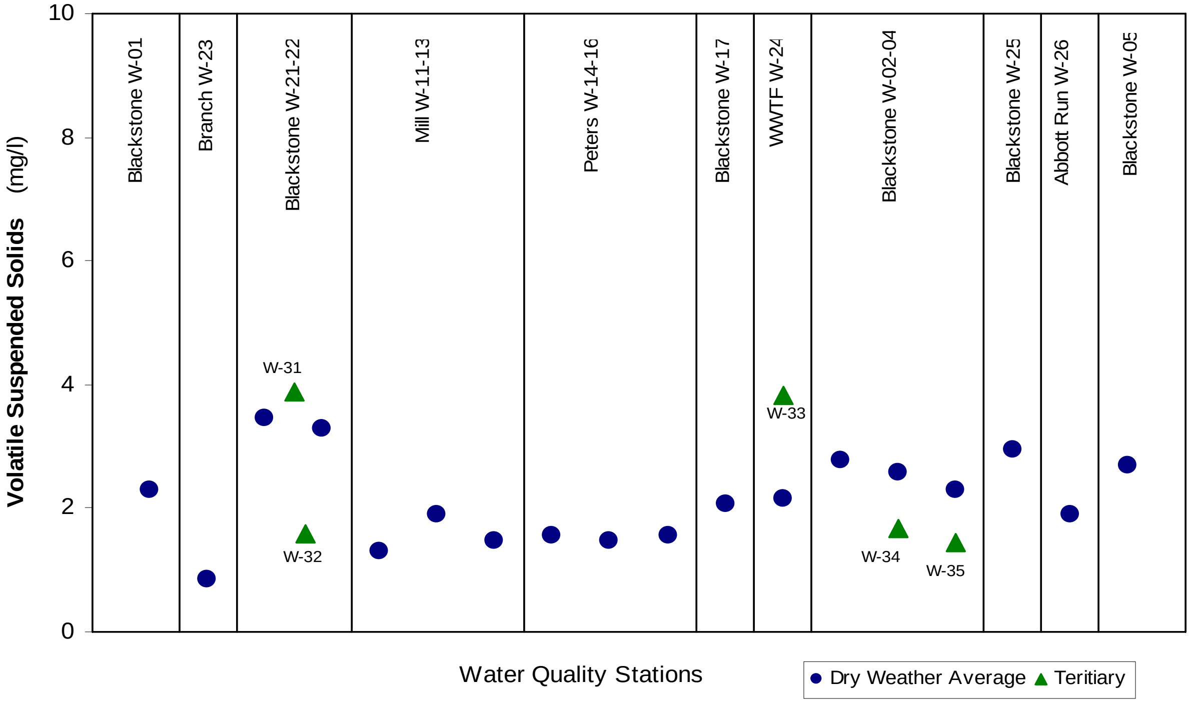


Figure 3-42: Dry Weather - Mean Volatile Suspended Solids Concentrations (upstream to downstream)

Figure 3-43: Dry Weather Concentrations and Mass Loads - Rankings for Total Suspended Solids

Concentration					
Station No.	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location**	**Mean**
					mg/l
W-31			●	Cherry Brook	12.24
W-33			●	Sylvestre Pond Outflow	8.73
W-21	●			Singleton Street	6.90
W-22	●			Below Thundermist Dam	6.58
W-25	●			Broad Street	6.10
W-02	●			Manville Dam	5.83
W-17	●			Hamlet Avenue	5.37
W-01	●			Millville *(**MA/RI** border)*	5.12
W-05	●			Slaters Mill Dam	5.03
W-24			●	Woonsocket WWTF	4.81
W-03	●			George Washington Hwy Bridge	4.80
W-04	●			Lonsdale Ave	4.70
W-35			●	Brook near Ann&Hope	4.08
W-34			●	Blackstone Canal at Lonsdale	4.00
W-16		●		Peters River (confluence w/ BR)	3.89
W-32			●	Front Street Drain	3.76
W-12		●		Mill River (pre-culvert entry)	3.66
W-15		●		Peters River (pre-culvert entry)	3.62
W-26		●		Abbott Run Brook	3.50
W-14		●		Peters River *(**MA/RI** border)*	3.31
W-13		●		Mill River (confluence w/ BR)	2.97
W-11		●		Mill River *(**MA/RI** border)*	2.53
W-23		●		Branch River	1.48

Mass Loading *(Events DW-7, 9, 11)*					
Station No.	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location**	**Mean**
					lbs/day
W-02	●			Manville Dam	7,449
W-05	●			Slaters Mill Dam	6,603
W-04	●			Lonsdale Ave	6,228
W-25	●			Broad Street	5,828
W-21	●			Singleton Street	5,648
W-03	●			George Washington Hwy Bridge	5,449
W-22	●			Below Thundermist Dam	5,021
W-01	●			Millville *(**MA/RI** border)*	4,461
W-17	●			Hamlet Avenue	3,639
W-26		●		Abbott Run Brook	627
W-24			●	Woonsocket WWTF	330
W-12		●		Mill River (pre-culvert entry)	194
W-23		●		Branch River	174
W-13		●		Mill River (confluence w/ BR)	115
W-11		●		Mill River *(**MA/RI** border)*	101
W-16		●		Peters River (confluence w/ BR)	72
W-15		●		Peters River (pre-culvert entry)	70
W-14		●		Peters River *(**MA/RI** border)*	52
W-33			●	Sylvestre Pond Outflow	19
W-32			●	Front Street Drain	18
W-31			●	Cherry Brook	12
W-35			●	Brook near Ann&Hope	8
W-34			●	Blackstone Canal at Lonsdale	2

Figure 3-44: Dry Weather Concentrations and Mass Loads - Rankings for Volatile Suspended Solids

Concentration					
Station No.	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location**	**Mean**
					mg/l
W-25	●			Broad Street	2.90
W-31			●	Cherry Brook	3.89
W-33			●	Sylvestre Pond Outflow	3.83
W-21	●			Singleton Street	3.44
W-22	●			Below Thundermist Dam	3.30
W-02	●			Manville Dam	2.77
W-05	●			Slaters Mill Dam	2.69
W-03	●			George Washington Hwy Bridge	2.57
W-04	●			Lonsdale Ave	2.31
W-01	●			Millville *(**MA/RI** border)*	2.30
W-24			●	Woonsocket WWTF	2.17
W-17	●			Hamlet Avenue	2.08
W-26		●		Abbott Run Brook	1.90
W-12		●		Mill River (pre-culvert entry)	1.90
W-34			●	Blackstone Canal at Lonsdale	1.67
W-32			●	Front Street Drain	1.59
W-16		●		Peters River (confluence w/ BR)	1.55
W-14		●		Peters River *(**MA/RI** border)*	1.55
W-15		●		Peters River (pre-culvert entry)	1.48
W-13		●		Mill River (confluence w/ BR)	1.48
W-35			●	Brook near Ann&Hope	1.43
W-11		●		Mill River *(**MA/RI** border)*	1.29
W-23		●		Branch River	0.84

Mass Loading *(Events DW-7, 9, 11)*					
Station No.	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location**	**Mean**
					lbs/day
W-02	●			Manville Dam	3,537
W-17	●			Hamlet Avenue	3,493
W-05	●			Slaters Mill Dam	3,031
W-04	●			Lonsdale Ave	2,839
W-21	●			Singleton Street	2,749
W-03	●			George Washington Hwy Bridge	2,652
W-25	●			Broad Street	2,501
W-22	●			Below Thundermist Dam	2,457
W-01	●			Millville *(**MA/RI** border)*	2,129
W-26		●		Abbott Run Brook	343
W-24			●	Woonsocket WWTF	120
W-12		●		Mill River (pre-culvert entry)	110
W-23		●		Branch River	97
W-11		●		Mill River *(**MA/RI** border)*	61
W-13		●		Mill River (confluence w/ BR)	56
W-16		●		Peters River (confluence w/ BR)	30
W-14		●		Peters River *(**MA/RI** border)*	24
W-15		●		Peters River (pre-culvert entry)	21
W-32			●	Front Street Drain	7
W-33			●	Sylvestre Pond Outflow	5
W-31			●	Cherry Brook	4
W-35			●	Brook near Ann&Hope	3
W-34			●	Blackstone Canal at Lonsdale	1

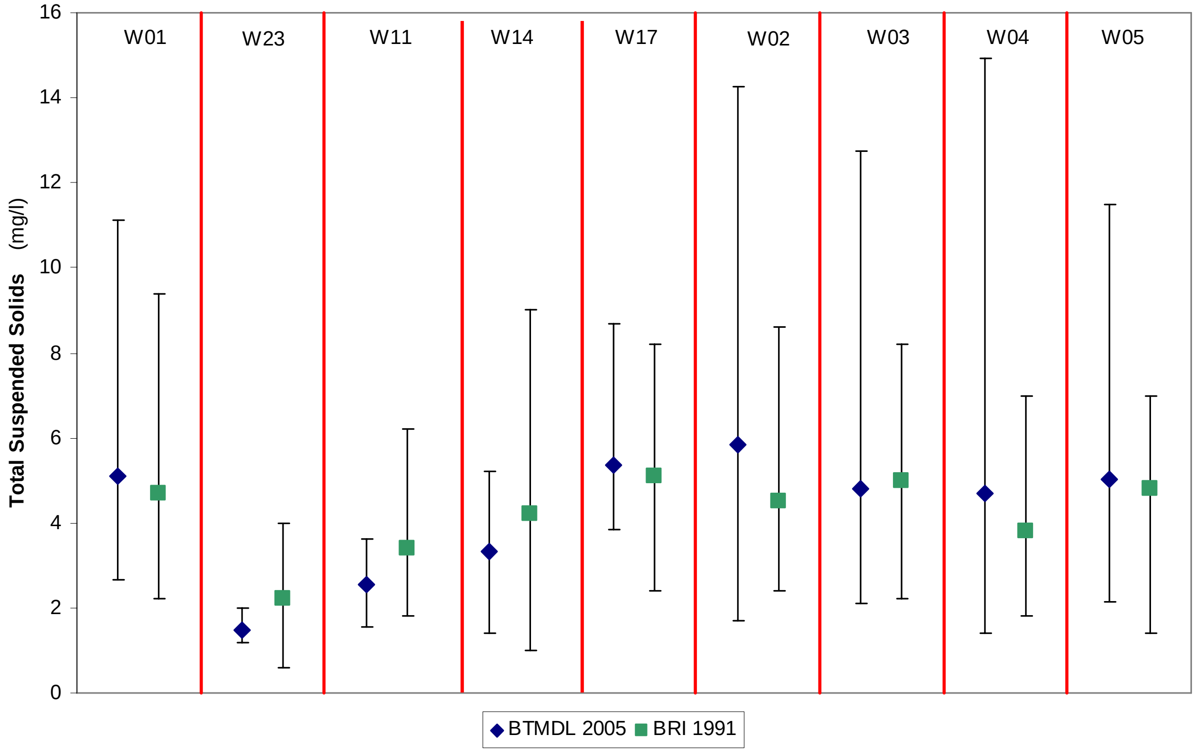


Figure 3-45: Dry Weather Total Suspended Solids Concentrations - Comparison between BTMDL (2005) and BRI (1991)

Figure 3-46: Dry Weather Concentrations - Dissolved Copper

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Location	Conc. (ug/l) - *Microinorganics*						Concentration (ug/l) - *STL and Microinorganics* (2)												Statistics (*Microinorg. & STL*)				
					Location **Event** No. (DW-__)	**16-Mar-05** 1	**20-Apr-05** 2	**11-May-05** 3	**23-May-05** 4	**9-Jun-05** 5	**27-Jun-05** 6	**21-Jul-05** 7	**3-Aug-05** 8	**11-Aug-05** 9	**25-Aug-05** 10	**14-Sep-05** 11	**26-Sep-05** 12	**7-Oct-05** 13	**22-Oct-05** 14	**29-Nov-05** 15	**22-Dec-05** 16	**27-Jan-06** 17	**17-Feb-06** 18	**Mean** *(3)*	**Standard Deviation** *(3)*	**Minimum**	**Maximum**	**Count**
W-01	Reach 1	●			Millville (***MA/RI*** *border)*		3.3	3.8	3.0			**7.1**	**7.6**	**7.5**	5.9	**10.0**	**7.5**	**8.1**	**5.4**	**4.0**	4.0	3.5	**5.0**	**5.7**	2.1	3.0	10.0	15
W-23			●		Branch River							2.0		1.3		1.1		1.6						**1.5**	0.4	1.1	2.0	4
W-21		●			Singleton Street							4.7		5.4		6.6								**5.6**	1.0	4.7	6.6	3
W-22		●			Below Thundermist Dam							5.1		5.5		6.3								**5.6**	0.6	5.1	6.3	3
W-11			●		Mill River (***MA/RI*** *border)*							2.1		1.2		1.3		1.5	2.6		2.6			**1.9**	0.6	1.2	2.6	6
W-12			●		Mill River (pre-culvert entry)							2.3		<1.0		1.6		1.9	2.9		2.6			**2.3**	0.5	<1.0	2.9	6
W-13			●		Mill River (confluence w/ BR)							2.5		1.2		1.6		3.8	2.9		2.3			**2.4**	0.9	1.2	3.8	6
W-14			●		Peters River (***MA/RI*** *border)*							1.6		<1.0		1.9		2.1	1.8		2.0			**1.9**	0.2	<1.0	2.1	6
W-15			●		Peters River (pre-culvert entry)							1.9		1.8		2.5		2.9	2.0		1.2			**2.1**	0.6	1.2	2.9	6
W-16			●		Peters River (confluence w/ BR)									1.5		2.0		2.1						**1.9**	0.3	1.5	2.1	3
W-17		●			Hamlet Avenue							4.1		5.1		6.6					3.3			**4.8**	1.4	3.3	6.6	4
W-24				●	Woonsocket WWTF							7.1				7.9								**7.5**	0.5	7.1	7.9	2
W-02	Reach 2	●			Manville Dam		2.3	2.4	2.3			4.2	5.6	5.5	**6.4**	**7.1**	5.6	6.0	**4.6**	3.1	3.0	2.8	4.0	**4.3**	1.6	2.3	7.1	15
W-03		●			George Washington Hwy Bridge		2.6	2.4	2.4			4.9	6.3	5.5	4.8	6.2	5.5	**8.9**	**4.8**	3.7	3.1	2.9	**4.7**	**4.6**	1.8	2.4	8.9	15
W-04	Reach 3	●			Lonsdale Ave		2.7	2.5	2.1			4.1	5.8	5.4	5.0	5.9	5.9	5.0	**4.8**	**4.0**	3.2	3.1	**4.9**	**4.3**	1.3	2.1	5.9	15
W-25		●			Broad Street							3.3		5.4		5.2								**4.6**	1.2	3.3	5.4	3
W-26			●		Abbott Run Brook							1.3		<1.0		<1.0								**1.3**		<1.0	1.3	3
W-05		●			Slaters Mill Dam		2.4	2.2	2.3			4.7	5.0	4.5	4.4	5.1	4.4	4.5	**4.9**	3.2	3.2	3.1	4.5	**3.9**	1.0	2.2	5.1	15
W-31	1			●	Cherry Brook							2.8		1.6		2.8								**2.4**	0.7	1.6	2.8	3
W-32				●	Front Street Drain							1.9		<1.0		1.5								**1.7**	0.3	<1.0	1.9	3
W-33				●	Sylvestre Pond Outflow							2.7		1.5		1.6								**1.9**	0.7	1.5	2.7	3
W-34	2			●	Blackstone Canal at Lonsdale							3.8		3.6										**3.7**	0.1	3.6	3.8	2
W-35	3			●	Brook near Ann&Hope															2.7	2.1	1.9	3.7	**2.6**	0.8	1.9	3.7	4
W-02	1 2	(=W-02)			Duplicate		2.1	2.3	2.3																			
W-05	3	(=W-05)			Duplicate																							
W-01	1	(=W-01)			Duplicate																							
W-41		(=W-11)			Duplicate							2.0		1.4		1.3			2.3		2.7							
W-42		(=W-14)			Duplicate							2.2		1.2		2.4		1.6	2.4									
W-43	2 3	(=W-04)			Duplicate							**4.4**	5.8	5.3	4.6	5.7	5.2	5.8	**4.8**	3.5	3.1		**5.2**					

Mean Hardness (mg/l)		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	Blackstone River	47	47	41	48	51	60	53	70	61	63	72	69	63	37	37	46	41	44
	Branch River	0	0	0	0	0	0	18	0	22	0	26	0	17	0	0	0	0	0
	Mill River	35				37		35		42		48		40	27		35		
	Peters River	45				49		56		74		76		64	48		53		
	Abbott Run Brook	0	0	0	0	0	0	34	0	72	0	30	0	0	0	0	0	0	0

(1) *Events DW-01 to DW-06:* All values analyzed by Mitkem were edited during quality control. Shown data were analyzed by Microinorganics.
(2) *Events DW-07 to DW-18:* Shown data averages of data largely analyzed by STL with some data from Microinorganics.
(3) Values below the RL were not included in calculations of means and standard deviations.
7.8 Exceeds Acute Criteria
5.5 Exceeds Chronic Criteria

Dissolved Copper Criteria	*for Hardness (mg/l as CaCO₃)*				
	25	*35*	*45*	*55*	*65*
Acute Criteria	3.6	5.0	6.3	7.7	9.0
Chronic Criteria	2.7	3.7	4.5	5.4	6.2

Reporting Limit: 1.0 ug/l (STL and Microinorganics)

Figure 3-47: Dry Weather Dissolved Copper Acute and Chronic Criteria by Waterbody

Event No (DW-_)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Waterbody/Station	**Mean Hardness** (mg/l)																	
Blackstone River	47	47	41	48	51	60	53	70	61	63	72	69	63	37	37	46	41	44
Branch River							18		22		26		17					
Mill River	35				37		35		42		48		40	27		35		
Peters River	45				49		56		74		76		64	48		53		
Abbott Run Brook							34		72		30							
W-31 Cherry Brook							43		85		84							
W-32 Front Street Drain							71		72		73							
W-33 Sylvestre Pond Outflow							42		51		44							
W-34 Blackstone Canal							51		64									
W-35 Brook near Ann&Hope															79	82	84	69
	Acute Copper Criteria (µg/l)																	
Blackstone River	6.6	6.5	5.9	6.7	7.1	8.3	7.4	9.6	8.4	8.7	9.9	9.4	8.7	5.2	5.3	6.5	5.8	6.3
Branch River							2.7		3.2		3.8		2.5					
Mill River	5.0				5.3		5.0		6.0		6.7		5.6	3.9		5.0		
Peters River	6.3				6.8		7.7		10.1		10.3		8.8	6.7		7.4		
Abbott Run Brook							4.9		9.9		4.5							
W-31 Cherry Brook							6.1		11.5		11.4							
W-32 Front Street Drain							9.7		9.9		10.0							
W-33 Sylvestre Pond Outflow							5.9		7.1		6.2							
W-34 Blackstone Canal							7.1		8.8									
W-35 Brook near Ann&Hope															10.8	11.1	11.4	9.5
	Chronic Copper Criteria (µg/l)																	
Blackstone River	4.7	4.7	4.2	4.8	5.0	5.8	5.2	6.6	5.8	6.1	6.8	6.5	6.1	3.8	3.8	4.6	4.2	4.5
Branch River							2.1		2.5		2.8		2.0					
Mill River	3.7				3.8		3.7		4.3		4.8		4.1	2.9		3.7		
Peters River	4.5				4.8		5.4		6.9		7.1		6.1	4.8		5.2		
Abbott Run Brook							3.6		6.8		3.2							
W-31 Cherry Brook							4.4		7.8		7.7							
W-32 Front Street Drain							6.7		6.8		6.8							
W-33 Sylvestre Pond Outflow							4.3		5.0		4.4							
W-34 Blackstone Canal							5.0		6.1									
W-35 Brook near Ann&Hope															7.3	7.6	7.7	6.5

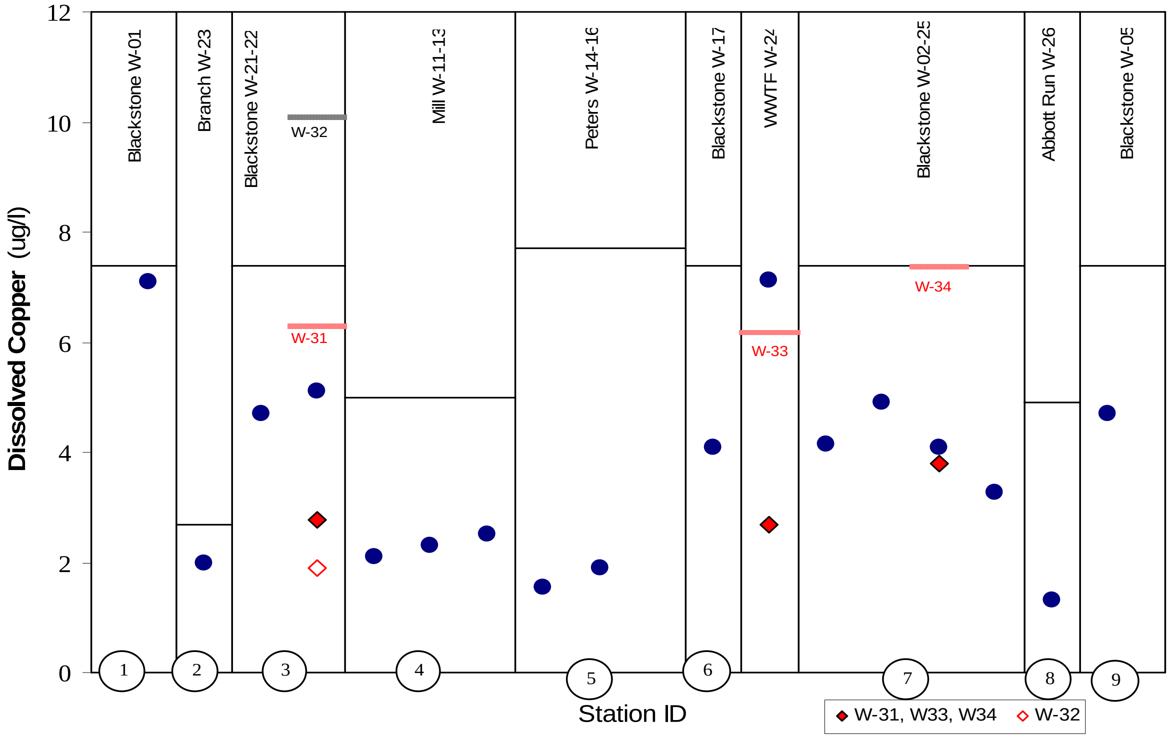


Figure 3-48: Dry Weather - Acute Criteria Dissolved Copper for July 21, 2005 (Event DW-07)

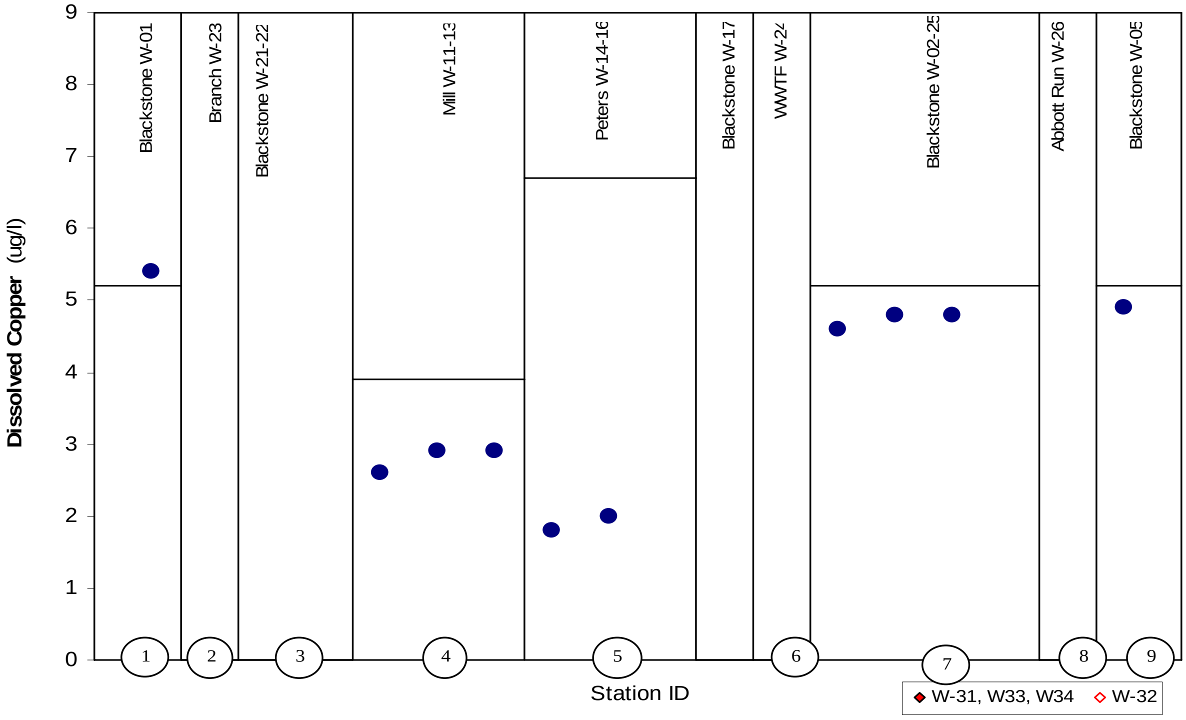


Figure 3-49: Dry Weather - Acute Criteria Dissolved Copper for October 22, 2005 (Event DW-14)

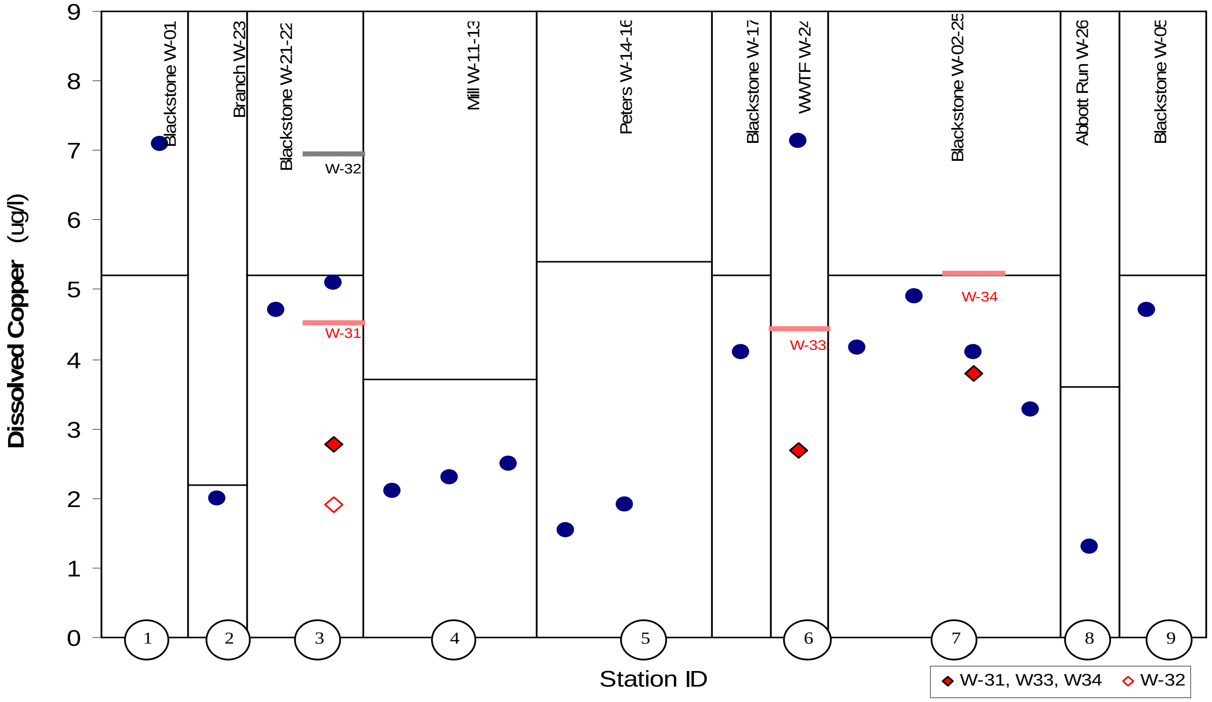


Figure 3-50: Dry Weather - Chronic Criteria Dissolved Copper for July 21, 2005 (Event DW-07)

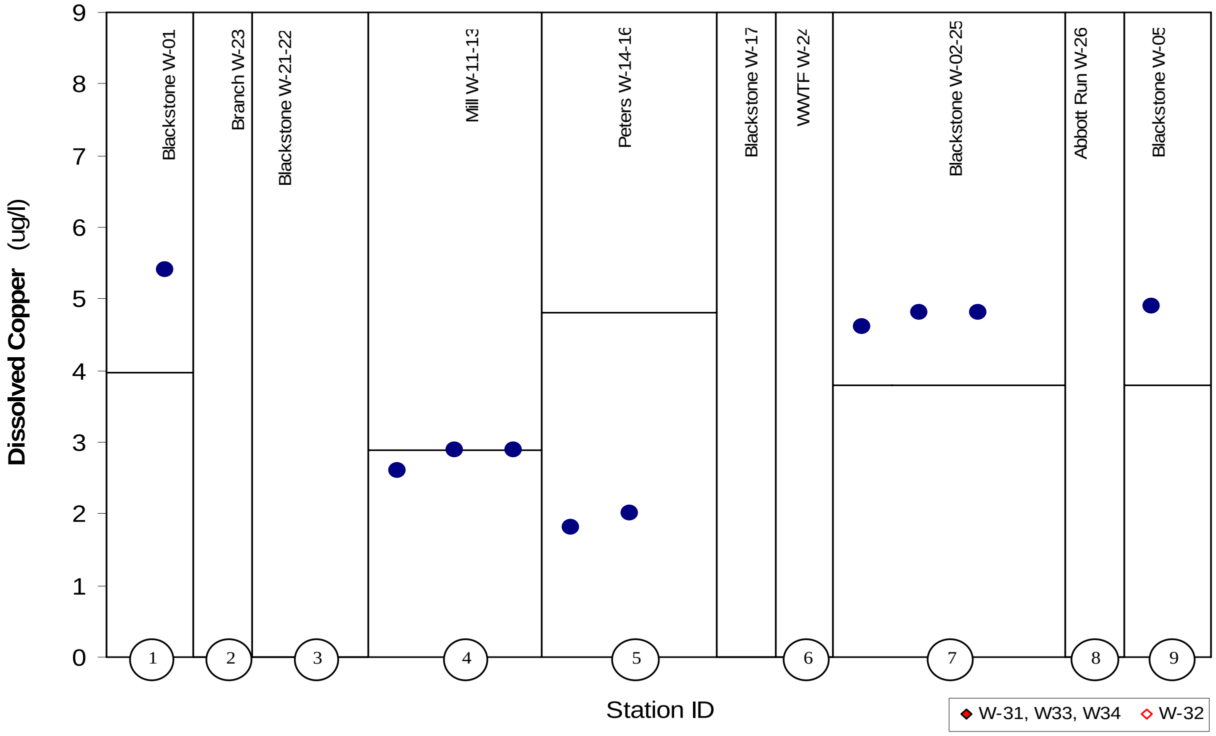


Figure 3-51: Dry Weather - Chronic Criteria Dissolved Copper for Oct. 22, 2005 (Event DW-14)

Figure 3-52: Dissolved Copper Acute and Chronic Exceedances in Dry Weather

Station		**Copper Acute Exceedances**	**Copper Chronic Exceedances**	**Available Events** *(STL + Microinorganics)*
W-01	Millville (MA/RI border)	2	9	15
W-23	Branch River			4
W-21	Singleton Street			3
W-22	Below Thundermist Dam			3
W-11	Mill River (MA/RI border)			6
W-12	Mill River (pre-culvert entry)			6
W-13	Mill River (confluence w/ BR)			6
W-14	Peters River (MA/RI border)			6
W-15	Peters River (pre-culvert entry)			6
W-16	Peters River (confluence w/ BR)			3
W-17	Hamlet Avenue			4
W-24	Woonsocket WWTF			2
W-02	Manville Dam		3	15
W-03	George Washington Hwy Bridge	1	3	15
W-04	Lonsdale Ave		3	15
W-25	Broad Street			3
W-26	Abbott Run Brook			3
W-05	Slaters Mill Dam		1	15
W-31	Cherry Brook			3
W-32	Front Street Drain			3
W-33	Sylvestre Pond Outflow			3
W-34	Blackstone Canal at Lonsdale			2
W-35	Brook near Ann&Hope			4

Figure 3-53: Dry Weather Concentrations - Dissolved Lead

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Location	**Conc.** (ug/l) - ***Microinorganics***						**Concentration** (ug/l) - ***STL and Microinorganics*** *(2)*												**Statistics *(Microinorg. & STL)***				
						16-Mar-05	**20-Apr-05**	**11-May-05**	**23-May-05**	**9-Jun-05**	**27-Jun-05**	**21-Jul-05**	**3-Aug-05**	**11-Aug-05**	**25-Aug-05**	**14-Sep-05**	**26-Sep-05**	**7-Oct-05**	**22-Oct-05**	**29-Nov-05**	**22-Dec-05**	**27-Jan-06**	**17-Feb-06**	**Mean** *(3)*	**Standard Deviation** *(3)*	**Minimum**	**Maximum**	**Count**
					Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18					
W-01	Reach 1	●			Millville *(**MA/RI** border)*		0.41	0.40	0.46			0.24	0.18	0.28	0.32	0.37	0.29	0.78	**1.30**	0.62	0.52	0.35	0.34	**0.46**	0.28	0.18	1.30	15
W-23			●		Branch River							**0.67**		**0.62**		0.29		**0.40**						**0.50**	0.18	0.29	0.67	4
W-21		●			Singleton Street							0.29		0.11		0.27								**0.22**	0.10	0.11	0.29	3
W-22		●			Below Thundermist Dam							0.47		0.10		0.25								**0.27**	0.19	0.10	0.47	3
W-11			●		Mill River *(**MA/RI** border)*							0.66		0.32		0.17		0.10	0.43		**0.96**			**0.44**	0.32	0.10	0.96	6
W-12			●		Mill River (pre-culvert entry)							0.66		0.11		0.24		0.50	0.43		**0.95**			**0.48**	0.30	0.11	0.95	7
W-13			●		Mill River (confluence w/ BR)							0.80		0.31		0.29		0.25	**0.71**		**0.86**			**0.54**	0.28	0.25	0.86	6
W-14			●		Peters River *(**MA/RI** border)*							0.39		<0.10		0.43		0.23	0.25		0.78			**0.42**	0.22	<0.10	0.78	6
W-15			●		Peters River (pre-culvert entry)							0.44		0.12		0.19		0.32	0.32		0.31			**0.28**	0.11	0.12	0.44	6
W-16			●		Peters River (confluence w/ BR)									0.10		0.18		0.18						**0.15**	0.05	0.10	0.18	3
W-17		●			Hamlet Avenue							0.27		<0.10		0.22					0.48			**0.32**	0.14	<0.10	0.48	4
W-24				●	Woonsocket WWTF							<0.10				0.10								**0.10**		<0.10	0.10	2
W-02	Reach 2	●			Manville Dam		0.32	0.35	0.42			0.24	<0.10	<0.10	0.24	0.38	0.21	0.26	**1.3**	0.57	0.46	0.40	0.36	**0.42**	0.28	<0.10	1.30	15
W-03		●			George Washington Hwy Bridge		0.29	0.32	0.39			0.18	<0.10	<0.10	0.18	0.13	0.24	0.15	**1.5**	0.72	0.48	0.39	0.36	**0.38**	0.36	<0.10	1.50	15
W-04	Reach 3	●			Lonsdale Ave		0.35	0.36	0.36			0.20	<0.10	<0.10	0.17	0.14	0.27	0.13	**1.4**	0.59	0.48	0.37	0.39	**0.35**	0.33	<0.10	1.40	15
W-25		●			Broad Street							0.29		<0.10		0.17								**0.23**	0.09	<0.10	0.29	3
W-26			●		Abbott Run Brook							0.23		0.10		0.16								**0.16**	0.06	0.10	0.23	3
W-05		●			Slaters Mill Dam		0.33	0.29	0.38			0.25	<0.10	<0.10	0.21	0.12	0.23	0.16	**1.4**	0.60	0.46	0.40	0.45	**0.38**	0.33	<0.10	1.40	15
W-31	1			●	Cherry Brook							**1.8**		0.55		0.36								**0.89**	0.76	0.36	1.77	3
W-32				●	Front Street Drain							0.26		<0.10		<0.10								**0.15**	0.15	<0.10	0.26	3
W-33				●	Sylvestre Pond Outflow							0.41		0.28		0.36								**0.35**	0.06	0.28	0.41	3
W-34	2			●	Blackstone Canal at Lonsdale							0.74		0.83										**0.79**	0.06	0.74	0.83	2
W-35	3			●	Brook near Ann&Hope															0.14	<0.10	<0.10	0.19	**0.17**	0.04	<0.10	0.19	4
W-02	1 2	(=W-02)			Duplicate		0.28	0.33	0.41																			
W-05	3	(=W-05)			Duplicate																							
W-01	1	(=W-01)			Duplicate																							
W-41		(=W-11)			Duplicate							0.65		0.21		0.18			0.40		1.1							
W-42		(=W-14)			Duplicate							0.63		0.14		1.90		0.11	0.40									
W-43	2 3	(=W-04)			Duplicate							0.23	<0.10	<0.10	0.19	0.13	0.23	0.14	**1.4**	0.68	0.46		0.49					

Mean Hardness (mg/l)		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	Blackstone River	47	47	41	48	51	60	53	70	61	63	72	69	63	37	37	46	41	44
	Branch River							18		22		26		17					
	Mill River	35				37		35		42		48		40	27		35		
	Peters River	45				49		56		74		76		64	48		53		
	Abbott Run Brook							34		72		30							

(1) *Events DW-01 to DW-06: All values analyzed by Mitkem were edited during quality control. Shown data were analyzed by Microinorganics.*
(2) *Events DW-07 to DW-18:* Shown data averages of data largely analyzed by STL with some data from Microinorganics.
(3) Values below the RL were not included in calculations of means and standard deviations.
7.8 Exceeds Acute Criteria
5.5 Exceeds Chronic Criteria
🟧 Sample likely affected by entrained water from the Blackstone River.

Dissolved Lead Criteria	*for Hardness (mg/l as $CaCO_3$)*				
	25	*35*	*45*	*55*	*65*
Acute Criteria	13.9	20.3	26.8	33.5	40.3
Chronic Criteria	0.54	0.79	1.04	1.31	1.57

Reporting Limit: 0.1 ug/l (STL and Microinorganics)

Figure 3-54: Dry Weather Dissolved Lead Acute and Chronic Criteria by Waterbody

Event No (DW-_)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Water Body/Station	**Mean Hardness** (mg/l)																	
Blackstone River	47	47	41	48	51	60	53	70	61	63	72	69	63	37	37	46	41	44
Branch River							18		22		26		17					
Mill River	35				37		35		42		48		40	27		35		
Peters River	45				49		56		74		76		64	48		53		
Abbott Run Brook							34		72		30							
W-31 Cherry Brook							43		85		84							
W-32 Front Street Drain							71		72		73							
W-33 Sylvestre Pond Outflow							42		51		44							
W-34 Blackstone Canal							51		64									
W-35 Brook near Ann&Hope															79	82	84	69
	Acute Lead Criteria (µg/l)																	
Blackstone River	28	28	24	29	31	37	32	43	37	39	45	43	39	21	22	27	24	26
Branch River							10		8		10		5					
Mill River	20				22		20		25		29		23	15		20		
Peters River	27				29		34		46		48		40	29		32		
Abbott Run Brook							20		45		17							
W-31 Cherry Brook							25		54		53							
W-32 Front Street Drain							44		45		46							
W-33 Sylvestre Pond Outflow							25		31		26							
W-34 Blackstone Canal							31		40									
W-35 Brook near Ann&Hope															50	52	53	43
	Chronic Lead Criteria (µg/l)																	
Blackstone River	1.09	1.09	0.95	1.12	1.20	1.44	1.26	1.69	1.45	1.52	1.77	1.67	1.53	0.83	0.84	1.07	0.95	1.03
Branch River							0.37		0.30		0.40		0.20					
Mill River	0.80				0.84		0.79		0.98		1.12		0.91	0.58		0.80		
Peters River	1.04				1.14		1.32		1.80		1.86		1.54	1.12		1.25		
Abbott Run Brook							0.76		1.76		0.66							
W-31 Cherry Brook							0.99		2.11		2.08							
W-32 Front Street Drain							1.73		1.76		1.78							
W-33 Sylvestre Pond Outflow							0.97		1.20		1.02							
W-34 Blackstone Canal							1.20		1.54									
W-35 Brook near Ann&Hope															1.95	2.03	2.08	1.68

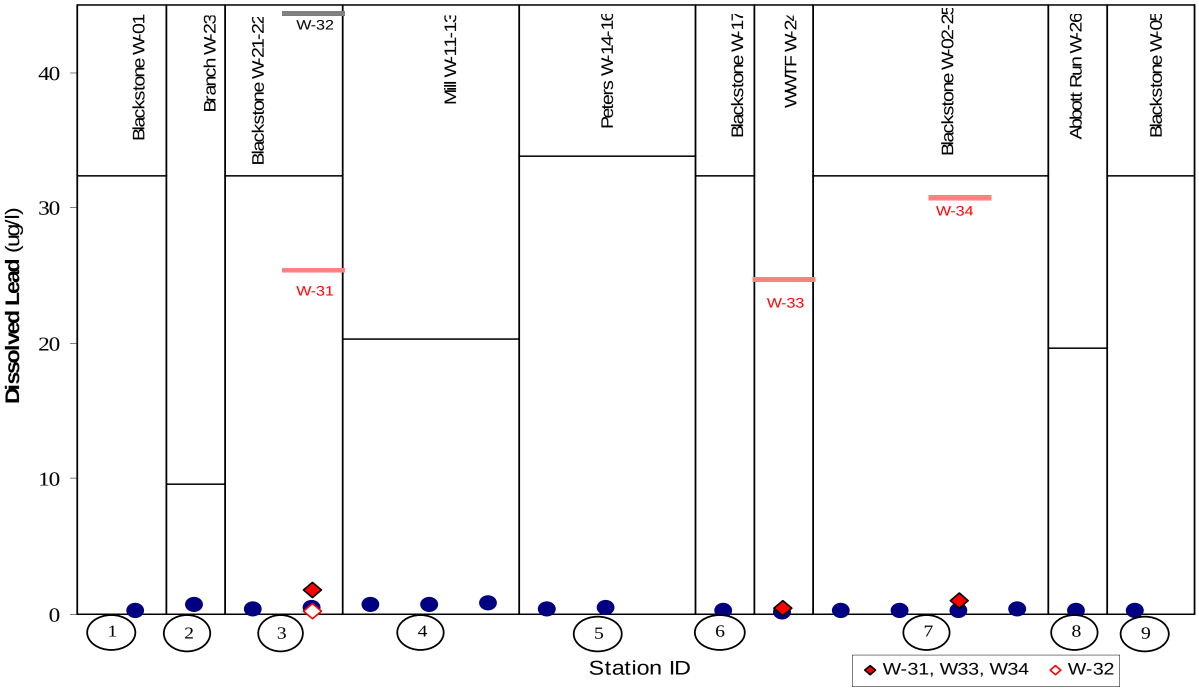


Figure 3-55: Dry Weather - Acute Criteria Dissolved Lead for July 21, 2005 (Event DW-07)

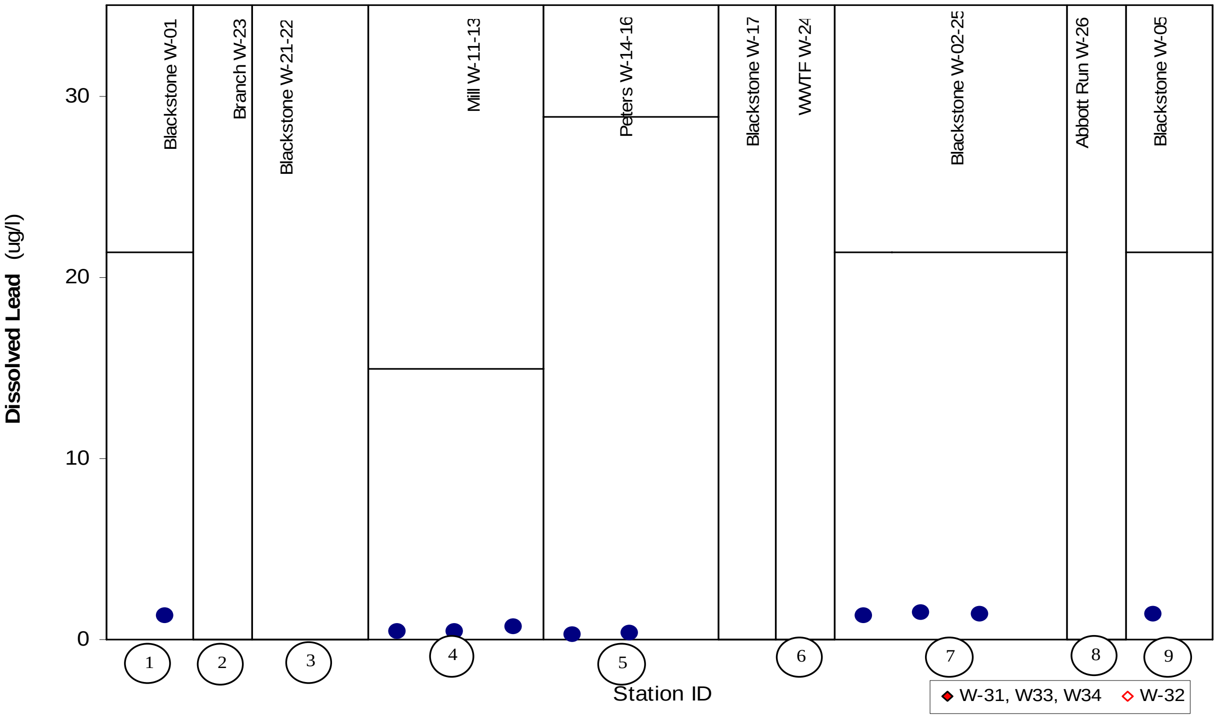


Figure 3-56: Dry Weather Acute Criteria Dissolved Lead for October 22, 2005 (Event DW-14)

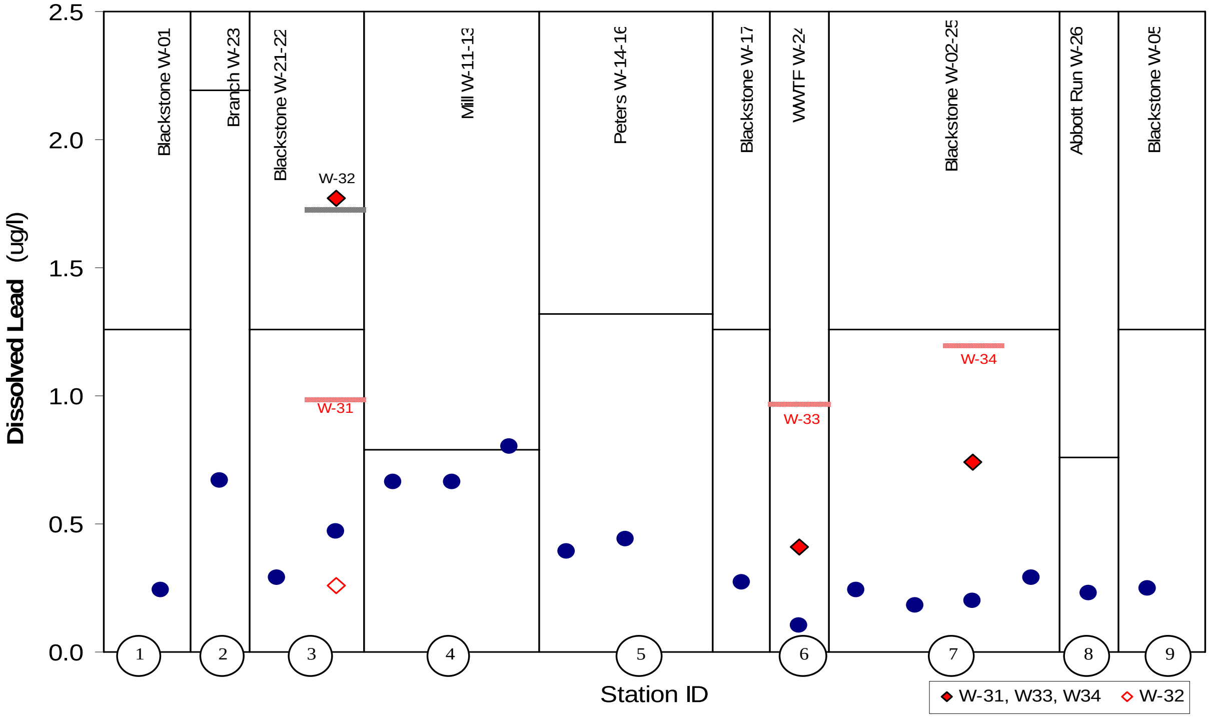


Figure 3-57: Dry Weather - Chronic Criteria Dissolved Lead for July 21, 2005 (Event DW-07)

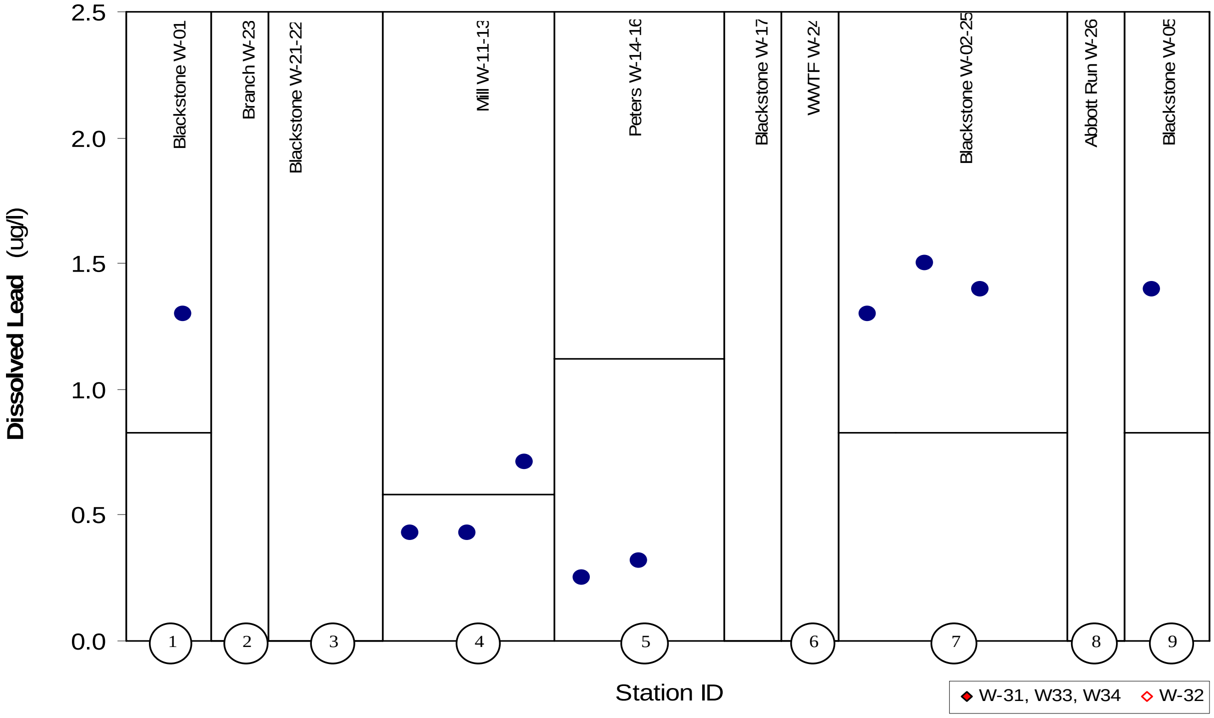


Figure 3-58: Dry Weather - Chronic Criteria Dissolved Lead for October 22, 2005 (Event DW-14)

Figure 3-59: Dissolved Lead Acute and Chronic Exceedances in Dry Weather

Station		**Lead Acute Exceedances**	**Lead Chronic Exceedances**	**Available Events** *(STL + Microinorganics)*
W-01	Millville (MA/RI border)		1	15
W-23	Branch River		3	4
W-21	Singleton Street			3
W-22	Below Thundermist Dam			3
W-11	Mill River (MA/RI border)		1	6
W-12	Mill River (pre-culvert entry)		1	6
W-13	Mill River (confluence w/ BR)		2	6
W-14	Peters River (MA/RI border)			6
W-15	Peters River (pre-culvert entry)			6
W-16	Peters River (confluence w/ BR)			3
W-17	Hamlet Avenue			4
W-24	Woonsocket WWTF			2
W-02	Manville Dam		1	15
W-03	George Washington Hwy Bridge		1	15
W-04	Lonsdale Ave		1	15
W-25	Broad Street			3
W-26	Abbott Run Brook			3
W-05	Slaters Mill Dam		1	15
W-31	Cherry Brook		1	3
W-32	Front Street Drain			3
W-33	Sylvestre Pond Outflow			3
W-34	Blackstone Canal at Lonsdale			2
W-35	Brook near Ann&Hope			4

Figure 3-60: Dry Weather Loads - Dissolved Copper

						Mass *(lbs/day) - Microinorganics*						**Mass** *(lbs/day) - STL and Microinorganics*												**Statistics**	
Station No.	**Reach**	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location** **Event No.** (DW-__)	**16-Mar-05** 1	**20-Apr-05** 2	**11-May-05** 3	**23-May-05** 4	**9-Jun-05** 5	**27-Jun-05** 6	**21-Jul-05** 7	**3-Aug-05** 8	**11-Aug-05** 9	**25-Aug-05** 10	**14-Sep-05** 11	**26-Sep-05** 12	**7-Oct-05** 13	**22-Oct-05** 14	**29-Nov-05** 15	**22-Dec-05** 16	**27-Jan-06** 17	**17-Feb-06** 18	**Mean** *(DW-7, 9, and 11)*	**Count**
W-01	Reach 1	●			Millville (MA/RI border)		10.32	16.02	6.91			6.38	3.79	3.74	2.90	3.30	4.39	4.61	46.49	18.48	13.59	18.30	27.42	4.47	3
W-23			●		Branch River							0.469		0.090		0.058		0.114						0.206	3
W-21		●			Singleton Street							5.46		3.12		2.54								3.70	3
W-22		●			Below Thundermist Dam							5.97		3.20		2.42								3.86	3
W-11			●		Mill River (MA/RI border)							0.124		0.034		0.027		0.089	1.217		0.753			0.062	3
W-12			●		Mill River (pre-culvert entry)							0.139		---		0.034		0.114	1.379		0.765			0.086	3
W-13			●		Mill River (confluence w/ BR)							0.152		0.035		0.034		0.229	1.379		0.677			0.073	3
W-14			●		Peters River (MA/RI border)							0.034		---		0.026		0.043	0.470		0.286			0.030	3
W-15			●		Peters River (pre-culvert entry)							0.041		0.009		0.035		0.061	0.536		0.177			0.028	3
W-16			●		Peters River (confluence w/ BR)									0.007		0.029		0.044						0.018	3
W-17		●			Hamlet Avenue							5.18		3.16		2.71					16.66			3.68	3
W-24				●	Woonsocket WWTF							0.44				0.42								0.43	3
W-02	Reach 2	●			Manville Dam		11.05	16.33	7.93			5.71	3.99	3.81	4.42	3.35	4.34	4.87	57.29	23.84	15.95	24.76	37.07	4.29	3
W-03		●			George Washington Hwy Bridge		12.88	16.87	8.51			6.81	4.54	3.87	3.37	2.94	4.31	7.33	61.26	29.26	17.03	26.33	44.70	4.54	3
W-04	Reach 3	●			Lonsdale Ave		13.51	17.75	7.51			5.73	4.19	3.82	3.52	2.79	4.64	4.14	61.74	31.91	17.76	28.38	46.98	4.12	3
W-25		●			Broad Street							4.62		3.83		2.47								3.64	3
W-26			●		Abbott Run Brook							0.189		---		---								0.189	3
W-05		●			Slaters Mill Dam		12.96	16.70	8.83			7.28	4.70	4.06	4.20	3.27	4.17	4.41	64.33	27.19	19.07	30.16	45.81	4.87	3
W-31	1			●	Cherry Brook							0.0090		0.0017		0.0005								0.0037	3
W-32				●	Front Street Drain							0.0102		---		0.0003								0.0053	2
W-33				●	Sylvestre Pond Outflow							0.0102		0.0024		0.0003								0.0043	3
W-34	2			●	Blackstone Canal at Lonsdale							0.0029		0.0015										0.0022	2
W-35	3			●	Brook near Ann&Hope															0.0109	0.0025	0.0035	0.0066	0.0059	4

--- Loads not calculated as concentrations were below the reporting limit.

▨ Sampling events used for statistical analyses.

Figure 3-61: Dry Weather Loads - Dissolved Lead

						Mass (lbs/day) - *Microinorganics*						**Mass (lbs/day)** - *STL and Microinorganics*												**Statistics**	
Station No.	**Reach**	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location**	**16-Mar-05**	**20-Apr-05**	**11-May-05**	**23-May-05**	**9-Jun-05**	**27-Jun-05**	**21-Jul-05**	**3-Aug-05**	**11-Aug-05**	**25-Aug-05**	**14-Sep-05**	**26-Sep-05**	**7-Oct-05**	**22-Oct-05**	**29-Nov-05**	**22-Dec-05**	**27-Jan-06**	**17-Feb-06**	**Mean** *(DW-7, 9, and 11)*	**Count**
					Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
W-01	Reach 1	●			Millville (MA/RI border)		1.28	1.69	1.06			0.216	0.090	0.139	0.158	0.122	0.170	0.444	11.19	2.86	1.77	1.73	1.86	0.159	3
W-23			●		Branch River							0.157		0.043		0.015		0.029						0.072	3
W-21		●			Singleton Street							0.337		0.064		0.104								0.168	3
W-22		●			Below Thundermist Dam							0.550		0.058		0.096								0.235	3
W-11			●		Mill River (MA/RI border)							0.039		0.009		0.003		0.006	0.20		0.28			0.017	3
W-12			●		Mill River (pre-culvert entry)							0.040		0.003		0.003		0.030	0.20		0.28			0.015	3
W-13			●		Mill River (confluence w/ BR)							0.049		0.009		0.007		0.015	0.34		0.25			0.022	3
W-14			●		Peters River (MA/RI border)							0.008		---		0.006		0.005	0.07		0.11			0.007	3
W-15			●		Peters River (pre-culvert entry)							0.009		0.001		0.003		0.007	0.09		0.05			0.004	3
W-16			●		Peters River (confluence w/ BR)									0.000		0.003		0.004						0.002	3
W-17		●			Hamlet Avenue							0.341		---		0.090					2.42			0.216	3
W-24				●	Woonsocket WWTF							---				0.005								0.005	3
W-02	Reach 2	●			Manville Dam		1.54	2.38	1.45			0.326	---	---	0.166	0.179	0.163	0.211	16.19	4.38	2.45	3.54	3.34	0.253	3
W-03		●			George Washington Hwy Bridge		1.44	2.25	1.38			0.250	---	---	0.126	0.062	0.188	0.124	19.14	5.69	2.64	3.54	3.42	0.156	3
W-04	Reach 3	●			Lonsdale Ave		1.75	2.56	1.29			0.280	---	---	0.120	0.066	0.212	0.108	18.01	4.71	2.66	3.39	3.74	0.173	3
W-25		●			Broad Street							0.406		---		0.081								0.243	3
W-26			●		Abbott Run Brook							0.033		0.019		0.027								0.027	3
W-05		●			Slaters Mill Dam		1.78	2.20	1.46			0.387	---	---	0.200	0.077	0.218	0.157	18.38	5.10	2.74	3.89	4.58	0.232	3
W-31	1			●	Cherry Brook							0.0057		0.0006		0.0001								0.0021	3
W-32				●	Front Street Drain							0.0014		---		---								0.0014	3
W-33				●	Sylvestre Pond Outflow							0.0015		0.0005		0.0001								0.0007	3
W-34	2			●	Blackstone Canal at Lonsdale							0.0006		0.0004										0.0005	2
W-35	3			●	Brook near Ann&Hope															0.0006	---	0.0001	0.0003	0.0003	4

--- Loads not calculated as concentrations were below the reporting limit.

▨ Sampling events used for statistical analyses.

Figure 3-62: Dry Weather Concentrations and Mass Loads - Rankings for Dissolved Copper

Concentration

Station No.	Blackstone River	Tributary	WWTF/outfall/other	Location	Mean ug/l
W-24			●	Woonsocket WWTF	7.5
W-01	●			Millville *(**MA/RI** border)*	5.7
W-22	●			Below Thundermist Dam	5.6
W-21	●			Singleton Street	5.6
W-17	●			Hamlet Avenue	4.8
W-25	●			Broad Street	4.6
W-03	●			George Washington Hwy Bridge	4.6
W-02	●			Manville Dam	4.3
W-04	●			Lonsdale Ave	4.3
W-05	●			Slaters Mill Dam	3.9
W-34			●	Blackstone Canal at Lonsdale	3.7
W-35			●	Brook near Ann&Hope	2.6
W-31			●	Cherry Brook	2.4
W-13		●		Mill River (confluence w/ BR)	2.4
W-12		●		Mill River (pre-culvert entry)	2.3
W-15		●		Peters River (pre-culvert entry)	2.1
W-33			●	Sylvestre Pond Outflow	1.9
W-11		●		Mill River *(**MA/RI** border)*	1.9
W-16		●		Peters River (confluence w/ BR)	1.9
W-14		●		Peters River *(**MA/RI** border)*	1.9
W-32			●	Front Street Drain	1.7
W-23		●		Branch River	1.5
W-26		●		Abbott Run Brook	1.3

Mass Loading *(Events DW-7, 9, 11)*

Station No.	Blackstone River	Tributary	WWTF/outfall/other	Location	Mean lbs/day
W-05	●			Slaters Mill Dam	4.87
W-03	●			George Washington Hwy Bridge	4.54
W-01	●			Millville *(**MA/RI** border)*	4.47
W-02	●			Manville Dam	4.29
W-04	●			Lonsdale Ave	4.12
W-22	●			Below Thundermist Dam	3.86
W-21	●			Singleton Street	3.70
W-17	●			Hamlet Avenue	3.68
W-25	●			Broad Street	3.64
W-24			●	Woonsocket WWTF	0.43
W-23		●		Branch River	0.21
W-26		●		Abbott Run Brook	0.14
W-12		●		Mill River (pre-culvert entry)	0.086
W-13		●		Mill River (confluence w/ BR)	0.073
W-11		●		Mill River *(**MA/RI** border)*	0.062
W-14		●		Peters River *(**MA/RI** border)*	0.030
W-15		●		Peters River (pre-culvert entry)	0.028
W-16		●		Peters River (confluence w/ BR)	0.018
W-35			●	Brook near Ann&Hope	0.006
W-33			●	Sylvestre Pond Outflow	0.0043
W-32			●	Front Street Drain	0.0040
W-31			●	Cherry Brook	0.0037
W-34			●	Blackstone Canal at Lonsdale	0.0022

Figure 3-63: Dry Weather Concentrations and Mass Loads - Rankings for Dissolved Lead

Concentration					
Station No.	Blackstone River	Tributary	WWTF/outfall/other	Location	Mean ug/l
W-31			●	Cherry Brook	0.89
W-34			●	Blackstone Canal at Lonsdale	0.79
W-13		●		Mill River (confluence w/ BR)	0.54
W-23		●		Branch River	0.50
W-12		●		Mill River (pre-culvert entry)	0.48
W-01	●			Millville *(**MA/RI** border)*	0.46
W-11		●		Mill River *(**MA/RI** border)*	0.44
W-14		●		Peters River *(**MA/RI** border)*	0.42
W-02	●			Manville Dam	0.38
W-03	●			George Washington Hwy Bridge	0.36
W-05	●			Slaters Mill Dam	0.36
W-04	●			Lonsdale Ave	0.35
W-33			●	Sylvestre Pond Outflow	0.35
W-17	●			Hamlet Avenue	0.32
W-15		●		Peters River (pre-culvert entry)	0.28
W-22	●			Below Thundermist Dam	0.27
W-21	●			Singleton Street	0.22
W-25	●			Broad Street	0.17
W-35			●	Brook near Ann&Hope	0.17
W-26		●		Abbott Run Brook	0.16
W-16		●		Peters River (confluence w/ BR)	0.15
W-32			●	Front Street Drain	0.15
W-24			●	Woonsocket WWTF	0.10

Mass Loading *(Events DW-7, 9, 11)*					
Station No.	Blackstone River	Tributary	WWTF/outfall/other	Location	Mean lbs/day
W-02	●			Manville Dam	0.253
W-25	●			Broad Street	0.243
W-22	●			Below Thundermist Dam	0.235
W-05	●			Slaters Mill Dam	0.232
W-17	●			Hamlet Avenue	0.216
W-04	●			Lonsdale Ave	0.173
W-21	●			Singleton Street	0.168
W-01	●			Millville *(**MA/RI** border)*	0.159
W-03	●			George Washington Hwy Bridge	0.156
W-23		●		Branch River	0.072
W-26		●		Abbott Run Brook	0.027
W-13		●		Mill River (confluence w/ BR)	0.022
W-11		●		Mill River *(**MA/RI** border)*	0.017
W-12		●		Mill River (pre-culvert entry)	0.015
W-14		●		Peters River *(**MA/RI** border)*	0.0070
W-24			●	Woonsocket WWTF	0.0053
W-15		●		Peters River (pre-culvert entry)	0.0042
W-31			●	Cherry Brook	0.0021
W-16		●		Peters River (confluence w/ BR)	0.0021
W-32			●	Front Street Drain	0.0014
W-33			●	Sylvestre Pond Outflow	0.0007
W-34			●	Blackstone Canal at Lonsdale	0.0005
W-35			●	Brook near Ann&Hope	0.0004

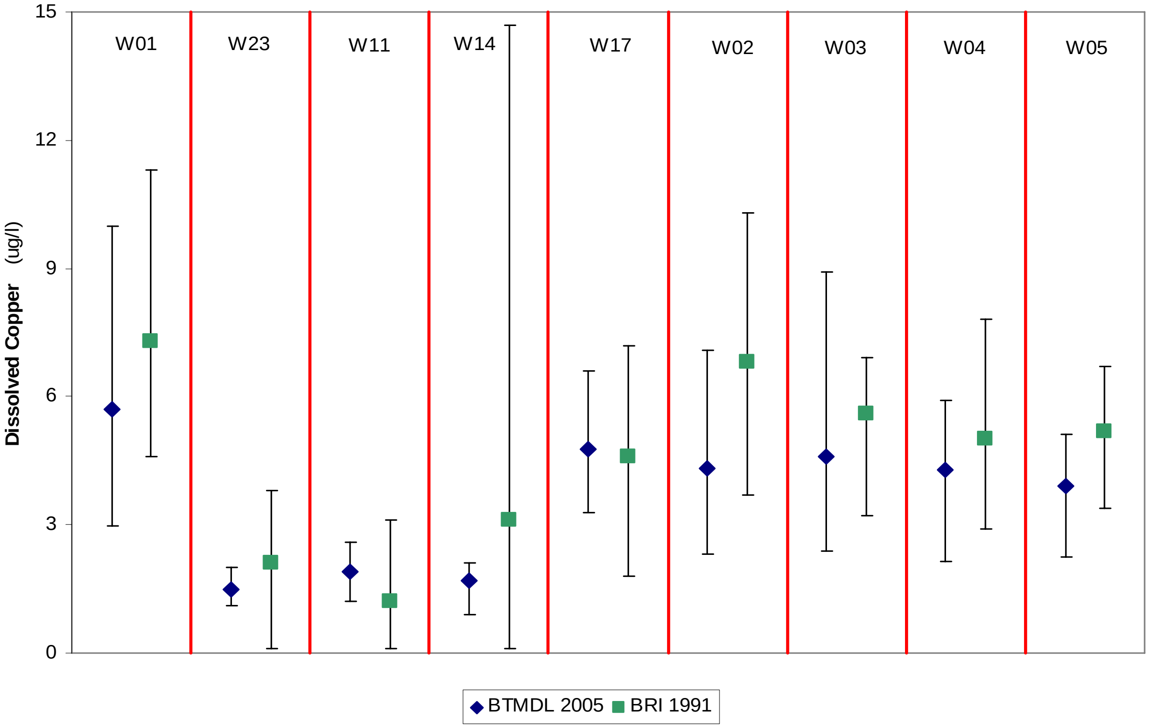


Figure 3-64: **Dry Weather Dissolved Copper Concentrations - Comparison between BTMDL (2005) and BRI (1991)**

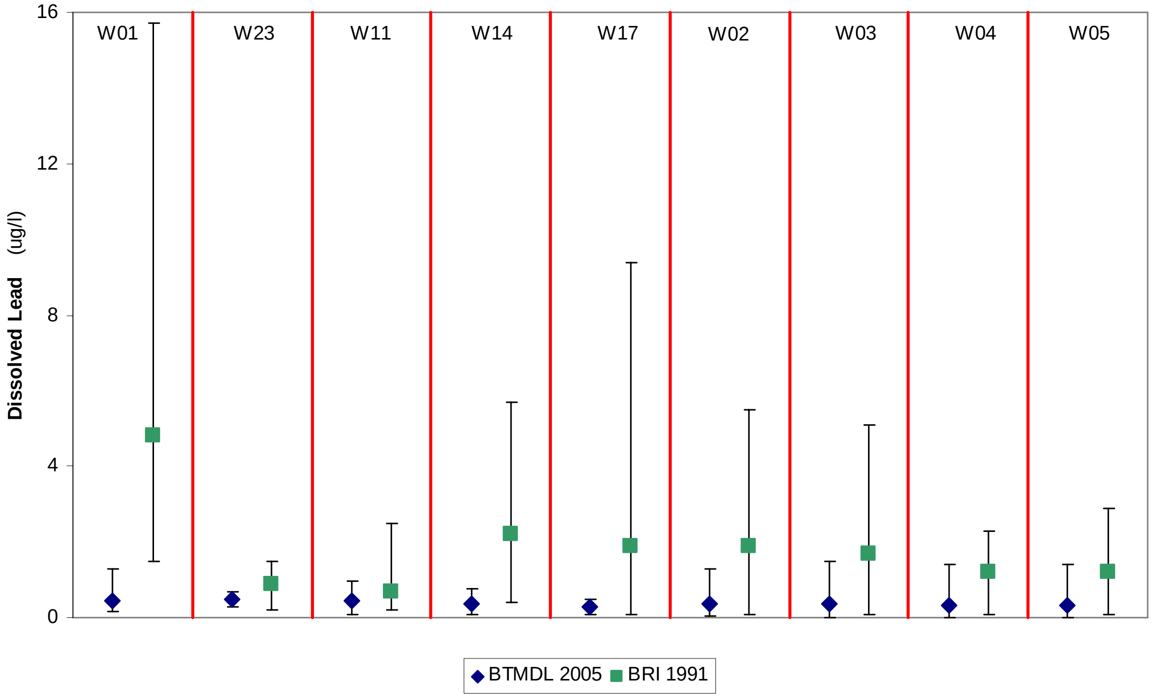


Figure 3-65: **Dry Weather Dissolved Lead Concentrations - Comparison between BTMDL (2005) and BRI (1991)**

Figure 3-66: Dry Weather Concentrations - Dissolved Oxygen

Station No.	Reach			Blackstone River	Tributary	WWTF/outfall/other	Location	Concentration (mg/l)																		Statistics				
								16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05	3-Aug-05	11-Aug-05	25-Aug-05	14-Sep-05	26-Sep-05	7-Oct-05	22-Oct-05	29-Nov-05	22-Dec-05	27-Jan-06	17-Feb-06	Mean	Standard Deviation	Minimum	Maximum	Count
							Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18					
W-01	Reach 1			●			Millville (***MA/RI*** *border*)	12.3	9.6	9.7	8.8	8.1	9.0	9.3	10.2	7.4	8.5	7.1	10.0	8.0	10.1	12.6	14.7	13.4	12.9	**10.1**	2.2	7.1	14.7	18
W-23					●		Branch River							8.0		8.4		7.8	9.5	8.8						**8.5**	0.7	7.8	9.5	5
W-21				●			Singleton Street							9.9		8.7		8.8								**9.1**	0.7	8.7	9.9	3
W-22				●			Below Thundermist Dam							8.5		8.0		9.1								**8.5**	0.6	8.0	9.1	3
W-11					●		Mill River (***MA/RI*** *border*)	13.2				8.5		7.4		7.4		8.2	9.3	8.8	10.7		15.0			**9.8**	2.7	7.4	15.0	9
W-12					●		Mill River (pre-culvert entry)	13.2				9.0		7.5		8.7		8.3	9.3	8.7	10.7		15.1			**10.1**	2.5	7.5	15.1	9
W-13					●		Mill River (confluence w/ BR)	12.8						7.8		8.0		8.3	9.5	9.0	10.8		15.2			**10.2**	2.6	7.8	15.2	8
W-14					●		Peters River (***MA/RI*** *border*)	12.8				7.2		5.5		**4.7**		**4.9**	6.8	**4.8**	8.8		13.5			**7.7**	3.4	**4.7**	13.5	9
W-15					●		Peters River (pre-culvert entry)	12.5				9.3		8.2		8.2		8.4	9.6	9.3	11.8		15.3			**10.3**	2.4	8.2	15.3	9
W-16					●		Peters River (confluence w/ BR)	12.6								7.7		8.2		8.9						**9.3**	2.2	7.7	12.6	4
W-17				●			Hamlet Avenue	13.2				9.3		9.1		9.6		10.1					15.4			**11.1**	2.6	9.1	15.4	6
W-24						●	Woonsocket WWTF											8.2								**8.2**		8.2	8.2	1
W-02		Reach 2		●			Manville Dam	13.3	8.8	9.8	9.1	8.1	10.2	9.4	13.0	11.0	8.4	8.4	9.8	9.2	11.0	13.3	16.3	13.3	13.5	**10.9**	2.3	8.1	16.3	18
W-03			Reach 3	●			George Washington Hwy Bridge	12.6	8.4	8.9	9.8	9.0	8.0	9.2	8.7	8.2	7.9	8.1	9.6	9.2	11.3	13.5	16.9	13.7	13.7	**10.4**	2.6	7.9	16.9	18
W-04				●			Lonsdale Ave	13.6	9.7	10.0	10.1	9.3	7.3	10.0	9.8	7.5	7.7	9.1	9.5	10.1	11.7	13.4	16.8	13.5	13.6	**10.7**	2.5	7.3	16.8	18
W-25				●			Broad Street							9.8		8.1		10.2								**9.4**	1.1	8.1	10.2	3
W-26					●		Abbott Run Brook							7.0		7.4		8.1								**7.5**	0.6	7.0	8.1	3
W-05				●			Slaters Mill Dam	13.3	8.7	10.1	9.8	9.4	7.6	8.4	9.2	8.7	8.4	7.7	9.8	9.1	11.5	13.6	17.1	13.8	13.7	**10.5**	2.7	7.6	17.1	18
W-31	1					●	Cherry Brook							7.4		6.7		7.2								**7.1**	0.4	6.7	7.4	3
W-32						●	Front Street Drain							9.0		9.2		9.8								**9.3**	0.4	9.0	9.8	3
W-33						●	Sylvestre Pond Outflow							8.5		6.6		7.4								**7.5**	1.0	6.6	8.5	3
W-34		2				●	Blackstone Canal at Lonsdale							6.8		5.8										**6.3**	0.7	5.8	6.8	2
W-35			3			●	Brook near Ann&Hope															9.7	12.3	10.5	11.0	**10.9**	1.1	9.7	12.3	4
W-02	1	2		(=W-02)			Duplicate																							
W-05			3	(=W-05)			Duplicate																							
W-01	1			(=W-01)			Duplicate																							
W-41				(=W-11)			Duplicate																							
W-42				(=W-14)			Duplicate																							
W-43		2	3	(=W-04)			Duplicate																							

Water Quality Criteria (Class B and B1):
Instantaneous minimum concentration of at least 5 mg/l, and 7-day man of at least 6 mg/l.

Figure 3-67: Dry Weather - Temperature

Station No.	Reach			Blackstone River	Tributary	WWTF/outfall/other	Location	Temperature (ºC)																		Statistics				
								16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05	3-Aug-05	11-Aug-05	25-Aug-05	14-Sep-05	26-Sep-05	7-Oct-05	22-Oct-05	29-Nov-05	22-Dec-05	27-Jan-06	17-Feb-06	Mean	Standard Deviation	Minimum	Maximum	Count
							Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18					
W-01	**Reach 1**			●			Millville *(**MA/RI** border)*	4.0	16.0	16.0	14.0	23.0	26.0	26.5	18.0	26.0	21.0	22.0	18.5	20.5	11.3	6.8	1.0	1.6	5.5	**15.4**	8.5	1.0	26.5	18
W-23					●		Branch River							28.0		27.0		23.0	20.0	21.2						**23.8**	3.5	20.0	28.0	5
W-21				●			Singleton Street							27.5		27.0		23.0								**25.8**	2.5	23.0	27.5	3
W-22				●			Below Thundermist Dam							27.0		27.0		22.0								**25.3**	2.9	22.0	27.0	3
W-11					●		Mill River *(**MA/RI** border)*	3.0				27.0		29.5		29.5		26.5	20.5	20.8	12.4		1.2			**18.9**	11.0	1.2	29.5	9
W-12					●		Mill River (pre-culvert entry)	3.0				27.0		28.0		28.0		26.0	19.8	21.9	12.2		1.4			**18.6**	10.6	1.4	28.0	9
W-13					●		Mill River (confluence w/ BR)	3.0						29.0		28.5		22.0	20.2	21.6	12.3		1.2			**17.2**	10.7	1.2	29.0	8
W-14					●		Peters River *(**MA/RI** border)*	3.0				24.0		24.5		24.0		21.0	20.0	18.3	9.0		0.5			**16.0**	9.4	0.5	24.5	9
W-15					●		Peters River (pre-culvert entry)	4.0				24.0		25.5		27.0		23.0	18.5	20.6	9.2		0.8			**17.0**	9.8	0.8	27.0	9
W-16					●		Peters River (confluence w/ BR)	4.5								25.0		23.0		19.9						**18.1**	9.3	4.5	25.0	4
W-17				●			Hamlet Avenue	4.0				22.0		27.0		27.5		24.0					1.0			**17.6**	11.9	1.0	27.5	6
W-24						●	Woonsocket WWTF											22.0								**22.0**		22.0	22.0	1
W-02		**Reach 2**		●			Manville Dam	7.0	18.0	15.5	14.5	21.0	26.0	27.0	20.0	28.5	23.0	24.0	20.0	21.0	11.7	5.9	1.0	2.2	4,7	**16.8**	8.6	1.0	28.5	17
W-03				●			George Washington Hwy Bridge	5.0	16.2	16.0	14.0	22.0	25.0	27.0	20.5	27.0	23.5	24.0	20.0	20.5	11.8	6.1	1.0	2.1	4.9	**15.9**	8.8	1.0	27.0	18
W-04			**Reach 3**	●			Lonsdale Ave	5.0	18.0	16.0	15.0	25.5	25.0	28.0	20.0	26.5	23.0	25.0	20.0	20.6	11.8	6.1	1.1	2.1	5.1	**16.3**	9.0	1.1	28.0	18
W-25				●			Broad Street							29.0		21.0		26.0								**25.3**	4.0	21.0	29.0	3
W-26					●		Abbott Run Brook							27.5		20.0		23.5								**23.7**	3.8	20.0	27.5	3
W-05				●			Slaters Mill Dam	5.0	17.0	16.0	14.5	25.0	25.0	27.5	19.5	20.0	23.0	25.0	19.8	20.9	12.0	6.8	1.3	2.3	5.2	**15.9**	8.5	1.3	27.5	18
W-31	1					●	Cherry Brook							23.5		22.0		19.0								**21.5**	2.3	19.0	23.5	3
W-32						●	Front Street Drain							16.0		16.5		16.0								**16.2**	0.3	16.0	16.5	3
W-33						●	Sylvestre Pond Outflow							26.5		25.5		23.0								**25.0**	1.8	23.0	26.5	3
W-34		2				●	Blackstone Canal at Lonsdale							28.0		19.5										**23.8**	6.0	19.5	28.0	2
W-35			3			●	Brook near Ann&Hope															13.4	8.4	7.7	9.8	**9.8**	2.5	7.7	13.4	4
W-02	1	2		(=W-02)			Duplicate																							
W-05			3	(=W-05)			Duplicate																							
W-01	1			(=W-01)			Duplicate																							
W-41				(=W-11)			Duplicate																							
W-42				(=W-14)			Duplicate																							
W-43		2	3	(=W-04)			Duplicate																							

Water Quality Criteria (Class B and B1):

No criteria for receiving water, only for anthropogenic discharges.

Figure 3-68: Dry Weather - Specific Conductance

Station No.	Reach			Blackstone River	Tributary	WWTF/outfall/other	Location	Concentration (uS/cm)																		Statistics				
								16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05	3-Aug-05	11-Aug-05	25-Aug-05	14-Sep-05	26-Sep-05	7-Oct-05	22-Oct-05	29-Nov-05	22-Dec-05	27-Jan-06	17-Feb-06	Mean	Standard Deviation	Minimum	Maximum	Count
							Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18					
W-01	Reach 1			●			Millville *(**MA/RI** border)*	380	380	198	340	460	450	450	400	370	450	475	445	460	220	175	220	220	260	**353**	107	175	475	18
W-23					●		Branch River							165		200		150	195	202						**182**	23	150	202	5
W-21				●			Singleton Street							480		200		400								**360**	144	200	480	3
W-22				●			Below Thundermist Dam							460		450		400								**437**	32	400	460	3
W-11					●		Mill River *(**MA/RI** border)*	200				320		345		395		260	280	270	180		185			**271**	74	180	395	9
W-12					●		Mill River (pre-culvert entry)	210				330		335		395		280	290	280	190		190			**278**	71	190	395	9
W-13					●		Mill River (confluence w/ BR)	210						340		410		260	310	282	190		190			**274**	78	190	410	8
W-14					●		Peters River *(**MA/RI** border)*	240				360		415		650		350	420	410	240		200			**365**	136	200	650	9
W-15					●		Peters River (pre-culvert entry)	240				375		445		600		425	280	410	240		200			**357**	129	200	600	9
W-16					●		Peters River (confluence w/ BR)	285								550		420		415						**418**	108	285	550	4
W-17				●			Hamlet Avenue	310				300		416		550		430					185			**365**	127	185	550	6
W-24						●	Woonsocket WWTF							1,000				420								**710**	410	420	1,000	2
W-02		Reach 2		●			Manville Dam	370	315	255	300	400	490	475	450	600	485	430	445	440	200	140	190	208	230	**357**	131	140	600	18
W-03				●			George Washington Hwy Bridge	340	325	260	310	390	470	465	400	550	440	430	435	420	195	140	195	215	222	**345**	118	140	550	18
W-04			Reach 3	●			Lonsdale Ave	345	335	260	295	370	420	460	450	390	440	440	432	420	200	140	200	225	220	**336**	105	140	460	18
W-25				●			Broad Street							450		420		440								**437**	15	420	450	3
W-26					●		Abbott Run Brook							225		215		140								**193**	46	140	225	3
W-05				●			Slaters Mill Dam	260	320	255	310	365	445	440	400	490	420	420	390	420	200	150	200	225	212	**329**	105	150	490	18
W-31	1					●	Cherry Brook							320		500		390								**403**	91	320	500	3
W-32						●	Front Street Drain							390		400		305								**365**	52	305	400	3
W-33						●	Sylvestre Pond Outflow							310		395		220								**308**	88	220	395	3
W-34		2				●	Blackstone Canal at Lonsdale							420		450										**435**	21	420	450	2
W-35			3			●	Brook near Ann&Hope															350	270	275	350	**311**	45	270	350	4
W-02	1	2		(=W-02)			Duplicate																							
W-05			3	(=W-05)			Duplicate																							
W-01	1			(=W-01)			Duplicate																							
W-41				(=W-11)			Duplicate																							
W-42				(=W-14)			Duplicate																							
W-43		2	3	(=W-04)			Duplicate																							

Water Quality Criteria (Class B and B1): None.

Figure 3-69: Dry Weather - Hardness

						Concentration (mg/l) - ***Mitkem***									**Concentration** (mg/l) - ***STL***									**Statistics**				
Station No.	**Reach**	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location** **Event** No. (DW-__)	**16-Mar-05** 1	**20-Apr-05** 2	**11-May-05** 3	**23-May-05** 4	**9-Jun-05** 5	**27-Jun-05** 6	**21-Jul-05** 7	**3-Aug-05** 8	**11-Aug-05** 9	**25-Aug-05** 10	**14-Sep-05** 11	**26-Sep-05** 12	**7-Oct-05** 13	**22-Oct-05** 14	**29-Nov-05** 15	**22-Dec-05** 16	**27-Jan-06** 17	**17-Feb-06** 18	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Count**
W-01	Reach 1	●			Millville (***MA/RI*** *border)*	54	52	46	52	59	63	62	68	67	66	79	71	66	41	41	52	45	48	**57**	11.0	41	79	18
W-23			●		Branch River							18		22		26		17						**21**	4.1	17	26	4
W-21		●			Singleton Street							49		56		60								**55**	5.6	49	60	3
W-22		●			Below Thundermist Dam							52		56		67								**58**	7.8	52	67	3
W-11			●		Mill River (***MA/RI*** *border)*	34				33		32		37		40		37	26		35			**34**	4.2	26	40	8
W-12			●		Mill River (pre-culvert entry)	36				41		37		47		55		44	28		36			**41**	8.2	28	55	8
W-13			●		Mill River (confluence w/ BR)	36						36		43		49		38	26		35			**38**	7.1	26	49	7
W-14			●		Peters River (***MA/RI*** *border)*	46				48		53		74		72		63	48		53			**57**	11.1	46	74	8
W-15			●		Peters River (pre-culvert entry)	47				49		58		73		77		64	48		53			**59**	11.6	47	77	8
W-16			●		Peters River (confluence w/ BR)	42								74		78		65						**65**	16.1	42	78	4
W-17		●			Hamlet Avenue	44				48		52		56		66					42			**51**	8.8	42	66	6
W-24				●	Woonsocket WWTF							160				150								**155**	7.1	150	160	2
W-02	Reach 2	●			Manville Dam	45	43	40	44	50	59	56	67	69	66	74	71	67	37	35	45	38	43	**53**	13.3	35	74	18
W-03		●			George Washington Hwy Bridge	45	44	42	48	48	57	53	70	70	61	76	68	61	37	35	45	40	44	**52**	12.6	35	76	18
W-04	Reach 3	●			Lonsdale Ave	46	46	38	47	50	60	46	72	70	62	78	70	62	35	37	46	40	43	**53**	13.5	35	78	18
W-25		●			Broad Street							57		33		74								**55**	20.6	33	74	3
W-26			●		Abbott Run Brook							34		72		30								**45**	23.2	30	72	3
W-05		●			Slaters Mill Dam	46	48	41	49	50	61	54	71	68	61	77	64	61	34	37	46	43	44	**53**	12.2	34	77	18
W-31	1			●	Cherry Brook							43		85		84								**71**	24.0	43	85	3
W-32				●	Front Street Drain							71		72		73								**72**	1.0	71	73	3
W-33				●	Sylvestre Pond Outflow							42		51		44								**46**	4.7	42	51	3
W-34	2			●	Blackstone Canal at Lonsdale							51		64										**58**	9.2	51	64	2
W-35	3			●	Brook near Ann&Hope															79	82	84	69	**79**	6.7	69	84	4
W-02	1 2	(=W-02)			Duplicate		43	37	45		59																	
W-05	3	(=W-05)			Duplicate	47																						
W-01		(=W-01)			Duplicate	53																						
W-41	1	(=W-11)			Duplicate							33		36		39			26		35							
W-42		(=W-14)			Duplicate							58		72		71		64	50									
W-43	2 3	(=W-04)			Duplicate							56	71	69	62	75	70	58	32	36	46	41	43					

Mean Hardness (mg/l)	Blackstone River	47	47	41	48	51	60	53	70	61	63	72	69	63	37	37	46	41	44	**53**
	Branch River							18		22		26		17						**21**
	Mill River	35				37		35		42		48		40	27		35			**37**
	Peters River	45				49		56		74		76		64	48		53			**58**
	Abbott Run Brook							34		72		30								**45**

Water Quality Criteria (Class B and B1): None.

Reporting Limit: 4 mg/l

Figure 3-70: Dry Weather - Turbidity

Station No.	Reach			Blackstone River	Tributary	WWTF/outfall/other	Location	**Turbidity** (NTU)																		**Statistics**				
								16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05	3-Aug-05	11-Aug-05	25-Aug-05	14-Sep-05	26-Sep-05	7-Oct-05	22-Oct-05	29-Nov-05	22-Dec-05	27-Jan-06	17-Feb-06	Mean	Standard Deviation	Minimum	Maximum	Count
							Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18					
W-01	Reach 1			●			Millville (***MA/RI*** *border)*	2.2	2.4	1.8	3.2	1.8	3.5	3.2	3.2	2.4	3.8	0.5	3.6	1.7	0.6	2.5	2.8	1.4	1.6	**2.3**	1.0	0.5	3.8	18
W-23					●		Branch River							1.0		0.9		0.4		1.2						**0.9**	0.3	0.4	1.2	4
W-21				●			Singleton Street							4.5		3.9		0.3								**2.9**	2.3	0.3	4.5	3
W-22				●			Below Thundermist Dam							3.3		3.8		0.4								**2.5**	1.9	0.4	3.8	3
W-11					●		Mill River (***MA/RI*** *border)*	1.5				1.2		1.7		1.8		1.5		0.9	0.7		1.4			**1.3**	0.4	0.7	1.8	8
W-12					●		Mill River (pre-culvert entry)	1.5				1.2		2.0		1.7		0.5		0.7	1.1		1.8			**1.3**	0.5	0.5	2.0	8
W-13					●		Mill River (confluence w/ BR)	1.8						2.3		2.4		0.6		1.4	0.6		1.7			**1.5**	0.7	0.6	2.4	7
W-14					●		Peters River (***MA/RI*** *border)*	1.4				1.9		3.1		2.8		0.4		1.5	0.5		1.4			**1.6**	1.0	0.4	3.1	8
W-15					●		Peters River (pre-culvert entry)	1.3				2.9		3.3		1.1		0.4		1.2	1.0		1.1			**1.5**	1.0	0.4	3.3	8
W-16					●		Peters River (confluence w/ BR)	1.5								2.5		0.3		0.9						**1.3**	0.9	0.3	2.5	4
W-17				●			Hamlet Avenue	2.8				1.7		3.1		4.3		0.5					2.1			**2.4**	1.3	0.5	4.3	6
W-24						●	Woonsocket WWTF							2.5				0.8								**1.7**	1.2	0.8	2.5	2
W-02		Reach 2		●			Manville Dam	2.2	2.2	2.0	2.0	2.0	4.4	4.0	7.0	6.8	4.4	0.3	2.6	1.1	1.2	2.0	5.2	1.9	0.9	**2.9**	2.0	0.3	7.0	18
W-03				●			George Washington Hwy Bridge	2.1	2.1	1.8	2.2	2.2	3.1	4.2	6.7	3.9	2.3	0.2	2.3	1.7	2.1	1.7	2.0	1.4	1.2	**2.4**	1.4	0.2	6.7	18
W-04			Reach 3	●			Lonsdale Ave	2.3	1.9	1.9	1.9	2.2	3.5	3.3	6.9	3.6	2.0	0.3	2.4	1.1	3.6	1.8	3.4	1.4	1.2	**2.5**	1.5	0.3	6.9	18
W-25				●			Broad Street							4.3		1.3		1.4								**2.3**	1.7	1.3	4.3	3
W-26					●		Abbott Run Brook							1.3		3.5		0.6								**1.8**	1.5	0.6	3.5	3
W-05				●			Slaters Mill Dam	3.0	2.2	1.9	2.1	2.5	3.7	3.6	5.7	3.8	2.3	0.3	2.3	1.6	3.9	3.6	2.6	1.5	1.0	**2.6**	1.3	0.3	5.7	18
W-31	1					●	Cherry Brook							2.8		2.7		0.6								**2.0**	1.2	0.6	2.8	3
W-32						●	Front Street Drain							0.5		0.3		0.2								**0.3**	0.2	0.2	0.5	3
W-33						●	Sylvestre Pond Outflow							9.5		3.2		0.5								**4.4**	4.6	0.5	9.5	3
W-34		2				●	Blackstone Canal at Lonsdale							6.3		6.0										**6.1**	0.2	6.0	6.3	2
W-35			3			●	Brook near Ann&Hope															0.6	0.9	0.6	7.5	**2.4**	3.4	0.6	7.5	4
W-02	1	2		(=W-02)			Duplicate		2.2	1.8	2.0	3.5	3.5																	
W-05			3	(=W-05)			Duplicate	2.4																						
W-01	1			(=W-01)			Duplicate	2.6				2.2																		
W-41				(=W-11)			Duplicate							2.0		1.8		0.7			1.7		1.5							
W-42				(=W-14)			Duplicate							3.5		2.9		1.0		1.9	1.1									
W-43		2	3	(=W-04)			Duplicate							3.9	7.1	4.0	1.4	0.3	2.6	1.5	4.0	2.1	2.7	1.1	1.1					

Water Quality Criteria (Class B and B1): Not to exceed 10 mg/l over background.

Figure 3-71: Dry Weather Concentrations - Chloride

Station No.	Reach			Blackstone River	Tributary	WWTF/outfall/other	Location	Concentration (mg/l)																		Statistics				
								16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05	3-Aug-05	11-Aug-05	25-Aug-05	14-Sep-05	26-Sep-05	7-Oct-05	22-Oct-05	29-Nov-05	22-Dec-05	27-Jan-06	17-Feb-06	Mean	Standard Deviation	Minimum	Maximum	Count
							Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18					
W-01	Reach 1			●			Millville *(**MA/RI** border)*	187	97	83	87	81	93	96	78	64	125	100	103	88	44	26	47	41	16	**81**	39	16	187	18
W-23					●		Branch River							39		22		37		32						**32**	8	22	39	4
W-21				●			Singleton Street							88		57		92								**79**	19	57	92	3
W-22				●			Below Thundermist Dam							84		55		97								**79**	21	55	97	3
W-11					●		Mill River *(**MA/RI** border)*	102				69		72		43		65		54	42		43			**61**	21	42	102	8
W-12					●		Mill River (pre-culvert entry)	107				64		69		42		59		51	41		41			**59**	22	41	107	8
W-13					●		Mill River (confluence w/ BR)	106						75		44		70		50	41		42			**61**	24	41	106	7
W-14					●		Peters River *(**MA/RI** border)*	119				77		86		70		104		76	57		41			**79**	25	41	119	8
W-15					●		Peters River (pre-culvert entry)	123				79		88		69		112		79	58		44			**81**	26	44	123	8
W-16					●		Peters River (confluence w/ BR)	119								68		110		78						**94**	24	68	119	4
W-17				●			Hamlet Avenue	163				73		86		55		97					39			**85**	43	39	163	6
W-24						●	Woonsocket WWTF							143				156								**150**	9	143	156	2
W-02		Reach 2		●			Manville Dam	142	82	72	75	69	95	87	62	60	115	97	94	80	41	13	42	39	15	**71**	33	13	142	18
W-03				●			George Washington Hwy Bridge	153	87	68	76	67	90	95	77	62	116	96	92	74	40	13	41	37	14	**72**	35	13	153	18
W-04			Reach 3	●			Lonsdale Ave	148	89	73	78	74	96	86	78	63	110	94	88	73	40	11	42	38	13	**72**	34	11	148	18
W-25				●			Broad Street							89		25		96								**70**	39	25	96	3
W-26					●		Abbott Run Brook							48		61		37								**49**	12	37	61	3
W-05				●			Slaters Mill Dam	175	89	68	77	72	97	86	75	62	156	95	81	76	41	13	44	42	12	**76**	41	12	175	18
W-31	1					●	Cherry Brook							77		69		112								**86**	23	69	112	3
W-32						●	Front Street Drain							90		53		88								**77**	21	53	90	3
W-33						●	Sylvestre Pond Outflow							62		44		59								**55**	9	44	62	3
W-34		2				●	Blackstone Canal at Lonsdale							85		64										**74**	15	64	85	2
W-35			3			●	Brook near Ann&Hope															18	36	38	14	**26**	12	14	38	4
W-02	1	2		(=W-02)			Duplicate		84	68	76	72	96																	
W-05			3	(=W-05)			Duplicate	189																						
W-01	1			(=W-01)			Duplicate	171				73																		
W-41				(=W-11)			Duplicate							74		42		64			43		41							
W-42				(=W-14)			Duplicate							88		69		107		73	59									
W-43		2	3	(=W-04)			Duplicate							90	66	63	140	99	92	66	44	13	41	41	12					

Water Quality Criteria (Class B and B1): Chronic criteria: 230 mg/l; Acute criteria: 860 mg/l

Figure 3-72: Dry Weather - pH

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Location	pH																		Statistics				
						16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05	3-Aug-05	11-Aug-05	25-Aug-05	14-Sep-05	26-Sep-05	7-Oct-05	22-Oct-05	29-Nov-05	22-Dec-05	27-Jan-06	17-Feb-06	Mean	Standard Deviation	Minimum	Maximum	Count
					Event No. (DW-__)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18					
W-01	Reach 1	●			Millville (***MA/RI*** *border)*	6.5	6.2	5.8	6.7	6.4	6.9	7.3	8.0	6.8	6.7	6.7	6.4	6.6	6.3	6.3	5.9	6.6	6.3	**6.6**	0.5	5.8	8.0	18
W-23			●		Branch River							7.7		8.1		7.4		7.1						**7.6**	0.4	7.1	8.1	4
W-21		●			Singleton Street							7.8		7.7		7.3								**7.6**	0.2	7.3	7.8	3
W-22		●			Below Thundermist Dam							7.7		8.0		7.3								**7.7**	0.4	7.3	8.0	3
W-11			●		Mill River (***MA/RI*** *border)*	6.7				6.8		7.6		7.8		7.4		7.0	6.5		6.2			**7.0**	0.5	6.2	7.8	8
W-12			●		Mill River (pre-culvert entry)	6.7				6.7		7.2		7.6		7.2		6.9	6.5		6.2			**6.9**	0.5	6.2	7.6	8
W-13			●		Mill River (confluence w/ BR)	6.7						7.4		7.6		7.2		6.9	6.5		6.4			**6.9**	0.5	6.4	7.6	7
W-14			●		Peters River (***MA/RI*** *border)*	6.5				6.6		7.0		6.8		6.8		6.7	6.3		6.1			**6.6**	0.3	6.1	7.0	8
W-15			●		Peters River (pre-culvert entry)	6.6				6.7		7.0		6.9		6.8		6.9	6.4		6.4			**6.7**	0.2	6.4	7.0	8
W-16			●		Peters River (confluence w/ BR)	6.6								7.2		7.0		6.9						**6.9**	0.3	6.6	7.2	4
W-17		●			Hamlet Avenue	6.7				6.8		7.5		7.8		7.4					6.4			**7.1**	0.6	6.4	7.8	6
W-24				●	Woonsocket WWTF							7.3				7.2								**7.2**	0.1	7.2	7.3	2
W-02	Reach 2	●			Manville Dam	6.6	6.5	6.3	6.8	6.5	7.0	7.3	8.3	8.5	6.9	7.0	6.6	6.7	6.5	6.4	5.8	6.6	6.3	**6.8**	0.7	5.8	8.5	18
W-03		●			George Washington Hwy Bridge	6.6	6.6	6.5	6.9	6.6	7.1	6.8	8.7	8.3	6.9	6.9	6.7	6.8	6.4	6.4	5.7	6.6	6.3	**6.8**	0.7	5.7	8.7	18
W-04	Reach 3	●			Lonsdale Ave	6.4	6.7	6.4	7.0	6.6	7.0	7.3	8.5	7.7	6.9	6.9	6.7	6.8	6.4	6.4	6.1	6.6	6.4	**6.8**	0.6	6.1	8.5	18
W-25		●			Broad Street							7.9		7.5		7.6								**7.7**	0.2	7.5	7.9	3
W-26			●		Abbott Run Brook							7.8		7.3		7.6								**7.6**	0.2	7.3	7.8	3
W-05		●			Slaters Mill Dam	6.7	6.7	6.6	7.0	6.7	7.1	7.6	8.3	7.6	7.0	7.2	6.7	6.8	6.4	6.4	6.2	6.6	6.4	**6.9**	0.5	6.2	8.3	18
W-31	1			●	Cherry Brook							7.5		7.1		7.2								**7.3**	0.2	7.1	7.5	3
W-32				●	Front Street Drain							7.4		7.4		7.2								**7.3**	0.1	7.2	7.4	3
W-33				●	Sylvestre Pond Outflow							7.5		7.2		7.2								**7.3**	0.2	7.2	7.5	3
W-34	2			●	Blackstone Canal at Lonsdale							7.0		7.1										**7.1**	0.1	7.0	7.1	2
W-35	3			●	Brook near Ann&Hope															6.6	6.4	6.6	6.3	**6.5**	0.1	6.3	6.6	4
W-02	1 2	(=W-02)			Duplicate		6.6	6.4	6.8	6.5	7.1																	
W-05	3	(=W-05)			Duplicate	6.4																						
W-01	1	(=W-01)			Duplicate	6.7				6.7																		
W-41		(=W-11)			Duplicate							7.5		7.4		7.6			6.6		6.6							
W-42		(=W-14)			Duplicate							7.0		6.7		6.9		6.7	6.4									
W-43	2 3	(=W-04)			Duplicate							7.6	8.4	6.9	6.9	6.9	6.7	6.9	6.6	6.7	6.5	6.8	6.5					

Water Quality Criteria (Class B and B1): pH of 6.5 to 9.0 or as naturally occurs.

Figure 3-73: Dry Weather - Rankings for DO, Temperature, Specific Conductance, and Hardness

Dissolved Oxygen Concentration					
Station No.	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location**	**Mean** mg/l
W-17	●			Hamlet Avenue	11.1
W-35			●	Brook near Ann&Hope	10.9
W-02	●			Manville Dam	10.9
W-04	●			Lonsdale Ave	10.7
W-05	●			Slaters Mill Dam	10.5
W-03	●			George Washington Hwy Bridge	10.4
W-15		●		Peters River (pre-culvert entry)	10.3
W-13		●		Mill River (confluence w/ BR)	10.2
W-01	●			Millville *(**MA/RI** border)*	10.1
W-12		●		Mill River (pre-culvert entry)	10.1
W-11		●		Mill River *(**MA/RI** border)*	9.8
W-25	●			Broad Street	9.4
W-16		●		Peters River (confluence w/ BR)	9.3
W-32			●	Front Street Drain	9.3
W-21	●			Singleton Street	9.1
W-22	●			Below Thundermist Dam	8.5
W-23		●		Branch River	8.5
W-24			●	Woonsocket WWTF	8.2
W-14		●		Peters River *(**MA/RI** border)*	7.7
W-26		●		Abbott Run Brook	7.5
W-33			●	Sylvestre Pond Outflow	7.5
W-31			●	Cherry Brook	7.1
W-34			●	Blackstone Canal at Lonsdale	6.3

Temperature					
Station No.	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location**	**Mean** ºC
W-21	●			Singleton Street	25.8
W-22	●			Below Thundermist Dam	25.3
W-25	●			Broad Street	25.3
W-33			●	Sylvestre Pond Outflow	25.0
W-23		●		Branch River	23.8
W-34			●	Blackstone Canal at Lonsdale	23.8
W-26		●		Abbott Run Brook	23.7
W-24			●	Woonsocket WWTF	22.0
W-31			●	Cherry Brook	21.5
W-11		●		Mill River *(**MA/RI** border)*	18.9
W-12		●		Mill River (pre-culvert entry)	18.6
W-16		●		Peters River (confluence w/ BR)	18.1
W-17	●			Hamlet Avenue	17.6
W-13		●		Mill River (confluence w/ BR)	17.2
W-15		●		Peters River (pre-culvert entry)	17.0
W-02	●			Manville Dam	16.8
W-04	●			Lonsdale Ave	16.3
W-32			●	Front Street Drain	16.2
W-14		●		Peters River *(**MA/RI** border)*	16.0
W-03	●			George Washington Hwy Bridge	15.9
W-05	●			Slaters Mill Dam	15.9
W-01	●			Millville *(**MA/RI** border)*	15.4
W-35			●	Brook near Ann&Hope	9.8

Specific Conductance					
Station No.	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location**	**Mean** uS/cm
W-24			●	Woonsocket WWTF	710
W-22	●			Below Thundermist Dam	437
W-25	●			Broad Street	437
W-34			●	Blackstone Canal at Lonsdale	435
W-16		●		Peters River (confluence w/ BR)	418
W-31			●	Cherry Brook	403
W-17	●			Hamlet Avenue	365
W-14		●		Peters River *(**MA/RI** border)*	365
W-32			●	Front Street Drain	365
W-21	●			Singleton Street	360
W-15		●		Peters River (pre-culvert entry)	357
W-02	●			Manville Dam	357
W-01	●			Millville *(**MA/RI** border)*	353
W-03	●			George Washington Hwy Bridge	345
W-04	●			Lonsdale Ave	336
W-05	●			Slaters Mill Dam	329
W-35			●	Brook near Ann&Hope	311
W-33			●	Sylvestre Pond Outflow	308
W-12		●		Mill River (pre-culvert entry)	278
W-13		●		Mill River (confluence w/ BR)	274
W-11		●		Mill River *(**MA/RI** border)*	271
W-26		●		Abbott Run Brook	193
W-23		●		Branch River	182

Hardness					
Station No.	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location**	**Mean** mg/l
W-24			●	Woonsocket WWTF	155
W-35			●	Brook near Ann&Hope	79
W-32			●	Front Street Drain	72
W-31			●	Cherry Brook	71
W-16		●		Peters River (confluence w/ BR)	65
W-15		●		Peters River (pre-culvert entry)	59
W-22	●			Below Thundermist Dam	58
W-34			●	Blackstone Canal at Lonsdale	58
W-01	●			Millville *(**MA/RI** border)*	57
W-14		●		Peters River *(**MA/RI** border)*	57
W-21	●			Singleton Street	55
W-25	●			Broad Street	55
W-05	●			Slaters Mill Dam	53
W-02	●			Manville Dam	53
W-04	●			Lonsdale Ave	53
W-03	●			George Washington Hwy Bridge	52
W-17	●			Hamlet Avenue	51
W-33			●	Sylvestre Pond Outflow	46
W-26		●		Abbott Run Brook	45
W-12		●		Mill River (pre-culvert entry)	41
W-13		●		Mill River (confluence w/ BR)	38
W-11		●		Mill River *(**MA/RI** border)*	34
W-23		●		Branch River	21

Figure 3-74: Dry Weather - Rankings for Turbidity and Chloride

Turbidity

Station No.	Blackstone River	Tributary	WWTF/outfall/other	Location	Mean NTU
W-34			●	Blackstone Canal at Lonsdale	6.15
W-33			●	Sylvestre Pond Outflow	4.42
W-02	●			Manville Dam	2.90
W-21	●			Singleton Street	2.87
W-05	●			Slaters Mill Dam	2.64
W-22	●			Below Thundermist Dam	2.49
W-04	●			Lonsdale Ave	2.49
W-17	●			Hamlet Avenue	2.42
W-03	●			George Washington Hwy Bridge	2.39
W-35			●	Brook near Ann&Hope	2.38
W-25	●			Broad Street	2.34
W-01	●			Millville *(**MA/RI** border)*	2.33
W-31			●	Cherry Brook	2.03
W-26		●		Abbott Run Brook	1.79
W-24			●	Woonsocket WWTF	1.65
W-14		●		Peters River *(**MA/RI** border)*	1.63
W-13		●		Mill River (confluence w/ BR)	1.55
W-15		●		Peters River (pre-culvert entry)	1.53
W-11		●		Mill River *(**MA/RI** border)*	1.33
W-12		●		Mill River (pre-culvert entry)	1.32
W-16		●		Peters River (confluence w/ BR)	1.30
W-23		●		Branch River	0.88
W-32			●	Front Street Drain	0.33

Chloride Concentration

Station No.	Blackstone River	Tributary	WWTF/outfall/other	Location	Mean mg/l
W-24			●	Woonsocket WWTF	149.5
W-16		●		Peters River (confluence w/ BR)	93.8
W-31			●	Cherry Brook	86.0
W-17	●			Hamlet Avenue	85.3
W-15		●		Peters River (pre-culvert entry)	81.5
W-01	●			Millville *(**MA/RI** border)*	80.9
W-21	●			Singleton Street	79.2
W-22	●			Below Thundermist Dam	78.8
W-14		●		Peters River *(**MA/RI** border)*	78.8
W-32			●	Front Street Drain	77.2
W-05	●			Slaters Mill Dam	75.6
W-34			●	Blackstone Canal at Lonsdale	74.2
W-03	●			George Washington Hwy Bridge	72.1
W-04	●			Lonsdale Ave	71.9
W-02	●			Manville Dam	71.1
W-25	●			Broad Street	70.0
W-11		●		Mill River *(**MA/RI** border)*	61.2
W-13		●		Mill River (confluence w/ BR)	61.0
W-12		●		Mill River (pre-culvert entry)	59.2
W-33			●	Sylvestre Pond Outflow	54.7
W-26		●		Abbott Run Brook	48.6
W-23		●		Branch River	32.3
W-35			●	Brook near Ann&Hope	26.4

Figure 3-75: Weighted Mean Annual Load and Percent Change in Loads between Reaches

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Location	**Mean Loads** (weighted over the 1-year sampling period)											
						Chloride	Hardness	Fecal Coliform (*)	Nitrate	Ammonia	Total Kjeldahl Nitrogen	Total Nitrogen (**)	Total Phosphorus	Total Suspended Solids	Volatile Suspended Solids	Dissolved Copper	Dissolved Lead
						lbs*1000 / day		MPN x 10^9 / day	lbs/day								
W-01	1	●			Millville *(MA/RI border)*	191	147	2,837	2,852	1,911	3,140	5,992	1,057	13,348	5,617	13.7	1.69
W-02		●			Manville Dam	252	203	6,851	3,996	2,790	4,660	8,656	1,814	20,786	9,094	16.5	2.54
W-03	2	●			George Washington Hwy Bridge	263	212	8,113	4,172	2,320	4,360	8,533	1,742	17,183	8,303	18.6	2.77
W-04	3	●			Lonsdale Ave	264	213	7,651	4,315	2,296	4,443	8,757	1,518	16,944	7,999	19.1	2.70
W-05		●			Slaters Mill Dam	304	235	8,518	4,323	2,306	4,414	8,737	1,645	23,808	13,379	19.1	2.89

Percent Comparison of Loads between Reaches *(bracketed by primary stations [W-__])*

Reach 1	W-01 (%load compared to W-02)	76%	72%	41%	71%	68%	67%	69%	58%	64%	62%	83%	67%
Reach 2	*W-03 (%load compared to W-02)*	*104%*	*104%*	*118%*	*104%*	*83%*	*94%*	*99%*	*96%*	*83%*	*91%*	*112%*	*109%*
	W-04 (%load compared to W-03)	*100%*	*101%*	*94%*	*103%*	*99%*	*102%*	*103%*	*87%*	*99%*	*96%*	*103%*	*97%*
	W-04 (%load compared to W-02)	105%	105%	112%	108%	82%	95%	101%	84%	82%	88%	116%	106%
Reach 3	W-05 (%load compared to W-04)	115%	110%	111%	100%	100%	99%	100%	108%	141%	167%	100%	107%
All Reaches	**W-05 (%load compared to W-01)**	**159%**	**160%**	**300%**	**152%**	**121%**	**141%**	**146%**	**156%**	**178%**	**238%**	**140%**	**171%**

(*) Geometric mean used for concentrations.
(**) Sum of Total Kjeldahl Nitrogen and nitrate.

Figure 3-76: Percent Change in Loads between Reaches for each Dry Weather Event

Parameter	Reach	Station	16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05	3-Aug-05	11-Aug-05	25-Aug-05	14-Sep-05	26-Sep-05	7-Oct-05	22-Oct-05	29-Nov-05	22-Dec-05	27-Jan-06	17-Feb-06	Mean Change	Count
		DW-__	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
Chloride	**Reach 1**	W-01 (% of W-02)	80%	78%	72%	78%	80%	64%	73%	88%	76%	77%	72%	83%	77%	74%	118%	71%	62%	64%	**77%**	18
	Reach 2	*W-03 (% of W-02)*	*111%*	*110%*	*98%*	*105%*	*97%*	*96%*	*113%*	*124%*	*104%*	*102%*	*99%*	*99%*	*94%*	*100%*	*104%*	*100%*	*97%*	*96%*	*103%*	18
		W-04 (% of W-03)	*98%*	*103%*	*108%*	*103%*	*110%*	*107%*	*91%*	*102%*	*102%*	*95%*	*98%*	*96%*	*100%*	*99%*	*83%*	*104%*	*105%*	*93%*	*100%*	18
		W-04 (% of W-02)	109%	114%	106%	108%	107%	103%	103%	127%	107%	98%	97%	95%	94%	99%	86%	103%	101%	89%	**103%**	18
	Reach 3	W-05 (% of W-04)	127%	107%	100%	107%	108%	118%	110%	124%	126%	192%	137%	111%	122%	105%	124%	112%	116%	101%	**119%**	18
	All Reaches	W-05 (% of W-01)	173%	158%	148%	149%	145%	188%	154%	180%	176%	242%	185%	128%	148%	141%	91%	163%	189%	142%	**161%**	18
Hardness	**Reach 1**	W-01 (% of W-02)	73%	79%	71%	79%	81%	70%	73%	71%	70%	71%	75%	75%	69%	77%	70%	74%	70%	66%	**73%**	18
	Reach 2	*W-03 (% of W-02)*	*103%*	*106%*	*108%*	*112%*	*97%*	*98%*	*97%*	*106%*	*103%*	*94%*	*103%*	*97%*	*92%*	*102%*	*103%*	*103%*	*108%*	*105%*	*102%*	18
		W-04 (% of W-03)	*103%*	*106%*	*91%*	*99%*	*104%*	*106%*	*87%*	*103%*	*101%*	*102%*	*103%*	*103%*	*102%*	*95%*	*107%*	*103%*	*101%*	*99%*	*101%*	18
		W-04 (% of W-02)	107%	111%	99%	111%	101%	103%	85%	109%	104%	96%	106%	100%	94%	98%	110%	107%	109%	103%	**103%**	18
	Reach 3	W-05 (% of W-04)	108%	113%	115%	112%	110%	119%	130%	128%	124%	133%	134%	110%	116%	99%	107%	107%	114%	109%	**116%**	18
	All Reaches	W-05 (% of W-01)	157%	159%	161%	157%	137%	175%	150%	197%	184%	179%	189%	146%	159%	126%	166%	155%	178%	170%	**164%**	18
Fecal Coliform	**Reach 1**	W-01 (% of W-02)	608%	29%	39%	134%	81%	101%	66%	16%	117%	125%	140%	56%	438%	90%	79%	166%	180%	34%	**139%**	18
	Reach 2	*W-03 (% of W-02)*	*290%*	*103%*	*28%*	*59%*	*27%*	*221%*	*102%*	*11%*	*24%*	*51%*	*95%*	*26%*	*101%*	*55%*	*134%*	*103%*	*94%*	*82%*	*89%*	18
		W-04 (% of W-03)	*17%*	*46%*	*77%*	*63%*	*167%*	*92%*	*178%*	*581%*	*101%*	*50%*	*1370%*	*217%*	*25%*	*101%*	*47%*	*485%*	*384%*	*55%*	*225%*	18
		W-04 (% of W-02)	48%	48%	22%	37%	46%	203%	182%	66%	24%	25%	1305%	57%	25%	56%	64%	501%	360%	45%	**173%**	18
	Reach 3	W-05 (% of W-04)	514%	376%	418%	601%	527%	90%	337%	319%	537%	880%	21%	65%	237%	29%	93%	13%	40%	65%	**287%**	18
	All Reaches	W-05 (% of W-01)	41%	628%	232%	167%	298%	181%	927%	1272%	112%	180%	194%	67%	14%	18%	76%	40%	80%	87%	**256%**	18
Nitrate	**Reach 1**	W-01 (% of W-02)	65%	54%	75%	79%		87%	92%	98%	108%	89%	128%	99%	88%	71%	86%	44%	76%	59%	**82%**	17
	Reach 2	*W-03 (% of W-02)*	*100%*	*113%*	*108%*	*112%*		*93%*	*86%*	*101%*	*93%*	*76%*	*79%*	*101%*	*86%*	*109%*	*112%*	*87%*	*101%*	*112%*	*98%*	17
		W-04 (% of W-03)	*104%*	*93%*	*105%*	*92%*		*100%*	*101%*	*100%*	*119%*	*127%*	*127%*	*100%*	*100%*	*104%*	*109%*	*95%*	*103%*	*109%*	*105%*	17
		W-04 (% of W-02)	103%	104%	114%	104%		93%	87%	102%	111%	97%	100%	101%	87%	113%	123%	82%	104%	122%	**103%**	17
	Reach 3	W-05 (% of W-04)	106%	98%	111%	107%		106%	111%	104%	98%	114%	77%	92%	111%	93%	120%	122%	108%	82%	**104%**	17
	All Reaches	W-05 (% of W-01)	168%	188%	169%	141%		113%	105%	108%	101%	124%	61%	94%	110%	148%	172%	229%	147%	169%	**138%**	17

Figure 3-76 *(cont.)*: Percent Change in Loads between Reaches for each Dry Weather Event

Parameter	Reach	Station	16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05	3-Aug-05	11-Aug-05	25-Aug-05	14-Sep-05	26-Sep-05	7-Oct-05	22-Oct-05	29-Nov-05	22-Dec-05	27-Jan-06	17-Feb-06	Mean Change	Count
		DW-__	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
Ammonia	**Reach 1**	W-01 (% of W-02)	71%	69%	90%	18%	81%	54%	58%	70%	64%	57%	46%	27%	33%	71%	62%	84%	38%	82%	**60%**	18
	Reach 2	W-03 (% of W-02)	15%	165%	80%	95%	110%	45%	80%	101%	80%	118%	59%	130%	48%	72%	44%	107%	131%	97%	88%	18
		W-04 (% of W-03)	414%	93%	123%	92%	66%	106%	47%	221%	98%	135%	77%	70%	100%	151%	115%	98%	22%	109%	119%	18
		W-04 (% of W-02)	61%	153%	98%	87%	72%	48%	37%	223%	78%	160%	45%	91%	49%	108%	51%	104%	29%	106%	**89%**	18
	Reach 3	W-05 (% of W-04)	129%	69%	68%	74%	93%	122%	122%	59%	74%	227%	118%	48%	118%	141%	104%	111%	106%	92%	**104%**	18
	All Reaches	W-05 (% of W-01)	110%	154%	74%	367%	83%	110%	79%	189%	91%	638%	116%	162%	172%	216%	86%	138%	81%	118%	**166%**	18
Total Kjeldahl Nitrogen	**Reach 1**	W-01 (% of W-02)	49%	50%	40%	132%	50%	75%	16%	56%	56%	70%	52%	70%	51%	103%	63%	71%	93%	77%	**65%**	18
	Reach 2	W-03 (% of W-02)	69%	78%	60%	77%	80%	92%	72%	101%	124%	93%	75%	109%	118%	126%	129%	85%	84%	123%	94%	18
		W-04 (% of W-03)	98%	175%	132%	139%	107%	98%	82%	147%	78%	95%	99%	96%	64%	85%	78%	123%	100%	84%	104%	18
		W-04 (% of W-02)	68%	136%	79%	106%	85%	90%	60%	149%	97%	88%	74%	104%	76%	107%	101%	104%	84%	103%	**95%**	18
	Reach 3	W-05 (% of W-04)	103%	64%	41%	39%	91%	130%	104%	77%	201%	142%	147%	91%	111%	99%	122%	143%	106%	106%	**106%**	18
	All Reaches	W-05 (% of W-01)	143%	173%	80%	31%	155%	156%	397%	204%	344%	177%	211%	135%	166%	103%	194%	210%	96%	143%	**173%**	18
Total Nitrogen (*)	**Reach 1**	W-01 (% of W-02)	55%	52%	54%	94%		84%	52%	77%	88%	83%	109%	93%	77%	87%	73%	63%	87%	68%	**76%**	17
	Reach 2	W-03 (% of W-02)	80%	94%	79%	102%		93%	79%	101%	105%	82%	78%	103%	96%	117%	122%	86%	91%	117%	95%	17
		W-04 (% of W-03)	101%	130%	117%	102%		100%	92%	124%	100%	115%	120%	99%	87%	94%	91%	114%	101%	97%	105%	17
		W-04 (% of W-02)	80%	122%	93%	104%		92%	73%	125%	105%	94%	94%	102%	83%	110%	110%	98%	91%	113%	**99%**	17
	Reach 3	W-05 (% of W-04)	105%	77%	76%	88%		113%	108%	88%	134%	122%	91%	91%	111%	96%	121%	138%	107%	92%	**103%**	17
	All Reaches	W-05 (% of W-01)	154%	180%	130%	98%		124%	150%	143%	160%	139%	78%	100%	121%	121%	183%	214%	113%	155%	**139%**	17
Total Phosphorus	**Reach 1**	W-01 (% of W-02)	36%	92%	62%	105%	52%	60%	99%	49%	110%	120%	91%	98%	1290%	69%	38%	73%	59%	51%	**142%**	18
	Reach 2	W-03 (% of W-02)	65%	129%	103%	98%	120%	71%	106%	98%	174%	44%	55%	67%	101%	102%	74%	102%	112%	95%	95%	18
		W-04 (% of W-03)	96%	88%	92%	76%	88%	85%	75%	99%	45%	335%	80%	81%	1527%	93%	79%	111%	90%	71%	178%	18
		W-04 (% of W-02)	62%	113%	95%	74%	106%	60%	79%	97%	78%	147%	44%	54%	1548%	95%	58%	113%	101%	67%	**166%**	18
	Reach 3	W-05 (% of W-04)	102%	116%	75%	165%	80%	106%	105%	51%	231%	153%	17%	101%	103%	145%	118%	103%	117%	104%	**111%**	18
	All Reaches	W-05 (% of W-01)	175%	142%	115%	116%	161%	106%	84%	101%	164%	187%	8%	56%	123%	199%	184%	158%	199%	138%	**134%**	18

(*) Sum of total Kjeldahl nitrogen and nitrate

Figure 3-76 *(cont.)*: Percent Change in Loads between Reaches for each Dry Weather Event

Parameter	Reach	Station	16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05	3-Aug-05	11-Aug-05	25-Aug-05	14-Sep-05	26-Sep-05	7-Oct-05	22-Oct-05	29-Nov-05	22-Dec-05	27-Jan-06	17-Feb-06	Mean Change	Count
		DW-__	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
Total Suspended Solids	Reach 1	W-01 (% of W-02)	117%	99%	79%	63%	76%	59%	93%	27%	24%	91%	50%	67%	106%	92%	66%	24%	52%	55%	**69%**	18
	Reach 2	*W-03 (% of W-02)*	*158%*	*107%*	*67%*	*81%*	*81%*	*97%*	*100%*	*90%*	*43%*	*56%*	*69%*	*180%*	*167%*	*117%*	*65%*	*29%*	*97%*	*86%*	*94%*	18
		W-04 (% of W-03)	*54%*	*90%*	*84%*	*98%*	*96%*	*105%*	*114%*	*117%*	*121%*	*141%*	*103%*	*45%*	*72%*	*99%*	*142%*	*126%*	*103%*	*85%*	*100%*	18
		W-04 (% of W-02)	86%	97%	57%	80%	78%	101%	114%	106%	52%	78%	71%	81%	120%	116%	93%	36%	100%	73%	**86%**	18
	Reach 3	W-05 (% of W-04)	238%	133%	192%	103%	122%	125%	83%	100%	114%	117%	252%	128%	114%	89%	235%	79%	158%	168%	**142%**	18
	All Reaches	W-05 (% of W-01)	175%	131%	138%	130%	124%	212%	102%	394%	247%	101%	355%	154%	130%	112%	331%	121%	301%	222%	**193%**	18
Volatile Susp. Solids	Reach 1	W-01 (% of W-02)	94%	60%	78%	61%	72%	55%	92%	28%	28%	76%	45%	71%	101%	79%	69%	23%	47%	66%	**64%**	18
	Reach 2	*W-03 (% of W-02)*	*136%*	*92%*	*87%*	*96%*	*98%*	*94%*	*99%*	*99%*	*51%*	*59%*	*63%*	*359%*	*158%*	*105%*	*87%*	*34%*	*110%*	*96%*	*107%*	18
		W-04 (% of W-03)	*77%*	*77%*	*85%*	*102%*	*90%*	*92%*	*106%*	*106%*	*114%*	*111%*	*91%*	*23%*	*89%*	*102%*	*124%*	*105%*	*92%*	*101%*	*94%*	18
		W-04 (% of W-02)	105%	70%	74%	98%	88%	86%	105%	106%	58%	65%	57%	81%	141%	108%	108%	36%	101%	97%	**88%**	18
	Reach 3	W-05 (% of W-04)	152%	130%	165%	107%	137%	122%	82%	106%	110%	155%	309%	136%	96%	106%	455%	54%	132%	147%	**150%**	18
	All Reaches	W-05 (% of W-01)	169%	152%	157%	171%	166%	191%	93%	396%	233%	132%	392%	155%	133%	145%	712%	83%	285%	217%	**221%**	18
Dissolved Copper	Reach 1	W-01 (% of W-02)		93%	98%	87%			112%	95%	98%	66%	99%	101%	95%	81%	78%	85%	74%	74%	**89%**	15
	Reach 2	*W-03 (% of W-02)*		*117%*	*103%*	*107%*			*119%*	*114%*	*102%*	*76%*	*88%*	*99%*	*150%*	*107%*	*123%*	*107%*	*106%*	*121%*	*109%*	15
		W-04 (% of W-03)		*105%*	*105%*	*88%*			*84%*	*92%*	*99%*	*105%*	*95%*	*108%*	*56%*	*101%*	*109%*	*104%*	*108%*	*105%*	*98%*	15
		W-04 (% of W-02)		122%	109%	95%			100%	105%	100%	80%	83%	107%	85%	108%	134%	111%	115%	127%	**105%**	15
	Reach 3	W-05 (% of W-04)		96%	94%	118%			127%	112%	106%	119%	117%	90%	107%	104%	85%	107%	106%	98%	**106%**	15
	All Reaches	W-05 (% of W-01)		126%	104%	128%			114%	124%	109%	145%	99%	95%	96%	138%	147%	140%	165%	167%	**126%**	15
Dissolved Lead	Reach 1	W-01 (% of W-02)		83%	71%	73%			66%			95%	68%	104%	210%	69%	65%	72%	49%	56%	**83%**	13
	Reach 2	*W-03 (% of W-02)*		*93%*	*94%*	*96%*			*77%*			*76%*	*34%*	*115%*	*58%*	*118%*	*130%*	*108%*	*100%*	*103%*	*93%*	13
		W-04 (% of W-03)		*122%*	*114%*	*93%*			*112%*			*95%*	*108%*	*113%*	*87%*	*94%*	*83%*	*101%*	*96%*	*109%*	*102%*	13
		W-04 (% of W-02)		114%	107%	89%			86%			72%	37%	130%	51%	111%	107%	109%	96%	112%	**94%**	13
	Reach 3	W-05 (% of W-04)		102%	86%	113%			138%			167%	116%	103%	146%	102%	108%	103%	115%	123%	**117%**	13
	All Reaches	W-05 (% of W-01)		139%	131%	138%			179%			127%	63%	129%	35%	164%	178%	155%	225%	246%	**147%**	13

Figure 3-77: Dry Weather Mass Balance during Events DW-07, DW-09, and DW-11 for Reach 1 (%loads relative to Station W-02)

Station No.	Blackstone R.	Tributary	Outfall/other	Location DW-__	21-Jul-05 7	11-Aug-05 9	14-Sep-05 11	Mean (DW-7, 9, and 11)	21-Jul-05 7	11-Aug-05 9	14-Sep-05 11	Mean (DW-7, 9, and 11)	21-Jul-05 7	11-Aug-05 9	14-Sep-05 11	Mean (DW-7, 9, and 11)	21-Jul-05 7	11-Aug-05 9	14-Sep-05 11	Mean (DW-7, 9, and 11)
					Chloride				***Hardness***				***Fecal Coliform***				***Nitrate***			
W-01	●			Millville *(MA/RI border)*	73.4%	76.4%	71.9%	73.9%	73.3%	69.9%	74.7%	72.6%	66.2%	116.9%	140.0%	107.7%	91.6%	107.9%	127.5%	109.0%
W-23		●		Branch River	7.8%	3.6%	4.2%	5.2%	5.5%	3.2%	3.9%	4.2%	9.3%	37.3%	279.2%	108.6%	3.1%	2.4%	1.3%	2.2%
W-31			●	Cherry Brook	0.2%	0.2%	0.0%	0.2%	0.2%	0.2%	0.0%	0.1%	9.4%	1.8%	0.7%	4.0%	0.1%	0.2%	0.0%	0.1%
W-32			●	Front Street Drain	0.4%	0.3%	0.0%	0.2%	0.5%	0.3%	0.0%	0.3%	0.1%	0.6%	1.1%	0.6%	0.8%	0.8%	0.0%	0.5%
W-13		●		Mill River (confluence w/ BR)	3.9%	3.1%	3.2%	3.4%	2.9%	2.6%	2.9%	2.8%	103.1%	42.3%	66.7%	70.7%	1.5%	1.6%	1.4%	1.5%
W-15		●		Peters River (pre-culvert entry)	1.6%	0.8%	3.4%	1.9%	1.6%	0.7%	3.1%	1.8%	3.6%	1.9%	10.4%	5.3%	0.9%	0.4%	1.2%	0.8%
W-24			●	Woonsocket WWTF	7.5%	--	17.9%	12.7%	12.9%	--	22.7%	17.8%	0.7%	--	11.2%	5.9%	14.2%	--	12.4%	13.3%
W-33			●	Sylvestre Pond Outflow	0.2%	0.2%	0.0%	0.1%	0.2%	0.2%	0.0%	0.1%	0.6%	0.2%	0.0%	0.3%	0.1%	0.1%	0.0%	0.1%
W-02	●			Manville Dam																
Mass Accounted for at Stn. W-02					94.8%	84.4%	100.7%	93.3%	97.1%	77.0%	107.5%	93.9%	192.8%	201.0%	509.4%	301.1%	112.3%	113.4%	143.8%	123.2%
					Ammonia				***Total Kjeldahl Nitrogen***				***Total Nitrogen***				***Total Phosphorus***			
W-01	●			Millville *(MA/RI border)*	57.7%	64.3%	46.2%	56.1%	15.6%	56.4%	51.5%	41.2%	52.2%	88.3%	108.9%	83.1%	99.2%	110.0%	91.3%	100.2%
W-23		●		Branch River	7.2%	6.8%	12.2%	8.7%	5.2%	4.3%	4.9%	4.8%	4.2%	3.1%	2.2%	3.2%	126.1%	55.6%	1.2%	61.0%
W-31			●	Cherry Brook	0.1%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%	0.2%	0.0%	0.1%	0.1%	0.1%	0.0%	0.1%
W-32			●	Front Street Drain	0.2%	0.1%	0.0%	0.1%	0.1%	0.1%	0.0%	0.1%	0.4%	0.5%	0.0%	0.3%	0.1%	0.0%	0.0%	0.1%
W-13		●		Mill River (confluence w/ BR)	0.8%	0.9%	0.8%	0.8%	1.7%	2.3%	2.9%	2.3%	1.6%	1.9%	1.7%	1.7%	1.2%	3.9%	0.2%	1.8%
W-15		●		Peters River (pre-culvert entry)	0.7%	0.1%	0.6%	0.5%	0.6%	0.3%	1.7%	0.8%	0.7%	0.4%	1.3%	0.8%	0.9%	0.7%	0.5%	0.7%
W-24			●	Woonsocket WWTF	18.9%	--	177.6%	98.3%	11.3%	--	12.3%	11.8%	12.7%	--	12.4%	12.6%	3.8%	--	56.0%	29.9%
W-33			●	Sylvestre Pond Outflow	1.0%	0.2%	0.0%	0.4%	0.2%	0.2%	0.0%	0.1%	0.1%	0.1%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%
W-02	●			Manville Dam																
Mass Accounted for at Stn. W-02					86.6%	72.4%	237.6%	132.2%	34.7%	63.6%	73.4%	57.2%	72.1%	94.4%	126.5%	97.7%	231.6%	170.4%	149.3%	183.8%
					Total Suspended Solids				***Volatile Suspended Solids***				***Dissolved Copper***				***Dissolved Lead***			
W-01	●			Millville *(MA/RI border)*	92.8%	23.9%	50.5%	55.7%	92.1%	27.6%	44.6%	54.8%	111.8%	98.1%	98.6%	102.9%	66.2%	--	68.2%	67.2%
W-23		●		Branch River	3.0%	1.0%	4.6%	2.9%	3.2%	1.1%	7.0%	3.8%	8.2%	2.4%	1.7%	4.1%	48.2%	--	8.5%	28.4%
W-31			●	Cherry Brook	0.2%	0.1%	0.1%	0.2%	0.2%	0.1%	0.1%	0.1%	0.2%	0.0%	0.0%	0.1%	1.8%	--	0.0%	0.9%
W-32			●	Front Street Drain	0.5%	0.0%	0.0%	0.2%	0.4%	0.0%	0.0%	0.1%	0.2%	--	0.0%	0.1%	0.4%	--	--	0.4%
W-13		●		Mill River (confluence w/ BR)	1.7%	1.2%	2.4%	1.7%	1.4%	1.5%	2.6%	1.9%	2.7%	0.9%	1.0%	1.5%	14.9%	--	4.0%	9.4%
W-15		●		Peters River (pre-culvert entry)	0.9%	0.1%	4.4%	1.8%	0.7%	0.1%	1.8%	0.9%	0.7%	0.2%	1.0%	0.7%	2.9%	--	1.5%	2.2%
W-24			●	Woonsocket WWTF	2.1%	--	18.5%	10.3%	1.6%	--	14.6%	8.1%	7.6%	--	12.5%	10.1%	--	--	2.9%	2.9%
W-33			●	Sylvestre Pond Outflow	0.2%	0.1%	0.9%	0.4%	0.2%	0.1%	0.1%	0.1%	0.2%	0.1%	0.0%	0.1%	0.5%	--	0.0%	0.3%
W-02	●			Manville Dam																
Mass Accounted for at Stn. W-02					101.5%	26.4%	81.4%	69.8%	99.9%	30.6%	70.9%	67.1%	131.6%	101.7%	114.9%	116.1%	134.8%	--	85.2%	110.0%

Figure 3-78: Dry Weather Mass Balance during Events DW-07, DW-09, and DW-11 for Reach 2 (%loads relative to Station W-02)

Station No.	**Blackstone R.**	**Tributary**	**Outfall/other**	**Location**	**21-Jul-05**	**11-Aug-05**	**14-Sep-05**	**Mean** *(DW-7, 9, and 11)*	**21-Jul-05**	**11-Aug-05**	**14-Sep-05**	**Mean** *(DW-7, 9, and 11)*	**21-Jul-05**	**11-Aug-05**	**14-Sep-05**	**Mean** *(DW-7, 9, and 11)*	**21-Jul-05**	**11-Aug-05**	**14-Sep-05**	**Mean** *(DW-7, 9, and 11)*
				DW-__	7	9	11		7	9	11		7	9	11		7	9	11	
					Chloride				***Hardness***				***Fecal Coliform***				***Nitrate***			
W-02	●			Manville Dam																
W-03	●			George Washington Hwy Bridge	112.6%	104.2%	98.9%	105.2%	96.7%	103.1%	103.0%	100.9%	102.2%	24.1%	95.2%	73.9%	86.5%	93.2%	78.8%	86.2%
W-34			●	Blackstone Canal at Lonsdale	0.05%	0.07%	--	0.06%	0.05%	0.06%	--	0.05%	0.55%	0.11%	--	0.33%	0.03%	0.03%	--	0.03%
W-04	●			Lonsdale Ave	102.6%	106.6%	96.8%	102.0%	84.5%	103.7%	105.8%	98.0%	182.1%	24.3%	1304.5%	503.6%	87.1%	110.7%	100.3%	99.4%
					Ammonia				***Total Kjeldahl Nitrogen***				***Total Nitrogen***				***Total Phosphorus***			
W-02	●			Manville Dam																
W-03	●			George Washington Hwy Bridge	79.9%	80.1%	58.7%	72.9%	72.3%	123.7%	75.0%	90.3%	79.1%	104.9%	77.9%	87.3%	106.1%	173.5%	54.5%	111.4%
W-34			●	Blackstone Canal at Lonsdale	0.01%	0.03%	--	0.02%	0.04%	0.07%	--	0.06%	0.04%	0.04%	--	0.03%	0.03%	0.01%	--	0.02%
W-04	●			Lonsdale Ave	37.4%	78.3%	45.4%	53.7%	59.5%	96.7%	73.9%	76.7%	72.8%	105.3%	93.9%	90.7%	79.1%	78.1%	43.6%	67.0%
					Total Suspended Solids				***Volatile Suspended Solids***				***Dissolved Copper***				***Dissolved Lead***			
W-02	●			Manville Dam																
W-03	●			George Washington Hwy Bridge	100.1%	42.9%	68.9%	70.6%	98.5%	51.1%	62.5%	70.7%	119.3%	101.7%	87.6%	102.9%	76.7%	--	34.3%	55.5%
W-34			●	Blackstone Canal at Lonsdale	0.01%	0.03%	--	0.02%	0.00%	0.03%	--	0.02%	0.05%	0.04%	--	0.03%	0.17%	--	--	0.17%
W-04	●			Lonsdale Ave	113.7%	51.7%	71.0%	78.8%	104.7%	58.1%	56.7%	73.2%	100.4%	100.3%	83.4%	94.7%	85.7%	--	37.0%	61.4%

Figure 3-79: Dry Weather Mass Balance during Events DW-07, DW-09, and DW-11 for Reach 3 (%loads relative to Station W-04)

Station No.	Blackstone R.	Tributary	Outfall/other	Location DW-__	21-Jul-05 7	11-Aug-05 9	14-Sep-05 11	Mean (DW-7, 9, and 11)	21-Jul-05 7	11-Aug-05 9	14-Sep-05 11	Mean (DW-7, 9, and 11)	21-Jul-05 7	11-Aug-05 9	14-Sep-05 11	Mean (DW-7, 9, and 11)	21-Jul-05 7	11-Aug-05 9	14-Sep-05 11	Mean (DW-7, 9, and 11)
					Chloride				***Hardness***				***Fecal Coliform***				***Nitrate***			
W-04	●			Lonsdale Ave																
W-26		●		Abbott Run Brook	5.8%	26.5%	13.9%	15.4%	7.7%	28.2%	13.5%	16.5%	0.9%	27.4%	2.6%	10.3%	4.3%	21.1%	4.2%	9.8%
W-05	●			Slaters Mill Dam	110.3%	126.0%	137.0%	124.4%	130.0%	124.0%	133.5%	129.1%	336.9%	537.3%	20.8%	298.3%	110.7%	98.2%	77.3%	95.4%
					Ammonia				***Total Kjeldahl Nitrogen***				***Total Nitrogen***				***Total Phosphorus***			
W-04	●			Lonsdale Ave																
W-26		●		Abbott Run Brook	5.2%	24.4%	14.7%	14.8%	4.5%	25.9%	17.9%	16.1%	4.4%	22.8%	6.8%	11.3%	9.4%	25.3%	4.4%	13.0%
W-05	●			Slaters Mill Dam	121.8%	74.5%	118.4%	104.9%	103.9%	200.6%	147.5%	150.7%	107.8%	134.1%	90.9%	110.9%	105.2%	230.8%	16.9%	117.6%
					Total Suspended Solids				***Volatile Suspended Solids***				***Dissolved Copper***				***Dissolved Lead***			
W-04	●			Lonsdale Ave																
W-26		●		Abbott Run Brook	2.7%	27.2%	15.6%	15.1%	3.1%	27.7%	23.5%	18.1%	3.3%	--	--	3.3%	11.9%		40.3%	26.1%
W-05	●			Slaters Mill Dam	83.4%	113.8%	252.5%	149.9%	81.6%	110.4%	308.8%	166.9%	126.9%	106.4%	117.0%	116.8%	138.4%		116.0%	127.2%

Figure 3-80: Dry Weather Mass Balance during Events for the Mill and Peters Rivers

(%change in load relative to previous station)

Station No.	Blackstone R.	Tributary	Outfall/other	Location	16-Mar-05	9-Jun-05	21-Jul-05	11-Aug-05	14-Sep-05	7-Oct-05	22-Oct-05	22-Dec-05	Mean (*) (DW-7, 9, and 11)	Count (DW-7, 9, 11)	Mean (all avail.DW events)	Count (all DW events)
				DW-___	1	5	7	9	11	13	14	16				
Chloride																
W-11		●		**Mill River** *(MA/RI border)*												
W-12		●		Mill River (pre-culvert entry)	107%	93%	97%	100%	92%	96%	99%	98%	97%	3	**98%**	8
W-13		●		Mill River (confluence w/ BR)	100%		110%	106%	119%	98%	100%	103%	112%	3	**105%**	7
Change from W-11 to W-13					107%		107%	106%	110%	94%	99%	101%	108%	3	**103%**	7
W-14		●		**Peters River** (MA/RI border)												
W-15		●		Peters River (pre-culvert entry)	106%	106%	105%	102%	111%	106%	104%	110%	106%	3	**106%**	8
W-15		●		Peters River (confluence w/ BR)	98%			100%	100%	100%			100%	2	**100%**	4
Change from W-14 to W-16					104%			102%	110%	107%			106%	2	**106%**	4
Hardness																
W-11		●		**Mill River** *(MA/RI border)*												
W-12		●		Mill River (pre-culvert entry)	108%	126%	118%	129%	140%	121%	109%	105%	129%	3	**119%**	8
W-13		●		Mill River (confluence w/ BR)	101%		98%	93%	90%	87%	94%	98%	94%	3	**94%**	7
Change from W-11 to W-13					109%		115%	119%	126%	105%	103%	103%	120%	3	**111%**	7
W-14		●		**Peters River** (MA/RI border)												
W-15		●		Peters River (pre-culvert entry)	105%	105%	112%	102%	110%	104%	103%	103%	108%	3	**106%**	8
W-15		●		Peters River (confluence w/ BR)	91%			103%	103%	103%			103%	2	**100%**	4
Change from W-14 to W-16					95%			105%	113%	107%			109%	2	**105%**	4
Fecal Coliform																
W-11		●		**Mill River** *(MA/RI border)*												
W-12		●		Mill River (pre-culvert entry)	7620%	2209%	1435%	8628%	132%	635%	695%	279%	3399%	3	**2704%**	8
W-13		●		Mill River (confluence w/ BR)	27%		126%	48%	101%	46%	31%	37%	92%	3	**59%**	7
Change from W-11 to W-13					2052%		1810%	4106%	134%	295%	216%	103%	2016%	3	**1245%**	7
W-14		●		**Peters River** (MA/RI border)												
W-15		●		Peters River (pre-culvert entry)	395%	349%	34%	88%	180%	324%	396%	26%	101%	3	**224%**	8
W-15		●		Peters River (confluence w/ BR)	182%			101%	247%	74%			174%	2	**151%**	4
Change from W-14 to W-16					721%			89%	443%	240%			266%	2	**373%**	4
Nitrate																
W-11		●		**Mill River** *(MA/RI border)*												
W-12		●		Mill River (pre-culvert entry)	105%		166%	234%	703%	60%	113%	4%	368%	3	**198%**	7
W-13		●		Mill River (confluence w/ BR)	104%		103%	102%	97%	93%	105%	100%	101%	3	**101%**	7
Change from W-11 to W-13					109%		171%	239%	679%	56%	119%	4%	363%	3	**197%**	7
W-14		●		**Peters River** (MA/RI border)												
W-15		●		Peters River (pre-culvert entry)	102%		111%	95%	104%	101%	105%	552%	103%	3	**167%**	7
W-15		●		Peters River (confluence w/ BR)	89%			103%	104%	100%			103%	2	**99%**	4
Change from W-14 to W-16					91%			98%	108%	101%			103%	2	**99%**	4
Ammonia																
W-11		●		**Mill River** *(MA/RI border)*												
W-12		●		Mill River (pre-culvert entry)	102%	91%	244%	51%	103%	102%	315%	153%	133%	3	**145%**	8
W-13		●		Mill River (confluence w/ BR)	101%		42%	100%	45%	100%	32%	105%	62%	3	**75%**	7
Change from W-11 to W-13					103%		103%	51%	47%	102%	102%	160%	67%	3	**95%**	7
W-14		●		**Peters River** (MA/RI border)												
W-15		●		Peters River (pre-culvert entry)	411%	146%	67%	28%	40%	109%	103%	83%	45%	3	**123%**	8
W-15		●		Peters River (confluence w/ BR)	10%			280%	353%	103%			317%	2	**186%**	4
Change from W-14 to W-16					42%			79%	141%	112%			110%	2	**93%**	4
Kjeldahl Nitrogen																
W-11		●		**Mill River** *(MA/RI border)*												
W-12		●		Mill River (pre-culvert entry)	131%	92%	94%	85%	135%	106%	102%	56%	105%	3	**100%**	8
W-13		●		Mill River (confluence w/ BR)	65%		109%	133%	89%	175%	110%	197%	111%	3	**125%**	7
Change from W-11 to W-13					85%		103%	113%	121%	186%	112%	111%	112%	3	**119%**	7
W-14		●		**Peters River** (MA/RI border)												
W-15		●		Peters River (pre-culvert entry)	76%	114%	78%	60%	62%	103%	115%	65%	67%	3	**84%**	8
W-15		●		Peters River (confluence w/ BR)	135%			93%	86%	77%			89%	2	**98%**	4
Change from W-14 to W-16					102%			56%	53%	79%			55%	2	**73%**	4

Figure 3-80 *(cont.)*: Dry Weather Mass Balance during Events for the Mill and Peters Rivers

(%change in load relative to previous station)

Station No.	**Blackstone R.**	**Tributary**	**Outfall/other**	**Location**	**16-Mar-05**	**9-Jun-05**	**21-Jul-05**	**11-Aug-05**	**14-Sep-05**	**7-Oct-05**	**22-Oct-05**	**22-Dec-05**	**Mean (*)** *(DW-7, 9, and 11)*	**Count** *(DW-7, 9, 11)*	**Mean** *(all avail.DW events)*	**Count** *(all DW events)*
				DW-__	1	5	7	9	11	13	14	16				
Total Nitrogen																
W-11		●		**Mill River** *(MA/RI border)*												
W-12		●		Mill River (pre-culvert entry)	117%		118%	138%	253%	83%	106%	18%	170%	3	**119%**	7
W-13		●		Mill River (confluence w/ BR)	83%		106%	114%	94%	144%	108%	180%	105%	3	**118%**	7
Change from W-11 to W-13					98%		126%	158%	236%	119%	114%	32%	173%	3	**126%**	7
W-14		●		**Peters River** (MA/RI border)												
W-15		●		Peters River (pre-culvert entry)	91%		95%	81%	86%	102%	109%	249%	87%	3	**116%**	7
W-15		●		Peters River (confluence w/ BR)	104%			100%	98%	91%			99%	2	**98%**	4
Change from W-14 to W-16					95%			81%	84%	92%			83%	2	**88%**	4
Total Phosphorus																
W-11		●		**Mill River** *(MA/RI border)*												
W-12		●		Mill River (pre-culvert entry)	116%	150%	62%	56%	37%	407%	124%	133%	52%	3	**136%**	8
W-13		●		Mill River (confluence w/ BR)	88%		64%	291%	100%	25%	100%	85%	152%	3	**108%**	7
Change from W-11 to W-13					103%		40%	163%	37%	102%	124%	114%	80%	3	**97%**	7
W-14		●		**Peters River** (MA/RI border)												
W-15		●		Peters River (pre-culvert entry)	36%	82%	160%	195%	139%	103%	139%	100%	165%	3	**119%**	8
W-15		●		Peters River (confluence w/ BR)	326%			61%	32%	320%			47%	2	**185%**	4
Change from W-14 to W-16					116%			118%	45%	328%			82%	2	**152%**	4
Total Suspended Solids																
W-11		●		**Mill River** *(MA/RI border)*												
W-12		●		Mill River (pre-culvert entry)	103%	105%	229%	91%	272%	141%	103%	125%	197%	3	**146%**	8
W-13		●		Mill River (confluence w/ BR)	119%		58%	120%	30%	95%	197%	80%	69%	3	**100%**	7
Change from W-11 to W-13					123%		133%	108%	82%	134%	203%	100%	108%	3	**126%**	7
W-14		●		**Peters River** (MA/RI border)												
W-15		●		Peters River (pre-culvert entry)	269%	83%	143%	52%	152%	36%	110%	113%	116%	3	**120%**	8
W-15		●		Peters River (confluence w/ BR)	35%			257%	46%	178%			152%	2	**129%**	4
Change from W-14 to W-16					95%			133%	71%	64%			102%	2	**91%**	4
Volatile Suspended Solids																
W-11		●		**Mill River** *(MA/RI border)*												
W-12		●		Mill River (pre-culvert entry)	106%	332%	260%	92%	151%	94%	117%	153%	168%	3	**163%**	8
W-13		●		Mill River (confluence w/ BR)	97%		35%	127%	40%	120%	180%	63%	67%	3	**95%**	7
Change from W-11 to W-13					103%		90%	117%	60%	113%	211%	96%	89%	3	**113%**	7
W-14		●		**Peters River** (MA/RI border)												
W-15		●		Peters River (pre-culvert entry)	308%	85%	150%	87%	48%	90%	117%	52%	95%	3	**117%**	8
W-15		●		Peters River (confluence w/ BR)	31%			218%	87%	24%			153%	2	**90%**	4
Change from W-14 to W-16					96%			191%	42%	22%			116%	2	**87%**	4
Dissolved Copper																
W-11		●		**Mill River** *(MA/RI border)*												
W-12		●		Mill River (pre-culvert entry)			112%		126%	129%	113%	102%	119%	2	**116%**	5
W-13		●		Mill River (confluence w/ BR)			110%		100%	200%	100%	88%	105%	2	**120%**	5
Change from W-11 to W-13							122%		126%	258%	113%	90%	124%	2	**142%**	5
W-14		●		**Peters River** (MA/RI border)												
W-15		●		Peters River (pre-culvert entry)			122%		137%	142%	114%	62%	129%	2	**115%**	5
W-15		●		Peters River (confluence w/ BR)				83%	83%	72%			83%	2	**80%**	3
Change from W-14 to W-16									114%	103%			114%	1	**108%**	2
Disssolved Lead																
W-11		●		**Mill River** *(MA/RI border)*												
W-12		●		Mill River (pre-culvert entry)			102%	35%	78%	509%	102%	101%	72%	3	**154%**	6
W-13		●		Mill River (confluence w/ BR)			122%	282%	262%	50%	165%	91%	222%	3	**162%**	6
Change from W-11 to W-13							125%	99%	205%	255%	168%	91%	143%	3	**157%**	6
W-14		●		**Peters River** (MA/RI border)												
W-15		●		Peters River (pre-culvert entry)			116%		46%	143%	131%	41%	81%	2	**95%**	5
W-15		●		Peters River (confluence w/ BR)				83%	98%	56%			91%	2	**79%**	3
Change from W-14 to W-16									45%	80%			45%	1	**63%**	2

(*) Dry weather events DW-7, 9 and 11 are highlighted and a mean computed for comparison with the Blackstone River data (Figures 3-77 to 3-79).

4.0 BLACKSTONE RIVER WATER QUALITY - WET WEATHER

A total of four storms were surveyed to assess the water quality in the Blackstone River during wet weather conditions. A storm was defined by at least 0.5 inches of rainfall, and three days of less than 0.1 inches of rainfall per day prior to a storm. Rainfall information was available through either the NWS stations at the Worcester and Providence Airports or through the network of real-time rainfall stations at Weather Underground. In the following discussion two rainfall stations were used to represent the rainfall record, Bellingham, MA and North Smithfield, RI.

During Storm WW-01 (July 8, 2005), Storm WW-03 (October 7-8, 2005), and Storm WW-04 (October 23, 2005) samples were collected along the Blackstone River within Rhode Island. Storm WW-02 (September 15, 2005) was focused on the Mill River and Peters River (during low-flow conditions in the Blackstone River). The goal of the WW-02 survey was to determine the water quality along the entire length of each tributary, including the section within the closed culvert underneath parts of the City of Woonsocket.

A comparison has been made between the BRI and this BTMDL study. The specific conditions of each storm are given in Figure 4-1.

4.1 Descriptions of Storms

4.1.1 Storm WW-01

Storm WW-01, on July 8, 2005, produced 0.96 inches of rainfall over a roughly 8-hour period. Rainfall had occurred on July 6, totaling 2.48 inches ending at approximately 17:00h. Rainfall for WW-01 started at approximately 17:00h on July 8. Although the necessary 3-day antecedent dry period did not occur, the decision to sample this storm was made in conjunction with RIDEM. Station W-16 was not sampled during this storm, as it was not accessible.

Hyetographs from North Smithfield and Bellingham are given in Figure 4-2. Based on the Intensity-Duration-Frequency curves available for Providence (NOAA, 1977), the storm was less than a 1 in 2 year event.

The storm was well distributed throughout the entire watershed although some higher rainfall occurred in some areas (Figures 4-3 and 4-4). The storm moved to the northeast. The time of each Doppler radar image is indicated by the red arrow on the embedded hyetograph for the storm.

Hydrographs of the flows of the Peters River and the Blackstone River (Woonsocket and Roosevelt Avenue stations) are shown in Figures 4-5 to 4-7. Shown on these graphs are also the sampling times for the nearby primary or secondary water quality sampling station (W-14, W-01, W-05, respectively) and the rainfall record of a nearby rainfall gage.

4.1.2 Storm WW-02

Storm WW-02, on September 15, 2005, involved only the Mill River and Peter River watersheds. The storm produced 1.76 inches of rainfall over a roughly 3-hour period. The antecedent dry period criteria were met. The low flow in the Blackstone River allowed access to Station W-16. The prestorm samples were collected as part of the dry weather sampling event DW-11 that occurred on September 14, 2005, approximately 24 hours prior to the start of WW-02.

The storm was very intense and of short duration (Figure 4-8). The two rainfall gaging stations were located near the top and directly west of the bottom of the watersheds. Rainfall patterns from the two stations were similar in size and timing, indicating that the rainfall was distributed across the watershed. Based on the Intensity-Duration-Frequency curves available for Providence (NOAA, 1977), the storm was approximately a 1-2 year event.

There were two peaks in the hydrograph from the Peters River USGS station (Figure 4-9). The first occurred approximately 2.5 hours after the start of the storm which is an indication of the local runoff. The second peak occurred approximately 10 hours after the start of the storm; it is an indication of the time of concentration in the watershed, rather than of multiple storm cells. The hyetographs only support a single storm cell. A total of seven samples were collected, distributed through the first flush of the event along the rising limb of the hydrograph and through the peak of the flow.

4.1.3 Storm WW-03

Storm WW-03, on October 7-8, 2005, produced 2.72 inches of rainfall over a roughly 29-hour period. The antecedent dry period criteria were met. Low flows in the Blackstone River allowed for sampling of Station W-16. The prestorm samples were collected on October 7, 2005 as part of dry weather event DW-13, approximately 12 hours prior to the start of WW-03.

The storm started gradually and had a peak toward the end of the storm, as shown on the two hyetographs (Figure 4-10). Based on the Intensity-Duration-Frequency curves available for Providence (NOAA, 1977), the storm was less than a 1 in 2 year event.

As shown on the Doppler images for WW-03 (Figures 4-11 to 4-13), the storm was a large system extending from Canada to North Carolina. Rainfall started around midnight on October 7, 2005. Over the next 24 hours it rained continuously between 0.02 and 0.07 inches/hr (between 0.6 and 0.7 inches of rainfall). During this time period, the primary stations were sampled 4 times.

Imbedded in the storm front were individual convective cells that had the potential for heavy rainfall (yellow areas in Figure 4-12, marked by red circles). At 08:19h on October 8, 2005, these thunderstorms were located in two groups: (1) eastern Pennsylvania and western New Jersey and (2) northeast North Carolina and Southern Virginia. The storm proceeded up the coast, gradually moving east. The first of the two thunderstorm groups moved west of Rhode Island in eastern New York state and western Connecticut. The second reached central Connecticut around midnight on October 8, 2005 (Figure 4-12). The eastern edge of the thunderstorm cell moved up through western Rhode Island and reached the Woonsocket area at around 02:00h on October 9, 26 hours after the start of the storm. The heavier rainfall lasted for approximately 2 to 3 hours. Approximately 2 inches of rain fell after midnight adding to the 0.6 to 0.7 inches for the preceding 24 hour period.

Flow in the Peters River and Blackstone River (Woonsocket and Roosevelt gaging stations) are shown in Figures 4-14 to 4-16. Shown on these graphs are also the sampling times for the respective nearest primary or secondary water quality sampling stations and the rainfall record of the nearest rainfall gage.

4.1.4 Storm WW-04

Storm WW-04, on October 23, 2005, produced 0.61 inches of rainfall over a 14-hour period. The antecedent dry period criteria were met. High water levels in the Blackstone River prevented sampling at Station W-16. The prestorm sample was taken on October 22, as part of dry weather event DW-14.

The storm lasted less than 20 hours (Figure 4-17). Based on the Intensity-Duration-Frequency curves available for Providence (NOAA, 1977), the storm was less than a 1 in 2 year event.

Storm WW-04 was a large yet not well organized system, moving to the northeast (Figure 4-18). Nevertheless, rainfall was continuous with no significant breaks. The storm covered the entire watershed.

Flow in the Peters River and Blackstone River (Woonsocket and Roosevelt Avenue gaging stations) are shown in Figures 4-19 to 4-21. Shown on these graphs are also the sampling times for a nearby primary or secondary water quality sampling stations and the rainfall record of a nearby rainfall gage.

4.2 Methodology

4.2.1 Stations

Original Sample Design

Samples were to be collected at the same stations as during the dry weather survey (Figure 3-1 in Section 3). The goal was to monitor the river until the wet weather contribution from Worcester had arrived and essentially passed the MA/RI State line and Slater Mill. Constant monitoring of depth at the station, and flows/depths at the USGS gages at Northbridge and Woonsocket was to be conducted to understand the storm pattern. A prestorm sample was to be collected for all four storms. Frequency intervals were to be determined during the storm with the goal to collect representative samples throughout the storm.

- *Stations W-01 and W-02:* The storm was to be sampled over a minimum of 36 hours and a maximum of 72 hours with a total of 16 samples to be taken with between 10 and 16 samples to be analyzed based on the hydrograph.

- *Stations W-03, W-04 and W-05:* The storm was to be sampled over a minimum of a 48 hour period and a maximum of 96 hours, starting at the same time as W-01 with a total of 24 samples to be taken with between 12 and 18 samples to be analyzed based on the hydrograph.

- *Mill/Peters River stations:* For stations along the Mill River (W-11, W-12, W-13) and the Peters River (W-14, W-15, W-16), all 5 collected samples were to be analyzed. These samples were to consist of the following: prestorm, first flush, and three other samples as the stormwater volume "tail off".

- *Tertiary Stations:* For these stations, the Worcester contribution was actually not desirable. Instead, desirable was only the RI/Woonsocket/Valley Falls Pond contribution. Specifically, we were only interested in the period surrounding the storm and for several hours after its completion. For Storm WW-01, two samples were to be collected at the river stations at or near the peak flow from local runoff. The end of pipe sampling was to include one sample during first flush and the second at or near the peak flow from local runoff.

Actual Sampling

A total of 349 samples had been proposed to be collected; 348 were actually collected (Figure 4-22). Samples were not taken at W-16 during WW-01 and WW-04 because the high Blackstone River water levels prohibited access.

The proposed and actual times of sampling are compared in Figure 4-23. All sampling frequencies from prestorm to the final run were within the proposed range.

The sampling runs corresponding with first flush, local peak and arrival of the flow peak from the Blackstone headwaters (Worcester Peak) are given in Figure 4-24. The requirements in the original sampling plan were met.

4.2.2 Parameters

Samples from Storms WW-01, WW-03 and WW-04 were analyzed for the same parameters as the samples collected during the dry weather events: pathogens (fecal coliform, enterococci), metals (dissolved copper and lead), hardness, total and volatile suspended solids, nutrients (total phosphorus, total Kjeldahl nitrogen, nitrate, and ammonia. In-situ parameters measured in the field consisted of dissolved oxygen, temperature, specific conductance, turbidity, pH, and chloride.

During Storm WW-02, a total of up to 7 samples were collected during the storm at each of the following stations: W-11 to W-13 (Mill River) and W-14 to W-16 (Peters River). Samples were analyzed for pathogens (fecal coliform, enterococci), metals (dissolved lead and copper), and hardness. In-situ field measurements consisted of temperature, specific conductance, turbidity, and pH.

Selected samples from Runs 2 and 4 of Storm WW-04 were reanalyzed for metals, because the original data obtained from the laboratory STL were very high. Reanalyses were performed by Microinorganics for dissolved lead on the unfiltered original sample and the sample filtered by STL (Samples W-21, W-22, W-23, W-31). Subsequently, reanalyses were performed by Microinorganics also for total lead on the unfiltered original sample after acidification to obtain the total recoverable (Samples W-01, W-02, W-21, W-22, W-23, W-31). Results are included in Table B-3 in Appendix B.

The wet weather concentrations in the data tables of this section are provided in the same manner as for the dry weather data (see Section 3.1.2). Dissolved copper and lead concentrations obtained by Mitkem for Storm 1 were removed from the data tables in Section 4, but provided in Tables B-6 and B-7 in Appendix B.

4.2.3 Flow

Flows along the Blackstone River were developed in the following manner (Figure 4-25):

- Flows were available from four USGS gages in RI at their 15 or 20 minute intervals including the Blackstone River at Woonsocket and Roosevelt Ave, Peters River, and Branch River.
- Flows were directly measured at the time of sampling for a few select stations.
- Stage-Discharge relationships for W-01, W-02 and W-05 were developed from the dry weather estimates of flow, and stage readings taken at the time of the sampling were used to estimate flows.
- Average flows from the Woonsocket WWTF (Station W-24) were available from WWTF personnel and RIDEM.

- For the Mill River, when USGS flows were not reported for several months at the end of the study, a relationship between the Mill River and Peters River was developed. Specifically, the Peters River flow for those months was used to estimate flows at Mill River station W-11.

- All other stations had flows estimated by mass balance using the groundwater incremental inflows estimated from stations with known flows.

The flows for all storms at each station are presented in Figures 4-26 to 4-29. A summary of the prestorm, local peak, and runoff peak flows are presented in Figure 4-30.

The two USGS gages along the mainstem of the Blackstone River provided valuable flow information for the generation of the river's hydrographs. The daily average flows for the two stations that were reported by USGS are given in Figures 4-31 to 4-33. All data have been reported as acceptable for publication except the October 2005 data at the Woonsocket gage, which was still listed as provisional at the time of the data analysis for this report.

The daily average flows at the USGS Woonsocket gage were higher than those reported at the Roosevelt Avenue gage, specifically for flows between approximately 1,000 and 6,000 cfs (Figures 4-31 to 4-33). This would be expected if there was significant time of travel between stations or if the peak of the hydrograph occurred at the end of a day and was recorded at the upper station on the day before it was recorded at the lower station (i.e., the offset would be a result of a time lag in travel of increased flows between stations). In general, however, average flows should be slightly higher on average (for the several days involving a storm signal) at the downstream station due to the contributions of tributaries, stormwater pipes, non-point source surface water runoff, and groundwater inflows between gages. This is not the case for all three storms. The greatest difference occurred during Storm WW-03. This was a problem for the evaluation of the mass loadings, particularly in Reach 2 for which the flows from the two gages were used to estimate flows at Stations W-03 and W-04. In our analysis, flows were used as published by the USGS. If indeed the recorded USGS flows were lower than the actual flows at the Roosevelt Avenue station, then the mass loads for Reaches 2 and 3 as determined in this study would be higher by possibly up 20% on specific days.

4.2.4 Evaluation of Data for Compliance

The evaluation of the wet weather event data for compliance with the regulatory requirements was discussed in Section 3.1.3 together with the evaluation of the dry weather data.

4.2.5 Data Analysis

Event Mean Concentrations (EMC), or geometric means for pathogens, were calculated for each station for each storm for all runs with the exception of the prestorm run.

The primary stations (W-01 to W-05), all located along the Blackstone River, allowed for the best evaluation for the entire storm, since these stations were sampled during all runs. Less frequently sampled Blackstone River stations (W-21, W-22, W-17, W-25) provided information at points in-between the primary stations. However, on average only 2 to 3 samples were collected, typically at first flush and at local flow peaks. Therefore, the EMCs for these stations may be higher than the complete storm EMC.

The stations along the Mill River and Peters River (W-11 to W-16) provided a comparable estimate of the storm's EMC from first flush through and just after the peak load. The sampling program did not extend to the end of the respective storm.

Two to three samples were collected at tributaries and outfalls. The goal was to monitor the first flush and local peak. Generally, there is a rapid response in the flow at these stations from rainfall changes. Therefore, the sampling scheme provided a reasonable estimate of the storm's EMC. The loading from the Branch River and Abbott Run Brook, on the other hand, may be underestimated, since the response of these comparatively large watersheds may be considerably longer than the monitoring period used in the study.

The samples collected at Station W-24 (Woonsocket WWTF) consisted of 24-hour flow-weighted composites. The samples represented the daily performance of the facility and provided a reasonable estimate of the WWTF's contribution for the 2 to 3 day period of the hydrograph.

4.3 Results

4.3.1 Pathogens

Fecal Coliform

Fecal coliform concentrations for all four storms are provided in Figures 4-34 and 4-35. Fecal coliform geometric means are summarized in Figure 4-36 for each station for each storm for all runs, with the exception of the prestorm run. Profiles for the study area are provided in Figures 4-37 to 4-40 for Storms WW-01 to WW-04, respectively. The 90th percentile values are also presented. The following observations are made from these figures (profiles are broken into watershed sections for ease of discussion; the section numbers are shown in circles along the x-axis):

- Station W-01 (Section 1): All samples at the MA/RI State line exceeded fecal coliform concentrations of 500 MPN/100 ml.

- W-23 (Section 2): Fecal coliform concentrations in the Branch River were high for two out of the three storms.

- For the Mill River (Section 3), the concentrations were the lowest at the State line (Station W-11) and highest at the middle station (W-12). Stations W-12 and W-13 significantly exceeded the 200 MPN/100 ml standard for three of the storms (Storms WW-01 to WW-03). W-11 was either at or below 200 MPN/100 ml. All three stations were below 200 MPN/100 ml during Storm WW-04. This was to be expected since the baseline flow during WW-04 was high and consequently the dilution ratio was high.

- For the Peters River (Section 4), all samples for all storms exceeded 500 MPN/100 ml. Some of the highest fecal coliform concentrations in the river were recorded at the State line.

- W-02 to W-04 (Section 5): No significant or consistent increases or decreases in the fecal coliform concentrations occurred between these stations.

- W-26 (Section 6): Fecal coliform concentrations in the Abbott Run Brook were very low. There was no upstream source indicated.

- W-05 (Section 7): There was a significant and consistent increase between Stations W-04 and W-05.

- For Storm WW-01, the three highest average values were in three out of four small tributary stations: W-31, W-32 and W-33. This was repeated during Storm WW-03 for all three stations and for Station W-32 during Storm WW-04. This is significant.

Enterococci

Enterococci concentrations were determined for all primary stations for Storms WW-01, 03, and 04 and for the Mill and Peters Rivers during WW-02. Enterococci concentrations for all four storms are provided in Figure 4-41 and 4-42. Geometric means are summarized in Figure 4-36 for each station for each storm for all runs, with the exception of the prestorm run. Profiles for the four storms are provided in Figures 4-43 to 4-46. The 90th percentile values are also presented. The following observations may be made from these data:

- All primary stations along the Blackstone River had similar concentrations. This was true for all storms. No consistent increase or decrease occurred between stations.

- In the Mill and Peters Rivers, the pattern for enterococci and fecal coliform were similar. Examples are as follows:

    - Mill River: The lowest concentrations occurred at the State line. There were significant increases between Stations W-11 and W-12. A slight decrease was observed at Station W-13.

    - Peters River: High concentrations occurred at the State line. No significant increase or decrease was observed between Stations W-14, W-15, and W-16.

Comparison between 1991 BRI and 2005 BTMDL Studies

There were nine stations used in the historic comparison between the 1991 BRI study and the 2005 BTMDL study. The location of seven of these stations was the same (W-23, 11, 14, 17, 02, 04, 05) and two stations were in close proximity (W-01 and 03). The geometric means with maximums and minimums are presented on Figure 4-47. The BRI data represent an average of three storms. BTMDL data are reported for Storms WW-01, WW-03 and WW-04 in this order for each station. Care must be taken in evaluating trends, since loadings are dependent on the characteristics of the storm. The comparison suggests the following:

- All three storms in the BTMDL had higher average and maximum concentrations at the State line (Station W-01) than in the BRI.

- Average concentrations along the Branch River had a relatively high variability during the BTMDL. The range observed during the BRI essentially covers the range of concentrations observed in the BTMDL.

- The high average concentration reported at Station W-14 during the BRI was not observed in the BTMDL.

- Concentrations were similar in the BRI and BTMDL studies in the lower Blackstone River (Stations W-02 to W-05).

- The most obvious and consistent change was an increase which occurred in the last reach between Stations W-04 and W-05.

4.3.2 Nutrients

Nutrient concentrations for all storms are presented in Figures 4-48 to 4-55. Nutrient EMCs were calculated for each station for each storm for all runs with the exception of the prestorm run (Figure 4-56). Profiles of nutrient EMCs for the entire study area for Storms WW-01, WW-03, and WW-04 are provided in Figures 4-57 to 4-60. These profiles include EMCs of the small tributary stations. The following observations were made:

Nitrate

- The Branch River, Mill River, Peters River, and Abbott Run Brook, as well as Station W-31 and W-33 had low nitrate concentrations relative to the Blackstone River, suggesting that there were no apparent sources in these watersheds.

- The nitrate concentrations in the mainstem Blackstone River did not vary much between Stations W-01 and W-05.

- Occasionally there were high concentrations both at secondary stations in the Blackstone River. As indicated above, these concentrations reflect more the first flush and peak flow conditions rather than overall average storm average condition.

- The data suggest that there is a potential source of nitrate in both watersheds draining to Stations W-32 (Front Street drain) and W-34 (Blackstone Canal).

Ammonia

- The majority of the samples taken during Storm WW-03 had concentrations below the reporting limit (i.e., of <0.20 mg/l). In determining the EMCs for ammonia all samples at this level were taken as one half of the reporting level. However, the low concentrations in many of the samples prevented any meaningful interpretation of the data.

- The Mill and Peters Rivers had low ammonia concentrations relative to the Blackstone River. There was no apparent source of ammonia in these watersheds.

- There appears to be a gradual decrease in ammonia concentrations in the Blackstone River below Station W-02. This may be an indication of nitrification.

- Occasionally there were high EMCs in the secondary stations of the Blackstone River. As indicated above, these EMCs reflect more the first flush and peak flow conditions rather than overall average storm average condition.

- The single high concentration reported for Abbott Run Brook (0.83 mg/l) was the highest reported concentration for all stations. This concentration was unusual and would need additional data to explain it since there was no resulting jump in the concentration at the downstream Blackstone River station W-05.

Total Phosphorus

- Concentrations in the Blackstone River were significantly higher during Storm WW-03 (approximately 0.40 mg/l) than during any other storm (typically in the 0.20 to 0.25 mg/l range).

- During the three storms (WW-01, 03, 04), concentrations at the State line were typically equal to or slightly greater than those on the lower Blackstone River.

- Concentrations in the Branch River, Mill River, Peters River, and Abbott Run Brook (typically in the 0.05 to 0.10 mg/l range) were low relative to the Blackstone River, suggesting that there were no apparent sources in these watersheds.

Comparison between 1991 BRI and 2005 BTMDL Studies

There are nine stations used in the historic comparison between the 1991 BRI study and this study conducted in 2005. The location of seven of these stations was the same (W-23, 11, 14, 17, 02, 04, 05) and two stations were in close proximity (W-01 and 03). The means with maximums and minimums are presented on Figure 4-61 to 4-62 for ammonia and nitrate, respectively. The BRI data consisted of an average of three storms. BTMDL data are reported for WW-01, WW-03 and WW-04 in this order for each station. Care must be taken in evaluating trends, since loadings are dependent on the characteristics of the storm. The comparison suggests the following:

- *Ammonia:* The major difference between the two studies is an obvious improvement along the mainstem of the Blackstone River. Concentrations at Stations W-02, W-04, and W-05 were higher in the BRI study than in the BTMDL study. The difference likely lies in the reduction of the ammonia load in the drainage area between W-17 and W-02 which would include the Woonsocket WWTF. The improvement would be higher dissolved oxygen concentrations along the mainstem, since oxygen demand, associated with nitrification, would have been significant during the BRI, but minor during the BTMDL.

- *Nitrate:* Similar to ammonia, the major difference between the studies are the nitrate EMCs below Station W-02. Nitrate EMCs are significantly higher for the BRI. The overall nitrate concentrations at the State line on average did not change.

4.3.3 Suspended Solids

Concentrations

Total suspended solids (TSS) and volatile suspended solids (VSS) concentrations for all storms are presented in Figures 4-63 to 4-66. EMCs were calculated for each station for each storm for all runs with the exception of the prestorm run (Figure 4-67). Profiles for TSS and VSS for the study area are provided in Figures 4-68 to 4-69, respectively. The following observations are made from these data:

- The average EMCs in the Blackstone River were comparatively constant.

- Highest concentrations were measured at the State line (Station W-01).

- EMCs of the Branch River, Mill River, Peters River, and Abbott Run Brook were generally lower than the EMCs in the Blackstone River.

Comparison between 1991 BRI and 2005 BTMDL Studies

Comparison of the mean, minimum and maximum of individual BTMDL storms are presented in Figures 4-70 to 4-71. For TSS, data are also available from the BRI study. The following observations are made:

- TSS concentrations in the Blackstone River were considerably higher during the BTMDL study than during the BRI study.
- TSS concentrations in the Mill and Peters Rivers were lower during the BTMDL study than during the BRI study.
- The TSS concentrations in the Branch River were comparatively low during the BTMDL study, but were higher than during the BRI study.
- The patterns of the EMCs for TSS and VSS are similar for the BTMDL data.

4.3.4 Chloride and Hardness

Chloride and hardness data for all storms are presented in Figures 4-72 to 4-75. EMCs were calculated for each station for each storm for all runs with the exception of the prestorm run (Figure 4-76). Profiles for the study area are provided in Figure 4-77 and 4-78 for chloride and hardness, respectively. The EMCs for WW-01, WW-03 and WW-04 are given on each figure along with the outfall stations. The following observations are made from these data:

Chloride

- The mean chloride concentrations along the mainstem of the Blackstone River ranged from 48 to 51 mg/l for all storms.
- Stations W-23 (Branch River) and W-26 (Abbott Run Brook) had the lowest average chloride concentrations, 26 and 31 mg/l, respectively.
- The highest average chloride concentration (68 mg/l) was measured at Station W-34 (Blackstone Canal).

Hardness

The mean hardness for each waterbody during each storm is summarized at the bottom of Figures 4-74 and 4-75. The following observations were made:

- The mean hardness along the mainstem of the Blackstone River ranged from 32 mg/l during Storm WW-04 (which had the highest flow) to 49 mg/l (WW-01) and 50 mg/l (WW-3). The hardness in the river throughout the storms generally decreased slightly between individual sample runs, justifying the approach used for the determination of separate acute metals criteria by sample runs.
- Station W-23 (Branch River) had the lowest range of hardness from 13 to 22 mg/l. This is significant, as it affected the regulatory criteria for copper and lead (see below).

- The mean hardness in the Mill River ranged from 27 to 39 mg/l for individual storms with the lowest hardness during the high-flow Storm WW-04. The hardness in the Peters River was more variable ranging from 25 mg/l (Storm WW-02) to 51 mg/l (Storm WW-03).

4.3.5 Dissolved Copper and Lead

In evaluating the trace metal data, the following must be considered for wet weather conditions (see also Section 3.1.3):

- Chronic criteria are determined by the average hardness calculated for each station for all samples taken during a storm event. A comparison between the criteria and the average metal values for each storm at individual stations is made to determine compliance with the regulatory standards. Computed chronic criteria that apply to the sampled storms are presented in Figure 4-79.

- Acute criteria for copper and lead are based on the average hardness of all stations on a waterbody by run for individual waterbodies (Figures 4-80 to 4-83). For the Blackstone River this consists of the average hardness for all stations along the main stem (W-01, 02, 03, 04, 05, 17, 21, 22, and 25). For the Mill River and Peters River this consists of all the average hardness for W-11 to W-13, and W-14 to W-16, respectively. Individual average hardness values were used for the Branch River (W-23) and Abbott Run Brook (W-26). Individual average hardness values were also used for all small tributaries (W-31, 32, 33, and 34).

It is noted that the dissolved lead and copper data from Storm WW-01 were analyzed by the ICP Method 200.7 with a reporting limit for dissolved lead of 5 ug/l and a method detection limit (MDL) of 0.23 ug/l; for dissolved copper, the limits were 15 ug/l and 3.2 ug/l, respectively. Samples from subsequent storms (WW-02, 03, 04) were analyzed by ICP-MS Method 200.8 with a more sensitive reporting limit for dissolved copper of 1 ug/l and a MDL of 0.4 ug/l; for dissolved lead, the limits were 0.1 ug/l and 0.04 ug/l, respectively. The high RL for Storm WW-01 did not allow for quantification of most samples. As a result, the dissolved copper and lead data from Storm WW-01 were edited. These data are attached as in Tables B-6 and B-7 in Appendix B, but were not used for analyses in this report. QA/QC comparisons for dissolved copper and lead between the STL and Microinorganics laboratories are presented in Tables B-3 and B-4 in Appendix B.

4.3.5.1 Dissolved Copper

Copper concentrations for all storms are presented in Figures 4-84 to 4-85. EMCs were calculated for each station for Storms WW-02 to WW-04 for all runs with the exception of the prestorm run (Figure 4-86). EMCs for key stations for Storms WW-03 and WW-04 are presented along with maximum and minimum observations (Figure 4-87). EMCs are also presented for all stations of Storms WW-02 to WW-04 for comparison (Figure 4-88).

Figures 4-89 to 4-91 presents the mean copper concentrations for three storms (along with the respective chronic criteria from Figure 4-79). Figures 4-92 to 4-94 presents the copper concentrations from three runs by storm (along with the respective computed acute criteria from Figures 4-80 to 4-81). The three runs selected vary between storms and are based on the designation of first flush, local peak and secondary peak (from Worcester). These designations are presented in Figure 4-24.

Concentrations from individual samples were compared to acute and chronic criteria to determine exceedances of the standards. These results are summarized by station in Figure 4-95.

The following observations are made:

Dissolved Copper Concentrations

- Blackstone River: The copper EMCs at the Blackstone River stations ranged between 4 and 8 ug/l (Figures 4-86 to 4-88). Highest concentrations were generally measured at the State line (W-01) and at stations in the City of Woonsocket (Reach 1). The concentrations in the Blackstone River decreased slightly further downstream.

- Branch River: On average, the copper EMCs in the Branch River were approximately two thirds of the EMCs in the Blackstone River.

- Mill and Peters Rivers: The copper EMCs in these two rivers were approximately one half of the EMCs in the Blackstone River. Generally, the EMC in the Mill River increased between the State line (Station W-11) and the confluence with the Blackstone River (Station W-13), suggesting that copper was added within the City of Woonsocket. For the Peters River, the EMC remained comparatively constant between the MA/RI State line (Station W-14) and stations downstream (W-15, 16).

- Abbot Run Brook: The EMC in Abbott Run Brook was low (less than 1 ug/l).

- Small tributaries: The EMCs of the small tributaries ranged between 2 and 5 ug/l.

Chronic Criteria

- Blackstone River: The mean copper concentrations exceeded the chronic criteria at most stations (Figures 4-90, 4-91, and 4-95).

- Branch River: The chronic criteria were exceeded during each storm. During Storm WW-03, the mean concentrations were comparatively low, although the low hardness resulted in an exceedance. During Storm WW-04, the mean concentration was as high as along the Blackstone River.

- Mill and Peters River: The mean copper concentrations were generally below the chronic criteria. Exceptions were copper concentrations in the Peters River during Storm WW-02 at all three stations; hardness values in the Peters River were comparatively low during this storm.

- Abbott Run Brook: Copper concentrations were consistently low and did not exceed the chronic criteria.

- Small tributaries: The chronic criteria were regularly exceeded at Stations W-31 (Cherry Brook) and W-32 (Front Street Drain) (Figures 4-84 and 4-85).

Acute Criteria

- Blackstone River: Acute copper criteria were exceeded partially during Storms WW-03 and WW-04 (Figures 4-84 and 4-85, 4-92 to 4-95). Many of the dissolved copper concentrations at the State line exceeded the acute criteria.

- Branch River: Acute copper criteria were exceeded in about half of the samples, in part due to the low hardness in the river.

- Mill and Peters Rivers: Most of the samples did not exceed the acute criteria, with some exceptions in the Peters River and one exception in the Mille River.

- Abbot Run Brook: No exceedances.

- Small Tributaries: The acute criteria were exceeded once at Stations W-31 and W-32.

4.3.5.2 Dissolved Lead

Lead concentrations for all storms are presented in Figures 4-96 and 4-97. EMCs were calculated for each station for Storms WW-02 to WW-04 for all runs with the exception of the prestorm run (Figure 4-98). EMCs for key stations for Storms WW-03 and WW-04 are presented along with maximum and minimum observations (Figure 4-99). EMCs have also been presented for all four storms for all stations for comparison (Figure 4-100).

Figures 4-101 to 4-103 presents the mean lead concentrations for each storm (along with the respective chronic criteria from Figure 4-79). Figures 4-104 to 4-106 presents the copper concentrations from three runs by storm (along with the respective computed acute criteria from Figures 4-82 and 4-83). The three runs selected vary between storms and are based on the designation of first flush, local peak and secondary peak (from Worcester). These designations are presented in Figure 4-24.

Lead concentrations from individual samples were compared to acute and chronic criteria to determine exceedances of the standards. These results are summarized by station in Figure 4-95.

The following observations are made:

Dissolved Lead Concentrations

- Blackstone River: The lead EMCs at the Blackstone River stations were below 1 ug/l (Figures 4-98 to 4-100). EMCs at the State line were slightly higher than concentrations further downstream for both Storm WW-03.

- Branch River: The lead EMCs in the Branch River were very low during Storm WW-03, but comparatively high during Storm WW-04. The reason for the high concentration during Storm WW-04 is not known. High concentrations occurred during two separate runs. The elevated concentrations are not considered laboratory errors, as the samples were analyzed twice by different laboratories.

- Mill and Peters Rivers: Most of the lead EMCs were below 0.5 ug/l.

- Abbot Run Brook: EMCs were very low (<0.2 mg/l).

- Small tributaries: The EMCs were less than 1.2 ug/l. The chronic criteria were exceeded during at Stations W-32 (front Street Drain) and W-33 (Sylvestre Pond outflow).

Chronic Criteria

- Blackstone River: The mean dissolved lead concentrations did not exceed the chronic criteria.
- Branch River: The chronic criteria were exceeded during Storm WW-04, but not during WW-03.
- Mill and Peters River: No chronic exceedance.
- Abbott Run Brook: No chronic exceedance.
- Small tributaries: No chronic exceedance.

Acute Criteria

- No exceedances of the acute criteria at any station.

4.3.6 Other Parameters

Other parameters consisted of dissolved oxygen, temperature, specific conductance, and pH. Data are presented in Figures 4-107 to 4-114. There are no specific comments except for dissolved oxygen.

Almost all dissolved oxygen concentrations were above the regulatory minimum concentrations of 5 mg/l. The only exception was Station W-14 along the Peters River during Storm WW-03. Concentrations were low during the first half of the storm. However, the dry weather concentration was also low suggesting that conditions other than the stormwater-related runoff caused the reduced dissolved oxygen concentrations.

4.4 Wet Weather Loading by Reach

The storm data were used to assess the wet weather loading of primarily pathogens, nutrients, lead, and copper within the Rhode Island portion of the Blackstone River watershed. For the loading analysis, in-stream geometric mean concentrations were used for pathogens, whereas EMCs were used for metals and nutrients. The data are discussed by significant reach.

4.4.1 Blackstone River Reach 1 *(Woonsocket)*

EMC values were used along with time-weighted flows to develop mass loads at a particular station for each storm. The primary stations were sampled for each run and represent a reasonable estimate of the entire storm's load. Reach 1 is bounded in the north (upstream) by Station W-01 and the south (downstream) by Station W-02.

Inputs within this reach that were monitored consisted of the Mill River and Peters River (represented by Stations W-13 and W-15, respectively), the Woonsocket WWTF (W-24), the Branch River (W-23), and three small tributary stations (W-31, W-32, W-33). None of these stations were impacted by the contribution from Worcester.

The wet weather loads calculated for the Mill and Peters Rivers (W-13, W-15) provide a comparable estimate of the storm's load from first flush through and just after the peak load. The sampling program did not extend to the end of the river's hydrograph.

Loads calculated for the Branch River (W-23), Cherry Brook (W-31), Front Street Drain (W-32) and Sylvestre Pond (W-33) are based on two to three samples. The goal of the sampling program for these stations was to monitor the first flush and local peak. Since there is a rapid flow response in the small tributaries (W-31 to W-33), this sampling scheme provided a reasonable estimate of the storm's contribution to the Blackstone River. For the Branch River, the loading may be underestimated, since the response of its watershed may be considerably longer than the monitoring period. Samples from the Woonsocket WWTF (W-24) were 24-hour flow-weighted composites, representing the daily performance of the facility. Thus, the calculated loads provide a reasonable estimate of the WWTF's contribution for the 2-3 day period of the hydrograph.

Mass balances for each constituent within Reach 1 are presented in Figures 4-115 to 4-121. The loading was related directly to the load at W-02. For instance, the percent of the chloride load contributed from each monitored source during Storm WW-01 relative to the total at W-02 is reported as: W-01 at 85.9%; W-23 at 4.7%; W-31 at 0.1%; W-32 at 0%; W-13 at 4.0%; W-15 at 2.0% W-24 at 2.4%; W-33 at 0.1% (Figure 4-115). When these contributions are totaled approximately 99.4% of the chloride load was identified. The mean loads for Storms WW-01, 03, 04 are presented in the last column of each table. The means are summarized in Figure 4-122.

The following conditions and observations are related to each constituent:

Chloride

On average, approximately 94% of the chlorides were identified with the monitored inputs. Since chloride is a conservative constituent, it indicates that only 6% of runoff/dry weather flow was not monitored.

Approximately 76% of the load at Station W-02 was contributed by Massachusetts (W-01).

Contributions from the Branch River, Mill River, Peters River, and the WWTF were consistent across the three storms and were on average 4.8%, 6.0%, 3.4% and 3.2%, respectively.

Mass contributions from the small tributary stations were small (0.1-0.2%).

Fecal Coliform

To evaluate fecal coliform is problematic. There was more fecal coliform mass at the beginning of Reach 1 (Station W-01) than at the end (W-02). When taking into consideration all measured inputs into this reach, there was on average approximately 1.7 times more fecal coliform entering the reach than leaving. Pathogens are not conservative and their numbers will decline over time and distance. It is possible that this is occurring within this reach. Another possibility is the potential residual disinfection caused by the WWTF effluent. The BRI (1991) found that the chlorine residual in the UBWPAD discharge did continue to kill off pathogens in the receiving water.

Contributions from the Branch, Mill, and Peters Rivers were consistent across the three storms, averaging 14.2%, 10.7%, and 12.7%, respectively.

All three small tributary stations had significant concentrations. The Front Street Drain (W-32) especially had wet weather concentrations that were the highest observed in Reach 1 (46,475, 7,714, and 2,133 MPN/100ml). The impact of these stations on the Blackstone River was collectively around 5% relative to Station W-02.

Additional pathogens are contributed to the Blackstone River by the numerous outfalls in the Woonsocket area. High wet weather fecal coliform concentrations were measured in Outfalls OF-242, 247, 258, 263, and 435 (Figure 5-17). However, only some of the largest outfalls were tested during this study. The total loading from the outfalls in Woonsocket is not known. In addition, a small brook monitored in Massachusetts (OF-601; Fox Brook) contained elevated fecal coliform concentrations during both dry and wet weather conditions.

Nitrate

Like chloride, nitrate is dissolved and thus conservative in the time period of a typical storm signal. Therefore, a balance has significance. On average, 91% of the nitrate load observed at the end of the Reach 1 (W-02) was identified with the monitored inputs. This is similar to the chloride load.

Approximately 74% of the load at W-02 was contributed by Massachusetts (W-01).

Contributions from the Branch, Mill, and Peters River, and the WWTF were consistent across the three storms, averaging 4.2%, 3.1%, 1.5% and 7.6%, respectively.

Mass contributions from the small tributary stations were small (0.1-0.4%)

Ammonia

Ammonia is not conservative. It may readily be converted into nitrite/nitrate. However, based on experiences during the monitoring and modeling in the BRI, the river segment where nitrification was important was below the WWTF, essentially in Reach 2. It was not a major factor in the area from the State line to the WWTF (i.e., within Reach 1).

The majority of the samples taken during Storm WW-03 had concentrations below the reporting limit of 20 mg/l. In determining the EMCs for ammonia all samples at this level were taken as one half of the reporting limit. As shown in Figure 4-118, most of the station EMCs for this storm were less than 0.15 mg/l, preventing a meaningful interpretation of the data.

During Storms WW-01 and WW-04, ammonia concentrations were not as low as during Storm WW-03. If all three storms are included in the mass balance approximately 84% of the ammonia was accounted for. If only WW-01 and WW-04 were used, approximately 97% was accounted for.

For Storms WW-01 and WW-04, approximately 78% of the load at W-02 was contributed by Massachusetts (W-01). Contributions from the Branch, Mill, and Peters River were 10.0%, 3.2%, and 2.4%, respectively. The ammonia load from the WWTF (3.3%) was similar to the loads of the Mill and Peters Rivers.

Mass contributions from the small tributary stations were small (0.1-0.2%).

Total Phosphorus

All of the total phosphorus observed at Station W-02 was accounted for in the mass balance. On average, 103% was monitored with individual storm balances of 95%, 106% and 108%. According to this analysis, there was no additional significant source of total phosphorus in Reach 1.

Approximately 84% of the total phosphorus at W-02 came from Massachusetts (W-01). Contributions from the Branch, Mill, and Peters Rivers, and the WWTF were on average 5.9%, 2.3%, 1.2% and 8.9%, respectively.

Mass contributions from the small tributary stations were small (0.1-0.2%).

Dissolved Copper

Like chloride and nitrate, dissolved copper is expected to be conservative for the length of Reach 1 and the time period of a typical storm signal. Therefore, a balance has significance. For dissolved copper, on average, approximately 110% of the load observed at the end of the reach was identified with the monitored inputs. There did not appear to be other significant sources of copper.

Most of the load at W-02 (91% of the 110% identified at W-02) was attributable to Massachusetts (W-01).

Contributions from the Branch River were not consistent. For Storm WW-03, the EMC was 2.6 µg/l; the mass contribution was 2.6%. The copper EMC and load of Storm WW-04 were much higher (5.45 µg/l and 21%, respectively. This contribution is of concern and further investigation is necessary to confirm this observation.

The Mill River, Peters River, and the WWTF loads were consistent across Storms WW-03 and WW-04 averaging 2.9%, 1.6%, and 1.9%, respectively.

Mass contributions from the small tributary stations were small (0.1-0.2%)

The outfall reconnaissance survey identified elevated copper concentrations in Outfalls OF-235, 242, 243, 247, 258, and 263 during wet weather (Figure 5-17).

Dissolved Lead

The analysis for dissolved lead only includes Storm WW-03. Most of the data from WW-01 and WW-04 were eliminated due to analytical problems.

Like copper, dissolved lead is conservative for the length of Reach 1 within a typical storm signal. Therefore, a balance has significance. For dissolved lead, on average 97% of the load observed at the end of the reach was identified with the monitored inputs. There do not appear to be other significant sources of lead in Reach 1.

Approximately 85% of the load at W-02 was contributed by Massachusetts (W-01).

Contributions from the Branch, Mill, and Peters Rivers, and the WWTF were 3.9%, 6.0%, 1.3% and 0.4%, respectively. The loading from Mill River (W-13) should be investigated further.

Mass contributions from the small tributary stations were small (0.6%).

The outfall reconnaissance survey identified elevated lead concentrations in Outfalls OF-205, 235, 242, 243, 247, 258, and 263 during wet weather (Figure 5-17).

4.4.2 Blackstone River Reach 2 *(Lincoln/Cumberland)*

EMC values were used along with time-weighted flows to develop a mass at a particular station for each storm. The primary stations were sampled for each run and represent a reasonable estimate of the entire storm's load. Reach 2 is the area of the Blackstone River bounded by two primary stations: in the north (upstream) by W-02 and in the south (downstream) by W-04. Primary station W-03 was located midway in the reach. The only other monitored source within Reach 2 was W-34, the outlet for the Blackstone Canal. Since the flow is so low at W-34 (discharge point from the Blackstone Canal), and the watershed area of the canal is comparatively small, it is expected that the mass contribution from this source is insignificant.

Mass balances for each constituent in Reach 2 are presented in Figures 4-123 to 4-131. The loads are related directly to the load at the upstream end of the reach (W-02).

A problem with the mass balance in the reach was the prediction of flows for Stations W-02, W-03 and W-04. These stations use the flows reported by the USGS for their gages at Woonsocket and Roosevelt Avenue. These flows do not balance (see discussion in Section 4.2.3). Flows at the Roosevelt Avenue gage were lower than those reported for the Woonsocket gage. This was especially true for Storms WW-03 and WW-04. Care must be taken in interpreting the data as some increases/reductions in mass may be due to the flow imbalances rather than changes in concentrations.

Chloride and Hardness

Chloride and hardness concentrations were consistent within the reach for each storm. There did not appear to be any significant additions of either constituent along the reach.

Since both are considered conservative and both did not have any real change in concentrations within the reach, the mass balance is a reflection of the flow imbalance. Both parameters are similar: for chloride and hardness, respectively, the results were 99% and 104% (WW-01), 90% and 89% (WW-03), and 77% and 84% (WW-04).

Fecal Coliform

There was no consistency across the storms for this reach. Fecal coliform increased during Storm WW-01, decreased in WW-03, and decreased then increased in WW-04. The comparatively small number of outfalls entering Reach 2 suggests that the variability in the coliform loads could have been a reflection of varying rates of pathogen decay during different storms within this comparatively long reach.

The outfall reconnaissance survey identified elevated fecal coliform concentrations in Outfalls OF-334, 333 (Sneech Brook), 326/327, 325 (Scott Brook), 324, 304, 448, and 422 during wet weather (Figure 5-17).

Total Suspended Solids

Solids concentrations did not vary within the reach, even though runoff from roadways occurs throughout this river segment. It could be that any increase in solids due to runoff was offset with solids settling and there was no net change in the water column. In addition, part of the urban runoff drains into the vegetated flood plain of the river, which allows solids to partially settle out.

Nitrate

There was no consistency in the nitrate loads across the storms for this reach. Nitrate rose slightly during Storm WW-01, decreased slightly in WW-03, and remained constant in WW-04.

Ammonia

During all three storms, ammonia loads decreased in Reach 2. This trend was observed during all three storms, suggesting that this is a real change. This is not unexpected since earlier dissolved oxygen models for the Blackstone River showed ammonia nitrification being important directly below the Woonsocket WWTF. However, if this decline is associated with nitrification, there was no measurable increase in nitrate during Storms WW-03 and WW-04 within this reach.

Total Phosphorus

Total phosphorus did not vary within the reach (Figures 4-85 and 4-130).

Dissolved Copper

Dissolved copper did not vary within the reach.

The outfall reconnaissance survey identified elevated copper concentrations in Outfalls OF-324 and OF-448 during wet weather (Figure 5-17).

Dissolved Lead

For the storm with available dissolved lead data (WW-03), lead concentrations and loads (Figures 4-97 and 4-131) decreased at a greater rate than could be attributed to the flow imbalance between Stations W-02 and W-04. This raises the questions why dissolved lead would decrease while dissolved copper would not. Lead is typically found in rivers with a higher percentage in the particulate fraction. Reach 2 is longer than both Reach 1 and Reach 3. Reach 2 has a series of impoundments between Stations W-02 and W-04. Settling may occur. If particulate lead is lost to the water column in the impoundments, it is possible that a repartitioning of the lead to adjust for this loss could occur reducing the dissolved lead concentration. This would be a viable possibility if the total suspended solids concentrations, in fact, decreased within the reach. Such a decrease was not observed, however, as discussed above.

As for copper, the outfall reconnaissance survey identified elevated lead concentrations in Outfalls OF-324 and OF-448 during wet weather (Figure 5-17).

4.4.3 Blackstone River Reach 3 *(Central Falls/Pawtucket)*

As for Reaches 1 and 2, EMC values were used along with time-weighted flows to develop a mass at a particular station that would be a result of each storm. The primary stations were sampled for each run and represent a reasonable estimate of the entire storm's load. Reach 3 is an area of the lower Blackstone River bounded by primary stations W-04 in the north (upstream) and W-05 in the south (downstream). The only other monitored source was Abbott Run Brook (Station W-26).

Mass balances for each constituent in Reach 3 are presented in Figures 4-132 to 4-140. The loading was related directly to the load at the beginning of the reach (W-04). Mean loads were calculated for all storms and are presented in the last column of each table. These means are summarized in Figure 4-141.

The flow problem of Reach 2 is not an issue in Reach 3. Flows from the Roosevelt Avenue gage were used in the flow estimations.

For many of the constituents (chloride, hardness, TSS, nitrate, total phosphorus), the concentrations and the mass loads did not change between Stations W-04 and W-05. For these constituents, there was no indication of an obvious source within the reach.

For dissolved copper there was no consistent increase or decrease in the concentrations and loads for Storms WW-03 and WW-04. On average, the copper load remained unchanged (99%).

Dissolved lead loads and concentrations decreased again between Stations W-04 and W-05, although data from only one Storm (WW-03) are available.

For ammonia, the majority of the samples taken during Storm WW-03 and WW-04 were below the reporting limit of 0.20 mg/l. In determining the EMCs for ammonia all samples at this level were taken as half of the reporting limit As can be seen in Figure 4-137, most of the station averages for these storms were less than 0.20 mg/l, preventing a meaningful interpretation of the data. For Storm WW-01, the concentrations and mass loads did not change between Stations W-04 and W-05.

The results for the wet weather fecal coliform summarized in Figure 4-134 for Reach 3 supports the dry weather conclusion of a consistent source(s) of fecal coliform within this reach. For the three storms, fecal coliform counts on average almost doubled in the reach. The likely coliform sources are the CSOs within this reach.

The outfall reconnaissance survey identified elevated fecal coliform concentrations in Outfalls OF-302, 318, 317, 316, 311, 501. Copper and lead were elevated in Outfalls OF-302, 318, 317, 316, and 311 (Figure 5-17). In addition, lead was elevated in OF-501 (Figure 5-17). The three most significant outfalls for further monitoring are OF-302, 317, and 501.

4.4.4 Mill River and Peters River

EMC values were used along with time-weighted flows to develop a mass at a particular station for each storm. The primary stations were sampled for each run and represent a reasonable estimate of the entire storm's load. The secondary stations along the Mill and Peters Rivers provide a comparable estimate of the storm's load from first flush through the peak load. The sampling program did not extend to the end of a storm.

Mass balances for each constituent are presented in Figures 4-142 to 4-150. The percent increase or decrease that occurred between stations is reported for each storm. The last column is the mean increase or decrease observed for all storms. This means was compiled for each constituent in a summary table (Figure 4-151).

Chloride/Hardness

In almost all cases, chloride and hardness concentrations did not increase significantly. There was one exception. This exception was during Storm WW-03 where an increase was observed in the EMCs between W-15 and W-16 for chloride and hardness (26 to 56 mg/l, and 36 to 56 mg/l, respectively). However, care must be taken in interpreting this as a positive change. The lowest values reported for W-15 occurred in Run 7, which was not sampled at W-16 and would not have occurred in the average. If a similar value (W-15/Run 7) were used in the average for W-16, the result would be similar to the average at W-15.

Fecal Coliform

In Mill River, Run 1 during Storm WW-02 had high fecal coliform concentrations. This run was taken during the first flush of the storm. The prestorm sample was taken the day before as a dry weather sample (Event DW-11).

The results in the Mill River during wet weather sampling support the dry weather conclusions. The main source of fecal coliform clearly occurred between Stations W-11 and W-12. Increases in the fecal coliform concentrations ranged from a low of 144% (38 to 92 MPN/100ml) to a high of 6,525% (76 to 4,956 MPN/100ml). Based on the outfall reconnaissance survey, the likely sources for this increase are Outfalls OF-703 and/or OF-704 (Figures 5-6 and 5-17).

On average the change in concentrations between Mill River stations W-12 and W-13 was small, suggesting no significant additions in loading.

The results in the Peters River during wet weather sampling were not as spatially specific. Wet weather concentrations at the State line were important with respect to the rest of the river and should be considered if pathogen concentrations are to be reduced in the Peters River. In two of the four storms, the concentrations at the MA/RI State line were the highest on the river. Elevated wet weather fecal coliform concentrations were only measured at Outfall OF-805 (Figures 5-6 and 5-17).

Care should be taken in evaluating the mass balance of the Peters River between Stations W-15 and W-16 during Storm WW-03. For the last sampling run (Run 7), the fecal coliform concentration at W-15 was the highest during the storm (>16,000 MPN/100ml). Station W-16 could not be accessed because of the high river stage in the Blackstone River. This is reflected by the mean concentration at Station W-16; the mean would most likely be higher if Run 7 was available. Also, it is difficult to draw a conclusion for the river segment between Stations W-15 and W-16 with only two data points. In comparison, dry weather data did not indicate a source between Stations W-15 and W-16.

Total Suspended Solids

There is a consistent rise in the total suspended solids load between Mill River stations W-11 and W-12 (231%). This is expected, since W-11 is at the outlet of an impoundment.

The velocity at Mill River station W-12 is very high just before the river goes underground. At the confluence with the Blackstone River (W-13), the channel is wider and the water depth greater, depending on the stage in the Blackstone River. As a result, the velocity in the Mill River is comparatively low. The consistent observation of the decline in solids between W-12 and W-13 is expected with the reduction in velocity (-44%).

Along the tunnel at the confluence of the Peters River with the Blackstone River, debris covers the entire channel. Water flow either has to go through or over the debris pile. There are obvious sand bars in and after the debris piles. Some of the solids likely settle out of the water column. This would not occur if the channel was cleaned out.

Nitrate

EMCs for nitrate are oftentimes separated by several hundreds of a mg/l. There is no obvious pattern in the data, suggesting no obvious source of nitrate in the river segments.

The missing Storm WW-03 Run 7 at Peters River station W-16 likely resulted in a somewhat higher EMC at this station, as compared to Station W-15.

Ammonia

All samples along the Mill and Peters Rivers taken during WW-03 were below the reporting limit of 20 mg/l. Any change suggested in the analysis during this storm would simply reflect the flow changes between stations.

There was a minor decrease in loading along the Mill River between stations W-11 and W-13 during both Storms WW-01 and WW-04 (Figure 4-147).

EMCs for the Peters River were also below the reporting limit during WW-04.

Total Phosphorus

EMCs for total phosphorus are low and oftentimes separated by one or two hundreds of a mg/l. It is difficult to see any significant pattern in most of the data. The only exception to this may be with respect to the small increase observed during all three storms between Mill River stations W-11 and W-12. However, at this time it is difficult to suggest a potential source along this river segment. Between Stations W-11 (MA/RI State line) and the confluence with the Blackstone River, there is essentially no net change.

Dissolved Copper

In two out of the three storms there was a steady rise in the dissolved copper concentrations along the Mill River. This is considered significant. Between Stations W-11 (MA/RI State line) and the confluence with the Blackstone River, the average increase is 32%. None of the discharges from the outfalls that were monitored during the reconnaissance survey had elevated concentrations of copper (Figure 5-17). It is not known if discharges enter the tunneled section of the river.

There is no obvious pattern in the Peters River. EMCs are very similar and indicate no significant source in these river segments. None of the discharges from the outfalls that were monitored during the reconnaissance survey had elevated concentrations of copper.

Dissolved Lead

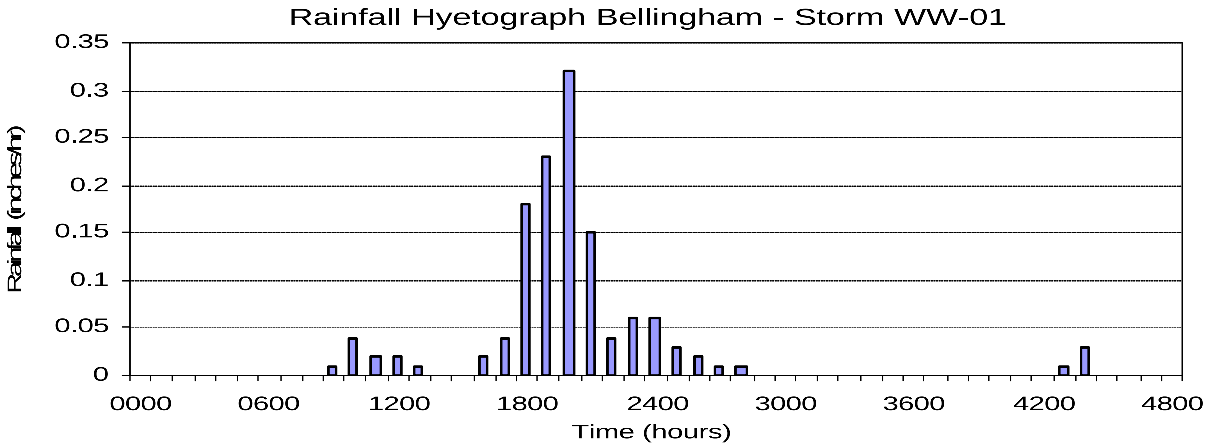
In two out of the three storms there was also a steady rise in dissolved lead concentrations along the Mill River. This is considered significant. Between Stations W-11 (MA/RI State line) and the confluence with the Blackstone River, the average increase was 182%. Storms WW-02 and WW-03 suggest that the increase primarily occurred between Stations W-11 and W-12. Elevated lead concentrations were measured in Outfall OF-704 (Figure 5-17), which enters Mill River within that river section.

Dissolved lead increased also in the Peters River within the tunneled section by on average 66%. As for the Mill River section, it is not known if discharges enter the tunneled section of the river. Slightly elevated lead concentrations were measured in Outfall OF-815 (Figure 5-17), which, however, is located upstream of the tunneled section. The river section between Stations W-14 and W-15 had a small decrease in dissolved lead load (average of -9%).

Figure 4-1: Average Rainfall Characteristics

Characteristic	Blackstone River Initiative (BRI) (1991)			Blackstone TMDL (BTMDL) (2005)			
	Storm 1	Storm 2	Storm 3	Storm WW-01	Storm WW-02	Storm WW-03	Storm WW-04
TR (inch)	0.56	0.88	0.81	0.96	1.76	2.72	0.61
D (hrs)	6.0	16.0	8.5	8.0	3.0	29.0	14.0
ADP (days)	11.0	8.0	8.0	2.0	14.0	9.0	5.0
PI (in/hr)	0.20	0.23	0.52	0.26 (NS)	1.13 (Bell)	0.71 (NS)	0.20 (NS)
AI (in/hr)	0.09	0.06	0.10	0.12	0.59	0.09	0.04

TR = Total Rainfall Based on Thiessen Method
D = Rainfall Duration
PI = Peak Intensity (Station ID)
Bell = Bellingham Rainfall Gaging Station
ADP = Antecedent Dry Period
AI = Average Intensity
NS = North Smithfield Rainfall Gaging Station



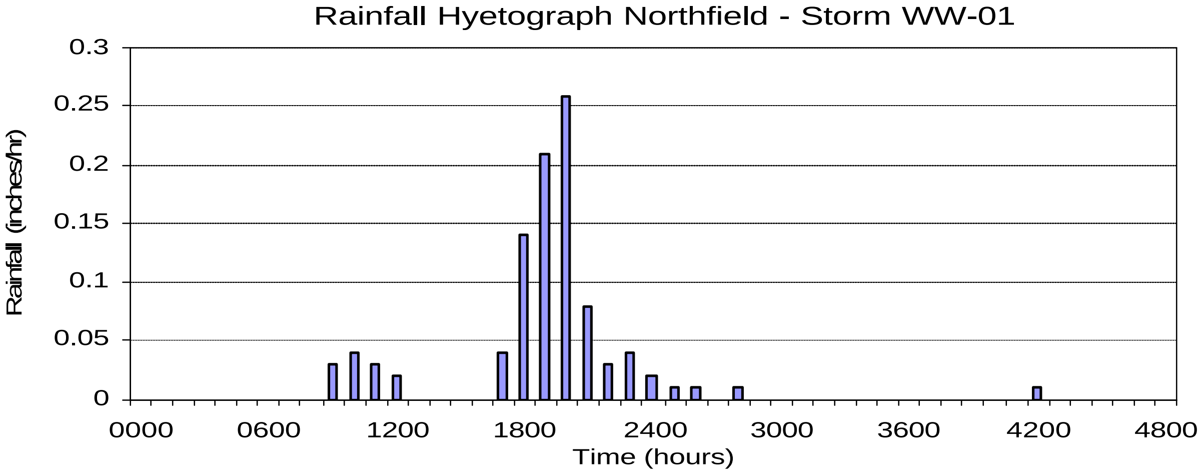


Figure 4-2: Hyetographs for Storm WW-01

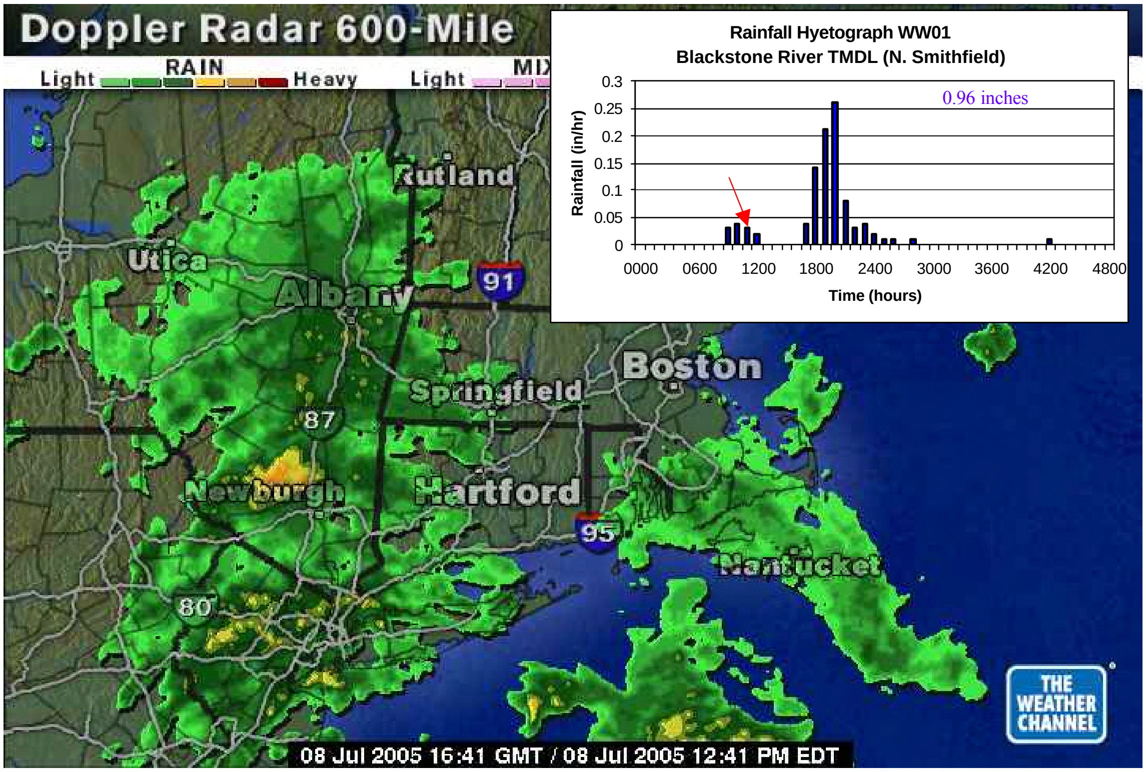


Figure 4-3: Doppler Radar and N. Smithfield Hyetograph, WW-01 (July 8, 2005 at 12:41h).

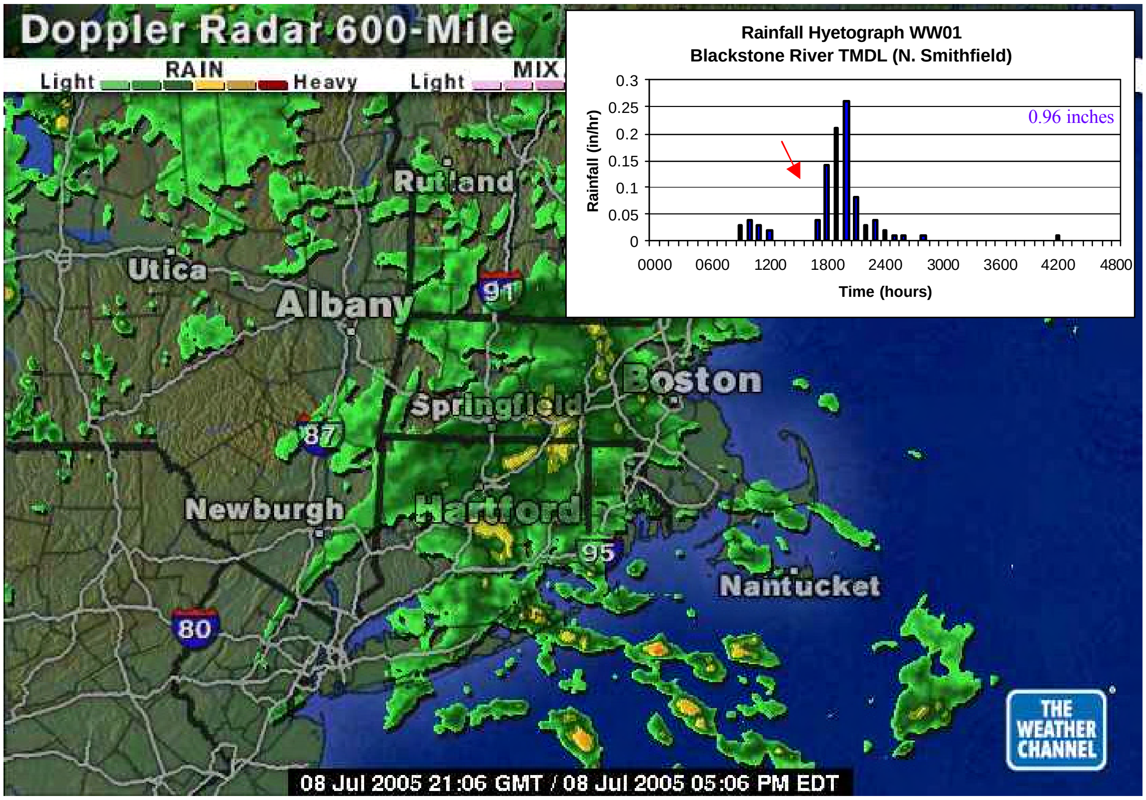


Figure 4-4: Doppler Radar and N. Smithfield Hyetograph, WW-01 (July 8, 2005 at 17:06h).

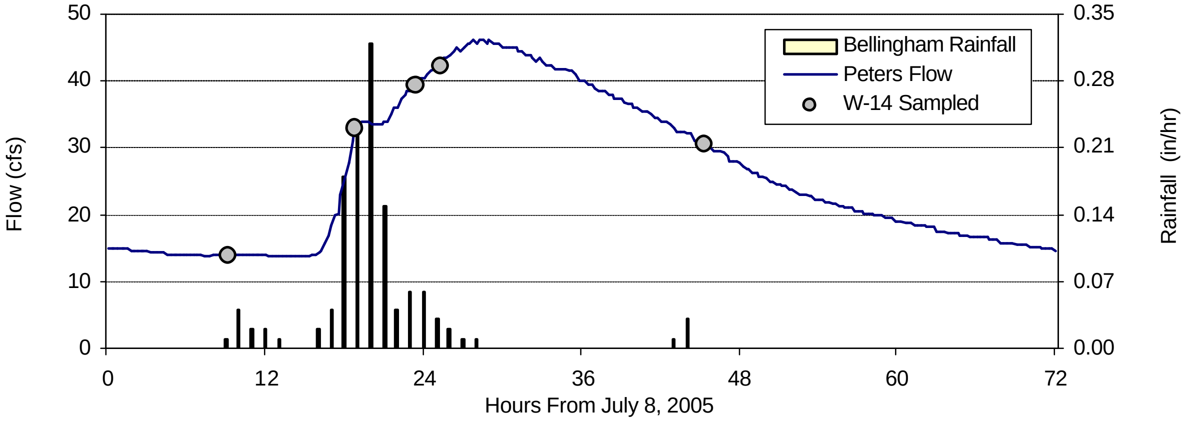


Figure 4-5: Comparison of Bellingham Rainfall and Peters River Flow for WW-01

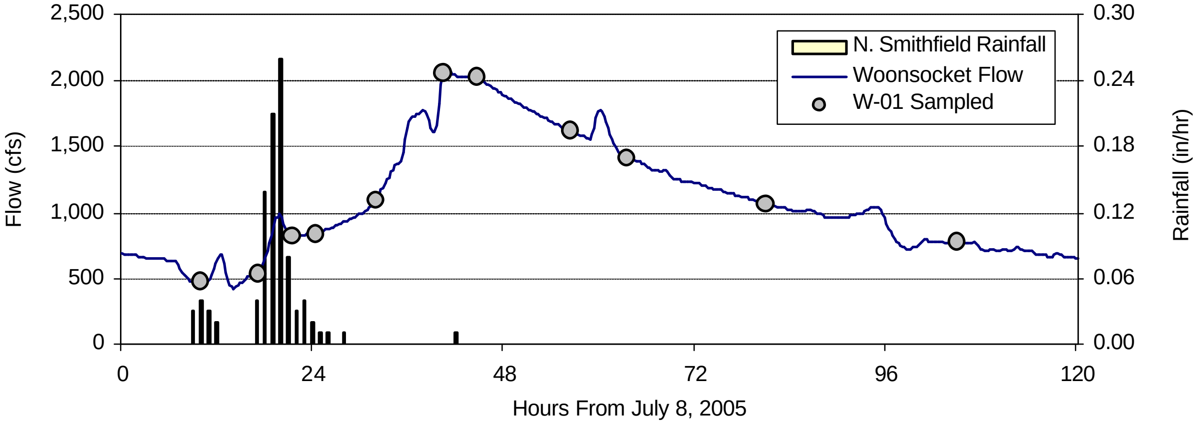


Figure 4-6: Comparison of N. Smithfield Rainfall and Woonsocket Flow for WW-01

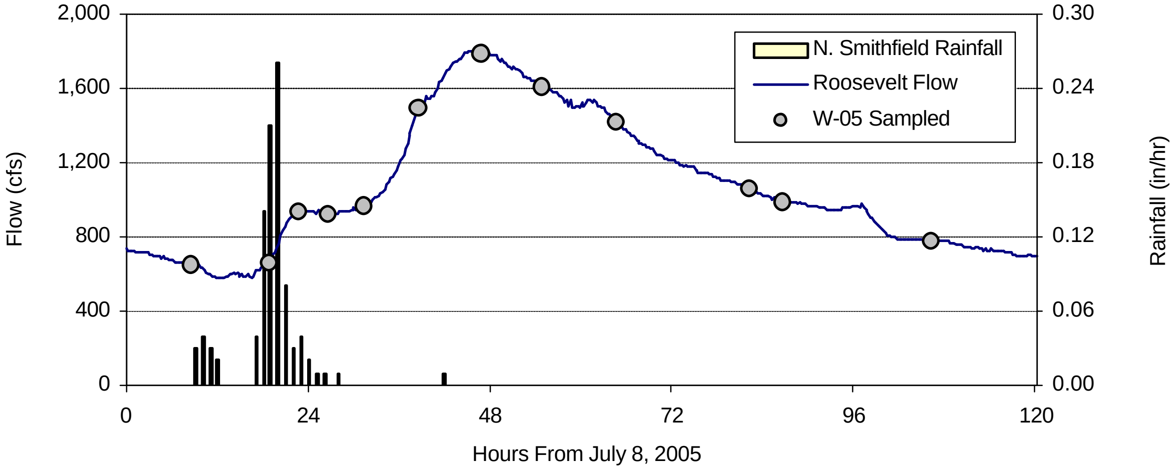


Figure 4-7: Comparison of N. Smithfield Rainfall and Roosevelt Flow for WW-01

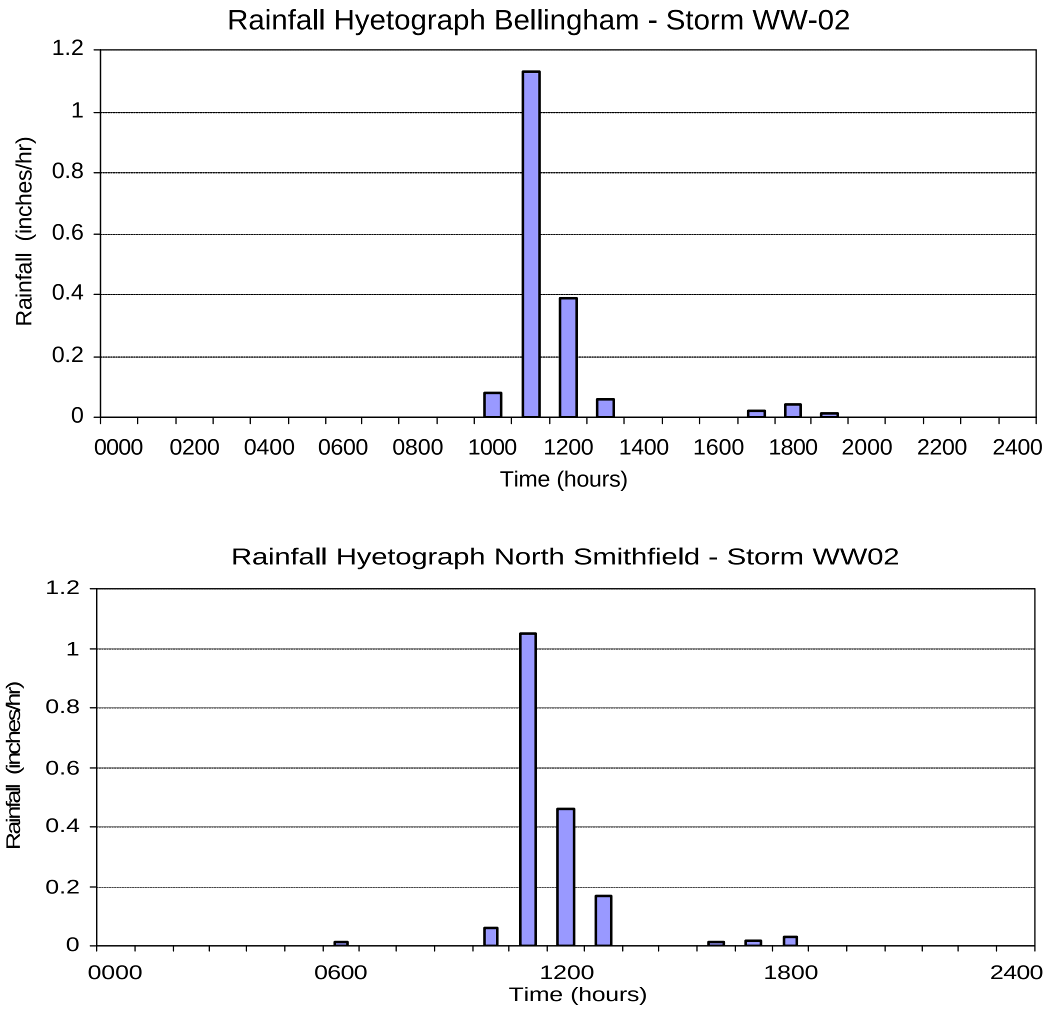


Figure 4-8: Hyetographs for Storm WW-02

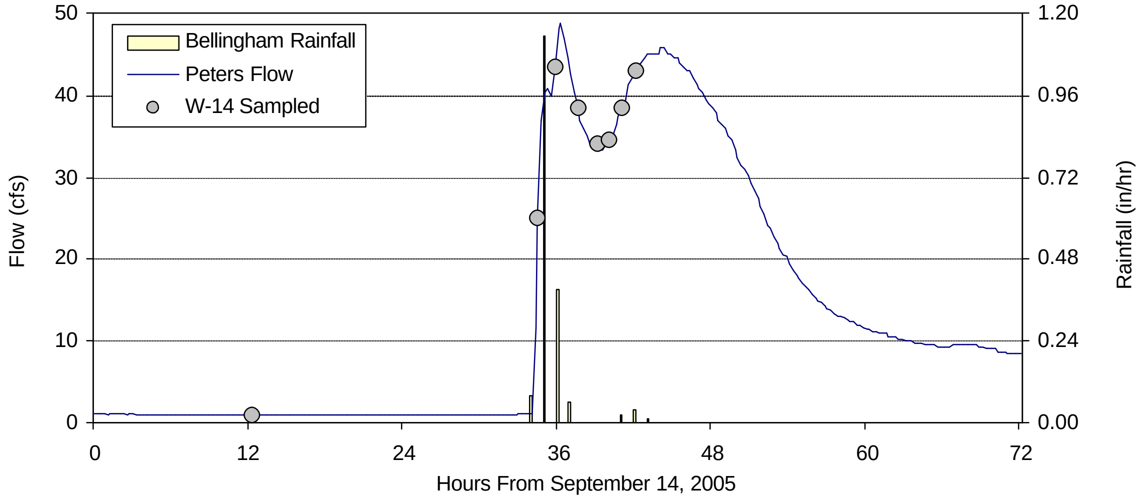


Figure 4-9: Comparison of Bellingham Rainfall and Peters River Flow for WW-02

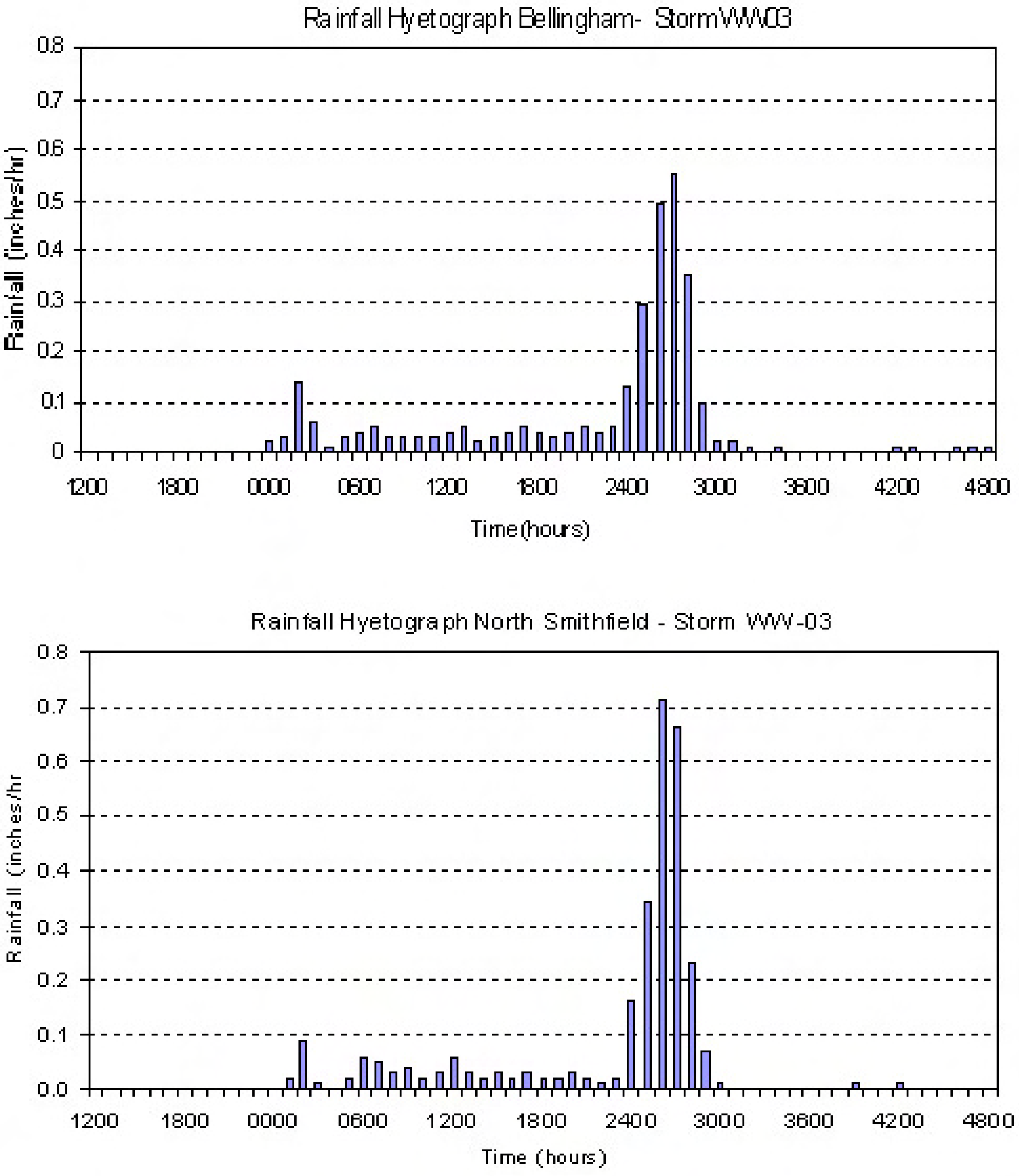


Figure 4-10: Hyetograph for Storm WW-03

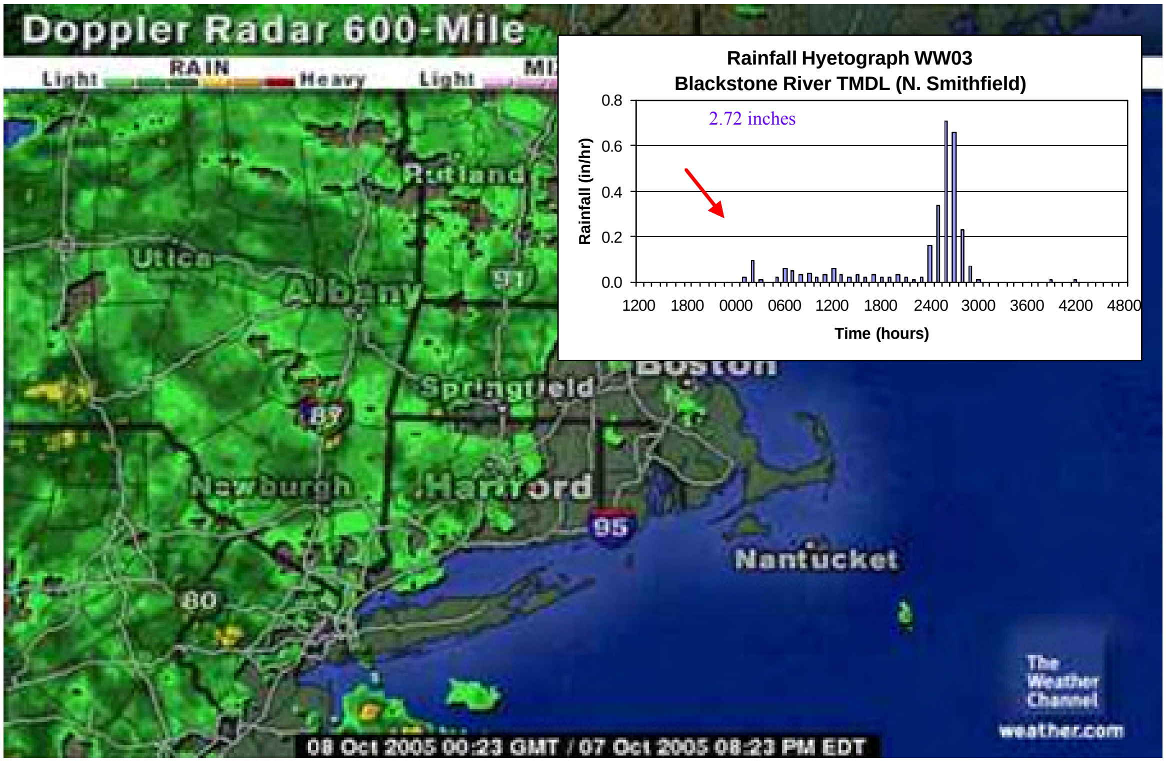


Figure 4-11: Doppler Radar and N. Smithfield Hyetograph, WW-03 (Oct. 7, 2005 at 20:23h).

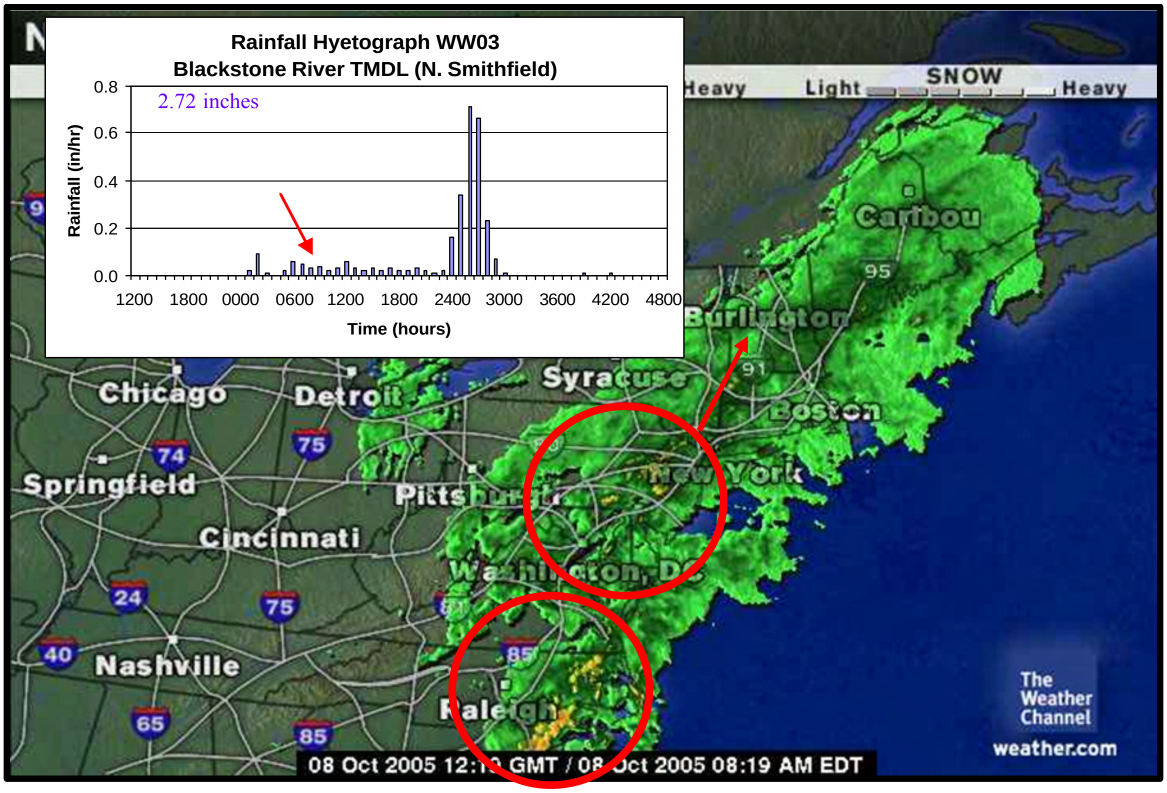


Figure 4-12: Doppler Radar and N. Smithfield Hyetograph, WW-03 (Oct. 8, 2005 at 08:19h).

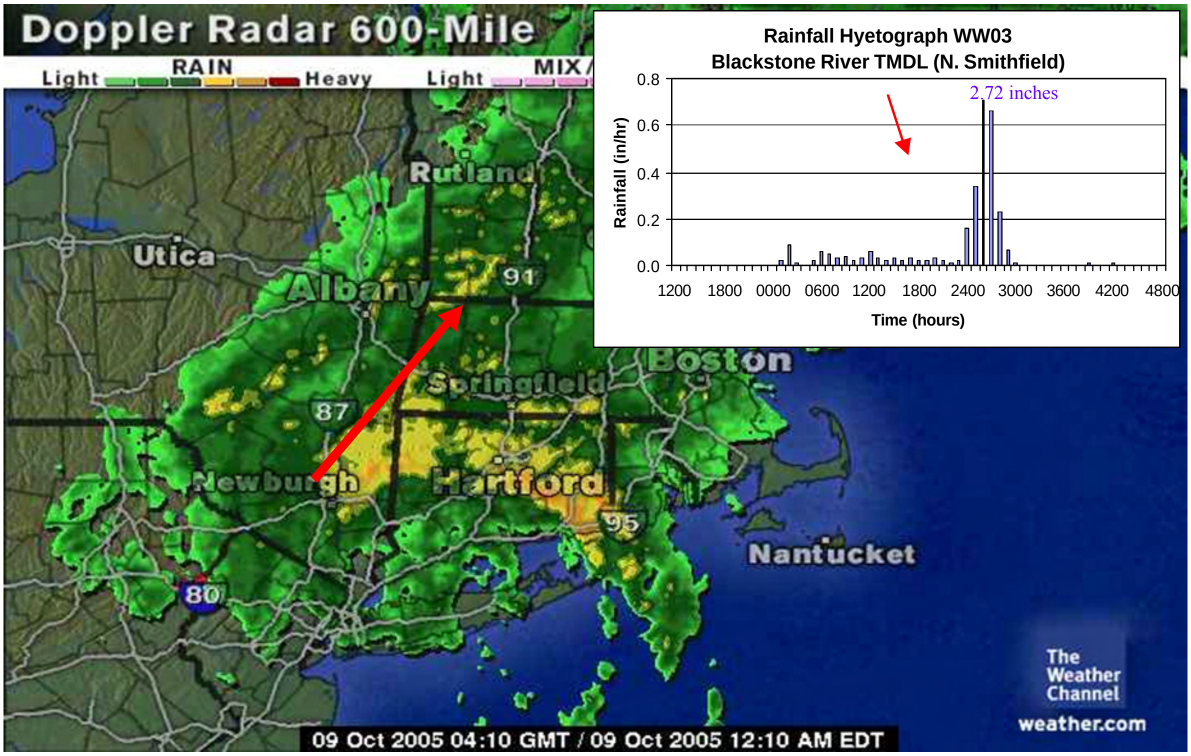


Figure 4-13: Doppler Radar and N. Smithfield Hyetograph, WW-03 (Oct. 9, 2005 at 00:10h).

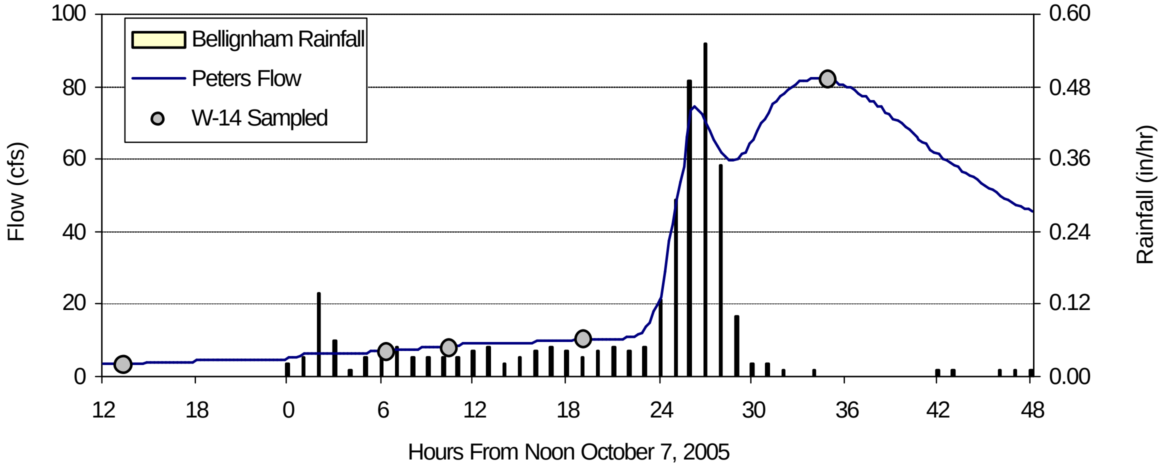


Figure 4-14: Comparison of Bellingham Rainfall and Peters River Flow for WW-03

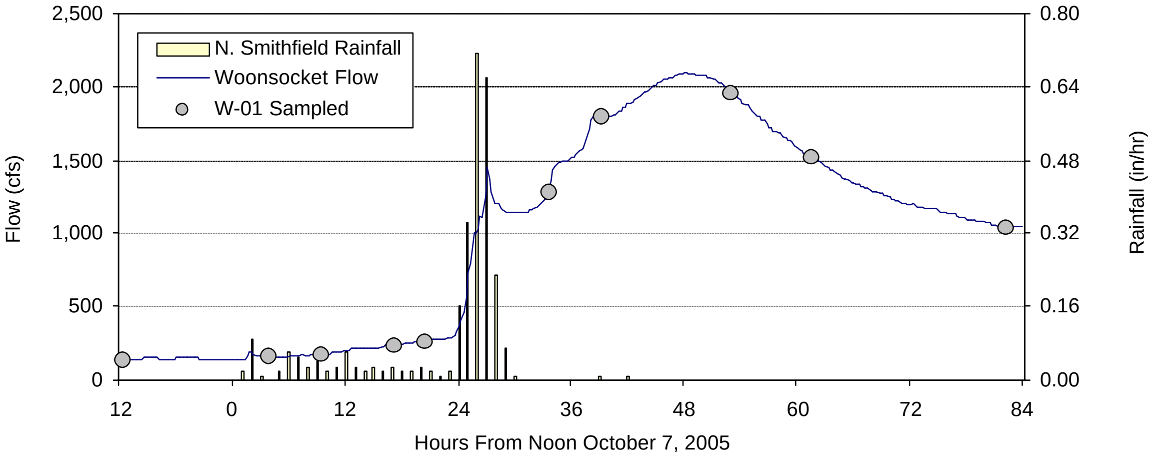


Figure 4-15: Comparison of N. Smithfield Rainfall and Woonsocket Flow for WW-03

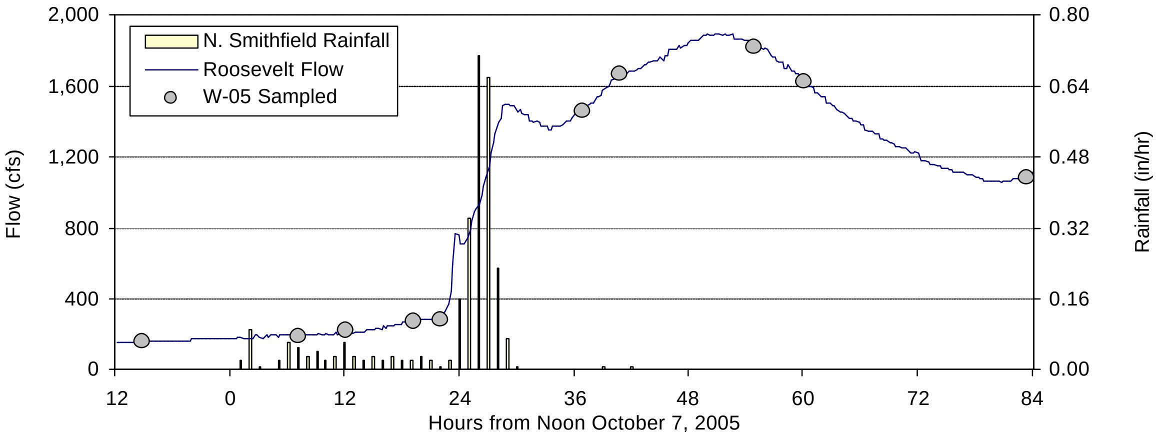
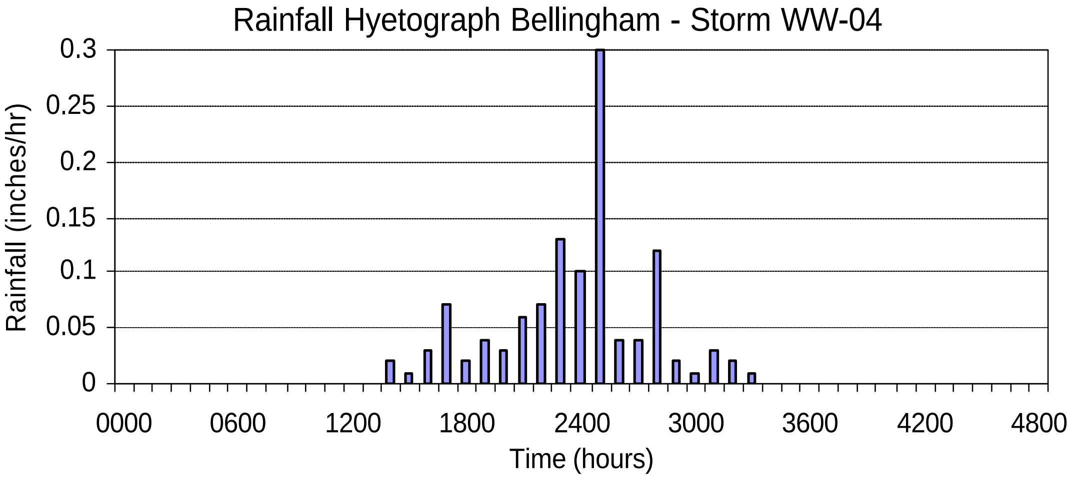


Figure 4-16: Comparison of N. Smithfield Rainfall and Roosevelt Flow for WW-03



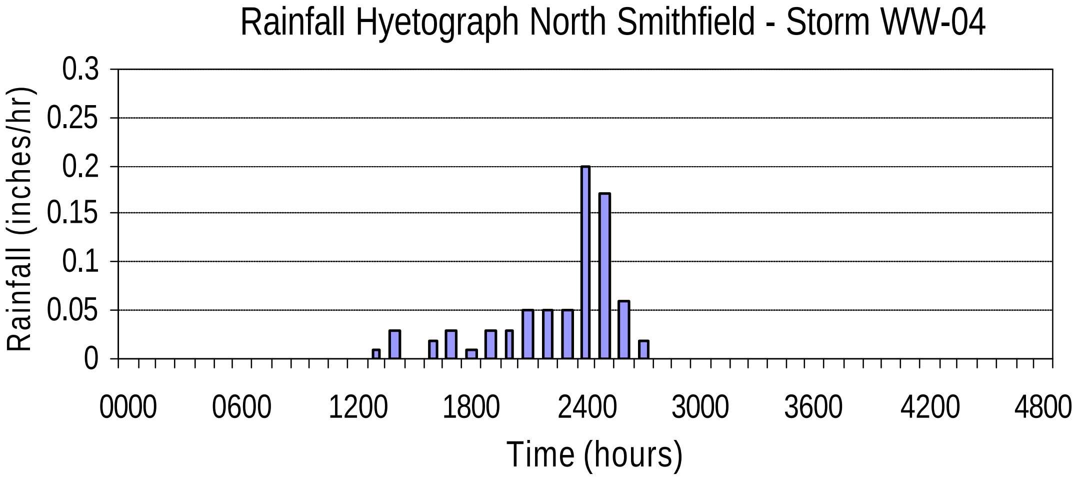


Figure 4-17: Hyetograph for Storm WW-04

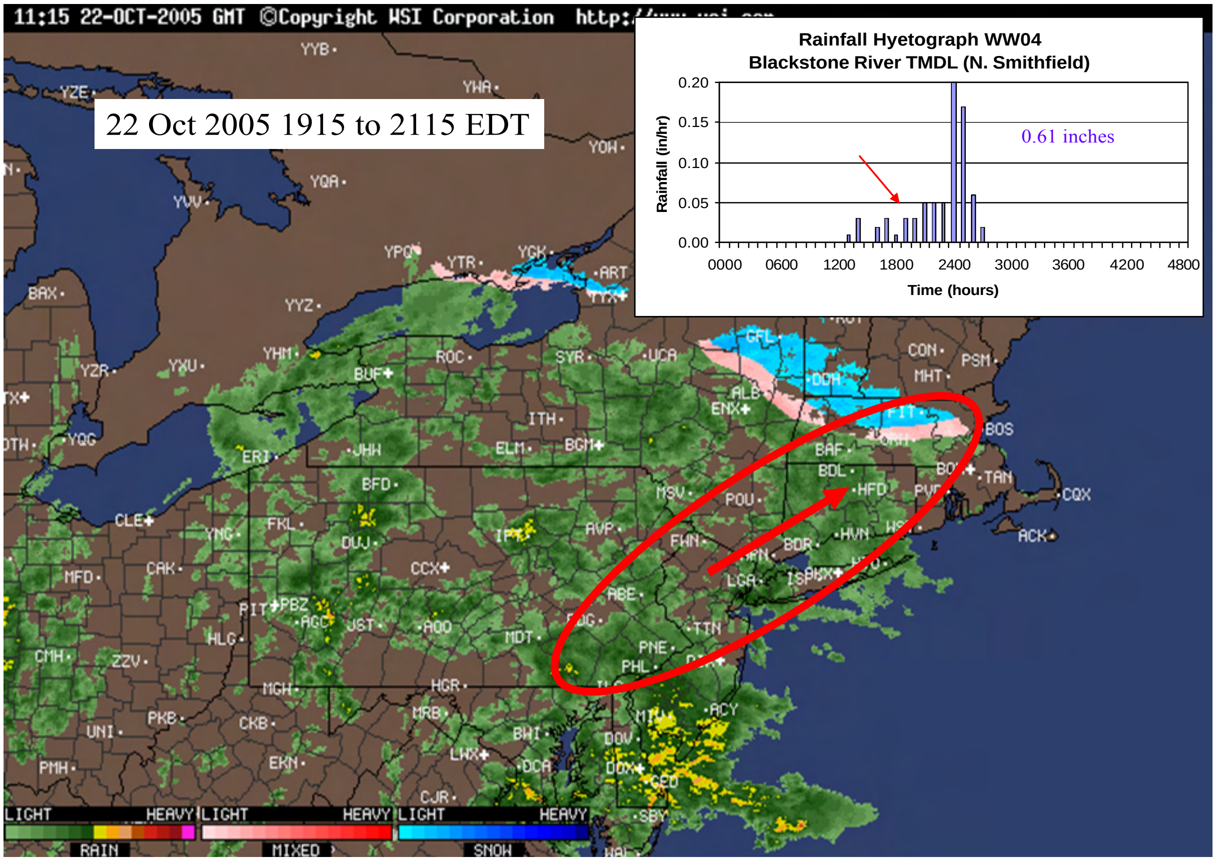


Figure 4-18: Doppler Radar and N. Smithfield Hyetograph, WW-04 (Oct. 22, 2005 at 19:15h)

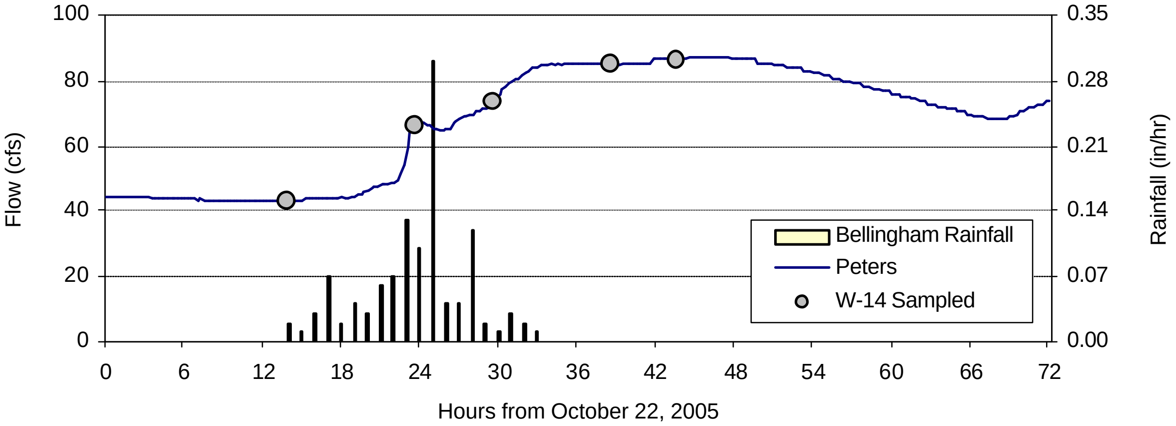


Figure 4-19: Comparison of Bellingham Rainfall and Peters River Flow for WW-04

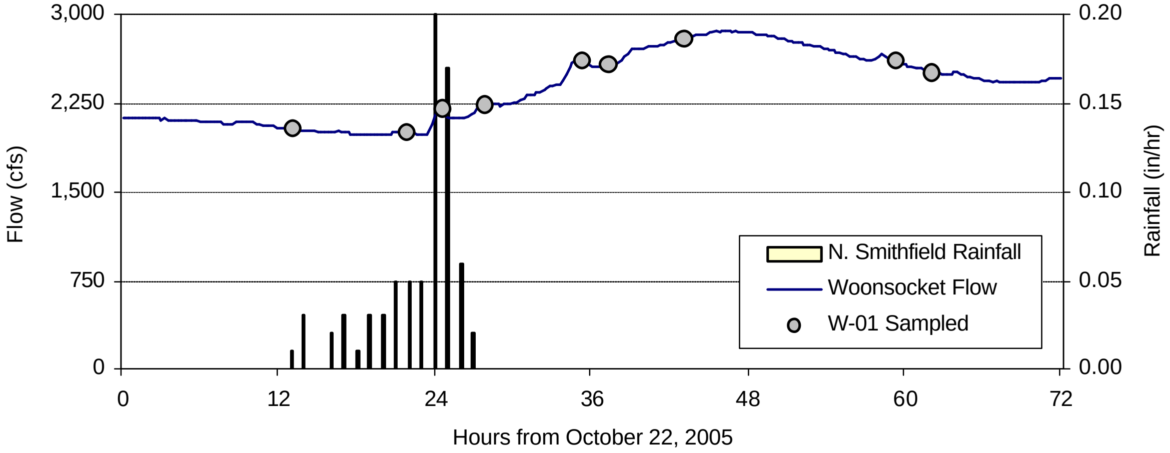


Figure 4-20: Comparison of N. Smithfield Rainfall and Woonsocket Flow for WW-04

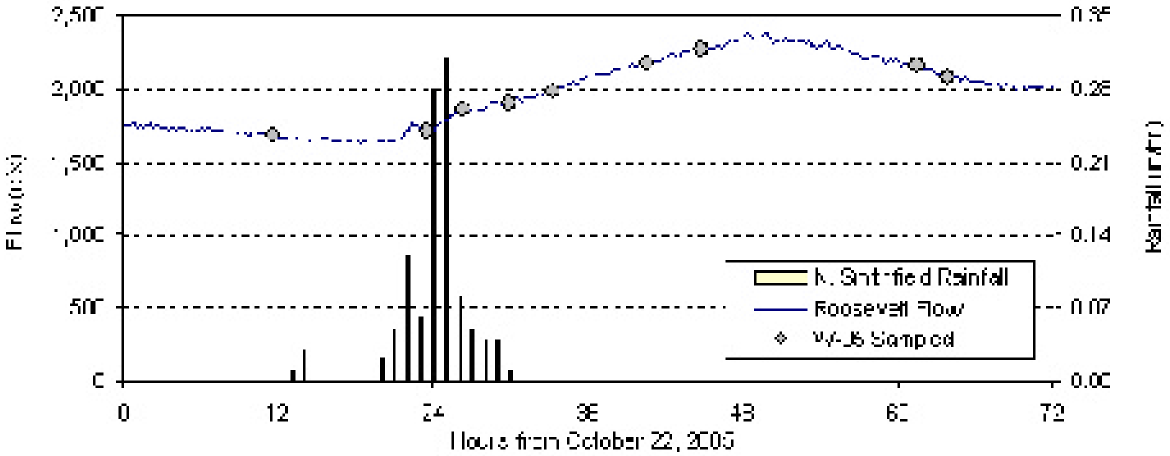


Figure 4-21: Comparison of N. Smithfield Rainfall and Roosevelt Flow for WW-04

Figure 4-22: Wet Weather Sampling Program - Blackstone TMDL

	WW-01		**WW-02**		**WW-03**		**WW-04**	
Station	**Proposed**	**Actual**	**Proposed**	**Actual** *(2)*	**Proposed**	**Actual** *(2)*	**Proposed**	**Actual** *(2)*
W-01	10	11			10	10	10	9
W-02	10	11			10	10	10	9
W-03	12	11			12	10	12	9
W-04	12	11			12	10	12	9
W-05	12	11			12	10	12	9
W-11	5	5	7	8	5	5	5	5
W-12	5	5	7	8	5	5	5	5
W-13	5	5	7	8	5	5	5	5
W-14	5	5	7	8	5	5	5	5
W-15	5	5	7	8	5	5	5	5
W-16[a]	0	0	7	8	4	4	0	0
W-21	2	2			2	3	2	2
W-22	2	2			2	3	2	2
W-23	2	2			2	4	2	2
W-24	2	2			2	1	2	2
W-25	2	3			2	3	2	2
W-26	2	3			2	3	2	2
W-31	2	2			2	3	2	2
W-32	2	2			2	3	2	2
W-33	2	2			2	2	2	2
W-34	2	3			2	3	2	2
Total	**101**	**103**	**42**	**48** *(2)*	**105**	**107** *(2)*	**101**	**90** *(2)*

(1) Samples were only taken at W-16 when the stage at USGS Gage Woonsocket was <1.4 feet

(2) The number of samples include the pre-storm samples that were taken the day before as a dry weather monitoring event.

Proposed: 349 samples
Actual: 348 samples

Figure 4-23: Time Covered by Sampling Program

Stations	**Proposed Duration of Sampling** (Time between 1st and last Run)	**Actual Time Between Runs**	
		Prestorm to Final Run	**First Run After Start of Rainfall to Final Run**
WW-01 *(July 8-12, 2005)*			
W-01 and 02	36-72 hours	95.0 hours	87.8 hours
W-03, 04 and 05	48-96 hours	97.8 hours	87.5 hours
WW-03 *(October 7-11, 2005)*			
W-01 and 02	36-72 hours	94.3 hours	69.8 hours
W-03, 04 and 05	48-96 hours	98.0 hours	68.5 hours
WW-04 *(October 22-24, 2005)*			
W-01 and 02	36-72 hours	49.0 hours	40.3 hours
W-03, 04 and 05	48-96 hours	52.3 hours	40.3 hours

Figure 4-24: Relationship between First Flush, Local Peak and Worcester Peaks for individual Storm Samples

Stations	Sample Runs in relation to Flows (*)											
Storm WW-01												
Primary Stations	1 - P	2 - FF	3 - LP	4 - LP	5	6 - WP	7	8	9	10	11	12
Mill/Peters	1 - P	2 - FF	3	4			7					
Tertiary		2	3									
Storm WW-02												
Mill/Peters	P	1 - FF	2	3	4	5	6	7				
Storm WW-03												
Primary	1 - P	2 - FF	3 - FF		5 - LP	6	7	8 - WP	9 - WP	10	11	
Mill/Peters	1 - P	2 - FF	3		5		7					
Tertiary		2			5		7					
Storm WW-04												
Primary	1 - P	2 - FF	3 - LP	4 - LP	5	6	7 - WP	8	9			
Mill/Peters	1 - P	2 - FF		4		6	7					
Tertiary		2		4								

P = Prestorm sample; FF = First Flush; LP = Local Peak; WP = Worcester Peak

(*) The relationships were determined after the storm, based on detailed flow information from USGS gages throughout the watershed, hyetographs, and sampling results.

Figure 4-25: Procedure followed for the Determination of Wet Weather Flows

WQ Station	Procedure used
W-01	Either stage-discharge relationships established during dry weather or USGS flows/drainage areas were used to develop incremental inflow rates.
W-02, W-05	Stage-discharge relationships established during dry weather.
W-03, W-04, W-12,, W-13 W-15, W-16, W-21, W-22	USGS gage flows/drainage area were used to develop incremental inflow rates.
W-11	When USGS flows were reported, these were used. For the months that did not have published flows, a relationship between Mill and Peters Rivers was determined and the Peters River flow was used to estimate the W-11 flow.
W-01, W-02, W-03, W-04, W-05, W-12, W13, W-15, W-16, W-21, W-22	USGS gage flows were used to develop incremental inflow rates.
W-14, W-17, W-23, W-26	USGS flows were used for all surveys.
W-24	Flows were received from WWTF personnel and RIDEM.
W-25	USGS flows at Roosevelt minus Abbott Run estimated flows at W-25.
W-31, W-32	Direct measurement or from incremental inflow rates determined from USGS gages.
W-33, W-34	Direct measurement.

Figure 4-26: Storm WW-01 - Flow

Station No.	Blackstone River	Tributary	WWTF/outfall/other	Location	**Flow** (cfs)												**Statistics**				
					8-Jul			9-Jul				10-Jul		11-Jul		12-Jul	Mean	Standard Deviation	Minimum	Maximum	Count
					8:30 - 10:15h	16:40 - 18:25h	21:00 - 23:15h	0:10 - 2:30h	6:20 - 7:50h	14:30 - 16:15h	20:30 - 22:40h	6:40 - 8:10h	15:15 - 16:30h	8:40 - 10:00h	14:50 - 15:30h	8:40 - 10:00h					
				Run No.	1	2	3	4	5	6	7	8	9	10	11	12					
W-01	●			Millville, MA	340	447	553	573	712	1,562	1,650	1,374	1,218	905		668	**909**	465	340	1,650	11
W-23		●		Branch River		78	121										**100**	31	78	121	2
W-21	●			Singleton Street		550	687										**618**	97	550	687	2
W-22	●			Below Thundermist Dam		554	691										**622**	97	554	691	2
W-11		●		Mill River (MA/RI border)	32.2	70.6	81.7	88.7			65.7						**67.8**	21.9	32.2	88.7	5
W-12		●		Mill River (pre-culvert entry)	32.7	71.7	83.0	90.2			66.8						**68.9**	22.2	32.7	90.2	5
W-13		●		Mill River (confluence w/ BR)	33.0	72.4	83.8	91.0			67.4						**69.5**	22.4	33.0	91.0	5
W-14		●		Peters River (MA/RI border)	14.0	33.0	39.5	42.5			30.6						**31.9**	11.1	14.0	42.5	5
W-15		●		Peters River (pre-culvert entry)	14.4	33.9	40.6	43.7			31.4						**32.8**	11.4	14.4	43.7	5
W-16		●		Peters River (confluence w/ BR)	14.6	34.4	41.1	44.3			31.9						**33.2**	11.6	14.6	44.3	5
W-17	●			Hamlet Avenue		527	845										**686**	225	527	845	2
W-24			●	Woonsocket WWTF													**11.4**				
W-02	●			Manville Dam	554	554	882	919	992	1,721	2,013	1,648	1,429	1,138	1,065	846	**1,147**	463	554	2,013	12
W-03	●			George Washington Hwy Bridge	601	603	886	879	935	1,579	1,826	1,600	1,401	1,067	996	774	**1,095**	408	601	1,826	12
W-04	●			Lonsdale Ave	616	618	887	866	917	1,533	1,766	1,585	1,391	1,044	975	751	**1,079**	391	616	1,766	12
W-25	●			Broad Street	619	622	888										**709**	154	619	888	3
W-26		●		Abbott Run Brook	30.9	38.5	45.1										**38.2**	7.1	30.9	45.1	3
W-05	●			Slaters Mill Dam	650	660	933	922	965	1,497	1,787	1,614	1,420	1,068	999	775	**1,108**	380	650	1,787	12
W-31			●	Cherry Brook		1.4	1.9										**1.63**	0.33	1.40	1.86	2
W-32			●	Front Street Drain		1.8	2.4										**2.10**	0.42	1.80	2.39	2
W-33			●	Sylvestre Pond Outflow		1.3	3.1										**2.20**	1.23	1.33	3.07	2
W-34			●	Blackstone Canal at Lonsdale	0.10	0.18	0.24										**0.17**	0.07	0.10	0.24	3
W-35			●	Brook near Ann&Hope																	

Figure 4-27: Storm WW-02 – Flow

Station No.	Blackstone River	Tributary	WWTF/outfall/other	Location	**Flow** (cfs)								**Statistics**				
					14-Sep	15-Sep							**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Count**
					8:30 - 10:15h	10:35 - 11:10h	11:45 - 12:46h	13:35 - 14:55h	15:00 - 15:50h	16:00-16:40h	16:50 - 17:35h	17:45 - 18:30h					
				Run No. *(1)*	DW-11	1	2	3	4	5	6	7					
W-01	●			Millville, MA													
W-23		●		Branch River													
W-21	●			Singleton Street													
W-22	●			Below Thundermist Dam													
W-11		●		Mill River (MA/RI border)	3.8	54.2	91.8	81.7	72.6	73.6	81.7	90.8	**68.8**	28.8	3.8	91.8	8
W-12		●		Mill River (pre-culvert entry)	3.9	55.1	93.2	83.0	73.7	74.8	83.0	92.2	**69.9**	29.3	3.9	93.2	8
W-13		●		Mill River (confluence w/ BR)	3.9	55.6	94.1	83.8	74.5	75.5	83.8	93.1	**70.5**	29.6	3.9	94.1	8
W-14		●		Peters River (MA/RI border)	2.5	24.9	43.5	38.5	34.0	34.5	38.5	43.0	**32.4**	13.4	2.5	43.5	8
W-15		●		Peters River (pre-culvert entry)	2.6	25.6	44.7	39.6	34.9	35.4	39.6	44.2	**33.3**	13.8	2.6	44.7	8
W-16		●		Peters River (confluence w/ BR)	2.7	25.9	45.3	40.1	35.4	35.9	40.1	44.8	**33.8**	14.0	2.7	45.3	8
W-17	●			Hamlet Avenue													
W-24			●	Woonsocket WWTF													
W-02	●			Manville Dam													
W-03	●			George Washington Hwy Bridge													
W-04	●			Lonsdale Ave													
W-25	●			Broad Street													
W-26		●		Abbott Run Brook													
W-05	●			Slaters Mill Dam													
W-31			●	Cherry Brook													
W-32			●	Front Street Drain													
W-33			●	Sylvestre Pond Outflow													
W-34			●	Blackstone Canal at Lonsdale													
W-35			●	Brook near Ann&Hope													

(1) DW-11 = The prestorm value was the dry weather sample that was taken on September 14, 2005 (Event DW-11). That makes 8 runs for this storm.

Figure 4-28: Storm WW-03 – Flow

Station No.	Blackstone River	Tributary	WWTF/outfall/other	Location	**Flow** (cfs)										**Statistics**				
					7-Oct	8-Oct				9-Oct		10-Oct			**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Count**
					12:00 - 14:50h	3:40 - 8:50h	9:10 - 11:55h	16:55 - 19:30h	20:15 - 21:40h	9:30 -12:40h	15:00 - 16:45h	5:00 - 6:45h	12:00 - 13:30h	10:00 - 11:15h					
				Run No.	1	2	3	5	6	7	8	9	10	11					
W-01	●			Millville, MA	111	111	127	186	202	977	1,214	1,596	1,217	885	**663**	574	111	1,596	10
W-23		●		Branch River	13	16		28		215					**68**	98	13	215	4
W-21	●			Singleton Street		129		216		1,215					**520**	603	129	1,215	3
W-22	●			Below Thundermist Dam		130		217		1,222					**523**	607	130	1,222	3
W-11		●		Mill River (MA/RI border)	10.8	18.3	19.9	24.7		169.9					**48.7**	68.0	10.8	169.9	5
W-12		●		Mill River (pre-culvert entry)	10.9	18.5	20.2	25.1		172.6					**49.5**	69.0	10.9	172.6	5
W-13		●		Mill River (confluence w/ BR)	11.1	18.7	20.4	25.4		174.3					**50.0**	69.7	11.1	174.3	5
W-14		●		Peters River (MA/RI border)	3.4	7.1	8.2	10.3		82.2					**22.2**	33.6	3.4	82.2	5
W-15		●		Peters River (pre-culvert entry)	3.5	7.3	8.4	10.6		84.5					**22.9**	34.5	3.5	84.5	5
W-16		●		Peters River (confluence w/ BR)	3.5	7.4	8.5	10.7		85.6					**23.2**	35.0	3.5	85.6	5
W-17	●			Hamlet Avenue		163		252		1,493					**636**	743	163	1,493	3
W-24			●	Woonsocket WWTF											**17.7**				
W-02	●			Manville Dam	153	189	189	225	335	1,502	1,794	1,940	1,575	1,065	**897**	751	153	1,940	10
W-03	●			George Washington Hwy Bridge	152	192	192	215	267	1,456	1,679	1,837	1,592	1,063	**864**	724	152	1,837	10
W-04	●			Lonsdale Ave	137	193	193	211	246	1,442	1,642	1,804	1,597	1,062	**853**	718	137	1,804	10
W-25	●			Broad Street		193		210		1,439					**614**	714	193	1,439	3
W-26		●		Abbott Run Brook		138		65		35					**79**	53	35	138	3
W-05	●			Slaters Mill Dam	163	191	222	274	291	1,471	1,667	1,828	1,627	1,089	**882**	715	163	1,828	10
W-31			●	Cherry Brook		0.25		0.43		3.31					**1.33**	1.72	0.25	3.31	3
W-32			●	Front Street Drain		0.32		0.55		4.25					**1.71**	2.21	0.32	4.25	3
W-33			●	Sylvestre Pond Outflow		1.43				1.69					**1.56**	0.18	1.43	1.69	2
W-34			●	Blackstone Canal at Lonsdale		0.07		0.11		0.12					**0.10**	0.03	0.07	0.12	3
W-35			●	Brook near Ann&Hope															

Figure 4-29: Storm WW-04 – Flow

Station No.	Blackstone River	Tributary	WWTF/outfall/other	Location	**Flow** (cfs)										**Statistics**				
					22-Oct		23-Oct					24-Oct		25-Oct	Mean	Standard Deviation	Minimum	Maximum	Count
					11:25 - 14:00h	21:10 - 23:50h	0:30 - 2:10h	3:45 - 5-45h	9:15 - 11:10h	13:15 - 16:25h	19:00 - 20:50h	11:00 - 13:30h	14:00 - 15:40h	11:00h					
				Run No.	1	2	3	4	5	6	7	8	9	10					
W-01	●			Millville, MA	1,446	1,349	1,539	1,466	1,685	1,705	1,863	1,732	1,701		**1,610**	167	1,349	1,863	9
W-23		●		Branch River		381		462							**421**	57	381	462	2
W-21	●			Singleton Street		1,721		1,970							**1,845**	176	1,721	1,970	2
W-22	●			Below Thundermist Dam		1,784		1,986							**1,885**	143	1,784	1,986	2
W-11		●		Mill River (MA/RI border)	91.8	133.4		149.3		176.8	178.4				**145.9**	35.7	91.8	178.4	5
W-12		●		Mill River (pre-culvert entry)	93.2	135.5		151.7		179.6	181.3				**148.3**	36.3	93.2	181.3	5
W-13		●		Mill River (confluence w/ BR)	94.1	136.8		153.2		181.4	183.0				**149.7**	36.7	94.1	183.0	5
W-14		●		Peters River (MA/RI border)	43.5	66.2		73.5		85.6	86.4				**71.0**	17.6	43.5	86.4	5
W-15		●		Peters River (pre-culvert entry)	44.7	68.0		75.5		88.0	88.8				**73.0**	18.1	44.7	88.8	5
W-16		●		Peters River (confluence w/ BR)	45	69		77		89	90				**74**	18	45	90	5
W-17	●			Hamlet Avenue		2,009		2,239							**2,124**	163	2,009	2,239	2
W-24			●	Woonsocket WWTF											**17.7**				
W-02	●			Manville Dam	2,055	2,012	2,187	2,324	2,560	2,782	2,884	2,608	2,488		**2,433**	310	2,012	2,884	9
W-03	●			George Washington Hwy Bridge	1,738	1,747	1,894	1,949	2,070	2,281	2,387	2,241	2,148		**2,051**	234	1,738	2,387	9
W-04	●			Lonsdale Ave	1,637	1,662	1,801	1,829	1,914	2,121	2,229	2,124	2,040		**1,928**	212	1,637	2,229	9
W-25	●			Broad Street		1,644		1,803							**1,723**	113	1,644	1,803	2
W-26		●		Abbott Run Brook		63		91							**77**	20	63	91	2
W-05	●			Slaters Mill Dam	1,667	1,707	1,856	1,897	1,980	2,170	2,267	2,157	2,075		**1,975**	210	1,667	2,267	9
W-31			●	Cherry Brook		5.85		7.00							**6.42**	0.82	5.85	7.00	2
W-32			●	Front Street Drain		7.52		9.00							**8.26**	1.05	7.52	9.00	2
W-33			●	Sylvestre Pond Outflow		2.60		4.03							**3.32**	1.01	2.60	4.03	2
W-34			●	Blackstone Canal at Lonsdale		0.35		0.48							**0.42**	0.09	0.35	0.48	2
W-35			●	Brook near Ann&Hope															

Figure 4-30: Wet Weather Prestorm and Peak Flows

USGS Flow Gage	Base Level Flow	Local Peak Flow	Runoff Peak Flow
	cfs		
Storm WW-01			
Peters River	15	33	46
Woonsocket, Blackstone R.	686	1,770	2,060
Roosevelt Ave, Blackstone R.	734	932	1,800
Storm WW-03			
Peters River	3	73	82
Woonsocket, Blackstone R.	143	1,376	2,096
Roosevelt Ave, Blackstone R.	150	1,497	1,897
Storm WW-04			
Peters River	47	66	86
Woonsocket, Blackstone R.	2,131	2,203	2,855
Roosevelt Ave, Blackstone R.	1,747	1,828	2,379

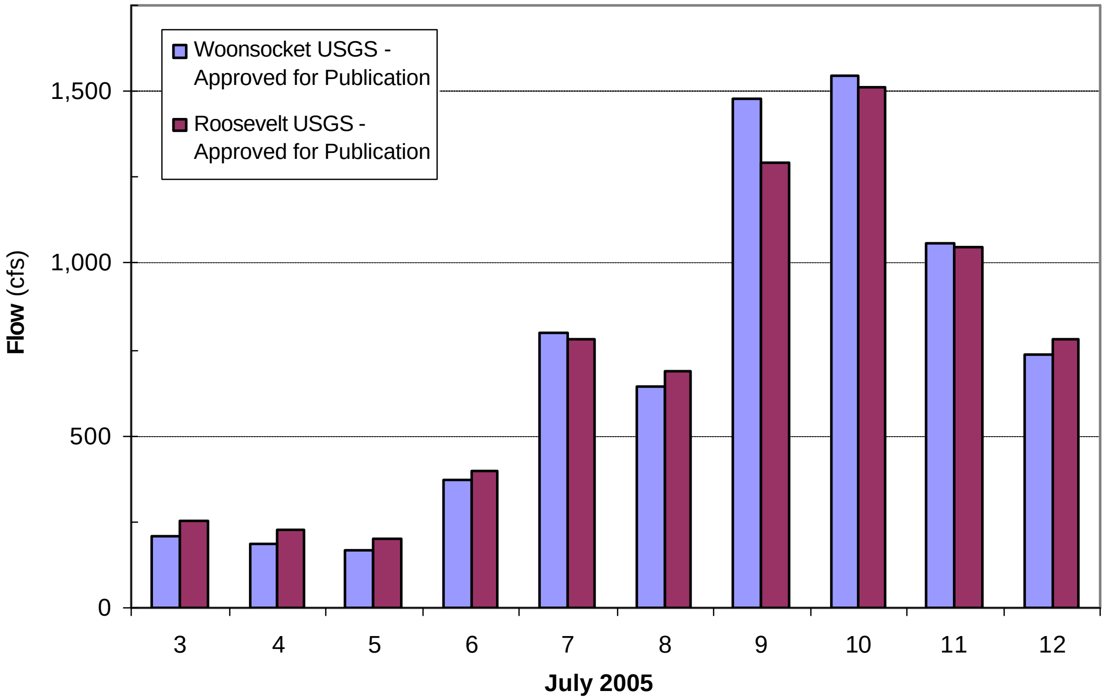


Figure 4-31: Daily average flows at Woonsocket and Roosevelt USGS stations for WW-01

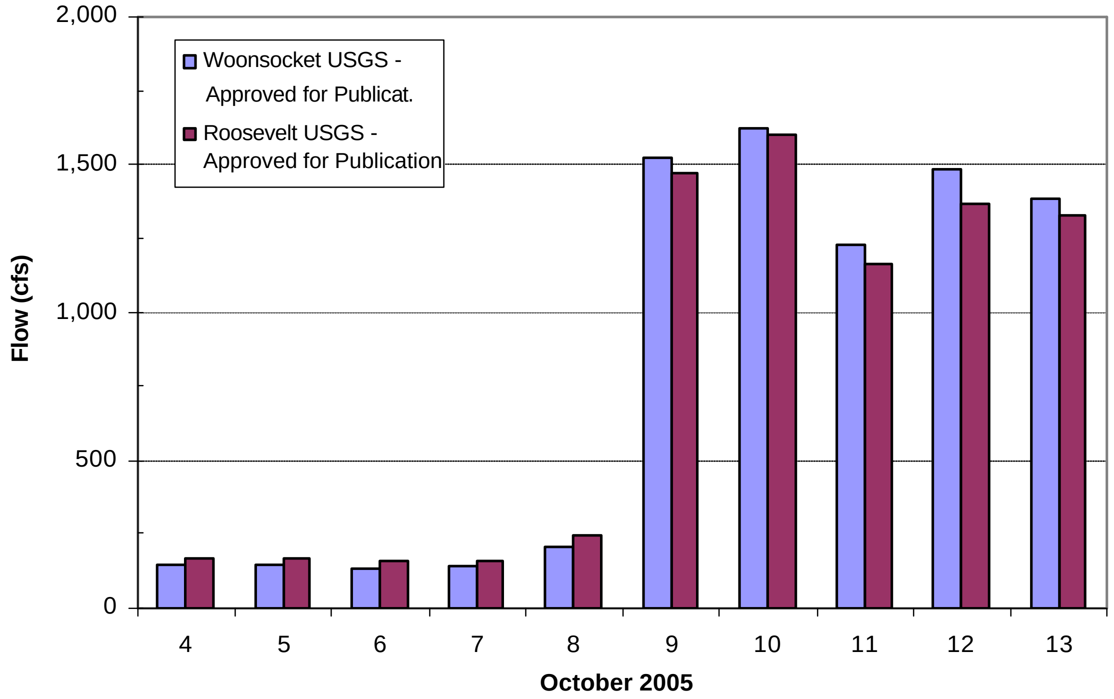


Figure 4-32: Daily average flows at Woonsocket and Roosevelt USGS stations for WW-03

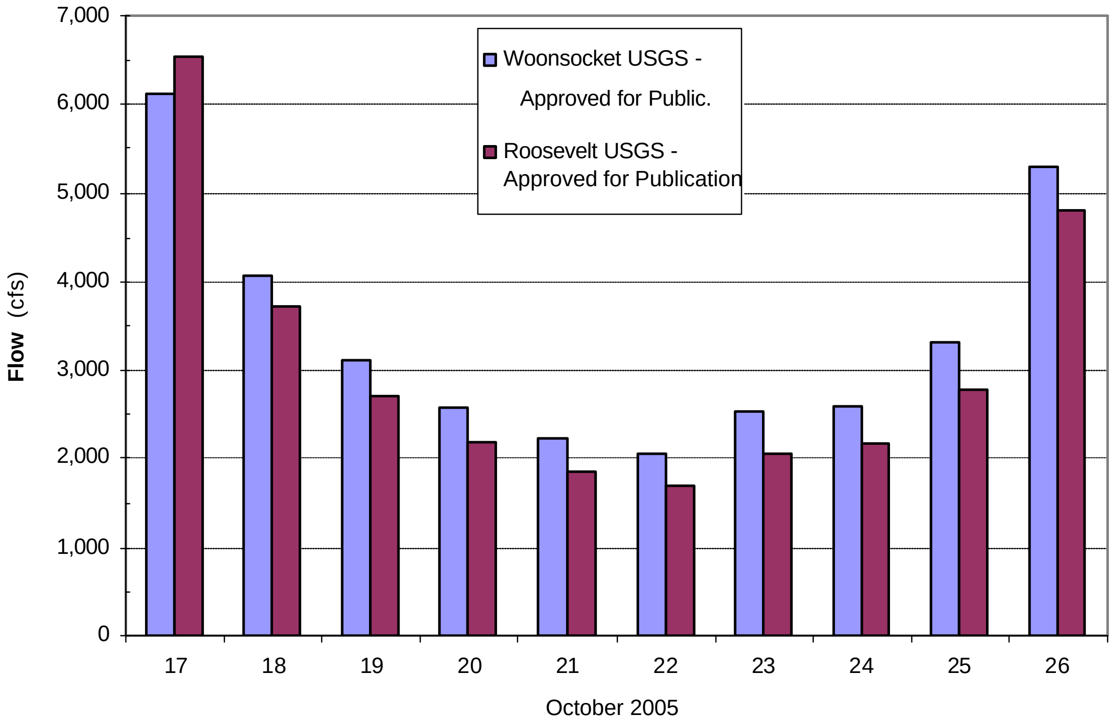


Figure 4-33: Daily average flows at Woonsocket and Roosevelt USGS stations for WW-01

Figure 4-34: Storms WW-01 and WW-02 - Fecal Coliform Concentrations (MPN/100ml)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm WW-01 (July 8 - 12, 2005)															Storm WW-02 (September 15, 2005)										
						8-Jul			9-Jul				10-Jul		11-Jul		12-Jul	Statistics (Runs 2-12)			14-Sep	15-Sep							Statistics (Runs 1-7)		
						8:30 - 10:15h	16:40 - 18:25h	21:00 - 23:15h	0:10 - 2:30h	6:20 - 7:50h	14:30 - 16:15h	20:30 - 22:40h	6:40 - 8:10h	15:15 - 16:30h	8:40 - 10:00h	14:50 -15:30h	8:40 - 10:00h	Minimum	Maximum	Geometric Mean	11:10 - 18:30h	10:35 - 11:10h	11:45 - 12:46h	13:35 -14:55h	15:00 - 15:50h	16:00-16:40h	16:50 - 17:35h	17:45 - 18:30h	Minimum	Maximum	Geometric Mean
					Run No.	1	2	3	4	5	6	7	8	9	10	11	12				DW-11	1	2	2	3	4	5	6			
W-01	Reach 1	●			Millville, MA	<200	800	2,600	2,300	400	30,000	8,000	1,700	2,200	<200		400	<200	30,000	1,628											
W-23			●		Branch River		17,000	1,300										1,300	17,000	4,701											
W-21		●			Singleton Street		700	1,100										700	1,100	877											
W-22		●			Below Thundermist Dam		800	2,300										800	2,300	1,356											
W-11			●		Mill River (MA/RI border)	<200	<200	<200	<200			1,300						<200	1,300	307	230	300	230	<20	170	20	80	40	<20	300	76
W-12			●		Mill River (pre-culvert entry)	2,300	9,000	5,000	900			3,000						900	9,000	3,320	300	>16,000	2,400	5,000	500	5,000	16,000	9,000	500	>16,000	4,956
W-13			●		Mill River (confluence w/ BR)	1,400	24,000	5,000	800			2,300						800	24,000	3,855	300	>16,000	5,000	3,000	1,700	1,300	770	1,100	770	>16,000	2,414
W-14			●		Peters River (MA/RI border)	1,300	1,100	24,000	800			3,000						800	24,000	2,821	40	500	>16,000	>16,000	>16,000	>16,000	>16,000	16,000	500	>16,000	10,857
W-15			●		Peters River (pre-culvert entry)	5,000	6,000	2,400	1,100			2,300						1,100	6,000	2,457	70	230	2,400	>16,000	>16,000	290	>16,000	16,000	230	>16,000	3,852
W-16			●		Peters River (confluence w/ BR)																170	>16,000	5,000	>16,000	>16,000	>16,000	290	>16,000	290	>16,000	7,979
W-17		●			Hamlet Avenue		800	3,000										800	3,000	1,549											
W-24				●	Woonsocket WWTF					<200			<200					<200	<200	190											
W-02	Reach 2	●			Manville Dam	<200	400	1,300	5,000	400	1,300	11,000	2,300	800	<200		1,100	<200	11,000	1,191											
W-03		●			George Washington Hwy Bridge	800	800	2,300	2,300	400	1,300	2,300	2,200	800	<200	<200	400	<200	2,300	830											
W-04	Reach 3	●			Lonsdale Ave	2,300	<200	2,300	1,300	600	400	2,300	3,000	1,400	700	<200	<200	<200	3,000	734											
W-25		●			Broad Street	400	1,100	3,000										1,100	3,000	1,817											
W-26			●		Abbott Run Brook	200	<200	<200										<200	<200	190											
W-05		●			Slaters Mill Dam	3,000	1,300	30,000	1,700	800	2,300	3,000	1,300	5,000	<200	800		<200	30,000	1,802											
W-31	1			●	Cherry Brook		50,000	13,000										13,000	50,000	25,495											
W-32				●	Front Street Drain		90,000	24,000										24,000	90,000	46,476											
W-33				●	Sylvestre Pond Outflow		3,000	17,000										3,000	17,000	7,141											
W-34	2			●	Blackstone Canal at Lonsdale	800	<200	3,000										<200	3,000	755											
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate	<200	<200	3,000	800	1,300	<200	2,300	700	2,300	400																
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate			<200	<200			400											230	220							
W-42		(=W-14)			Duplicate			11,000	2,300			2,300											190	16,000				>16,000			
W-43	2 3	(=W-04)			Duplicate																										

Water Quality Criteria (Class B and B1): Not to exceed a geometric mean of 200 MPN/100 ml and not more than 10% of samples shall exceed a 400 MPN/100 ml.

Detection Limits: <200 to >16,000 MPN/100 ml for Event WW-01; <20 to >16,000 MPN/100 ml for Event WW-02.

▨ 500 Concentration of duplicate samples differ considerably from original sample.

300 Concentration exceeding 200 MPN/100 ml.

Figure 4-35: Storms WW-03 and WW-04 - Fecal Coliform Concentrations (MPN/100ml)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm WW-03 (October 7 - 11, 2005)													Storm WW-04 (October 22 - 25, 2005)												
						7-Oct	8-Oct				9-Oct		10-Oct		11-Oct	Statistics (Runs 2-11)			22-Oct		23-Oct					24-Oct		25-Oct	Statistics (Runs 2-10)		
						12:00 - 14:50h	3:40 - 8:50h	9:10 - 11:55h	16:55 - 19:30h	20:15 - 21:40h	9:30 -12:40h	15:00 - 16:45h	5:00 - 6:45h	12:00 - 13:30h	10:00 - 11:15h	Minimum	Maximum	Geometric Mean	11:25 - 14:00h	21:10 - 23:50h	0:30 - 2:10h	3:45 - 5-45h	9:15 - 11:10h	13:15 - 16:25h	19:00 - 20:50h	11:00 - 13:30h	14:00 - 15:40h	11:00h	Minimum	Maximum	Geometric Mean
					Run No.	1	2	3	5	6	7	8	9	10	11				1	2	3	4	5	6	7	8	9	10			
W-01	Reach 1	●			Millville, MA	500	300	170	1,700	230	9,000	>16,000	3,000	9,000	500	170	>16,000	1,512	170	110	500	300	200	2,400	2,400	500	2,200		110	2,400	617
W-23			●		Branch River	500	330		700		1,700					330	1,700	732		80		130							80	130	102
W-21		●			Singleton Street		300		300		>16,000					300	>16,000	1,152		140		500							140	500	265
W-22		●			Below Thundermist Dam		900		300		3,000					300	3,000	932		140		170							140	170	154
W-11			●		Mill River (MA/RI border)	80	130	300	300		300					130	300	243		70		40		40	<20				<20	70	38
W-12			●		Mill River (pre-culvert entry)	500	500	2,400	3,000		700					500	3,000	1,260	130	130		170		170	<20				<20	170	92
W-13			●		Mill River (confluence w/ BR)	230	900	2,400	>16,000		800					800	>16,000	2,328	40	270		130		20	20				20	270	61
W-14			●		Peters River (MA/RI border)	130	900	1,100	3,000		16,000					900	16,000	2,626	70	300		1,700		700	170				170	1,700	496
W-15			●		Peters River (pre-culvert entry)	410	1,700	2,200	>16,000		>16,000					1,700	>16,000	5,734	270	1,300		1,100		1,300	1,100				1,100	1,300	1,196
W-16			●		Peters River (confluence w/ BR)	300	5,000	800	9,000							800	9,000	3,302													
W-17		●			Hamlet Avenue		1,100		2,400		1,700					1,100	2,400	1,649		170		500							170	500	292
W-24				●	Woonsocket WWTF		20									20	20	20								40		40	40	40	40
W-02	Reach 2	●			Manville Dam	80	170	80	110	1,300	2,400	3,000	9,000	5,000	210	80	9,000	799	130	300	130	300	370	500	300	1,300	56		56	1,300	288
W-03		●			George Washington Hwy Bridge	80	20	1,300	300	80	16,000	5,000	5,000	3,000	700	20	16,000	931	70	230	230	170	220	300	500	300	56		56	500	217
W-04	Reach 3	●			Lonsdale Ave	20	500	230	300	200	9,000	2,400	5,000	16,000	300	200	16,000	1,152	70	500	170	220	370	220	300	500	500		170	500	322
W-25		●			Broad Street		170		340		5,000					170	5,000	661		130		220							130	220	169
W-26			●		Abbott Run Brook		<20		<20		300					<20	300	48		<20		36							<20	36	26
W-05		●			Slaters Mill Dam	40	230	500	300	500	9,000	>16,000	3,000	16,000	500	230	>16,000	1,586	20	1,100	700	230	3,000	300	80	130	2,400		80	3,000	501
W-31	1			●	Cherry Brook		>16,000		2,400		2,400					2,400	>16,000	4,609		500		260							260	500	361
W-32				●	Front Street Drain		3,000		9,000		>16,000					3,000	>16,000	7,714		1,300		3,500							1,300	3,500	2,133
W-33				●	Sylvestre Pond Outflow		1,100				16,000					1,100	16,000	4,195		230		1,700							230	1,700	625
W-34	2			●	Blackstone Canal at Lonsdale		1,100		1,700		2,200					1,100	2,200	1,602		20		130							20	130	51
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate																										
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate		130	230	300										<20	<20		110		40							
W-42		(=W-14)			Duplicate	500	130	900	2,200										120	500		1,400		1,700							
W-43	2 3	(=W-04)			Duplicate	80	500	3,000	500	300									80	80	500	130	1,300	500							

Water Quality Criteria (Class B and B1): Not to exceed a geometric mean of 200 MPN/100 ml and not more than 10% of samples shall exceed a 400 MPN/100 ml.

Detection Limits: <20 to >16,000 MPN/100 ml.

500 Concentration of duplicate samples differ considerably from original sample.

300 Concentration exceeding 200 MPN/100 ml.

No Run 4 for WW-03

Figure 4-36: Geometric Mean Concentrations for Fecal Coliform and Enterococci

Station	**Fecal Coliform** (MPN/100 ml)				**Enterococci** (col/100 ml)			
	Storms				**Storms**			
	WW-01	**WW-02**	**WW-03**	**WW-04**	**WW-01**	**WW-02**	**WW-03**	**WW-04**
W-01	1,628		1,512	617	231		266	195
W-23	4,701		732	102				
W-21	877		1,152	265				
W-22	1,356		932	154				
W-11	307	76	243	38		61		
W-12	3,320	4,956	1,260	92		3,929		
W-13	3,855	2,414	2,328	61		2,076		
W-14	2,821	10,857	2,626	496		13,801		
W-15	2,457	3,852	5,734	1,196		16,408		
W-16		7,979	3,302			16,257		
W-17	1,549		1,649	292				
W-24	190		20	40				
W-02	1,191		799	288	236		221	152
W-03	830		931	217	189		249	177
W-04	734		1,152	322	209		448	160
W-25	1,817		661	169				
W-26	190		48	26				
W-05	1,802		1,586	501	189		314	197
W-31	25,495		4,609	361				
W-32	46,476		7,714	2,133				
W-33	7,141		4,195	625				
W-34	755		1,602	51				
W-35								

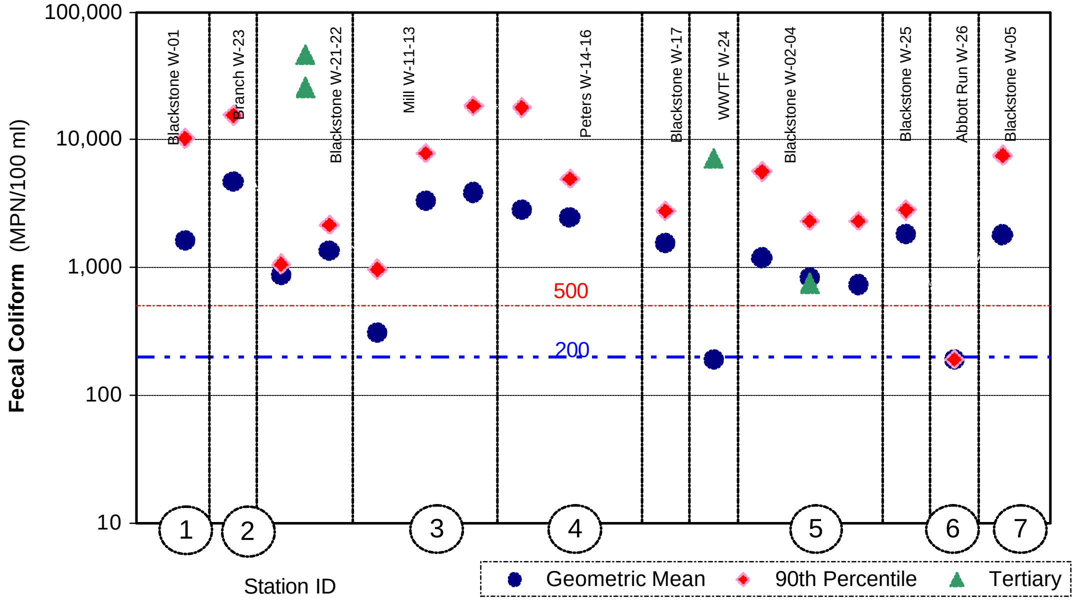


Figure 4-37: Fecal Coliform for Storm WW-01

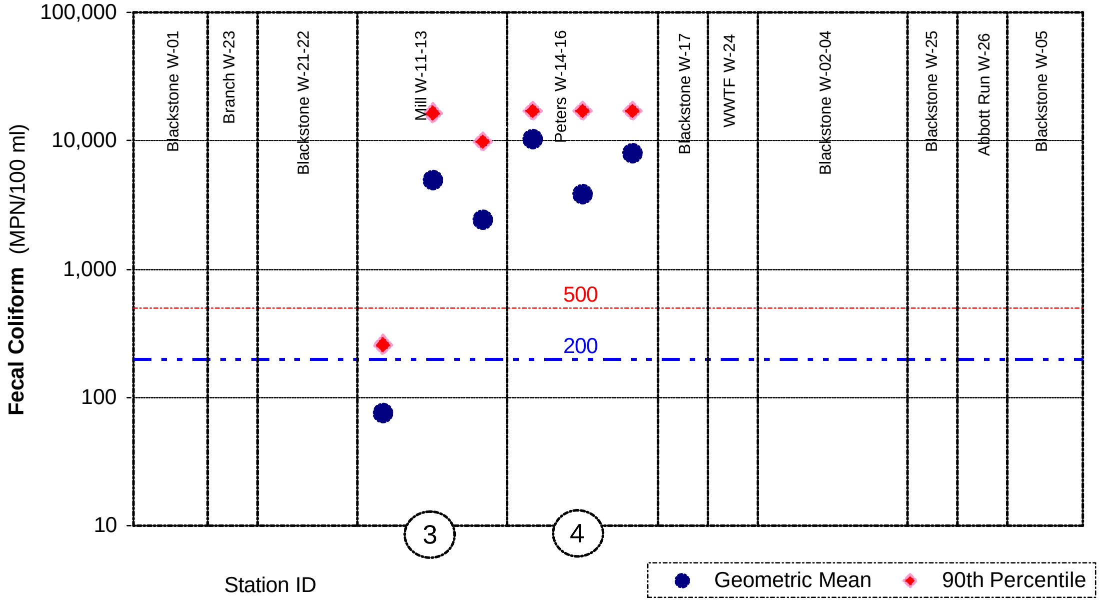


Figure 4-38: Fecal Coliform for Storm WW-02

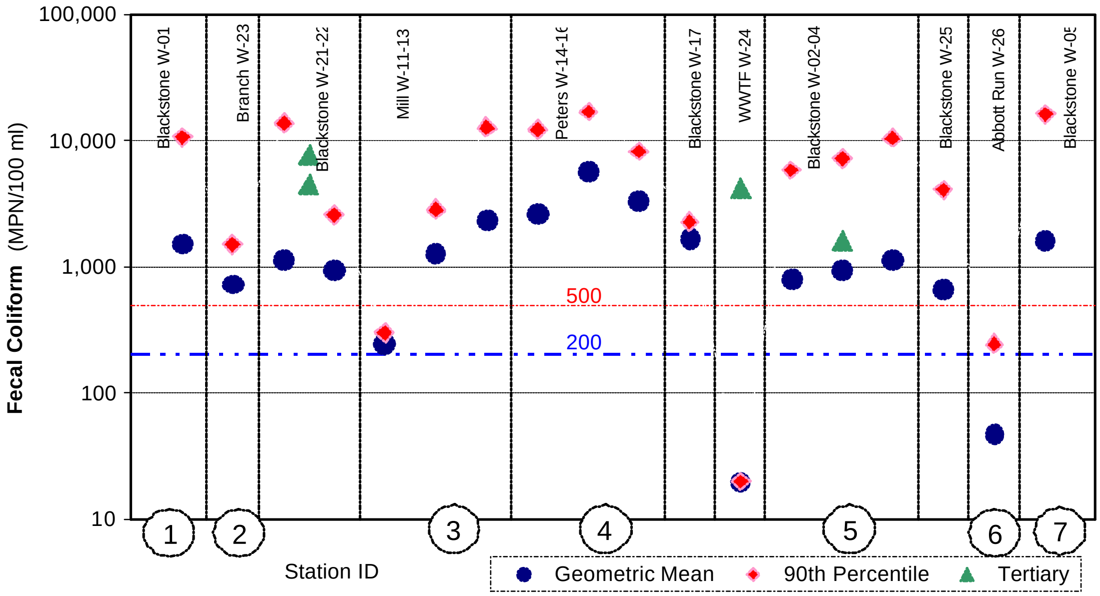


Figure 4-39: Fecal Coliform for Storm WW-03

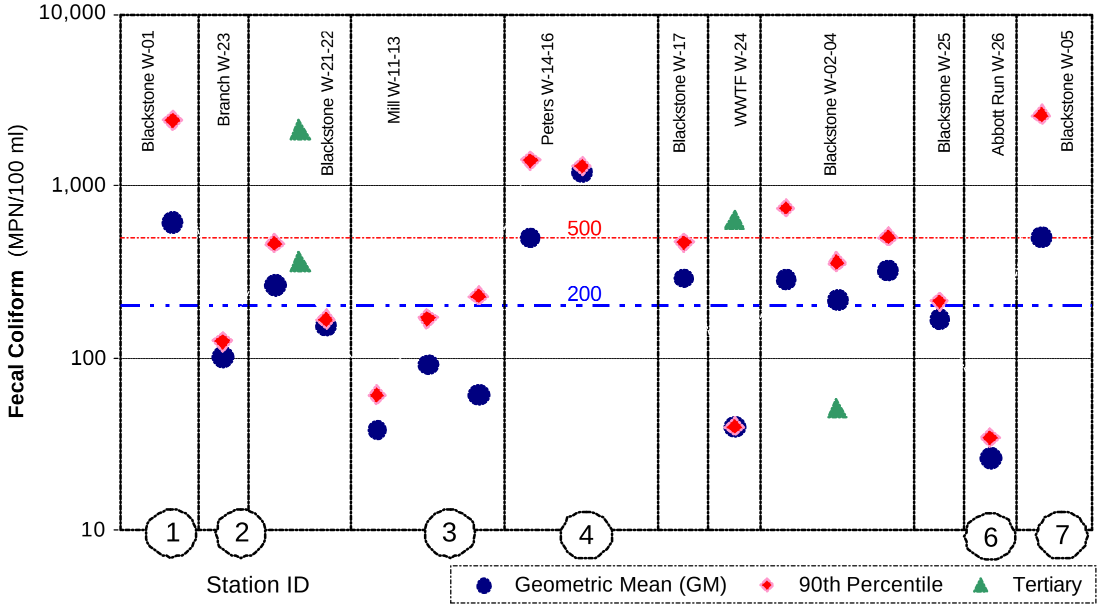


Figure 4-40: Fecal Coliform for Storm WW-04

Figure 4-41: Storms WW-01 and WW-02 - Enterococci Concentrations (col/100ml)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm WW-01 (July 8 - 12, 2005)															Storm WW-02 (September 15, 2005)										
						8-Jul			9-Jul				10-Jul		11-Jul		12-Jul	Statistics (Runs 2-12)			14-Sep	15-Sep							Statistics (Runs 1-7)		
						8:30 - 10:15h	16:40 - 18:25h	21:00 - 23:15h	0:10 - 2:30h	6:20 - 7:50h	14:30 - 16:15h	20:30 - 22:40h	6:40 - 8:10h	15:15 - 16:30h	8:40 - 10:00h	14:50 - 15:30h	8:40 - 10:00h	Minimum	Maximum	Geometric Mean	11:10 - 18:30h	10:35 - 11:10h	11:45 - 12:46h	13:35 - 14:55h	15:00 - 15:50h	16:00-16:40h	16:50 - 17:35h	17:45 - 18:30h	Minimum	Maximum	Geometric Mean
					Run No.	1	2	3	4	5	6	7	8	9	10	11	12				11	1	2	3	4	5	6	7			
W-01	Reach 1	●			Millville, MA	81	28	580	870	170	>2,400	>2,400	490	90	27		24	24	>2,400	231											
W-23			●		Branch River																										
W-21		●			Singleton Street																										
W-22		●			Below Thundermist Dam																										
W-11			●		Mill River (MA/RI border)																41	52	62	63	52	160	20	96	20	160	61
W-12			●		Mill River (pre-culvert entry)																160	>24,000	9,200	1,700	1,600	1,200	3,700	5,200	1,200	>24,000	3,929
W-13			●		Mill River (confluence w/ BR)																110	13,000	10,000	780	700	930	1,800	1,400	700	13,000	2,076
W-14			●		Peters River (MA/RI border)																20	12,000	8,700	14,000	8,700	12,000	>24,000	>24,000	8,700	>24,000	13,801
W-15			●		Peters River (pre-culvert entry)																52	24,000	17,000	6,900	13,000	14,000	>24,000	>24,000	6,900	>24,000	16,408
W-16			●		Peters River (confluence w/ BR)																10	>24,000	4,900	9,800	16,000	>24,000	>24,000	>24,000	4,900	>24,000	16,257
W-17		●			Hamlet Avenue																										
W-24				●	Woonsocket WWTF																										
W-02	Reach 2	●			Manville Dam	41	26	580	1,600	390	290	>2,400	820	120	29		28	26	>2,400	236											
W-03		●			George Washington Hwy Bridge	83	53	730	550	440	300	650	>2,400	170	21	21	33	21	>2,400	189											
W-04	Reach 3	●			Lonsdale Ave	170	160	380	610	400	410	690	>2,400	150	28	24	32	24	>2,400	209											
W-25		●			Broad Street																										
W-26			●		Abbott Run Brook																										
W-05		●			Slaters Mill Dam	280	150	830	290	210	410	520	1,300	360	31	24	19	19	1,300	189											
W-31	1			●	Cherry Brook																										
W-32				●	Front Street Drain																										
W-33				●	Sylvestre Pond Outflow																										
W-34	2			●	Blackstone Canal at Lonsdale																										
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate	45	34	490	770	770	340	>2,400	1,100	220	29																
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate																		20	41							
W-42		(=W-14)			Duplicate																		7,300	24,000				>24,000			
W-43	2 3	(=W-04)			Duplicate																										

Water Quality Criteria (Class B and B1): The proposed criteria is 54 col/100 ml (geometric mean).

Detection Limits: <10 to >2,400 col/100 ml for Event WW-01; <10 to >24,000 col/100 ml for Event WW-02.

225 Concentration exceeding 54 col/100 ml.

Figure 4-42: Storms WW-03 and WW-04 - Enterococci Concentrations (col/100ml)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm **WW-03** (October 7 - 11, 2005)													Storm **WW-04** (October 22 - 25, 2005)												
						7-Oct	8-Oct				9-Oct		10-Oct		11-Oct	**Statistics** (Runs 2-11)			22-Oct		23-Oct					24-Oct		25-Oct	**Statistics** (Runs 2-10)		
						12:00 - 14:50h	3:40 - 8:50h	9:10 - 11:55h	16:55 - 19:30h	20:15 - 21:40h	9:30 -12:40h	15:00 - 16:45h	5:00 - 6:45h	12:00 - 13:30h	10:00 - 11:15h	**Minimum**	**Maximum**	**Geometric Mean**	11:25 - 14:00h	21:10 - 23:50h	0:30 - 2:10h	3:45 - 5-45h	9:15 - 11:10h	13:15 - 16:25h	19:00 - 20:50h	11:00 - 13:30h	14:00 - 15:40h	11:00h	**Minimum**	**Maximum**	**Geometric Mean**
					Run No.	1	2	3	5	6	7	8	9	10	11				1	2	3	4	5	6	7	8	9	10			
W-01	**Reach 1**	●			Millville, MA	10	74	41	<10	85	800	16,000	1,300	640	270	<10	16,000	266	<10	370	230	260	180	160	210	96	160		96	370	195
W-23			●		Branch River																										
W-21		●			Singleton Street																										
W-22		●			Below Thundermist Dam																										
W-11			●		Mill River (MA/RI border)																										
W-12			●		Mill River (pre-culvert entry)																										
W-13			●		Mill River (confluence w/ BR)																										
W-14			●		Peters River (MA/RI border)																										
W-15			●		Peters River (pre-culvert entry)																										
W-16			●		Peters River (confluence w/ BR)																										
W-17		●			Hamlet Avenue																										
W-24				●	Woonsocket WWTF																										
W-02	**Reach 2**	●			Manville Dam	10	31	<10	<10	210	3,300	2,200	5,200	710	75	<10	5,200	221	41	52	200	260	310	96	150	310	75		52	310	152
W-03		●			George Washington Hwy Bridge	10	20	97	<10	<10	8,200	3,400	4,000	1,100	160	<10	8,200	249	10	52	310	400	440	130	86	180	170		52	440	177
W-04	**Reach 3**	●			Lonsdale Ave	<10	120	52	31	160	8,900	3,600	2,800	2,000	130	<10	8,900	448	10	75	170	320	240	150	85	210	160		75	320	160
W-25		●			Broad Street																										
W-26			●		Abbott Run Brook																										
W-05		●			Slaters Mill Dam	<10	31	52	52	110	6,500	11,000	390	1,200	96	<10	11,000	314	10	140	160	130	260	280	220	240	200		130	280	197
W-31	1			●	Cherry Brook																										
W-32				●	Front Street Drain																										
W-33				●	Sylvestre Pond Outflow																										
W-34	2			●	Blackstone Canal at Lonsdale																										
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate																										
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate																										
W-42		(=W-14)			Duplicate																										
W-43	2 3	(=W-04)			Duplicate	<10	250	31	120	170									20	63	31	390	200	210							

Water Quality Criteria (Class B and B1): The proposed criteria is 54 col/100 ml (geometric mean).

Detection Limits: <10 to >24,000 col/100 ml.

225 Concentration exceeding 54 col/100 ml.

No Run 4 for WW-03.

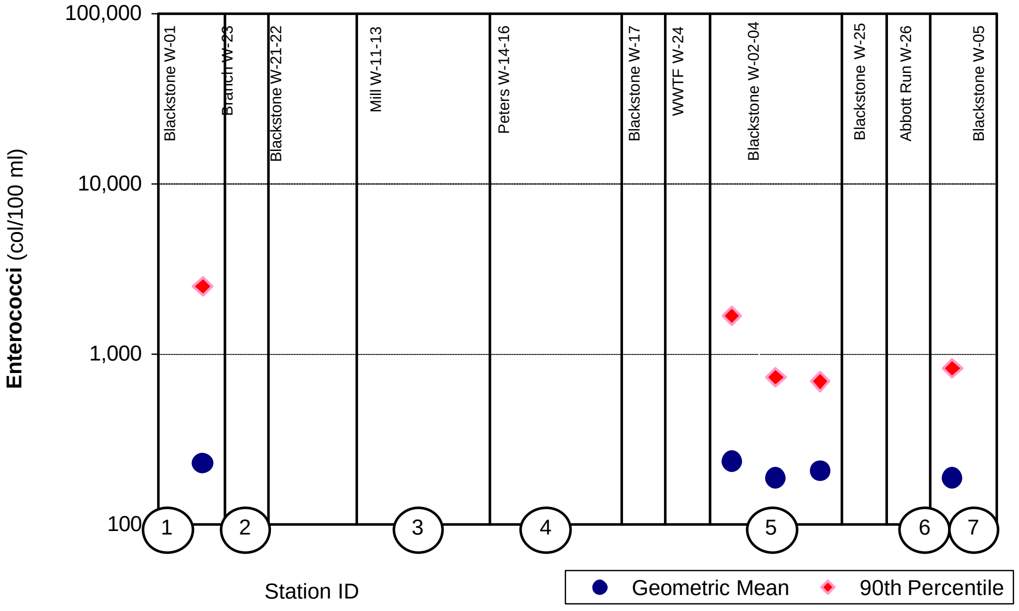


Figure 4-43: Enterococci for Storm WW-01

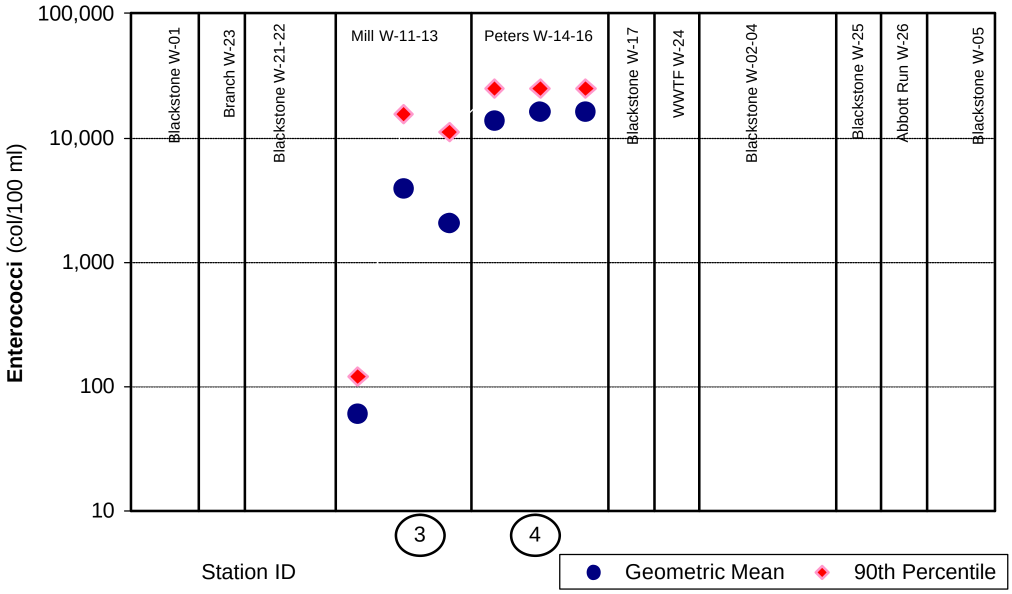


Figure 4-44: Enterococci for Storm WW-02

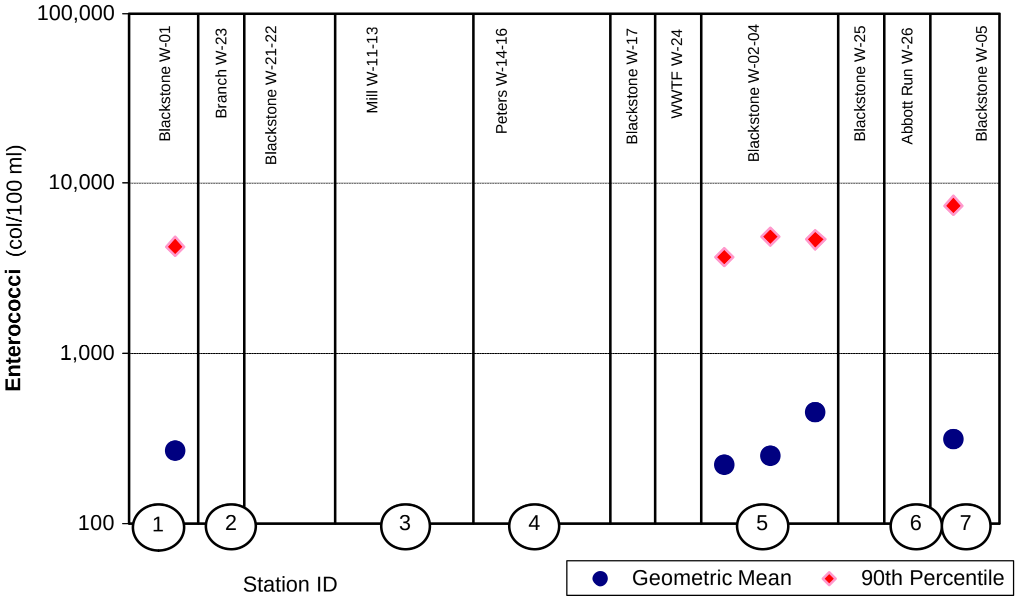


Figure 4-45: Enterococci for Storm WW-03

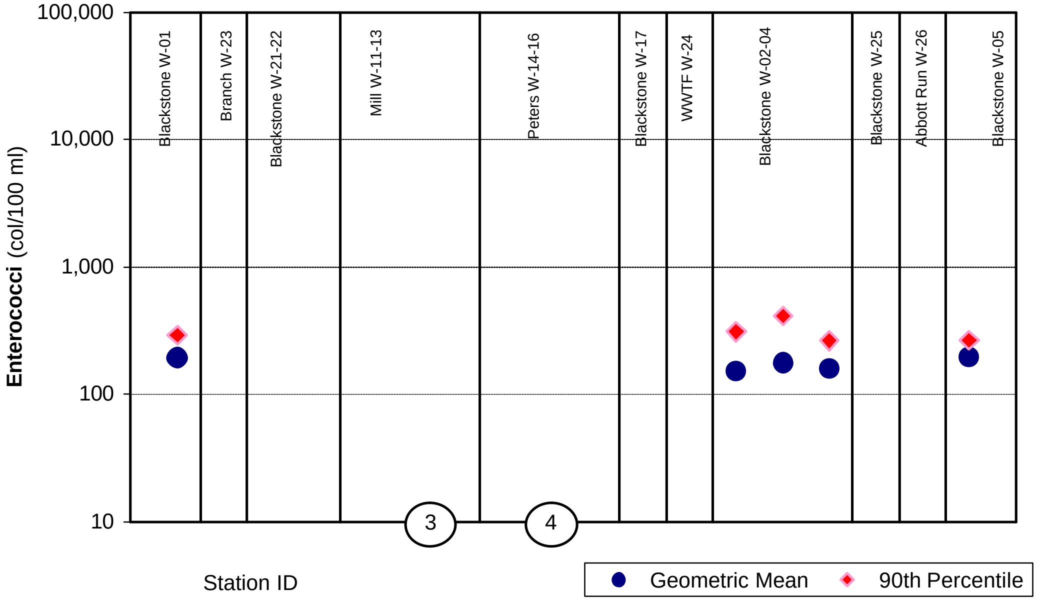


Figure 4-46: Enterococci for Storm WW-04

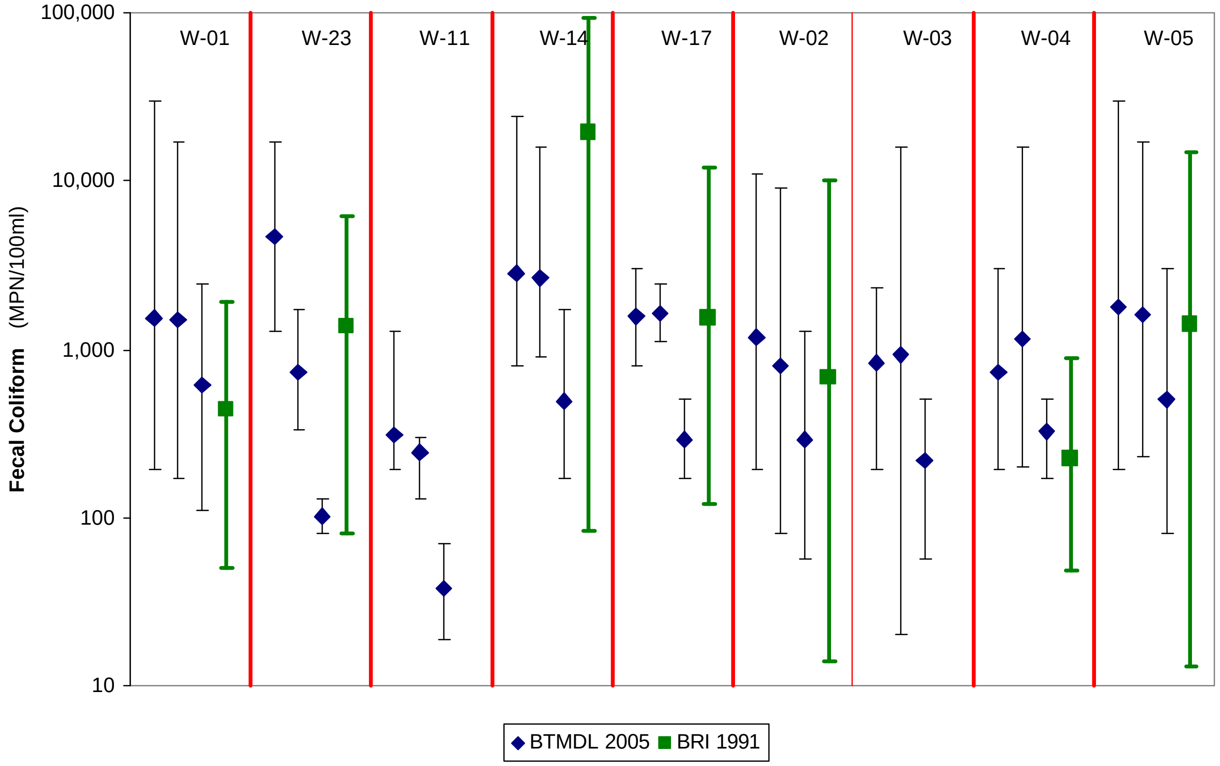


Figure 4-47: **Wet Weather Fecal Coliform Concentration Comparison between BTMDL (2005; Storms WW-01, 03, 04) and BRI (1991) (geometric means)**

Figure 4-48: Storms WW-01 and WW-02 - Nitrate Concentrations (mg/l N)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm WW-01 (July 8 - 12, 2005)															Storm WW-02 (September 15, 2005)										
						8-Jul			9-Jul				10-Jul		11-Jul		12-Jul	Statistics (Runs 2-12)			14-Sep	15-Sep							Statistics (Runs 1-7)		
						8:30 - 10:15h	16:40 - 18:25h	21:00 - 23:15h	0:10 - 2:30h	6:20 - 7:50h	14:30 - 16:15h	20:30 - 22:40h	6:40 - 8:10h	15:15 - 16:30h	8:40 - 10:00h	14:50 -15:30h	8:40 - 10:00h	Minimum	Maximum	Mean	11:10 - 18:30h	10:35 - 11:10h	11:45 - 12:46h	13:35 -14:55h	15:00 - 15:50h	16:00-16:40h	16:50 - 17:35h	17:45 - 18:30h	Minimum	Maximum	Mean
					Run No.	1	2	3	4	5	6	7	8	9	10	11	12				11	1	2	3	4	5	6	7			
W-01	Reach 1	●			Millville, MA	1.20	1.20	1.10	1.10	0.94	0.63	0.67	0.63	0.68	0.62		0.65	0.62	1.20	0.82											
W-23			●		Branch River		0.31	0.39										0.31	0.39	0.35											
W-21		●			Singleton Street		1.00	1.10										1.00	1.10	1.05											
W-22		●			Below Thundermist Dam		1.00	0.94										0.94	1.00	0.97											
W-11			●		Mill River (MA/RI border)	0.55	0.58	0.56	0.54			0.45						0.45	0.58	0.53											
W-12			●		Mill River (pre-culvert entry)	0.58	0.57	0.58	0.59			0.53						0.53	0.59	0.57											
W-13			●		Mill River (confluence w/ BR)	0.59	0.59	0.58	0.58			0.52						0.52	0.59	0.57											
W-14			●		Peters River (MA/RI border)	0.48	0.56	0.37	0.38			0.27						0.27	0.56	0.40											
W-15			●		Peters River (pre-culvert entry)	0.50	0.49	0.42	0.35			0.28						0.28	0.49	0.39											
W-16			●		Peters River (confluence w/ BR)																										
W-17		●			Hamlet Avenue		1.10	0.96										0.96	1.10	1.03											
W-24				●	Woonsocket WWTF					6.40			4.80					4.80	6.40	5.60											
W-02	Reach 2	●			Manville Dam	1.50	1.20	1.20	0.93	0.86	0.80	0.65	0.61	0.60	0.59		0.72	0.59	1.20	0.82											
W-03		●			George Washington Hwy Bridge	1.70	1.70	1.30	1.10	0.87	0.87	0.85	0.63	0.61	0.68	0.64	0.67	0.61	1.70	0.90											
W-04	Reach 3	●			Lonsdale Ave	1.50	1.80	1.60	1.20	0.93	0.90	0.78	0.63	0.61	0.68	0.67	0.67	0.61	1.80	0.95											
W-25		●			Broad Street	1.50	1.70	1.70										1.70	1.70	1.70											
W-26			●		Abbott Run Brook	0.42	0.46	0.44										0.44	0.46	0.45											
W-05		●			Slaters Mill Dam	1.40	1.40	1.70	1.60	1.10	0.93	0.86	0.76	0.64	0.67	0.71	0.64	0.64	1.70	1.00											
W-31	1			●	Cherry Brook		<0.25	<0.25										<0.25	<0.25	<0.25											
W-32				●	Front Street Drain		0.40	0.90										0.40	0.90	0.65											
W-33				●	Sylvestre Pond Outflow		0.40	0.37										0.37	0.40	0.39											
W-34	2			●	Blackstone Canal at Lonsdale	1.50	1.60	1.40										1.40	1.60	1.50											
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate	1.50	1.20	1.00	0.92		0.80	0.72	0.61	0.60	0.64																
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate			0.57	0.46			0.48																			
W-42		(=W-14)			Duplicate			0.38	0.34			0.27																			
W-43	2 3	(=W-04)			Duplicate																										

Water Quality Criteria (Class B and B1): Criteria related to impact to the waterbody.

Figure 4-49: Storms WW-03 and WW-04 - Nitrate Concentrations (mg/l N)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm WW-03 (October 7 - 11, 2005)													Storm WW-04 (October 22 - 25, 2005)												
						7-Oct	8-Oct				9-Oct		10-Oct		11-Oct	Statistics (Runs 2-11)			22-Oct		23-Oct					24-Oct		25-Oct	Statistics (Runs 2-10)		
						12:00 - 14:50h	3:40 - 8:50h	9:10 - 11:55h	16:55 - 19:30h	20:15 - 21:40h	9:30 -12:40h	15:00 - 16:45h	5:00 - 6:45h	12:00 - 13:30h	10:00 - 11:15h	Minimum	Maximum	Mean	11:25 - 14:00h	21:10 - 23:50h	0:30 - 2:10h	3:45 - 5-45h	9:15 - 11:10h	13:15 - 16:25h	19:00 - 20:50h	11:00 - 13:30h	14:00 - 15:40h	11:00h	Minimum	Maximum	Mean
					Run No.	1	2	3	5	6	7	8	9	10	11				1	2	3	4	5	6	7	8	9	10			
W-01	Reach 1	●			Millville, MA	2.50	2.30	2.10	2.20	2.30	0.99	0.72	0.79	0.84	0.83	0.72	2.30	1.45	0.64	0.54	0.58	0.60	0.61	0.60	0.53	0.51	0.65		0.51	0.65	0.58
W-23			●		Branch River	0.33	0.46		0.33		0.28					0.28	0.46	0.36		0.21		0.23							0.21	0.23	0.22
W-21		●			Singleton Street		2.40		2.30		1.70					1.70	2.40	2.13		0.49		0.49							0.49	0.49	0.49
W-22		●			Below Thundermist Dam		2.30		2.30		1.70					1.70	2.30	2.10		0.49		0.50							0.49	0.50	0.50
W-11			●		Mill River (MA/RI border)	0.49	0.24	0.29	0.28		0.29					0.24	0.29	0.28	0.36	0.36		0.38		0.35	0.38				0.35	0.38	0.37
W-12			●		Mill River (pre-culvert entry)	0.29	0.30	0.29	<0.025		0.30					<0.025	0.30	0.23	0.40	0.40		0.35		0.41	0.39				0.35	0.41	0.39
W-13			●		Mill River (confluence w/ BR)	0.27	0.30	0.30	0.33		0.29					0.29	0.33	0.31	0.42	0.38		0.37		0.38	0.37				0.37	0.38	0.38
W-14			●		Peters River (MA/RI border)	0.65	0.69	<0.025	0.49		0.29					<0.025	0.69	0.37	0.54	0.54		0.47		0.35	0.28				0.28	0.54	0.41
W-15			●		Peters River (pre-culvert entry)	0.64	0.55	0.58	<0.025		0.27					<0.025	0.58	0.35	0.55	0.50		0.46		0.31	0.29				0.29	0.50	0.39
W-16			●		Peters River (confluence w/ BR)	0.64	0.68	0.50	0.45							0.45	0.68	0.54													
W-17		●			Hamlet Avenue		2.10		2.20		1.70					1.70	2.20	2.00		0.51		0.49							0.49	0.51	0.50
W-24				●	Woonsocket WWTF		6.90									6.90	6.90	6.90								5.90		3.40	3.40	5.90	4.65
W-02	Reach 2	●			Manville Dam	2.00	2.10	2.10	2.20	2.20	1.50	1.30	0.47	0.67	0.69	0.47	2.20	1.47	0.62	0.58	0.55	0.52	0.48	0.54	0.51	0.48	0.47		0.47	0.58	0.52
W-03		●			George Washington Hwy Bridge	1.70	2.00	2.10	2.10	2.30	1.20	1.40	<0.025	0.64	0.73	<0.025	2.30	1.39	0.66	0.57	0.58	0.55	0.51	0.53	0.52	0.46	0.48		0.46	0.58	0.53
W-04	Reach 3	●			Lonsdale Ave	1.70	1.90	2.00	2.10	2.30	1.50	1.20	0.05	0.66	0.76	0.05	2.30	1.39	0.68	0.59	0.57	0.55	0.51	0.50	0.53	0.46	0.46		0.46	0.59	0.52
W-25		●			Broad Street		1.90		1.80		1.80					1.80	1.90	1.83		0.52		0.54							0.52	0.54	0.53
W-26			●		Abbott Run Brook		<0.025		0.25		0.26					<0.025	0.26	0.17		0.73		0.69							0.69	0.73	0.71
W-05		●			Slaters Mill Dam	1.60	1.60	1.60	1.70	1.80	1.60	1.20	0.70	0.32	0.77	0.32	1.80	1.25	0.62	0.57	0.59	0.56	0.54	0.54	0.51	0.47	0.47		0.47	0.59	0.53
W-31	1			●	Cherry Brook		0.57		0.43		0.36					0.36	0.57	0.45		0.25		0.25							0.25	0.25	0.25
W-32				●	Front Street Drain		1.60		1.10		2.90					1.10	2.90	1.87		1.20		1.10							1.10	1.20	1.15
W-33				●	Sylvestre Pond Outflow		0.49				0.32					0.32	0.49	0.41		0.89		0.81							0.81	0.89	0.85
W-34	2			●	Blackstone Canal at Lonsdale		2.70		2.70		2.00					2.00	2.70	2.47		0.59		0.61							0.59	0.61	0.60
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate																										
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41	1	(=W-11)			Duplicate		0.41	0.23	0.23										0.37	0.38		0.34		0.37							
W-42		(=W-14)			Duplicate	0.66	0.65	0.62	0.50										0.51	0.56		0.45		0.31							
W-43	2 3	(=W-04)			Duplicate	1.70	1.80	1.80	2.10	2.30									0.64	0.58	0.57	0.54	0.51	0.53							

No Run 4 for WW-03.

▨ Concentration of duplicate sample W-42 over 20 times of original sample (W-14).

Water Quality Criteria (Class B and B1): Criteria related to impact to the waterbody.
Reporting Limit: 0.025 mg/l

Figure 4-50: Storms WW-01 and WW-02 - Ammonia Concentrations (mg/l N)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm WW-01 (July 8 - 12, 2005)															Storm WW-02 (September 15, 2005)										
						8-Jul			9-Jul				10-Jul		11-Jul		12-Jul	Statistics (Runs 2-12)			14-Sep	15-Sep							Statistics (Runs 1-7)		
						8:30 - 10:15h	16:40 - 18:25h	21:00 - 23:15h	0:10 - 2:30h	6:20 - 7:50h	14:30 - 16:15h	20:30 - 22:40h	6:40 - 8:10h	15:15 - 16:30h	8:40 - 10:00h	14:50 -15:30h	8:40 - 10:00h	Minimum	Maximum	Mean	11:10 - 18:30h	10:35 - 11:10h	11:45 - 12:46h	13:35 -14:55h	15:00 - 15:50h	16:00-16:40h	16:50 - 17:35h	17:45 - 18:30h	Minimum	Maximum	Mean
					Run No.	1	2	3	4	5	6	7	8	9	10	11	12				11	1	2	3	4	5	6	7			
W-01	Reach 1	●			Millville, MA	0.95	0.48	0.35	0.42	0.30	0.41	0.29	<0.20	0.34	<0.20		<0.20	<0.20	0.48	0.29											
W-23			●		Branch River		0.22	0.39										0.22	0.39	0.31											
W-21		●			Singleton Street		0.28	<0.20										<0.20	0.28	0.19											
W-22		●			Below Thundermist Dam		0.31	0.31										0.31	0.31	0.31											
W-11			●		Mill River (MA/RI border)	0.61	<0.20	0.21	0.45			<0.20						<0.20	0.45	0.22											
W-12			●		Mill River (pre-culvert entry)	0.81	0.35	<0.20	0.22			<0.20						<0.20	0.35	0.19											
W-13			●		Mill River (confluence w/ BR)	0.42	<0.20	0.25	0.20			<0.20						<0.20	0.25	0.16											
W-14			●		Peters River (MA/RI border)	0.65	0.74	0.40	0.41			<0.20						<0.20	0.74	0.41											
W-15			●		Peters River (pre-culvert entry)	0.47	0.31	0.26	1.20			0.23						0.23	1.20	0.50											
W-16			●		Peters River (confluence w/ BR)																										
W-17		●			Hamlet Avenue		0.31	0.36										0.31	0.36	0.34											
W-24				●	Woonsocket WWTF					1.50			1.70					1.50	1.70	1.60											
W-02	Reach 2	●			Manville Dam	0.58	0.23	0.32	0.28	0.24	0.26	0.47	0.26	<0.20	0.24		0.24	<0.20	0.47	0.26											
W-03		●			George Washington Hwy Bridge	0.54	0.34	0.34	0.39	0.28	<0.20	0.23	0.30	0.24	0.20	0.22	<0.20	<0.20	0.39	0.26											
W-04	Reach 3	●			Lonsdale Ave	0.37	0.26	<0.20	0.46	0.26	0.25	<0.20	<0.20	0.35	0.20	<0.20	<0.20	<0.20	0.46	0.21											
W-25		●			Broad Street	0.50	0.24	0.33										0.24	0.33	0.29											
W-26			●		Abbott Run Brook	0.50	1.30	0.42										0.42	1.30	0.86											
W-05		●			Slaters Mill Dam	0.56	0.25	0.28	0.44	0.29	0.28	<0.20	<0.20	0.28	<0.20	0.23	<0.20	<0.20	0.44	0.22											
W-31	1			●	Cherry Brook		0.35	0.55										0.35	0.55	0.45											
W-32				●	Front Street Drain		0.36	<0.20										0.36	0.36	0.23											
W-33				●	Sylvestre Pond Outflow		0.29	0.29										0.29	0.29	0.29											
W-34	2			●	Blackstone Canal at Lonsdale	0.49	0.43	0.35										0.35	0.43	0.39											
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate	1.80	0.58	0.42	0.37		0.86	0.28	0.41	0.29	<0.20																
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate			0.33	0.50			<0.20																			
W-42		(=W-14)			Duplicate			0.34	0.67			0.24																			
W-43	2 3	(=W-04)			Duplicate																										

pH	Acute Criteria mg/l N	Chronic Criteria mg/l N		
		10ºC	*15ºC*	*20ºC*
6.5	48.8	8.9	6.5	4.7
7.0	36.1	7.9	5.7	4.2
7.5	19.9	5.8	4.2	3.1

Figure 4-51: Storms WW-03 and WW-04 - Ammonia Concentrations (mg/l N)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm WW-03 (October 7 - 11, 2005)													Storm WW-04 (October 22 - 25, 2005)												
						7-Oct	8-Oct				9-Oct		10-Oct		11-Oct	Statistics (Runs 2-11)			22-Oct		23-Oct					24-Oct		25-Oct	Statistics (Runs 2-10)		
						12:00 - 14:50h	3:40 - 8:50h	9:10 - 11:55h	16:55 - 19:30h	20:15 - 21:40h	9:30 -12:40h	15:00 - 16:45h	5:00 - 6:45h	12:00 - 13:30h	10:00 - 11:15h	Minimum	Maximum	Mean	11:25 - 14:00h	21:10 - 23:50h	0:30 - 2:10h	3:45 - 5-45h	9:15 - 11:10h	13:15 - 16:25h	19:00 - 20:50h	11:00 - 13:30h	14:00 - 15:40h	11:00h	Minimum	Maximum	Mean
					Run No.	1	2	3	5	6	7	8	9	10	11				1	2	3	4	5	6	7	8	9	10			
W-01	Reach 1	●			Millville, MA	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.25	<0.20	<0.20	0.25		0.41	0.38	0.21	0.46	0.35	0.39	<0.20	0.31	0.33		<0.20	0.46	0.32
W-23			●		Branch River	0.52	0.94		<0.20		<0.20					<0.20	0.94			0.28		<0.20							<0.20	0.28	0.19
W-21		●			Singleton Street		<0.20		<0.20		0.21					<0.20	0.21			0.35		<0.20							<0.20	0.35	0.23
W-22		●			Below Thundermist Dam		0.33		<0.20		<0.20					<0.20	0.33			0.64		0.38							0.38	0.64	0.37
W-11			●		Mill River (MA/RI border)	<0.20	<0.20	<0.20	<0.20		<0.20					<0.20	<0.20		<0.20	0.36		0.33		0.34	<0.20				<0.20	0.36	0.28
W-12			●		Mill River (pre-culvert entry)	<0.20	<0.20	<0.20	<0.20		<0.20					<0.20	<0.20		0.31	0.28		<0.20		<0.20	<0.20				<0.20	0.28	0.15
W-13			●		Mill River (confluence w/ BR)	<0.20	<0.20	<0.20	<0.20		<0.20					<0.20	<0.20		<0.20	<0.20		0.41		<0.20	<0.20				<0.20	0.41	0.18
W-14			●		Peters River (MA/RI border)	0.34	<0.20	<0.20	<0.20		<0.20					<0.20	<0.20		<0.20	<0.20		<0.20		<0.20	<0.20				<0.20	<0.20	<0.20
W-15			●		Peters River (pre-culvert entry)	0.36	<0.20	<0.20	<0.20		<0.20					<0.20	<0.20		<0.20	<0.20		<0.20		<0.20	<0.20				<0.20	<0.20	<0.20
W-16			●		Peters River (confluence w/ BR)	0.37	<0.20	<0.20	<0.20							<0.20	<0.20														
W-17		●			Hamlet Avenue		<0.20		<0.20		<0.20					<0.20	<0.20			0.27		<0.20							<0.20	0.27	0.19
W-24				●	Woonsocket WWTF		0.66									0.66	0.66									0.85		0.19	0.19	0.85	0.52
W-02	Reach 2	●			Manville Dam	0.21	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.69	0.23	<0.20	<0.20	0.69		0.40	0.37	0.41	0.42	0.23	<0.20	0.28	<0.20	0.30		<0.20	0.42	0.28
W-03		●			George Washington Hwy Bridge	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.27	0.42	<0.20	<0.20	<0.20	0.42		0.28	0.45	0.22	0.22	<0.20	0.39	0.21	0.26	0.22		<0.20	0.45	0.26
W-04	Reach 3	●			Lonsdale Ave	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.38	0.24	<0.20	<0.20	0.38		0.42	0.26	<0.20	0.23	<0.20	0.25	<0.20	<0.20	<0.20		<0.20	0.26	0.16
W-25		●			Broad Street		0.68		0.43		<0.20					<0.20	0.68			0.27		0.23							0.23	0.27	0.25
W-26			●		Abbott Run Brook		<0.20		<0.20		<0.20					<0.20	<0.20			0.22		<0.20							<0.20	0.22	0.16
W-05		●			Slaters Mill Dam	<0.20	0.22	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.22	0.22		0.58	0.27	<0.20	0.26	0.22	<0.20	<0.20	0.32	0.26		<0.20	0.32	0.20
W-31	1			●	Cherry Brook		0.68		<0.20		<0.20					<0.20	0.68			0.27		<0.20							<0.20	0.27	0.19
W-32				●	Front Street Drain		0.64		<0.20		<0.20					<0.20	0.64			0.31		<0.20							<0.20	0.31	0.21
W-33				●	Sylvestre Pond Outflow		<0.20				0.33					<0.20	0.33			0.38		<0.20							<0.20	0.38	0.24
W-34	2			●	Blackstone Canal at Lonsdale		<0.20		<0.20		0.39					<0.20	0.39			<0.20		<0.20							<0.20	<0.20	<0.20
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate																										
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41	1	(=W-11)			Duplicate		<0.20	<0.20	<0.20										0.25	<0.20		<0.20		<0.20							
W-42		(=W-14)			Duplicate	0.50	<0.20	<0.20	0.24										0.28	<0.20		<0.20		<0.20							
W-43	2 3	(=W-04)			Duplicate	0.63	<0.20	<0.20	0.27	<0.20									0.36	0.26	0.26	0.49	0.21	0.21							

No Run 4 for WW-03.

0.61 Concentration of duplicate samples differ considerably from original sample.

Reporting Limit: 0.20 mg/l

pH	Acute Criteria mg/l N	Chronic Criteria mg/l N		
		10ºC	15ºC	20ºC
6.5	48.8	8.90	6.5	4.7
7.0	36.1	7.90	5.7	4.2
7.5	19.9	5.80	4.2	3.1

Figure 4-52: Storms WW-01 and WW-02 - Total Kjeldahl Nitrogen Concentrations (mg/l N)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm WW-01 (July 8 - 12, 2005)															Storm WW-02 (September 15, 2005)										
						8-Jul			9-Jul				10-Jul		11-Jul		12-Jul	Statistics (Runs 2-12)			14-Sep	15-Sep							Statistics (Runs 1-7)		
						8:30 - 10:15h	16:40 - 18:25h	21:00 - 23:15h	0:10 - 2:30h	6:20 - 7:50h	14:30 - 16:15h	20:30 - 22:40h	6:40 - 8:10h	15:15 - 16:30h	8:40 - 10:00h	14:50 -15:30h	8:40 - 10:00h	Minimum	Maximum	Mean	11:10 - 18:30h	10:35 - 11:10h	11:45 - 12:46h	13:35 -14:55h	15:00 - 15:50h	16:00-16:40h	16:50 - 17:35h	17:45 - 18:30h	Minimum	Maximum	Mean
					Run No.	1	2	3	4	5	6	7	8	9	10	11	12				DW-11	1	2	3	4	5	6	7			
W-01	Reach 1	●			Millville, MA	0.75	0.85	0.68	0.78	0.94	1.20	0.92	0.83	0.71	0.66		0.74	0.66	1.20	0.83											
W-23			●		Branch River		0.39	0.88										0.39	0.88	0.64											
W-21		●			Singleton Street		0.78	0.64										0.64	0.78	0.71											
W-22		●			Below Thundermist Dam		0.67	0.61										0.61	0.67	0.64											
W-11			●		Mill River (MA/RI border)	0.23	0.52	0.51	0.30			0.37						0.30	0.52	0.43											
W-12			●		Mill River (pre-culvert entry)	0.30	0.67	0.61	0.34			0.86						0.34	0.86	0.62											
W-13			●		Mill River (confluence w/ BR)	0.34	0.61	0.51	0.56			0.74						0.51	0.74	0.61											
W-14			●		Peters River (MA/RI border)	0.32	0.41	0.58	0.63			0.78						0.41	0.78	0.60											
W-15			●		Peters River (pre-culvert entry)	0.25	0.53	0.62	0.66			0.70						0.53	0.70	0.63											
W-16			●		Peters River (confluence w/ BR)																										
W-17		●			Hamlet Avenue		0.81	0.79										0.79	0.81	0.80											
W-24				●	Woonsocket WWTF					3.00			3.10					3.00	3.10	3.05											
W-02	Reach 2	●			Manville Dam	0.78	0.69	0.91	0.57	0.76	0.85	1.30	0.81	0.74	0.52		0.65	0.52	1.30	0.78											
W-03		●			George Washington Hwy Bridge	0.52	0.81	0.78	0.76	0.75	0.73	1.00	0.83	0.71	0.65	0.56	0.62	0.56	1.00	0.75											
W-04	Reach 3	●			Lonsdale Ave	0.71	0.83	0.77	1.70	0.80	0.74	0.67	0.81	0.75	0.65	0.46	0.62	0.46	1.70	0.80											
W-25		●			Broad Street	0.66	0.75	0.79										0.75	0.79	0.77											
W-26			●		Abbott Run Brook	0.14	0.45	0.32										0.32	0.45	0.39											
W-05		●			Slaters Mill Dam	0.98	0.80	0.78	0.65	0.69	0.66	0.90	0.85	0.78	0.66	0.56	0.34	0.34	0.90	0.70											
W-31	1			●	Cherry Brook		0.78	0.69										0.69	0.78	0.74											
W-32				●	Front Street Drain		1.10	0.40										0.40	1.10	0.75											
W-33				●	Sylvestre Pond Outflow		0.81	0.16										0.16	0.81	0.48											
W-34	2			●	Blackstone Canal at Lonsdale	0.54	0.88	0.64										0.64	0.88	0.76											
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate	0.35	0.98	0.92	0.71	0.69	0.90	1.20	0.89	0.66	0.64																
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate			0.77	0.61			1.30																			
W-42		(=W-14)			Duplicate			0.67	0.57			0.80																			
W-43	2 3	(=W-04)			Duplicate																										

Note: Concentrations for TKN were reported down to the Method Detection Limit; the Reporting Limit was 1.6 mg/l.

▨ 0.61 Concentration of duplicate samples differ considerably from original sample.

Water Quality Criteria (Class B and B1): Criteria related to impact to the waterbody.

Figure 4-53: Storms WW-03 and WW-04 - Total Kjeldahl Nitrogen Concentrations (mg/l N)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm **WW-03** (October 7 - 11, 2005)													Storm **WW-04** (October 22 - 25, 2005)												
						7-Oct	8-Oct				9-Oct		10-Oct		11-Oct	Statistics (Runs 2-11)			22-Oct		23-Oct					24-Oct		25-Oct	Statistics (Runs 2-10)		
						12:00 - 14:50h	3:40 - 8:50h	9:10 - 11:55h	16:55 - 19:30h	20:15 - 21:40h	9:30 -12:40h	15:00 - 16:45h	5:00 - 6:45h	12:00 - 13:30h	10:00 - 11:15h	**Minimum**	**Maximum**	**Mean**	11:25 - 14:00h	21:10 - 23:50h	0:30 - 2:10h	3:45 - 5:45h	9:15 - 11:10h	13:15 - 16:25h	19:00 - 20:50h	11:00 - 13:30h	14:00 - 15:40h	11:00h	**Minimum**	**Maximum**	**Mean**
					Run No.	1	2	3	5	6	7	8	9	10	11				1	2	3	4	5	6	7	8	9	10			
W-01	Reach 1	●			Millville, MA	0.62	1.00	0.71	0.91	0.80	1.40	0.91	0.66	0.79	0.90	0.66	1.40	0.90	0.92	1.00	0.72	1.10	1.10	0.73	0.47	0.97	0.80		0.47	1.10	0.86
W-23			●		Branch River	0.46	0.90		0.78		0.68					0.68	0.90	0.79		0.12		0.97							0.12	0.97	0.55
W-21		●			Singleton Street		0.36		0.94		0.86					0.36	0.94	0.72		1.10		0.98							0.98	1.10	1.04
W-22		●			Below Thundermist Dam		0.88		0.94		1.10					0.88	1.10	0.97		0.89		1.10							0.89	1.10	1.00
W-11			●		Mill River (MA/RI border)	0.46	0.50	0.72	0.63		0.40					0.40	0.72	0.56	0.51	0.78		0.61		0.62	0.61				0.61	0.78	0.66
W-12			●		Mill River (pre-culvert entry)	0.48	3.30	0.35	0.49		0.43					0.35	3.30	1.14	0.05	0.50		0.62		0.58	0.51				0.50	0.62	0.55
W-13			●		Mill River (confluence w/ BR)	0.84	0.46	0.56	0.61		0.50					0.46	0.61	0.53	0.56	0.57		0.67		0.67	0.68				0.57	0.68	0.65
W-14			●		Peters River (MA/RI border)	0.44	0.52	0.71	0.55		0.43					0.43	0.71	0.55	0.42	0.82		0.62		0.60	0.47				0.47	0.82	0.63
W-15			●		Peters River (pre-culvert entry)	0.44	0.30	0.36	0.41		0.59					0.30	0.59	0.42	0.47	0.99		0.98		0.70	0.57				0.57	0.99	0.81
W-16			●		Peters River (confluence w/ BR)	0.34	0.40	0.32	0.54							0.32	0.54	0.42													
W-17		●			Hamlet Avenue		0.88		0.89		0.86					0.86	0.89	0.88		0.68		0.89							0.68	0.89	0.79
W-24				●	Woonsocket WWTF		1.70									1.70	1.70	1.70								1.40		3.70	1.40	3.70	2.55
W-02	Reach 2	●			Manville Dam	0.86	0.70	0.59	0.78	1.00	0.69	0.89	0.85	0.69	0.76	0.59	1.00	0.77	0.62	0.73	0.96	0.71	0.76	0.61	0.98	0.60	0.77		0.60	0.98	0.77
W-03		●			George Washington Hwy Bridge	1.00	0.64	0.81	0.81	0.75	0.69	0.73	0.76	0.76	0.68	0.64	0.81	0.74	0.76	0.69	0.89	0.46	0.74	0.56	0.83	0.69	0.76		0.46	0.89	0.70
W-04	Reach 3	●			Lonsdale Ave	0.64	1.60	0.81	0.88	0.93	0.66	0.60	0.61	0.89	0.73	0.60	1.60	0.86	0.64	0.92	0.81	0.79	0.82	0.62	0.72	0.66	0.68		0.62	0.92	0.75
W-25		●			Broad Street		0.50		0.59		0.79					0.50	0.79	0.63		0.53		1.10							0.53	1.10	0.82
W-26			●		Abbott Run Brook		0.26		0.40		0.30					0.26	0.40	0.32		0.36		0.79							0.36	0.79	0.58
W-05		●			Slaters Mill Dam	0.60	0.66	0.48	0.95	0.69	0.63	0.56	0.68	0.91	0.80	0.48	0.95	0.71	0.62	0.69	0.73	0.66	0.80	0.91	0.66	0.69	0.68		0.66	0.91	0.73
W-31	1			●	Cherry Brook		0.74		0.59		0.62					0.59	0.74	0.65		0.88		0.64							0.64	0.88	0.76
W-32				●	Front Street Drain		0.24		0.54		0.55					0.24	0.55	0.44		0.51		0.61							0.51	0.61	0.56
W-33				●	Sylvestre Pond Outflow		0.60				0.79					0.60	0.79	0.70		0.69		0.80							0.69	0.80	0.75
W-34	2			●	Blackstone Canal at Lonsdale		0.66		0.86		0.90					0.66	0.90	0.81		0.52		0.88							0.52	0.88	0.70
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate																										
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate		0.58	0.49	0.54										0.54	0.51		0.49		0.87							
W-42		(=W-14)			Duplicate	0.42	0.70	1.00	0.50										0.52	0.76		0.57		0.51							
W-43	2 3	(=W-04)			Duplicate	0.68	0.76	0.63	0.62	0.63									0.68	0.52	0.77	0.80	0.78	0.57							

Note: Concentrations for TKN were reported down to the Method Detection Limit; the Reporting Limit was 1.6 mg/l.

No Run 4 for WW-03.

▨ 0.61 Concentration of duplicate samples differ considerably from original sample.

Water Quality Criteria (Class B and B1): Criteria related to impact to the waterbody.

Reporting Limit: 0.1 mg/l

Figure 4-54: Storms WW-01 and WW-02 - Total Phosphorus Concentrations (mg/l P)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	**Storm WW-01** (July 8 - 12, 2005)															**Storm WW-02** (September 15, 2005)										
						8-Jul			9-Jul				10-Jul		11-Jul		12-Jul	**Statistics** (Runs 2-12)			14-Sep	15-Sep							**Statistics** (Runs 1-7)		
						8:30 - 10:15h	16:40 - 18:25h	21:00 - 23:15h	0:10 - 2:30h	6:20 - 7:50h	14:30 - 16:15h	20:30 - 22:40h	6:40 - 8:10h	15:15 - 16:30h	8:40 - 10:00h	14:50 -15:30h	8:40 - 10:00h	**Minimum**	**Maximum**	**Mean**	11:10 - 18:30h	10:35 - 11:10h	11:45 - 12:46h	13:35 -14:55h	15:00 - 15:50h	16:00-16:40h	16:50 - 17:35h	17:45 - 18:30h	**Minimum**	**Maximum**	**Mean**
					Run No.	1	2	3	4	5	6	7	8	9	10	11	12				11	1	2	3	4	5	6	7			
W-01	**Reach 1**	●			Millville, MA	0.25	0.29	0.26	0.23	0.15	0.23	0.38	0.15	0.17	0.15		0.17	0.15	0.38	0.22											
W-23			●		Branch River		0.06	0.07										0.06	0.07	0.06											
W-21		●			Singleton Street		0.22	0.27										0.22	0.27	0.25											
W-22		●			Below Thundermist Dam		0.28	0.23										0.23	0.28	0.26											
W-11			●		Mill River (MA/RI border)	0.08	0.12	0.07	0.08			0.05						0.05	0.12	0.08											
W-12			●		Mill River (pre-culvert entry)	0.07	0.19	0.10	0.08			0.07						0.07	0.19	0.11											
W-13			●		Mill River (confluence w/ BR)	0.09	0.11	0.07	0.07			0.06						0.06	0.11	0.07											
W-14			●		Peters River (MA/RI border)	0.16	0.11	0.11	0.13			0.09						0.09	0.13	0.11											
W-15			●		Peters River (pre-culvert entry)	0.11	0.12	0.08	0.08			0.11						0.08	0.12	0.10											
W-16			●		Peters River (confluence w/ BR)																										
W-17		●			Hamlet Avenue		0.26	0.21										0.21	0.26	0.24											
W-24				●	Woonsocket WWTF					2.90			0.18					0.18	2.90	1.54											
W-02	**Reach 2**	●			Manville Dam	0.27	0.31	0.31	0.16	0.13	0.21	0.36	0.39	0.23	0.13		0.11	0.11	0.39	0.23											
W-03		●			George Washington Hwy Bridge	0.30	0.35	0.29	0.26	0.19	0.32	0.21	0.18	0.23	0.14	0.09	0.10	0.09	0.35	0.21											
W-04	**Reach 3**	●			Lonsdale Ave	0.21	0.36	0.24	0.40	0.30	0.20	0.23	0.23	0.19	0.12	0.14	0.12	0.12	0.40	0.23											
W-25		●			Broad Street	0.26	0.24	0.41										0.24	0.41	0.33											
W-26			●		Abbott Run Brook	0.07	0.06	0.12										0.06	0.12	0.09											
W-05		●			Slaters Mill Dam	0.26	0.30	0.23	0.47	0.19	0.16	0.16	0.25	0.21	0.13	0.10	0.10	0.10	0.47	0.21											
W-31	1			●	Cherry Brook		0.19	0.17										0.17	0.19	0.18											
W-32				●	Front Street Drain		0.19	0.11										0.11	0.19	0.15											
W-33				●	Sylvestre Pond Outflow		0.12	0.23										0.12	0.23	0.18											
W-34	2			●	Blackstone Canal at Lonsdale	0.17	0.15	0.12										0.12	0.15	0.14											
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate	0.42	0.25	0.21	0.23		0.15	0.20	0.18	0.12	0.09																
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate			0.13	0.06			0.09																			
W-42		(=W-14)			Duplicate			0.14	0.12			0.19																			
W-43	2 3	(=W-04)			Duplicate																										

Water Quality Criteria (Class B and B1): Criteria related to impact to the waterbody.

Figure 4-55: Storms WW-03 and WW-04 - Total Phosphorus Concentrations (mg/l P)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm WW-03 (October 7 - 11, 2005)													Storm WW-04 (October 22 - 25, 2005)												
						7-Oct	8-Oct				9-Oct		10-Oct		11-Oct	Statistics (Runs 2-11)			22-Oct		23-Oct					24-Oct		25-Oct	Statistics (Runs 2-10)		
						12:00 - 14:50h	3:40 - 8:50h	9:10 - 11:55h	16:55 - 19:30h	20:15 - 21:40h	9:30 -12:40h	15:00 - 16:45h	5:00 - 6:45h	12:00 - 13:30h	10:00 - 11:15h	Minimum	Maximum	Mean	11:25 - 14:00h	21:10 - 23:50h	0:30 - 2:10h	3:45 - 5-45h	9:15 - 11:10h	13:15 - 16:25h	19:00 - 20:50h	11:00 - 13:30h	14:00 - 15:40h	11:00h	Minimum	Maximum	Mean
					Run No.	1	2	3	5	6	7	8	9	10	11				1	2	3	4	5	6	7	8	9	10			
W-01	Reach 1	●			Millville, MA	0.46	0.49	0.41	0.44	0.48	0.82	0.68	0.30	0.24	0.27	0.24	0.82	0.46	0.13	0.20	0.15	0.21	0.19	0.20	0.37	0.20	0.17		0.15	0.37	0.21
W-23			●		Branch River	0.06	0.07		0.05		0.06					0.05	0.07	0.06		0.17		0.14							0.14	0.17	0.16
W-21		●			Singleton Street		0.40		0.39		0.43					0.39	0.43	0.41		0.16		0.20							0.16	0.20	0.18
W-22		●			Below Thundermist Dam		0.35		<0.05		0.39					<0.05	0.39	0.37		0.18		0.11							0.11	0.18	0.15
W-11			●		Mill River (MA/RI border)	<0.05	<0.05	<0.05	<0.05		<0.05					<0.05	<0.05	<0.05	0.09	0.06		0.07		0.09	0.16				0.06	0.16	0.10
W-12			●		Mill River (pre-culvert entry)	0.10	0.09	<0.05	0.30		0.10					<0.05	0.30	0.13	0.11	0.07		0.12		0.10	0.19				0.07	0.19	0.12
W-13			●		Mill River (confluence w/ BR)	<0.05	0.08	<0.05	0.07		<0.05					<0.05	0.08	0.05	0.11	0.11		0.12		0.11	0.17				0.11	0.17	0.13
W-14			●		Peters River (MA/RI border)	<0.05	0.13	<0.05	0.07		<0.05					<0.05	0.13	0.06	0.14	0.16		0.19		0.09	0.12				0.09	0.19	0.14
W-15			●		Peters River (pre-culvert entry)	<0.05	<0.05	0.09	0.12		0.10					<0.05	0.12	0.08	0.19	0.19		0.11		0.10	0.15				0.10	0.19	0.14
W-16			●		Peters River (confluence w/ BR)	0.08	0.09	<0.05	0.12							<0.05	0.12	0.08													
W-17		●			Hamlet Avenue		0.39		0.36		0.38					0.36	0.39	0.38		0.13		0.15							0.13	0.15	0.14
W-24				●	Woonsocket WWTF		3.70									3.70	3.70	3.70								0.37		2.10	0.37	2.10	1.24
W-02	Reach 2	●			Manville Dam	<0.05	0.38	0.44	<0.05	0.45	0.33	0.46	0.46	0.35	0.29	<0.05	0.46	0.35	0.13	0.19	0.15	0.23	0.14	0.15	0.22	0.11	0.16		0.11	0.23	0.17
W-03		●			George Washington Hwy Bridge	<0.05	0.47	<0.05	0.43	0.33	0.34	0.44	0.52	0.36	0.23	<0.05	0.52	0.35	0.13	0.15	0.15	0.22	0.11	0.16	0.19	0.17	0.15		0.11	0.22	0.16
W-04	Reach 3	●			Lonsdale Ave	0.38	0.41	0.42	0.42	0.42	0.40	0.48	0.49	0.34	0.27	0.27	0.49	0.41	0.12	0.05	0.12	0.24	0.13	0.15	0.23	0.13	0.19		0.05	0.24	0.15
W-25		●			Broad Street		0.40		0.39		0.40					0.39	0.40	0.40		0.15		0.05							0.05	0.15	0.10
W-26			●		Abbott Run Brook		0.11		<0.05		0.08					<0.05	0.11	0.07		0.08		0.11							0.08	0.11	0.09
W-05		●			Slaters Mill Dam	0.33	0.30	0.36	0.30	0.19	0.42	0.42	0.45	0.41	0.38	0.19	0.45	0.36	0.17	0.14	0.14	0.18	0.16	0.13	0.15	0.19	0.15		0.13	0.19	0.16
W-31	1			●	Cherry Brook		0.20		0.12		0.22					0.12	0.22	0.18		0.15		0.38							0.15	0.38	0.27
W-32				●	Front Street Drain		0.11		0.08		0.10					0.08	0.11	0.10		0.14		0.13							0.13	0.14	0.14
W-33				●	Sylvestre Pond Outflow		0.07				0.10					0.07	0.10	0.09		0.12		0.10							0.10	0.12	0.11
W-34	2			●	Blackstone Canal at Lonsdale		0.23		0.21		0.28					0.21	0.28	0.24		0.12		0.13							0.12	0.13	0.13
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate																										
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate		<0.05	0.05	<0.05										0.09	0.07		0.08		0.09							
W-42		(=W-14)			Duplicate	0.22	<0.05	0.14	0.11										0.13	0.08		0.10		0.08							
W-43	2 3	(=W-04)			Duplicate	0.37	0.42	0.42	0.44	0.50									0.12	0.17	0.13	0.14	0.17	0.17							

No Run 4 for WW-03.

▨ 0.11 Concentration of duplicate samples differ considerably from original sample.

Water Quality Criteria (Class B and B1): Criteria related to impact to the waterbody.

Reporting Limit: 0.05 mg/l (WW-03); 0.033 mg/l (WW-04)

Figure 4-56: Summary of Event Mean Concentrations (EMC) for Nutrients

Station	**Nitrate** (mg/l N)			**Ammonia** (mg/l N)			**Total Kjeldahl Nitrogen** (mg/l)			**Total Phosphorus** (mg/l)		
	Storms			**Storms**			**Storms**			**Storms**		
	WW-01	**WW-03**	**WW-04**	**WW-01**	**WW-03**	**WW-04**	**WW-01**	**WW-03**	**WW-04**	**WW-01**	**WW-03**	**WW-04**
W-01	0.75	0.96	0.58	0.28	0.13	0.31	0.87	0.89	0.85	0.22	0.45	0.21
W-23	0.36	0.30	0.22	0.32	0.15	0.18	0.69	0.70	0.59	0.06	0.06	0.15
W-21	1.06	1.84	0.49	0.18	0.19	0.22	0.70	0.83	1.04	0.25	0.42	0.18
W-22	0.97	1.83	0.50	0.31	0.12	0.50	0.64	1.06	1.00	0.25	0.34	0.14
W-11	0.54	0.29	0.37	0.23	0.10	0.27	0.42	0.46	0.65	0.08	0.03	0.10
W-12	0.57	0.27	0.39	0.19	0.10	0.14	0.60	0.65	0.55	0.11	0.11	0.12
W-13	0.57	0.30	0.37	0.17	0.10	0.17	0.60	0.51	0.65	0.07	0.03	0.13
W-14	0.39	0.31	0.40	0.42	0.10	0.10	0.60	0.47	0.62	0.11	0.04	0.14
W-15	0.38	0.29	0.33	0.53	0.10	0.10	0.62	0.54	0.69	0.09	0.10	0.12
W-16		0.53			0.10			0.43			0.08	
W-17	1.01	1.80	0.50	0.34	0.10	0.18	0.80	0.87	0.79	0.23	0.38	0.14
W-24												
W-02	0.76	1.06	0.51	0.28	0.25	0.27	0.71	0.79	0.76	0.21	0.38	0.17
W-03	0.85	0.91	0.52	0.24	0.20	0.25	0.76	0.73	0.70	0.21	0.39	0.16
W-04	0.88	0.93	0.52	0.20	0.18	0.15	0.78	0.73	0.74	0.22	0.41	0.16
W-25	1.70	1.81	0.53	0.29	0.20	0.25	0.77	0.74	0.83	0.34	0.40	0.10
W-26	0.45	0.11	0.71	0.83	0.10	0.15	0.38	0.30	0.61	0.09	0.08	0.10
W-05	0.95	1.00	0.53	0.21	0.10	0.20	0.72	0.71	0.73	0.20	0.40	0.16
W-31	0.13	0.38	0.25	0.47	0.14	0.18	0.74	0.63	0.75	0.18	0.21	0.28
W-32	0.69	2.63	1.15	0.21	0.13	0.20	0.70	0.53	0.56	0.14	0.10	0.13
W-33	0.38	0.40	0.84	0.29	0.22	0.16	0.35	0.70	0.76	0.20	0.09	0.11
W-34	1.49	2.42	0.60	0.38	0.22	0.10	0.74	0.83	0.73	0.13	0.24	0.13
W-35												

All samples listed as less than the detection limit were taken as 1/2 the detection limit for EMC calculation.

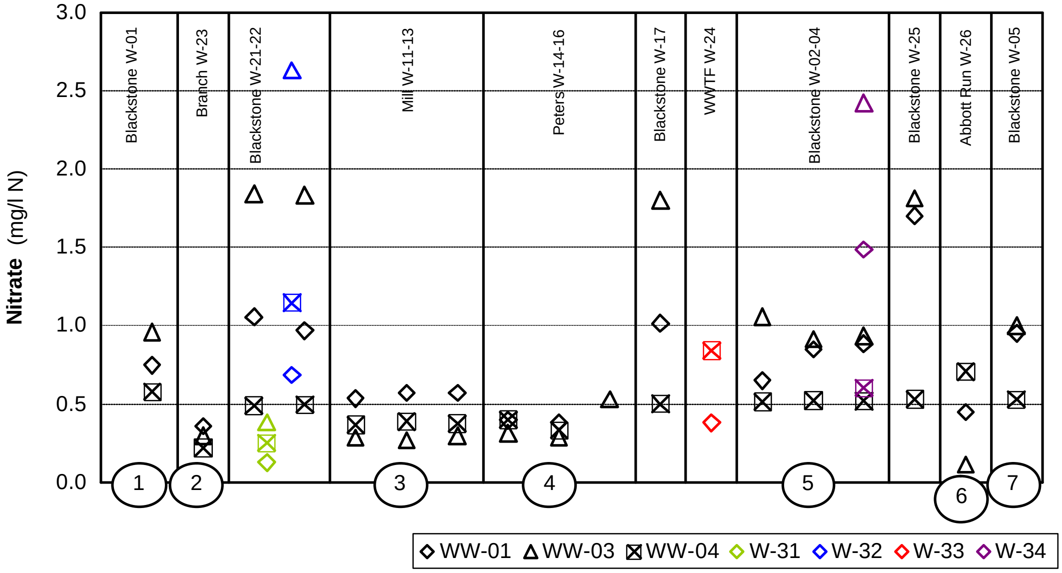


Figure 4-57: Nitrate EMC Profiles for all Storms

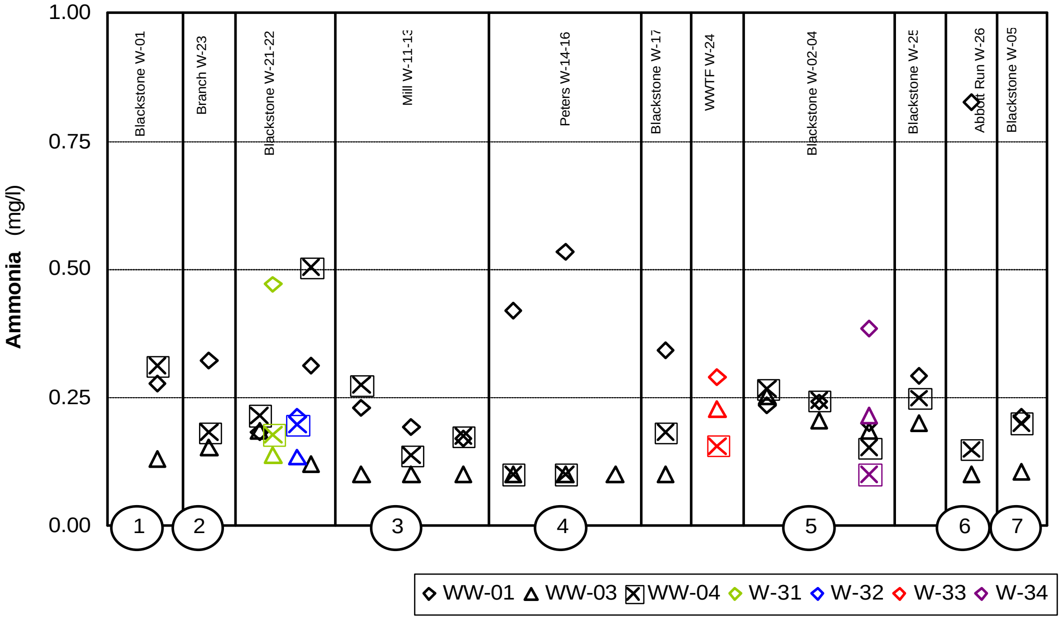


Figure 4-58: Ammonia EMC Profiles for all Storms

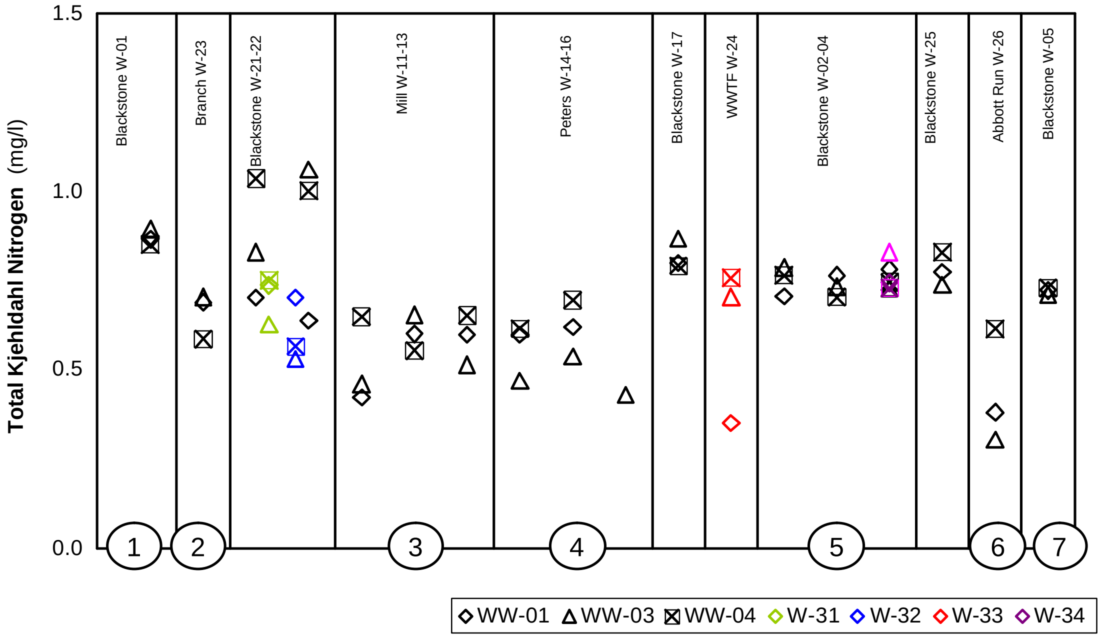


Figure 4-59: Total Kjeldahl Nitrogen EMC Profiles for all Storms

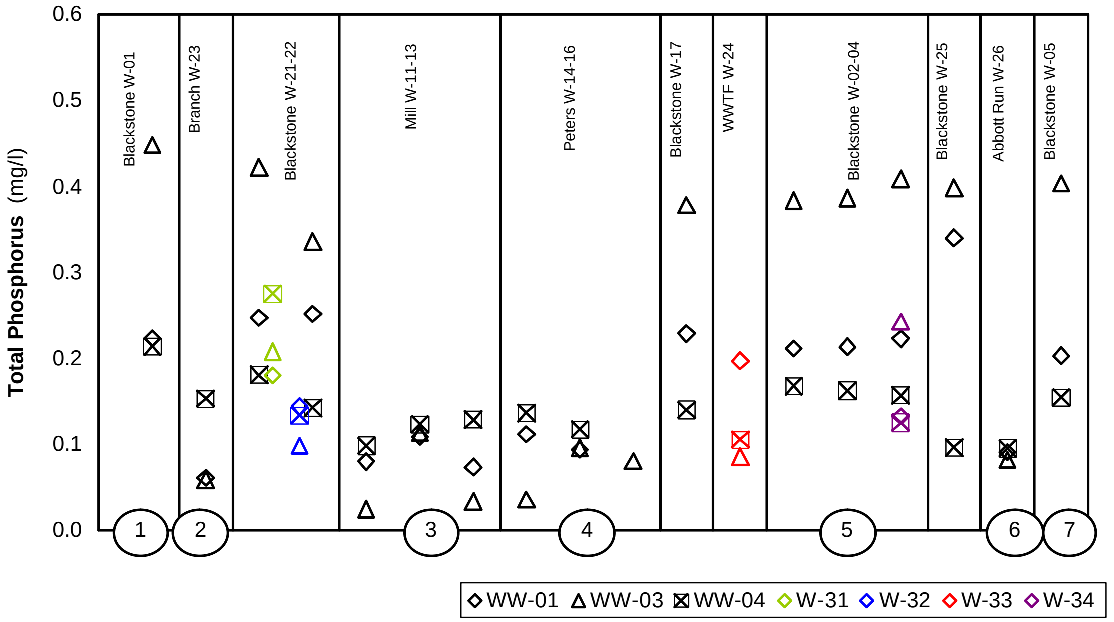


Figure 4-60: Total Phosphorus EMC Profiles for all Storms

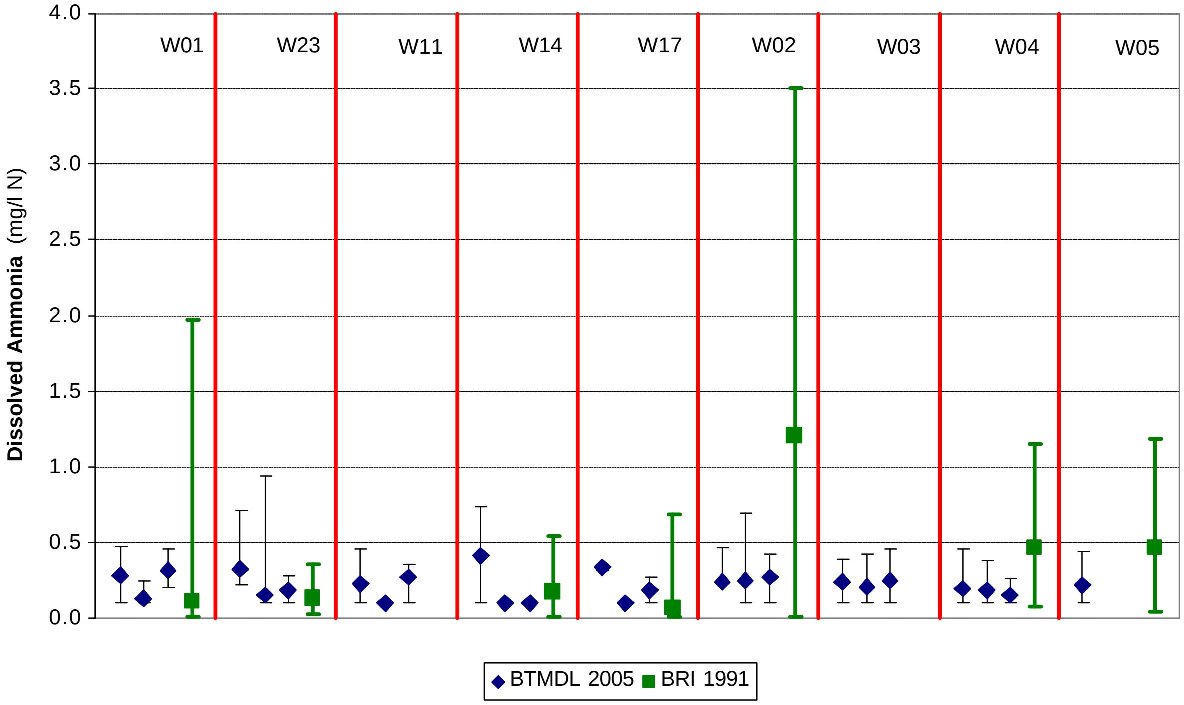


Figure 4-61: **Wet Weather Ammonia Concentration Comparison between BTML (2005; Storms WW-01, 03, 04) and BRI (1991)**

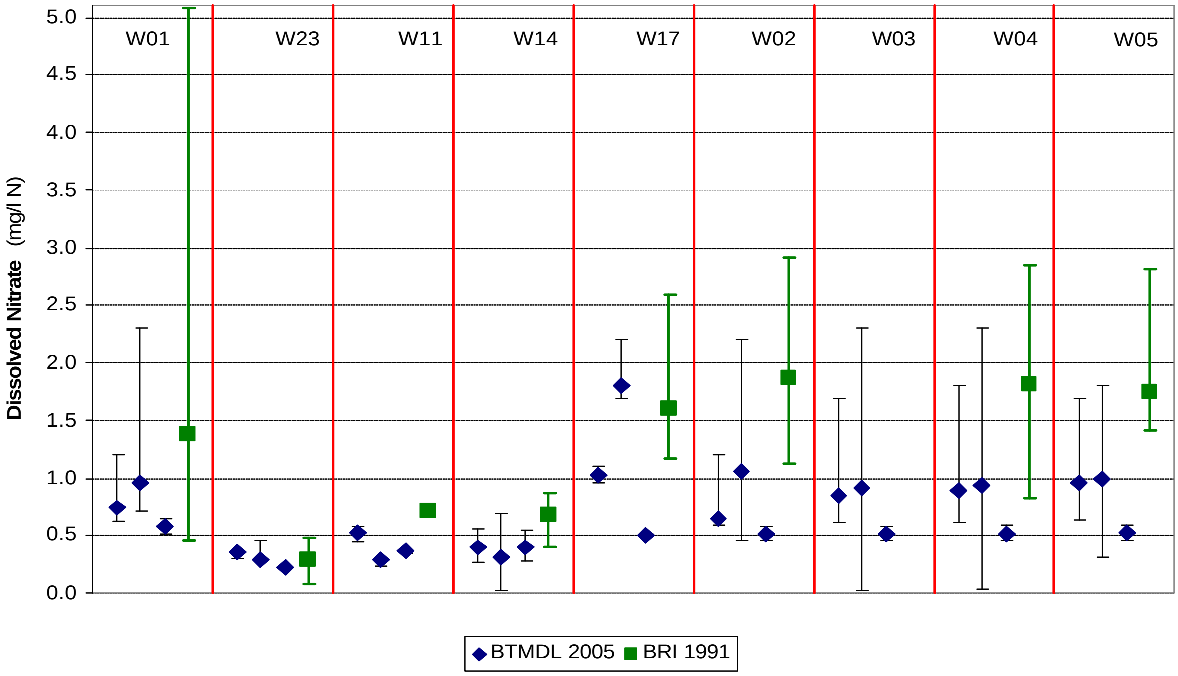


Figure 4-62: **Wet Weather Nitrate Concentration Comparison between BTML (2005; Storms WW-01, 03, 04) and BRI (1991)**

Figure 4-63: Storms WW-01 and WW-02 - Total Suspended Solids Concentrations (mg/l)

Station No.	Reach			Blackstone River	Tributary	WWTF/outfall/other	**Sampling Dates and Times**	**Storm WW-01** (July 8 - 12, 2005)															**Storm WW-02** (September 15, 2005)										
								8-Jul			9-Jul				10-Jul		11-Jul		12-Jul	**Statistics** (Runs 2-12)			14-Sep	15-Sep							**Statistics** (Runs 1-7)		
								8:30 - 10:15h	16:40 - 18:25h	21:00 - 23:15h	0:10 - 2:30h	6:20 - 7:50h	14:30 - 16:15h	20:30 - 22:40h	6:40 - 8:10h	15:15 - 16:30h	8:40 - 10:00h	14:50 -15:30h	8:40 - 10:00h				11:10 - 18:30h	10:35 - 11:10h	11:45 - 12:46h	13:35 -14:55h	15:00 - 15:50h	16:00-16:40h	16:50 - 17:35h	17:45 - 18:30h			
							Run No.	1	2	3	4	5	6	7	8	9	10	11	12	**Minimum**	**Maximum**	**Mean**	DW-11	1	2	3	4	5	6	7	**Minimum**	**Maximum**	**Mean**
W-01	**Reach 1**			●			Millville, MA	14.4	12.4	15.8	21.0	39.4	46.4	27.4	18.3	18.8	16.0		13.6	12.4	46.4	22.9											
W-23					●		Branch River		3.2	11.3										3.2	11.3	7.2											
W-21				●			Singleton Street		7.9	8.6										7.9	8.6	8.2											
W-22				●			Below Thundermist Dam		9.6	10.3										9.6	10.3	10.0											
W-11					●		Mill River (MA/RI border)	4.9	5.1	6.0	7.5			5.7						5.1	7.5	6.1											
W-12					●		Mill River (pre-culvert entry)	6.5	23.1	8.1	8.5			8.6						8.1	23.1	12.1											
W-13					●		Mill River (confluence w/ BR)	9.0	10.4	8.6	7.2			8.3						7.2	10.4	8.6											
W-14					●		Peters River (MA/RI border)	5.7	5.7	6.2	8.0			7.1						5.7	8.0	6.8											
W-15					●		Peters River (pre-culvert entry)	5.0	12.5	10.2	9.2			6.0						6.0	12.5	9.5											
W-16					●		Peters River (confluence w/ BR)																										
W-17				●			Hamlet Avenue		17.9	10.7										10.7	17.9	14.3											
W-24						●	Woonsocket WWTF					4.5			4.8					4.5	4.8	4.7											
W-02		**Reach 2**		●			Manville Dam	9.1	17.9	17.3	11.3	9.3	23.9	36.8	20.6	15.8	10.5		8.3	8.3	36.8	17.2											
W-03				●			George Washington Hwy Bridge	9.6	9.6	12.7	11.4	13.3	26.8	27.0	22.4	19.1	11.7	9.8	7.8	7.8	27.0	15.6											
W-04			**Reach 3**	●			Lonsdale Ave	10.1	11.2	14.5	12.2	12.1	14.5	36.5	23.6	19.2	11.9	11.2	9.9	9.9	36.5	16.1											
W-25				●			Broad Street	11.9	10.6	11.4										10.6	11.4	11.0											
W-26					●		Abbott Run Brook	2.7	1.8	2.0										1.8	2.0	1.9											
W-05				●			Slaters Mill Dam	13.9	11.0	11.6	17.7	11.0	14.3	32.9	21.7	19.8	13.5	10.5	8.0	8.0	32.9	15.6											
W-31	1					●	Cherry Brook		60.3	13.8										13.8	60.3	37.1											
W-32						●	Front Street Drain		126.3	6.0										6.0	126.3	66.1											
W-33						●	Sylvestre Pond Outflow		7.2	9.5										7.2	9.5	8.4											
W-34		2				●	Blackstone Canal at Lonsdale	11.4	13.5	10.6										10.6	13.5	12.0											
W-35			3			●	Brook near Ann&Hope																										
W-02	1	2		(=W-02)			Duplicate	9.7	16.2	15.2	12.4	12.5	23.4	36.8	21.2	16.0	12.4																
W-05			3	(=W-05)			Duplicate																										
W-01	1			(=W-01)			Duplicate																										
W-41				(=W-11)			Duplicate			6.6	5.7			6.5																			
W-42				(=W-14)			Duplicate			7.9	8.4			6.2																			
W-43		2	3	(=W-04)			Duplicate																										

Water Quality Criteria (Class B and B1): None.

Figure 4-64: Storms WW-03 and WW-04 - Total Suspended Solids Concentrations (mg/l)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm WW-03 (October 7 - 11, 2005)													Storm WW-04 (October 22 - 25, 2005)												
						7-Oct	8-Oct				9-Oct		10-Oct		11-Oct	Statistics (Runs 2-11)			22-Oct		23-Oct					24-Oct		25-Oct	Statistics (Runs 2-10)		
						12:00 - 14:50h	3:40 - 8:50h	9:10 - 11:55h	16:55 - 19:30h	20:15 - 21:40h	9:30 -12:40h	15:00 - 16:45h	5:00 - 6:45h	12:00 - 13:30h	10:00 - 11:15h	Minimum	Maximum	Mean	11:25 - 14:00h	21:10 - 23:50h	0:30 - 2:10h	3:45 - 5:45h	9:15 - 11:10h	13:15 - 16:25h	19:00 - 20:50h	11:00 - 13:30h	14:00 - 15:40h	11:00h	Minimum	Maximum	Mean
					Run No.	1	2	3	5	6	7	8	9	10	11				1	2	3	4	5	6	7	8	9	10			
W-01	Reach 1	●			Millville, MA	3.6	3.4	4.5	6.1	7.9	84.9	66.4	17.1	16.1	14.1	3.4	84.9	24.5	8.3	8.8	8.4	10.1	13.9	10.6	12.4	6.4	7.9		6.4	13.9	9.8
W-23			●		Branch River	4.5	2.3		1.2		8.1					1.2	8.1	3.9		4.3		4.9							4.3	4.9	4.6
W-21		●			Singleton Street		3.1		2.8		15.6					2.8	15.6	7.2		7.0		8.4							7.0	8.4	7.7
W-22		●			Below Thundermist Dam		4.7		3.1		13.0					3.1	13.0	6.9		6.5		7.9							6.5	7.9	7.2
W-11			●		Mill River (MA/RI border)	1.6	2.3	1.5	1.9		1.7					1.5	2.3	1.9	2.5	3.3		3.1		3.0	3.1				3.0	3.3	3.1
W-12			●		Mill River (pre-culvert entry)	2.2	4.6	3.0	7.5		5.8					3.0	7.5	5.2	2.6	5.8		49.0		4.1	3.0				3.0	49.0	15.5
W-13			●		Mill River (confluence w/ BR)	2.1	4.9	4.6	3.0		2.4					2.4	4.9	3.7	5.1	4.4		15.9		3.9	3.1				3.1	15.9	6.8
W-14			●		Peters River (MA/RI border)	2.2	19.4	6.1	4.9		8.3					4.9	19.4	9.7	1.9	4.3		4.0		3.3	3.3				3.3	4.3	3.7
W-15			●		Peters River (pre-culvert entry)	0.8	4.2	1.8	6.2		13.8					1.8	13.8	6.5	2.0	3.1		4.2		2.8	2.6				2.6	4.2	3.2
W-16			●		Peters River (confluence w/ BR)	1.4	15.8	1.9	4.0							1.9	15.8	7.2													
W-17		●			Hamlet Avenue		3.7		4.5		16.6					3.7	16.6	8.3		5.5		7.9							5.5	7.9	6.7
W-24				●	Woonsocket WWTF		2.6									2.6	2.6	2.6								7.4		5.7	5.7	7.4	6.6
W-02	Reach 2	●			Manville Dam	2.4	2.1	2.3	3.4	23.4	13.6	21.9	33.9	16.6	8.8	2.1	33.9	14.0	6.2	6.4	8.7	9.6	7.1	7.8	9.9	6.8	6.6		6.4	9.9	7.9
W-03		●			George Washington Hwy Bridge	3.9	2.1	8.9	2.8	3.5	17.9	22.1	32.2	22.1	9.5	2.1	32.2	13.4	7.1	6.0	8.3	9.3	7.2	7.5	7.1	6.7	6.9		6.0	9.3	7.4
W-04	Reach 3	●			Lonsdale Ave	2.8	3.1	4.1	2.9	4.2	17.6	19.7	29.2	22.5	11.3	2.9	29.2	12.7	7.0	6.1	6.9	8.4	9.7	7.0	8.6	6.3	7.2		6.1	9.7	7.5
W-25		●			Broad Street		3.2		2.9		17.8					2.9	17.8	8.0		6.7		7.7							6.7	7.7	7.2
W-26			●		Abbott Run Brook		1.0		0.9		1.2					0.9	1.2	1.1		1.9		1.6							1.6	1.9	1.8
W-05		●			Slaters Mill Dam	2.7	1.6	3.0	2.6	3.9	15.0	25.5	30.1	32.7	11.4	1.6	32.7	14.0	6.1	5.7	8.7	8.2	8.4	5.8	6.1	6.5	8.8		5.7	8.8	7.3
W-31	1			●	Cherry Brook		17.3		7.4		10.1					7.4	17.3	11.6		8.0		7.2							7.2	8.0	7.6
W-32				●	Front Street Drain		7.1		2.5		1.0					1.0	7.1	3.5		3.6		3.2							3.2	3.6	3.4
W-33				●	Sylvestre Pond Outflow		5.8				8.6					5.8	8.6	7.2		4.3		5.3							4.3	5.3	4.8
W-34	2			●	Blackstone Canal at Lonsdale		21.1		2.3		5.9					2.3	21.1	9.7		18.4		4.4							4.4	18.4	11.4
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate																										
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate		2.3	2.2	1.9										3.4	2.2		3.3		3.4							
W-42		(=W-14)			Duplicate	1.9	4.3	4.7	5.3										2.2	3.4		4.7		2.4							
W-43	2 3	(=W-04)			Duplicate	2.3	4.3	3.8	3.4	4.3									6.8	7.5	7.1	9.2	6.0	6.3							

No Run 4 for WW-03.

Water Quality Criteria (Class B and B1): None.

🟨 85 Concentrations for W-01 (Runs 7 and 8) comparatively high.

▨ 4.3 Concentration of duplicate sample W-42 only 22% of original sample (W-14).

Figure 4-65: Storms WW-01 and WW-02 - Volatile Suspended Solids Concentrations (mg/l)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm WW-01 (July 8 - 12, 2005)															Storm WW-02 (September 15, 2005)										
						8-Jul			9-Jul				10-Jul		11-Jul		12-Jul	Statistics (Runs 2-12)			14-Sep	15-Sep							Statistics (Runs 1-7)		
						8:30 - 10:15h	16:40 - 18:25h	21:00 - 23:15h	0:10 - 2:30h	6:20 - 7:50h	14:30 - 16:15h	20:30 - 22:40h	6:40 - 8:10h	15:15 - 16:30h	8:40 - 10:00h	14:50 - 15:30h	8:40 - 10:00h				11:10 - 18:30h	10:35 - 11:10h	11:45 - 12:46h	13:35 - 14:55h	15:00 - 15:50h	16:00-16:40h	16:50 - 17:35h	17:45 - 18:30h			
					Run No.	1	2	3	4	5	6	7	8	9	10	11	12	Minimum	Maximum	Mean	DW-11	1	2	3	4	5	6	7	Minimum	Maximum	Mean
W-01	Reach 1	●			Millville, MA	9.3	4.5	5.5	6.8	10.0	11.2	8.2	6.1	6.2	6.1		5.2	4.5	11.2	7.0											
W-23			●		Branch River		1.4	3.4										1.4	3.4	2.4											
W-21		●			Singleton Street		3.2	3.8										3.2	3.8	3.5											
W-22		●			Below Thundermist Dam		3.7	4.4										3.7	4.4	4.1											
W-11			●		Mill River (MA/RI border)	2.7	2.7	2.9	3.4			2.4						2.4	3.4	2.8											
W-12			●		Mill River (pre-culvert entry)	3.2	10.4	3.3	3.3			3.9						3.3	10.4	5.2											
W-13			●		Mill River (confluence w/ BR)	3.7	4.6	3.7	2.8			3.4						2.8	4.6	3.6											
W-14			●		Peters River (MA/RI border)	2.8	2.7	3.5	3.0			3.3						2.7	3.5	3.1											
W-15			●		Peters River (pre-culvert entry)	2.6	5.1	4.5	4.1			3.1						3.1	5.1	4.2											
W-16			●		Peters River (confluence w/ BR)																										
W-17		●			Hamlet Avenue		3.7	4.5										3.7	4.5	4.1											
W-24				●	Woonsocket WWTF					3.1			2.6					2.6	3.1	2.9											
W-02	Reach 2	●			Manville Dam	7.7	13.6	4.6	3.7	3.2	7.3	10.2	6.3	5.4	4.0		3.5	3.2	13.6	6.2											
W-03		●			George Washington Hwy Bridge	7.8	4.0	4.8	3.5	5.0	11.4	8.2	7.4	6.6	4.5	4.0	3.6	3.5	11.4	5.7											
W-04	Reach 3	●			Lonsdale Ave	8.3	4.7	5.1	1.6	4.3	4.1	15.1	8.0	6.5	4.4	4.8	3.9	1.6	15.1	5.7											
W-25		●			Broad Street	8.3	4.3	4.3										4.3	4.3	4.3											
W-26			●		Abbott Run Brook	1.6	1.1	1.3										1.1	1.3	1.2											
W-05		●			Slaters Mill Dam	9.2	4.4	4.6	5.5	4.4	4.7	8.6	7.4	7.0	5.3	4.7	3.6	3.6	8.6	5.5											
W-31	1			●	Cherry Brook		14.6	6.1										6.1	14.6	10.4											
W-32				●	Front Street Drain		27.8	2.6										2.6	27.8	15.2											
W-33				●	Sylvestre Pond Outflow		3.8	4.3										3.8	4.3	4.1											
W-34	2			●	Blackstone Canal at Lonsdale	7.9	4.6	3.9										3.9	4.6	4.3											
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate	7.9	10.4	4.5	3.4	4.1	7.3	10.1	7.1	5.7	4.3																
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate			3.0	1.7			2.8																			
W-42		(=W-14)			Duplicate			4.0	3.4			2.9																			
W-43	2 3	(=W-04)			Duplicate																										

Water Quality Criteria (Class B and B1): None.

Figure 4-66: Storms WW-03 and WW-04 - Volatile Suspended Solids Concentrations (mg/l)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	**Storm WW-03** (October 7 - 11, 2005)													**Storm WW-04** (October 22 - 25, 2005)												
						7-Oct	8-Oct				9-Oct		10-Oct		11-Oct	**Statistics** (Runs 2-11)			22-Oct		23-Oct					24-Oct		25-Oct	**Statistics** (Runs 2-10)		
						12:00 - 14:50h	3:40 - 8:50h	9:10 - 11:55h	16:55 - 19:30h	20:15 - 21:40h	9:30 -12:40h	15:00 - 16:45h	5:00 - 6:45h	12:00 - 13:30h	10:00 - 11:15h	**Minimum**	**Maximum**	**Mean**	11:25 - 14:00h	21:10 - 23:50h	0:30 - 2:10h	3:45 - 5-45h	9:15 - 11:10h	13:15 - 16:25h	19:00 - 20:50h	11:00 - 13:30h	14:00 - 15:40h	11:00h	**Minimum**	**Maximum**	**Mean**
					Run No.	1	2	3	5	6	7	8	9	10	11				1	2	3	4	5	6	7	8	9	10			
W-01	Reach 1	●			Millville, MA	1.6	2.3	2.1	2.6	2.7	19.2	15.9	5.2	5.5	4.3	2.1	19.2	6.6	2.7	3.5	2.9	3.8	4.5	3.7	3.9	2.5	3.0		2.5	4.5	3.5
W-23			●		Branch River	3.1	2.2		1.0		2.6					1.0	2.6	1.9		2.6		2.5							2.5	2.6	2.5
W-21		●			Singleton Street		2.3		1.6		5.0					1.6	5.0	3.0		3.0		3.4							3.0	3.4	3.2
W-22		●			Below Thundermist Dam		2.4		2.1		4.2					2.1	4.2	2.9		2.9		2.5							2.5	2.9	2.7
W-11			●		Mill River (MA/RI border)	1.2	1.2	1.3	1.5		1.6					1.2	1.6	1.4	1.3	1.7		1.7		1.8	1.6				1.6	1.8	1.7
W-12			●		Mill River (pre-culvert entry)	1.4	1.8	1.2	2.4		1.9					1.2	2.4	1.8	1.5	2.5		8.3		2.1	1.8				1.8	8.3	3.7
W-13			●		Mill River (confluence w/ BR)	1.6	2.4	2.9	0.7		0.0					0.0	2.9	1.5	2.7	2.1		4.1		2.2	1.5				1.5	4.1	2.5
W-14			●		Peters River (MA/RI border)	1.4	7.0	4.5	2.7		4.1					2.7	7.0	4.6	1.0	2.4		2.3		2.1	1.9				1.9	2.4	2.2
W-15			●		Peters River (pre-culvert entry)	0.3	2.1	0.3	3.0		5.1					0.3	5.1	2.6	1.1	2.4		2.1		2.1	1.6				1.6	2.4	2.0
W-16			●		Peters River (confluence w/ BR)	1.1	5.4	1.3	2.5							1.3	5.4	3.1													
W-17		●			Hamlet Avenue		2.1		2.4		4.7					2.1	4.7	3.1		2.0		2.9							2.0	2.9	2.4
W-24				●	Woonsocket WWTF		2.4									2.4	2.4	2.4								4.4		3.2	3.2	4.4	3.8
W-02	Reach 2	●			Manville Dam	1.1	1.3	1.4	1.5	6.5	4.2	5.7	9.4	5.3	3.2	1.3	9.4	4.3	2.4	2.0	2.7	3.3	2.7	2.9	3.5	2.5	2.1		2.0	3.5	2.7
W-03		●			George Washington Hwy Bridge	1.8	1.4	7.4	1.6	2.0	4.5	5.8	9.1	6.8	3.7	1.4	9.1	4.7	2.4	2.1	4.2	3.0	3.0	3.1	2.8	3.0	2.8		2.1	4.2	3.0
W-04	Reach 3	●			Lonsdale Ave	1.6	1.7	1.9	1.4	2.3	4.7	7.1	8.6	7.4	5.7	1.4	8.6	4.5	2.5	2.4	2.6	3.2	3.5	2.8	3.6	2.9	2.8		2.4	3.6	3.0
W-25		●			Broad Street		2.0		1.7		4.4					1.7	4.4	2.7		2.2		2.8							2.2	2.8	2.5
W-26			●		Abbott Run Brook		0.5		0.5		1.0					0.5	1.0	0.7		0.7		1.0							0.7	1.0	0.8
W-05		●			Slaters Mill Dam	1.3	1.1	1.9	1.4	1.5	4.9	6.9	9.1	9.4	4.3	1.1	9.4	4.5	2.6	2.0	2.6	3.3	3.3	2.4	2.4	2.6	3.4		2.0	3.4	2.7
W-31	1			●	Cherry Brook		7.0		3.1		4.6					3.1	7.0	4.9		4.3		4.0							4.0	4.3	4.2
W-32				●	Front Street Drain		3.8		1.7		0.5					0.5	3.8	2.0		2.2		1.5							1.5	2.2	1.9
W-33				●	Sylvestre Pond Outflow		3.4				4.1					3.4	4.1	3.8		1.8		2.0							1.8	2.0	1.9
W-34	2			●	Blackstone Canal at Lonsdale		20.1		1.6		3.0					1.6	20.1	8.2		17.1		1.8							1.8	17.1	9.5
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate																										
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate		1.8	1.6	1.7										1.7	1.9		2.2		2.0							
W-42		(=W-14)			Duplicate	1.4	2.3	2.9	3.0										1.1	2.2		2.8		1.8							
W-43	2 3	(=W-04)			Duplicate	1.7	2.3	1.8	1.7	2.2									2.6	2.6	2.5	3.4	3.1	2.7							

No Run 4 for WW-03.

Water Quality Criteria (Class B and B1): None.

19	Concentrations for W-01 (Runs 7 and 8) comparatively high.
2.3	Concentration of duplicate sample W-42 only 22% of original sample (W-14).

Figure 4-67: Summary of Event Mean Concentrations (EMC) for Solids

Stations	**Total Suspended Solids** (mg/l)			**Volatile Suspended Solids** (mg/l)		
	Storm			Storm		
	WW-01	WW-03	WW-04	WW-01	WW-03	WW-04
W-01	25.22	34.76	9.87	7.45	8.96	3.49
W-23	8.12	7.03	4.61	2.65	2.43	2.53
W-21	8.27	12.82	7.75	3.50	4.28	3.21
W-22	9.99	10.94	7.25	4.11	3.78	2.69
W-11	6.17	1.78	3.12	2.88	1.55	1.69
W-12	11.78	5.65	14.64	5.06	1.86	3.56
W-13	8.54	2.84	6.58	3.57	0.54	2.43
W-14	7.46	8.52	3.65	3.19	4.19	2.18
W-15	9.54	11.56	3.15	4.23	4.34	2.02
W-16		6.56			2.93	
W-17	13.44	13.88	6.75	4.23	4.19	2.46
W-24						
W-02	19.39	19.35	7.92	6.34	5.62	2.75
W-03	17.70	20.16	7.38	6.38	5.93	3.00
W-04	18.08	19.24	7.54	6.46	6.35	3.00
W-25	11.06	14.55	7.22	4.29	3.84	2.50
W-26	1.89	1.03	1.76	1.19	0.57	0.86
W-05	17.37	21.71	7.26	5.85	6.57	2.75
W-31	33.94	10.31	7.57	9.83	4.60	4.13
W-32	57.59	1.54	3.40	13.43	0.86	1.85
W-33	8.85	7.33	4.90	4.18	3.78	1.95
W-34	11.84	8.11	10.34	4.21	6.47	8.29
W-35						

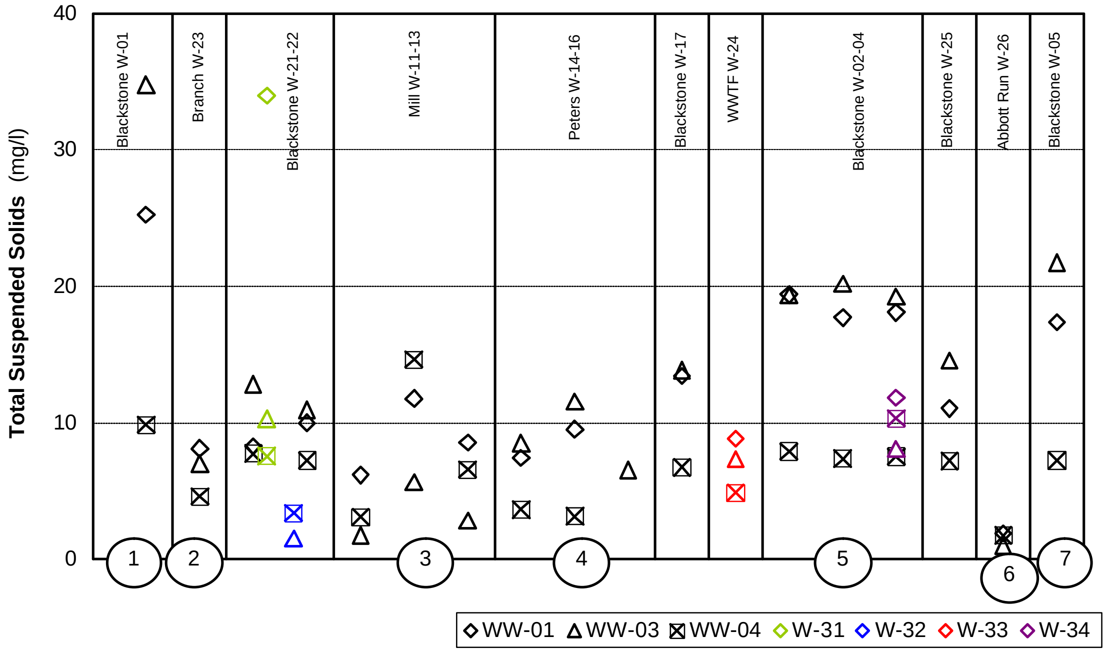


Figure 4-68: Total Suspended Solids EMC Profiles for all Storms

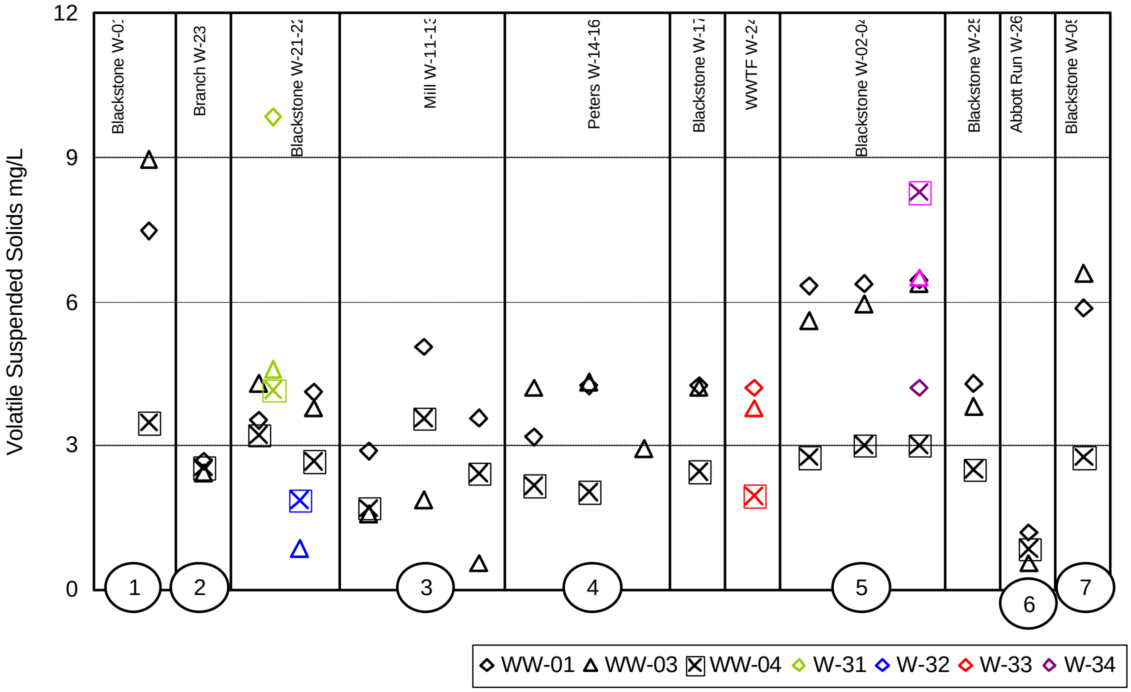


Figure 4-69: Volatile Suspended Solids EMC Profiles for all Storms

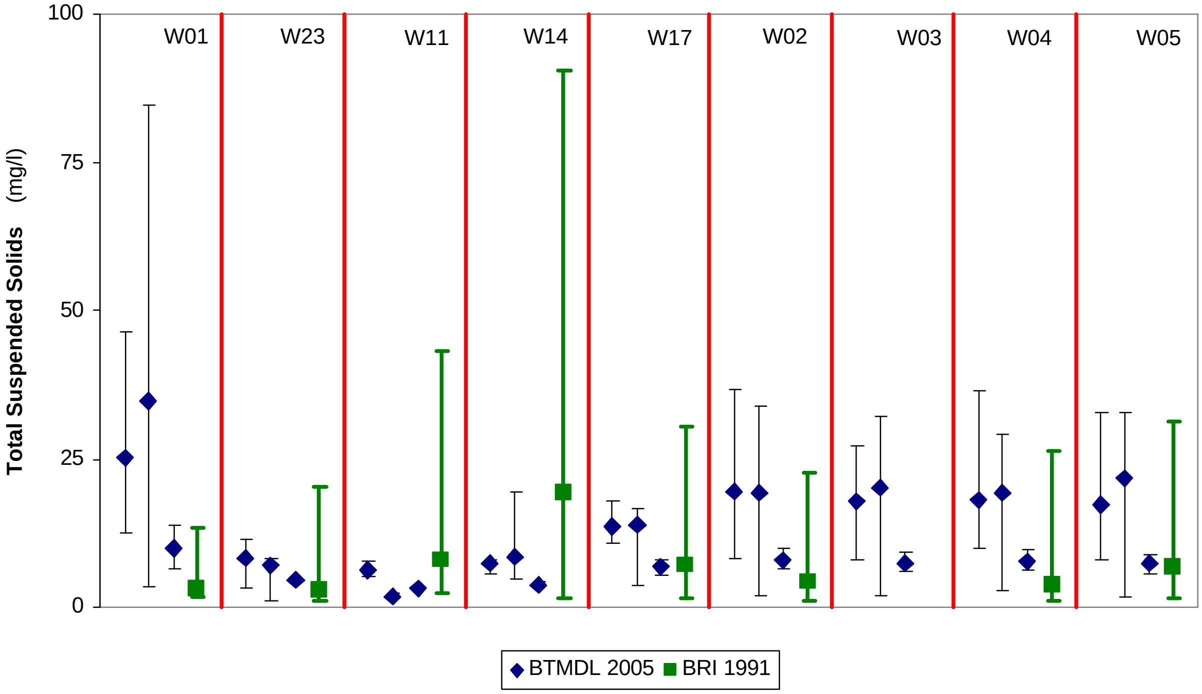


Figure 4-70: Wet Weather Total Suspended Solids Comparison between BTMDL (2005) and BRI (1991)

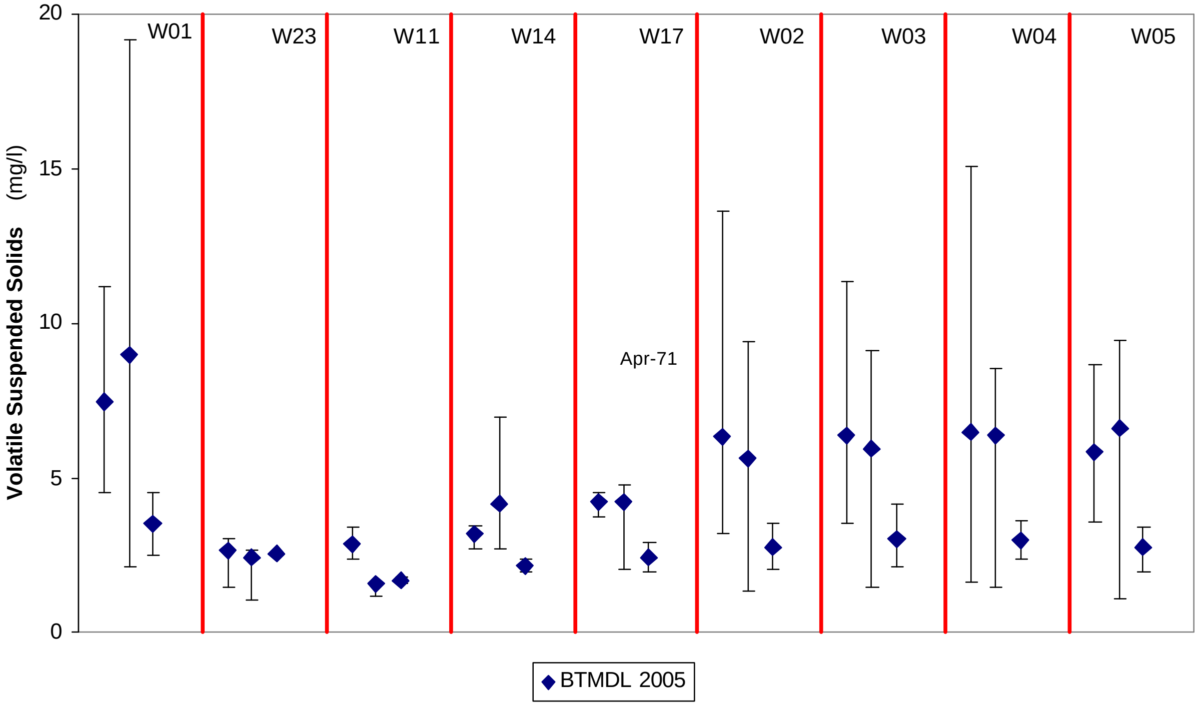


Figure 4-71: Wet Weather Volatile Suspended Solids EMCs with Maximum and Minimum

Figure 4-72: Storms WW-01 and WW-02 - Chloride Concentrations (mg/l)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	**Storm WW-01** (July 8 - 12, 2005)															**Storm WW-02** (September 15, 2005)										
						8-Jul			9-Jul				10-Jul		11-Jul		12-Jul	**Statistics** (Runs 2-12)			14-Sep	15-Sep							**Statistics** (Runs 1-7)		
						8:30 - 10:15h	16:40 - 18:25h	21:00 - 23:15h	0:10 - 2:30h	6:20 - 7:50h	14:30 - 16:15h	20:30 - 22:40h	6:40 - 8:10h	15:15 - 16:30h	8:40 - 10:00h	14:50 -15:30h	8:40 - 10:00h	Minimum	Maximum	Mean	11:10 - 18:30h	10:35 - 11:10h	11:45 - 12:46h	13:35 -14:55h	15:00 - 15:50h	16:00-16:40h	16:50 - 17:35h	17:45 - 18:30h	Minimum	Maximum	Mean
					Run No.	1	2	3	4	5	6	7	8	9	10	11	12				DW-11	1	2	3	4	5	6	7			
W-01	Reach 1	●			Millville, MA	93.2	102.0	88.3	90.4	88.3	54.3	60.8	78.9	79.8	84.5		92.3	54.3	102.0	82.0											
W-23			●		Branch River		43.6	40.2										40.2	43.6	41.9											
W-21		●			Singleton Street		80.6	81.1										80.6	81.1	80.9											
W-22		●			Below Thundermist Dam		80.8	70.4										70.4	80.8	75.6											
W-11			●		Mill River (MA/RI border)	82.8	83.2	73.3	76.7			73.9						73.3	83.2	76.8											
W-12			●		Mill River (pre-culvert entry)	82.5	67.7	73.9	69.8			74.2						67.7	74.2	71.4											
W-13			●		Mill River (confluence w/ BR)	84.2	73.6	70.7	73.6			72.7						70.7	73.6	72.7											
W-14			●		Peters River (MA/RI border)	88.2	87.9	54.0	60.1			65.5						54.0	87.9	66.9											
W-15			●		Peters River (pre-culvert entry)	86.2	83.2	73.3	76.7			73.9						73.3	83.2	76.8											
W-16			●		Peters River (confluence w/ BR)																										
W-17		●			Hamlet Avenue		81.5	71.0										71.0	81.5	76.3											
W-24				●	Woonsocket WWTF					188.0			178.0					178.0	188.0	183.0											
W-02	Reach 2	●			Manville Dam	87.2	80.0	70.7	66.8	73.3	79.2	60.3	60.3	72.1	78.2		82.1	60.3	82.1	72.3											
W-03		●			George Washington Hwy Bridge	95.8	95.0	89.0	67.1	72.1	78.2	81.1	57.0	57.2	79.2	77.3	82.4	57.0	95.0	76.0											
W-04	Reach 3	●			Lonsdale Ave	92.5	101.0	81.1	70.4	74.5	75.7	77.6	56.3	81.8	73.9	77.3	81.1	56.3	101.0	77.3											
W-25		●			Broad Street	95.4	96.9	90.1										90.1	96.9	93.5											
W-26			●		Abbott Run Brook	51.8	50.2	46.2										46.2	50.2	48.2											
W-05		●			Slaters Mill Dam	91.0	95.8	83.4	82.4	72.7	72.1	79.2	64.7	61.6	73.9	77.0	80.1	61.6	95.8	76.6											
W-31	1			●	Cherry Brook		48.2	57.0										48.2	57.0	52.6											
W-32				●	Front Street Drain		8.3	30.4										8.3	30.4	19.3											
W-33				●	Sylvestre Pond Outflow		51.2	51.5										51.2	51.5	51.4											
W-34	2			●	Blackstone Canal at Lonsdale	116.0	117.0	94.5										94.5	117.0	105.8											
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate	86.5	72.7	69.6	69.3	73.4	79.2	60.3	60.3	72.1	78.2																
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate			74.5	76.7			67.3																			
W-42		(=W-14)			Duplicate			54.3	76.7			64.1																			
W-43	2 3	(=W-04)			Duplicate																										

Water Quality Criteria (Class B and B1): None.

Figure 4-73: Storms WW-03 and WW-04 - Chloride Concentrations (mg/l)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm **WW-03** (October 7 - 11, 2005)													Storm **WW-04** (October 22 - 25, 2005)												
						7-Oct	8-Oct				9-Oct		10-Oct		11-Oct	**Statistics** (Runs 2-11)			22-Oct		23-Oct					24-Oct		25-Oct	**Statistics** (Runs 2-10)		
						12:00 - 14:50h	3:40 - 8:50h	9:10 - 11:55h	16:55 - 19:30h	20:15 - 21:40h	9:30 -12:40h	15:00 - 16:45h	5:00 - 6:45h	12:00 - 13:30h	10:00 - 11:15h	**Minimum**	**Maximum**	**Mean**	11:25 - 14:00h	21:10 - 23:50h	0:30 - 2:10h	3:45 - 5:45h	9:15 - 11:10h	13:15 - 16:25h	19:00 - 20:50h	11:00 - 13:30h	14:00 - 15:40h	11:00h	**Minimum**	**Maximum**	**Mean**
					Run No.	1	2	3	5	6	7	8	9	10	11				1	2	3	4	5	6	7	8	9	10			
W-01	Reach 1	●			Millville, MA	87.8	74.1	61.6	65.0	58.7	36.9	22.2	28.0	32.7	38.6	22.2	74.1	46.4	44.1	45.1	44.7	40.4	44.1	41.5	38.7	38.2	38.2		38.2	45.1	41.4
W-23			●		Branch River	31.7	27.5		24.0		19.9					19.9	27.5	23.8		15.3		14.0							14.0	15.3	14.7
W-21		●			Singleton Street		63.7		60.1		45.9					45.9	63.7	56.6		43.0		36.6							36.6	43.0	39.8
W-22		●			Below Thundermist Dam		60.7		61.9		44.1					44.1	61.9	55.6		40.1		37.6							37.6	40.1	38.9
W-11			●		Mill River (MA/RI border)	54.2	45.0	40.1	38.4		37.6					37.6	45.0	40.3	42.2	42.4		40.0		39.3	40.3				39.3	42.4	40.5
W-12			●		Mill River (pre-culvert entry)	51.1	43.0	40.3	38.0		34.6					34.6	43.0	39.0	41.2	41.4		40.2		39.7	40.9				39.7	41.4	40.6
W-13			●		Mill River (confluence w/ BR)	49.7	43.5	39.0	37.4		42.2					37.4	43.5	40.5	40.9	45.1		39.4		39.9	40.3				39.4	45.1	41.2
W-14			●		Peters River (MA/RI border)	75.9	66.9	63.1	51.6		16.9					16.9	66.9	49.6	57.2	58.2		49.9		38.5	38.2				38.2	58.2	46.2
W-15			●		Peters River (pre-culvert entry)	78.5	51.6	50.9	54.2		17.4					17.4	54.2	43.5	57.7	51.2		46.4		38.7	35.5				35.5	51.2	43.0
W-16			●		Peters River (confluence w/ BR)	77.8	52.7	47.3	64.4							47.3	64.4	54.8													
W-17		●			Hamlet Avenue		60.7		59.8		45.0					45.0	60.7	55.2		42.2		33.7							33.7	42.2	38.0
W-24				●	Woonsocket WWTF		114.0									114.0	114.0	114.0								146.0		128.0	128.0	146.0	137.0
W-02	Reach 2	●			Manville Dam	79.7	70.9	62.8	60.7	56.4	43.5	42.6	21.7	26.8	33.5	21.7	70.9	46.5	41.4	42.8	43.2	38.7	38.7	35.5	37.4	32.9	34.1		32.9	43.2	37.9
W-03		●			George Washington Hwy Bridge	73.7	63.7	58.9	59.2	57.2	30.8	43.0	21.7	23.7	32.2	21.7	63.7	43.4	40.3	41.6	43.2	41.0	38.1	35.0	34.6	29.4	30.3		29.4	43.2	36.7
W-04	Reach 3	●			Lonsdale Ave	73.4	64.0	61.0	58.9	57.0	38.0	40.3	23.3	22.3	32.4	22.3	64.0	44.1	39.7	42.8	43.9	41.6	39.1	35.2	36.1	32.7	30.6		30.6	43.9	37.8
W-25		●			Broad Street		58.4		55.0		47.3					47.3	58.4	53.6		42.4		40.0							40.0	42.4	41.2
W-26			●		Abbott Run Brook		21.5		20.2		18.8					18.8	21.5	20.2		15.3		28.7							15.3	28.7	22.0
W-05		●			Slaters Mill Dam	75.9	56.7	55.6	54.0	53.2	44.3	34.4	29.4	21.9	30.6	21.9	56.7	42.2	40.9	42.4	43.0	41.0	40.4	35.0	35.4	32.6	32.7		32.6	43.0	37.8
W-31	1			●	Cherry Brook		23.7		31.1		58.9					23.7	58.9	37.9		40.1		31.6							31.6	40.1	35.9
W-32				●	Front Street Drain		31.7		23.0		42.0					23.0	42.0	32.2		32.6		26.3							26.3	32.6	29.5
W-33				●	Sylvestre Pond Outflow		28.7				39.6					28.7	39.6	34.2		47.5		42.0							42.0	47.5	44.8
W-34	2			●	Blackstone Canal at Lonsdale		62.8		59.8		51.1					51.1	62.8	57.9		45.7		42.2							42.2	45.7	44.0
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate																										
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate		41.4	41.4	39.0										42.8	41.6		44.9		40.7							
W-42		(=W-14)			Duplicate	73.0	64.4	64.4	50.9										59.1	56.9		50.8		39.5							
W-43	2 3	(=W-04)			Duplicate	66.3	55.9	60.1	58.7	57.8									43.9	43.0	42.0	41.2	40.6	35.7							

No Run 4 for WW-03.

Water Quality Criteria (Class B and B1): None.

Figure 4-74: Storms WW-01 and WW-02 - Hardness (mg/l)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm WW-01 (July 8 - 12, 2005)															Storm WW-02 (September 15, 2005)										
						8-Jul			9-Jul				10-Jul		11-Jul		12-Jul	Statistics (Runs 2-12)			14-Sep	15-Sep							Statistics (Runs 1-7)		
						8:30 - 10:15h	16:40 - 18:25h	21:00 - 23:15h	0:10 - 2:30h	6:20 - 7:50h	14:30 - 16:15h	20:30 - 22:40h	6:40 - 8:10h	15:15 - 16:30h	8:40 - 10:00h	14:50 -15:30h	8:40 - 10:00h	Minimum	Maximum	Mean	11:10 - 18:30h	10:35 - 11:10h	11:45 - 12:46h	13:35 -14:55h	15:00 - 15:50h	16:00-16:40h	16:50 - 17:35h	17:45 - 18:30h	Minimum	Maximum	Mean
					Run No.	1	2	3	4	5	6	7	8	9	10	11	12				11	1	2	3	4	5	6	7			
W-01	Reach 1	●			Millville, MA	50	52	52	49	46	28	31	40	43	45		94	28	94	48											
W-23			●		Branch River		21	22										21	22	22											
W-21		●			Singleton Street		41	47										41	47	44											
W-22		●			Below Thundermist Dam		38	40										38	40	39											
W-11			●		Mill River (MA/RI border)	38	37	39	39			36						36	39	38	40	42	42	42	42	41	40	38	38	42	41
W-12			●		Mill River (pre-culvert entry)	40	36	40	41			37						36	41	39	55	26	30	43	44	45	43	42	26	45	39
W-13			●		Mill River (confluence w/ BR)	38	35	39	39			35						35	39	37	49	17	36	39	41	41	41	40	17	41	36
W-14			●		Peters River (MA/RI border)	49	49	35	38			37						35	49	40	72	5	68	26	15	16	24	35	5	68	27
W-15			●		Peters River (pre-culvert entry)	48	39	36	37			37						36	39	37	77	21	9	48	29	21	17	21	9	48	24
W-16			●		Peters River (confluence w/ BR)																78	21	25	32	27	19	17	25	17	32	24
W-17		●			Hamlet Avenue		39	41										39	41	40											
W-24				●	Woonsocket WWTF					170			150					150	170	160											
W-02	Reach 2	●			Manville Dam	45	42	43	40	40	41	32	33	37	41		88	32	88	44											
W-03		●			George Washington Hwy Bridge	52	51	42	41	39	40	40	30	35	42	83	85	30	85	48											
W-04	Reach 3	●			Lonsdale Ave	50	53	49	41	40	41	41	30	33	42	81	89	30	89	49											
W-25		●			Broad Street	50	51	53										51	53	52											
W-26			●		Abbott Run Brook	34	34	37										34	37	36											
W-05		●			Slaters Mill Dam	49	50	52	49	41	39	43	35	34	42	83	80	34	83	50											
W-31	1			●	Cherry Brook		24	33										24	33	29											
W-32				●	Front Street Drain		8	25										8	25	17											
W-33				●	Sylvestre Pond Outflow		35	41										35	41	38											
W-34	2			●	Blackstone Canal at Lonsdale	61	56	52										52	56	54											
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate	46	41	43	39	39	39	32	32	37	42																
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate			38	39			35											41	40							
W-42		(=W-14)			Duplicate			36	38			37											66	25				35			
W-43	2 3	(=W-04)			Duplicate																										
Mean Hardness (mg/l)					Blackstone River	49	46	47	44	41	38	37	34	36	42	82	87	34	87	**49**											
					Branch River		21	22										21	22	**22**											
					Mill River	39	36	39	40			36						36	40	**38**	48	28	36	41	42	42	41	40	36	42	**39**
					Peters River	49	44	36	38			37						36	44	**39**	76	16	34	35	24	19	19	27	19	35	**25**
					Abbott Run Brook	34	34	37										34	37	**36**											

Water Quality Criteria (Class B and B1): None.

Reporting Limit: 4 mg/l

Figure 4-75: Storms WW-03 and WW-04 - Hardness (mg/l)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	**Storm WW-03** (October 7 - 11, 2005)													**Storm WW-04** (October 22 - 25, 2005)												
						7-Oct	8-Oct				9-Oct		10-Oct		11-Oct	**Statistics** (Runs 2-11)			22-Oct		23-Oct					24-Oct		25-Oct	**Statistics** (Runs 2-10)		
						12:00 - 14:50h	3:40 - 8:50h	9:10 - 11:55h	16:55 - 19:30h	20:15 - 21:40h	9:30 -12:40h	15:00 - 16:45h	5:00 - 6:45h	12:00 - 13:30h	10:00 - 11:15h				11:25 - 14:00h	21:10 - 23:50h	0:30 - 2:10h	3:45 - 5-45h	9:15 - 11:10h	13:15 - 16:25h	19:00 - 20:50h	11:00 - 13:30h	14:00 - 15:40h	11:00h			
					Run No.	1	2	3	5	6	7	8	9	10	11	**Minimum**	**Maximum**	**Mean**	1	2	3	4	5	6	7	8	9	10	**Minimum**	**Maximum**	**Mean**
W-01	Reach 1	●			Millville, MA	66	62	69	62	54	36	26	38	39	43	26	69	48	41	38	35	32	34	34	32	32	34		32	38	34
W-23			●		Branch River	17	24		24		19					19	24	22		12		14							12	14	13
W-21		●			Singleton Street		58		67		45					45	67	57		29		28							28	29	29
W-22		●			Below Thundermist Dam		58		66		44					44	66	56		29		31							29	31	30
W-11			●		Mill River (MA/RI border)	37	36	43	35		37					35	43	38	26	25		26		26	26				25	26	26
W-12			●		Mill River (pre-culvert entry)	44	39	40	44		38					38	44	40	28	30		27		28	28				27	30	28
W-13			●		Mill River (confluence w/ BR)	38	38	38	41		35					35	41	38	26	26		25		28	26				25	28	26
W-14			●		Peters River (MA/RI border)	63	64	64	55		26					26	64	52	48	48		46		37	43				37	48	44
W-15			●		Peters River (pre-culvert entry)	64	52	56	67		29					29	67	51	48	43		39		40	44				39	44	42
W-16			●		Peters River (confluence w/ BR)	65	54	52	61							52	61	56													
W-17		●			Hamlet Avenue		56		66		45					45	66	56		30		31							30	31	31
W-24				●	Woonsocket WWTF		280									280	280	280								150		150	150	150	150
W-02	Reach 2	●			Manville Dam	67	64	78	70	71	45	47	30	32	45	30	78	54	37	32	31	30	31	31	30	30	30		30	32	31
W-03		●			George Washington Hwy Bridge	61	61	75	61	64	38	49	30	29	38	29	75	49	37	32	32	34	31	30	31	28	29		28	34	31
W-04	Reach 3	●			Lonsdale Ave	62	60	70	61	63	44	49	29	28	37	28	70	49	35	34	34	35	37	31	36	29	28		28	37	33
W-25		●			Broad Street		66		69		50					50	69	62		36		34							34	36	35
W-26			●		Abbott Run Brook		29		30		24					24	30	28		33		37							33	37	35
W-05		●			Slaters Mill Dam	61	58	67	58	59	54	47	38	28	36	28	67	49	34	32	32	32	32	31	36	29	29		29	36	32
W-31	1			●	Cherry Brook		34		47		37					34	47	39		36		32							32	36	34
W-32				●	Front Street Drain		44		40		60					40	60	48		34		33							33	34	34
W-33				●	Sylvestre Pond Outflow		36				18					18	36	27		48		47							47	48	48
W-34	2			●	Blackstone Canal at Lonsdale		63		70		62					62	70	65		39		35							35	39	37
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate																										
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate		45	38	43										26	26		28		27							
W-42		(=W-14)			Duplicate	64	78	63	64										50	47		47		40							
W-43	2 3	(=W-04)			Duplicate	58	61	59	72	63									32	34	32	40	32	33							
Mean Hardness (mg/l)					Blackstone River	63	60	72	64	62	45	44	33	31	40	31	72	**50**	37	32	33	32	33	31	33	30	30		30	33	**32**
					Branch River	17	24		24		19					19	24	**22**		12		14							12	14	**13**
					Mill River	40	38	40	40		37					37	40	**39**	27	27		26		27	27				26	27	**27**
					Peters River	64	57	57	61		28					28	61	**51**	48	46		43		39	44				39	46	**43**
					Abbott Run Brook		29		30		24					24	30	**28**		33		37							33	37	**35**

Water Quality Criteria (Class B and B1): None.

Reporting Limit: 4 mg/l

Figure 4-76: Summary of Event Mean Concentrations (EMCs) for Chloride and Hardness

Station	**Chloride** (mg/l)				**Hardness** (mg/l)				
	Storms				**Storms**				
	WW-01	**WW-03**	**WW-04**	***Mean***	**WW-01**	**WW-02**	**WW-03**	**WW-04**	***Mean***
W-01	76	34	41	*51*	43		39	34	*39*
W-23	42	21	15	*26*	22		20	13	*18*
W-21	81	49	40	*57*	44		49	28	*41*
W-22	75	48	39	*54*	39		48	30	*39*
W-11	77	38	40	*52*	38	41	37	26	*36*
W-12	71	36	41	*49*	39	38	39	28	*36*
W-13	73	42	41	*52*	37	35	36	26	*34*
W-14	70	27	45	*48*	41	25	34	43	*36*
W-15	77	26	42	*48*	37	21	36	42	*34*
W-16		56		*56*		23	56		*40*
W-17	75	48	38	*54*	40		49	31	*40*
W-24									
W-02	71	36	38	*48*	41		43	31	*38*
W-03	74	33	36	*48*	45		40	31	*38*
W-04	76	34	37	*49*	46		40	33	*40*
W-25	93	49	41	*61*	52		54	35	*47*
W-26	48	21	23	*31*	36		29	35	*33*
W-05	75	34	38	*49*	47		43	32	*41*
W-31	54	54	35	*48*	30		38	34	*34*
W-32	21	39	29	*30*	18		57	33	*36*
W-33	51	35	44	*43*	39		26	47	*38*
W-34	104	57	44	*68*	54		65	37	*52*
W-35									

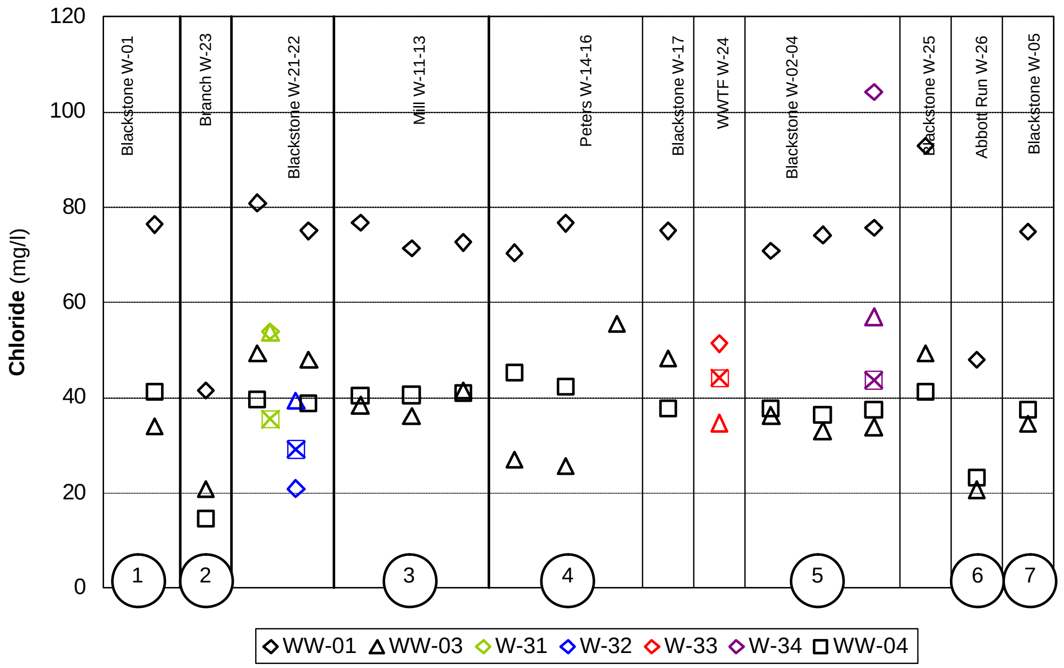


Figure 4-77: Chloride EMC Profiles for all Storms

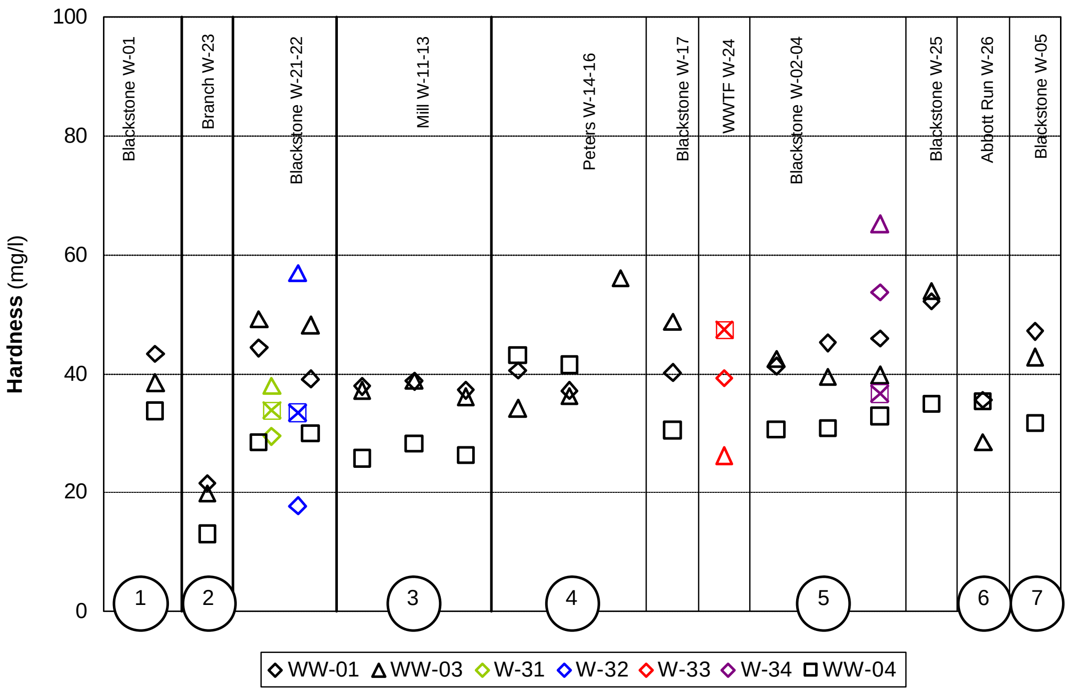


Figure 4-78: Hardness EMC Profiles for all Storms

Figure 4-79: Wet Weather Dissolved Copper and Lead Chronic Criteria

Station		Mean Hardness (mg/l)				Chronic Copper Criteria (µg/l)				Chronic Lead Criteria (µg/l)			
		Storms				Storms				Storms			
		WW-01	WW-02	WW-03	WW-04	WW-01	WW-02	WW-03	WW-04	WW-01	WW-02	WW-03	WW-04
W-01	Millville, MA	48		48	34	4.8		4.9	3.6	1.13		1.16	0.78
W-23	Branch River	22		22	13	2.4		2.4	1.6	0.46		0.44	0.26
W-21	Singleton Street	44		57	29	4.4		5.5	3.1	1.02		1.35	0.63
W-22	Below Thundermist Dam	39		56	30	4.0		5.5	3.2	0.89		1.33	0.66
W-11	Mill River (MA/RI border)	38	41	38	26	3.9	4.2	3.9	2.8	0.86	0.94	0.86	0.56
W-12	Mill River (pre-culvert entry)	39	39	40	28	4.0	4.0	4.2	3.0	0.89	0.89	0.94	0.62
W-13	Mill River (confluence w/ BR)	37	36	38	26	3.8	3.8	3.9	2.9	0.84	0.83	0.87	0.57
W-14	Peters River (MA/RI border)	40	27	52	44	4.2	2.9	5.3	4.5	0.96	0.59	1.29	1.03
W-15	Peters River (pre-culvert entry)	37	24	51	42	4.0	2.6	5.3	4.3	0.90	0.51	1.27	0.99
W-16	Peters River (confluence w/ BR)		24	56			2.6	5.6			0.51	1.38	
W-17	Hamlet Avenue	40		56	31	4.1		5.4	3.2	0.92		1.32	0.68
W-02	Manville Dam	44		54	31	4.4		5.4	3.3	1.01		1.30	0.70
W-03	George Washington Hwy Bridge	48		49	31	4.8		5.0	3.3	1.13		1.19	0.70
W-04	Lonsdale Ave	49		49	33	4.9		5.0	3.5	1.15		1.18	0.74
W-25	Broad Street	52		62	35	5.1		5.9	3.7	1.21		1.48	0.79
W-26	Abbott Run Brook	36		28	35	3.7		3.0	3.7	0.79		0.61	0.79
W-05	Slaters Mill Dam	50		49	32	4.9		5.0	3.4	1.17		1.19	0.71
W-31	Cherry Brook	29		39	34	3.1		4.0	3.6	0.63		0.90	0.76
W-32	Front Street Drain	17		48	34	1.9		4.8	3.5	0.34		1.12	0.75
W-33	Sylvestre Pond Outflow	38		27	48	3.9		2.9	4.7	0.87		0.59	1.11
W-34	Blackstone Canal at Lonsdale	54		65	37	5.5		6.2	3.8	1.34		1.57	0.84

Figure 4-80: Wet Weather Copper Acute Criteria by Waterbody for Storms WW-01 and WW-02

Water Body/Station	**Storm WW-01: Runs**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Mean Hardness *(mg/l)*												
Blackstone River	49	46	47	44	41	38	37	34	36	42	82	87
Branch River		21	22									
Mill River	39	36	39	40			36					
Peters River	49	44	36	38			37					
Abbott Run Brook	34	34	37									
W-31 Cherry Brook		24	33									
W-32 Front Street Drain		8	25									
W-33 Sylvestre Pond Outflow		35	41									
W-34 Blackstone Canal	61	56	52									
Acute Copper Criteria *(ug/l)*												
Blackstone River	6.9	6.5	6.5	6.2	5.8	5.4	5.3	4.8	5.2	6.0	11.2	11.8
Branch River		3.1	3.2									
Mill River	5.5	5.1	5.6	5.6			5.1					
Peters River	6.8	6.2	5.1	5.3			5.3					
Abbott Run Brook	4.9	4.9	5.3									
W-31 Cherry Brook		3.5	4.7									
W-32 Front Street Drain		1.2	3.6									
W-33 Sylvestre Pond Outflow		5.0	5.8									
W-34 Blackstone Canal	8.4	7.8	7.3									

Water Body/Station	**Storm WW-02: Runs**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Mean Hardness *(mg/l)*							
Blackstone River							
Branch River							
Mill River	28	36	41	42	42	41	40
Peters River	16	34	35	24	19	19	27
Abbott Run Brook							
W-31 Cherry Brook							
W-32 Front Street Drain							
W-33 Sylvestre Pond Outflow							
W-34 Blackstone Canal							
Acute Copper Criteria *(ug/l)*							
Blackstone River							
Branch River							
Mill River	4.1	5.1	5.8	6.0	6.0	5.8	5.7
Peters River	2.3	4.9	5.0	3.5	2.8	2.9	3.9
Abbott Run Brook							
W-31 Cherry Brook							
W-32 Front Street Drain							
W-33 Sylvestre Pond Outflow							
W-34 Blackstone Canal							

Figure 4-81: Wet Weather Copper Acute Criteria by Waterbody for Storms WW-03 and WW-04

Water Body/Station	**Storm WW-03: Runs**									
	1	**2**	**3**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Mean Hardness *(mg/l)*										
Blackstone River	63	60	72	64	62	45	44	33	31	40
Branch River	17	24		24		19				
Mill River	40	38	40	40		37				
Peters River	64	57	57	61		28				
Abbott Run Brook		29		30		24				
W-31 Cherry Brook		34		47		37				
W-32 Front Street Drain		44		40		60				
W-33 Sylvestre Pond Outflow		36				18				
W-34 Blackstone Canal		63		70		62				
Acute Copper Criteria *(ug/l)*										
Blackstone River	8.7	8.3	9.8	8.9	8.6	6.3	6.1	4.7	4.5	5.6
Branch River	2.5	3.5		3.5		2.8				
Mill River	5.6	5.4	5.7	5.7		5.2				
Peters River	8.8	7.9	8.0	8.4		4.0				
Abbott Run Brook		4.2		4.3		3.5				
W-31 Cherry Brook		4.9		6.6		5.3				
W-32 Front Street Drain		6.2		5.7		8.3				
W-33 Sylvestre Pond Outflow		5.1				2.7				
W-34 Blackstone Canal		8.7		9.6		8.6				

Water Body/Station	**Storm WW-04: Runs**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Mean Hardness *(mg/l)*									
Blackstone River	37	32	33	32	33	31	33	30	30
Branch River		12		14					
Mill River	27	27		26		27	27		
Peters River	48	46		43		39	44		
Abbott Run Brook		33		37					
W-31 Cherry Brook		36		32					
W-32 Front Street Drain		34		33					
W-33 Sylvestre Pond Outflow		48		47					
W-34 Blackstone Canal		39		35					
Acute Copper Criteria *(ug/l)*									
Blackstone River	5.2	4.7	4.7	4.6	4.7	4.5	4.7	4.3	4.3
Branch River		1.8		2.1					
Mill River	3.9	3.9		3.8		4.0	3.9		
Peters River	6.7	6.4		6.0		5.5	6.1		
Abbott Run Brook		4.7		5.3					
W-31 Cherry Brook		5.1		4.6					
W-32 Front Street Drain		4.9		4.7					
W-33 Sylvestre Pond Outflow		6.7		6.6					
W-34 Blackstone Canal		5.5		5.0					

Figure 4-82: Wet Weather Lead Acute Criteria by Waterbody for Storms WW-01 and WW-02

Water Body/Station	**Storm WW-01: Runs**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Mean Hardness *(mg/l)*												
Blackstone River	49	46	47	64	41	45	37	34	36	42	82	87
Branch River		21	22									
Mill River	39	36	39	40			36					
Peters River	49	44	36	38		28	37					
Abbott Run Brook	34	34	37									
W-31 Cherry Brook		24	33									
W-32 Front Street Drain		8	25									
W-33 Sylvestre Pond Outflow		35	41									
W-34 Blackstone Canal	61	56	52									
Acute Lead Criteria *(ug/l)*												
Blackstone River	30	28	28	26	24	22	22	19	21	25		56
Branch River		11	12									
Mill River	23	21	23	23			21					
Peters River	29	26	21	22			22					
Abbott Run Brook	20	20	22									
W-31 Cherry Brook		13	19									
W-32 Front Street Drain		4	14									
W-33 Sylvestre Pond Outflow		20	24									
W-34 Blackstone Canal	38	34	31									

Water Body/Station	**Storm WW-02: Runs**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Mean Hardness *(mg/l)*							
Blackstone River							
Branch River							
Mill River	28	36	41	42	42	41	40
Peters River	16	34	35	24	19	19	27
Abbott Run Brook							
W-31 Cherry Brook							
W-32 Front Street Drain							
W-33 Sylvestre Pond Outflow							
W-34 Blackstone Canal							
Acute Lead Criteria *(ug/l)*							
Blackstone River							
Branch River							
Mill River	16	21	24	25	25	24	24
Peters River	8	20	20	13	10	10	15
Abbott Run Brook							
W-31 Cherry Brook							
W-32 Front Street Drain							
W-33 Sylvestre Pond Outflow							
W-34 Blackstone Canal							

Figure 4-83: Wet Weather Lead Acute Criteria by Waterbody for Storms WW-03 and WW-04

Water Body/Station	Storm WW-03: Runs									
	1	**2**	**3**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Mean Hardness *(mg/l)*										
Blackstone River	63	60	72	64	62	45	44	33	31	40
Branch River	17	24		24		19				
Mill River	40	38	40	40		37				
Peters River	64	57	57	61		28				
Abbott Run Brook		29		30		24				
W-31 Cherry Brook		34		47		37				
W-32 Front Street Drain		44		40		60				
W-33 Sylvestre Pond Outflow		36				18				
W-34 Blackstone Canal		63		70		62				
Acute Lead Criteria *(ug/l)*										
Blackstone River	39	37	45	40	38	27	26	19	18	23
Branch River	9	13		13		10				
Mill River	23	22	24	24		21				
Peters River	40	35	35	38		15				
Abbott Run Brook		16		17		13				
W-31 Cherry Brook		20		28		22				
W-32 Front Street Drain		26		24		37				
W-33 Sylvestre Pond Outflow		21				10				
W-34 Blackstone Canal		39		44		38				

Water Body/Station	Storm WW-04: Runs								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Mean Hardness *(mg/l)*									
Blackstone River	37	32	33	32	33	31	33	30	30
Branch River		12		14					
Mill River	27	27		26		27	27		
Peters River	48	46		43		39	44		
Abbott Run Brook		33		37					
W-31 Cherry Brook		36		32					
W-32 Front Street Drain		34		33					
W-33 Sylvestre Pond Outflow		48		47					
W-34 Blackstone Canal		39		35					
Acute Lead Criteria *(ug/l)*									
Blackstone River	21	19	19	18	19	18	19	17	17
Branch River		6		7					
Mill River	15	15		15		15	15		
Peters River	29	27		25		23	26		
Abbott Run Brook		19		22					
W-31 Cherry Brook		21		18					
W-32 Front Street Drain		20		19					
W-33 Sylvestre Pond Outflow		29		28					
W-34 Blackstone Canal		23		20					

Figure 4-84: Storms WW-01 and WW-02 - Dissolved Copper Concentrations (ug/l)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	**Storm WW-01** (July 8 - 12, 2005) (*Mitkem [1]*)															**Storm WW-02** (September 15, 2005) (*STL + Microinorg.*)										
						8-Jul			9-Jul				10-Jul		11-Jul		12-Jul	**Statistics** (Runs 2-12)			14-Sep	15-Sep							**Statistics** (Runs 1-7)		
						8:30 - 10:15h	16:40 - 18:25h	21:00 - 23:15h	0:10 - 2:30h	6:20 - 7:50h	14:30 - 16:15h	20:30 - 22:40h	6:40 - 8:10h	15:15 - 16:30h	8:40 - 10:00h	14:50 -15:30h	8:40 - 10:00h	**Minimum**	**Maximum**	**Mean**	11:10 - 18:30h	10:35 - 11:10h	11:45 - 12:46h	13:35 -14:55h	15:00 - 15:50h	16:00-16:40h	16:50 - 17:35h	17:45 - 18:30h	**Minimum**	**Maximum**	**Mean**
					Run No.	1	2	3	4	5	6	7	8	9	10	11	12				DW-11	1	2	3	4	5	6	7			
W-01	Reach 1	●			Millville, MA	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*		*ed*														
W-23			●		Branch River		*ed*	*ed*																							
W-21		●			Singleton Street		*ed*	*ed*																							
W-22		●			Below Thundermist Dam		*ed*	*ed*																							
W-11			●		Mill River (MA/RI border)	*ed*	*ed*	*ed*	*ed*			*ed*									1.3	2.0	1.4	1.4	1.5	1.2	1.6	1.4	1.2	2.0	1.5
W-12			●		Mill River (pre-culvert entry)	*ed*	*ed*	*ed*	*ed*			*ed*									1.6	3.9	2.8	2.0	1.5	1.7	1.5	1.9	1.5	3.9	2.2
W-13			●		Mill River (confluence w/ BR)	*ed*	*ed*	*ed*	*ed*			*ed*									1.6	***4.3***	2.8	2.2	1.6	1.5	2.2	1.9	1.5	4.3	2.4
W-14			●		Peters River (MA/RI border)	*ed*	*ed*	*ed*	*ed*			*ed*									1.9	***4.4***	2.4	4.0	3.3	***3.3***	***3.0***	2.5	2.4	4.4	**3.3**
W-15			●		Peters River (pre-culvert entry)	*ed*	*ed*	*ed*	*ed*			*ed*									2.5	2.2	3.3	2.5	3.4	***3.5***	***4.3***	3.6	2.2	4.3	**3.3**
W-16			●		Peters River (confluence w/ BR)																2.0	***3.5***	2.0	2.9	2.9	***4.7***	***3.4***	3.2	2.0	4.7	**3.2**
W-17		●			Hamlet Avenue		*ed*	*ed*																							
W-24				●	Woonsocket WWTF					*ed*			*ed*																		
W-02	Reach 2	●			Manville Dam	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*		*ed*														
W-03		●			George Washington Hwy Bridge	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*														
W-04	Reach 3	●			Lonsdale Ave	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*														
W-25		●			Broad Street	*ed*	*ed*	*ed*																							
W-26			●		Abbott Run Brook	*ed*	*ed*	*ed*																							
W-05		●			Slaters Mill Dam	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*														
W-31	1			●	Cherry Brook		*ed*	*ed*																							
W-32				●	Front Street Drain		*ed*	*ed*																							
W-33				●	Sylvestre Pond Outflow		*ed*	*ed*																							
W-34	2			●	Blackstone Canal at Lonsdale	*ed*	*ed*	*ed*																							
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*																
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate			*ed*	*ed*			*ed*											1.1	1.3							
W-42		(=W-14)			Duplicate			*ed*	*ed*			*ed*											2.1	3.5				2.4			
W-43	2 3	(=W-04)			Duplicate																										

[1] Samples for Storm WW-01 were analyzed by Mitkem at a higher Reporting Limit than Storms WW-02 to WW-04 by other laboratories. Thus, data were edited but attached in an Appendix to the report.

ed Edited due to likely laboratory error.

7.7 Exceedance of Chronic Criteria (based on mean concentrations of hardness and copper per station).

8.1 Exceedance of Acute Criteria (based on mean hardness per waterbody), and typically also of chronic criteria.

Dissolved Copper Criteria	for Hardness (mg/l as $CaCO_3$)				
	25	*35*	*45*	*55*	*65*
Acute Criteria	3.6	5.0	6.3	7.7	9.0
Chronic Criteria	2.7	3.7	4.5	5.4	6.2

Figure 4-85: Storms WW-03 and WW-04 - Dissolved Copper Concentrations (ug/l)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm WW-03 (October 7 - 11, 2005) (*STL + Microinorganics*)													Storm WW-04 (October 22 - 25, 2005) (*STL + Microinorganics*)												
						7-Oct	8-Oct				9-Oct		10-Oct		11-Oct	Statistics (Runs 2-11)			22-Oct		23-Oct					24-Oct		25-Oct	Statistics (Runs 2-10)		
						12:00 - 14:50h	3:40 - 8:50h	9:10 - 11:55h	16:55 - 19:30h	20:15 - 21:40h	9:30 -12:40h	15:00 - 16:45h	5:00 - 6:45h	12:00 - 13:30h	10:00 - 11:15h	Minimum	Maximum	Mean	11:25 - 14:00h	21:10 - 23:50h	0:30 - 2:10h	3:45 - 5-45h	9:15 - 11:10h	13:15 - 16:25h	19:00 - 20:50h	11:00 - 13:30h	14:00 - 15:40h	11:00h	Minimum	Maximum	Mean
					Run No.	1	2	3	5	6	7	8	9	10	11				1	2	3	4	5	6	7	8	9	10			
W-01	1	●			Millville, MA	8.1	7.9	6.8	7.4	7.3	***8.2***	***7.4***	***8.2***	***8.6***	***7.1***	6.8	8.6	**7.7**	***5.4***	***7.4***	***4.8***	***6.2***	4.6	***4.8***	***6.1***	***4.8***	***4.5***		4.5	7.4	**5.4**
W-23	1		●		Branch River	1.6	***4.4***		3.4		2.3					2.3	4.4	**3.4**		***7.7***		***3.6***							3.6	7.7	**5.7**
W-21	1	●			Singleton Street		***10.0***		7.0		***6.5***					6.5	10.0	**7.8**		***7.1***		***5.6***							5.6	7.1	**6.4**
W-22	1	●			Below Thundermist Dam		***10.0***		6.7		6.0					6.0	10.0	**7.6**		***9.1***		***5.9***							5.9	9.1	**7.5**
W-11	1		●		Mill River (MA/RI border)	1.5	1.8	1.8	1.7		1.4					1.4	1.8	1.7	2.6	2.7		3.3		2.1	2.4				2.1	3.3	2.6
W-12	1		●		Mill River (pre-culvert entry)	1.9	1.5	1.6	1.6		1.9					1.5	1.9	1.6	2.9	2.2		2.5		2.2	2.5				2.2	2.5	2.3
W-13	1		●		Mill River (confluence w/ BR)	3.8	3.4	3.8	2.2		2.0					2.0	3.8	2.9	2.9	2.3		2.2		2.2	2.4				2.2	2.4	2.3
W-14	1		●		Peters River (MA/RI border)	2.1	2.1	3.7	2.2		2.1					2.1	3.7	2.5	1.8	3.5		3.1		2.1	1.9				1.9	3.5	2.7
W-15	1		●		Peters River (pre-culvert entry)	2.9	2.5	2.7	2.3		2.8					2.3	2.8	2.6	2.0	3.9		2.8		1.8	2.1				1.8	3.9	2.7
W-16	1		●		Peters River (confluence w/ BR	2.1	2.6	2.6	2.7							2.6	2.7	2.6													
W-17	1	●			Hamlet Avenue		7.9		6.4		5.8					5.8	7.9	**6.7**		4.3		4.4							4.3	4.4	**4.4**
W-24	1			●	Woonsocket WWTF		***12.0***									12.0	12.0	**12.0**								3.5		4.8	3.5	4.8	**4.2**
W-02	2	●			Manville Dam	6.0	5.9	6.3	6.0	6.0	4.7	5.5	***6.4***	***6.3***	***5.8***	4.7	6.4	**5.9**	**4.6**	4.4	***4.8***	4.0	3.8	3.9	***4.8***	4.2	4.1		3.8	4.8	**4.3**
W-03	2	●			George Washington Hwy Bridg	8.9	5.3	5.6	5.2	5.3	4.4	5.0	***6.4***	***6.6***	***6.8***	4.4	6.8	**5.6**	**4.8**	4.4	4.5	4.4	4.5	3.9	4.4	4.1	***4.7***		3.9	4.7	**4.4**
W-04	2 3	●			Lonsdale Ave	5.0	4.8	8.5	4.8	5.7	5.2	4.9	***5.7***	***6.5***	***6.8***	4.8	8.5	**5.9**	**4.8**	4.6	4.5	***5.0***	4.6	3.8	4.4	***4.4***	4.2		3.8	5.0	**4.4**
W-25	3	●			Broad Street		4.4		4.5		5.5					4.4	5.5	4.8		***5.0***		***4.7***							4.7	5.0	**4.9**
W-26	3		●		Abbott Run Brook		<1.0		1.0		1.0					<1.0	1.0	1.0		1.0		1.0							1.0	1.0	1.0
W-05	3	●			Slaters Mill Dam	4.5	4.2	4.7	5.7	4.7	5.2	4.3	***5.3***	***5.8***	***6.0***	4.2	6.0	**5.1**	**4.9**	***4.8***	4.6	***4.9***	***4.8***	4.0	4.5	4.3	***4.4***		4.0	4.9	**4.5**
W-31	1			●	Cherry Brook		***5.2***		4.4		4.4					4.4	5.2	**4.7**		4.1		3.9							3.9	4.1	**4.0**
W-32	1			●	Front Street Drain		5.7		***8.1***		4.1					4.1	8.1	**6.0**		3.8		3.0							3.0	3.8	**3.4**
W-33	1			●	Sylvestre Pond Outflow		3.1				2.4					2.4	3.1	2.8		1.9		2.0							1.9	2.0	2.0
W-34	2			●	Blackstone Canal at Lonsdale		4.4		4.7		4.4					4.4	4.7	4.5		4.4		4.1							4.1	4.4	**4.3**
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate																										
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41	1	(=W-11)			Duplicate		3.0	1.8	1.6										2.3	3.1		2.2		2.1							
W-42	1	(=W-14)			Duplicate	1.6	2.8	2.6	2.8										2.4	5.0		3.5		1.8							
W-43	2 3	(=W-04)			Duplicate	5.8	5.0	5.3	4.8	5.7									4.8	4.7	4.4	4.9	4.7	3.9							

No Run 4 for WW-03.

7.7 Exceedance of Chronic Criteria (based on mean concentrations of hardness and copper per station).
8.1 Exceedance of Acute Criteria (based on mean hardness per waterbody).

Dissolved Copper Criteria	*for Hardness (mg/l as $CaCO_3$)*				
	25	*35*	*45*	*55*	*65*
Acute Criteria	3.6	5.0	6.3	7.7	9.0
Chronic Criteria	2.7	3.7	4.5	5.4	6.2

Figure 4-86: Summary of Event Mean Concentrations (EMC) for Dissolved Copper

Station	**Dissolved Copper** (ug/l)		
	Storm		
	WW-02	**WW-03**	**WW-04**
W-01		7.76	5.35
W-23		2.55	5.45
W-21		6.86	6.30
W-22		6.43	7.41
W-11	1.41	1.50	2.57
W-12	1.92	1.77	2.33
W-13	2.06	2.28	2.27
W-14	3.05	2.23	2.58
W-15	3.10	2.73	2.57
W-16	3.14	2.63	
W-17		6.06	4.35
W-24			
W-02		5.80	4.24
W-03		5.76	4.35
W-04		5.77	4.42
W-25		5.27	4.84
W-26		0.94	0.95
W-05		5.23	4.52
W-31		4.46	3.99
W-32		4.63	3.36
W-33		2.72	1.96
W-34		4.51	4.23
W-35			

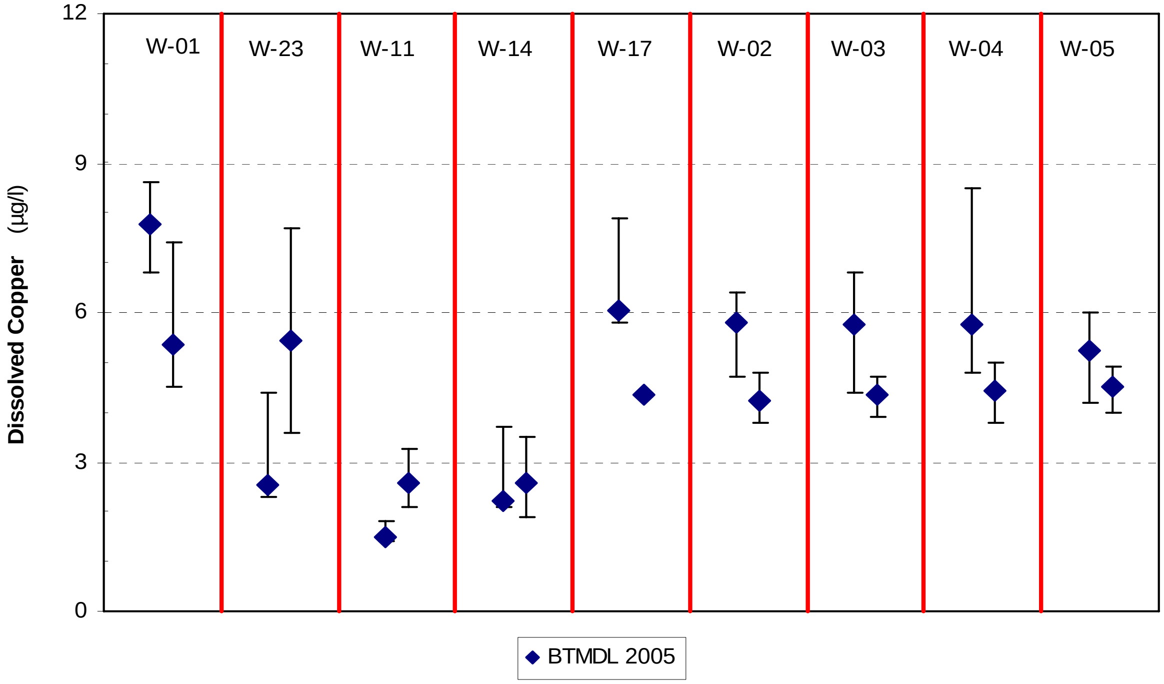


Figure 4-87: Wet Weather Dissolved Copper EMCs for Storms WW-03 and WW-04 (with Maximum and Minimum)

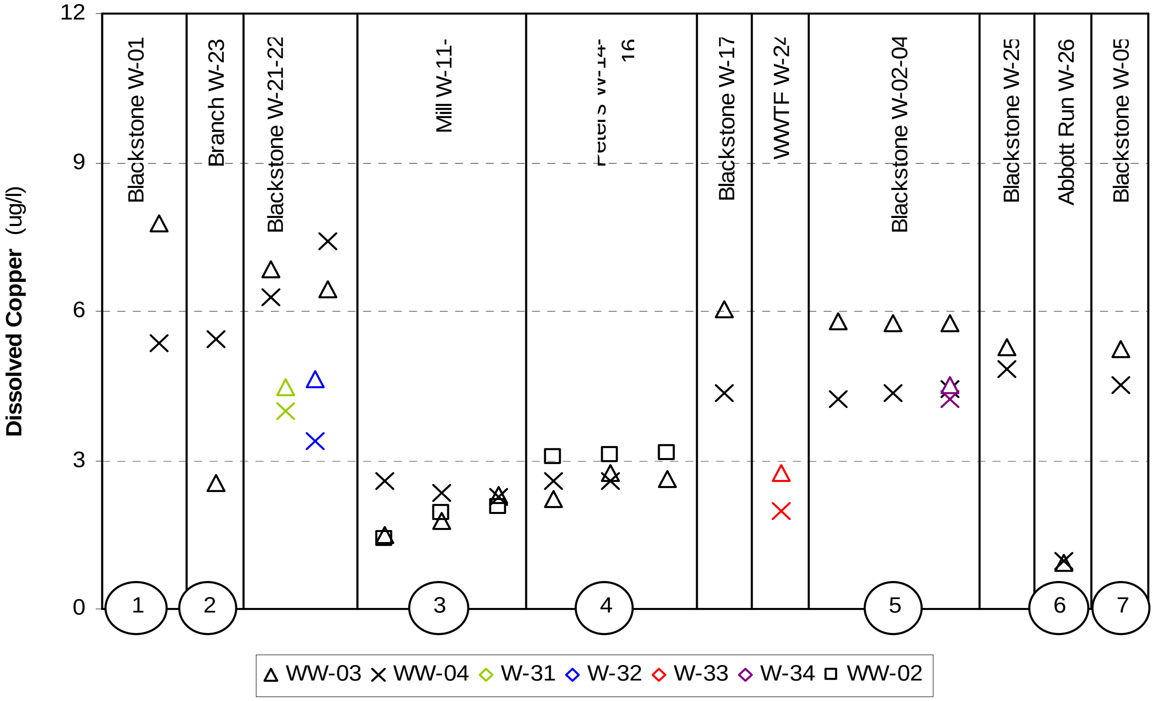


Figure 4-88: Dissolved Copper EMC Profiles for Storms WW-03 and WW-04

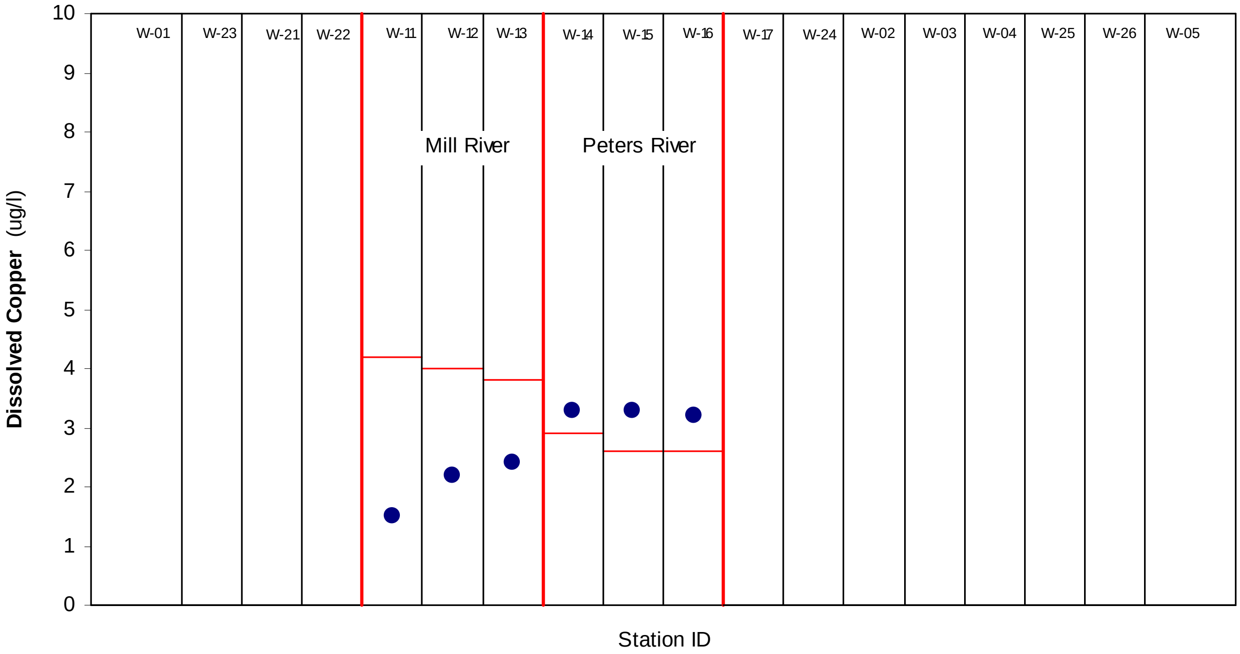


Figure 4-89: Chronic Criteria for Dissolved Copper for Storm WW-02

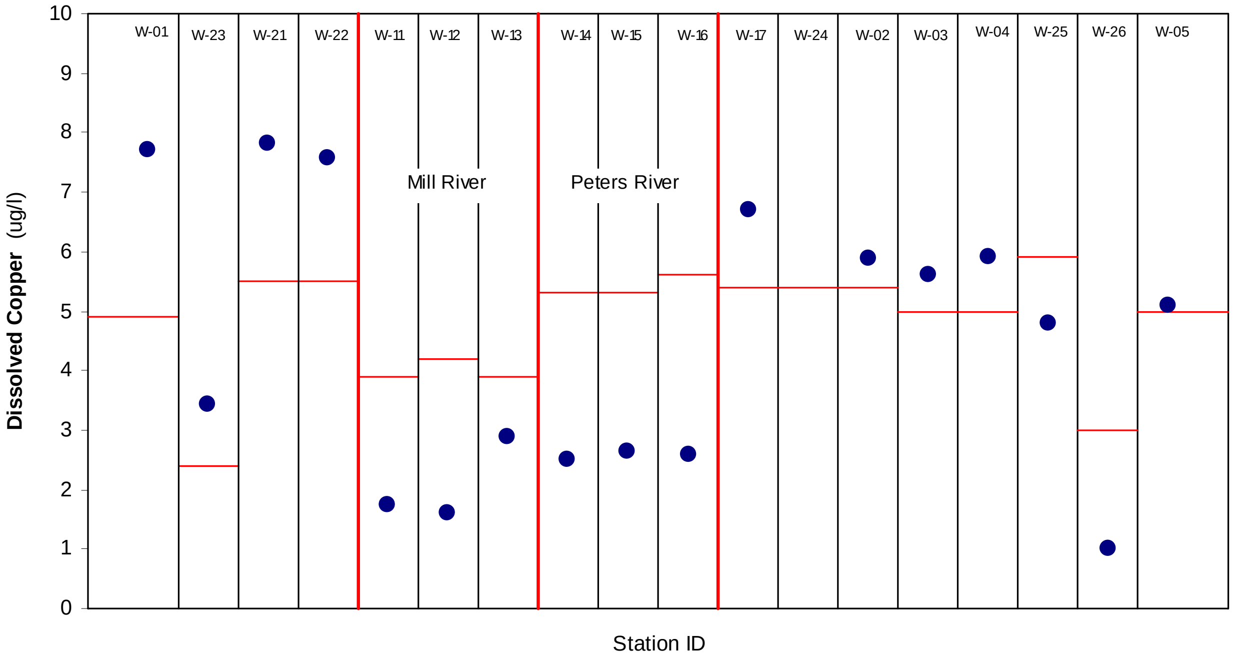


Figure 4-90: Chronic Criteria for Dissolved Copper for Storm WW-03

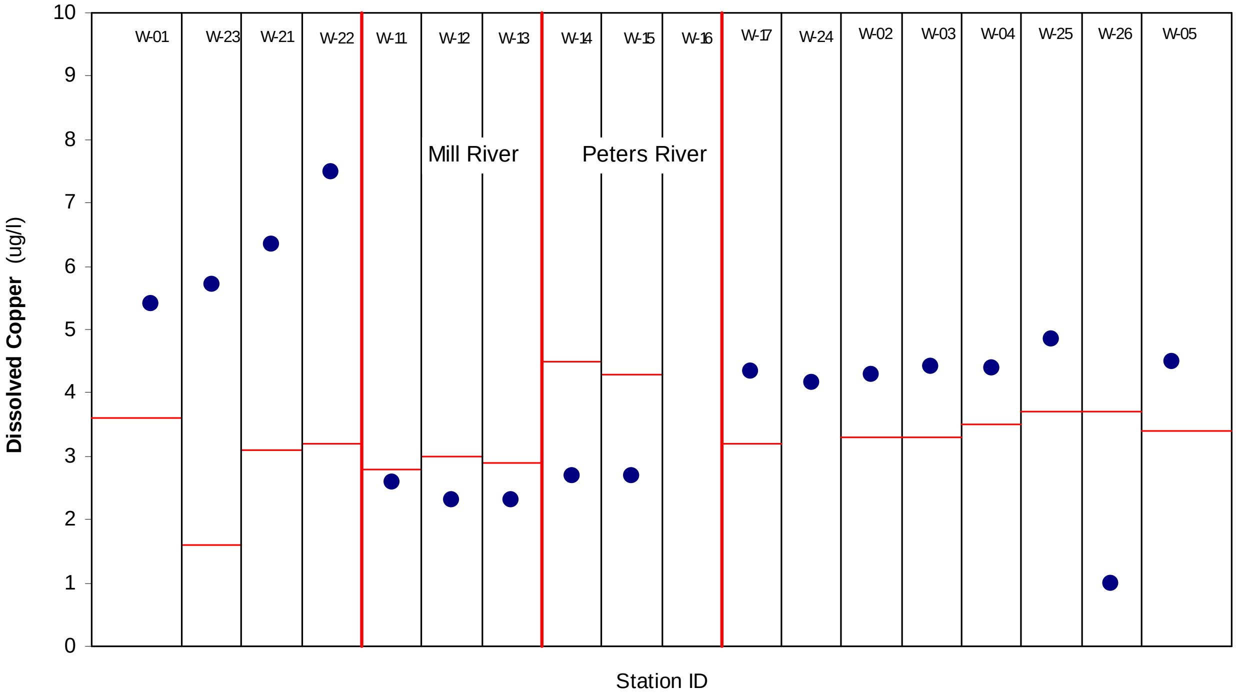


Figure 4-91: Chronic Criteria for Dissolved Copper for Storm WW-04

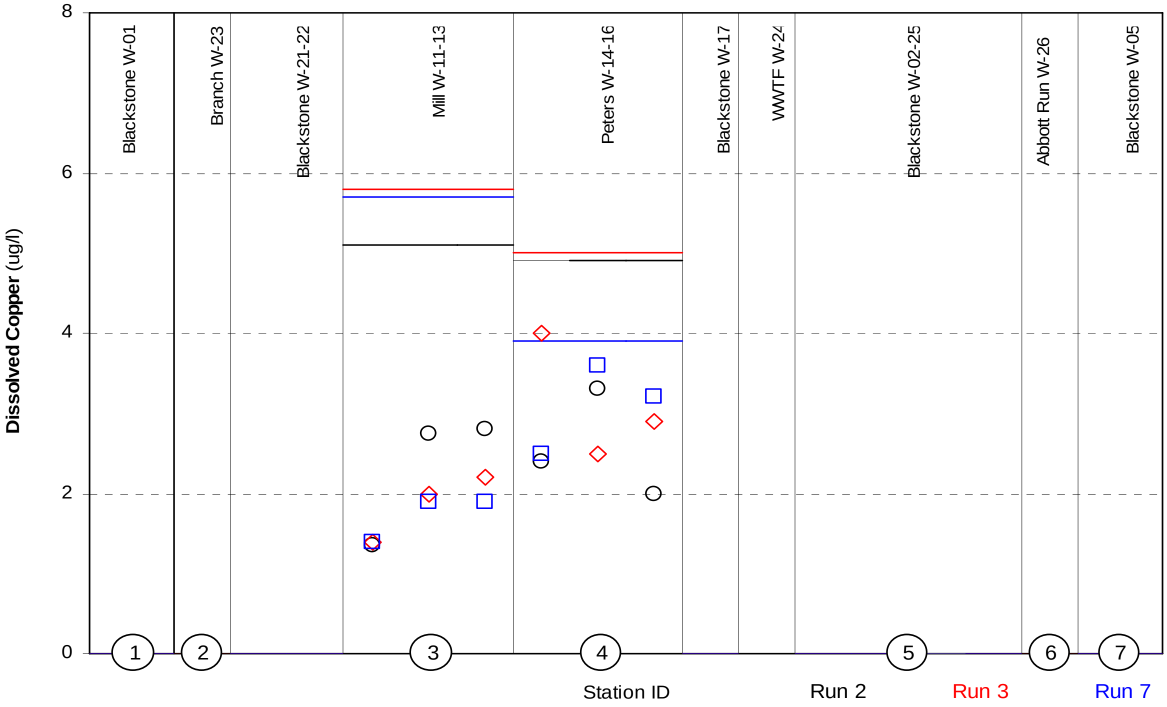


Figure 4-92: Acute Criteria for Dissolved Copper for Storm WW-02

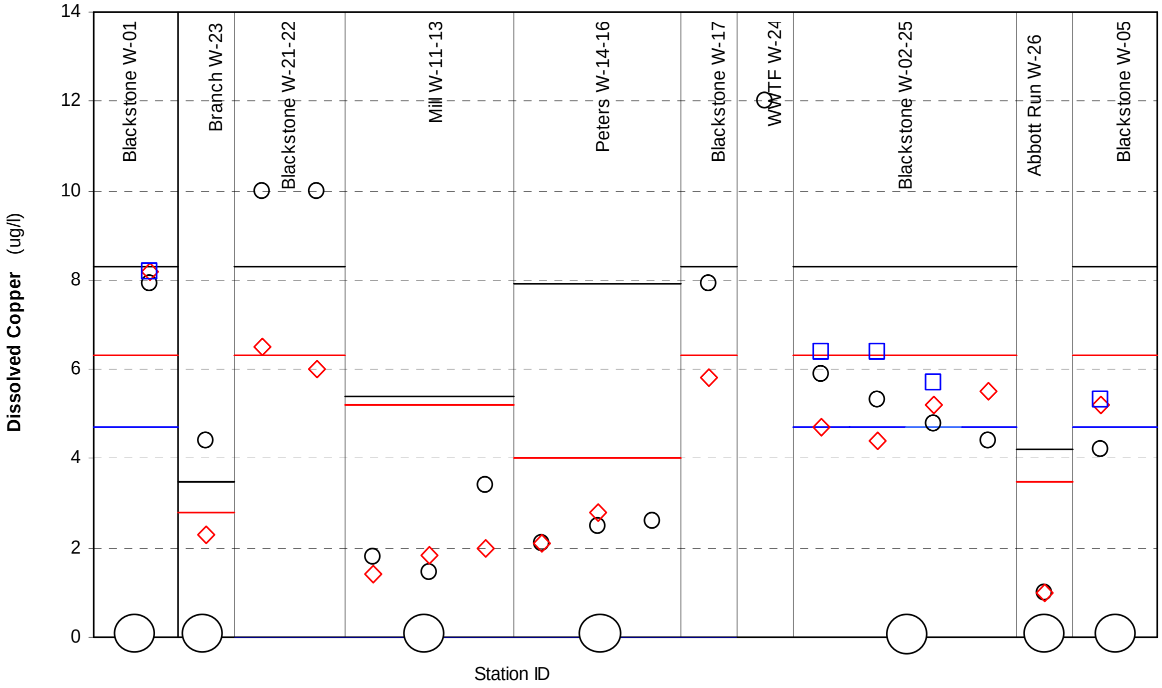


Figure 4-93: Acute Criteria for Dissolved Copper for Storm WW-03

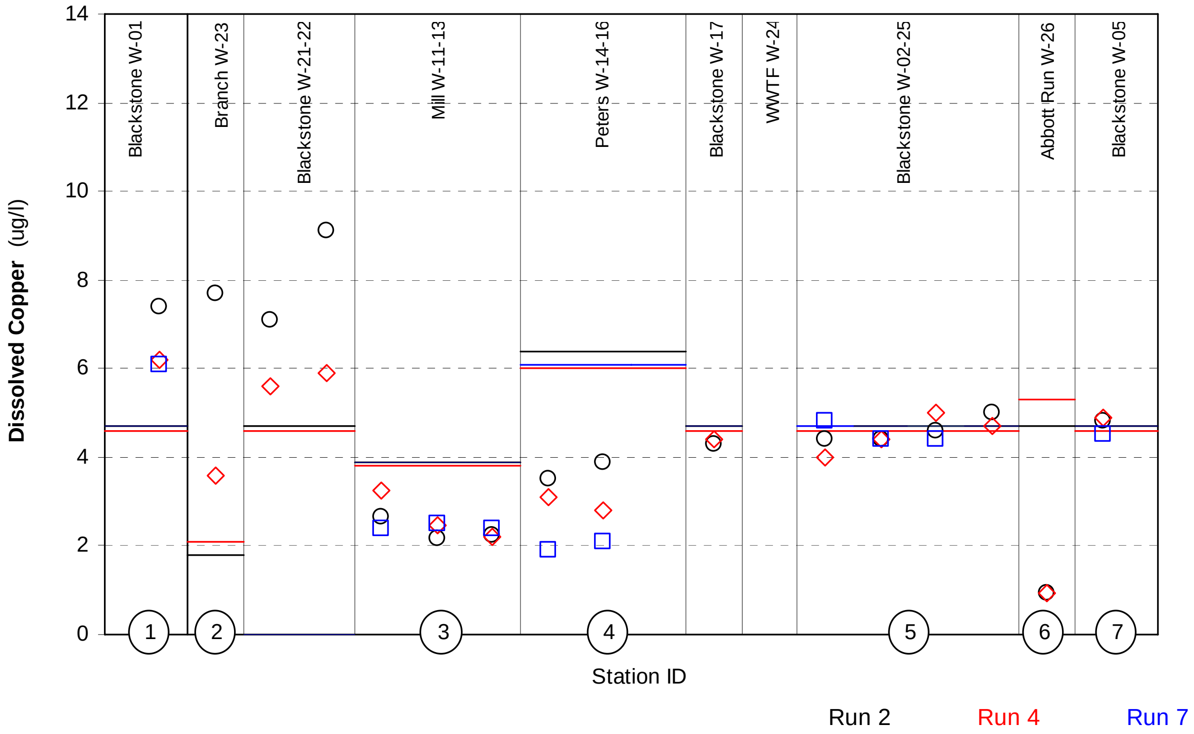


Figure 4-94: Acute Criteria for Dissolved Copper for Storm WW-04

Figure 4-95: Summary of Copper and Lead Acute and Chronic Criteria Exceedences in Wet Weather

Station		**Dissolved Copper**						**Dissolved Lead**					
		Acute Violations			**Chronic Violations** *(1)*			**Acute Violations**			**Chronic Violations** *(1)*		
Storm No. (WW-__)		02	03	04	02	03	04	02	03	04	02	03	04
W-01	Millville, MA		5	7		x	x						
W-23	Branch River		1	2		x	x						x
W-21	Singleton Street		2	2		x	x						
W-22	Below Thundermist Dam		1	2		x	x						
W-11	Mill River (MA/RI border)												
W-12	Mill River (pre-culvert entry)												
W-13	Mill River (confluence w/ BR)	1											
W-14	Peters River (MA/RI border)	3			x								
W-15	Peters River (pre-culvert entry)	2			x								
W-16	Peters River (confluence w/ BR)	3			x								
W-17	Hamlet Avenue					x	x						
W-24	Woonsocket WWTF		3										
W-02	Manville Dam		2	2		x	x						
W-03	George Washington Hwy Bridge		3	1		x	x						
W-04	Lonsdale Ave		3	2		x	x						
W-25	Broad Street			2			x						
W-26	Abbott Run Brook												
W-05	Slaters Mill Dam		3	4			x						
W-31	Cherry Brook		1			x	x						
W-32	Front Street Drain					x	x					x	
W-33	Sylvestre Pond Outflow											x	
W-34	Blackstone Canal at Lonsdale						x						

(1) Exceedance of the chronic criteria by the mean concentration for the respective station.

Figure 4-96: Storms WW-01 and WW-02 - Dissolved Lead Concentrations (ug/l)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm WW-01 (July 8 - 12, 2005) (*Mitkem [1]*)															Storm WW-02 (September 15, 2005) (*STL + Microinorg.*)										
						8-Jul			9-Jul				10-Jul		11-Jul		12-Jul	Statistics (Runs 2-12)			14-Sep	15-Sep							Statistics (Runs 1-7)		
						8:30 - 10:15h	16:40 - 18:25h	21:00 - 23:15h	0:10 - 2:30h	6:20 - 7:50h	14:30 - 16:15h	20:30 - 22:40h	6:40 - 8:10h	15:15 - 16:30h	8:40 - 10:00h	14:50 -15:30h	8:40 - 10:00h	Minimum	Maximum	Mean	11:10 - 18:30h	10:35 - 11:10h	11:45 - 12:46h	13:35 -14:55h	15:00 - 15:50h	16:00-16:40h	16:50 - 17:35h	17:45 - 18:30h	Minimum	Maximum	Mean
					Run No.	1	2	3	4	5	6	7	8	9	10	11	12				11	1	2	3	4	5	6	7			
W-01	Reach 1	●			Millville, MA	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*		*ed*														
W-23			●		Branch River		*ed*	*ed*																							
W-21		●			Singleton Street		*ed*	*ed*																							
W-22		●			Below Thundermist Dam		*ed*	*ed*																							
W-11			●		Mill River (MA/RI border)	*ed*	*ed*	*ed*	*ed*			*ed*									0.17	0.18	0.10	<0.10	<0.10	0.10	<0.10	0.10	<0.10	0.18	0.12
W-12			●		Mill River (pre-culvert entry)	*ed*	*ed*	*ed*	*ed*			*ed*									0.13	0.75	0.48	0.24	0.13	0.21	0.19	0.48	0.13	0.75	0.35
W-13			●		Mill River (confluence w/ BR)	*ed*	*ed*	*ed*	*ed*			*ed*									0.34	1.28	0.21	0.43	0.29	0.17	0.26	0.30	0.17	1.28	0.42
W-14			●		Peters River (MA/RI border)	*ed*	*ed*	*ed*	*ed*			*ed*									0.43	1.10	0.26	0.55	0.47	0.47	0.35	0.37	0.26	1.10	0.51
W-15			●		Peters River (pre-culvert entry)	*ed*	*ed*	*ed*	*ed*			*ed*									0.19	0.19	0.34	0.31	0.38	0.41	0.52	0.34	0.19	0.52	0.36
W-16			●		Peters River (confluence w/ BR)																0.18	0.48	0.82	0.38	0.35	0.75	0.34	0.35	0.34	0.82	0.50
W-17		●			Hamlet Avenue		*ed*	*ed*																							
W-24				●	Woonsocket WWTF					*ed*			*ed*																		
W-02	Reach 2	●			Manville Dam	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*		*ed*														
W-03		●			George Washington Hwy Bridge	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*														
W-04	Reach 3	●			Lonsdale Ave	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*														
W-25		●			Broad Street	*ed*	*ed*	*ed*																							
W-26			●		Abbott Run Brook	*ed*	*ed*	*ed*																							
W-05		●			Slaters Mill Dam	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*														
W-31	1			●	Cherry Brook		*ed*	*ed*																							
W-32				●	Front Street Drain		*ed*	*ed*																							
W-33				●	Sylvestre Pond Outflow		*ed*	*ed*																							
W-34	2			●	Blackstone Canal at Lonsdale	*ed*	*ed*	*ed*																							
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*																
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate			*ed*	*ed*			*ed*											<0.10	0.19							
W-42		(=W-14)			Duplicate			*ed*	*ed*			*ed*											<0.10	0.45				0.14			
W-43	2 3	(=W-04)			Duplicate																										

[1] Samples for Storm WW-01 were analyzed by Mitkem at a higher Reporting Limit than Storms WW-02 to WW-04 by other laboratories. Thus, data were edited but attached in an Appendix to the report.

ed Edited due to likely laboratory error.
1.8 Exceedance of Chronic Criteria (based on mean concentrations of hardness and copper per station).
8.1 Exceedance of Acute Criteria (based on mean hardness per waterbody).

Dissolved Lead Criteria	*for Hardness (mg/l as CaCO $_3$)*				
	25	*35*	*45*	*55*	*65*
Acute Criteria	13.9	20.3	26.8	33.5	40.3
Chronic Criteria	0.54	0.79	1.045	1.31	1.57

Figure 4-97: Storms WW-03 and WW-04 - Dissolved Lead Concentrations (ug/l)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	**Storm WW-03** (October 7 - 11, 2005) ***(STL + Microinorganics)***													**Storm WW-04** (October 22 - 25, 2005) ***(Microinorganics)***													
						7-Oct	8-Oct				9-Oct		10-Oct		11-Oct	**Statistics** (Runs 2-11)			22-Oct		23-Oct					24-Oct		25-Oct	**Statistics** (Runs 2-10)		
						12:00 - 14:50h	3:40 - 8:50h	9:10 - 11:55h	16:55 - 19:30h	20:15 - 21:40h	9:30 -12:40h	15:00 - 16:45h	5:00 - 6:45h	12:00 - 13:30h	10:00 - 11:15h	**Minimum**	**Maximum**	**Mean**	11:25 - 14:00h	21:10 - 23:50h	0:30 - 2:10h	3:45 - 5-45h	9:15 - 11:10h	13:15 - 16:25h	19:00 - 20:50h	11:00 - 13:30h	14:00 - 15:40h	11:00h	**Minimum**	**Maximum**	**Mean**
					Run No.	1	2	3	5	6	7	8	9	10	11				1	2	3	4	5	6	7	8	9	10			
W-01	Reach 1	●			Millville, MA	0.78	0.21	0.25	0.36	0.35	0.35	1.10	0.63	0.96	0.64	0.21	1.10	0.56				0.37									0.37
W-23			●		Branch River	0.40	0.25		0.41		0.43					0.25	0.43	0.37		2.43		2.31							2.31	2.43	**2.37**
W-21		●			Singleton Street		1.00		0.92		0.98					0.92	1.00	0.97													
W-22		●			Below Thundermist Dam		0.30		0.22		0.49					0.22	0.49	0.34													
W-11			●		Mill River (MA/RI border)	0.10	0.20	0.22	0.19		0.14					0.14	0.22	0.17		0.49		0.66							0.49	0.66	0.58
W-12			●		Mill River (pre-culvert entry)	0.50	0.22	0.14	0.12		0.61					0.12	0.61	0.32		0.30		0.41							0.30	0.41	0.36
W-13			●		Mill River (confluence w/ BR)	0.25	0.55	0.39	0.73		0.63					0.39	0.73	0.51		0.41		0.65							0.41	0.65	0.53
W-14			●		Peters River (MA/RI border)	0.23	0.13	0.12	0.18		0.16					0.12	0.18	0.16													
W-15			●		Peters River (pre-culvert entry)	0.32	0.22	0.30	0.19		0.13					0.13	0.30	0.23													
W-16			●		Peters River (confluence w/ BR)	0.18	0.16	0.33	0.31							0.16	0.33	0.25													
W-17		●			Hamlet Avenue		0.21		0.19		0.42					0.19	0.42	0.27													
W-24				●	Woonsocket WWTF		0.15									0.15	0.15	0.15													
W-02	Reach 2	●			Manville Dam	0.26	0.30	0.13	0.31	0.22	0.26	0.42	0.67	1.40	0.55	0.13	1.40	0.45													
W-03		●			George Washington Hwy Bridge	0.15	0.19	0.11	0.12	0.18	0.30	0.28	0.64	0.68	1.00	0.11	1.00	0.37													
W-04	Reach 3	●			Lonsdale Ave	0.13	0.16	0.17	0.12	0.19	0.24	0.29	0.70	0.71	0.72	0.12	0.72	0.34													
W-25		●			Broad Street		0.14		0.14		0.24					0.14	0.24	0.17													
W-26			●		Abbott Run Brook		0.18		0.22		0.18					0.18	0.22	0.19		0.17		0.11							0.11	0.17	0.14
W-05		●			Slaters Mill Dam	0.16	0.18	0.12	0.25	0.18	0.16	0.23	0.48	0.65	0.78	0.12	0.78	0.32													
W-31	1			●	Cherry Brook		0.75		0.73		1.00					0.73	1.00	0.83													
W-32				●	Front Street Drain		1.40		1.90		0.66					0.66	1.90	**1.32**													
W-33				●	Sylvestre Pond Outflow		1.20				1.10					1.10	1.20	**1.15**													
W-34	2			●	Blackstone Canal at Lonsdale		0.26		0.41		0.22					0.22	0.41	0.30													
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate																										
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate		0.29	0.11	0.18													1.18									
W-42		(=W-14)			Duplicate	0.11	0.13	0.16	0.19																						
W-43	2 3	(=W-04)			Duplicate	0.14	0.21	0.21	0.11	0.38																					

No Run 4 for WW-03.

0.61 Concentration of duplicate samples differ considerably from original sample.

1.8 Exceedance of Chronic Criteria (based on mean concentrations of hardness and copper per station).

8.1 Exceedance of Acute Criteria (based on mean hardness per waterbody).

Dissolved Lead Criteria	*for Hardness (mg/l as $CaCO_3$)*				
	25	*35*	*45*	*55*	*65*
Acute Criteria	13.9	20.3	26.8	33.5	40.3
Chronic Criteria	0.54	0.79	1.04	1.31	1.57

Figure 4-98: Summary of Event Mean Concentrations (EMC) for Dissolved Lead

Station	**Dissolved Lead** (ug/l)		
	Storm		
	WW-02	**WW-03**	**WW-04**
W-01		0.70	
W-23		0.41	2.36
W-21		0.97	
W-22		0.44	
W-11	0.10	0.16	0.58
W-12	0.30	0.49	0.36
W-13	0.28	0.61	0.54
W-14	0.41	0.16	
W-15	0.34	0.15	
W-16	0.50	0.27	
W-17		0.37	
W-24			
W-02		0.62	
W-03		0.51	
W-04		0.49	
W-25		0.22	
W-26		0.19	0.13
W-05		0.41	
W-31		0.96	
W-32		0.84	
W-33		1.15	
W-34		0.30	
W-35			

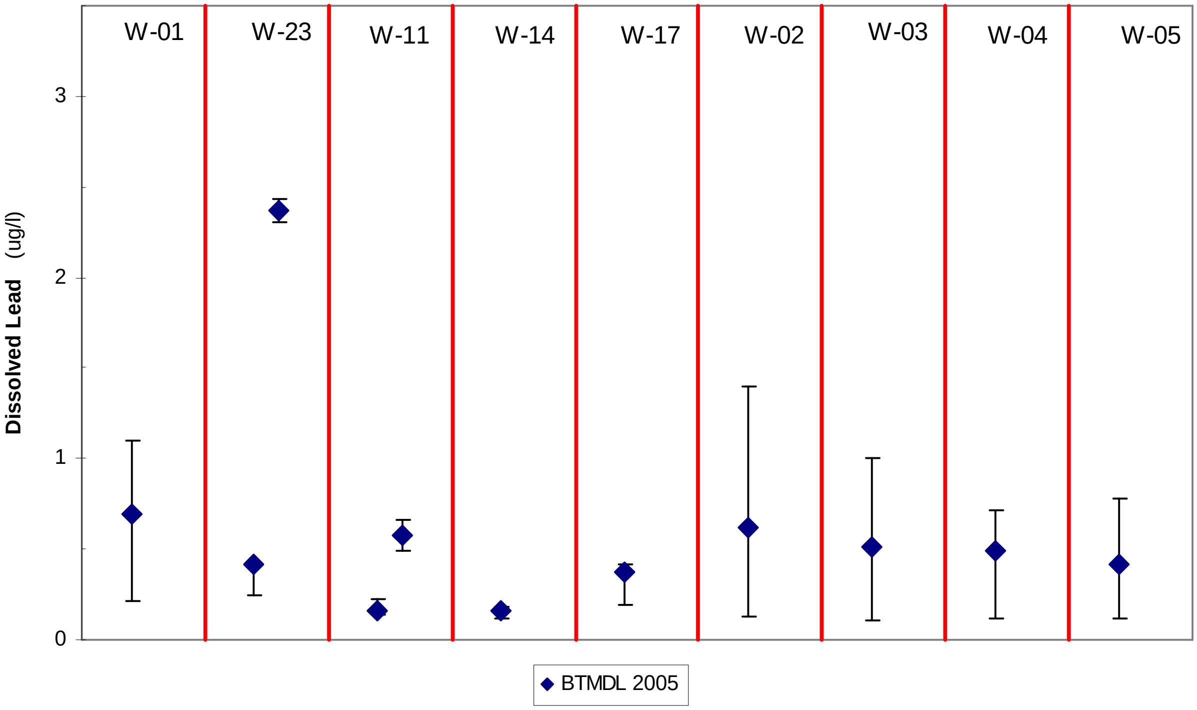


Figure 4-99: **Wet Weather Dissolved Lead EMCs for Storms WW-03 and WW-04 (partial) with Maximum and Minimum)**

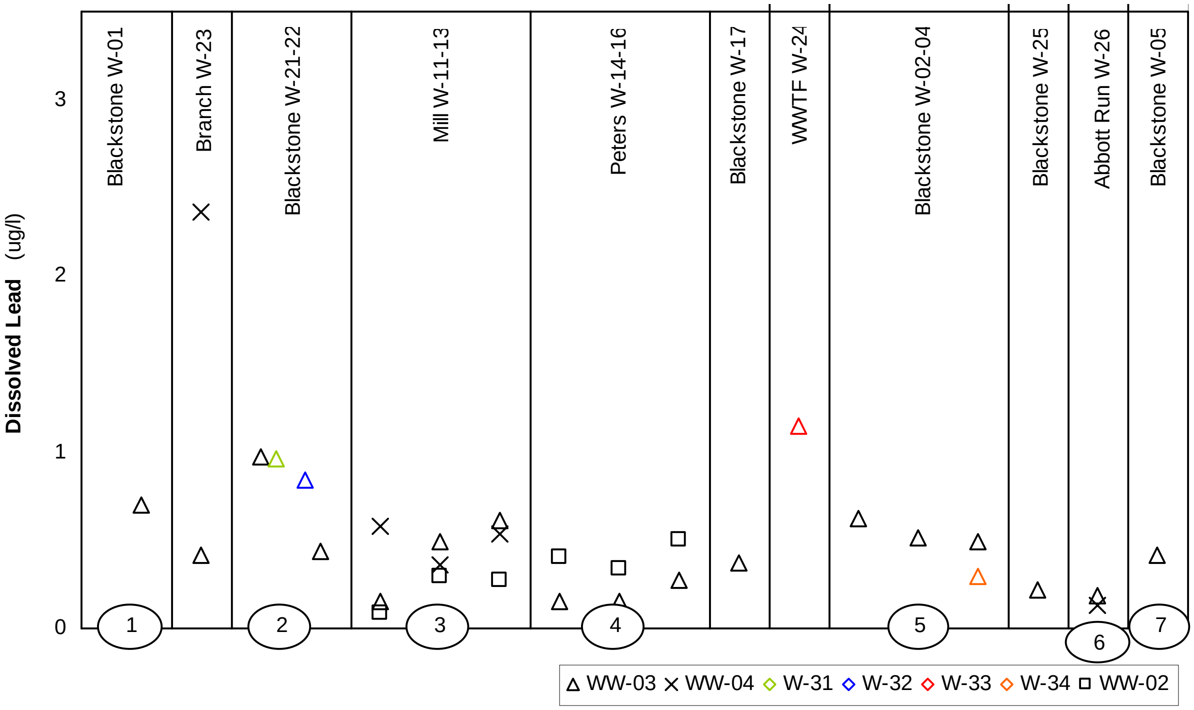


Figure 4-100: Dissolved Lead EMC Profiles for Storms WW-03 and WW-04

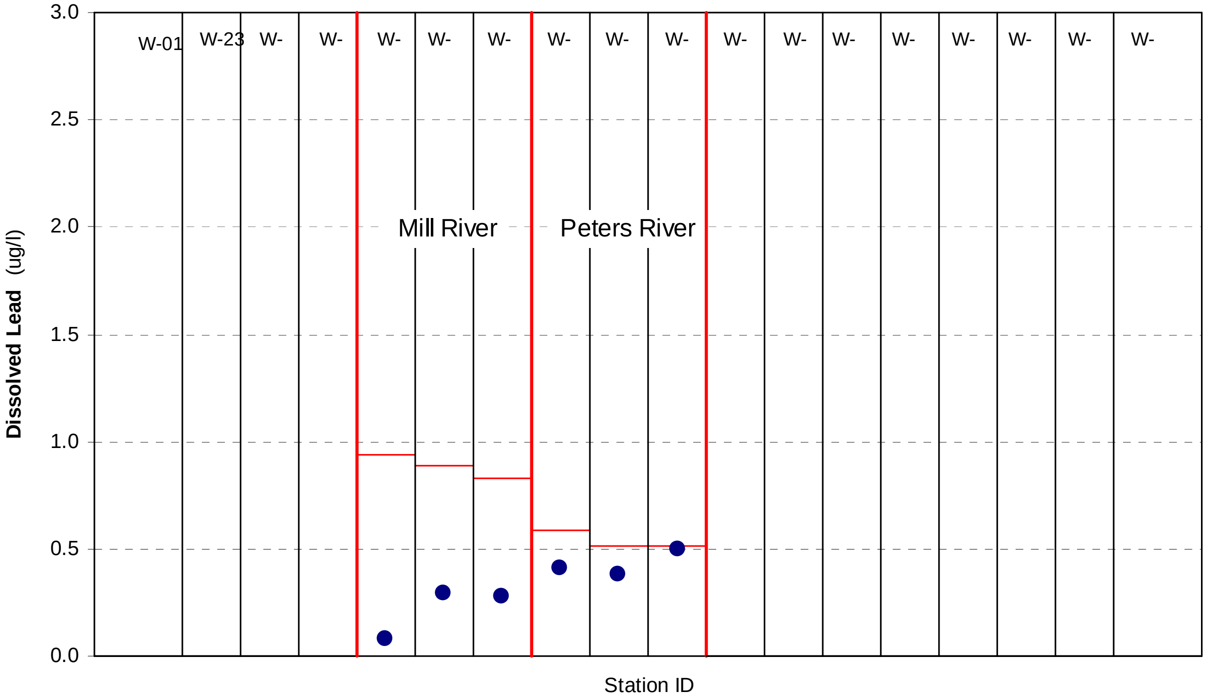


Figure 4-101: Chronic Criteria for Dissolved Lead for Storm WW-02

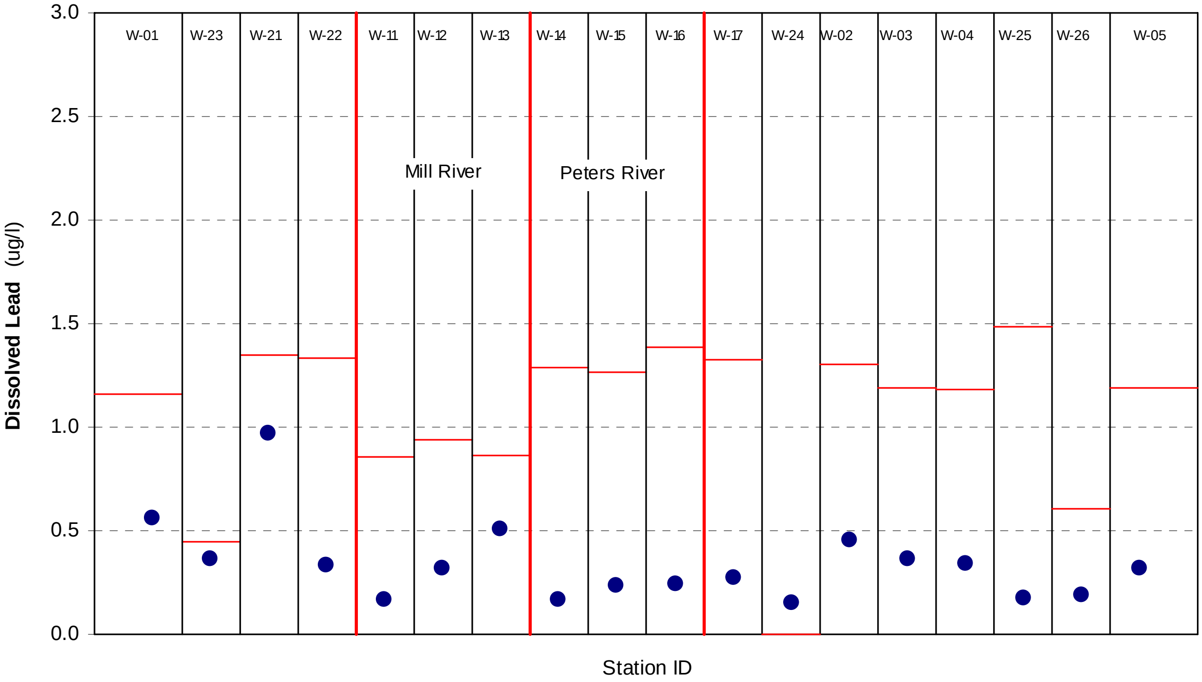


Figure 4-102: Chronic Criteria for Dissolved Lead for Storm WW-03

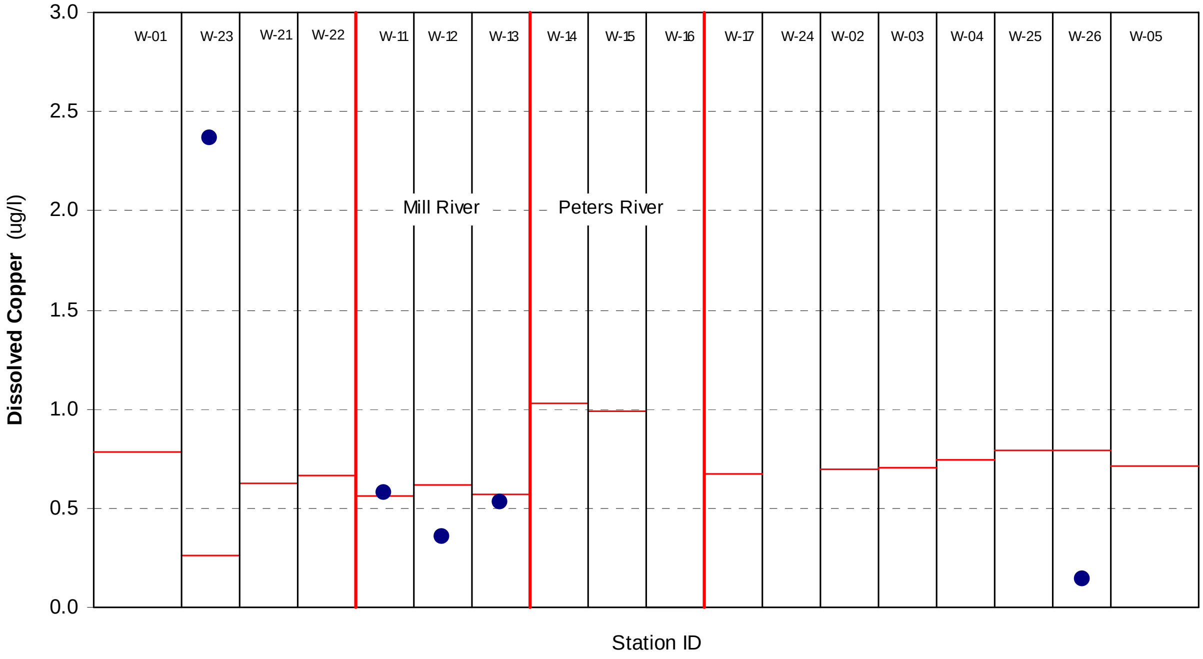


Figure 4-103: Chronic Criteria for Dissolved Lead for Storm WW-04

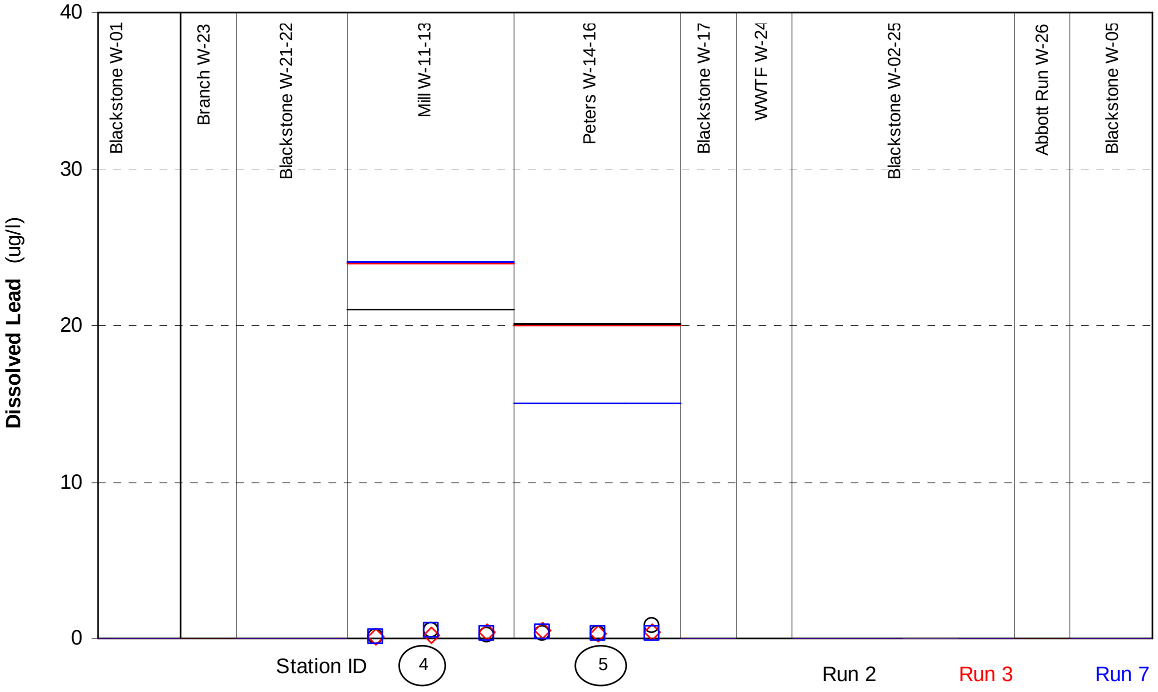


Figure 4-104: Acute Criteria for Dissolved Lead for Storm WW-02

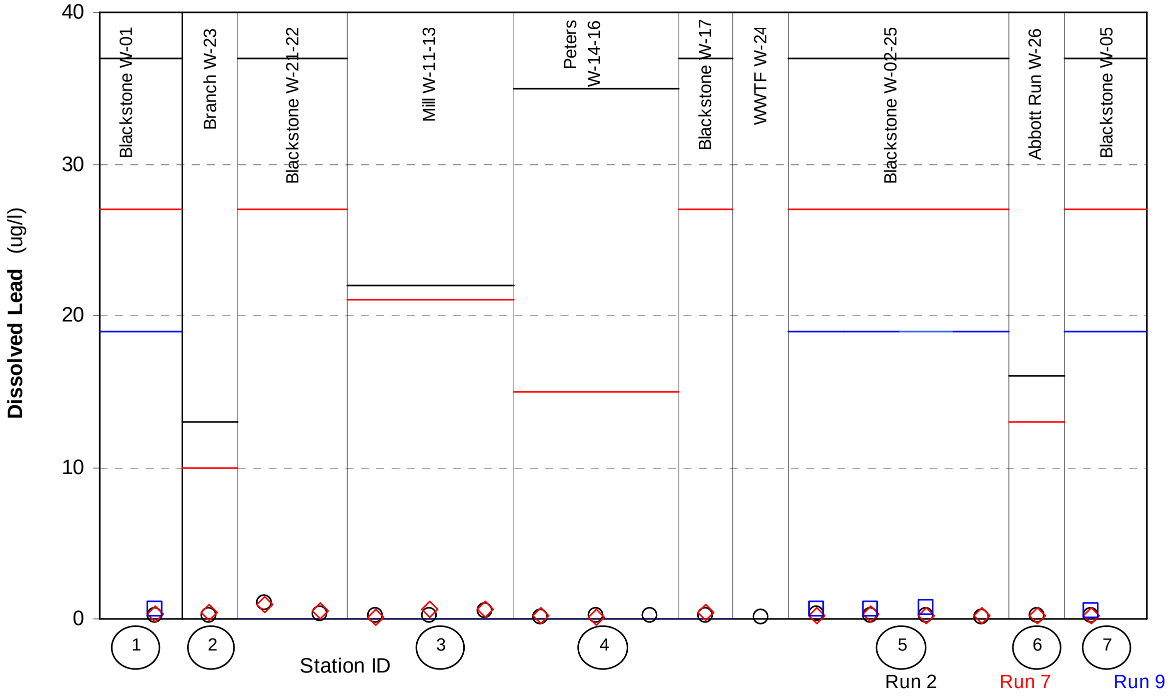


Figure 4-105: Acute Criteria for Dissolved Lead for Storm WW-03

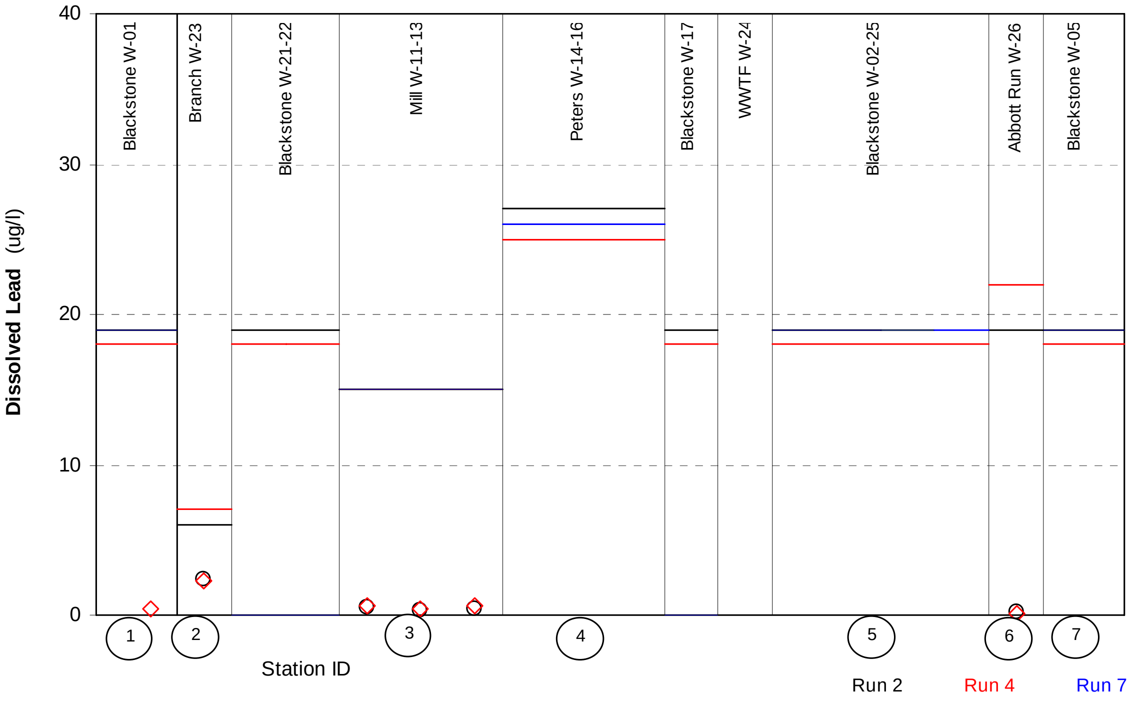


Figure 4-106: Acute Criteria for Dissolved Lead for Storm WW-04

Figure 107: Storms WW-01 and WW-02- Dissolved Oxygen Concentration (mg/l)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	**Storm WW-01** (July 8 - 12, 2005)															**Storm WW-02** (September 15, 2005)										
						8-Jul			9-Jul				10-Jul		11-Jul		12-Jul	**Statistics** (Runs 2-12)			14-Sep	15-Sep							**Statistics** (Runs 1-7)		
						8:30 - 10:15h	16:40 - 18:25h	21:00 - 23:15h	0:10 - 2:30h	6:20 - 7:50h	14:30 - 16:15h	20:30 - 22:40h	6:40 - 8:10h	15:15 - 16:30h	8:40 - 10:00h	14:50 -15:30h	8:40 - 10:00h	**Minimum**	**Maximum**	**Mean**	11:10 - 18:30h	10:35 - 11:10h	11:45 - 12:46h	13:35 -14:55h	15:00 - 15:50h	16:00-16:40h	16:50 - 17:35h	17:45 - 18:30h	**Minimum**	**Maximum**	**Mean**
					Run No.	1	2	3	4	5	6	7	8	9	10	11	12				DW-11	1	2	3	4	5	6	7			
W-01	Reach 1	●			Millville, MA	8.3	8.5	8.6	8.7	7.9	7.8	7.0	7.8	7.7	7.6		7.5	7.0	8.7	7.9											
W-23			●		Branch River		9.4	9.2										9.2	9.4	9.3											
W-21		●			Singleton Street		8.6	9.1										8.6	9.1	8.9											
W-22		●			Below Thundermist Dam		9.0	9.0										9.0	9.0	9.0											
W-11			●		Mill River (MA/RI border)	10.0	9.4	9.6	9.8			8.7						8.7	9.8	9.4											
W-12			●		Mill River (pre-culvert entry)	8.4	8.6	9.2	9.0			8.2						8.2	9.2	8.8											
W-13			●		Mill River (confluence w/ BR)	8.6	9.8	8.9	9.2			8.5						8.5	9.8	9.1											
W-14			●		Peters River (MA/RI border)	8.0	8.1	9.8	8.5			7.1						7.1	9.8	8.4											
W-15			●		Peters River (pre-culvert entry)	10.0	9.8	9.8	10.0			8.7						8.7	10.0	9.6											
W-16			●		Peters River (confluence w/ BR)																										
W-17		●			Hamlet Avenue		8.4	8.3										8.3	8.4	8.4											
W-24				●	Woonsocket WWTF																										
W-02	Reach 2	●			Manville Dam	7.9	8.2	7.9	9.5	8.5	8.4	8.6	8.6	8.5	8.0		7.8	7.8	9.5	8.4											
W-03		●			George Washington Hwy Bridge	8.6	8.6	8.4	9.9	9.0	8.7	9.0	9.1	8.7	8.5	8.1	8.5	8.1	9.9	8.8											
W-04	Reach 3	●			Lonsdale Ave	8.4	8.4	8.2	9.4	8.7	8.7	8.8	8.9	8.5	8.3	8.3	8.3	8.2	9.4	8.6											
W-25		●			Broad Street	8.0	8.4	7.8										7.8	8.4	8.1											
W-26			●		Abbott Run Brook	7.2	8.5	8.2										8.2	8.5	8.4											
W-05		●			Slaters Mill Dam	9.0	8.7	8.4	10.1	8.8	8.9	8.9	9.2	8.7	8.6	8.6	8.4	8.4	10.1	8.8											
W-31	1			●	Cherry Brook		9.6	9.2										9.2	9.6	9.4											
W-32				●	Front Street Drain		10.4	9.1										9.1	10.4	9.8											
W-33				●	Sylvestre Pond Outflow		8.5	8.1										8.1	8.5	8.3											
W-34	2			●	Blackstone Canal at Lonsdale	7.7	6.5	6.3										6.3	6.5	6.4											
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate	7.9	8.2	7.9	9.5	8.5	8.4	8.6	8.6	8.5	8.0																
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate			9.6	9.8			8.7																			
W-42		(=W-14)			Duplicate			9.8	8.5			7.1																			
W-43	2 3	(=W-04)			Duplicate																										

Water Quality Criteria (Class B and B1): Instantaneous minimum concentration of at least 5 mg/l, and 7-day man of at least 6 mg/l.

Figure 108: Storms WW-03 and WW-04 - Dissolved Oxygen Concentration (mg/l)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm WW-03 (October 7 - 11, 2005)													Storm WW-04 (October 22 - 25, 2005)												
						7-Oct	8-Oct				9-Oct		10-Oct		11-Oct	Statistics (Runs 2-11)			22-Oct		23-Oct					24-Oct		25-Oct	Statistics (Runs 2-10)		
						12:00 - 14:50h	3:40 - 8:50h	9:10 - 11:55h	16:55 - 19:30h	20:15 - 21:40h	9:30 -12:40h	15:00 - 16:45h	5:00 - 6:45h	12:00 - 13:30h	10:00 - 11:15h	Minimum	Maximum	Mean	11:25 - 14:00h	21:10 - 23:50h	0:30 - 2:10h	3:45 - 5-45h	9:15 - 11:10h	13:15 - 16:25h	19:00 - 20:50h	11:00 - 13:30h	14:00 - 15:40h	11:00h	Minimum	Maximum	Mean
					Run No.	1	2	3	5	6	7	8	9	10	11				1	2	3	4	5	6	7	8	9	10			
W-01	Reach 1	●			Millville, MA	8.0	7.7	7.3	7.9	7.8	8.1	8.2	8.6	8.8	9.0	7.3	9.0	8.1	10.1	10.1	10.0	10.2	10.3	10.1	10.0	10.4	10.6		10.0	10.6	10.2
W-23			●		Branch River	8.8	7.8		8.1		9.2					7.8	9.2	8.4		10.9		11.0							10.9	11.0	10.9
W-21		●			Singleton Street		8.2		8.3		8.9					8.2	8.9	8.5		10.8		10.9							10.8	10.9	10.8
W-22		●			Below Thundermist Dam		8.7		8.7		9.3					8.7	9.3	8.9		11.1		10.6							10.6	11.1	10.8
W-11			●		Mill River (MA/RI border)	8.8	8.9	8.9	8.9		9.2					8.9	9.2	9.0	10.7	10.6		10.4		10.7	10.8				10.4	10.8	10.6
W-12			●		Mill River (pre-culvert entry)	8.7	8.4	8.4	8.2		9.1					8.2	9.1	8.5	10.7	10.5		10.2		10.4	10.8				10.2	10.8	10.5
W-13			●		Mill River (confluence w/ BR)	9.0	7.8	8.6	8.4		9.1					7.8	9.1	8.5	10.8	10.6		10.4		10.7	10.5				10.4	10.7	10.6
W-14			●		Peters River (MA/RI border)	**4.8**	**4.4**	**4.6**	**4.2**		7.7					**4.2**	7.7	5.2	8.8	8.7		8.5		7.9	8.0				7.9	8.7	8.3
W-15			●		Peters River (pre-culvert entry)	9.3	8.4	8.5	8.6		10.1					8.4	10.1	8.9	11.8	11.2		11.3		11.4	11.3				11.2	11.4	11.3
W-16			●		Peters River (confluence w/ BR)	8.9	8.3	8.6	8.7							8.3	8.7	8.5													
W-17		●			Hamlet Avenue		8.4		8.6		9.2					8.4	9.2	8.7		11.1		10.9							10.9	11.1	11.0
W-24				●	Woonsocket WWTF																										
W-02	Reach 2	●			Manville Dam	9.2	7.7	8.4	7.9	7.5	8.8	9.0	9.3	9.3	9.3	7.5	9.3	8.6	11.0	10.9	10.8	10.6	11.1	11.0	11.0	11.4	10.4		10.4	11.4	10.9
W-03		●			George Washington Hwy Bridge	9.2	8.6	8.8	8.9	8.9	9.7	9.5	9.5	9.4	9.8	8.6	9.8	9.2	11.3	11.3	11.1	11.0	11.5	11.4	11.4	11.7	11.7		11.0	11.7	11.4
W-04	Reach 3	●			Lonsdale Ave	10.1	7.8	8.3	8.6	8.2	9.3	9.4	9.3	9.6	9.6	7.8	9.6	8.9	11.5	11.1	11.0	10.8	11.2	11.2	11.3	11.6	11.5		10.8	11.6	11.2
W-25		●			Broad Street		8.1		7.8		9.0					7.8	9.0	8.3		10.9		10.7							10.7	10.9	10.8
W-26			●		Abbott Run Brook		8.9		9.0		9.1					8.9	9.1	9.0		10.8		10.7							10.7	10.8	10.7
W-05		●			Slaters Mill Dam	9.1	8.4	9.0	8.5	8.4	9.4	9.7	9.6	9.9	9.8	8.4	9.9	9.2	11.7	11.3	11.3	11.2	11.6	11.5	11.7	11.9	11.7		11.2	11.9	11.5
W-31	1			●	Cherry Brook		7.2		6.6		9.2					6.6	9.2	7.7		10.8		10.7							10.7	10.8	10.8
W-32				●	Front Street Drain		9.0		9.2		10.2					9.0	10.2	9.5		10.9		10.9							10.9	10.9	10.9
W-33				●	Sylvestre Pond Outflow		8.0				9.6					8.0	9.6	8.8		10.6		10.5							10.5	10.6	10.5
W-34	2			●	Blackstone Canal at Lonsdale		7.7		8.0		7.5					7.5	8.0	7.8		10.1		10.0							10.0	10.1	10.1
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate																										
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate																										
W-42		(=W-14)			Duplicate																										
W-43	2 3	(=W-04)			Duplicate																										

No Run 4 for WW-03.

4.8 Dissolved oxgen of less than 5 mg/l.

Water Quality Criteria (Class B and B1): Instantaneous minimum concentration of at least 5 mg/l, and 7-day man of at least 6 mg/l.

Figure 109: Storms WW-01 and WW-02 – Temperature (ºC)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	**Storm WW-01** (July 8 - 12, 2005)															**Storm WW-02** (September 15, 2005)										
						8-Jul			9-Jul				10-Jul		11-Jul		12-Jul	**Statistics** (Runs 2-12)			14-Sep	15-Sep							**Statistics** (Runs 1-7)		
						8:30 - 10:15h	16:40 - 18:25h	21:00 - 23:15h	0:10 - 2:30h	6:20 - 7:50h	14:30 - 16:15h	20:30 - 22:40h	6:40 - 8:10h	15:15 - 16:30h	8:40 - 10:00h	14:50 -15:30h	8:40 - 10:00h	**Minimum**	**Maximum**	**Mean**	11:10 - 18:30h	10:35 - 11:10h	11:45 - 12:46h	13:35 -14:55h	15:00 - 15:50h	16:00-16:40h	16:50 - 17:35h	17:45 - 18:30h	**Minimum**	**Maximum**	**Mean**
					Run No.	1	2	3	4	5	6	7	8	9	10	11	12				DW-11	1	2	3	4	5	6	7			
W-01	Reach 1	●			Millville, MA	19.2	19.5	18.5	18.0	18.0	19.0	19.0	19.5	22.0	22.0		22.2	18.0	22.2	19.8											
W-23			●		Branch River		21.0	19.5										19.5	21.0	20.3											
W-21		●			Singleton Street		20.0	19.0										19.0	20.0	19.5											
W-22		●			Below Thundermist Dam		19.5	19.0										19.0	19.5	19.3											
W-11			●		Mill River (MA/RI border)	20.5	21.0	20.0	20.0			21.0						20.0	21.0	20.5	26.5	24.0	23.0	23.5	24.0	23.0	22.0	23.5	22.0	24.0	23.3
W-12			●		Mill River (pre-culvert entry)	20.0	19.0	19.0	19.0			20.5						19.0	20.5	19.4	26.0	24.0	23.5	24.0	24.5	23.0	23.0	23.5	23.0	24.5	23.6
W-13			●		Mill River (confluence w/ BR)	20.5	20.0	19.8	19.0			21.0						19.0	21.0	19.9	22.0	24.0	23.0	24.0	23.0	22.0	22.0	23.0	22.0	24.0	23.0
W-14			●		Peters River (MA/RI border)	17.2	17.5	17.0	16.5			18.0						16.5	18.0	17.3	21.0	23.5	23.0	24.0	24.0	23.0	22.5	23.0	22.5	24.0	23.3
W-15			●		Peters River (pre-culvert entry)	17.0	17.0	16.5	16.0			18.0						16.0	18.0	16.9	23.0	23.5	23.0	24.0	23.0	22.0	22.0	23.0	22.0	24.0	22.9
W-16			●		Peters River (confluence w/ BR)																23.0	23.5	23.0	24.0	24.0	23.0	22.5	23.0	22.5	24.0	23.3
W-17		●			Hamlet Avenue		20.0	19.5										19.5	20.0	19.8											
W-24				●	Woonsocket WWTF																										
W-02	Reach 2	●			Manville Dam	21.0	20.5	20.0	19.0	19.0	19.8	19.5	19.0	21.0	22.0		23.0	19.0	23.0	20.3											
W-03		●			George Washington Hwy Bridge	21.0	20.5	20.0	19.0	19.0	19.8	19.5	19.0	21.0	22.0	23.0	23.0	19.0	23.0	20.5											
W-04	Reach 3	●			Lonsdale Ave	21.0	20.0	20.0	19.0	19.0	20.0	19.5	19.0	22.0	22.0	23.5	23.0	19.0	23.5	20.6											
W-25		●			Broad Street	21.0	20.5	20.0										20.0	20.5	20.3											
W-26			●		Abbott Run Brook	21.0	20.5	20.0										20.0	20.5	20.3											
W-05		●			Slaters Mill Dam	21.0	20.0	20.0	19.0	19.0	20.2	20.0	19.0	21.5	22.0	23.0	23.0	19.0	23.0	20.6											
W-31	1			●	Cherry Brook		17.5	16.5										16.5	17.5	17.0											
W-32				●	Front Street Drain		17.0	15.5										15.5	17.0	16.3											
W-33				●	Sylvestre Pond Outflow		19.5	18.0										18.0	19.5	18.8											
W-34	2			●	Blackstone Canal at Lonsdale	20.5	20.0	19.0										19.0	20.0	19.5											
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate	21.0	20.5	20.0	19.0	19.0	19.8	19.5	19.0	21.0	22.0																
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate			20.0	20.0			21.0											23.0	24.0							
W-42		(=W-14)			Duplicate			17.0	16.5			18.0											23.0	23.0				22.0			
W-43	2 3	(=W-04)			Duplicate																										

Water Quality Criteria (Class B and B1): No criteria for receiving water, only for anthropogenic discharges.

Figure 110: Storms WW-03 and WW-04 - – Temperature (°C)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm WW-03 (October 7 - 11, 2005)													Storm WW-04 (October 22 - 25, 2005)												
						7-Oct	8-Oct				9-Oct		10-Oct		11-Oct	Statistics (Runs 2-11)			22-Oct		23-Oct					24-Oct		25-Oct	Statistics (Runs 2-10)		
						12:00 - 14:50h	3:40 - 8:50h	9:10 - 11:55h	16:55 - 19:30h	20:15 - 21:40h	9:30 -12:40h	15:00 - 16:45h	5:00 - 6:45h	12:00 - 13:30h	10:00 - 11:15h				11:25 - 14:00h	21:10 - 23:50h	0:30 - 2:10h	3:45 - 5-45h	9:15 - 11:10h	13:15 - 16:25h	19:00 - 20:50h	11:00 - 13:30h	14:00 - 15:40h	11:00h			
					Run No.	1	2	3	5	6	7	8	9	10	11	Minimum	Maximum	Mean	1	2	3	4	5	6	7	8	9	10	Minimum	Maximum	Mean
W-01	Reach 1	●			Millville, MA	20.5	20.6	20.8	21.1	21.9	17.8	17.2	15.6	15.7	15.5	15.5	21.9	18.5	11.3	11.0	10.8	10.8	10.9	11.1	10.9	10.5	10.5		10.5	11.1	10.8
W-23			●		Branch River	21.2	21.0		21.4		17.7					17.7	21.4	20.0		11.0		11.3							11.0	11.3	11.2
W-21		●			Singleton Street		20.4		21.0		18.1					18.1	21.0	19.8		11.0		11.1							11.0	11.1	11.1
W-22		●			Below Thundermist Dam		20.2		20.4		18.4					18.4	20.4	19.7		11.0		10.9							10.9	11.0	11.0
W-11			●		Mill River (MA/RI border)	20.8	20.5	20.6	20.6		18.9					18.9	20.6	20.2	12.4	11.9		11.8		11.8	11.6				11.6	11.9	11.8
W-12			●		Mill River (pre-culvert entry)	21.9	20.4	20.3	20.6		18.2					18.2	20.6	19.9	12.2	11.9		11.8		11.8	11.6				11.6	11.9	11.8
W-13			●		Mill River (confluence w/ BR)	21.6	20.3	20.5	20.7		18.5					18.5	20.7	20.0	12.3	11.9		11.6		11.7	11.3				11.3	11.9	11.6
W-14			●		Peters River (MA/RI border)	18.3	18.6	18.8	19.5		14.7					14.7	19.5	17.9	9.0	9.2		9.5		9.9	10.0				9.2	10.0	9.7
W-15			●		Peters River (pre-culvert entry)	20.6	19.7	20.2	20.0		14.7					14.7	20.2	18.7	9.2	9.5		9.5		9.9	9.9				9.5	9.9	9.7
W-16			●		Peters River (confluence w/ BR)	19.9	19.7	20.5	20.4							19.7	20.5	20.2													
W-17		●			Hamlet Avenue		20.3		20.5		18.3					18.3	20.5	19.7		11.2		11.2							11.2	11.2	11.2
W-24				●	Woonsocket WWTF																										
W-02	Reach 2	●			Manville Dam	21.0	20.3	20.9	20.8	20.7	18.2	18.1	16.4	16.4	16.0	16.0	20.9	18.6	11.7	11.4	11.3	11.3	11.2	11.2	11.2	10.6	10.7		10.6	11.4	11.1
W-03		●			George Washington Hwy Bridge	20.5	20.3	20.6	20.6	20.5	17.0	18.0	16.4	16.3	16.0	16.0	20.6	18.4	11.8	11.4	11.2	11.3	11.2	11.2	11.1	10.6	10.6		10.6	11.4	11.1
W-04	Reach 3	●			Lonsdale Ave	20.6	20.3	20.5	20.8	20.7	17.7	17.7	16.7	16.2	16.0	16.0	20.8	18.5	12.0	11.4	11.1	11.2	11.1	11.2	11.0	10.7	10.6		10.6	11.4	11.0
W-25		●			Broad Street		20.8		20.7		18.5					18.5	20.8	20.0		11.4		11.3							11.3	11.4	11.4
W-26			●		Abbott Run Brook		20.6		20.6		19.2					19.2	20.6	20.1		11.5		11.0							11.0	11.5	11.3
W-05		●			Slaters Mill Dam	20.9	20.4	20.7	20.8	20.7	18.6	17.6	17.1	16.5	16.0	16.0	20.8	18.7	11.8	11.4	11.2	11.3	11.3	11.2	11.2	10.8	10.8		10.8	11.4	11.2
W-31	1			●	Cherry Brook		19.9		20.4		15.4					15.4	20.4	18.6		9.0		9.3							9.0	9.3	9.2
W-32				●	Front Street Drain		18.1		19.1		14.3					14.3	19.1	17.2		10.5		10.6							10.5	10.6	10.6
W-33				●	Sylvestre Pond Outflow		21.0				15.7					15.7	21.0	18.4		11.2		10.9							10.9	11.2	11.1
W-34	2			●	Blackstone Canal at Lonsdale		19.6		20.5		17.5					17.5	20.5	19.2		10.6		10.5							10.5	10.6	10.6
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate																										
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate																										
W-42		(=W-14)			Duplicate																										
W-43	2 3	(=W-04)			Duplicate																										

Water Quality Criteria (Class B and B1): No criteria for receiving water, only for anthropogenic discharges.

Figure 111: Storms WW-01 and WW-02 – Specific Conductance (uS/cm)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm WW-01 (July 8 - 12, 2005)															Storm WW-02 (September 15, 2005)										
						8-Jul			9-Jul				10-Jul		11-Jul		12-Jul	Statistics (Runs 2-12)			14-Sep	15-Sep							Statistics (Runs 1-7)		
						8:30 - 10:15h	16:40 - 18:25h	21:00 - 23:15h	0:10 - 2:30h	6:20 - 7:50h	14:30 - 16:15h	20:30 - 22:40h	6:40 - 8:10h	15:15 - 16:30h	8:40 - 10:00h	14:50 -15:30h	8:40 - 10:00h				11:10 - 18:30h	10:35 - 11:10h	11:45 - 12:46h	13:35 -14:55h	15:00 - 15:50h	16:00-16:40h	16:50 - 17:35h	17:45 - 18:30h			
					Run No.	1	2	3	4	5	6	7	8	9	10	11	12	Minimum	Maximum	Mean	DW-11	1	2	3	4	5	6	7	Minimum	Maximum	Mean
W-01	Reach 1	●			Millville, MA	390	375	350	330	320	210	245	295	300	290		365	210	375	315											
W-23			●		Branch River		180	160										160	180	170											
W-21		●			Singleton Street		295	310										295	310	303											
W-22		●			Below Thundermist Dam		290	270										270	290	280											
W-11			●		Mill River (MA/RI border)	320	290	285	280			280						280	290	291	260	300	300	300	300	300	300	300	300	300	300
W-12			●		Mill River (pre-culvert entry)	325	240	255	270			275						240	275	273	280	140	190	280	280	290	290	280	190	290	250
W-13			●		Mill River (confluence w/ BR)	320	260	275	250			275						250	275	276	260	105	220	270	290	290	290	280	220	290	249
W-14			●		Peters River (MA/RI border)	320	295	200	215			245						200	295	255	350	30	405	180	110	110	155	210	110	405	171
W-15			●		Peters River (pre-culvert entry)	300	240	205	205			240						205	240	238	425	120	60	290	180	140	120	140	60	290	150
W-16			●		Peters River (confluence w/ BR)																420	130	160	200	225	130	120	160	120	225	161
W-17		●			Hamlet Avenue		290	280										280	290	285											
W-24				●	Woonsocket WWTF																										
W-02	Reach 2	●			Manville Dam	340	290	280	265	280	310	250	235	280	290		320	235	320	285											
W-03		●			George Washington Hwy Bridge	365	350	290	285	275	315	300	225	270	310	330	310	225	350	302											
W-04	Reach 3	●			Lonsdale Ave	350	370	305	280	290	310	300	220	265	315	335	335	220	370	306											
W-25		●			Broad Street	360	365	350										350	365	358											
W-26			●		Abbott Run Brook	190	190	180										180	190	187											
W-05		●			Slaters Mill Dam	230	345	340	340	285	290	310	250	255	310	315	460	250	460	311											
W-31	1			●	Cherry Brook		160	210										160	210	185											
W-32				●	Front Street Drain		41	120										41	120	81											
W-33				●	Sylvestre Pond Outflow		170	200										170	200	185											
W-34	2			●	Blackstone Canal at Lonsdale	420	420	360										360	420	400											
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate	340	290	280	265	280	310	250	235	280	290																
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate			285	280			280											300	300							
W-42		(=W-14)			Duplicate			200	215			245											410	180				210			
W-43	2 3	(=W-04)			Duplicate																										

Water Quality Criteria (Class B and B1): None.

Figure 112: Storms WW-03 and WW-04 - Specific Conductance (uS/cm)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	**Storm WW-03** (October 7 - 11, 2005)													**Storm WW-04** (October 22 - 25, 2005)												
						7-Oct	8-Oct				9-Oct		10-Oct		11-Oct	**Statistics** (Runs 2-11)			22-Oct		23-Oct					24-Oct		25-Oct	**Statistics** (Runs 2-10)		
						12:00 - 14:50h	3:40 - 8:50h	9:10 - 11:55h	16:55 - 19:30h	20:15 - 21:40h	9:30 -12:40h	15:00 - 16:45h	5:00 - 6:45h	12:00 - 13:30h	10:00 - 11:15h	**Minimum**	**Maximum**	**Mean**	11:25 - 14:00h	21:10 - 23:50h	0:30 - 2:10h	3:45 - 5:45h	9:15 - 11:10h	13:15 - 16:25h	19:00 - 20:50h	11:00 - 13:30h	14:00 - 15:40h	11:00h	**Minimum**	**Maximum**	**Mean**
					Run No.	1	2	3	5	6	7	8	9	10	11				1	2	3	4	5	6	7	8	9	10			
W-01	Reach 1	●			Millville, MA	460	485	485	490	455	295	190	230	260	305	190	490	355	220	210	210	208	200	200	190	188	190		188	210	200
W-23			●		Branch River	202	210		212		175					175	212	199		85		85							85	85	85
W-21		●			Singleton Street		460		470		375					375	470	435		190		165							165	190	178
W-22		●			Below Thundermist Dam		480		470		375					375	480	442		189		180							180	189	185
W-11			●		Mill River (MA/RI border)	270	310	303	310		300					300	310	306	180	190		195		185	190				185	195	190
W-12			●		Mill River (pre-culvert entry)	280	310	303	309		275					275	310	299	190	30		170		185	190				30	190	144
W-13			●		Mill River (confluence w/ BR)	282	300	305	300		295					295	305	300	190	10		165		190	185				10	190	138
W-14			●		Peters River (MA/RI border)	410	430	425	370		155					155	430	345	240	250		200		180	180				180	250	203
W-15			●		Peters River (pre-culvert entry)	410	360	360	380		160					160	380	315	240	215		200		185	180				180	215	195
W-16			●		Peters River (confluence w/ BR)	415	360	349	345							345	360	351													
W-17		●			Hamlet Avenue		451		465		365					365	465	427		180		170							170	180	175
W-24				●	Woonsocket WWTF																										
W-02	Reach 2	●			Manville Dam	440	455	490	475	450	345	350	195	225	270	195	490	362	200	190	190	180	170	180	180	170	165		165	190	178
W-03		●			George Washington Hwy Bridge	420	440	470	460	455	270	350	195	205	260	195	470	345	195	190	200	180	175	175	180	165	165		165	200	179
W-04	Reach 3	●			Lonsdale Ave	420	420	430	420	415	380	295	235	200	250	200	430	338	200	190	200	180	180	180	180	165	165		165	200	180
W-25		●			Broad Street		435		430		390					390	435	418		190		180							180	190	185
W-26			●		Abbott Run Brook		180		180		170					170	180	177		150		140							140	150	145
W-05		●			Slaters Mill Dam	420	420	430	420	415	380	295	235	200	250	200	430	338	200	190	200	180	190	180	175	165	165		165	200	181
W-31	1			●	Cherry Brook		211		258		290					211	290	253		175		150							150	175	163
W-32				●	Front Street Drain		271		205		330					205	330	269		170		150							150	170	160
W-33				●	Sylvestre Pond Outflow		245				125					125	245	185		210		100							100	210	155
W-34	2			●	Blackstone Canal at Lonsdale		450		450		405					405	450	435		200		190							190	200	195
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate																										
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate																										
W-42		(=W-14)			Duplicate																										
W-43	2 3	(=W-04)			Duplicate																										

No Run 4 for WW-03.

Water Quality Criteria (Class B and B1): None.

Figure 113: Storms WW-01 and WW-02 - pH

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm WW-01 (July 8 - 12, 2005)															Storm WW-02 (September 15, 2005)										
						8-Jul			9-Jul				10-Jul		11-Jul		12-Jul	Statistics (Runs 2-12)			14-Sep	15-Sep							Statistics (Runs 1-7)		
						8:30 - 10:15h	16:40 - 18:25h	21:00 - 23:15h	0:10 - 2:30h	6:20 - 7:50h	14:30 - 16:15h	20:30 - 22:40h	6:40 - 8:10h	15:15 - 16:30h	8:40 - 10:00h	14:50 - 15:30h	8:40 - 10:00h	Minimum	Maximum	Mean	11:10 - 18:30h	10:35 - 11:10h	11:45 - 12:46h	13:35 -14:55h	15:00 - 15:50h	16:00-16:40h	16:50 - 17:35h	17:45 - 18:30h	Minimum	Maximum	Mean
					Run No.	1	2	3	4	5	6	7	8	9	10	11	12				DW-11	1	2	3	4	5	6	7			
W-01	Reach 1	●			Millville, MA	6.3	6.6	6.7	6.7	6.7	6.9	6.4	6.8	6.7	6.8		6.7	6.4	6.9	6.7											
W-23			●		Branch River		6.7	6.9										6.7	6.9	6.8											
W-21		●			Singleton Street		6.7	6.8										6.7	6.8	6.7											
W-22		●			Below Thundermist Dam		6.7	6.8										6.7	6.8	6.7											
W-11			●		Mill River (MA/RI border)	6.6	6.7	6.9	6.8			6.9						6.7	6.9	6.8	7.4	6.4	6.8	6.9	7.0	6.8	7.0	6.9	6.4	7.0	6.8
W-12			●		Mill River (pre-culvert entry)	6.6	6.7	6.8	6.8			6.9						6.7	6.9	6.8	7.2	7.0	6.8	6.8	6.9	6.8	6.9	6.9	6.8	7.0	6.9
W-13			●		Mill River (confluence w/ BR)	6.6	6.7	6.8	6.8			6.9						6.7	6.9	6.8	7.2	7.0	6.6	6.9	6.9	6.9	6.9	6.9	6.6	7.0	6.9
W-14			●		Peters River (MA/RI border)	6.5	6.5	6.8	6.7			6.7						6.5	6.8	6.7	6.8	7.1	6.5	6.8	7.0	6.8	6.8	6.8	6.5	7.1	6.8
W-15			●		Peters River (pre-culvert entry)	6.5	6.6	6.7	6.6			6.8						6.6	6.8	6.7	6.8	7.0	6.9	6.7	6.8	6.7	6.8	6.8	6.7	7.0	6.8
W-16			●		Peters River (confluence w/ BR)																7.0	6.7	6.8	6.8	7.0	6.9	7.0	7.0	6.7	7.0	6.9
W-17		●			Hamlet Avenue		6.7	6.7										6.7	6.7	6.7											
W-24				●	Woonsocket WWTF					6.6			6.7					6.6	6.7	6.6											
W-02	Reach 2	●			Manville Dam	6.3	6.6	6.7	6.7	6.8	6.9	6.4	6.8	6.7	6.9		6.9	6.4	6.9	6.7											
W-03		●			George Washington Hwy Bridge	6.3	6.7	6.8	6.8	6.7	6.8	6.9	6.9	6.8	7.0	6.9	7.1	6.7	7.1	6.8											
W-04	Reach 3	●			Lonsdale Ave	6.3	6.7	6.8	6.7	6.8	6.8	6.8	6.9	6.9	7.0	7.0	7.0	6.7	7.0	6.9											
W-25		●			Broad Street	6.6	6.7	6.8										6.7	6.8	6.8											
W-26			●		Abbott Run Brook	6.6	6.7	6.8										6.7	6.8	6.8											
W-05		●			Slaters Mill Dam	6.5	6.6	6.8	6.7	6.8	6.8	6.9	6.9	6.9	7.0	7.0	7.1	6.6	7.1	6.9											
W-31	1			●	Cherry Brook		6.7	6.7										6.7	6.7	6.7											
W-32				●	Front Street Drain		6.9	6.8										6.8	6.9	6.8											
W-33				●	Sylvestre Pond Outflow		6.6	6.6										6.6	6.6	6.6											
W-34	2			●	Blackstone Canal at Lonsdale	6.6	6.7	6.8										6.7	6.8	6.7											
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate	6.3	6.6	6.8	6.7	6.8	6.8	6.7	6.8	6.8	6.9																
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate			6.9	6.8			6.9											6.8	6.6							
W-42		(=W-14)			Duplicate																		6.6	7.0				6.8			
W-43	2 3	(=W-04)			Duplicate																										

Water Quality Criteria (Class B and B1): pH of 6.5 to 9.0 or as naturally occurs.

Figure 114: Storms WW-03 and WW-04 – pH

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm WW-03 (October 7 - 11, 2005)													Storm WW-04 (October 22 - 25, 2005)												
						7-Oct	8-Oct				9-Oct		10-Oct		11-Oct	Statistics (Runs 2-11)			22-Oct		23-Oct					24-Oct		25-Oct	Statistics (Runs 2-10)		
						12:00 - 14:50h	3:40 - 8:50h	9:10 - 11:55h	16:55 - 19:30h	20:15 - 21:40h	9:30 -12:40h	15:00 - 16:45h	5:00 - 6:45h	12:00 - 13:30h	10:00 - 11:15h	Minimum	Maximum	Mean	11:25 - 14:00h	21:10 - 23:50h	0:30 - 2:10h	3:45 - 5-45h	9:15 - 11:10h	13:15 - 16:25h	19:00 - 20:50h	11:00 - 13:30h	14:00 - 15:40h	11:00h	Minimum	Maximum	Mean
					Run No.	1	2	3	5	6	7	8	9	10	11				1	2	3	4	5	6	7	8	9	10			
W-01	Reach 1	●			Millville, MA	6.6	5.8	6.8	6.6	6.7	7.0	6.8	6.9	6.6	6.7	5.8	7.0	6.7	6.3	6.5	6.5	6.5	6.5	6.5	6.4	6.7	6.6		6.4	6.7	6.5
W-23			●		Branch River	7.1	6.7		6.9		6.9					6.7	6.9	6.8		6.7		6.6							6.6	6.7	6.7
W-21		●			Singleton Street		6.6		6.8		6.7					6.6	6.8	6.7		6.5		6.5							6.5	6.5	6.5
W-22		●			Below Thundermist Dam		6.6		6.8		6.7					6.6	6.8	6.7		6.5		6.5							6.5	6.5	6.5
W-11			●		Mill River (MA/RI border)	7.0	6.9	6.9	6.9		7.0					6.9	7.0	6.9	6.5	6.6		6.6		6.6	6.5				6.5	6.6	6.6
W-12			●		Mill River (pre-culvert entry)	6.9	6.7	6.9	6.8		6.9					6.7	6.9	6.8	6.5	6.6		6.5		6.5	6.5				6.5	6.6	6.5
W-13			●		Mill River (confluence w/ BR)	6.9	6.7	6.9	6.8		6.9					6.7	6.9	6.8	6.5	6.5		6.5		6.5	6.4				6.4	6.5	6.5
W-14			●		Peters River (MA/RI border)	6.7	6.4	6.6	6.6		6.9					6.4	6.9	6.6	6.3	6.3		6.3		6.3	6.3				6.3	6.3	6.3
W-15			●		Peters River (pre-culvert entry)	6.9	6.6	6.6	6.7		6.8					6.6	6.8	6.7	6.4	6.3		6.3		6.3	6.4				6.3	6.4	6.3
W-16			●		Peters River (confluence w/ BR)	6.9	6.5	6.8	6.8							6.5	6.8	6.7													
W-17		●			Hamlet Avenue		6.6		6.8		6.7					6.6	6.8	6.7		6.5		6.4							6.4	6.5	6.5
W-24				●	Woonsocket WWTF		6.8									6.8	6.8	6.8								6.5		6.7	6.5	6.7	6.6
W-02	Reach 2	●			Manville Dam	6.7	6.4	6.8	6.8	6.6	6.9	6.8	6.8	6.7	6.7	6.4	6.9	6.7	6.5	6.5	6.5	6.6	6.5	6.5	6.5	6.7	6.6		6.5	6.7	6.5
W-03		●			George Washington Hwy Bridge	6.8	6.6	6.7	6.8	6.8	6.9	6.9	6.8	6.7	6.6	6.6	6.9	6.7	6.4	6.5	6.5	6.5	6.5	6.6	6.5	6.7	6.6		6.5	6.7	6.6
W-04	Reach 3	●			Lonsdale Ave	6.8	6.7	6.7	6.7	6.9	6.8	6.9	6.6	6.6	6.6	6.6	6.9	6.7	6.4	6.5	6.5	6.5	6.5	6.5	6.5	6.7	6.6		6.5	6.7	6.5
W-25		●			Broad Street		7.1		6.8		6.8					6.8	7.1	6.9		6.5		6.5							6.5	6.5	6.5
W-26			●		Abbott Run Brook		7.3		6.9		6.8					6.8	7.3	7.0		6.6		6.6							6.6	6.6	6.6
W-05		●			Slaters Mill Dam	6.8	6.6	6.7	6.7	6.9	6.8	6.9	6.6	6.6	6.6	6.6	6.9	6.7	6.4	6.5	6.5	6.5	6.5	6.6	6.5	6.7	6.6		6.5	6.7	6.5
W-31	1			●	Cherry Brook		7.1		6.7		6.8					6.7	7.1	6.9		6.6		6.5							6.5	6.6	6.5
W-32				●	Front Street Drain		6.9		6.7		6.8					6.7	6.9	6.8		6.5		6.5							6.5	6.5	6.5
W-33				●	Sylvestre Pond Outflow		6.9				7.0					6.9	7.0	7.0		6.5		6.4							6.4	6.5	6.4
W-34	2			●	Blackstone Canal at Lonsdale		6.8		6.5		6.8					6.5	6.8	6.7		6.5		6.4							6.4	6.5	6.5
W-35	3			●	Brook near Ann&Hope																										
W-02	1 2	(=W-02)			Duplicate																										
W-05	3	(=W-05)			Duplicate																										
W-01	1	(=W-01)			Duplicate																										
W-41		(=W-11)			Duplicate		6.9	6.9	6.5										6.6	6.6		6.5		6.4							
W-42		(=W-14)			Duplicate	6.7	6.7	6.6	6.4										6.4	6.4		6.3		6.3							
W-43	2 3	(=W-04)			Duplicate	6.9	6.8	6.6	6.4	6.9									6.6	6.5	6.6	6.5	6.5	6.5							

No Run 4 for WW-03.

Water Quality Criteria (Class B and B1): pH of 6.5 to 9.0 or as naturally occurs.

Figure 4-115: Wet Weather Mass Balance in Reach 1 for Chloride

Station	**Storm WW-01**			**Storm WW-03**			**Storm WW-04**			**Mean**
	EMC (mg/l)	**Flow** (cfs)	**% of Load**	**EMC** (mg/l)	**Flow** (cfs)	**% of Load**	**EMC** (mg/l)	**Flow** (cfs)	**% of Load**	**% of Load** (WW-01, 03, 04)
W-01	76.0	1,005	85.9%	34.0	866	70.2%	41.2	1,681	71.4%	75.9%
W-23	42.0	99.6	4.7%	20.8	68.0	3.4%	14.6	421.4	6.3%	4.8%
W-31	54.0	1.6	0.1%	53.8	1.3	0.2%	35.5	6.4	0.2%	0.2%
W-32	21.0	2.1	0.0%	39.3	1.7	0.2%	29.2	8.3	0.2%	0.2%
W-13	72.6	49.4	4.0%	41.5	70.9	7.0%	41.0	167.6	7.1%	6.0%
W-15	76.7	23.6	2.0%	55.6	33.9	4.5%	42.3	81.7	3.6%	3.4%
W-24	183.0	11.4	2.4%	114.0	17.7	4.8%	137.0	17.7	2.5%	3.2%
W-33	51.0	2.2	0.1%	34.6	1.6	0.1%	44.2	3.3	0.2%	0.1%
W-02	70.8	1,255		36.3	1,158		37.6	2,576		
Chloride Mass Accounted			99.4%			90.3%			91.6%	93.7%

EMC = Event Mean Concentration

Figure 4-116: Wet Weather Mass Balance in Reach 1 for Fecal Coliform

Station	**Storm WW-01**			**Storm WW-03**			**Storm WW-04**			**Mean**
	Concen-tration (MPN/100 ml)	**Flow** (cfs)	**% of Load**	**Concen-tration** (MPN/100 ml)	**Flow** (cfs)	**% of Load**	**Concen-tration** (MPN/100 ml)	**Flow** (cfs)	**% of Load**	**% of Load** (WW-01, 03, 04)
W-01	1,628	1,005	109.4%	1,512	866	141.5%	617	1,681	139.8%	130.2%
W-23	4,701	99.6	31.3%	732	68.0	5.4%	102	421.4	5.8%	14.2%
W-31	25,495	1.6	2.8%	4,609	1.3	0.7%	361	6.4	0.3%	1.3%
W-32	46,475	2.1	6.5%	7,714	1.7	1.4%	2,133	8.3	2.4%	3.4%
W-13	3,855	49.4	12.7%	2,328	70.9	17.8%	61	167.6	1.4%	10.7%
W-15	2,457	23.6	3.9%	5,734	33.9	21.0%	1,196	81.7	13.2%	12.7%
W-24	190	11.4	0.1%	20	17.7	0.0%	40	17.7	0.1%	0.1%
W-33	7,141	2.2	1.1%	4,195	1.6	0.7%	625	3.3	0.3%	0.7%
W-02	1,191	1,255		799	1,158		288	2,576		
FC Mass Accounted			167.8%			188.6%			163.2%	173.2%

Figure 4-117: Wet Weather Mass Balance in Reach 1 for Nitrate

Station	**Storm WW-01**			**Storm WW-03**			**Storm WW-04**			**Mean**
	EMC (mg/l)	**Flow** (cfs)	**% of Load**	**EMC** (mg/l)	**Flow** (cfs)	**% of Load**	**EMC** (mg/l)	**Flow** (cfs)	**% of Load**	**% of Load** (WW-01, 03, 04)
W-01	0.75	1,005	79.0%	0.96	866	67.7%	0.58	1,681	74.2%	73.6%
W-23	0.36	99.6	3.8%	0.30	68.0	1.7%	0.22	421.4	7.1%	4.2%
W-31	0.13	1.6	0.0%	0.38	1.3	0.0%	0.25	6.4	0.1%	0.1%
W-32	0.69	2.1	0.2%	2.63	1.7	0.4%	1.15	8.3	0.7%	0.4%
W-13	0.57	49.4	3.0%	0.30	70.9	1.7%	0.37	167.6	4.7%	3.1%
W-15	0.38	23.6	0.9%	0.53	33.9	1.5%	0.33	81.7	2.1%	1.5%
W-24	5.60	11.4	6.7%	6.90	17.7	9.9%	4.65	17.7	6.3%	7.6%
W-33	0.38	2.2	0.1%	0.40	1.6	0.1%	0.84	3.3	0.2%	0.1%
W-02	0.76	1,255		1.06	1,158		0.51	2,576		
Nitrate Mass Accounted			93.6%			83.0%			95.4%	90.7%

EMC = Event Mean Concentration

Figure 4-118: Wet Weather Mass Balance in Reach 1 for Ammonia

Station	**Storm WW-01**			**Storm WW-03**			**Storm WW-04**			**Mean**	
	EMC (mg/l)	**Flow** (cfs)	**% of Load**	**EMC** (mg/l)	**Flow** (cfs)	**% of Load**	**EMC** (mg/l)	**Flow** (cfs)	**% of Load**	**% of Load** (WW-01, 03, 04)	**% of Load** (WW-01, 04)
W-01	0.28	1005	80.0%	0.13	866	44.2%	0.31	1681	74.9%	66.4%	77.5%
W-23	0.32	99.6	9.1%	0.15	68.0	4.0%	0.18	421.4	10.9%	8.0%	10.0%
W-31	0.47	1.6	0.2%	0.14	1.3	0.1%	0.18	6.4	0.2%	0.2%	0.2%
W-32	0.21	2.1	0.1%	0.13	1.7	0.1%	0.20	8.3	0.2%	0.2%	0.2%
W-13	0.17	49.4	2.4%	0.10	70.9	2.8%	0.17	167.6	4.1%	3.1%	3.2%
W-15	0.53	23.6	3.6%	0.10	33.9	1.3%	0.10	81.7	1.2%	2.0%	2.4%
W-24	1.60	11.4	5.2%	0.66	17.7	4.6%	0.52	17.7	1.3%	3.7%	3.3%
W-33	0.29	2.2	0.2%	0.22	1.6	0.1%	0.16	3.3	0.1%	0.1%	0.1%
W-02	0.28	1255		0.22	1158		0.27	2576			
Ammonia Mass Accounted:			100.8%			57.2%			92.9%	83.6%	96.8%

EMC = Event Mean Concentration

Figure 4-119: Wet Weather Mass Balance in Reach 1 for Total Phosphorus

Station	**Storm WW-01**			**Storm WW-03**			**Storm WW-04**			**Mean**
	EMC (mg/l)	**Flow** (cfs)	**% of Load**	**EMC** (mg/l)	**Flow** (cfs)	**% of Load**	**EMC** (mg/l)	**Flow** (cfs)	**% of Load**	**% of Load** (WW-01, 03, 04)
W-01	0.22	1,005	83.8%	0.45	866	88.6%	0.21	1,681	80.6%	84.3%
W-23	0.06	99.6	2.3%	0.06	68.0	0.9%	0.15	421.4	14.4%	5.9%
W-31	0.18	1.6	0.1%	0.21	1.3	0.1%	0.28	6.4	0.4%	0.2%
W-32	0.14	2.1	0.1%	0.10	1.7	0.0%	0.13	8.3	0.2%	0.1%
W-13	0.07	49.4	1.3%	0.03	70.9	0.5%	0.13	167.6	5.0%	2.3%
W-15	0.09	23.6	0.8%	0.08	33.9	0.6%	0.12	81.7	2.2%	1.2%
W-24	1.54	11.4	6.7%	3.70	17.7	14.9%	1.24	17.7	5.0%	8.9%
W-33	0.20	2.2	0.2%	0.09	1.6	0.0%	0.11	3.3	0.1%	0.1%
W-02	0.21	1,255		0.38	1,158		0.17	2,576		
Total Phosphorus Mass Accounte			95.3%			105.6%			108.0%	103.0%

EMC = Event Mean Concentration

Figure 4-120: Wet Weather Mass Balance in Reach 1 for Dissolved Copper

Station	**Storm WW-01**			**Storm WW-03**			**Storm WW-04**			**Mean**
	EMC (ug/l)	**Flow** (cfs)	**% of Load**	**EMC** (ug/l)	**Flow** (cfs)	**% of Load**	**EMC** (ug/l)	**Flow** (cfs)	**% of Load**	**% of Load** (WW-03, 04)
W-01		1,005		7.76	866	100.1%	5.35	1,681	82.3%	91.2%
W-23		99.6		2.55	68.0	2.6%	5.45	421.4	21.0%	11.8%
W-31		1.6		4.46	1.3	0.1%	3.99	6.4	0.2%	0.2%
W-32		2.1		4.63	1.7	0.1%	3.36	8.3	0.3%	0.2%
W-13		49.4		2.28	70.9	2.4%	2.27	167.6	3.5%	2.9%
W-15		23.6		2.63	33.9	1.3%	2.57	81.7	1.9%	1.6%
W-24		11.4		12.00	17.7	3.2%	4.20	17.7	0.7%	1.9%
W-33		2.2		2.72	1.6	0.1%	1.96	3.3	0.1%	0.1%
W-02		1,255		5.80	1,158		4.24	2,576		
Copper Mass Accounted						109.8%			110.0%	109.9%

EMC = Event Mean Concentration

Figure 4-121: Wet Weather Mass Balance in Reach 1 for Dissolved Lead

Station	Storm WW-01			Storm WW-03			Storm WW-04			
	EMC (ug/l)	**Flow** (cfs)	**% of Load**	**EMC** (ug/l)	**Flow** (cfs)	**% of Load**	**EMC** (ug/l)	**Flow** (cfs)	**% of Load**	
W-01		1,005		0.70	866	84.4%		1,681		
W-23		99.6		0.41	68.0	3.9%		421.4		
W-31		1.6		0.96	1.3	0.2%		6.4		
W-32		2.1		0.84	1.7	0.2%		8.3		
W-13		49.4		0.61	70.9	6.0%		167.6		
W-15		23.6		0.27	33.9	1.3%		81.7		
W-24		11.4		0.15	17.7	0.4%		17.7		
W-33		2.2		1.15	1.6	0.2%		3.3		
W-02		1,255		0.62	1,158			2,576		
Lead Mass Accounted						96.6%				

EMC = Event Mean Concentration

Figure 4-122: Wet Weather Mass Balance in Reach 1 - Summary of Mean % Load

Station	Fecal Coliform	Chloride	Nitrate	Ammonia	Total Phos-phorus	Dissolved Copper	Dissolved Lead
Average Wet Weather Percent Load, relative to Station W-02							
W-01	129.9%	75.9%	73.6%	66.4%	84.3%	91.2%	84.4%
W-23	14.9%	4.8%	4.2%	8.0%	5.9%	11.8%	3.9%
W-31	1.3%	0.2%	0.1%	0.2%	0.2%	0.2%	0.2%
W-32	3.6%	0.2%	0.4%	0.2%	0.1%	0.2%	0.2%
W-13	10.8%	6.0%	3.1%	3.1%	2.3%	2.9%	6.0%
W-15	12.6%	3.4%	1.5%	2.0%	1.2%	1.6%	1.3%
W-24	0.1%	3.2%	7.6%	3.7%	8.9%	1.9%	0.4%
W-33	0.7%	0.1%	0.1%	0.1%	0.1%	0.1%	0.2%
Total Average Wet Weather Percent Accounted for in Reach 1 (W-01, W-23, W-13, W-15, W-24, W-31, W-32, W-33)							
W-02	173.9%	93.7%	90.7%	83.6%	103.0%	109.9%	96.6%

Figure 4-123: Wet Weather Mass Balance in Reach 2 for Chloride

Station	**Storm WW-01**			**Storm WW-03**			**Storm WW-04**		
	EMC (mg/l)	**Flow** (cfs)	**% of W-02**	**EMC** (mg/l)	**Flow** (cfs)	**% of W-02**	**EMC** (mg/l)	**Flow** (cfs)	**% of W-02**
W-02	71	1,255		36	1,158		38	2,576	
W-03	74	1,187	99%	33	1,120	89%	36	2,161	79%
W-34	104	2.2	0%	57	0.1	0%	44	0.4	0%
W-04	76	1,165	99%	34	1,108	90%	37	2,029	77%

EMC = Event Mean Concentration

Figure 4-124: Wet Weather Mass Balance in Reach 2 for Hardness

Station	**Storm WW-01**			**Storm WW-03**			**Storm WW-04**		
	EMC (mg/l)	**Flow** (cfs)	**% of W-02**	**EMC** (mg/l)	**Flow** (cfs)	**% of W-02**	**EMC** (mg/l)	**Flow** (cfs)	**% of W-02**
W-02	41	1,255		43	1,158		31	2,576	
W-03	45	1,187	104%	40	1,120	90%	31	2,161	84%
W-34	54	2.2	0%	65	0.1	0%	37	0.4	0%
W-04	46	1,165	104%	40	1,108	89%	33	2,029	84%

EMC = Event Mean Concentration

Figure 4-125: Wet Weather Mass Balance in Reach 2 for Fecal Coliform

Station	**Storm WW-01**			**Storm WW-03**			**Storm WW-04**		
	Concentration (MPN/ 100 ml)	**Flow** (cfs)	**% of W-02**	**Concentration** (MPN/ 100 ml)	**Flow** (cfs)	**% of W-02**	**Concentration** (MPN/ 100 ml)	**Flow** (cfs)	**% of W-02**
W-02	1,191	1,255		799	1,158		288	2,576	
W-03	830	1,187	66%	931	1,120	113%	217	2,161	63%
W-34	755	2.2	0%	1,602	0.1	0%	51	0.4	0%
W-04	734	1,165	57%	1,152	1,108	138%	322	2,029	88%

Figure 4-126: Wet Weather Mass Balance in Reach 2 for Total Suspended Solids

Station	**Storm WW-01**			**Storm WW-03**			**Storm WW-04**		
	EMC (mg/l)	**Flow** (cfs)	**% of W-02**	**EMC** (mg/l)	**Flow** (cfs)	**% of W-02**	**EMC** (mg/l)	**Flow** (cfs)	**% of W-02**
W-02	19.4	1,255		19.4	1,158		7.9	2,576	
W-03	17.7	1,187	86%	20.2	1,120	101%	7.4	2,161	78%
W-34	11.8	2.2	0%	8.1	0.1	0%	10.3	0.4	0%
W-04	18.1	1,165	87%	19.2	1,108	95%	7.5	2,029	75%

EMC = Event Mean Concentration

Figure 4-127: Wet Weather Mass Balance in Reach 2 for Nitrate

Station	**Storm WW-01**			**Storm WW-03**			**Storm WW-04**		
	EMC (mg/l)	**Flow** (cfs)	**% of W-02**	**EMC** (mg/l)	**Flow** (cfs)	**% of W-02**	**EMC** (mg/l)	**Flow** (cfs)	**% of W-02**
W-02	0.76	1,255		1.06	1,158		0.51	2,576	
W-03	0.85	1,187	106%	0.91	1,120	83%	0.52	2,161	86%
W-34	1.49	2.2	0%	2.42	0.1	0%	0.60	0.4	0%
W-04	0.88	1,165	107%	0.93	1,108	84%	0.52	2,029	80%

EMC = Event Mean Concentration

Figure 4-128: Wet Weather Mass Balance in Reach 2 for Ammonia

Station	**Storm WW-01**			**Storm WW-03**			**Storm WW-04**		
	EMC (mg/l)	**Flow** (cfs)	**% of W-02**	**EMC** (mg/l)	**Flow** (cfs)	**% of W-02**	**EMC** (mg/l)	**Flow** (cfs)	**% of W-02**
W-02	0.28	1,255		0.25	1,158		0.27	2,576	
W-03	0.24	1,187	81%	0.20	1,120	77%	0.25	2,161	78%
W-34	0.38	2.2	0%	0.22	0.1	0%	0.10	0.4	0%
W-04	0.20	1,165	66%	0.18	1,108	69%	0.15	2,029	44%

EMC = Event Mean Concentration

Figure 4-129: Wet Weather Mass Balance in Reach 2 for Total Phosphorus

Station	Storm WW-01			Storm WW-03			Storm WW-04		
	EMC (mg/l)	**Flow** (cfs)	**% of W-02**	**EMC** (mg/l)	**Flow** (cfs)	**% of W-02**	**EMC** (mg/l)	**Flow** (cfs)	**% of W-02**
W-02	0.21	1,255		0.38	1,158		0.17	2,576	
W-03	0.21	1,187	95%	0.39	1,120	99%	0.16	2,161	79%
W-34	0.13	2.2	0%	0.24	0.1	0%	0.13	0.4	0%
W-04	0.22	1,165	97%	0.41	1,108	103%	0.16	2,029	74%

EMC = Event Mean Concentration

Figure 4-130: Wet Weather Mass Balance in Reach 2 for Dissolved Copper

Station	Storm WW-01			Storm WW-03			Storm WW-04		
	EMC (ug/l)	**Flow** (cfs)	**% of W-02**	**EMC** (ug/l)	**Flow** (cfs)	**% of W-02**	**EMC** (ug/l)	**Flow** (cfs)	**% of W-02**
W-02		1,255		5.80	1,158		4.24	2,576	
W-03		1,187		5.76	1,120	96%	4.35	2,161	86%
W-34		2.2		4.51	0.1	0%	4.23	0.4	0%
W-04		1,165		5.77	1,108	95%	4.42	2,029	82%

EMC = Event Mean Concentration

Figure 4-131: Wet Weather Mass Balance in Reach 2 for Dissolved Lead

Station	Storm WW-01			Storm WW-03			Storm WW-04		
	EMC (ug/l)	**Flow** (cfs)	**% of W-02**	**EMC** (ug/l)	**Flow** (cfs)	**% of W-02**	**EMC** (ug/l)	**Flow** (cfs)	**% of W-02**
W-02		1,255		0.62	1,158			2,576	
W-03		1,187		0.51	1,120	80%		2,161	
W-34		2.2		0.30	0.1	0%		0.4	
W-04		1,165		0.49	1,108	76%		2,029	

EMC = Event Mean Concentration

Figure 4-132: Wet Weather Mass Balance in Reach 3 for Chloride

Station	Storm WW-01			Storm WW-03			Storm WW-04			Mean
	EMC (mg/l)	**Flow** (cfs)	**% of W-04**	**EMC** (mg/l)	**Flow** (cfs)	**% of W-04**	**EMC** (mg/l)	**Flow** (cfs)	**% of W-04**	**% of Load** (WW-01, 03, 04)
W-04	76	1,165		34	1,107		37	2,029		
W-26	48	38	2.1%	21	79	4.4%	23	77	2.4%	3.0%
W-05	75	1,191	101%	34	1,137	103%	38	2,075	105%	103%

EMC = Event Mean Concentration

Figure 4-133: Wet Weather Mass Balance in Reach 3 for Hardness

Station	Storm WW-01			Storm WW-03			Storm WW-04			Mean
	EMC (mg/l)	**Flow** (cfs)	**% of W-04**	**EMC** (mg/l)	**Flow** (cfs)	**% of W-04**	**EMC** (mg/l)	**Flow** (cfs)	**% of W-04**	**% of Load** (WW-01, 03, 04)
W-04	46	1,165		40	1,107		33	2,029		
W-26	36	38	2.6%	29	79	5.2%	35	77	4.0%	3.9%
W-05	47	1,191	104%	43	1,137	110%	32	2,075	99%	105%

EMC = Event Mean Concentration

Figure 4-134: Wet Weather Mass Balance in Reach 3 for Fecal Coliform

Station	Storm WW-01			Storm WW-03			Storm WW-04			Mean
	Concentration (MPN/100 ml)	**Flow** (cfs)	**% of W-04**	**Concentration** (MPN/100 ml)	**Flow** (cfs)	**% of W-04**	**Concentration** (MPN/100 ml)	**Flow** (cfs)	**% of W-04**	**% of Load** (WW-01, 03, 04)
W-04	734	1,165		1,152	1,107		322	2,029		
W-26	190	38	0.8%	48	79	0.3%	26	77	0.3%	0.5%
W-05	1,802	1,191	251%	1,586	1,137	141%	501	2,075	159%	184%

EMC = Event Mean Concentration

Figure 4-135: Wet Weather Mass Balance in Reach 3 for Total Suspended Solids

Station	Storm WW-01			Storm WW-03			Storm WW-04			Mean
	EMC (mg/l)	**Flow** (cfs)	**% of W-04**	**EMC** (mg/l)	**Flow** (cfs)	**% of W-04**	**EMC** (mg/l)	**Flow** (cfs)	**% of W-04**	**% of Load** (WW-01, 03, 04)
W-04	18	1,165		19	1,107		8	2,029		
W-26	2	38	0.3%	1	79	0.4%	2	77	0.9%	0.5%
W-05	17	1,191	98%	22	1,137	116%	7	2,075	98%	104%

EMC = Event Mean Concentration

Figure 4-136: Wet Weather Mass Balance in Reach 3 for Nitrate

Station	Storm WW-01			Storm WW-03			Storm WW-04			Mean
	EMC (mg/l)	**Flow** (cfs)	**% of W-04**	**EMC** (mg/l)	**Flow** (cfs)	**% of W-04**	**EMC** (mg/l)	**Flow** (cfs)	**% of W-04**	**% of Load** (WW-01, 03, 04)
W-04	0.88	1,165		0.93	1,107		0.52	2,029		
W-26	0.45	38	1.7%	0.11	79	0.8%	0.71	77	5.2%	2.6%
W-05	0.95	1,191	110%	1.00	1,137	110%	0.53	2,075	104%	108%

EMC = Event Mean Concentration

Figure 4-137: Wet Weather Mass Balance in Reach 3 for Ammonia

Station	Storm WW-01			Storm WW-03			Storm WW-04			Mean
	EMC (mg/l)	**Flow** (cfs)	**% of W-04**	**EMC** (mg/l)	**Flow** (cfs)	**% of W-04**	**EMC** (mg/l)	**Flow** (cfs)	**% of W-04**	**% of Load** (WW-01, 03, 04)
W-04	0.20	1,165		0.18	1,107		0.15	2,029		
W-26	0.83	38	13.6%	0.10	79	4.0%	0.15	77	3.8%	7.1%
W-05	0.21	1,191	107%	0.10	1,137	57%	0.20	2,075	136%	100%

EMC = Event Mean Concentration

Figure 4-138: Wet Weather Mass Balance in Reach 3 for Total Phosphorus

Station	Storm WW-01			Storm WW-03			Storm WW-04			Mean
	EMC (mg/l)	Flow (cfs)	% of W-04	EMC (mg/l)	Flow (cfs)	% of W-04	EMC (mg/l)	Flow (cfs)	% of W-04	% of Load (WW-01, 03, 04)
W-04	0.22	1,165		0.41	1,107		0.16	2,029		
W-26	0.09	38	1.3%	0.08	79	1.4%	0.10	77	2.4%	1.7%
W-05	0.20	1,191	93%	0.40	1,137	100%	0.16	2,075	102%	98%

EMC = Event Mean Concentration

Figure 4-139: Wet Weather Mass Balance in Reach 3 for Dissolved Copper

Station	Storm WW-01			Storm WW-03			Storm WW-04			Mean
	EMC (ug/l)	Flow (cfs)	% of W-04	EMC (ug/l)	Flow (cfs)	% of W-04	EMC (ug/l)	Flow (cfs)	% of W-04	% of Load (WW-03, 04)
W-04		1,165		5.77	1,107		4.42	2,029		
W-26		38		0.94	79	1.2%	0.95	77	0.8%	1.0%
W-05		1,191		5.23	1,137	93%	4.52	2,075	105%	99%

EMC = Event Mean Concentration

Figure 4-140: Wet Weather Mass Balance in Reach 3 for Dissolved Lead

Station	Storm WW-01			Storm WW-03			Storm WW-04			Mean
	EMC (ug/l)	Flow (cfs)	% of W-04	EMC (ug/l)	Flow (cfs)	% of W-04	EMC (ug/l)	Flow (cfs)	% of W-04	% of Load (WW-03)
W-04		1,165		0.49	1,107			2,029		
W-26		38		0.19	79	2.8%		77		2.8%
W-05		1,191		0.41	1,137	86%		2,075		86%

EMC = Event Mean Concentration

Figure 4-141: Wet Weather Mass Balance in Reach 3 - Summary of Mean % Load

Station	Fecal Coliform	Chloride	Hardness	Total Susp. Solids	Nitrate	Ammonia	Total Phos-phorus	Dissolved Copper	Dissolved Lead
Average Wet Weather Percent Load, relative to Station W-04									
W-26	0.3%	3.0%	3.9%	0.5%	2.6%	7.1%	1.7%	1.0%	2.8%
W-05	193%	103%	105%	104%	108%	100%	98%	99%	86%

Figure 4-142: Wet Weather Mass Balance for Mill and Peters Rivers for Chloride

Station	**Storm WW-01**			**Storm WW-02**			**Storm WW-03**			**Storm WW-04**			**Mean**
	EMC (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**%Change of Load** (WW-01, 02, 03, 04)
Mill River													
W-11	77	48.14			78.55		38	69.16		40	163.4		
W-12	71	48.91	-6%		79.81		36	70.26	-4%	41	166.0	4%	-1%
W-13	73	49.39	4%		80.59		42	70.95	18%	41	167.6	1%	6%
Change from W-11 to W-13			*-3%*						*13%*			*5%*	*5%*
Peters River													
W-14	70	22.98			36.96		27	32.96		45	79.53		
W-15	77	23.61	13%		37.97		26	33.87	-1%	42	81.71	-4%	2%
W-16		23.93			38.48		56	34.32	118%		82.82		118%

EMC = Event Mean Concentration

Figure 4-143: Wet Weather Mass Balance for Mill and Peters Rivers for Hardness

Station	**Storm WW-01**			**Storm WW-02**			**Storm WW-03**			**Storm WW-04**			**Mean**
	EMC (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**%Change of Load** (WW-01, 02, 03, 04)
Mill River													
W-11	38	48.14		41	78.55		37	69.16		26	163.4		
W-12	39	48.91	4%	38	79.81	-6%	39	70.26	7%	28	166.0	9%	4%
W-13	37	49.39	-4%	35	80.59	-7%	36	70.95	-7%	26	167.6	-6%	-6%
Change from W-11 to W-13			*0%*			*-12%*			*0%*			*3%*	*-3%*
Peters River													
W-14	41	22.98		25	36.96		34	32.96		43	79.53		
W-15	37	23.61	-7%	21	37.97	-14%	36	33.87	9%	42	81.71	0%	-3%
W-16		23.93		23	38.48	11%	56	34.32	58%		82.82		34%

EMC = Event Mean Concentration

Figure 4-144: Wet Weather Mass Balance for Mill and Peters Rivers for Fecal Coliform

Station	**Storm WW-01**			**Storm WW-02**			**Storm WW-03**			**Storm WW-04**			**Mean**
	Concentration (MPN/ 100 ml)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**Concentration** (MPN/ 100 ml)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**Concentration** (MPN/ 100 ml)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**Concentration** (MPN/ 100 ml)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**%Change of Load** (WW-01, 02, 03, 04)
Mill River													
W-11	307	48.14		76	78.55		243	69.16		38	163.4		
W-12	3,320	48.91	999%	4,956	79.81	6525%	1,260	70.26	426%	92	166.0	146%	2024%
W-13	3,855	49.39	17%	2,414	80.59	-51%	2,328	70.95	87%	61	167.6	-33%	5%
Change from W-11 to W-13			*1188%*			*3159%*			*881%*			*65%*	*1323%*
Peters River													
W-14	2,821	22.98		10,857	36.96		2,626	32.96		496	79.53		
W-15	2,457	23.61	-11%	3,852	37.97	-64%	5,734	33.87	124%	1,196	81.71	148%	49%
W-16		23.93		7,979	38.48	110%	3,302	34.32	-42%		82.82		34%

Figure 4-145: Wet Weather Mass Balance for Mill and Peters Rivers for Total Suspended Solids

Station	**Storm WW-01**			**Storm WW-02**			**Storm WW-03**			**Storm WW-04**			**Mean**
	EMC (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**%Change of Load** (WW-01, 02, 03, 04)
Mill River													
W-11	6.2	48.14			78.55		1.8	69.16		3.1	163.4		
W-12	11.8	48.91	94%		79.81		5.7	70.26	222%	14.6	166.0	377%	231%
W-13	8.5	49.39	-27%		80.59		2.8	70.95	-49%	6.6	167.6	-55%	-44%
Change from W-11 to W-13			*42%*						*64%*			*116%*	*74%*
Peters River													
W-14	7.5	22.98			36.96		8.5	32.96		3.7	79.53		
W-15	9.5	23.61	31%		37.97		11.6	33.87	39%	3.2	81.71	-11%	20%
W-16		23.93			38.48		6.6	34.32	-42%		82.82		-42%

EMC = Event Mean Concentration

Figure 4-146: Wet Weather Mass Balance for Mill and Peters Rivers for Nitrate

Station	Storm WW-01			Storm WW-02			Storm WW-03			Storm WW-04			Mean
	EMC (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**%Change of Load** (WW-01, 02, 03, 04)
Mill River													
W-11	0.54	48.14			78.55		0.29	69.16		0.37	163.4		
W-12	0.57	48.91	7%		79.81		0.27	70.26	-5%	0.39	166.0	7%	3%
W-13	0.57	49.39	1%		80.59		0.30	70.95	12%	0.37	167.6	-4%	3%
Change from W-11 to W-13			*8%*						*6%*			*3%*	*6%*
Peters River													
W-14	0.39	22.98			36.96		0.31	32.96		0.40	79.53		
W-15	0.38	23.61	0%		37.97		0.29	33.87	-4%	0.33	81.71	-15%	-6%
W-16		23.93			38.48		0.53	34.32	85%		82.82		85%

EMC = Event Mean Concentration

Figure 4-147: Wet Weather Mass Balance for Mill and Peters Rivers for Ammonia

Station	Storm WW-01			Storm WW-02			Storm WW-03			Storm WW-04			Mean
	EMC (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**%Change of Load** (WW-01, 02, 03, 04)
Mill River													
W-11	0.23	48.14			78.55		0.10	69.16		0.27	163.4		
W-12	0.19	48.91	-16%		79.81		0.10	70.26	2%	0.14	166.0	-47%	-21%
W-13	0.17	49.39	-10%		80.59		0.10	70.95	1%	0.17	167.6	23%	5%
Change from W-11 to W-13			*-24%*						*3%*			*-35%*	*-19%*
Peters River													
W-14	0.42	22.98			36.96		0.10	32.96		0.10	79.53		
W-15	0.53	23.61	30%		37.97		0.10	33.87	3%	0.10	81.71	3%	12%
W-16		23.93			38.48		0.10	34.32	1%		82.82		1%

EMC = Event Mean Concentration

Figure 4-148: Wet Weather Mass Balance for Mill and Peters Rivers for Total Phosphorus

Station	**Storm WW-01**			**Storm WW-02**			**Storm WW-03**			**Storm WW-04**			**Mean**
	EMC (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (mg/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**%Change of Load** (WW-01, 02, 03, 04)
Mill River													
W-11	0.08	48.14			78.55		0.03	69.16		0.10	163.4		
W-12	0.11	48.91	40%		79.81		0.11	70.26	273%	0.12	166.0	22%	111%
W-13	0.07	49.39	-36%		80.59		0.03	70.95	-72%	0.13	167.6	9%	-33%
Change from W-11 to W-13			*-10%*						*3%*			*33%*	*9%*
Peters River													
W-14	0.11	22.98			36.96		0.04	32.96		0.14	79.53		
W-15	0.09	23.61	-16%		37.97		0.10	33.87	157%	0.12	81.71	-12%	43%
W-16		23.93			38.48		0.08	34.32	-19%		82.82		-19%

EMC = Event Mean Concentration

Figure 4-149: Wet Weather Mass Balance for Mill and Peters Rivers for Dissolved Copper

Station	**Storm WW-01**			**Storm WW-02**			**Storm WW-03**			**Storm WW-04**			**Mean**
	EMC (ug/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (ug/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (ug/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (ug/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**%Change of Load** (WW-02, 03, 04)
Mill River													
W-11		48.14		1.41	78.55		1.50	69.16		2.57	163.4		
W-12		48.91		1.92	79.81	38%	1.77	70.26	20%	2.33	166.0	-8%	17%
W-13		49.39		2.06	80.59	8%	2.28	70.95	30%	2.27	167.6	-2%	12%
Change from W-11 to W-13						*50%*			*56%*			*-9%*	*32%*
Peters River													
W-14		22.98		3.05	36.96		2.23	32.96		2.58	79.53		
W-15		23.61		3.10	37.97	4%	2.73	33.87	26%	2.57	81.71	2%	11%
W-16		23.93		3.14	38.48	3%	2.63	34.32	-2%		82.82		0%

EMC = Event Mean Concentration

Figure 4-150: Wet Weather Mass Balance for Mill and Peters Rivers for Dissolved Lead

Station	Storm WW-01			Storm WW-02			Storm WW-03			Storm WW-04			Mean
	EMC (ug/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (ug/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (ug/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**EMC** (ug/l)	**Flow** (cfs)	**% Change in Load** (from previous Station)	**%Change of Load** (WW-02, 03, 04)
Mill River													
W-11		48.14		0.08	78.55		0.16	69.16		0.58	163.4		
W-12		48.91		0.30	79.81	281%	0.49	70.26	211%	0.36	166.0	-37%	152%
W-13		49.39		0.28	80.59	-6%	0.61	70.95	26%	0.54	167.6	51%	24%
Change from W-11 to W-13						*259%*			*291%*			*-4%*	*182%*
Peters River													
W-14		22.98		0.41	36.96		0.16	32.96			79.53		
W-15		23.61		0.34	37.97	-15%	0.15	33.87	-4%		81.71		-9%
W-16		23.93		0.50	38.48	49%	0.27	34.32	82%		82.82		66%

EMC = Event Mean Concentration

Figure 4-151: Wet Weather Mass Balance for Mill and Peters Rivers - Summary of %Change in Mean Load

Station		Fecal Coliform	Chloride	Hardness	Total Susp. Solids	Nitrate	Ammonia	Total Phos-phorus	Dissolved Copper	Dissolved Lead
from	***to***									
Mill River										
W-11	W-12	2345%	-1%	4%	231%	3%	-21%	111%	17%	152%
W-12	W-13	7%	6%	-6%	-44%	3%	5%	-33%	12%	24%
W-11	*W-13*	*1323%*	*5%*	*-3%*	*74%*	*6%*	*-19%*	*9%*	*32%*	*182%*
Peters River										
W-14	W-15	49%	2%	-3%	20%	-6%	12%	43%	11%	-9%
W-15	W-16	33%	118%	34%	-42%	85%	1%	-19%	0%	66%

5.0 POINT SOURCES

Runoff in the Rhode Island watershed enters the Blackstone River via large tributaries (Branch River, Miller River, Peters River, and Abbott Run Brook), as well as small tributaries, numerous outfalls, and other smaller point sources along the Blackstone River. A reconnaissance survey was conducted of these point sources to better understand their contribution to the contaminant loading in the Blackstone River. Recommendations were developed for specific point sources with actual or possible water quality concerns.

5.1 Methodology

Point sources were surveyed along the Blackstone River, Peters River, Mill River, and Valley Falls Pond. This investigation consisted of a compilation of existing information, field surveys, and reconnaissance sampling during dry and wet weather conditions.

5.1.1 Existing Information

Existing plans were reviewed from the Cities and Towns of North Smithfield, Woonsocket, Lincoln, Cumberland, Central Falls, and Pawtucket. In addition, the RIPDES Phase 2 Stormwater Management Plans for the respective communities were reviewed. As part of the Phase II RIPDES regulation, the Cities and Towns are required to identify stormwater sources entering waterbodies and streams. Available information collected by the Cities and Towns was incorporated.

Municipal and State offices were visited on October 5, 2005 (Lincoln) and July 27 and 29, 2004 (other communities) to obtain information on drainage entering the Blackstone River as follows:

Town/City/State Office	Name	Title (or Office)
North Smithfield	Michael Philips	Town Planner
Woonsocket	Michael Delrossi	City Engineer
	Scott Sanford	(Engineering Division)
Cumberland	Dennis Szwec	Public Works Engineering Aide
Lincoln	Kim Wiegand	Town Engineer
Central Falls	Joseph Nield	Public Works Director
Pawtucket	Ross Adrain	(Town Engineering Office)
RI Dept. of Transportation	Don Soares	(Plan Room)

Staff knowledgeable at the municipalities was asked about identifying and describing known drainage pipes/conduits that enter the river. The information sought included size of drainage area, dimensions of pipes/conduits, discharge volume, etc. Detailed storm drain information from the towns is included in Appendix C.

5.1.2 Field Survey

The characteristics of selected drainage areas were investigated in the field. The goal was to maximize existing information to increase the likelihood of finding significant contaminant sources. The survey focused on larger drainage areas, larger impervious areas, larger commercial and industrial areas, and highways and other larger roads with discharges to the river.

The survey was conducted as follows:

- **Blackstone River**

  - *Tupperware Dam to former hydropower plant at the MA/RI State line, including lower Branch River:* The survey was conducted from land for selected locations identified by the Town of North Smithfield, and by a site visit of the riverfront of the former Tupperware Mill.

  - *Hydropower plant to Saranac Dam:* Not surveyed in the field. This section is located in Blackstone, MA. Based on information from aerial photographs, discharges to the Blackstone River are expected to be minor along this stretch.

  - *Saranac Dam to Woonsocket WWTF:* This section was surveyed by canoe (July 30, 2004) and from land (various dates). The canoe was launched in the Town of Blackstone behind 'Thrifty Discount Liquors' on Main Street, approximately 200 m (650 feet) below the Saranac Dam. The river was flowing free until approximately 100 m (330 feet) upstream of the St. Paul Street bridge, which was the upstream end of the impoundment from the Thundermist Dam. The canoe was taken out of the water at the Thundermist Dam and relaunched at the River Island Park, located to the south of Bernon Street approximately 500 m (1,600 feet) downstream from Thundermist Dam. In addition, the area around the remnants of the Blackstone Canal were surveyed from land. The canal starts at the Saranac Dam. Water flowing through parts of the canal rejoins the Blackstone River approximately 200 m (650 feet) upstream from the Singleton Street bridge. The area between the Thundermist Dam and the River Island Park was also surveyed by land. The canoe survey largely confirmed the detailed survey conducted by the City of Woonsocket, although some additional drainage structures were identified (presumably pipes from private property). Water flow in the river during the canoe survey was 280 cfs, as measured at the Woonsocket USGS gage. The weather was sunny. There was only minor rainfall in Woonsocket during the seven days preceding the canoe survey on July 30, 2004 with 0.05 inches of rain on July 28 and 29 each, and 0.01 inches on July 26 (Table A-4 in Appendix A).

  - *Woonsocket WWTF to Lonsdale Bleachery: This* stretch was investigated from land, using the plans and information of the City of Woonsocket, and the Towns of Cumberland and Lincoln. The survey consisted largely of the investigation of individual point sources, as appropriate, based on their identification from maps, discussions, and other sources.

  - *Lonsdale Bleachery to Valley Falls Dam:* Survey by boat and land.

  - *Valley Falls Dam to Slater Mill Dam:* Not surveyed, as the contaminant loading from surface water runoff in the area will be largely mitigated through the ongoing CSO abatement plan.

- **Mill River and Peters River:** Walk alongside river banks up to the MA/RI State line. The shore was accessible in most areas. In addition, survey information from the City of Woonsocket was incorporated.

The following information was recorded from relevant discharge points, as appropriate:

- Location of point sources on aerial photographs.
- Description of point sources (pipe, culvert, trench, brook, etc.) and surroundings

- Construction material of point sources.
- Dimensions.
- Flow at the time of survey, if any.
- Lat/Long were determined from the RIGIS system rather than by GIS in the field, as many point sources were underneath trees, not allowing a satellite connection. Therefore, the positions are considered approximate.
- Other observations (trash, algae, odor, color of flow, etc.).

The surveyed point sources are marked on RIGIS aerial photographs for the entire project area (Figures 5-1 to 5-13). Observations at each point source are listed in Figure 5-14. This mapping includes the following additional information:

- Water quality monitoring stations for wet and dry weather ('W-__').
- Stormwater drainage system information from the City of Woonsocket in the vicinity of the surveyed rivers.

Attached in Appendix C is additional storm drain information, consisting of the following:

- Large aerial photograph will the complete storm line information mapped by the City of Woonsocket. The original storm line maps from the City are included on the enclosed CD.
- Map with a rough estimate of drainage boundaries for main municipal outfall pipes as provided by the Town of Cumberland. It is noted that these outlines are only a rough guide for further investigations of potential sources, and therefore do not accurately identify the drainage boundaries. However, they may assist in understanding the results of the reconnaissance sampling, and were therefore presented.
- Maps with locations of the NBC CSOs in the Cities of Pawtucket and Central Falls.

5.1.3 Reconnaissance Sampling

Reconnaissance sampling was conducted in the fall of 2005 at selected discharge points. Specifically, dry weather sampling occurred on October 6 (Event OUTFALL-01a), October 7 (OUTFALL-01b), November 14 (OUTFALL-03), and November 29 (OUTFALL-04). Each event was preceded by at least 3 days of no rainfall (Table A-5 in Appendix A). Samples were collected from the more significant point sources with flow, including brooks in developed areas. Samples were analyzed for fecal coliform, hardness, and dissolved lead and copper. In addition, the pH, temperature, DO, turbidity, and specific conductance were measured. Flows were measured with a flow meter or graduated bucket, or were estimated.

Reconnaissance wet weather surveys were conducted at the larger discharge point sources on October 8, 2005 (Event OUTFALL-02) and November 30, 2005 (OUTFALL-05). Selection criteria were access, size of drainage area, and existence of potential sources of contamination. Samples were analyzed for the same parameters as the dry weather samples. Observations were made that included color of the water, odor, and trash surrounding point sources, as appropriate. Flow was measured or estimated, as feasible. Information was recorded about the storm characteristics including intensity, duration, and antecedent dry period to allow for appropriate interpretation of the sampling results. The goal of the sampling was not to quantify the load from the specific point sources, but to further narrow the field in the identification of the more significant stormwater runoff sources.

The total rainfall on October 8, 2005 (Event OUTFALL-02) was 0.91 inches at a station in Cumberland. Rain started falling at 1:00h and continued falling slowly during the entire day. Samples were collected between 13:47h and 19:15h. The total amount of rainfall recorded in Cumberland by the end of the sampling period was approximately 0.6 inches.

The total rainfall on November 30, 2005 (Event OUTFALL-05) was 1.13 inches at a station in Cumberland. Rain started falling around 4:00h, peaked at 5:00h, decreased until about 10:00h, and then intensified again for approximately 2 hours. It gradually decreased in intensity until it stopped at 18:00h. One third of the rain had fallen by the beginning of the sampling period (6:38h). Approximately 80% of the rain for the day had fallen by the end of the sampling period (12:40h).

Several stations were visited multiple times to check for dry weather flow and to collect samples under different weather conditions.

In the data tables, fecal coliform and metals data are reported to the reporting limit (RL). Values below (and above for fecal coliform) are flagged as <[RL] (and >[RL]).

5.2 Description of Point Sources

This section summarizes available information and observations. Point sources are sorted by community, and from stations upstream to downstream. Included also is a discussion of point sources sampled during dry weather and wet conditions, as applicable. Data are summarized in Figure 5-14 and mapped in Figures 5-1 to 5-13. This description includes flow information. Water quality data are discussed in Section 5.3.

5.2.1 Town of North Smithfield

The largest point source to the Blackstone River in Rhode Island is the Branch River. The hydrology and the potential contaminant transport are affected strongly by large impoundments in the lower reaches of the river, specifically the Slatersville Pond and Slatersville Reservoirs. The distance between the lower Slatersville Reservoir dam and the confluence of the Branch River with the Blackstone River is only approximately 4 km (2.5 miles). Located within this stretch is another small impoundment (Forestdale Pond). The largest tributary to the Branch River, downstream of the Slatersville Reservoir is Dawley Brook, draining into the Forestdale Pond.

The number of stormwater outfalls in the Town of North Smithfield is small (Town of North Smithfield, 2003). Specifically, outfalls identified along the Branch River downstream of the Forestdale Pond consist of the following:

- **OF-101** (Atlantic Thermoplastics Manufacturing, formerly owned by Tupperware; RIPDES permit No. RI0000566): The facility is located at the bridge of Route 146A crossing the Branch River. The permit includes discharges for fecal coliform.

- **OF-102** (Outfall from St. Paul Street): This outfall drains a small residential/commercial area and wooded areas. The outfall was not investigated in the field.

Other potential discharges along the river below the Forestdale Dam include the following:

- Drainage from Route 146 (North Smithfield Expressway) crossing the Branch River.
- Drainage from Route 146A, crossing the Branch River.

Point sources identified downstream of the confluence between the Blackstone River and the Branch River consist of the following:

- **OF-105** (Blackstone-Smithfield Corporation, the former Tupperware Mill; RIPDES permit No. RI0000485): The permit allows for discharges of total phosphorus and fecal coliform from a small treatment plant. Monthly NPDES monitoring data from 2000 to 2004 show a pH range of 6.0 to 7.6, and TSS concentrations of typically less than 1 mg/l. Until March 2002, fecal coliform concentrations consistently were reported as 1,600 col/100 ml, which was likely the upper detection limit. Thereafter, fecal coliform concentrations were less than 2 col/100 ml, with the exception of a few events with concentrations reported as 1,600 col/100 ml. The sudden decrease in fecal coliform concentrations in March 2002 was likely the result of better treatment such as chlorination of the effluent, thereby effectively removing the outfall as a pathogen source to the Blackstone River on most days. The average flow of the effluent from the facility between 2000 and 2004 was 2,880 gallons per day.

- **OF-103 and OF-104:** Pipes located in the northeastern corner of the town near the intersection of St. Paul Street and Mendon Road. These outfalls appear to drain largely residential developments. The outfalls were not investigated in the field.

- **OF-106** (section of former Blackstone Canal): The site was investigated on July 22, 2004. Flow in the inlet originates approximately 10 m upstream of the Saranac Dam, where the water flows through a pipe on the right side of the Blackstone River into a section of the former Blackstone Canal. At Mill Street, the water flows from the canal through a culvert underneath Canal Street toward the inlet. The area along the western bank of the inlet is occupied by the BF Transfer Station and an auto salvage yard. The area along the eastern bank is largely occupied by sport facilities. The southern portion of the inlet was surveyed by canoe on July 30, 2004. A high berm surrounds the salvage yard, reducing the potential of direct stormwater runoff. No pipes were observed entering the inlet from the salvage yard. The section of the inlet adjacent to the BF Transfer Station was not surveyed. Water appears to flow through the inlet at all times.

Pond along Canal Street: The pond to the west of Canal Street, across from the salvage yard, receives drainage from a residential and wooded area. There do not appear to be industrial facilities in the drainage areas of the watershed. It is not known, however, if there are discharges from the abutting BF Transfer Station and auto salvage yard on the other side of Canal Street. Also, at this time, the location of the outflow of the pond is not known. Water may flow out at its northern end, and from there toward the inlet (OF-106).

5.2.2 Town of Blackstone (MA)

Information along this stretch of the river was only obtained from observations during the canoe survey and from selected land observations.

- **OF-601:** Fox Brook, draining a large primarily suburban residential and wooded area. The brook appears to flow at all times.

- **OF-602:** Approximately 10 to 15 small pipes, extending from a red building. The diameter of the pipes range from 3 to 6 inches. The pipes were dry, and there were no indications if they have dry weather or wet weather discharges. The large number of pipes from the building suggests that the building is, or has been, used for industrial or commercial purposes.

- **OF-603:** Two 6-inch pipes draining either the residential area upstream of the pipes and/or possibly the drugstore property on the north side of Main Street. The drainage area appears to be small. It is not known if these pipes are active.

- **OF-604 to OF-606:** Cluster of three pipes with a diameter of 24 inches (OF-604) and 14 inches (OF-605 and OF-606). OF-606 had dry weather flow of approximately 0.1 cfs on July 30, 2004. On October 7, 2005, all three pipes were dry. OF-604 may drain Castle Hill Way; the other two pipes may drain the parking lot of the commercial area to the east.

5.2.3 City of Woonsocket

5.2.3.1 Blackstone River Mainstem

The City of Woonsocket is a densely populated area. Approximately 95% of the city is connected to the sewer system. A few streets and a "couple of hundred houses" are still on a septic system, however (Scott Sanford, City of Woonsocket, July 29, 2004, personal communication). The City maintains a list of these houses. There are no CSOs in the city. However there are a few combined sewer and stormwater manholes. Pipes in these manholes are open. The sewer line typically runs 0.9 to 1.2 m (3 to 4 feet) below the stormwater line. Sewage could only enter the stormwater line if it backs up inside the manhole.

The City recently prepared plans of the stormwater system (referred to below as 'storm line plans') that were kindly provided to us (City of Woonsocket, 2004). The plans are in GIS format, which allowed for the determination of the drainage areas of the larger pipes and brooks. The locations of the stormwater pipes were imported into Figures 5-5 to 5-7, as well as onto the larger aerial (Figure C-1 in Appendix C). The original plans are presented in CD Folder 2.

Most of the pipes and other drainage structures that are mapped by the City of Woonsocket were observed during the field survey. Some of the structures identified by the City were not located and were likely hidden in the vegetation along the Blackstone River. During the field survey, a few additional pipes or other structures were observed that may be private and were therefore not mapped by the City.

- **OF-201:** Open channel with a width of approximately 1.2 m (4 feet). Large barren rocks in the channel indicated that there was heavy flow during rain storms. The channel appears to drain primarily a wetland and a residential area in Woonsocket. Some of the drainage may come from the commercial area on Main Street in the Town of Blackstone (that may drain to OF-604 to OF-606 instead, however). There was dry weather flow of 0.14 cfs on July 30, 2004, but no flow on October 7, 2005.

- **OF-202:** Concrete pipe with small drainage area of industrial facilities including the yard of the Public Works Department. The pipe is mostly submerged at the entry point to the river and therefore not easily accessible. There are several industrial buildings located along the adjacent River Street.

- **OF-203:** Outfall from the Singleton Street Pumping Station (not surveyed).

- **OF-204:** Drain entering the Blackstone River adjacent to an auto salvage yard. Another business is located upgradient from the salvage yard on the western side of River Street. The remaining drainage area appears to be residential. The drain is submerged during higher flow rates in the river (e.g., during the survey on November 14, 2005).

- **OF-205:** Intermittent brook, flowing alongside Cold Spring Park. A 24-inch diameter pipe and a 12-inch diameter pipe drain into the brook further upgradient. The pipes carry runoff from Winter Street, Highland Street, and parts of Harris Avenue. The brook had no dry weather flow on July 30, 2005, but flowed on November 14, 2005 at a rate of 0.05 cfs.

- **OF-206:** This pipe, identified on the City's storm line plans as an 18-inch diameter corrugated metal pipe, appears to be the pipe located in the corner of the beige industrial facility on River Street. The pipe was observed as plugged during the July 30, 2004 survey. Also, the storm line plans show an open ditch upgradient of the discharge point. This ditch, however, is not visible on a 1999 aerial photograph. The ditch may have been filled and the plans have not yet been updated. OF-206 may have been superfluous since it appeared to have drained the same area as OF-204.

- **OF-207:** PVC pipe extending from a wall of a beige industrial building, 3 m of the ground. It is not known if this pipe is active. However, the stained wall and the absent vegetation underneath the pipe suggested that there was recent flow. The pipe is not shown on the City's storm line plans.

- **OF-208:** Pipe underneath a yellow building with a tall vertical 'tower". The drainage area of this pipe is small but it drains solely an industrial/commercial area. The storm line plans show an 18-inch pipe; the pipe measured in the field had a diameter of 20 inches.

- **OF-209:** Pipe underneath the east side of River Street bridge, draining a mid-size, primarily industrial/commercial area.

- **OF-210 and OF-211:** Two pipes 6 m (20 feet) apart, draining an oil loading facility. The upstream pipe (PVC, blue; OF-210) had been flowing prior to the survey as it was still wet, although the dense vegetation in front of the pipe suggested that the flow through this pipe was minor. There was foamy material in front of the pipe. The second pipe (OF-211) appeared to have no or only minor flow during rain. These pipes were not shown on the City's storm line plans.

- **OF-212:** Old flow structure as part of the former mill adjacent to the river. It has a brick headwall and a defunct control gate. The debris within the gate suggested that there had not been any flow through this structure for a while.

- **OF-213:** Drainage pipe that used to drain a wetland, according to the storm line plans. The wetland shown on the City's storm line plans is not present on the 1999 aerial photograph, suggesting that is was filled and paved over. The drainage area is residential and industrial/commercial.

- **OF-214:** Large outfall pipe that drains a large residential area. It flows underneath a commercial building near its confluence with the Blackstone River.

- **OF-215:** Grated square opening with concrete headwall. It appears to be a former intake structure. The area is surrounded by a fence that extends into the river. There appeared to be no flow. The site is located approximately 15 m (50 feet) downstream of OF-214.

- **OF-216:** Pipe underneath Fairmont Street bridge, draining a comparatively small residential area.

- **OF-217:** Pipe with small drainage area. It may be draining the parking lot of the old mill.

- **OF-218:** Drainage pipe of a comparatively small residential area and Costa Park. The pipe shown on the storm line plans seems to be extended to the edge of the river.

- **OF-219** (also **W-31):** Cherry Brook. The brook has a large drainage area in Woonsocket and in North Smithfield. The brook was investigated also as part of the dry and wet weather sampling program (Sections 3 and 4). There are several industrial facilities adjacent to the brook, such as the Fairmont Foundry which was observed to have questionable housekeeping practices during our site visit.

- **OF-220:** Open ditch next to the railroad bridge. It appears to have a small drainage area. It is shown on the storm line plans, but was not located in the field.

- **OF-221:** Discharge from Water Street. It is shown on the City's storm line plans, but was not located in the field.

- **OF-222:** Overflow from parking lot. No dry weather flow was observed. The absence of vegetation indicated that there could be considerable flow at times. The overflow is not shown on the storm line plans.

- **OF-223:** Discharge from Northeast Street. It is shown on the storm line plans, but was not located in the field. The drainage area appears to be small.

- **OF-224:** Discharge from Northeast Street. It is shown on the storm line plans, but was not located in the field. The drainage area appears to be small, consisting of roadway runoff.

- **OF-225:** Large (42-inch diameter) pipe with an apparently small drainage area. The reason for the large pipe diameter is unclear. There was no dry weather flow on July 30, 2004 or November 14, 2005.

- **OF-226:** Pipe draining River Street. The drainage area appears to be small. There was no dry weather flow on July 30, 2004 or November 14, 2005.

- **OF-227:** Small metal pipe extending out of a green building, located on River Street just to the north of the Sayles Street bridge. Absent vegetation below the pipe suggested that the pipe had flow at times. There was no dry weather flow on July 30, 2004 or November 14, 2005.

- **OF-228:** Pipe draining River Street. The drainage area appears to be small.

- **OF-229:** Another pipe draining River Street. The drainage area appears to be small.

- **OF-230:** This small culvert is located high up on the wall in the southwestern corner of the South Main Street bridge. There was no flow on October 7, 2005 (dry weather). The flow rate at 8:15h during the wet weather survey on November 30, 2005 was 0.3 cfs. The site is difficult to access for sample collection.

- **OF-231** (also **W-32;** Front Street Drain): Large pipe with large drainage area. The pipe carries a brook and has dry weather flow. The drainage area is largely residential and commercial. The outfall was investigated also as part of the dry and wet weather sampling program (Sections 3 and 4).

- **OF-232:** Unknown pipe located just below Thundermist Dam. This pipe is also identified on the City's storm line plans.

- **OF-233:** Pipe draining a larger area containing primarily residences.

- **OF-234:** Culvert draining a comparatively small residential area.

- **OF-235:** Drainage of the former mill area that now houses the Museum of Work and Culture and the Market Square commercial area. The pipe is set back from the river by approximately 20 m (65 feet). The channel to the river may also receive sheet runoff from the River Island Park. The park has a lot of waterfowl (geese, ducks) which could result in elevated pathogen concentrations during rain storms.

- **OF-236:** Pipe high up on the embankment, not shown on the City's storm line plans. There was no dry weather flow on July 30, 2004 or November 14, 2005.

- **OF-237:** Pipe draining part of the Bernon Street neighborhood to the south of the river.

- **OF-238:** Pipe draining a small area adjacent to the Bernon Street bridge.

- **OF-239:** Pipe draining a commercial area along the southwestern end of Truman Drive and Allen Street. There was no dry weather flow on November 14, 2005.

- **OF-240:** Pipes in red old mill building on the left side of the river. The pipes enter the river approximately 20 to 30 m (65 to 100 feet) apart. These pipes appear to be inactive (e.g., one of the pipes had a fragile bird egg in it, indicating that it had not been flowing for a while).

- **OF-241:** Pipes coming out of an old mill building opposite from OF-240. Most pipes are rusty suggesting they are not active. However, one small pipe with a 3-inch diameter square cross-section may have flow at times as the wall underneath the pipe was stained.

- **OF-242:** Pipe under the bridge of Court Street entering a small channel, approximately 20 m (65 feet) from river's edge. There was dry weather flow of 0.01 cfs on November 14, 2005. The drainage area appears to be mainly Truman Drive.

- **OF-243:** Large concrete pipe between the bridges of Court Street and the railroad track. The drainage area appears to be Main Street.

- **OF-244:** Pipe located approximately 20 m (65 feet) downstream of the old railroad bridge. The drainage area appears to be Truman Drive and part of Clinton Street.

- **OF-245:** Not investigated in the field.

- **OF-246:** Not investigated in the field.

- **OF-247:** Pipe with broken sluice gate located approximately 20 m (65 feet) upstream of the Mill River confluence.

- **OF-248 (= W-13):** Mouth of Mill River. The site was investigated also as part of the dry and wet weather sampling program (Sections 3 and 4).

- **OF-249:** Outflow of pumping station. Not investigated in the field.

- **OF-250 (=W-16):** Mouth of Peters River. The site was investigated also as part of the dry and wet weather sampling program (Sections 3 and 4).

- **OF-251:** Pipe with small drainage area.

- **OF-252:** Large pipe not shown on storm line plans. The base of the pipe was only 5 inches (15 cm) above the water elevation of the river on July 30, 2004.

- **OF-253:** Pipe with small drainage area.

- **OF-254:** Pipe with small drainage area.

- **OF-255:** Pipe draining part of Cass Avenue (residential/commercial).

- **OF-256:** Pipe with small drainage area.

- **OF-257:** Pipe with small drainage area.

- **OF-258:** Large pipe draining a large industrial area. The sluice gate in front of the pipe is broken. The pipe was partially submerged at higher flows.

- **OF-259:** Pipe draining the intersection between Cumberland Hill Road and Hamlet Avenue.

- **OF-260:** Pipe draining part of Cumberland Hill Road.

- **OF-261:** Pumping station. Not investigated in the field.

- **OF-262** (also **W-33**)**:** Brook draining Sylvestre Pond as well as Cass Pond further upstream. This drainage system receives stormwater runoff from surrounding residential neighborhoods. The brook was investigated also as part of the dry and wet weather sampling program (Sections 3 and 4).

- **OF-263:** This large pipe discharges approximately 20 m (65 feet) from the Blackstone River. The outfall drains a largely residential area to the northwest of Manville Road. There was dry weather flow of approximately 0.15 cfs on October 7, 2005.

- **OF-264:** Pipe with broken headwall. The end of the pipe was submerged; therefore, it was not possible to determine if there was dry weather flow on July 30, 2004.

- **OF-265** (also **W-24**): Outfall of Woonsocket wastewater treatment plant. The outfall discharges below the water surface of the river. The WWTF is RIPDES-permitted (RI0100111). The site was investigated as part of the dry and wet weather sampling program (Sections 3 and 4).

There are additional point sources to the Blackstone River to the south of the WWTF. These pipes drain into the buffer zone in the Blackstone River valley. Discharges from the western side of the Blackstone River are residential. Discharges from the eastern side of the river are largely commercial. The commercial area includes a large auto salvage yard on Columbus Street; stormwater drains from the yard into the river valley as non-point source runoff.

- **OF-266:** Large (48-inch diameter) outfall to the south of the CVS Distribution Center in the Industrial Park. The outfall drains stormwater from much of the Industrial Park, as well as Cumberland Hill Road and upgradient areas. The pipe discharges to the Blackstone River via a channel. On November 14, 2005, the outfall had dry weather flow of approximately 0.5 cfs.

5.2.3.2 Mill River

The point source survey was conducted by walking along the exposed part of Mill River in Rhode Island between the dam of Harris Pond (i.e., "Saucy Falls") and Privilege Street, and Privilege Street halfway toward East School Street. In addition, the vicinity of East School Street was spot-checked. Much of the river is surrounded by stone berms for flood control. Therefore, the likelihood of pipes in the unsurveyed sections of river is considered to be small. There is a salvage yard to the south of Privilege Street immediately to the west of Peters River; runoff from the yard appears to enter the river via non-point source runoff, as pipes or other drainage structures were not located.

- **OF-701:** Gully at the entrance to the Menard Field (i.e., baseball field). The gully may drain seepage from the dam, or runoff from industrial/commercial facilities to the west of the river. There was very low dry weather flow of 0.03 cfs on November 29, 2005.

- **OF-702:** Two pipes discharge stormwater underneath Mill Street bridge.

- **OF-703:** Pipe entering Mill River below a small dam. The pipe appears to carry stormwater runoff from the vicinity of Privilege Street and Roland Street which appears to be largely residential. This pipe was not surveyed.

- **OF-704:** Large pipe discharging to a ditch that empties into Mill River just to the north of East School Street. The pipe was dry, but flows during heavy rain. The pipe drains the western part of East School Street, and part of Pond Street. The drainage area contains residential and industrial facilities.

5.2.3.3 Peters River

The point source survey was conducted by walking along the exposed part of Peters River in Rhode Island between Elm Street and Havelock Street. Both shorelines were visible with the exception of a stretch just downstream of the Wood Avenue bridge. The section between Havelock Street and the MA/RI State line was also spot-checked (i.e., point sources south of Salisbury Street, Diamond Hill Road bridge). The likelihood of sources in the unsurveyed section of the river is considered to be small.

- **OF-801:** Pipe changing to an open trench extending from St. Louis Avenue to the river. The drainage area is small, consisting of residences.

- **OF-802:** Pipe draining the eastern section of Diamond Hill Road. The flow includes an open brook that originates in a wetland to the east of Linden Road. The dry weather flow on November 29, 2005 was approximately 1.5 cfs. According to the storm line plans, there is a brook that drains the wetland which could explain the dry weather flow.

- **OF-803:** Four 12-inch pipes underneath Diamond Hill Road bridge. These pipes discharge roadway runoff from this street via curb inlets.

- **OF-804:** Outfall in a concrete headwall. It was 1/3 submerged in Peters River and appeared dry (or had only very low dry weather flow). The outfall drains part of East Hill Road, Salisbury Street and surrounding residential neighborhoods.

- **OF-805**: Surface drainage structure for stormwater from Havelock Street.

- **OF-806:** Pipe entering Peters River on the southeastern side of the bridge. The outfall drains the southern part of Wood Street.

- **OF-807:** Pipe entering Peters River on the northeastern side of the bridge. The outfall drains the northern part of Wood Street.

- **OF-808:** Several 4-inch pipes in the retaining wall for a residential building. The pipes were dry and appeared to drain groundwater from behind the wall.

- **OF-809:** White PVC pipe expending from a 10 m (30 foot) tall wall made of concrete blocks. The pipe was approximately 2 m (7 feet) below the top of the wall. Staining of the wall indicated that this pipe was active. The source of the discharge is not known. The site is not very accessible.

- **OF-810:** Drain from lawn of River Haven Condominiums.

- **OF-811:** Approximately 5 to 8 pipes (4 inches in diameter) in the basement wall of old (residential?) buildings. These buildings are located directly alongside Peters River where the river changes from a westerly flow direction to a southerly direction. Staining of the wall underneath some of the pipes suggested that there was occasional flow, but for the most part the pipes appeared to be inactive. Possibly, they are pipes for the discharge of groundwater behind the wall.

- **OF-812:** Pipe behind a concrete wall, 2 m (7 feet) above Peters River. Staining of the wall underneath the pipe indicated that it was active.

- **OF-813:** Drain from River Haven Condominiums. It was not clear what part of the complex was being drained by this pipe.

- **OF-814:** Five 4-inch diameter pipes in the retaining wall. The pipes were dry and appeared to drain groundwater from behind the wall.

- **OF-815:** Large ribbed PVC pipe (24 inches in diameter) extending from the River Haven Condominiums. It appeared to be a storm drain, but there was dry weather flow of approximately 0.1 cfs. At the point of discharge there was white foam in Peters River, suggesting that the discharge from the pipe may have included domestic wastewater containing detergents. Just upstream of the location is an artificial wetland that collects stormwater from some of the parking areas of the new condominium development. The overflow of this wetland appears to drain, however, directly into Peters River via overland runoff, and therefore does not appear to be connected to OF-815. This wetland had a small oil sheen in it on November 29, 2005.

- **OF-816:** Pipe draining the eastern part of Mill Street according to the storm line plans. This pipe was not surveyed.

- **OF-817:** Four 12-inch diameter metals pipes underneath the Mill Road bridge draining roadway runoff via curb inlets from this street.

- **OF-818:** Pipe approximately 20 m (65 feet) to the south of the Mill Road Bridge. The pipe is positioned in a concrete wall, 0.5 m (1.5 feet) above Peters River. A small 2-inch diameter pipe was located 1.5 m (5 feet) diagonally above the large pipe. Both pipes were dry. The sources for potential discharge are not known. It is also not known if the pipes are active.

- **OF-819:** Clay pipe along the slope to Peters River. The pipe is located approximately 20 m (65 feet) to the east of the river. It appears inactive.

5.2.4 Town of Cumberland

The Town has prepared a Stormwater Monitoring Project Plan (Town of Cumberland, 2005). However, as of October 2005, the Town did not yet have drainage plans available. Therefore, outfalls were kindly identified on a town map by Mr. Dennis Szwec in July 2004, along with very rough estimates of drainage area boundaries (Figure C-2 in Appendix C). Drains with larger drainage areas were field-verified.

Route 99: Records of the drainage system from this State Highway were not located at the RIDOT office. The stormwater drainage system of the eastern side highway bridge across the Blackstone River was not investigated in the field.

- **OF-350**: Outfall at the end of Grand Avenue or Sherman Avenue draining into a small brook. The outfall was not investigated in the field.

- **OF-351**: Outfall draining into a quarry. The outfall is supposedly located at the corner of Corn Street and Rubin Avenue. The outfall was not investigated in the field.

- **OF-352**: Outfall to quarry. The outfall is supposedly located at the corner of Plant Street and Stoney View Drive. The outfall was not investigated in the field.

- **OF-336:** Pipe underneath the Manville Hill Road bridge. This pipe either drains the Manville Hill Road and/or the parking lot of the Riverside Village apartment complex, or it is a remnant pipe from former industrial facilities that were located on the property of the present apartment complex. The staining of the wall below the pipe indicates that this pipe is active at times.

- **OF-334** (Unnamed brook near Manville Dam): This brook is located approximately 0.3 km (0.2 miles) downstream of the Manville Dam. It enters the Blackstone River near the Old Albion Road. The brook had dry weather flow of approximately 2 cfs on October 7, 2005. A sample was collected just upstream of the Herrick & White Ltd, carpentry works. There was a clay pipe (12-inch diameter) at the sampling location discharging from the supporting wall adjacent to the brook, approximately 1.5 m (5 feet) above the brook. The pipe presumably appears to originate on the “Riverside Village” property. The pipe did not have flow during the dry weather surveys on October 7 and November 29, 2005, or during the wet weather survey on October 8, 2005.

- **OF-354**: Drain entering a wooded area at the end of Plantation Drive. This drain was not investigated in the field.

- **OF-333** (Sneech Brook): The brook crosses Albion Road. It flows through a wetland area located approximately 20 m (65 feet) upstream. The dry weather flow in the brook was approximately 0.5 to 1 cfs on October 5, 2005. The brook originates in Sneech Pond and flows through predominantly residential areas.

- **OF-353** (Interstate Route 295): The drainage plan for the area (RIDOT, 1963) shows an outfall discharging near the Blackstone River. It is located adjacent to the new bike path. The outfall collects drainage from the east side of Route 295 for northbound and southbound lanes and at least part of its ramps of Exit 10, as well as from Mendon Road. The distance of the outfall from the river is approximately 30 m (100 feet). The outfall had dry weather flow of approximately 1 cfs on November 14, 2005.

- **OF-326** (George Washington Highway [Route 116]): Pipe exiting at the northern side of the eastern bridge pier, draining the northeastern side of the highway.

- **OF-327** (George Washington Highway [Route 116]): Pipe exiting at the southern side of the eastern bridge pier, draining the southeastern side of the highway.

- **OF-330** (at former Ashton Mill): The pipe exits from a stone wall in front of this former mill. It was located approximately 1 m (3 feet) above the water surface of the (low-flowing) Blackstone River on October 6, 2005. It did not have dry weather flow. It also did not have wet weather flow on October 8, 2005. In the more recent past, Ashton Mill had been used by Owens Corning as a fiberglass mill.

- **OF-331** (at former Ashton Mill): The pipe is adjacent to OF-330, approximately 2.5 m (8 feet) above the water surface of the Blackstone River at low flow conditions. The pipe was welded shut. Two other pipes were observed between OF-331 and OF-325 where the end points were filled with concrete, presumably as part of the ongoing conversion of Ashton Mill into apartments.

- **OF-325** (at former Ashton Mill): This concrete culvert is located at the southern end of the former Ashton Mill building. The culvert appears to be the conduit for Scott Brook. Scott Brook enters the subsurface just to the east of the intersection between Mendon Road and Scott Road. There was no dry weather flow at OF-325 on October 6, 2005, indicating that the brook carries water only intermittently. As part of the ongoing conversion of Ashton Mills into apartments, the drainage system of the property appears to have been updated. New manholes were constructed in the vicinity of OF-325. Pipes that may have formerly discharged into the Blackstone River (OF-330, OF-331, and others) were disconnected. Stormwater runoff from the site may now be discharged entirely into OF-325 approximately 10 m (33 feet) upgradient prior to the exit point of the culvert adjacent to the river (this assumption was not verified with construction plans for the redeveloped site).

- **OF-324**: The pipe is located to the north of the Durham School Bus Service parking lot, along the John C Dean Memorial Boulevard. The end of the pipe is badly corroded. The pipe appears to extend toward the industrial facilities along Ashton Park Way, located between Mendon Road and the rail line. One of these buildings is occupied by Swissline (a metals finishing company). Another building, a former Owens Corning manufacturing plant, is used for activities such as storage and car repair. OF-324 had dry weather flow of 0.05 cfs on October 6, 2005. There was also an odor at the location (septic?). On October 7, 2005 (dry weather conditions as well), there was just a trickle of water exiting the pipe. On November 14, 2005, the dry weather flow was 0.3 cfs. This pipe may extend further to Mendon Road.

- **OF-304** (Okonite outfall): The outfall is located approximately 5 m (16 feet) from the north side of the former Martin Street Bridge. It appears to the NPDES-permitted outfall from the Okonite facility. The dry weather flows observed on October 5/6/7 and November 14/30, 2005 ranged from approximately 0.4 to 1 cfs. It only increased to 1.3 cfs during wet weather. There was no odor. The discharged water was clear. The discharge point was estimated to be approximately 0.9 to 1.2 m (3 to 4 feet) above the water surface of the (low-flowing) Blackstone River, approximately 10 m (33 feet) from the river's edge. The end of the pipe was corroded and surrounded by vegetation. The pipe had continuous flow. It is not known if this pipe also receives stormwater from Martin Street; the comparatively small diameter of the pipe suggests that it does not. It is not likely that the pipe receives effluent from CCL Custom Manufacturing, located to the East of the Okonite plant. CCL does bottling of aerosols and other liquids (David Newton, EPA, personal communication, October 19, 2005). CCL does not have NPDES-permitted discharges. Stormwater from the CCL plant appears to enter the channel of an intermittent brook that runs along the northern and western perimeter of the CCL facility. The brook crosses over to the western side of the rail line and extends to Martin Street where it enters a pipe in the subsurface. It is not known where this brook discharges to the river; David Newton (USEPA) stated that it may discharge through a pipe located just to the south of the Martin Street bridge, apparently only visible during very low elevations in the Blackstone River. This pipe was not observed during our survey; maybe the river's water elevation was not low enough.

- **OF-305:** This 12-inch diameter clay pipe is located immediately to the south of Martin Street Bridge. It had no dry weather flow, and may not be active.

- **OF-323**: The pipe appears active, although did not have dry weather flow on October 6, 2005. It is located only approximately 0.15 m (0.5 feet) above the water surface of the Blackstone River at low flow rates. The pipe is submerged during higher flow rates such as during the wet weather survey on November 30, 2005. The pipe is located beyond the berm along the Blackstone River to the south of Hope Global's headquarter on 50 Martin Street. Hope Global develops, markets, and manufactures engineered textile components for commercial and industrial customers, according to their website. The pipe supposedly connects up to Mendon Road; Hope Global supposedly does not have industrial discharges and is connected to the sewer system (David Newton, EPA, personal communication, October 18, 2005). It is possible that this pipe also receives stormwater runoff from the former mill building on southern side of Martin Street, across from the CCL facility. This former mill building houses a mix of smaller commercial and industrial operations.

Peterson Puritan Site: The Peterson and Puritan site is located in an industrial area adjacent to the Blackstone River in Cumberland and Lincoln between the Martin Street bridge and Pratt Dam (Figure 5-15). The site includes several areas: Peterson/Puritan, Pacific Chemical (Lonza and Universal Chemical), and JM Landfill. During operation, Peterson and Puritan packaged and distributed a variety of aerosol products including perfumes, oven cleaners, pesticides, hairspray, deodorants, and window cleaners. Pacific Chemical manufactured general industrial chemicals and specialty chemical materials for use in detergents, cosmetics, agriculture, and food. The site contains volatile organic compounds, organics, and metals. Samples from the groundwater and the on-site ponds within "Operable Unit 2", consisting of the J.M. Landfill and the Unnamed Island, have been analyzed for lead and copper (e.g., BBL, 2003; 2006). Only some of these data consist of dissolved concentrations; most of the data consist of total concentrations. Some of the older groundwater and pond samples contained elevated lead and copper concentrations (Susan Chapnick, personal communication, Quality Assurance Officer, New Environmental Horizons, Inc., May 30, 2006). However, lead and copper concentrations in both groundwater and surface water were low in more recent samples. It appears that there were quality control problems associated with the older samples, and some of the detection limits were higher than the regulatory limits for water quality in the river. All data for the site are currently being synthesized. The site characterization report is expected to be issued in 2007. The report will also consider rates of groundwater flow and frequency of flooding of the on-site ponds by the Blackstone River. Flooding in essence has the effect of eliminating any elevated concentrations from potentially contaminated groundwater that seeps into the pond. The completed data synthesis will allow for a better understanding of the site as a potential source of dissolved lead and copper to the river.

Former Lonsdale Arena: This site was an auto racetrack up to the mid 1950s. As part of the construction of the bike path, soil was removed. The soil contained high lead content. Some of the lead-contaminated soil remained, as its removal would have compromised the structural integrity of a wall along the Pratt Dam. In addition, lead concentrations in the soil of the abutting Nunes Parcel have yet to be investigated (David Newton, personal communication, October 19, 2005). This parcel is located between the Stop&Shop parking lot, the Peterson Puritan site, and the bike path to the south of Pratt Dam. It is not known if the groundwater in the area is/was a potential source to the Blackstone River.

- **OF-321** (channel): The new bike path crosses over the channel that extends to the impoundment to the northwest of the Stop&Shop parking lot. The impoundment receives stormwater runoff from the northern part of the Stop&Shop parking lot. The channel underneath the bike path was vegetated, suggesting that the channel flows only infrequently. During the wet weather survey on November 30, the flow rate in the channel was 0.3 cfs at 12:55h.

- **OF-320**: Pipe crossing the new bike path, capturing non-point source runoff from the vegetated area between the bike path and the Stop&Shop parking lot. The distance to the parking lot is approximately 200 m (650 feet). It is unlikely that there is flow through this pipe, except during very large storms. This is partly due to the stormwater infiltration area along the southern edge of the Stop&Shop parking lot (OF-322). This area consists of a cobble infiltration zone and a vegetated swale thereafter. It is anticipated that stormwater runoff from most rainstorms is absorbed by this system.

- **OF-319**: Pipe located 5 m (16 feet) from the northwest corner of the Mendon Street bridge. There was no dry weather flow. There was a small puddle in front of the pipe with an oil sheen. The pipe appears to drain the adjacent portion of Mendon Road and Ann and Hope Way.

- **OF-303**: The brook drains neighborhoods on Monastery Heights in the Town of Cumberland. It discharges into the wetland to the northeast of the Peterson Puritan site. There was no dry weather flow in the brook on October 5, 2005, indicating that it only flows intermittently. The brook drains a largely forested area.

- **OF-302**: The outfall is located near the intersection of Marshall Avenue and Mendon Road, near the Panda Restaurant. It is draining into the southeastern part of the wetland to the northeast of the Peterson Puritan site. There was low dry weather flow of 0.014 cfs, 0.014 cfs, 0.003 cfs on October 5, 6, and 7, respectively. A more detailed water quality study for this outfall was conducted by the Center of Environmental Studies at Brown University (Brown University, 2003). This study included an assessment of the watershed for the outfall (Figure 5-16).

- **OF-301:** Channel draining the wetland to the northeast of the Peterson Puritan site on the other side of the rail line. There is very limited development surrounding this wetland. It is not known if there is an abundant bird population in the wetland, which could act as a source of pathogens. Judging by the size of the channel, outflow from the wetland via the channel appears to be rare. This wetland receives runoff from a brook (OF-303) and from the outfall near the intersection of Marshall Avenue and Mendon Road, beyond the parking lot of the Panda Restaurant (OF-302), as described above. Runoff from the wetland flows into a channel along the northern side of the rail line. On the eastern side of Mendon Road, the channel crosses to the southern side of the track. From there, it extends toward Ann and Hope Way. It enters a 36-inch diameter corrugated metal pipe at location OF-301, which extends underneath Ann and Hope Way and the "Blackstone Auto Body and Sales" facility to the Blackstone River. The outfall location directly at the river was not surveyed. It does not appear to be very exposed, as it was not readily observed during an initial boat survey along the river on July 14, 2004. The channel at site OF-301 was dry on October 5, 2005. There was wet weather flow of 4 cfs on November 30, 2005.

Section between Mendon Road and OF-318: The river section between Mendon Road and OF-318 contains the outflow of OF-301 and may contain a few additional pipes from the small businesses to the south of Ann and Hope Way. The shoreline is overgrown, but pipes should be investigated in the field from the river during the fall after the leaves have fallen.

- **OF-318**: Pipe located on the southern side of the railroad track that extends parallel to the Ann&Hope parking lot. The exit point of the pipe is contained within an approximately 1.8 m (6 foot) high rock structure. There was not dry weather flow on July 14, 2004 or October 6, 2005. Wet weather flow was observed on October 8 and November 30, 2005. The pipe appears to discharge water from the parking lot, and may in the past also have discharged water from the mill building.

- **OF-317** (also **W-35** (Brook near Ann&Hope): Culvert, located on the southern side of the railroad tracks, to the south of the eastern end of the Ann&Hope parking lot. The culvert is build from large rocks, and is 1.2 m (4 feet) wide and 2.4 m (8 feet) high. It appears to drain a small brook. There was dry weather flow during all site visits. For example, approximately 0.25 cfs was recorded on October 6, 2005, and 0.7 cfs on November 14, 2005. A small pool has formed in front of the culvert opening. The pool contained some garbage and an abandoned shopping cart. The color of the water was gray-blue-green, and may have contained detergents or septic matter. The water had a slight odor. The drainage area supposedly includes the area around Meadowcrest Drive. The wet weather flow observed on November 30, 2005 was 6 cfs. The site was investigated also as part of the dry and wet weather sampling program (Sections 3 and 4).

- **OF-316**: Outfall at the end of River Street which has a manhole in the small lawn between the end of the street and the Blackstone River valley (a distance of approximately 7 m [20 feet]). The end of the pipe could not be located along the slope to the river valley, as it was covered by a considerable amount of dumped materials at this location. A small channel is cut into the slope of the valley and into the valley floor until it reaches the river. There was no dry weather flow, but flow was observed during wet weather. Adjacent to this channel there was a 2-inch white PVC pipe that extended from the valley slope toward the river along the valley floor. The end point of this pipe was cracked. It is not known if this pipe is still active.

Area between drainage area of OF-316 and OF-314: The area to the west of Valley Falls has largely non-point source runoff directly to the Blackstone River. The area contains a large auto salvage yard that backs up against the Valley Falls Marsh. The area further contains some commercial buildings, including industrial and commercial operations in former mill buildings on Silva Street. The nature of these operations was not investigated.

According to Mr. Szwec (Town of Cumberland), there may be an outfall at the western end of Jones Street carrying stormwater from the central part of Broad Street. However, Jones Street is at a higher elevation than Broad Street. Beyond the western end of Jones Street there is a steep slope toward the Blackstone River valley, therefore a pipe extending from Broad Street to the valley would only have enough of a gradient if it were installed at a sufficient depth. However, a pipe could not be located on the slope. It is possible that the pipe is buried, as a considerable amount of dumping has occurred at this location. If there was stormwater flow from a buried pipe, at least a channel in the soil should be visible extending to the river. Such a channel was not observed, suggesting that this location does not receive significant stormwater runoff.

- **OF-314**: Pipe underneath Broad Street bridge in the Town of Cumberland. The lower 2 inches in the pipe were submerged in the Blackstone River; therefore it was not possible to tell if there was dry weather flow. The pipe discharges stormwater from the southern part of Broad Street.

- **OF-313**: The pipe is located on the bottom of the bypass channel of the Valley Falls Dam in the northeast corner of the Broad Street bridge across the Blackstone River. It exits the wall at the northern side of the channel and connects to the Valley Falls impoundment upstream of the dam. It is not known if the pipe is still active, or if it was used as an intake pipe or water discharge pipe.

- **OF-311:** This outfall flows into Abbott Run Brook. It is located approximately 10 m (33 feet) from the southwestern corner of the Mill Street bridge, discharging to Abbott Run Brook. It is located downstream of the Happy Hollow Pond. The outfall supposedly receives much of the drainage from High Street. There was dry weather flow of approximately 0.5 cfs and 0.3 cfs on October 6 and October 7, 2005, respectively. There was a light brown precipitate at the end point of the outfall and on the rocks downgradient from it (iron-oxide?).

- **OF-312:** This pipe also flows into Abbott Run Brook. It is located on the slope opposite from OF-311, approximately 5 m (16 feet) from the southeastern corner of the Mill Street bridge.

5.2.5 Town of Lincoln

The stormwater outfall and other source information from the Town of Lincoln is separated into four sections along the river as a result of the different sources of information that were available. These sections are Woonsocket to Albion, Albion to Lonsdale Bleachery, Lonsdale Bleachery, and Lonsdale Bleachery to Central Falls. Outfalls were Stormwater outfalls entering Scott Pond to the south of the Bleachery are discussed in Section 8.4.3.2.

5.2.5.1 Woonsocket to Albion

- **OF-441** (Crookfall Brook): This brook is located along the border between the City of Woonsocket and the Town of Lincoln. It drains a reservoir and largely wooded lands. It is not expected to be a major source for contaminants to the Blackstone River. The flow on November 29, 2005 was approximately 25 cfs.

- **OF-440** (Route 99): State Highway Route 99 crosses the Blackstone River approximately 0.2 km (0.15 miles) from the border with the City of Woonsocket. Records of the drainage system from this highway were not located at the RIDOT office. It appears that the discharge exits the pipe underneath the bridge, between the railroad track and Railroad Street in Manville. However, a more detailed survey of the stormwater drainage system of the western side of the highway bridge across the Blackstone River was not conducted. OF-440 probably also receives runoff from Railroad Street, although the expected volume of this street alone would not justify the large diameter of OF-440. There was no dry weather flow on November 29, 2005. There was also no wet weather flow at 9:05h on November 30, 2005, which may have been the result of a low rainfall rate at the time of the site visit.

Between June 22 and 25, 2004, the Town of Lincoln conducted a survey of outfall pipes along the Blackstone River along the stretch of the river from the border with Woonsocket to the Albion Road bridge in the Village of Albion, as part of the Lincoln Stormwater Management Plan study. Outfall numbers used by the town are listed in brackets (i.e., *BLA#W)*. Pertinent survey information, kindly made available by the Town, was included below. Observations made during our reconnaissance survey were added.

- **OF-438** *(BLA01W*): The outfall appears to drain a small residential neighborhood. A 24-inch diameter corrugated metal pipe discharges into a very small open channel approximately 75 m (245 feet) upstream from outfall OF-438. The discharged water flows through the channel toward the riprap-lined slope to the west of the railroad track. The water then enters a catch basin and passes underneath the railroad track though a 24-inch diameter concrete pipe (OF-438). It appears that in the past the runoff descended the slope approximately 100 m (330 feet) further to the north; the associated natural stone culvert under the railroad track is now inactive, however.

- **OF-437** (*BLA02W):* Two-foot diameter outfall across from Vose Street. The pipe was wet during the Town's survey. There was dry weather flow of 0.1 cfs during our survey on November 29, 2005.

- **OF-436** *(BLA03W):* Black coiled PVC (15-inch diameter) that drains into a remnant of the Blackstone Canal and from there to the river. The distance to the river was approximately 15 m (50 feet). The end of the pipe was approximately 1.2 m (4 feet) above the water elevation of the river in the Town's survey. The pipe drains the upgradient side of the railroad tracks only, and is not connected to the streets in Manville.

- **OF-435** *(BLA04W):* Granite block culvert across from Winter Street on the upgradient side of the railroad track. The culvert extends underneath Railroad Street and drains Winter Street and its vicinity in Manville. The Town survey shows this outfall across from Summer Street, although this may be the exit point immediately adjacent to the river after crossing the railroad service road (not investigated during our survey). There are several pipes that enter the culvert upgradient. There was a moldy smell inside the culvert. The distance to the Blackstone River is approximately 6 m (20 feet). The block culvert has the dimensions of 0.6 x 0.6 m (2 x 2 feet).

- **OF-447** *(BLA05W):* Located adjacent to Railroad Street across from Spring Street. The outfall crosses the railroad track, then extends parallel to the track adjacent to the service road (first as a pipe than as an open channel). Thereafter, runoff enters an 18-inch diameter ribbed PVC pipe in the vicinity of OF-448, crossing the service road and discharging approximately 1.8 m (6 feet) diagonally above OF-448 on the retaining wall. The pipe did not have dry weather flow during any of the visits. The pipe was only observed once during (modest) wet weather conditions (October 8, 2005); there was also no flow.

- **OF-448** *(BLA06W):* Pipe with a diameter of 21 or 24 inches, draining into the Blackstone River below the Manville Dam. On the land side of the railroad tracks, there is an open culvert that is accessible for sampling. The pipe discharges to the Blackstone River from a tall retaining wall downstream of the Manville Dam, approximately 4 m (13 feet) above the water surface. Dry weather flow was not observed by the Town (June 23, 2004), or during several of our site visits. The exception was November 29, 2005, when dry weather flow of 0.05 cfs was observed at the point of discharge to the river, but not at the open location upgradient of the railroad tracks. There was wet weather flow on October 8 and November 30, 2005. The upgradient location only accounts for part of the flow that is being discharged at the point of entry to the river. It is noted that the discharge point from the headwall is only accessible without boat during low river flow conditions.

- **OF-434** *(not identified by the Town):* Concrete pipe 8-inches in diameter, approximately 1.8 m (6 feet) to the south of the Manville Hill bridge. The pipe appears to be inactive.

- **OF-433** *(BLA07W):* The pipe is located approximately 10 m (33 feet) from the south side of the Manville Hill bridge, between the railroad tracks and the Blackstone River. It is located approximately 10 m (33 feet) above the water surface of the river. The pipe appears to be inactive.

Cotton Warehouse Center (70 New River Road): The small complex of re-used industrial facilities along the Blackstone River is located approximately 0.3 km (0.2 miles) to the south of the Manville Hill bridge. It houses a finished woodworking facility and a mechanical services shop. Our survey along the water front of this facility did not identify pipes or other types of outfalls to the river.

- **OF-449** *(unnumbered in Town survey):* Water flows into drains near the intersection between New River Street and Angle Street. The underground pipe follows the bike path and eventually flows into a catch basin near the bike path (OF-449). From this point, the water flows toward the river via a small intermittent stream bed.

- **OF-431** *(BLA08W):* Unnamed brook in the southern part of the Village of Manville, just to the north of the Northern Lincoln Elementary School. The brook crosses New River Road via a natural stone culvert. The brook flows during dry weather. The watershed for the brook appears to consist of some residences in southern Manville, the school, and wooded areas.

- **OF-432** *(unnumbered in Town survey):* Drainage pipe entering the northern downgradient side of the brook (OF-431). The pipe is connected to two catch basins on New River Road.

- **OF-430** *(unnumbered in Town survey):* Mussey Brook, crossing New River Road. This brook flows largely through residential and wooded land. Approximately 1.2 km (0.75 miles) upstream from the road, it flows through Handy Pond, which is part of the Handy Pond Conservation Area.

- **OF-443** *(BLA09W):* The pipe drains into Mussey Brook just upstream from the New River Road crossing. It appears to drain the residential area around Kennedy Boulevard. This outfall had high dry weather flow of 0.26 cfs on November 14, 2005 and 1.3 cfs on November 29, 2005. The source of this high flow may be groundwater. The water did not have any odor or discoloration.

- **OF-429** *(unnumbered in Town survey):* Pipe just to the south of the intersection between New River Road and Mitris Boulevard. The outfall was covered with debris. Water flows from the outfall through a wooded area into a stone culvert just upgradient of the railroad track.

- **OF-445** *(BLA10W):* Pipe entering the Blackstone River between the railroad track and the river, approximately 3 m (10 feet) from the river's edge. The outfall was approximately 0.3 m (1 foot) above the water surface of the river. The Town observed an oil sheen on the surrounding water. The location connects to a 12-inch diameter pipe along New River Road, approximately 210 m (700 feet) from its intersection with Ledge Way.

- **OF-446** *(BLA11W):* Concrete pipe (30 inches in diameter) with riprap stone entering the Blackstone River between the railroad track and the river, approximately 2.5 m (8 feet) from the river's edge. The outfall was approximately 0.6 (2 feet) *below* the water surface of the river. There was water flowing *into* the pipe from the Blackstone River, which is likely flowing toward the basin in front of the former Albion Mill (see Section 5.2.5.2).

- **OF-428** *(BLA12W):* Two flared concrete pipes, 24 inches in diameter, underneath the bike path. The outfalls discharge approximately 8 m (25 feet) from the river's edge; their elevations are approximately 0.6 m (2 feet) above the river's surface. There was dry weather flow during each site visit as the pipes appear to carry a brook.

5.2.5.2 Albion to Lonsdale Bleachery

Former Albion Mill: The former Albion Mill has been converted to condominiums. There is a basin between the former mill building and the Blackstone River. This basin appears to be a remnant section of the Blackstone Canal. The basin has an area of approximately 46 x 11 m (150 x 35 feet). Water likely enters approximately 100 m (330 feet) upstream of the Albion Dam at OF-446 and flows via pipe toward the former Albion Mill, from where it drains into the basin. The basin overflows into the Blackstone River. There was flow through the basin of approximately 0.5 cfs. There are three pipes entering the basin (OF-424 to OF-426). Two additional pipes were located at the southern end of the former mill (OF-422 and OF-423).

- **OF-424:** The pipe appears to drain a small parking lot of the former mill. There was no dry weather flow.

- **OF-425:** Metal pipe (4-inch diameter) draining into the basin. It appears to be inactive.

- **OF-426:** Metal pipe (8-inch diameter) also draining into the basin. It also appears to be inactive.

- **OF-422:** Corrugated metal pipe (24 inches in diameter) located at the southern end of the parking lot of the former mill. The pipe discharges approximately 5 m (16 feet) from the river's edge. The pipes had low flow (0.05 cfs) during dry weather surveys on November 14 and 29, 2005. The drainage system of the mill may be connected to the outfall and/or the pipe may drain residential uphill areas in Albion. In addition, groundwater may seep into the pipe. There was no odor, but some oil sheen in front of the pipe.

- **OF-423:** Metal pipe (6 inches in diameter) connected to a tank, approximately 24 m (80 feet) upslope from the river's edge. It is unknown if the pipe is active. It is located approximately 10 m (33 feet) downstream from OF-422. Dry weather flow was not observed.

Albion Mill to Ashton Dam: The stretch south of the former Albion Mill is rural, thus stormwater flows are expected to consist of non-point source discharges from wooded areas. The only active point source appears to be a brook (OF-427).

- **OF-427:** Unnamed brook. It drains part of the golf course of the Kirkbrae Country Club, aside from a residential area in Albion. The brook crosses Brushwood Drive, where it had a dry weather flow of 1.2 cfs on November 14, 2005.

Interstate Route 295: Route 295 crosses the Blackstone River approximately 0.5 km (0.3 miles) upstream of the Ashton Dam. A stormwater drainage plan for the Lincoln side of the Route 295 was not located in the RIDOT office. The plan of the Cumberland side of the Route 295 suggests that the stormwater is being discharged to the river through a drainage system. The location of an outfall and the level of treatment were not investigated.

Blackstone Canal Section between Ashton Dam and Bleachery: Discharges from the Town of Lincoln south of the Ashton Dam up to the Lonsdale Bleachery exclusively enter the Blackstone Canal. There are two weirs and one high-water overflow in the canal (OF-450 and OF-451), as discussed in Section 8.4.2.1. The Blackstone River watershed in this stretch is comparatively narrow, extending on average approximately 0.8 km (0.5 miles) from the river to the west. In addition, the villages along this stretch of the river (Quinnville and Lonsdale) are largely residential and sewered. Most houses are connected to the sewer system.

- **OF-450** (Northern Blackstone Canal weir): Weir approximately 100 m (330 feet) from the confluence of the canal and the Blackstone River. The confluence is located approximately 50 m (160 feet) to the south of the Ashton Dam. This weir discharges largely Blackstone River water that had just entered the canal.

- **OF-420** (George Washington Highway [Route 116]): Pipe exit at the northern side of the western bridge pier, draining the northwestern side of the highway.

- **OF-421** (George Washington Highway [Route 116]): Pipe exit at the southern side of the western bridge pier, draining the southeastern side of the highway.

- **OF-451** (also labeled as **W-34** and **P-06** during other surveys): Southern Blackstone Canal weir, approximately 100 m (330 feet) to the north of the Lonsdale Bleachery, downstream of the Pratt Dam on the Blackstone River. Discharges through this weir are affected by discharges from the residential areas to the west of the canal. A greater proportion of the water in the canal typically continues south along the canal and flows into Scott Pond. The flow rates through the weir vary and are occasionally controlled by the Town of Lincoln through the removal of boards to avoid flooding along the canal (see discussion in Section 8.4.2.1). The discharge through the weir was investigated also as part of the dry and wet weather sampling program (Sections 3 and 4).

5.2.5.3 Lonsdale Bleachery

Discharges of the industrial and commercial facilities of the Lonsdale Bleachery either enter the Blackstone Canal or the Blackstone River. A site plan from 1953 kindly provided by Mr. John Faile (Water Superintendent of the Town of Lincoln) shows some of the outfalls adjacent to the Blackstone River (London and Company, 1953). A walkover was conducted on October 6, 2005, along the waterfront of the bleachery and outfalls were recorded. Many of the pipes are only visible at low flow conditions in the Blackstone River. The following point sources were observed:

- **OF-401** (Leaking oil storage tanks): In the fall of 2005, oil storage tanks were being removed from the ground in the northeastern corner of the Lonsdale Bleachery. Oil had leaked into the soil surrounding the site. The site was only approximately 10 m (33 feet) to the west of the Blackstone River. It is likely that oil was seeping into the river. Oil residues were observed at a number of locations for a few hundred yards along the banks of the river downstream from this location. The site was in the process of remediation.

- **OF-419:** Pipe within a stone wall approximately 20 m (65 feet) upstream of the former tailrace (OF-402). On October 6, 2005, it was located only approximately 0.3 m (1 foot) above the water surface of the Blackstone River. It is not known if it is active.

- **OF-412:** Pipe located approximately 15 m (50 feet) upstream of the former tailrace (OF-402), protruding approximately 0.9 m (3 feet) out of a stone wall. This pipe may be active. On October 6, 2005, it was located approximately 1.2 m (4 feet) above the water surface of the Blackstone River; dry weather flow was not observed. Wet weather flow was also not observed at 12:40h on November 30, 2005.

- **OF-418:** Metal pipe with elbow at the end. This pipe is inactive. On October 6, 2005, it was located approximately 1.2 m (4 feet) above the water surface of the Blackstone River; dry weather flow was not observed. Wet weather flow was also not observed at 12:40h on November 30, 2005.

- **OF-402:** The large opening under the Boiler House is the tailrace of the former power plant at the site. It is not known if water discharges currently into this opening. Dry weather flow was not observed. Wet weather flow was also not observed at 12:40h on November 30, 2005.

- **OF-411:** Metal pipe located within a stone wall approximately 10 m (30 feet) downstream of the former tailrace (OF-402). The stone wall is covered with moss, suggesting that that the pipe is inactive. On October 6, 2005, it was located approximately 1.2 m (4 feet) above the water surface of the Blackstone River.

- **OF-415:** Metal pipe, not active. On October 6, 2005, it was located approximately 1.5 m (5 feet) above the water surface of the Blackstone River.

- **OF-416:** Small brick and stone box culvert. There was no dry weather flow during the survey, but the culvert may flow during wet weather. On October 6, 2005, it was located only 0.3 m (1 foot) above the water surface of the Blackstone River.

- **OF-417:** Metal pipe, not active. On October 6, 2005, it was located approximately 2.1 m (7 feet) above the water surface of the Blackstone River; dry weather flow was not observed. Wet weather flow was also not observed at 12:40h on November 30, 2005.

- **OF-410:** Large (24-ich diameter) concrete pipe. This pipe is half-buried and may be inactive. On October 6, 2005, it was located approximately 0.6 m (2 feet) above the water surface of the Blackstone River.

- **OF-409:** Metal pipe, not active. On October 6, 2005, it was located approximately 0.9 m (3 feet) above the water surface of the Blackstone River.

- **OF-414:** Small concrete culvert. Outfall lined with concrete topped with a 0.6 m (2 foot) length of railroad track. The outfall appears to have flow during wet weather. On October 6, 2005, it was located approximately 1.2 m (4 feet) above the water surface of the Blackstone River.

- **OF-413:** Corrugated metal pipe, 15-inches in diameter. The pipe protrudes from the slope of the Lonsdale Bleachery and drains into a small wetland. There was no dry weather flow on October 6, 2005. The wet weather flow was 0.5 cfs on November 30, 2005. The base of the channel from the wetland was stained light brown (iron oxides?). There was also an oil sheen at this location, which may have been the result of leaking oil from the underground storage tank area further upstream on the Bleachery site (OF-401).

- **OF-408:** Clay pipe with broken end, not active. On October 6, it was located approximately 3 inches (0.1 m) above the water surface of the (low-flowing) Blackstone River.

5.2.5.4 Lonsdale Bleachery to Central Falls

Outfalls on the Lincoln side of Whipple Bridge (connecting Mendon Road with Lonsdale Avenue) were not observed. The John Street bridge was not inspected for potential outfalls. There are no discharges entering the river from Valley Falls Marsh, assuming that there are no seeps from historic landfilling activities in the marsh. The only relevant point source observed in this area was an animal farm on Carrington Street (OF-403).

- **OF-403:** Small farm with animals including goats, sheep, cows, and chicken. The farm is located on a hill to the south of Carrington Street, upgradient of a carwash. The farm did not appear to have a facility to capture stormwater runoff from the land. As observed during the storm of November 30, 2005, runoff from the farm flows westerly along the southern side of Carrington Street, then crosses over to the northern side of Cook Street, and flows easterly along the northern side of Cook Street into a drain located at the corner of Cook Street and Lonsdale Avenue; the flow at 12:55h on that day was approximately 0.3 cfs. Presumably this drain discharges into the Blackstone River in the vicinity of Whipple Bridge; an outfall was not located during a brief initial survey under the bridge, however. The runoff from the farm contained soil and had a septic odor. A strong septic odor was also observed on October 5, 2005, emanating from the soil between the fence of the facility and Carrington Street. It is likely that the runoff from this farm carries high pathogen concentrations.

5.2.6 City of Central Falls

More than 90% of the stormwater of the City of Central Falls drains into the Blackstone River via CSOs (Figures C-3 and C-4 in Appendix C). There may be additional pipes and inflows along the river from industrial facilities along the shore, some of which are historic mills. There is also an auto salvage yard along the shore between High Street and the river. The only RIPDES-permitted facility along this stretch of the river is the Osram Sylvania facility on Broad Street. However, its industrial wastewater is now being discharged via the NBC sanitary system to the Bucklin Point WWTF along the Seekonk River. A detailed boat survey for non-CSO pipes was not performed between the Valley Falls Dam and Slater Mill Dam.

Discharges in Central Falls between the border with the Town of Lincoln and Valley Falls Dam consist of the following:

- **OF-501** (NBC CSO #007): Large (48 inches in diameter) corrugated metal pipe. The outfall is located at the intersection of Aetna Street and Richmond Street, approximately 20 m (65 feet) beyond the road at the base of the steep slope toward Valley Falls Pond. The metal pipe is encased in concrete. There was dry weather flow of approximately 0.5 cfs and 0.2 cfs on October 6 and 7, 2005, respectively. NBC sent out a crew on October 6, 2005, after being notified by RIDEM and investigated the dry weather flow. They observed that the CSO invert was about 0.5 m (1.5 feet) above the mainstem requiring a substantial backup in order to create an overflow. Therefore, the dry weather flow could either have been groundwater leaking into the CSO, or illicit connection(s). On November 30, 2005, the wet weather flow rate at OF-501 was approximately 3 or 4 cfs.

Shorefront to Valley Falls Pond: Stormwater and wastewater from streets along Valley Falls Pond is largely collected. Only a small number of houses are located at a lower elevation than the closest street with stormwater and sewer pipes (i.e., Shawmut Avenue). This includes houses on Temple Street and Arrow Street. However, a resident at 44 Temple Street stated on October 6, 2005, that she has a pump that pumps the wastewater to the drain on Shawmut Street. She did not know if that is the case also for the other houses. Her house was built approximately 5 years ago. The total volume of stormwater entering Valley Falls Pond is expected to be very small. In addition, some of the houses at lower elevations have septic systems. It is possible, that some of the non-septic wastewater (such as laundry discharges) from these houses bypass the septic system, and are discharged directly into the Valley Falls Pond watershed.

- **OF-502:** There is a pipe underneath the wooden deck of the Blackstone River Tourism Council pier. Only a 1.2 m (4 foot) long section of the pipe is exposed. The pipe extends below the surface of the Blackstone River. It is not known if this pipe is active. It is also not obvious what may be connected to this pipe. It extends upgradient toward the western side of the gray building (former mill building?) and the parking lot.

CSOs along the Blackstone River downstream of Valley Falls Dam: There are a total of six CSOs in Central Falls along the Blackstone River (Figures C-3 and C-4 in Appendix C).

5.2.7 City of Pawtucket

As for Central Falls, more than 90% of the stormwater of the City of Pawtucket drains to the Blackstone River via CSOs (Figure C-5 in Appendix C). There may be additional pipes and inflows along the river from industrial facilities along the shore, some of which are historic mills. There are no RIPDES-permitted facilities along this stretch of the river. A detailed boat survey for non-CSO pipes was not performed between the Valley Falls Dam and Slater Mill Dam.

CSOs along the Blackstone River: Upstream of Slater Mill, there are a total of nine CSOs in Pawtucket (Figure C-5 in Appendix C). An additional five CSOs are located in Pawtucket between Slater Mill Dam and the confluence of the Blackstone River with the Seekonk River.

5.3 Water Quality of Point Sources

The water quality data for all point sources are summarized in Figure 5-17. As for Figure 5-14, data are sorted by community, from upstream to downstream stations. Data sorted by individual dry and wet weather sampling event (OUTFALL-__) are attached as Table D-1 in Appendix D. The laboratory reports are attached as in CD Folder 1.

Most dry weather flows are associated with small brooks in the watershed, some of which flow in their natural stream bed, others flow in man-made open channels or underground pipes and culverts. In addition, there are some stormwater outfalls that may carry groundwater that seeps into the pipes during dry or wet weather conditions. Some of these brooks appear to carry man-made dry weather discharges (such as is likely the case for OF-317).

During the limited wet weather survey, many of the outfalls carry flow as designed. At the same time, there are a considerable number of point sources along the Blackstone River which appear to be inactive. Typically, these point sources are located at former industrial sites such as the Lonsdale Bleachery and Albion Mill.

Following is a summary of the key findings from the limited water quality survey of the point sources.

5.3.1 Fecal Coliform

Fecal coliform concentrations measured in the point sources were typically higher during wet weather than during dry weather. Most stations (brooks as well as outfalls) carried concentrations that exceeded 200 col/100 ml. Stations of note consist of the following:

- **OF-601 (Fox Brook, Blackstone [MA]):** This brook had fecal coliform concentrations of 2,200 col/100 ml during wet weather, and comparatively high flow rates of 3 cfs.
- **OF-231** (also **W-32**) **(Front Street Drain):** Similar to Fox Brook (OF-601), this brook had high fecal coliform concentrations (16,000 col/100 ml), and comparatively high flow rates (5 cfs). Pathogen concentrations during dry weather were low, however. This was also observed during two of the three regular dry weather sampling events at this location (see Figure 3-9 in Section 3).
- **OF-247, OF-258, OF-263 (Stormwater outfalls in Woonsocket)**: These large diameter outfalls carry high fecal coliform concentrations during wet weather. Flows at the time of the survey ranged from 0.3 to 3.5 cfs.
- **OF-333 (Sneech Brook, Cumberland):** Fecal coliform concentrations in this brook ranged from 800 to 2,400 col/100 ml during both wet and dry weather.
- **OF-326/327 (Route 116):** The fecal coliform concentration was high (>16,000 col/100 ml) but the flow rate was very low (0.05 cfs).
- **OF-325 (Scott Brook, Cumberland):** The wet weather sample from October 8, 2005 contained an elevated fecal coliform concentration, while the concentration in the wet weather sample from November 30, 2005 was low.
- **OF-324 (Outfall from area of former Owens Corning facility, Cumberland):** Fecal coliform concentrations were consistently high during dry and wet weather. The measured flow reached 0.5 cfs.
- **OF-304 (Okonite Outfall, Cumberland)**: Results for this outfall are split. This outfall carried low fecal coliform concentrations (<200 col/100 ml) during both dry and wet weather conditions on October 7 and November 14, 2005, respectively. During the dry and wet conditions on October 8 and November 30, 2005, respectively, the outfall carried high fecal coliform concentrations (>16,000 col/100 ml).
- **OF-302 (Outfall west of Marshall Street, Cumberland):** This outfall near the Panda Restaurant parking lot had very low dry weather flow, which however, contained fecal coliform concentrations of >16,000 col/100 ml. During the wet weather survey on November 30, 2005, the fecal coliform concentration was 1,700 col/100 ml at a flow rate of 2 cfs. High fecal coliform concentrations in this outfall were also recorded in a study by Brown University in 2003 (Brown University, 2003).
- **OF-317 (Brook near Ann & Hope, Cumberland):** The water at this station contained consistently high fecal coliform concentrations of at least 16,000 col/100 ml during both dry and wet weather. The flow at OF-317 ranged from 0.3 to 6 cfs. In addition, the water looked gray and had an odor. High fecal coliform concentrations were also recorded during regular dry weather monitoring events

at this location (see Figure 3-9 in Section 3). It is likely that this brook receives domestic wastewater at all times. The dissolved oxygen concentration in the brook during one of the October 7, 2005 dry weather events was only 5.1 mg/l. In addition, as stated in Section 5.2.4, the water is gray-blue-green, and had a septic odor at times.

- **OF-311 (Outfall near Abbott Run Brook, Cumberland):** Fecal coliform concentrations were high during mostly wet weather conditions.

- **OF-435, OF-448 (Outfalls in Manville, Lincoln)**: Fecal coliform concentrations were high in these two outfalls in Manville, exceeding 16,000 col/100 ml at times.

- **OF-501 (NBC CSO #007, Central Falls):** This CSO carried flow of 0.1 to 3.5 cfs and contained at least 16,000 col/100 ml during each of the three sampling events.

There are possibly other outfalls with high pathogen concentrations. During high flows along the Blackstone River, some of the pipes were partially submerged.

5.3.2 Dissolved Copper and Lead

Metals data were compared against acute and chronic criteria using an average hardness of 53 mg/l. This hardness represents the mean of the hardness from all Blackstone River stations during the one-year dry weather survey (see Figure 3-69 in Section 3). At this hardness the acute and chronic criteria for dissolved copper are 9.4 and 6.6 ug/l, respectively. Similarly, the acute and chronic criteria for dissolved lead are 32 and 1.3 ug/l, respectively.

Stations with high lead and copper concentrations consisted of the following:

- **Blackstone River outfalls, Woonsocket:** There were several stormwater outfalls in Woonsocket with elevated lead and copper concentrations during wet weather, such as OF-242 and OF-243, both located adjacent to Truman Drive, and OF-258, located to the northwest of the Hamlet Street bridge.

- **OF-704 (Mill River, Woonsocket):** High lead concentrations of 7.2 ug/l were measured at this location adjacent to School Street during wet weather.

- **OF-324 (Outfall from area of former Owens Corning facility, Cumberland):** Two of the four samples contained dissolved copper concentrations of 11 to 16 ug/l.

- **OF-302 (Outfall west of Marshall Street, Cumberland):** This outfall contained elevated copper (up to 14 ug/l) and elevated dissolved lead concentrations (up to 11 ug/l).

- **OF-318 and OF-317 (Ann & Hope):** The outfall from the parking lot at Ann & Hope (OF-318), and the brook adjacent to the parking lot (OF-317) contained elevated copper concentrations reaching 23 ug/l in OF-317.

- **OF-316 (River Street):** Outfall just to the west of OF-317 contained elevated dissolved copper and lead concentrations.

- **OF-311 (Outfall near Abbott Run Brook, Cumberland):** Dissolved lead and copper concentrations during both wet weather sampling events were elevated.

- **OF-448:** The only station surveyed in the Town of Lincoln with consistently elevated lead and copper concentrations was OF-448 in Manville.

5.4 Recommendations

The goal of this task was to provide an overview of the largest sources and identify potential key sources of discharges. This inventory has been conducted on a reconnaissance level so far. Following are recommendations for further activities to refine the understanding of the sources of contamination.

5.4.1 Reconnaissance for Locating additional Point Sources

The following stretches of river could be investigated in more detail by land and boat to locate additional point sources:

- *Branch River - Slatersville Reservoir to confluence with Blackstone River:* It is possible that outfalls exist from the commercial/industrial facilities between the Slatersville Reservoir and the Forestdale Pond dam.

- *Blackstone River – Hydropower plant to Fox Brook:* While this area has a low density of development, some outfalls may exist specifically around the Saranac Dam.

- *Canal between Saranac Dam and OF-106:* There are several houses along Canal Street, adjacent to the former Blackstone Canal. In addition, water that flows through the remnant section of the Blackstone Canal toward Station OF-106 passes by the BF Transfer Station and an auto salvage yard. The destination of the stormwater runoff from these two facilities has not yet been determined.

- *Blackstone River - Stretch between the Woonsocket Treatment Plant and Route 99 bridge:* Good information is available from the City of Woonsocket about the location of individual point sources. Additional surveys could field-verify these point sources, and search for other potential point sources from private sources such as the Industrial Park and auto salvage yard area to the east of the river.

- *Blackstone River – Lincoln Golf Course:* The discharge location for the golf course in Lincoln should be determined, as fertilizers are likely being applied to the course.

- *Blackstone Canal – Ashton to Bleachery:* Discharges to the Blackstone Canal from the Town of Lincoln were not individually investigated during this study. The drainage area is nearly completely residential. Discharges from this area were summarily addressed in this study by sampling at the southern weir between the canal and the Blackstone River (Station OF-451, identical to W-34]), and at the entrance to Scott Pond underneath Front Street bridge (Station P-11). This assessment should incorporate the locations identified by Brown University (2003) along the canal.

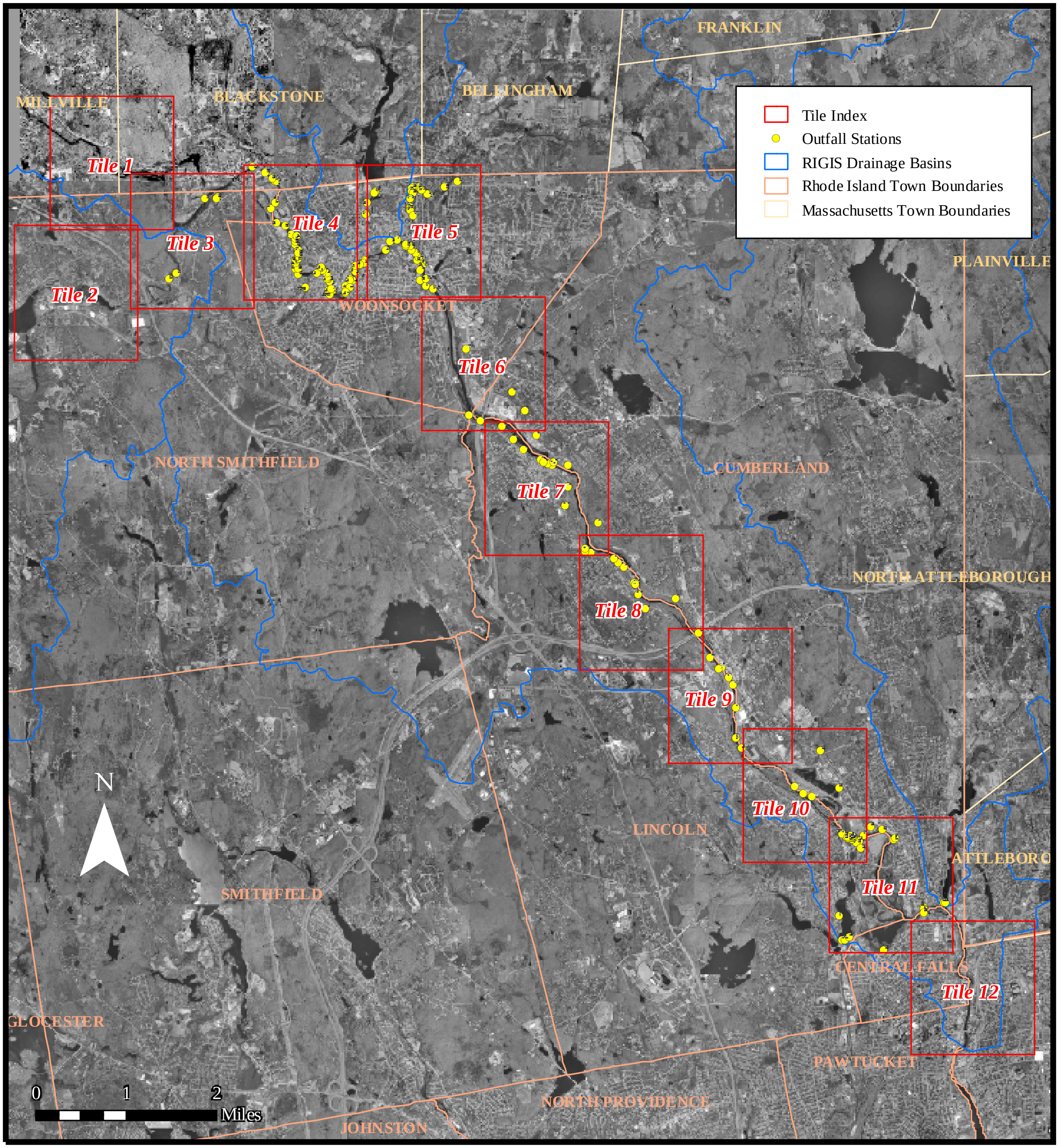
- *Peterson/Puritan Site:* Leachate samples from seeps at the site contained very high total copper and lead concentrations (David Newton, EPA, personal communication, October 19, 2005). Information about flow rates are not available, thus not allowing for load estimates. Contaminant loading from the seeps of the site to the Blackstone River (specifically for lead and copper) should be investigated as part of the ongoing remedial investigations of the site (if not already planned). This investigation should include flow rates and concentrations of the total and dissolved fractions, and an estimate of the total load of leached metals from the entire site into the river. Data collection should consider seasonal variability and wet versus dry weather conditions.

- *Lonsdale Bleachery:* The site has many pipes. While dry weather flow was not observed, a detailed accounting should be performed of the various wastewater and stormwater streams that are generated at the facility as part of future redevelopment of the site. Also, discharges into the canal from buildings adjacent or above it should be examined in more detail.

- *Blackstone River – Stretch between Lonsdale Ave bridge and Ann&Hope outfall OF-318:* This stretch is overgrown. A more in-depth survey should be performed to investigate this stretch to locate potential small pipes from abutting industrial facilities.

5.4.2 Further Investigations of Specific Point Sources

Based on the field reconnaissance as well as laboratory results of the water quality survey, additional investigations should be performed. Suggestions are included in Figure 5-14 for the various point sources that were investigated. The suggestions are ranked in the order of perceived significance, and should include dry and/or wet weather sampling at varying levels of intensity, as appropriate for the specific point sources.



The Louis Berger Group, Inc.

Rhode Island DEM

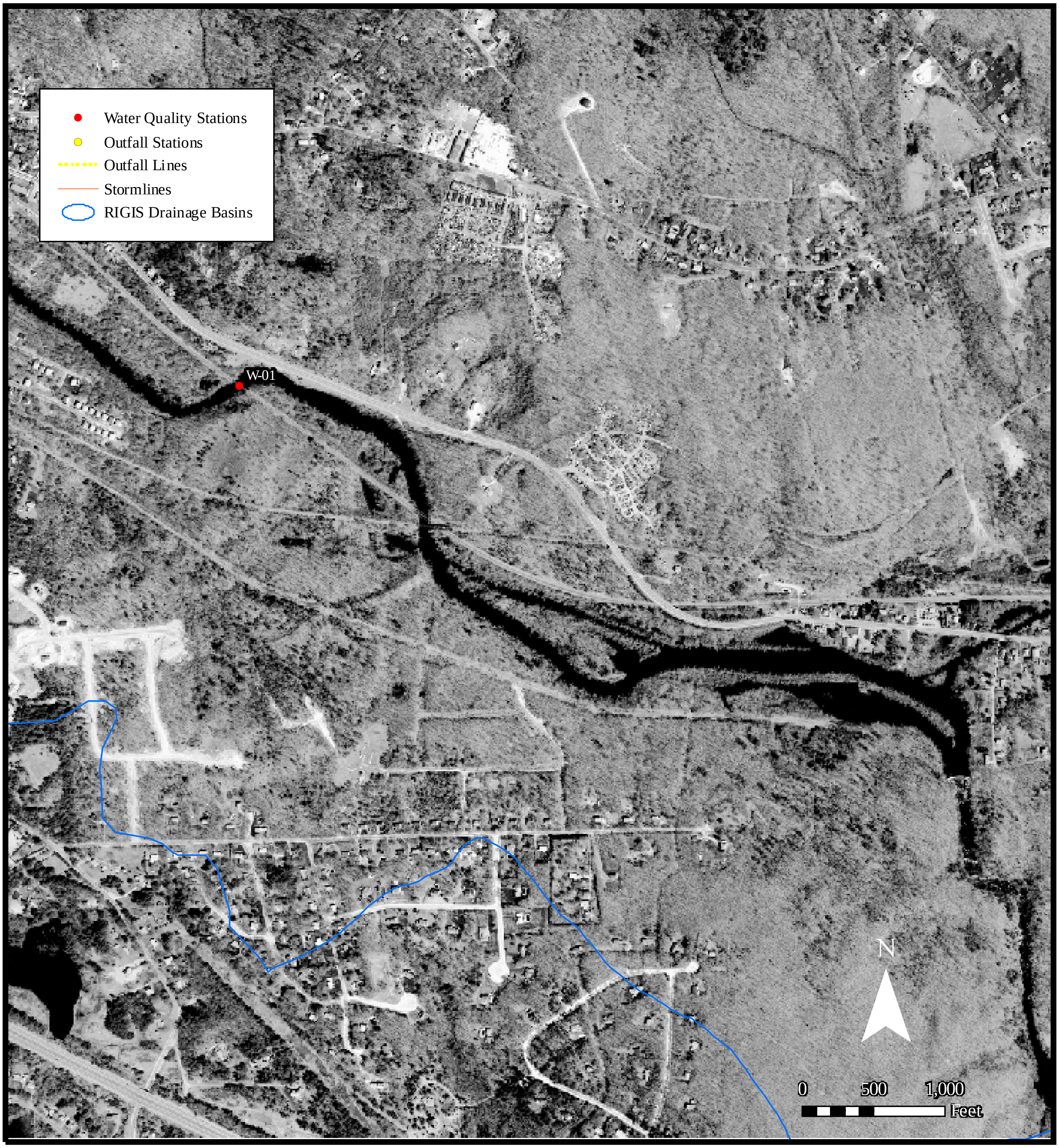
Source: RIGIS, MassGIS

SamplingIndex.mxd

2006-04-14

Blackstone River Water Quality

Figure 5-1
POINT SOURCES AND SURVEY STATIONS (Index Map)



The Louis Berger Group, Inc.

Rhode Island DEM

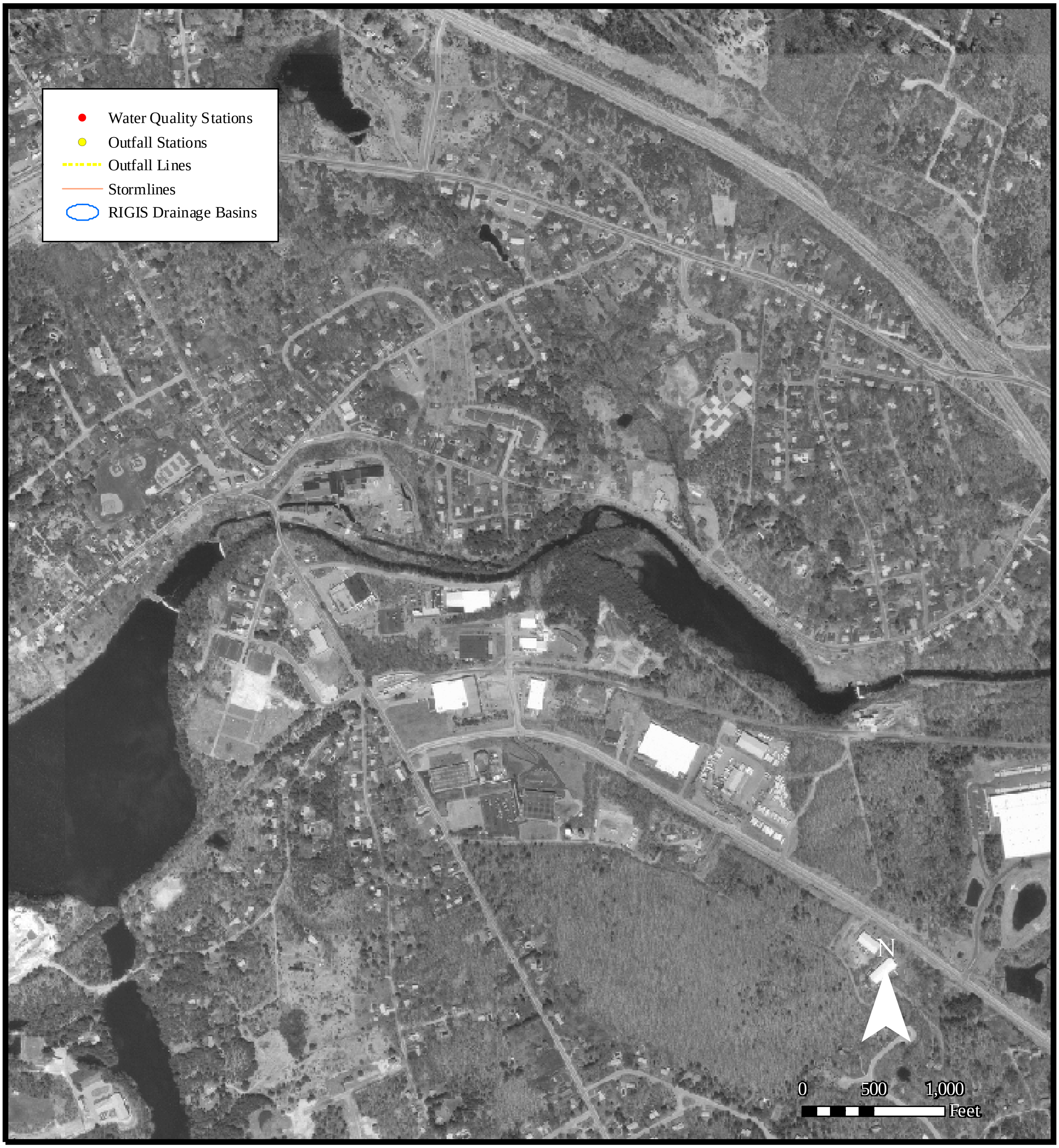
Source: RIGIS, MassGIS

Sampling01.mxd	2006-04-14

Blackstone River Water Quality

Figure 5-2

POINT SOURCES AND SURVEY STATIONS (Tile 1 of 12)



The Louis Berger Group, Inc.

Rhode Island DEM

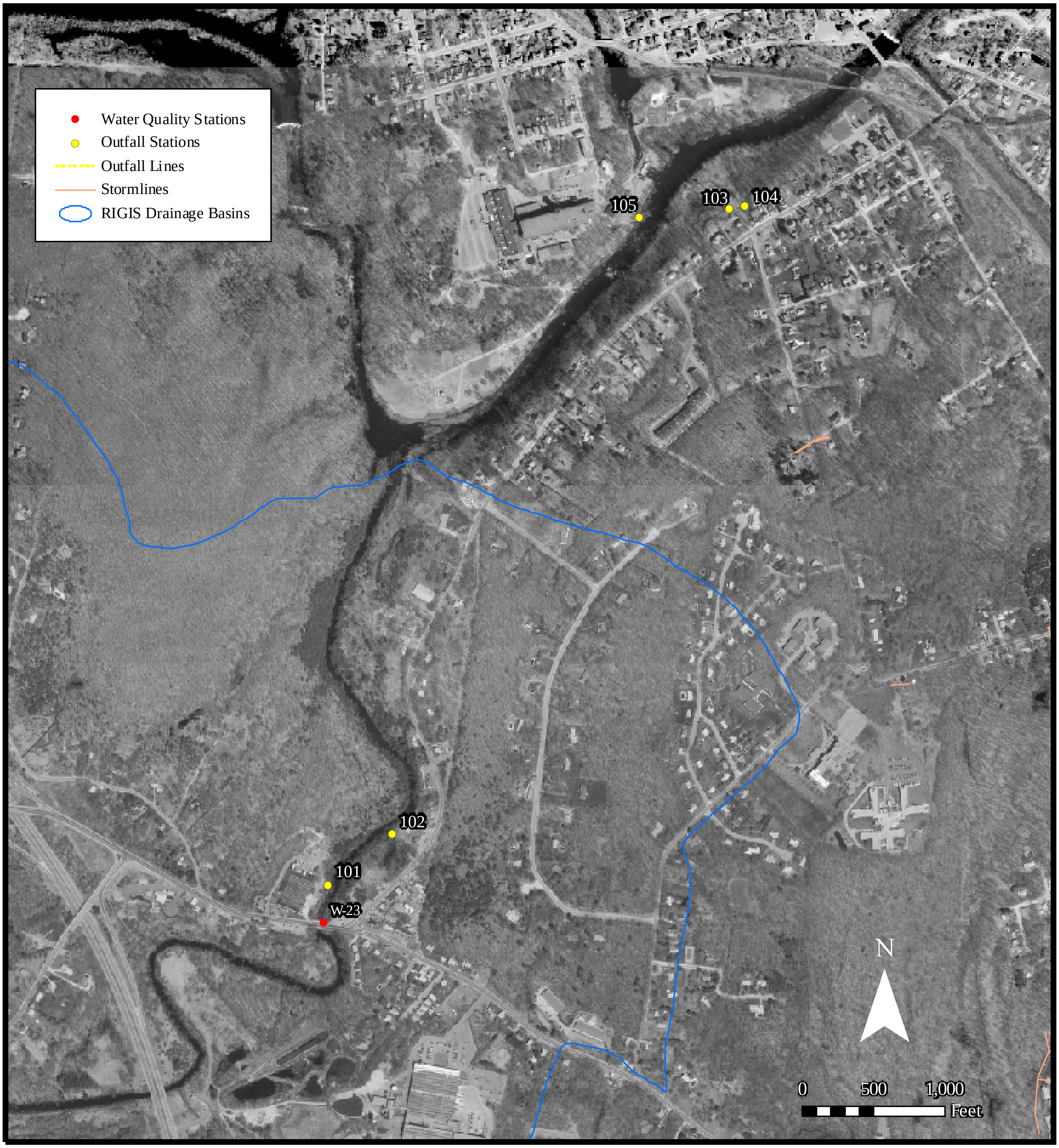
Source: RIGIS, MassGIS

Sampling02.mxd	2006-04-14

Blackstone River Water Quality

Figure 5-3

POINT SOURCES AND SURVEY STATIONS (Tile 2 of 12)



The Louis Berger Group, Inc.

Rhode Island DEM

Source: RIGIS, MassGIS

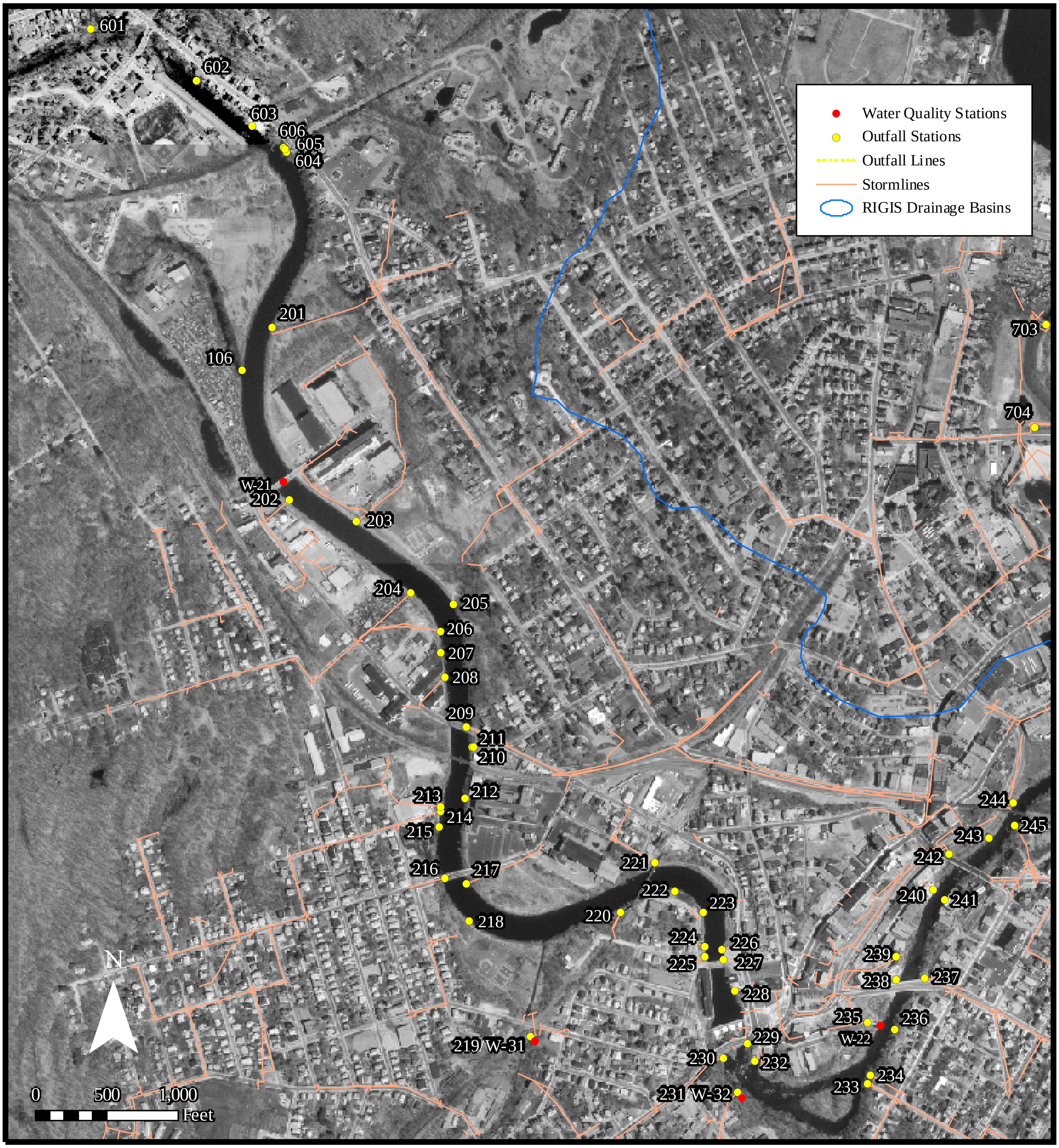
Sampling03.mxd

2006-04-14

Blackstone River Water Quality

Figure 5-4

Point Sources and Survey Stations (Tile 3 of 12)



The Louis Berger Group, Inc.

Rhode Island DEM

Source: RIGIS, MassGIS

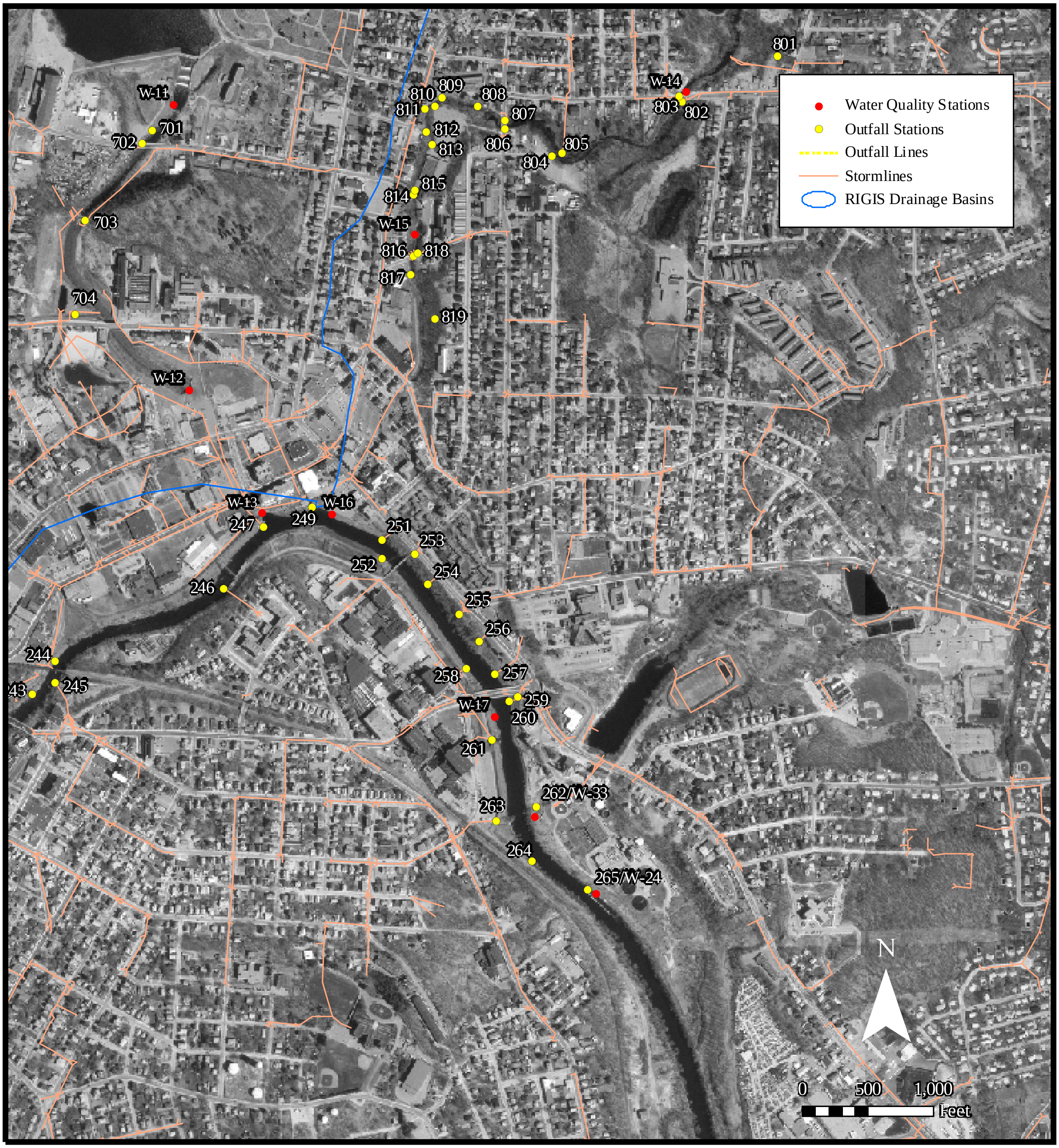
Sampling04.mxd

2006-04-14

Blackstone River Water Quality

Figure 5-5

POINT SOURCES AND SURVEY STATIONS (Tile 4 of 12)



The Louis Berger Group, Inc.

Rhode Island DEM

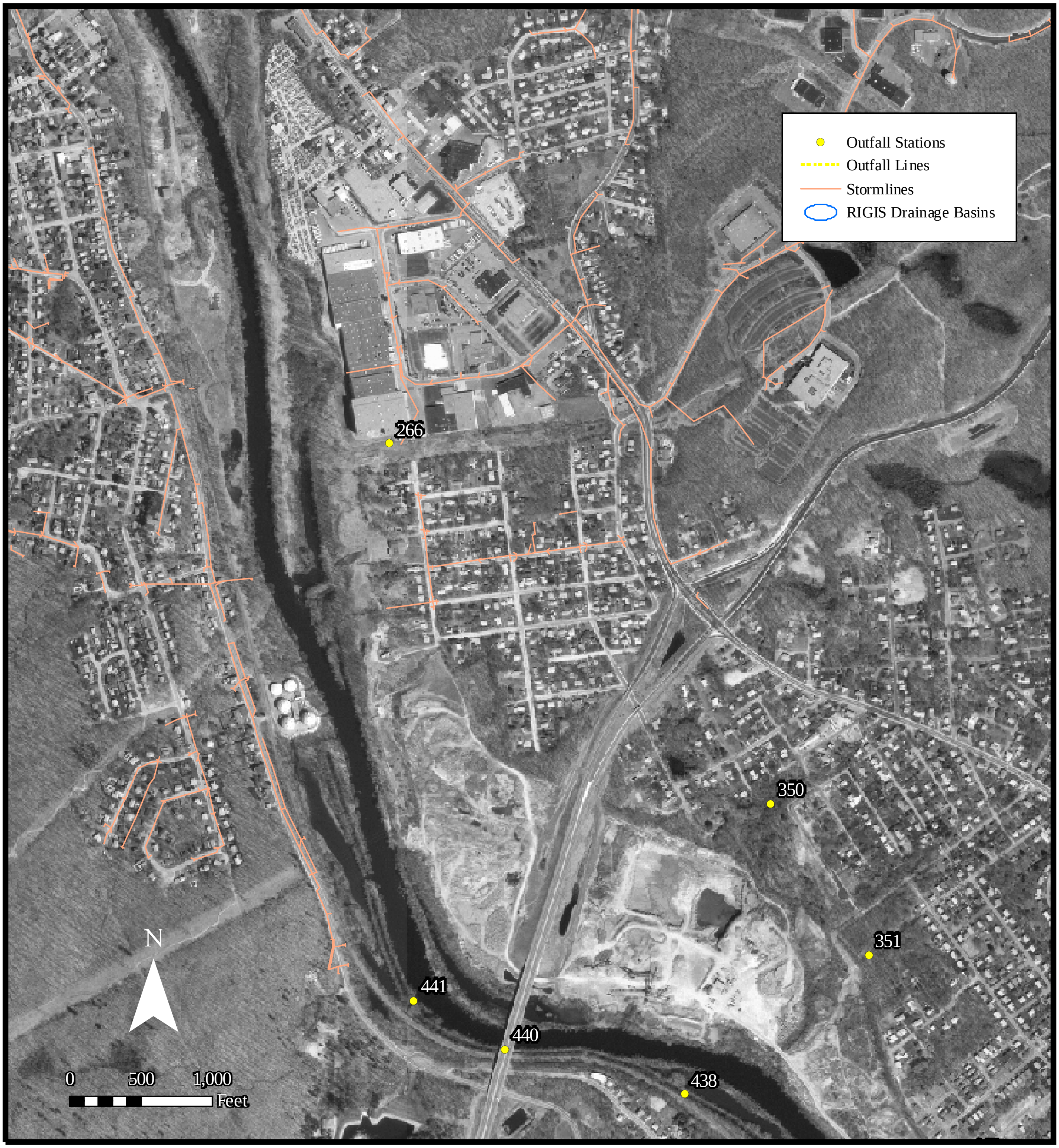
Source: RIGIS, MassGIS

Sampling05.mxd	2006-04-14

Blackstone River Water Quality

Figure 5-6

POINT SOURCES AND SURVEY STATIONS (Tile 5 of 12)



The Louis Berger Group, Inc.

Rhode Island DEM

Source: RIGIS, MassGIS

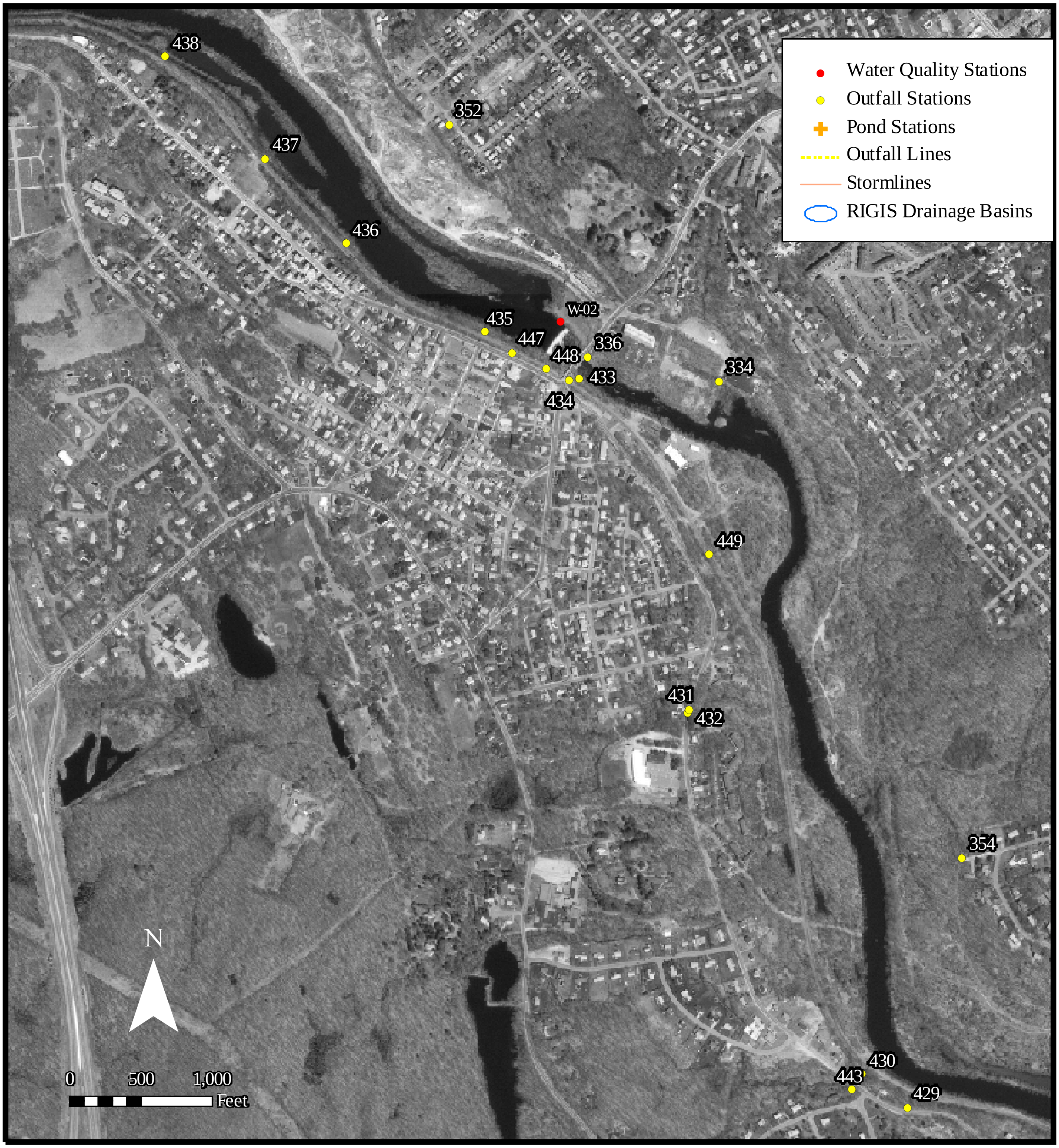
Sampling06.mxd

2006-04-14

Blackstone River Water Quality

Figure 5-7

POINT SOURCES AND SURVEY STATIONS (Tile 6 of 12)



The Louis Berger Group, Inc.

Rhode Island DEM

Source: RIGIS, MassGIS

Sampling07.mxd

2006-04-14

Blackstone River Water Quality

Figure 5-8

POINT SOURCES AND SURVEY STATIONS (Tile 7 of 12)

The Louis Berger Group, Inc.

Rhode Island DEM

Source: RIGIS, MassGIS

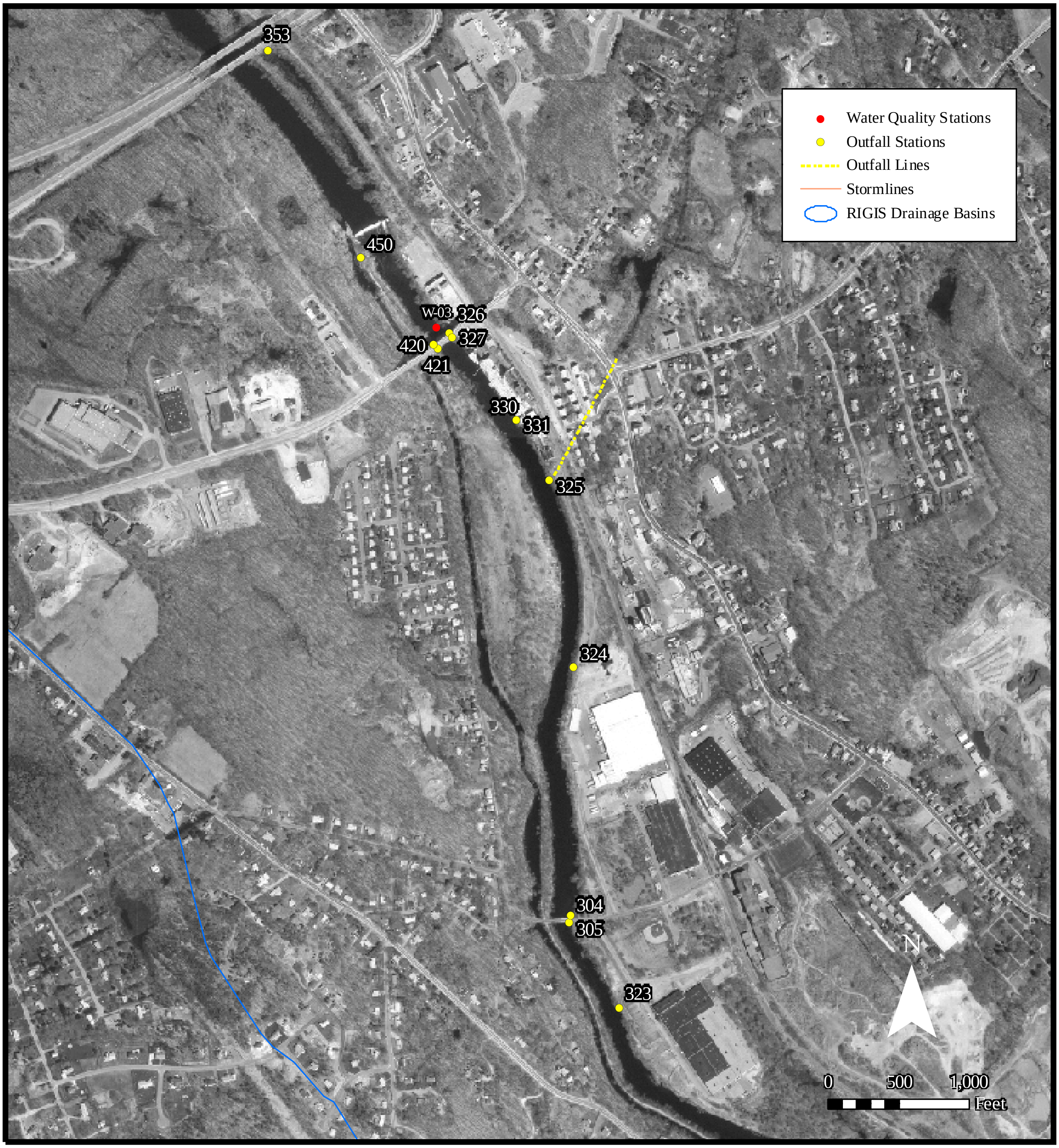
Sampling08.mxd

2006-04-14

Blackstone River Water Quality

Figure 5-9

POINT SOURCES AND SURVEY STATIONS (Tile 8 of 12)



The Louis Berger Group, Inc.

Rhode Island DEM

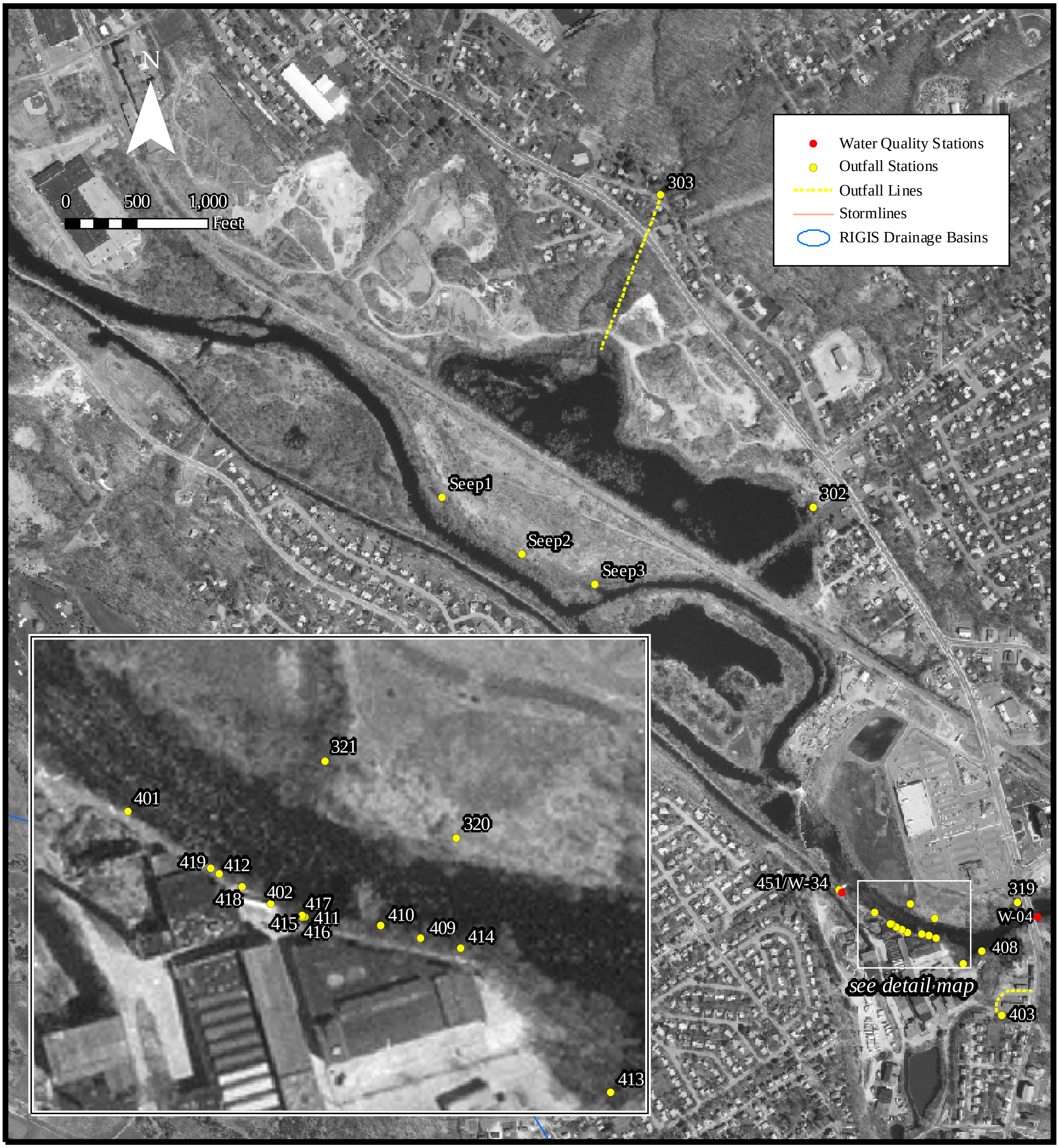
Source: RIGIS, MassGIS

Sampling09.mxd	2006-04-14

Blackstone River Water Quality

Figure 5-10

POINT SOURCES AND SURVEY STATIONS (Tile 9 of 12)



The Louis Berger Group, Inc.

Rhode Island DEM

Source: RIGIS, MassGIS

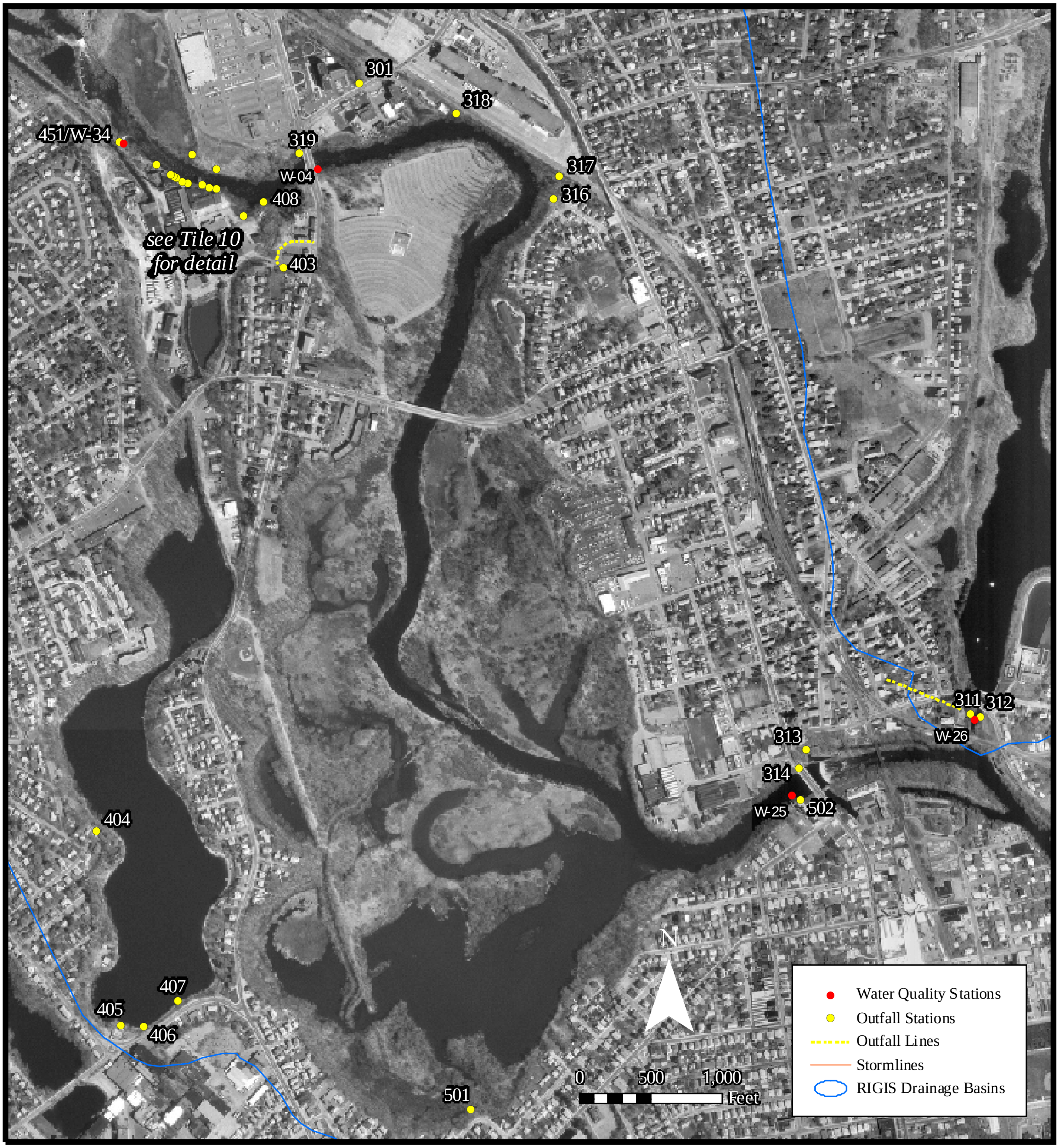
Sampling10.mxd

2006-04-14

Blackstone River Water Quality

Figure 5-11

POINT SOURCES AND SURVEY STATIONS (Tile 10 of 12)



The Louis Berger Group, Inc.

Rhode Island DEM

Source: RIGIS, MassGIS

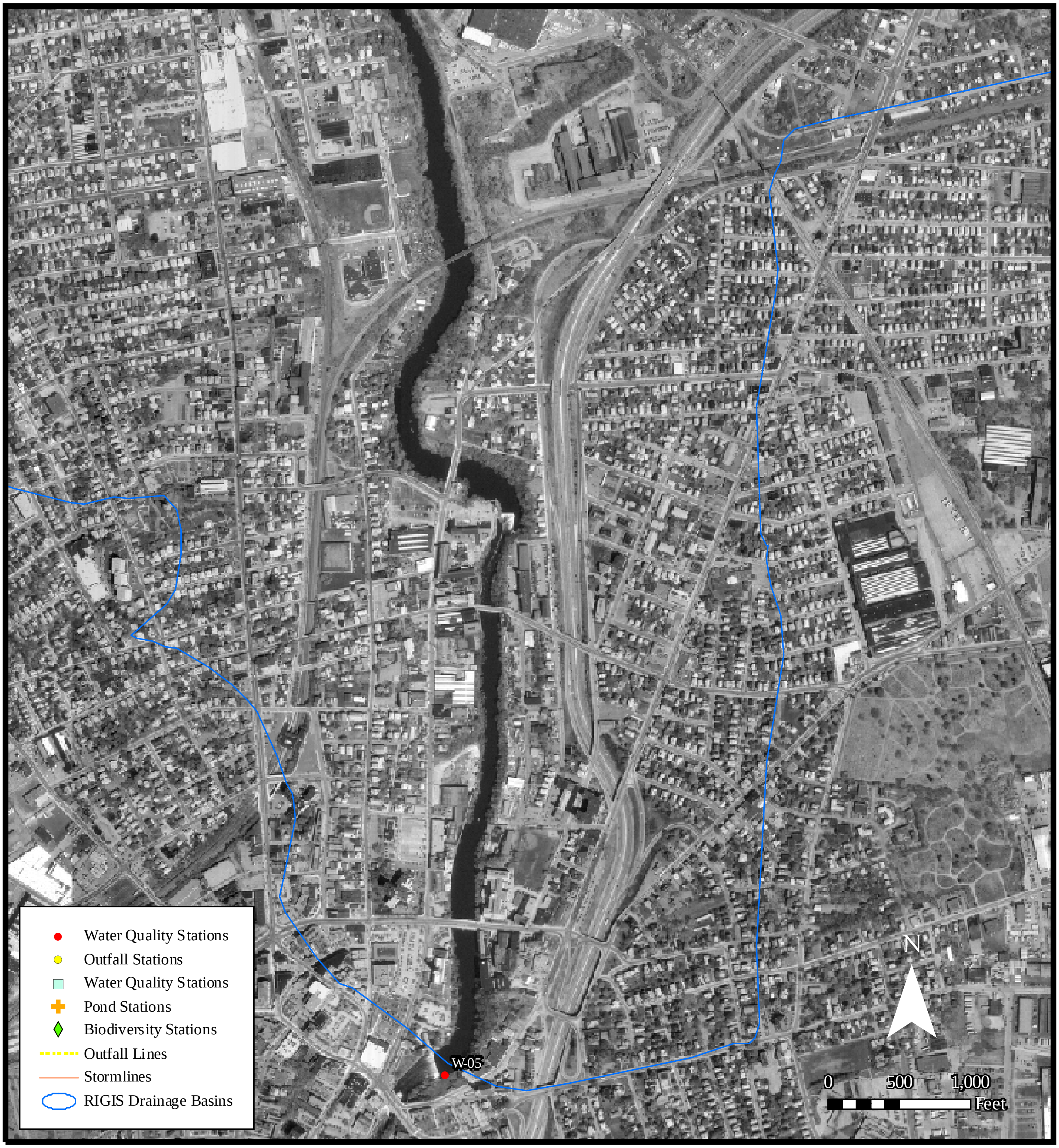
Sampling11.mxd

2006-04-14

Blackstone River Water Quality

Figure 5-12

POINT SOURCES AND SURVEY STATIONS (Tile 11 of 12)



The Louis Berger Group, Inc.

Rhode Island DEM

Source: RIGIS, MassGIS

Sampling12.mxd

2006-04-14

Blackstone River Water Quality

Figure 5-13

POINT SOURCES AND SURVEY STATIONS (Tile 12 of 12)

Figure 5-14: Blackstone River - Points of Stormwater Runoff (from upstream to downstream for respective communities)

				Survey Mode				River Bank		Type						Dry Weather Flow ?		Drainage Area					Further Investig.*(6)*		
Report ID (OF-___)	Laboratory/ Field ID	Other Field/Lab ID or Town ID	Survey Date	Shore / Land	Boat / Canoe	Mun. Engin. Off.	from map	Left *(2)*	Right *(2)*	Brook	Culvert	Pipe	Other	Material/ Comments	Width / Diameter	Yes (cfs)	None	Road	Residential	Wooded	Industrial/Comm.	Comments	Dry Weather	Wet Weather	Comment
North Smithfield																									
Branch River																									
101	OF-101		n/s				●	●				?									●	RIPDES permitted (Atlantic Thermoplastics Manufacturing).	1		
102	OF-102		n/s				●		●			●		concrete	36 inch			●	●	●					
Blackstone River (mainstem)																									
105	OF-3-6		n/s				●	●				?									●	Drains small WWTF of Blackstone-Smithfield Corporation (RIPDES permitted).	2		
103	OF-103		n/s			●			●			●		concrete	24 inch			●	●					1	
104	OF-104		n/s			●			●			●		concrete	24 inch			●	●					1	
106	OF-4-15		7/22/04	●	●				●				●	Inlet		yes			●		●	Flow originates through diversion at Saranac Dam.		2	
Blackstone (MA)																									
601	OF-4-10		7/30/04		●			●		●				Fox Brook		0.5 - 1.0			●	●		Appears to discharge high volume of water during storm.	2	2	
602	OF-4-11		7/30/04		●			●				●	●	10 - 15 pipes	3 - 6 inch		●					Pipes from building from industrial processes.			4
603	OF-4-12		7/30/04		●			●				●		2 pipes	6 inch		●					Appear to be minor stormwater drainage pipes.			
604	OF-4-13a		7/30/04		●			●				●		CMP	24 inch		●	●	●	●	●	Appears to carry heavy flow during rainstorm.		2	
605	OF-4-13b		7/30/04		●			●				●		clay	14 inch		●	●	●	●	●			2	
606	OF-4-13c		7/30/04		●			●				●		clay	14 inch	0.08		●	●	●	●		1	2	
Woonsocket																									
201	OF-4-01		7/30/04		●			●					●	Channel	4 feet	0.14		●	●			On another dry weather site visit, there was no flow.		2	
202	OF-4-02		7/30/04		●				●			●		concrete	18 inch	submerged		●			●	Mostly submerged in river.		2	LF
203	OF-4-07		10/14/05				●	●										●	●		●	Outflow from the Singleton Street Pumping Station.			
204	OF-4-03		7/30/04		●				●			●		CMP	18 inch		●	●	●		●	Drains adjacent to salvage yard.		2	LF
205	OF-4-08		7/30/04		●			●		●					5 feet		●	●	●			Partly drains Cold Spring Park.		2	
206	OF-4-06		7/30/04		●				●			●		CMP, plugged	18 inch		●		●		●	Shared drainage area with OF-204?			
207	OF-4-14		7/30/04		●				●			●		PVC	6 inch		●				●	Coming out of wall of beige industrial building, 3 m above the ground; wall stained; rocks without vegetation below.	1	1	4

Figure 5-14 *(cont.)*: Blackstone River - Points of Stormwater Runoff (from upstream to downstream for respective communities)

				Survey Mode				River Bank		Type						Dry Weather Flow ?		Drainage Area					Further Investig.*(6)*		
Report ID (OF-___)	Laboratory/ Field ID	Other Field/Lab ID or Town ID	Survey Date	Shore / Land	Boat / Canoe	Mun. Engin. Off.	from map	Left *(2)*	Right *(2)*	Brook	Culvert	Pipe	Other	Material/ Comments	Width / Diameter	Yes (cfs)	None	Road	Residential	Wooded	Industrial/Comm.	Comments	Dry Weather	Wet Weather	Comment
208	OF-4-09		7/30/04		●				●			●		clay	20 inch *(3)*		●				●			2	LF
209	OF-5-01		7/30/04		●			●				●			18 inch		●	●			●			1	
210	OF-5-18a		7/30/04		●			●				●		PVC, blue	10 inch		●				●	Foamy material in front of pipe; drains oil loading facility; flow suspected to be minor.	1	1	LF
211	OF-5-18b		7/30/04		●			●				●		clay	12 inch		●					Flow rate likely small.		1	LF
212	OF-5-19		7/30/04		●			●					●	Control gate			●				●	Does not seem to be operating.			
213	OF-5-02		7/30/04		●				●			●		CMP	36 inch		●	●	●		●		2	2	LF
214	OF-5-03		7/30/04		●				●			●		concrete	48 inch	0.14		●	●		●	Dry weather flow.	2	2	LF
215	OF-5-20		7/30/04		●				●				●	Grated opening	3 feet wide	(submerged)						Appears to be former intake structure.			
216	OF-5-07		7/30/04		●				●			●		CMP	10 inch		●	●	●			Small drainage area.			
217	OF-5-05		7/30/04		●			●				●		clay	15 inch *(4)*		●	●			●	May also drain parking lot of old mill.			
218	OF-5-06		7/30/04		●				●			●		CMP	30 inch		●	●	●			Costa Park. Appears to have low flow.		1	LF
219	OF-5-04	W-31	7/30/04		●				●	●				Cherry Brook	6 feet	2 to 3		●	●		●		2	2	
220	OF-5-08		n/s				●		●				●	open ditch			●	●							
221	OF-5-25		n/s				●	●				●		15 inch			●	●			●				
222	OF-5-23		7/30/04		●				●				●	Parking lot overflow	3 feet wide		●	●	●		●				
223	OF-5-09		n/s				●		●			●			12 inch			●	●		●				
224	OF-5-10		n/s				●		●			●						●				Very small drainage area.			
225	OF-5-11		7/30/04		●				●			●			42 inch		●	●				Size of drainage area appears to be small not justifying the size of the pipe. Other source?		2	LF, 4
226	OF-5-12		7/30/04		●				●			●		concrete	16 inch *(5)*		●				●	Appears to have small drainage area.			
227	OF-5-24		7/30/04		●				●			●		metal	2.5 or 3 inch		●	●			●	Pipe extending from a building on River Street.		1	LF
228	OF-5-13		n/s				●	●				●			12 inch			●			●	Appears to have small drainage area.			
229	OF-5-14		n/s				●	●				●			15 inch			●			●	Appears to have small drainage area.			
230	OF-5-15		10/5/05	●					●		●				18 inch		●	●			●			1	
231	OF-5-16	W-32	10/5/05	●					●	●		●			48 inch		●	●	●		●	Drains a brook; has large drainage area.		2	LF

Figure 5-14 *(cont.)*: Blackstone River - Points of Stormwater Runoff (from upstream to downstream for respective communities)]

				Survey Mode				River Bank		Type						Dry Weather Flow ?		Drainage Area					Further Investig.*(6)*		
Report ID (OF-___)	Laboratory/ Field ID	Other Field/Lab ID or Town ID	Survey Date	Shore / Land	Boat / Canoe	Mun. Engin. Off.	from map	Left *(2)*	Right *(2)*	Brook	Culvert	Pipe	Other	Material/ Comments	Width / Diameter	Yes (cfs)	None	Road	Residential	Wooded	Industrial/Comm.	Comments	Dry Weather	Wet Weather	Comment
232	OF-5-26		n/s				●	●				●										Unknown pipe.			
233	OF-6-01		n/s				●		●			●			30 inch			●	●						
234	OF-6-02		n/s				●		●		●				3x3 feet			●	●					1	
235	OF-6-03		7/30/04	●								●		concrete	15 inch		●	●			●	Drains Market Square and River Island Park with lots of geese.		2	
236	OF-6-25		7/30/04		●				●			●		clay	8 inch		●	?			●				
237	OF-6-04		7/30/04		●				●			●			20 inch		●	●	●		●				
238	OF-6-06		11/14/05	●				●										●				Drains parking lot.			
239	OF-6-05		11/14/05	●				●			●							●			●	Access difficult.		2	LF
240	OF-6-07		7/30/04		●			●				●		several pipes	various		●				●	Inactive? Pipes extend underneath old mill building.			
241	OF-6-26		7/30/04		●				●			●		several pipes	various		●				●	Inactive? Likely discharge pipes from the old mill building.			
242	OF-6-32			●				●				●			30 inch	0.01		●			●	Drainage area appears to be mainly Truman Drive.		2	LF
243	OF-6-08		n/s				●	●				●			48 inch						●			3	LF
244	OF-6-10		7/30/04		●			●				●			18 inch		●	●			●			2	LF
245	OF-6-11		7/30/04		●				●					oval opening	36x48 inch				●		●		1	2	LF
246	OF-6-12		7/30/04		●				●			●			12 inch			●			●		1	1	LF
247	OF-6-13		7/30/04		●			●				●			72 inch		●	●			●		2	3	LF
248		W-13	7/30/04		●			●					●	Mill River		yes		●	●	●	●				
249			n/s				●	●					●					●	●		●	Overflow of Pump station.			
250		W-16	7/30/04		●			●					●	Peters River		yes		●	●	●	●				
251	OF-6-14		7/30/04		●			●				●			24 inch		●	●	●						
252	OF-6-30		7/30/04		●				●			●			24 inch		●	?				Source unknown. Not on City's storm line plans.	2	2	LF
253	OF-6-15		n/s		●			●				●			18 inch			●							
254	OF-6-16		n/s		●			●				●			12 inch			●							
255	OF-6-17		n/s		●			●				●			27 inch			●	●					1	
256	OF-6-18		n/s		●			●										●							

Figure 5-14 *(cont.)*: Blackstone River - Points of Stormwater Runoff (from upstream to downstream for respective communities)]

				Survey Mode				River Bank		Type						Dry Weather Flow ?		Drainage Area					Further Investig. *(6)*		
Report ID (OF-___)	Laboratory/ Field ID	Other Field/Lab ID or Town ID	Survey Date	Shore / Land	Boat / Canoe	Mun. Engin. Off.	from map	Left *(2)*	Right *(2)*	Brook	Culvert	Pipe	Other	Material/ Comments	Width / Diameter	Yes (cfs)	None	Road	Residential	Wooded	Industrial/Comm.	Comments	Dry Weather	Wet Weather	Comment
257	OF-6-20		n/s		●			●				●			15 inch			●			●				
258	OF-6-19		7/30/04		●				●			●			60 inch		●	●			●	A private 12" drainage pipe connects to it (from commercial parking lot?)		3	LF
259	OF-6-21		n/s					●				●			12 inch			●							
260	OF-6-22		n/s					●				●			24 inch			●							
261	OF-6-31		n/s						●				●									Overflow from Pumping station.			
262	OF-6-23	W-33	7/30/04		●			●		●						1 to 2		●	●		●	Outflow from Sylvestre Pond; flows underneath Woonsocket WWTF.		2	LF
263	OF-6-24		7/30/04		●				●			●			36 inch	0.03		●	●		●		2	3	
264	OF-6-33		7/30/04		●				●			●				partly submerg.						Inactive? Not on City's storm line plans.			
265		W-24	7/30/04		●			●				●				submerged					●	Treated discharge of Woonsocket WWTF.			
266	OF-8-02		11/14/05	●				●				●		brook?	48 inch	0.5			●		●		2	2	
Mill River																									
701	OF-7-20		11/29/05	●									●	small gully		0.03		●			●	Could be seepage from dam of Harris Pond.		1	4
702	OF-7-23		11/29/05	●								●		two pipes			●	●							
703	OF-7-22		11/29/05			●						●			24 inch		?	●	●					3	
704	OF-7-19		11/29/05	●								●			36 inch		●	●	●		●			2	4
Peters River																									
801	OF-7-21		11/29/05			●		●				●		then open trench	12 inch		?	●							
802	OF-7-18		11/29/05	●				●				●		concrete	24 inch	1.5		●	●		●	Includes wetland.		2	
803	OF-7-17		11/29/05	●				●	●			●		4 pipes	12 inch		●	●							
804	OF-7-15		11/29/05	●				●					●	paved open drain	6 ft wide		●	●			●				
805	OF-7-16		11/29/05	●					●			●			18 inch		?	●	●			Pipe was half submerged in the river. Appeared without flow.	1	2	LF
806	OF-7-14		11/29/05	●				●				●			18-24 inch		?	●				Pipe was half submerged in the river. Appeared without flow.			
807	OF-7-13		11/29/05	●					●			●		concrete	12 inch		●	●							

Figure 5-14 *(cont.)*: Blackstone River - Points of Stormwater Runoff (from upstream to downstream for respective communities)]

				Survey Mode				River Bank		Type						Dry Weather Flow ?		Drainage Area					Further Investig.*(6)*		
Report ID (OF-___)	Laboratory/ Field ID	Other Field/Lab ID or Town ID	Survey Date	Shore / Land	Boat / Canoe	Mun. Engin. Off.	from map	Left *(2)*	Right *(2)*	Brook	Culvert	Pipe	Other	Material/ Comments	Width / Diameter	Yes (cfs)	None	Road	Residential	Wooded	Industrial/Comm.	Comments	Dry Weather	Wet Weather	Comment
808	OF-7-12		11/29/05	●					●			●		several	4 inch		●					Appears to drain groundwater behind retention wall.			
809	OF-7-11		11/29/05	●					●			●		PVC, white	8 inch		●					Source unknown.		1	4
810	OF-7-10		11/29/05	●				●				●		ribbed PVC	6 inch		●		●			Lawn drain.			
811	OF-7-09		11/29/05	●					●			●		several	4 inch		●		●		●	Appear to drain largely groundwater behind retention wall.			
812	OF-7-08		11/29/05	●					●			●			6 inch		●		●			Appears to drain groundwater behind retention wall.			
813	OF-7-07		11/29/05	●				●				●		ribbed PVC	6 inch		●		●			Pipe originates at adjacent condominium complex.			
814	OF-7-06		11/29/05	●					●			●		5 pipes	4 inch		●					Appear to drain groundwater behind retention wall.			
815	OF-7-05		11/29/05	●				●				●		ribbed PVC	24 inch	0.1			●			There was a "soapy patch" in river from dry weather discharge.	2	2	4
816	OF-7-04		n/s			●		●				●			18 inch			●							
817	OF-7-03		11/29/05	●				●	●			●		4 pipes	12 inch		●	●							
818	OF-7-02		11/29/05	●					●			●		clay	15-18 inch		●				●		1	2	
819	OF-7-01		11/29/05	●				●				●		clay	6 inch		●		?			Inactive.			
Cumberland																									
350	OF-350		n/s			●		●				?						●	●			Drains into quarry.			
351	OF-351		n/s			●		●				?						●	●			Drains into quarry.			
352	OF-352		n/s			●		●				?						●	●			Drains into quarry.			
336	OF-336		11/30/05	●				●				●			12-18 inch		●	?				Active. Could drain road and/or parking lot of apartment complex. It may be a remnant pipe from former industrial facilities on the site.			
334	OF-334		10/5/05	●		●		●		●						2		●	●	●			2	2	LF
354	OF-354		n/s			●		●				?						●	●						
333	OF-333		10/5/05	●		●		●		●								●	●	●	●	Wetland just upstream from Albion Road.	2	2	
353	OF-353		n/s				●	●			●				42x48 inch			●				Drains Route 295, east of river.		2	LF
326	OF-326		10/6/05	●				●				●		clay	8 inch		●	●				Drains Route 116, southbound lane, east of river.			
327	OF-327		10/6/05	●				●				●		clay	8 inch		●	●				Drains Route 116, northbound lane, east of river.			
330	OF-330		10/6/05	●				●				●		clay	12 inch		●				●	In wall at former Ashton Mill.			

Figure 5-14 *(cont.)*: Blackstone River - Points of Stormwater Runoff (from upstream to downstream for respective communities)]

				Survey Mode				River Bank		Type						Dry Weather Flow ?		Drainage Area					Further Investig.(6)		
Report ID (OF-___)	Laboratory/ Field ID	Other Field/Lab ID or Town ID	Survey Date	Shore / Land	Boat / Canoe	Mun. Engin. Off.	from map	Left (2)	Right (2)	Brook	Culvert	Pipe	Other	Material/ Comments	Width / Diameter	Yes (cfs)	None	Road	Residential	Wooded	Industrial/Comm.	Comments	Dry Weather	Wet Weather	Comment
331	OF-331		10/6/05	●				●				●		metal	6 inch		●				●	In wall at former Ashton Mill, welded shut.			
325	OF-325		10/6/05	●				●			●			concrete	4x4 feet		●		●			Discharges water from Scott Brook.		2	
324	OF-324		10/6/05	●				●				●		corrugated metal	24 inch	0.05					●	Appears to drain industrial facility around Ashton Park Way.	3	3	LF, 4
304	OF-304		10/6/05	●				●				●		corrugated metal	12 inch	0.5 - 1					●	Outfall of Okonite plant.	2	2	LF
305	OF-305		10/6/05	●				●				●		clay	12 inch		●	?				Source unknown. Inactive?			
323	OF-323		10/6/05	●				●				●		concrete	24 inch		●					Drainage area not certain (parking lot, road?).	1	2	LF, 4
321	OF-321		10/7/05	●				●						channel			●				●	Channel that drains the pond that captures stormwater drainage from the Stop & Shop parking lot.			
320	OF-320		10/6/05	●				●				●		concrete, flared	24 inch		●			●	●	Drains underneath bike path; for Stop & Shop parking lot overflow during large rainstorms.			
319	OF-319		10/6/05	●				●				●		corrugated metal, flared concrete end	30 inch		●	●			●				
303	OF-303		10/6/05	●				●		●				intermittent			●			●		Drains to wetland; from there to OF-301 during large storms.			
302	OF-302		10/5/05	●				●				●		concrete, flared	36 inch	0.01		●	●	●			2	3	
301	OF-301		10/5/05	●				●					●	channel/pipe	36" (pipe)		●					Drains the large wetland north of the Peterson-Puritan site.		2	HR
318	OF-318		10/6/05	●				●				●		clay	18 inch		●				●	Likely drains parking lot of Ann& Hope building.		2	
317	OF-317	W-35	10/6/05	●				●			●			concrete	4x8 feet	0.25			●		●	Odor, low dissolved oxygen in the dry weather flow.	3	3	4
316	OF-316		10/6/05	●				●					●	surface overflow			●		●			There is supposed to be a drainage pipe at this location, but this pipe may be covered up by dumping.		2	
314	OF-314		10/6/05	●				●				●		concrete?	24 inch			●		●	●				
313	CF-313		10/6/05	●				●				●		metal or clay	12 inch							Not sure if this an intake pipe or a drainage pipe.			
311	OF-311		10/6-7/05	●				●				●		concrete, flared	24 inch	0.3 - 0.5			●		●	Apparently drains much of High Street.		2	
312	OF-312		10/6/05	●				●				●		concrete	24 inch		●		●						
Lincoln																									
441	OF-441		11/29/05	●						●						25				●		Drains reservoir and wooded lands.			
440	OF-440		11/29/05	●								●		concrete	24 inch		●	●				Appears to drain Route 99.			
438	OF-438	BLA01W	11/29/05	●		●			●			●		concrete	24 inch	0.10			●			Drains small residential area. Drains to Blackstone Canal, then to river.			
437	OF-437	BLA02W	11/29/05	●		●			●			●			24 inch	0.10		●	●			Drains to Blackstone Canal, then to river .			

Figure 5-14 *(cont.)*: Blackstone River - Points of Stormwater Runoff (from upstream to downstream for respective communities)]

				Survey Mode				River Bank		Type						Dry Weather Flow ?		Drainage Area					Further Investig. *(6)*		
Report ID (OF-___)	Laboratory/ Field ID	Other Field/Lab ID or Town ID	Survey Date	Shore / Land	Boat / Canoe	Mun. Engin. Off.	from map	Left *(2)*	Right *(2)*	Brook	Culvert	Pipe	Other	Material/ Comments	Width / Diameter	Yes (cfs)	None	Road	Residential	Wooded	Industrial/Comm.	Comments	Dry Weather	Wet Weather	Comment
436	OF-436	BLA03W	11/29/05	●		●			●			●		ribbed PVC	15 inch		●					Drains railroad bed only. Flows to Blackstone Canal, then to river .			
435	OF-435	BLA04W	11/29/05	●		●			●		●			granite	2 x 2 feet	0.15		●	●			Several pipes drain into culvert.	2	3	
442		BLA05W	11/29/05	●		●			●			●		PVC, ribbed	18 inch		●		●		●	Flows in part as open channel along railroad track.			
448	OF-335	BLA06W	11/29/05	●		●			●			●		CMP	21-24 inch	0.05 (11/29/05)	●		●		●		3	3	
433		BLA07W	11/29/05	●		●			●			●		concrete/metal ?	15 inch		●					Appears to be inactive.			
449		no No.	11/29/05			●			●			●		concrete	12 inch		●		●			Drains primarily New River Road and Angle Street.			
431	OF-431	BLA08W	11/29/05	●		●			●	●				concrete	3 feet	1.2			●			small brook.			
432	OF-432	no No.	11/29/05	●		●			●			●		metal	12 inch		●	●	●				2		
430	OF-430		11/29/05	●					●	●				Mussey Brook		4			●	●		Mussey Brook drains through Handy Pond.		2	
443	OF-443	BLA09W	11/14/05	●		●			●			●		concrete	21 inch	0.26			●			Drains primarily area around Kennedy Blvd. Discharges groundwater?			
429	OF-429	no No.	11/14/05	●		●			●			●		metal	15 inch		●	●	●						
445	OF-445	BLA10W	11/14/05	●		●			●			●		concrete	18 inch		●	●	●						
446	OF-446	BLA11W	11/14/05	●		●			●			●		concrete	30 inch			●	●			Edge of pipe was 2 feet below water surface of the river.			
428	OF-428	BLA12W	9/14/05	●		●			●			●		concrete, flared	24 inch (2x)	1.2			●			Small brook.	2	2	
424	OF-424		11/14/05	●					●			●		concrete	12 inch		●					Drain small parking area on Albion Mill.			
425	OF-425		11/14/05	●					●			●		metal	4 inch		●				●	Drains into Blackstone Canal. Inactive.			
426	OF-426		11/14/05	●					●			●		metal	8 inch		●				●	Drains into Blackstone Canal. Inactive.			
422	OF-422		11/14/05	●					●			●		CMP	24 inch	0.05			●			May drain uphill residential area and/or groundwater.		2	
423	OF-423		11/14/05	●					●			●		metal	6 inch		●				●	Pipe leads to tank on-site. Inactive?			
427	OF-427		11/14/05	●					●	●						1.2			●			Drains part of Kirkbrae Country Club golf course.		2	
450			multiple	●					●				●	overflow weir	3 feet wide	variable		●	●	●		Northern overflow of Blackstone Canal.			
420	OF-420		10/6/05	●					●			●		clay	8 inch		●	●				Drains Route 116.			
421	OF-421		10/6/05	●					●			●		clay	8 inch		●	●				Drains Route 116.			
451	P-06	W-34	multiple	●					●				●	overflow weir	4 feet wide	variable		●	●	●		Southern overflow of Blackstone Canal.		3	

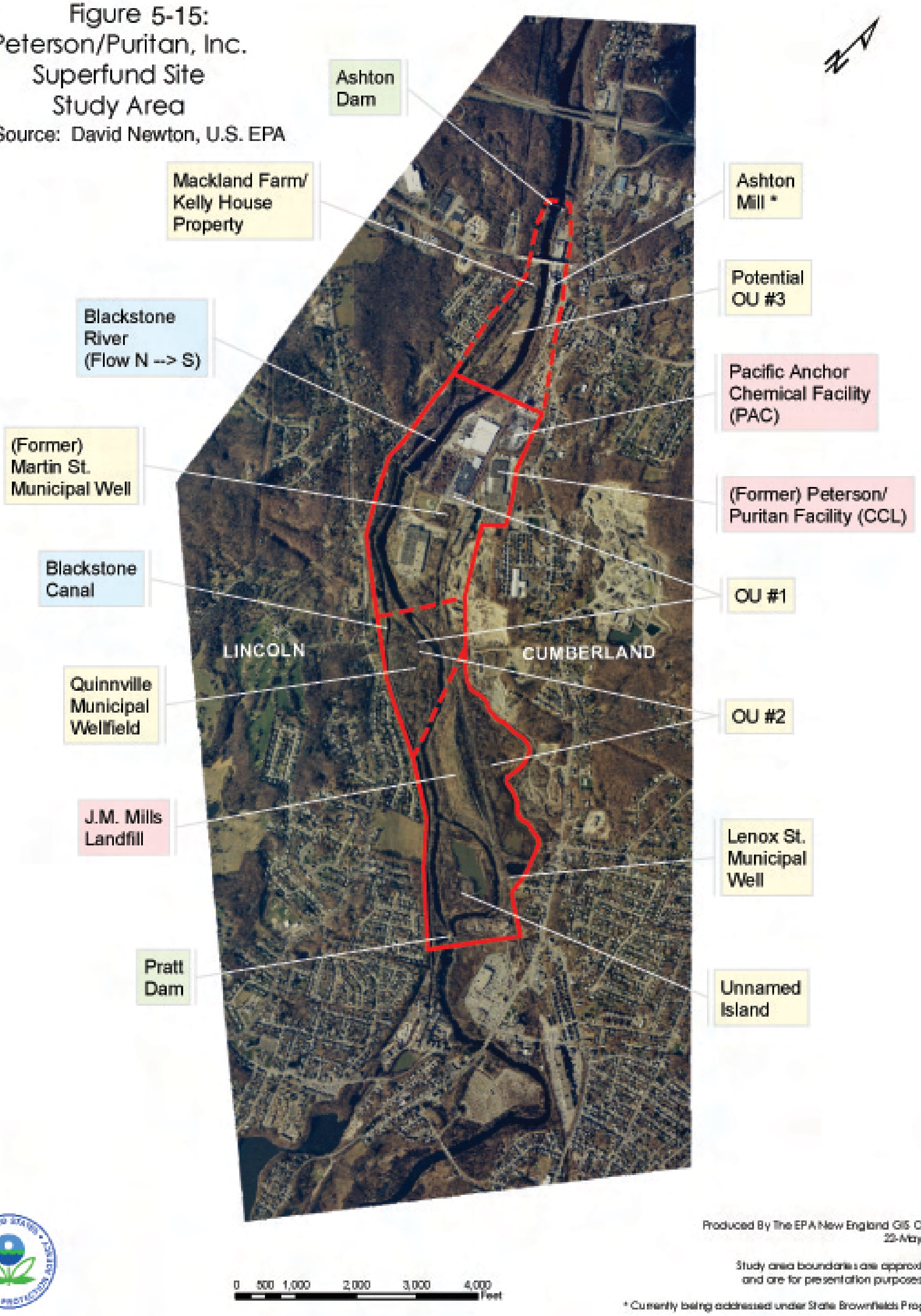
Figure 5-14 *(cont.)*: Blackstone River - Points of Stormwater Runoff (from upstream to downstream for respective communities)]

Report ID (OF-___)	Laboratory/ Field ID	Other Field/Lab ID or Town ID	Survey Date	Survey Mode				River Bank		Type						Dry Weather Flow ?		Drainage Area				Comments	Further Investig.*(6)*		
				Shore / Land	Boat / Canoe	Mun. Engin. Off.	from map	Left *(2)*	Right *(2)*	Brook	Culvert	Pipe	Other	Material/ Comments	Width / Diameter	Yes (cfs)	None	Road	Residential	Wooded	Industrial/Comm.		Dry Weather	Wet Weather	Comment
Lonsdale Bleachery, Lincoln																									
401	OF-401		10/5/05	●					●				●	groundwater seepage								Groundwater seepage from leaking oil storage tanks.			
419	OF-419		10/6/05	●					●			●			12 inch ?		●				●	Inactive?	1	1	LF
412	OF-412		10/6/05	●					●			●		clay / concrete ?	12 inch ?		●				●	Active?	2	2	LF
418	OF-418		10/6/05	●					●			●		metal	4 inch		●					Inactive?			
402	OF-402		10/6/05	●					●				●	former Tail Race			●				●				
411	OF-411		10/6/05	●					●			●		metal	10 inch		●					Inactive.			
415	OF-415		10/6/05	●					●			●		metal	6 inch		●					Inactive.			
416	OF-416		10/6/05	●					●		●			brick/stone	2.5 x 2 feet		●				●		1	1	LF
417	OF-417		10/6/05	●					●			●		metal	3 inch		●					Inactive.			
410	OF-410		10/6/05	●					●			●		concrete	24 inch		●				●	Active?		1	LF
409	OF-409		10/6/05	●					●			●		metal	8 inch		●					Inactive.			
414	OF-414		10/6/05	●					●		●			concrete	15x12 inch		●				●	Active?		1	LF
413	OF-413		10/6/05	●					●			●		corrugate metal	15 inch		●				●	Active.	2	2	LF
408	OF-408		10/6/05	●					●			●		clay	12 inch		●					Inactive.			
403	OF-403		10/5/05	●					●				●	animal farm runoff			●					Likely a larger non-point source of bacteria during rainstorms. Located approx. 100 yards west of the Bleachery.		2	
Central Falls																									
501	OF-501		10/6/05	●					●			●		CMP	48 inch	0.5		●	●			NBC CSO #007. Drains into Valley Falls Pond.	3	3	
502	OF-502		10/6/05	●					●			●		clay or metal	12 inch							Closed pipe underneath Blackstone River Tourism Council pier.			
Point sources between Broad Street Bridge and the mouth of the Blackstone River were not surveyed.																									
Pawtucket																									
Point sources between Broad Street Bridge and the mouth of the Blackstone River were not surveyed.																									

(1) Vegetation did not grow do to erosion from occasionally flowing water.
(2) Bank of respective stream, looking downstream.
(3) Woonsocket storm line plans lists a diameter of 18"; measured was 20".
(4) Woonsocket storm line plans lists a diameter of 18"; measured was 15".
(5) Woonsocket storm line plans lists a diameter of 12"; measured was 16".
n/s = not surveyed CMP = Corrugated metal pipe

(6) **Key to recommended further Investigations:**
LF = Sampling during low flow in Blackstone River.
HR = Sampling during storm with high rainfall amount.
1 = Reconnaissance investigation without sampling.
2 = Further reconnaissance investigation with sampling.
3 = Systematic sampling program.
4 = Tracing source of pipe.

Figure 5-15:
Peterson/Puritan, Inc.
Superfund Site
Study Area
(Source: David Newton, U.S. EPA



Produced By The EPA New England GIS Center
23-May-2006

Study area boundaries are approximate
and are for presentation purposes only.

* Currently being addressed under State Brownfields Program.

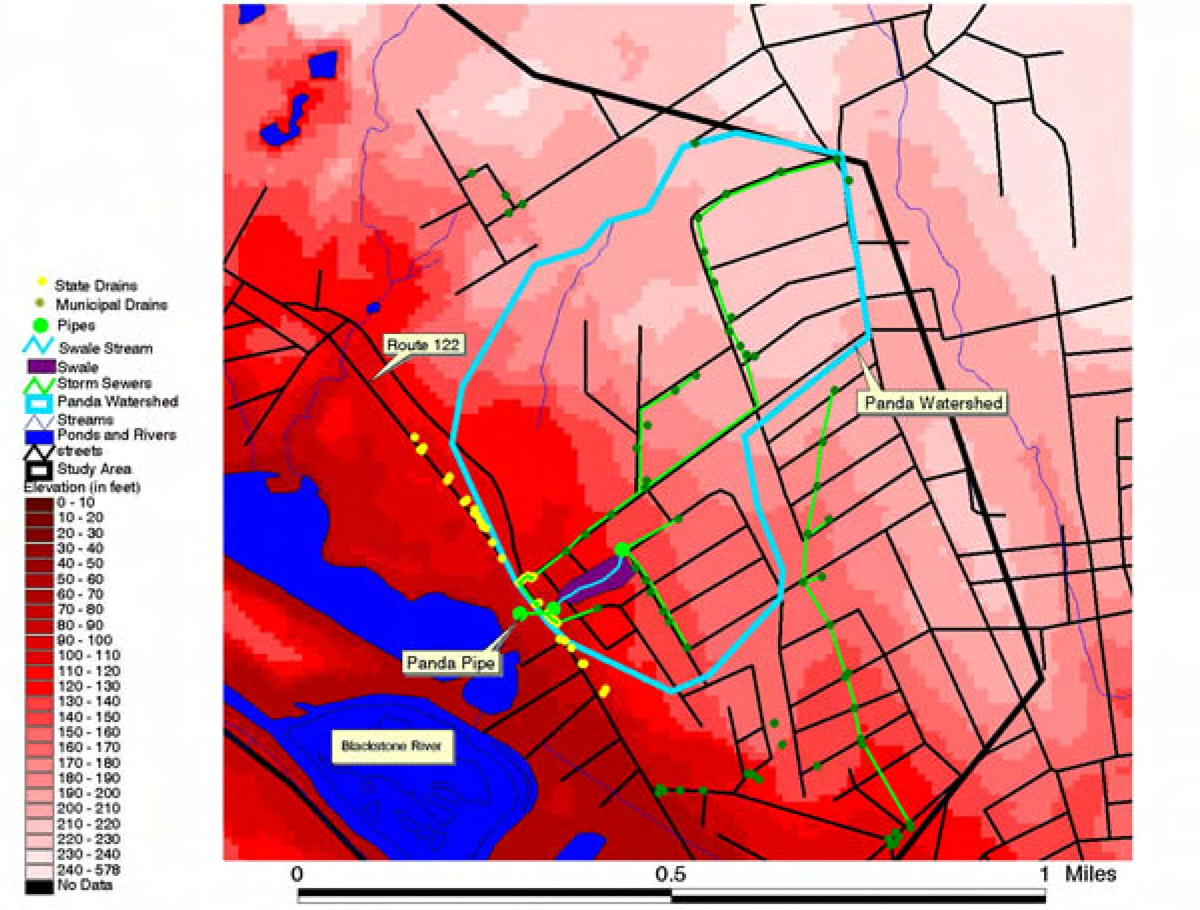


Figure 5-16: Watershed of Storm Drain from Marshall Avenue Area (Source: Brown University, 2003).

Figure 5-17: Water Quality of Point Sources to the Blackstone River and Scott Pond

Report ID (OF-___)	Laboratory/ Field ID	Other Field/Lab ID or Town ID	North Smithfield	Blackstone (MA)	Woonsocket	Cumberland	Lincoln	Central Falls	Pawtucket	Location	Event (OUTFALL-__)	Date	Time	Dry Weather	Wet Weather	Flow (estimate) cfs	Temperature ºC	Conductivity uS/ cm	Dissolved Oxygen mg/l	pH	Turbidity NTU	Fecal Coliform col/ 100 ml	Dissolved Copper ug/l	Dissolved Lead ug/l		Hardness mg/l	Comments
Town of Blackstone (MA)																											
601	OF-4-10			●						Fox Brook	01b	10/7/05	10:22	☐		0.5 - 1.0	17.9	319	8.2	7.2	0.2	**800**	1.4	<0.10		49	
											02	10/8/05	18:40		●	3	19.8	223	7.6	6.9	3.2	**2,200**	1.9	0.36		43	
City of Woonsocket																											
201	OF-4-01				●					Main Street / Gaskill Street	05	11/30/05	8:45		●	5		277		7.0	2.2	110	1.8	0.19		44	(9)
205	OF-4-08				●					Cold Spring Park	03	11/14/05	13:30	☐		0.05	14.6	589	7.8	7.1	0.6	40	1.8	**3.4**		100	
											05	11/30/05	8:33		●	0.2		458		6.8	20.6	**270**	5.3	**5.7**		38	
219	OF-5-04	W-31			●					Cherry Brook	05	10/7/05	11:09	☐		0.75	17.3	540	7.0	6.9	0.9	**300**	4.2	0.23		87	
231	OF-5-16	W-32			●					Front Street outfall	01b	10/7/05	11:35	☐		2.0	13.9	450	9.3	6.9	0.3	70	1.2	<0.10		66	
											05	11/30/05	8:10		●	5		271		7.0	7.7	**16,000**	3.1	**1.5**		36	
235	OF-6-03				●					River Island Park	02	10/8/05	18:00		●	0.03	21.9	125	7.4	7.0	24.4	**2,200**	**8.5**	**2.0**		23	
											03	11/14/05		☐		n/f											
											05	11/30/05	7:31		●	0.1		159		7.1	39.4	**800**	5.4	**1.4**		8	
242	OF-6-32				●					Truman Drive	03	11/14/05	12:25	☐		0.08	14.7		8.7	7.4	4.6	130	5.3	0.51		260	
											05	11/30/05	7:18		●	0.2		496		6.8	9.5	**3,000**	***12.0***	**3.7**		51	
243	OF-6-08				●					Truman Drive	03	11/14/05		☐		n/f											
											05	11/30/05	7:10		●	0.4		1,347		7.0	24.8	**1,700**	***17.0***	**8.1**		4	
244	OF-6-10				●					north of railroad crossing	03	11/14/05		☐		n/f											
											05	11/30/05	7:08		●	0.2		79		7.1	15.5	130	5.4	**3.4**		4	
247	OF-6-13				●					just west of mouth of Mill River	02	10/8/05	17:47		●	3.50	21.6	132	7.4	6.7	8.1	**>16,000**	**8.9**	**4.6**		23	
											05	11/30/05	7:50		●	?											(7)
258	OF-6-19				●					NW of Hamlet Street	02	10/8/05	16:49		●	0.25	21.0	37	8.2	7.0	6.8	**>16,000**	***12.0***	**3.3**		9	
											05	11/30/05	7:55		●	?											(7)
262	OF-6-23	W-33			●					Sylvestre Pond outflow	01b	10/7/05	12:06	☐		1.0	20.3	324	7.8	6.6	2.6	**230**	1.6	0.60		40	
											02	10/8/05	19:15		●	6	21.0	263	8.3	6.7	3.5	**1,300**	2.2	0.74		38	
263	OF-6-24				●					Davison Avenue	01b	10/7/05	12:15	☐		0.15	20.3	442	8.3	7.2	0.4	**500**	1.9	0.38		55	
											02	10/8/05	16:56		●	2.5	21.9	53	8.1	6.5	5.1	**>16,000**	**7.1**	**2.4**		8	
											05	11/30/05	7:47		●	1		298		7.0	19.6	**2,400**	6.6	**3.5**		27	
266	OF-8-02				●					CVS Distribution Center	03	11/14/05	14:09	☐		0.5	12.6	522	9.8	7.5	1.0	<20	2.9	0.10		83	
											05	11/30/05	6:38		●	6		62		7.1	11.1	**220**	4.8	0.70		4	

Figure 5-17 *(cont.)*: Water Quality of Point Sources to the Blackstone River and Scott Pond

Report ID (OF-___)	Laboratory/ Field ID	Other Field/Lab ID or Town ID	North Smithfield	Blackstone (MA)	Woonsocket	Cumberland	Lincoln	Central Falls	Pawtucket	Location	Event (OUTFALL-__)	Date	Time	Dry Weather	Wet Weather	Flow (estimate) cfs	Temperature ºC	Conductivity uS/ cm	Dissolved Oxygen mg/l	pH	Turbidity NTU	Fecal Coliform col/ 100 ml	Dissolved Copper ug/l	Dissolved Lead ug/l		Hardness mg/l	Comments
Mill River																											
W-11	W-11				●					Mill River, near MA/RI border	04	11/29/05	15:13	☐		135	4.5	259	14.2	7.2	4.8	170	1.6	0.35		27	
701	OF-7-20				●					north of Privilege Street	04	11/29/05	15:30	☐		0.03	10.5	248	9.0	6.9	8.0	20	1.0	<0.10		37	
704	OF-7-19				●					East School Street	04	11/29/05		☐		n/f											
											05	11/30/05	7:00		●	0.5		59		6.9	16.8	**2,400**	5.7	**7.2**		5	
Peters River																											
W-14	W-14				●					Peters River, near MA/RI border	04	11/29/05	14:43	☐		32.5	7.8	314	10.0	7.1	0.8	20	1.2	0.18		42	
802	OF-7-18				●					Diamond Hill Road	04	11/29/05	14:23	☐		1.5	9.6	330	10.5	7.7	1.2	40	2.0	0.27		66	
											05	11/30/05	6:45		●	5		174		7.0	8.4	110	2.5	1.1		24	
805	OF-7-16				●					Salisbury Street	04	11/29/05		☐		n/f?											
											05	11/30/05	6:50		●	2		70		7.1	9.2	**2,200**	4.9	**2.2**		3	
815	OF-7-05				●					River Haven Condominium	04	11/29/05	13:48	☐		0.1	14.3	597	9.7	7.5	0.3	<20	1.7	<0.10		80	
W-15	W-15				●					Peters River, at Elm Street	04	11/29/05		☐		35											
Town of Cumberland																											
334	OF-334					●				Brook near Manville Dam	01b	10/7/05	13:06	☐		2.0	19.4	377	8.1	7.2	0.8	**220**	3.2	0.19		54	
											02	10/8/05	16:27		●	2.50	20.3	269	8.7	7.1	1.2	**800**	3.8	0.37		41	
											05	11/30/05	9:09		●	7		236		7.1	1.6	**700**	1.6	0.40		36	
333	OF-333					●				Sneech Brook	01b	10/7/05	13:27	☐		0.5	19.9	424	7.0	6.6	0.8	**1,300**	1.6	<0.10		76	
											02	10/8/05	15:46		●	2.00	19.7	395	7.3	7.0	6.5	**2,400**	2.2	0.11		83	
											05	11/30/05	9:56		●	6		559		7.0	2.1	**800**	2.3	0.28		67	
353	OF-353					●				Route 295	03	11/14/05	14:37	☐		1	14.1		9.0	7.6	0.1	<20	4.5	<0.10		140	
326/327	OF-326/327					●				Route 116 bridge	02	10/8/05	15:25		●	0.045	22.3	101	8.1	7.6	5.0	**>16,000**	4.0	0.86		16	(1)
325	OF-325					●				Scott Brook at Ashton Mill	02	10/8/05	15:08		●	2.00	20.9	189	8.5	7.1	18.5	**>16,000**	6.3	0.94		34	
											05	11/30/05	10:04		●	12		309		7.2	0.3	200	1.5	0.18		54	
324	OF-324					●				John Dean Memorial Blvd	01a	10/6/05	13:50	☐		0.05							6.3	**2.10**		43	
											01b	10/7/05	13:50	☐		0.001											
											02	10/8/05	14:52		●	0.41	20.9	99	7.8	6.8	12.1	**>16,000**	***11.0***	0.85		14	
											03	11/14/05	15:00	☐		0.30	13.8	734	7.8	7.6	4.3	**9,000**	***16.0***	0.27		96	
											05	11/30/05	10:12		●	0.5		542		7.0	11.5	**>16,000**	4.1	0.25		87	

Figure 5-17 *(cont.)*: Water Quality of Point Sources to the Blackstone River and Scott Pond

Report ID (OF-____)	Laboratory/ Field ID	Other Field/Lab ID or Town ID	North Smithfield	Blackstone (MA)	Woonsocket	Cumberland	Lincoln	Central Falls	Pawtucket	Location	Event (OUTFALL-__)	Date	Time	Dry Weather	Wet Weather	Flow (estimate) cfs	Temperature ºC	Conductivity uS/cm	Dissolved Oxygen mg/l	pH	Turbidity NTU	Fecal Coliform col/100 ml	Dissolved Copper ug/l	Dissolved Lead ug/l		Hardness mg/l	Comments
304	OF-304					●				Okonite outfall	05	10/6/05	13:16	☐		0.5 - 1.0							4.0	<0.10		91	
											01b	10/7/05	13:45	☐		0.5 - 1.0	22.9	305	7.7	7.0	5.1	130	3.8	<0.10		62	
											02	10/8/05	14:38		●	1.25	22.0	268	8.2	7.4	7.3	170	5.5	0.38		73	
											03	11/14/05	14:50	☐		0.40	15.9	412	8.5		1.5	**>16,000**	3.5	0.29		110	
											05	11/30/05	10:16		●	0.8		275		7.2	79.3	**>16,000**	4.3	1.3		75	
302	OF-302					●				near Panda Restaurant	01b	10/7/05	14:05	☐		0.001						**>16,000**					
											02	10/8/05	14:28		●	0.13	20.9	115	8.2	6.4	69.2	**>16,000**	***14.0***	**11.0**		19	
											05	11/30/05	10:25		●	2		209		7.4	23.2	**1,700**	**6.8**	0.76		46	(9)
301	OF-301					●				Canal from wetland	02	10/8/05	14:20		●	n/f											
											05	11/30/05	10:36		●	4		251		7.2	1.3	<20	2.9	0.41		57	
318	OF-318					●				Ann & Hope, south of parking lot	02	10/8/05	14:25		●	0.27	22.7	51	8.2	6.0	19.4	**9,000**	***14.0***	**1.7**		5	
											05	11/30/05	10:44		●	0.5		45		7.3	11.9	500	**6.7**	1.1		4	
317	OF-317					●				Brook near Ann & Hope	05	10/6/05	11:07	☐		0.25							3.1	0.10		43	
											01b	10/7/05	14:07	☐		0.5	23.7	266	5.1	6.7	5.4	**16,000**	***12.0***	0.14		41	
											02	10/8/05	14:22		●	0.3 - 0.5	22.2	151	7.8	6.9	8.4	**>16,000**	***23.0***	0.76		26	
											03	11/14/05	15:35	☐		0.70	14.4	438	7.5	7.5	0.0	**>16,000**	2.0	<0.10		79	
											05	11/30/05	10:50		●	6		332		6.7	16.1	**>16,000**	**7.1**	**2.0**		44	
316	OF-316					●				River Street	05	11/30/05	10:55		●	0.3		158		7.2	34.7	**3,000**	**9.2**	**4.2**		9	
311	OF-311					●				Outfall, Abbot Run Brook - West	01a	10/6/05	10:01	☐		0.50							1.3	<0.10		54	
											01b	10/7/05	15:00	☐		0.30	18.9	227	7.0	6.5	3.0	**500**	1.5	0.11		37	
											02	10/8/05	13:47		●	1.20	20.9	107	7.3	7.3	18.5	**>16,000**	***14.0***	**2.3**		17	
											03	11/14/05	15:45	☐		0.20	14.4	310	7.5	7.7	0.4	140	1.6	<0.10		61	
											05	11/30/05	11:42		●	6		58		7.1	18.6	**5,000**	**7.0**	**2.4**		4	
312	OF-312					●				Outfall, Abbot Run Brook - East	02	10/8/05	13:50		●	<0.5											
											05	11/30/05	11:42		●	0.7											
Town of Lincoln																											
438	OF-438	BLA01W					●			northern Manville	04	11/29/05	11:28	☐		0.10	11.5	395	10.3	7.6	1.0	20	2.6	0.10		66	(5,6)
437	OF-437	BLA02W					●			Vose Street	04	11/29/05	11:10	☐		0.10	9.0	720	10.7	7.8	0.1	40	2.8	0.10		91	
											05	11/30/05	9:00		●	0.3		519		6.8	2.0	**500**	2.7	0.40		65	

Figure 5-17 *(cont.)*: Water Quality of Point Sources to the Blackstone River and Scott Pond

Report ID (OF-____)	Laboratory/ Field ID	Other Field/Lab ID or Town ID	North Smithfield	Blackstone (MA)	Woonsocket	Cumberland	Lincoln	Central Falls	Pawtucket	Location	Event (OUTFALL-__)	Date	Time	Dry Weather	Wet Weather	Flow (estimate) cfs	Temperature ºC	Conductivity uS/cm	Dissolved Oxygen mg/l	pH	Turbidity NTU	Fecal Coliform col/100 ml	Dissolved Copper ug/l	Dissolved Lead ug/l		Hardness mg/l	Comments
435	OF-435	BLA04W					●			Winter Street	04	11/29/05	10:59	☐		0.15	10.9	471	10.2	8.0	5.5	**2,400**	2.3	0.20		74	
											05	11/30/05	9:25		●	0.3		283		7.0	25.2	**>16,000**	5.1	**1.7**		35	
448	OF-335	BLA-06W					●			Manville Hill Road bridge	02	10/8/05	16:02		●	0.42	22.8	26	7.9	7.2	12.8	**>16,000**	**8.2**	**3.2**		11	
											04	11/29/05		☐		0.05											(4)
											05	11/30/05	9:16		●	0.05		206		7.2	58.6	**3,000**	**9.2**	**4.3**		10	(11)
431	OF-431	BLA08W					●			Brook at Northern Lincoln Elem. School	04	11/29/05	10:45	☐		1.2	10.3	472	10.3	7.8	0.7	80	2.0	0.18		73	clear
430	OF-430						●			Mussey Brook	03	11/14/05	12:10	☐		2.00	10.8		9.3	7.5	0.2	<20	1.8	<0.10		100	
											04	11/29/05		☐		4											
443	OF-443	BLA09W					●			Pipe entering Mussey Brook	03	11/14/05	12:15	☐		0.26	12.1	650	9.1	7.4	0.05	<20	1.5	<0.10		130	(3)
	BLA-09W										04	11/29/05	10:35	☐		1.3	11.0	630	9.3	8.0	0.12	**300**	1.6	<0.10		120	
											05	11/30/05	9:34		●	1		535		6.8	0.08	<20	1.7	0.12		110	(12)
428	OF-428	BLA12W					●			Brook just downstream of Albion Dam	03	11/14/05	11:50	☐		1.2	12.1	390	8.6	7.3	0.9	<20	2.7	0.30		49	
											05	11/30/05	9:50		●	7		295		7.0	1.0	**230**	3.3	0.61		36	
422	OF-422						●			Albion Mill	03	11/14/05	11:05	☐		0.05	11.9	299	10.6	8.1	2.2	20	<1.0	<0.10		56	(2)
											04	11/29/05	9:07	☐		0.05											
											05	11/30/05	9:40		●	0.3						**1,700**	1.4	<0.10		57	
427	OF-427						●			Brushwood Drive	03	11/14/05	11:40	☐		1.2	12.3	580	9.8	7.6	0.3	20	1.5	<0.10		80	
451	P-06						●			Blackstone Canal weir	01b	10/7/05	14:30	☐		0.4	19.1	511	8.3	6.8	2.2	<20	2.5	0.10		82	
413	OF-413						●			Lonsdale Bleachery	05	11/30/05	11:05		●	0.5		312		6.8	20.7	130	3.2	**1.5**		62	
Scott Pond																											
405	OF-405						●			Scott Pond, Walker Street	05	11/30/05	11:10		●	0.5		62		6.8	24.3	**5,000**	***7.3***	**9.4**		5	
407	OF-407						●			Scott Pond, Walker Street	02	10/8/05	14:10		●	0.005	22.0	69	8.6	7.4	33.0	**2,400**	***17.0***	**5.2**		22	(8)
											05	11/30/05	11:13		●	0.02											(10)
City of Central Falls																											
501	OF-501							●		NBC CSO #107	01b	10/7/05	14:52	☐		0.1 - 0.2	16.9	554	7.1	6.6	0.3	**16,000**	1.6	0.10		130	
											02	10/8/05	14:00		●	0.50	17.8	390	7.1	6.6	3.2	**16,000**	3.4	0.47		94	
											05	11/30/05	11:34		●	3.5		218		6.7	16.7	**>16,000**	5.9	**3.6**		38	

n/f = No flow.
(1) The sample is a composite of OF-326 and OF-327 (the two drains from the Cumberland side of the bridge. Each drain had a flow of 0.022 cfs.
(2) Small oil sheen near pipe.
(3) Sample OF-443 was labeled OF-431 in Chain-of Custody and Laboratory Reports. Correction is noted on Data CD.
(4) Discharge point to river; no flow upgradient by rail tracks.
(5) Sampled upslope from CMP, prior to flowing into the channel toward OF-438.
(6) Sample OF-438 accidentally labeled OF-429 for MITKEM lab (fecal coliform).
(7) 50% submerged, no distinct flow visible.
(8) Runoff seemed to come from Walker Street.
(9) STL sample submitted as separate batch (Lab Batch ID: 360-995)
(10) Raining at the time of the survey.
(11) Sample collected upgradient of railtrack. At the wall adjacent to the Manville Dam downgradient, the flow was 0.4 cfs, reflecting an additional source to the outfall.
(12) Sample OF-443 accidentally labeled as OF-438 for MITKEM and STL labs.

6.0 BIODIVERSITY

The Blackstone River is listed as impaired for biodiversity on the 303(d) list. The determination for this listing was based on the following types of historic biological monitoring data (Connie Carey, RIDEM, personal communication, June 1, 2004):

- Rapid Bioassessment Protocol (RBP) monitoring at Manville for shallow river sites, carried out by Roger Williams University; and

- Artificial Substrate Monitoring (AS) for deep river habitat using plate samplers, carried out by Bob Richardson from RIDEM (now retired), at Millville (MA) and at the Manville Dam (RI).

Monitoring benthic macroinvertebrate assemblages has been used as an indicator of stream conditions for many years (Cairns and Pratt, 1993). Plate samplers used for the AS monitoring tend to sample the epifaunal community. As such, the results tend to be biased toward certain aquatic species that are more likely to colonize on the samplers. The samplers may simply act as a focal point for colonization by invertebrates in areas where other suitable substrates are unavailable. The RBP method allows for a more complete representation of the invertebrate community at the station, but there is local variability caused by varying types of river bottom and depth. Results from AS monitoring may differ from results of other biomonitoring techniques such as RBP monitoring. Therefore, simultaneous AS and RBP monitoring generally provides complimentary information for benthic community assessments.

6.1 Methodology

As part of this study, the biodiversity in the Blackstone River was monitored again with both methods to determine the current level of impairment. The biodiversity assessment was conducted in the summers of 2004 and 2005 at the following stations (Figures 6-1 and 6-2):

- **Station M-01** *(AS):* At Millville (MA), upstream of the MA/RI State line (same station as occupied by Bob Richardson). This station was located close to water quality monitoring station W-01. Specifically, the station was located on the southern side of the river, approximately 30 m (100 feet) downstream from the railroad bridge. The samplers were suspended from birch trees that hung over the water.

- **Station M-02** *(AS):* Upstream of Manville Dam (same station as occupied by Bob Richardson). This station was located adjacent to water quality monitoring station W-02. The station was located on the eastern side of the river, approximately 15 m (50 feet) upstream from the dam. The samplers were suspended from a forked silver maple that overhung the water.

- **Station M-03** *(RBP):* Downstream of Manville Dam in shallow wadeable riffle area (station of previous macroinvertebrate assessments by Roger Williams University). This station was located approximately 10 m (300 feet) downstream of Station M-02.

- **Station M-04** *(RBP):* Wood River (reference station for RBP assessments; same station as occupied by Roger Williams University in the past).

- **Station M-05** *(AS):* Wood River (Skunk Hill Road; reference station for AS analyses; same station as occupied by Bob Richardson). Specifically, the Wood River station was located approximately 15 m (50 feet) downstream from the Skunk Hill Road bridge over the river in

Hopkinton, Rhode Island. The samplers were hung from a stand of sweet pepper bushes on the south side of the river.

The RBP survey was conducted by ESS, Inc. as part of their state-wide assessment (Appendix E). The AS survey was conducted by Berger staff. Protocols established by RIDEM were followed for biological sampling, taxonomic identification, determination of metrics, and evaluation of data.

6.1.1 Rapid Bioassessment Protocol Monitoring

ESS sampled the Blackstone River at Manville (M-03) on August 30, 2004 and September 2, 2005. Aquatic macroinvertebrates were sampled within the fast run/riffle habitat just downstream of the Manville dam, but upstream of the Manville Road bridge (Figure 6-1). The Wood River reference station (M-04) was sampled on August 20, 2004 and August 19, 2005 (Figure 6-2). Aquatic macroinvertebrates were sampled downstream of the dam and Old Nooseneck Road. The monitoring of the macroinvertebrate community was conducted according to USEPA's Rapid Bioassessment Protocols (RBPs) (Barbour et al., 1999), and the appropriate QAPP (ESS, 2002).

6.1.1.1 Habitat Assessment

The habitat quality was assessed at both stations using a *Habitat Assessment Field Data Sheet for High Gradient Streams*, which was similar to data sheets recommended by the USEPA (Barbour et al., 1999). The habitat assessment process involves rating ten habitat parameters as optimal, sub-optimal, marginal, or poor based on the USEPA-developed criteria. These parameters consist of instream cover, epifaunal substrate, embeddedness, channel alteration, sediment deposition, frequency of riffles/velocity-depth combinations, channel flow status, bank vegetative protection, and riparian vegetative zone width. A more detailed description of these parameters as well as the completed assessment sheets are attached in the complete report by ESS (Appendix E).

The habitat assessment included physical characterization and in-field measurements of water quality parameters. This information served as further insight into the ability of the stream to support a healthy aquatic community. Physical characterization included documenting surrounding land use; subsystem classification; presence or absence of dams, local water erosion and potential sources of non-point source pollution; width, depth and flow; inorganic and organic substrate types; and presence of odors, oils and deposits. Water quality parameters measured in the field included dissolved oxygen, pH, specific conductance, turbidity, temperature, and flow.

For the habitat data analysis, the “habitat assessment matrix” approach was used. This approach was developed in Plafkin et al. (1989), but has since been modified to include additional assessment parameters for high gradient streams. The approach weighs various habitat parameters to emphasize those parameters that are biologically most significant. All parameters are evaluated for each stream segment studied and rated on a numerical scale of 0 to 20 (highest). The ratings are then totaled and compared to the score of the appropriate reference station. This provides a final habitat ranking in the form of a “percent comparability measure”. Scores increase as habitat quality increases.

The score for the Blackstone River station (M-03) was compared to the Wood River reference station (M-04). The ratio between the score for the two stations provided a percent comparability measure. The Blackstone River station was then classified on the basis of its similarity to expected conditions (as represented by the reference station).

6.1.1.2 Macroinvertebrate Assessment

Macroinvertebrate sampling was conducted following the USEPA approach (Barbour et al., 1999). This approach entailed sampling benthic macroinvertebrates from riffle/run communities at the selected stream segments. Taxonomic identification and enumeration of the macroinvertebrates were conducted by ESS and laboratories subcontracted by ESS (Aquatic Resource Center, Inc.; Nashville, TN; Dr. Doug Smith [Smith, 1995], a retired UMASS professor). Macroinvertebrate data were analyzed by employing a number of USEPA approved metrics (Plafkin et al., 1989). Select metrics were used to develop an empirical value representative of the macroinvertebrate community at the Blackstone River station (M-03). These results were compared to the Wood River reference station (M-04). Details of the sampling, data sheets, laboratory procedures, and data analysis are described in Appendix E.

6.1.2 Artificial Substrate Monitoring

Data were collected to evaluate and compare current instream biological community conditions of the Blackstone River with conditions observed over the last 10 years. RIDEM had conducted this sampling effort using Fullner-multiple plate artificial substrate sets with 14 square plates. Each plate had an area of 2.5 x 2.5 inches (6.35 x 6.35 cm) and a thickness of 0.1 inch (0.25 cm). The same plates were used for both the 2004 and 2005 sampling efforts. Fullner multiple-plate artificial substrates were deployed in early September 2004 and August 2005 in accordance with methods in USEPA (1990) and the QAPP submitted to RIDEM.

Two stations were located along the Blackstone River in Millville (M-01) and at the Manville Dam (M-02, close to RBP station M-03). One station was located along the Wood River for reference (M-05, close to RBP reference station M-04). The samplers were deployed in the same locations and depths as they were in the past. At each station, two or three samplers were either suspended above the substrate (using a flotation device), or suspended from the water surface with nylon rope and secured with an anchored line at a depth of approximately 0.45 to 0.6 m (1.5 to 2 feet) below the water surface.

The artificial substrate samplers were left in place for approximately 8 weeks to allow for proper organism colonization. Recovery techniques were critical for insuring collection of all organisms retained on the sampler. To minimize loss of organisms during retrieval, we approached from downstream of the site, placed the entire intact samplers into individual tubs of screened water, and dismantled onsite. Each individual piece of the substrate was rinsed, examined visually, and placed in a labeled plastic storage bag. The water in the bucket was then poured through a standard No. 30 sieve to remove fine particles. Organisms left scattered over the surface of the screen were picked from the screen with forceps and placed in the sample container for preservation in 70-80% ethanol. After sampling was completed at a given site, all sieves, pans, etc. that came in contact with the sample were rinsed thoroughly, examined carefully, and picked free of any remaining organisms or debris. Any additional organisms found were placed into the appropriate sample containers. The equipment was examined again prior to use at the next sampling site.

Water quality parameters recorded during deployment and recovery consisted of temperature, dissolved oxygen, pH, specific conductance, turbidity, and relative flow.

Laboratory processing of all samples was performed within two weeks after collection. Berger sorted and identified all organisms in each sample using a dissecting microscope. Organisms were preserved in 70% ethanol solution and were later identified to family level using appropriate keys. Primary reliance was placed on the taxonomic keys for macroinvertebrates in Northeastern North America in Peckarsky et al. (1990), but a number of taxonomic references were used for more specific identification (Mason, 1973; Merritt and Cummins, 1996; Pennak, 1978; Stewart and Stark, 2002; Wiggins, 1996; and Thorp and Covich, 1991).

Macroinvertebrates (mostly aquatic insect larvae) collected on the artificial substrates were classified according to their tolerance of pollutants. All organisms were enumerated and placed in one of the categories described below:

- *Intolerant or Sensitive (Class I Organisms):* Organisms that are not found associated with even moderate levels of organic contaminants and generally intolerant of even moderate reductions in dissolved oxygen.

- *Facultative or Intermediate (Class II Organisms):* Organisms having a wide range of tolerance and frequently associated with moderate levels of organic contamination.

- *Tolerant (Class III Organisms):* Organisms frequently associated with gross organic contamination and generally capable of thriving under periods of anaerobic conditions, some even in the presence of toxic wastes.

The investigation used Beck's Biotic Index to assess environmental quality in the Blackstone River and the Wood River reference site. Beck's Biotic Index is a score that weighs the taxonomic richness of the sample and the tolerance of the taxa to pollution (Beck, 1954). According to this approach, an undisturbed community will include representatives of the majority of the groups contained in Class I as well as some representatives of Classes II and III. By contrast, a sample which consists mainly of Class II organisms is being "limited" or impacted by either natural factors, such as low flow, homogenous substrate, etc., or is impacted due to human activities. Waters dominated by Class III organisms are probably adversely affected by organic pollution and are not included in the index calculation.

6.2 Results

6.2.1 Rapid Bioassessment Protocol Monitoring

The habitat scores for the Blackstone River station (M-03) for years 2004 and 2005 suggest that the habitat of the Blackstone River station was “supporting” (Figure 6-3). The water quality at the Blackstone River stations at the time of sampling was good and largely comparable to the water quality at the Wood River station (Figure 6-4). Dissolved oxygen levels were high and turbidity was low, although turbidity was slightly higher at the Blackstone River station in 2005 compared to 2004. However, specific conductance levels were high in 2004 and 2005 compared to the Wood River station, which could be indicative of anthropogenic sources of pollution. In addition, the water temperature at the Blackstone River station was a few degrees higher than that observed at the reference station M-04 in both 2004 and 2005.

Macroinvertebrate taxa observed at the two stations are presented in Figure 6-5, organized under their relevant class, order, or family. Summary statistics for years 2004 and 2005 are presented in Figure 6-6 and 6-7, along with published historic data from previous years. In 2004 and 2005, the Blackstone River station (M-03) was generally comparable to the reference station (M-04) for many of the metrics calculated, although the scores were typically indicative of relatively poor water and/or habitat quality at the Blackstone River station. However, these metrics should be interpreted in light of the fact that the Blackstone River at station M-03 is larger, both in catchment area and stream order, than the Wood River at station M-04. The size of the Blackstone River catchment area is approximately 1,180 km^2 (454 square miles); the size of the Wood River catchment area is approximately 230 km^2 (89 square miles).

In 2004, total taxa richness and EPT taxa richness were actually slightly higher at the Blackstone River station than at the reference station. However, in 2005 these two metrics were much lower at the Blackstone River station compared to the reference station, which is indicative of relatively poor water and habitat quality. In addition, the Hilsenhoff Biotic Index was higher at the Blackstone River station and was classified as "good" compared to "very good" at the reference station in both 2004 and 2005, which suggests that a greater degree of organic pollution existed at the Blackstone River station than at the reference station (Hilsenhoff, 1987). Furthermore, the percentage of Hydropsychidae caddisflies was greater at the Blackstone River station than at the reference station in 2004 and 2005. Hydropsychidae, although included in EPT taxa metrics, are perceived to be pollution-tolerant relative to other more pollution-sensitive Trichopterans (Barbour et al., 1999), therefore this is also indicative of environmental stress at the Blackstone River station.

The metrics calculated for the Blackstone River station in 2004 and 2005 were improved in nearly every case compared to metrics calculated from 1998 through to 2001 (Figure 6-6). Taxa richness and "percent dominant taxon" in 2004 and 2005 were both markedly improved compared to the 1998 to 2001 set of results, which may, in part, be due to the less detailed taxonomic identification achieved in those previous studies. The only metric to score worse in 2004 and 2005 compared to metrics calculated from 1998 to 2001 was the EPT to chironomid ratio. This metric was lower in 2004 (and then lower again in 2005) than was observed at any time from 1998 to 2001, which indicates that the population was more skewed toward chironomids in 2004 and 2005 than was previously observed. Chironomids are generally more pollution-tolerant than EPT taxa, which suggest that the Blackstone River station was under more environmental stress in 2004/2005 than in previous years (Plafkin et al., 1989).

The ratio of scrapers to filterers was lower in 2004 and 2005 than was observed in 1998, 2000 or 2001 (Figure 6-6). These lower numbers indicate a macroinvertebrate community more dominated by filter feeders than was previously observed at the Blackstone River station. Domination by filter feeders is indicative of an overabundance of suspended fine particulate organic matter and also of filamentous algae and aquatic mosses, which are both associated with organic enrichment (Plafkin et al., 1989). This may suggest that there was an increase in organic enrichment at the Blackstone River station over the past few years, a conclusion that is supported by the fact that the Hilsenhoff Biotic Index value increased (i.e., worsened) slightly at the Blackstone River station in 2005 compared to 2004. However, increased levels of fine particulate organic matter are also associated with stream reaches downstream of impoundments, as occurs at the Blackstone River Station M-03. Therefore, high abundances of filter feeders might be expected to occur even without additional organic enrichment. The increase in filter feeders appears to have been progressive since 2000, although there was a slight decrease in 2005 compared to 2004.

Also of note, there were no shredders found at the Blackstone River station (M-03) in 2005, which was consistent with data collected from 2000, although some shredders were found at the Blackstone River station in 1998, 1999, 2001 and 2004. Shredders are good indicators of toxic effects and are particularly sensitive to riparian zone impacts (Plafkin et al., 1989).

The Blackstone River station was classified as "Slightly Impaired" in both 2004 and 2005, with percent comparability scores of 79% and 61%, respectively (Figure 6-7). The percent comparability scores ranged between 21% and 69% from 1994 to 2001. The results of this RBP assessment indicate that, overall, the macroinvertebrate community at the Blackstone River station in 2004 was the healthiest it had been since biomonitoring began in 1994. The results of this assessment also suggest that the health of the macroinvertebrate community declined slightly in 2005 compared to 2004. However, this was matched by a similar decline at the reference station in 2005, so that the overall the biological condition category remained the same. In addition, the apparent differences in the metrics and the percent comparability scores from 2004 to 2005 may be attributed to natural variation associated with weather patterns, population dynamics, or other dynamic forces.

6.2.2 Artificial Substrate Monitoring

The water quality during the AS monitoring at both Blackstone River stations (M-01 and M-02) was good, and was largely comparable to the reference station (M-05) (Figure 6-8). The dissolved oxygen concentrations ranged from 7.4 to 10.2 mg/l in 2004 and 6.9 to 9.6 mg/l in 2005. The water temperature varied slightly between stations. The water temperature in the Blackstone River was a few degrees higher than at the reference station in both 2004 and 2005. As also observed during the RBP monitoring, the specific conductance and turbidity were higher in the Blackstone River than at the reference station, although these parameters remained relatively stable between years. The flow rate was slow along the shoreline where the multiple-plate samplers were secured, but adequate dissolved oxygen concentrations were measured.

The distribution of the macroinvertebrates to the taxonomic level of family from the artificial substrate monitoring is presented in Figure 6-9. In 2004, a total of 105 organisms were collected at Station M-01, 318 organisms at Station M-02, and 64 organisms at reference station M-05. In 2005, a total of 63 organisms were collected at Station M-01, 333 organisms at Station M-02, and 44 organisms at reference station M-05.

Overall, the assemblages at the Blackstone River stations were similar in composition to each other, but were less diverse than at the M-05 Wood River reference station. Biological impairment of the benthic community is generally indicated by the absence of pollution-sensitive macroinvertebrates such as ephemeroptera, plecoptera, and trichoptera (EPT) and the dominance of pollution-tolerant families such as Chironominidae and Oligochaete taxa (Plafkin et al., 1989). The Blackstone River stations M-01 and M-02 contained both pollution-tolerant and pollution-sensitive species. Station M-02 had considerably more chironomids colonizing on the plates than any other station for both 2004 and 2005 with the total abundance of chironomids increasing almost threefold in 2005. Plecoptera, many of which are very intolerant of low oxygen, were present only at Station M-01 in 2005 but none were found in 2004 at any station.

The taxa richness ranged from 2 to 6 families between the various stations and years. Taxa richness (i.e., the number of distinct taxa) reflects the diversity within a sample. Taxa richness usually consists of species-level identifications but, in this case, was evaluated as designated groupings of a higher taxonomic group (i.e., family) in the assessment of invertebrate assemblages. Increasing diversity correlates with increasing health of the assemblage and suggests that niche space, habitat, and food source are adequate to support survival and propagation of many species (Barbour et al., 1999).

The structure of the benthic macroinvertebrate community in waterways enriched by organic waste differs quantitatively from communities in unpolluted waterways. That is, organic enrichment results not just in a reduction in taxa richness, but also in an increase in relative abundance (Mandaville, 2000). Station M-02, in particular, exhibited reduced taxa richness and an abundance of chironomids representing 38% and 98% of the total abundance in the sample in 2004 and 2005, respectively. Chironomids and other pollution-tolerant taxa were absent at the Wood River reference station in 2004; however, 12 chironomids (27% of the sample) were collected in 2005.

The diversity of the macroinvertebrate community varied little between Stations M-01 and M-02 in 2004. In 2005, the diversity was lower at Station M-02 than in 2004. Specifically, the benthic assemblages at both Blackstone River stations had a Biotic Indic (BI) of 4 in 2004, reflecting a moderately impaired benthic community compared to the Wood River reference station M-05, which had a BI of 8 (Figure 6-9). In 2005, the BI at Station M-01 was 7, while the BI at Station M-02 was only 1 due to the dominance of pollution-tolerant species and poor taxa richness. Biomonitoring results for the period 1974 to the present reveal a variable BI ranging from 0 to 8 at the two Blackstone River stations (Figure 6-10). Generally, the BI was within the range of values for the last 30 years for both stations. Within just the last eight years, the BI has been slightly higher on average in 2004 and 2005 at both stations.

As expected, the macroinvertebrate community conditions at the Wood River reference station M-05 reflected good quality habitat supported by the reach. The benthic community conditions at this station were characterized by relatively high total taxa richness, high mayfly/stonefly/caddisfly taxa richness, and low dominance by one taxon. Over the past decade, the BI at Station M-05 ranged from 7 to 13. The 2004 and 2005 data suggest that this station is slightly impaired possibly due to a recent infestation of fanwort (*Cabomba caroliniana*) below the Skunk Hill Road bridge and backwatered areas.

In general, the macroinvertebrate assemblages at the Blackstone River stations were dominated by amphipods and chironomids in 2004. In 2005, amphipods were less abundant, while pollution-tolerant species were more abundant. At the family level, amphipods are generally classified as moderately tolerant (facultative) of organic pollution, although there is considerable variation among individual species, ranging from very tolerant to very intolerant. Similarly, certain species of chironomids are more tolerant of stressors such as metal pollution, and may be dominant in habitats exposed to metal discharges where EPT taxa cannot persist; therefore, they provide a good indicator of the presence of metal toxicity (Winner et al., 1980). Shredders, such as amphipods, are good indicators of toxic effects and are sensitive to habitat impacts (Plafkin et al., 1989). However, based on the existing data from Station M-02 where taxa richness was poor, the main stressor appears to be organic loading and not metal toxicity (Berger, 2004). This conclusion is supported by the data collected in 2004 and 2005 at Station M-02 where the taxa that are known to be sensitive to organic enrichment are not as common at M-02 as compared to the reference station. For example, Station M-02 has relatively few Coleoptera (beetle) taxa, but the single taxa that was present at M-02 in 2004 is the Coleoptera *Ancyronyx* sp. that is the beetle taxon that is least sensitive to organic enrichment in the study. Similarly, the Ephemeroptera (mayfly) taxa that were observed to occur at Station M-02 were dominated by *Baetis* sp., the mayfly taxon that is least sensitive to organic enrichment in the study. Organic loading was the basis for placing the Blackstone River on the 303(d) list for biodiversity impairments.

6.3 Conclusions

Impairment of the benthic community may be indicated by the absence of generally pollution-sensitive macroinvertebrate taxa; dominance of a particular taxon; low taxa richness; or shifts in community composition relative to the reference station (Plafkin et al. 1989). Both Blackstone River sites were similar in family composition and percent similarity compared to the Wood River reference station. During the AS survey, Station M-02 had a higher percentage of pollution-tolerant species (38% in 2004 and 98% in 2005) than Station M-01 (17% in 2004 and 67% in 2005). All stations, including the reference station, exhibited an increase in pollution-tolerant species in 2005 compared to 2004. A slightly increased presence of more pollution-tolerant species at the two Blackstone River stations during the 2005 survey suggests a slight decline in macroinvertebrate community health compared to 2004. However, a similar decline in macroinvertebrate community health was observed at the M-05 reference station.

The RBP survey resulted in similar trends. Station M-03 (near Station M-02) was “slightly impaired”, both in 2004 and 2005. The health of the macroinvertebrate community declined slightly in 2005 compared to 2004. However, this was matched by a similar decline at the reference station in 2005, so that the overall the biological condition category remained the same.

Based on 2004 and 2005 results and historic data (Figures 6-7 and 6-10), the Blackstone River benthic community at the M-01 and M-02 stations were slightly to moderately impaired. This finding reflects a very slight overall decrease in impairment over the last two decades.

Comparing the Biotic Index over the last 10 years (Figures 6-10), the level of impairment at the Manville Dam (M-02) is slightly higher than at the Millville station (M-01). This finding suggests that organic loading is added in the Woonsocket reach of the river between the MA/RI State line and Manville. The Manville data, however, may be affected by the location of the M-02 station. Specifically, Station M-02 is positioned only 15 m (50 feet) upstream of the stone wall of the Manville Dam. Sediments behind the dam may be affected by localized effects such as higher sediment accumulation rates and occasionally lower dissolved oxygen conditions. By comparison, the Millville station is located approximately 1.6 km (1 mile) upstream from the Tupperware Dam.

The nutrient data obtained during the wet and dry weather monitoring suggest that approximately three quarters of the nutrient load measured at the Manville Dam is contributed by Massachusetts. Additional nutrients are added within Reach 1 (Woonsocket), which could also explain the slightly higher Biotic Index at Station M-02 as compared to Station M-01.

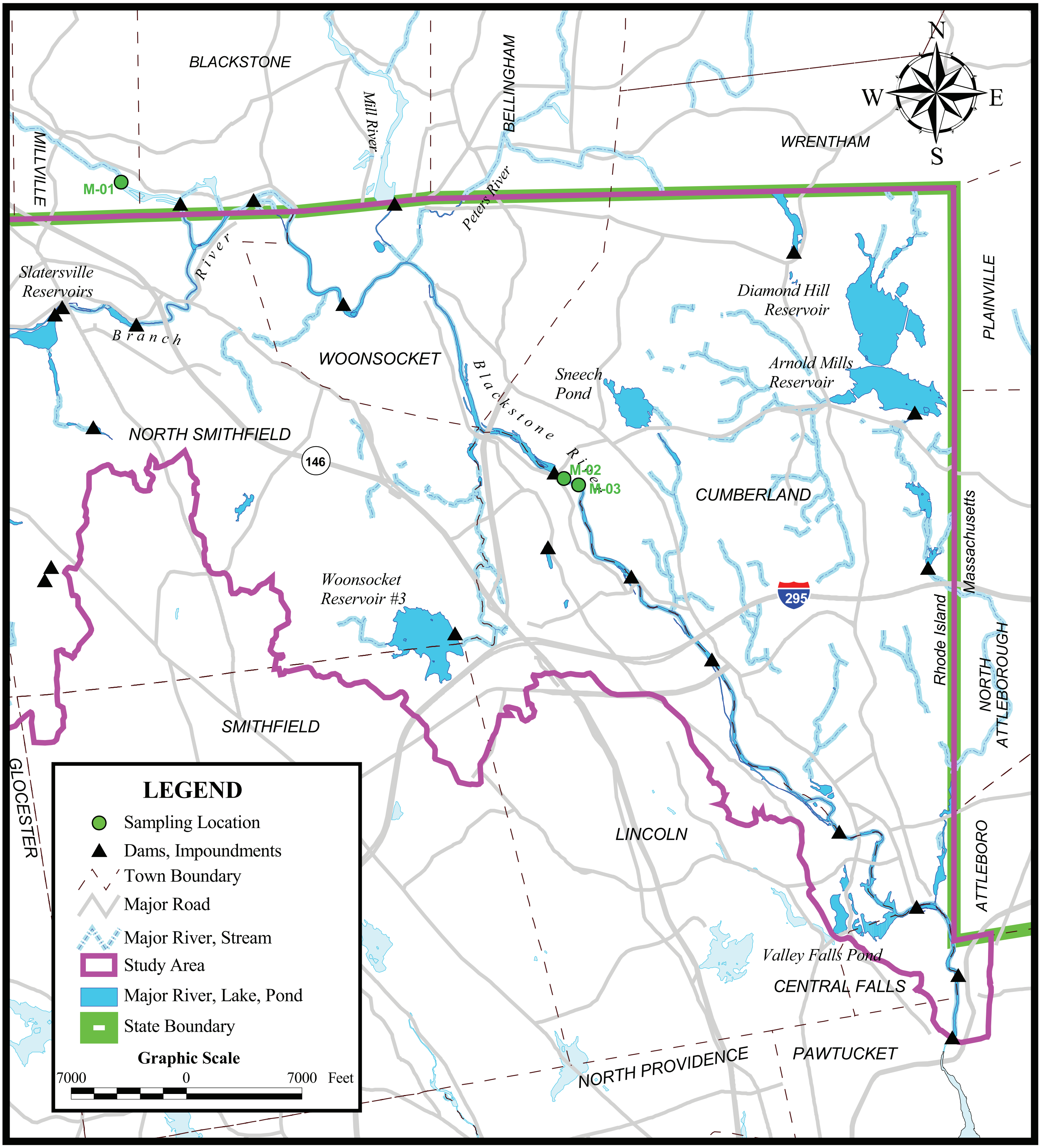
Based on the historic data from the Manville station, the main stressor appeared to be organic loading (Berger, 2004), and this was supported by the 2004 and 2005 data collected in this study. Isolating the relevant stressors can be very expensive, as direct measurements cannot be performed. On the other hand, likely improvements to the water quality as part of the mitigation for other contaminants on the 303(d) list will also have a positive impact on the biodiversity in the river.

6.4 Recommendations

Additional data would need to be collected (using comparable sampling and data analysis techniques) to better understand natural trends in the macroinvertebrate community at the Blackstone River station and thus be able to distinguish between natural changes and those potentially caused by anthropogenic impacts.

In addition, at Manville, a second station should be chosen that is located at least 400 m (0.25 miles) upstream of the dam to be compatible to the conditions at the M-01 station. At the same time, the current station M-02 should be maintained to allow for comparisons with historic data.

Given the possibly less impaired conditions at the Millville Station (M-01) compared to the Manville Dam station (M-02), we also recommend artificial substrate monitoring upstream of the Thundermist Dam. The recommended location is just upstream of the Fairmont Street bridge. This location would capture effects from the Branch River, but not from the Mill and Peters Rivers.



The Louis Berger Group, Inc.

Rhode Island DEM

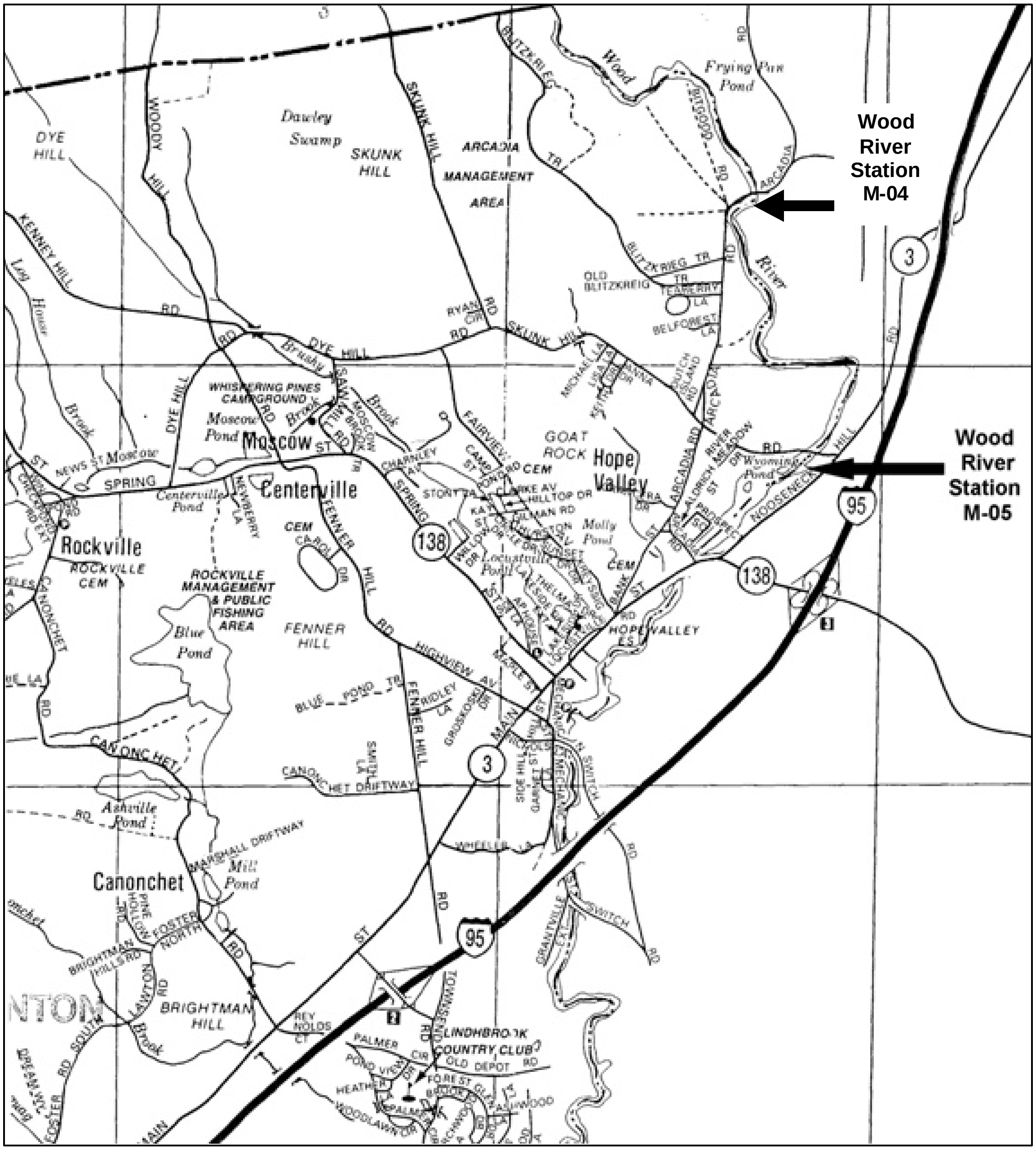
Source: RIGIS, MASSGIS

File: bw-report-07.apr

Blackstone River Water Quality

Figure 6-1

MACROINVERTEBRATE SAMPLING STATIONS



Wood River Station M-04

Wood River Station M-05

Figure 6-2: Reference stations along the Wood River for Artificial Substrate Assessment (M-05) and Rapid Bioassessment Protocol (M-04)

Figure 6-3: Habitat Assessment Score and EPA Assigned Assessment Category for the Blackstone River at Manville Dam based on a comparison with the Reference Station for the Southern New England Coastal Plains and Hills Ecoregion, 2004 and 2005

Station	Habitat Score *(1)*	Percent of Comparability to Reference Station	EPA Assessment Category
2004 Survey			
Blackstone River at Manville dam (M-03)	152	86.9	Supporting
Wood River Reference Station (M-04)	175		
2005 Survey			
Blackstone River at Manville dam (M-03)	154	88.0	Supporting
Wood River Reference Station (M-04)	175		

(1) Habitat assessment methodology used for this study was comparable to that of the EPA Rapid Bioassessment Protocols for use in Streams and Rivers.

Figure 6-4: Water quality results for the Blackstone River at Manville Dam and the Reference Station for the Southern New England Coastal Plains and Hills Ecoregion, during 2004 and 2005.

Station	Date	Tempe-rature (°C)	Dissolved Oxygen (mg/l)	Dissolved Oxygen (% Saturation)	Turbidity (NTU)	pH	Specific Conductance (µmhos/cm)	Flow (cfs)
Blackstone River at Manville Dam (M-03)	8/30/2004	25.1	7.8	94.8	3.5	7.2	452	90
	9/2/2005	23.5	7.7	90.5	6.2	7.1	478	60
Wood River Reference Station (M-04)	8/20/2004	22.0	8.4	93.4	4.3	6.3	98	125
	8/19/2005	21.1	9.1	102.0	4.7	7.4	88	67

Figure 6-5: **Invertebrates at the Blackstone River at Manville Dam and Wood River from Rapid ioassessment Protocol Monitoring in 2004 and 2005**

Invertebrate Taxa	**Blackstone River (M-03)**		**Wood River Ref. Stn. (M-04)**	
	2004	**2005**	**2004**	**2005**
Bivalvia (Pelecypoda)				
Pisidiidae (Sphaeriidae)				
Musculium spp.	56	32		4
Pisidium sp.	12	112	16	
Crustacea				
Amphipoda				
Gammarus sp.		16		
Hyalella azteca			8	
Decapoda				
Orconectes sp.	4			
Gastropoda				
Valvatidae				
Valvata sp.		8		
Hirudinea				
Arhynchobdellida				
Erpobdellidae		8		
Insecta				
Coleoptera				
Ancyronyx sp. (Larvae)	8			
Microcylloepus sp. (Larvae)		8	8	24
Optioservus sp. (Larvae)			20	12
Oulimnius sp. (Adult)			8	8
Promoresia sp. (Larvae)			180	176
Promoresia sp. (Adult)			20	12
Diptera				
Antocha sp. (Larvae)	68			
Antocha sp. (Pupae)	16			
Bezzia sp.			4	
Chironomidae (Pupae)	16	8		
Chironomini	48	88	28	12
Hemerodromia sp. (Pupae)	8			
Hemerodromia sp.	8			
Orthocladiinae	108	48	160	40
Simulium sp.		8	12	16
Tanypodinae	4		28	8
Tanytarsini	172	296	16	28
Tipula sp.	4		4	
Ephemeroptera				
Acentrella sp.	36	8		
Attenella sp.			24	4
Baetis sp.	72	104		8
Centroptilum sp.			32	8
Heterocloeon sp.	4	64		
Paraleptophlebia sp.	4			
Stenacron sp.	4			
Stenonema sp.	24		52	92
Megaloptera				
Corydalus sp.			4	
Nigronia sp.			4	
Plecoptera				
Acroneuria sp.		8		4
Trichoptera				
Brachycentidae			24	
Brachycentrus sp.			20	4
Ceraclea sp.			4	
Ceratopysche sp.	232	400	144	76
Cheumatopsyche sp.	176	360	16	
Chimarra sp.	256	16		
Glossosoma sp.			4	
Hydropsychidae (Pupae)	12	16		4
Hydropsyche sp.	300	280	48	16
Hydroptila sp.	4			
Lepidostoma sp.				8
Leucotrichia sp.	12			
Macrostemum sp.	12		8	4
Mayatrichia sp.			4	
Micrasema sp.			36	
Ochrotrichia sp.	4			
Oecetis sp.			20	4
Nematoda			4	
Nemertea	4			
Oligochaeta				
Lumbriculidae				4
Naididae				16
Tubificida	8			4
Turbellaria	52	48		
Total Number	**1748**	**1936**	**960**	**596**

Figure 6-6: Biometric Indices

	Wood River Reference Station (M-04) *(1)*						**Blackstone River Station (M-03)** *(1)*					
	1998	**1999**	**2000**	**2001**	**2004**	**2005**	**1998**	**1999**	**2000**	**2001**	**2004**	**2005**
Total Number	100	100	100	100	960	596	100	100	100	100	1,748	1,936
Taxa Richness	6	5	12	15	31	26	6	4	6	12	32	21
Ratio Shredder/Total	0.06	0.25	0.33	0.35	0.0667	0.0134	0.01	0.01	0.00	0.08	0.2288	0.000052
EPT Index	90	74	18	61	14	12	95	91	76	69	15	9
FBI	4.20	4.36	4.76	4.43			4.36	4.62	5.00	5.33		
% Contribution of dominant taxon	82%	36%	19%	16%	19%	30%	79%	91%	46%	60%	17%	13%
Ratio Scrapers/Filterers	0.05	0.36	0.55	0.78	1.09	3.00	0.20	0.00	0.54	0.12	0.05	0.08
Ratio EPT/Chironomids			3.6	10.17	1.88	2.64	95	13	9.5	6.9	3.31	2.86
Community Loss							0.98	0.99	0.96	0.92	0.63	0.71
Jaccard Coefficient							0.200	0.125	0.286	0.421		
Hilsenhoff Biotic Index					3.85	3.67					4.81	5.15
Taxa Richness			6		6	6	6	3	3	3	6	6
Ratio Shredders/Total			6		6	6	0	0	0	0	6	0
EPT Index			6		6	6	6	6	6	6	6	2
FBI			6				6	6	6	6		
% Contribution of dominant taxon			0		6	4	0	0	0	0	6	6
Ratio Scrapers/Filterers			6		6	6	6	0	6	0	0	0
Ratio EPT/Chironomids			6		6	6	6	6	6	6	6	6
Community loss			3		6	6	3	3	3	3	4	4
Hilsenhoff Biotic Index					**6**	**6**					**6**	**0**
Total Score					**48**	**46**					**38**	**28**
Comparability Score							**68.8%**	**50.0%**	**62.5%**	**50.0%**	**79.2%**	**60.9%**

Sources: 1998 (Gould, 1998); 1999 and 2000 (Pomeroy, 2000), 2001 (da Silva, 2002).
2004 and 2005: This study (ESS, 2002)

(1) NOTE: The 1998 to 2001 data do not have the same taxonomic resolution as the 2004 to 2005 data, and that the State of Rhode Island currently employs. Therefore, comparisons between the data sets need to be conducted with caution

Figure 6-7: Summary of Blackstone River Biomonitoring Data

Year	Comparability Score (%)	Biomonitoring Rating
1994	55.8	Moderately Impaired
1995	21.0	Severely Impaired
1996	56.3	Moderately Impaired
1997	62.5	Slightly Impaired
1998	68.8	Slightly Impaired
1999	50.0	Moderately Impaired
2000	62.5	Slightly Impaired
2001	50.0	Moderately Impaired
2004	79.2	Slightly Impaired
2005	60.9	Slightly Impaired

Sources:

1994 to 2001:	Roger Williams University (Gould, 1998; Pomeroy, 2000; da Silva, 2002)
2004 & 2005:	This study by the ESS Group, Inc., under subcontract to the Louis Berger Group, Inc.

Figure 6-8: Water quality in the Blackstone River and Wood River during Artificial Substrate Monitoring in 2004 and 2005

Station	Date	Activity	Tempe-rature (°C)	Dissolved Oxygen (mg/l)	Dissolved Oxygen (% Saturation)	Turbidity (NTU)	Specific Conduc-tance (µmhos/cm)
Blackstone River Millville (M-01)	4-Sep-04	Deploym.	23.0	7.9	91.7	3.8	453
	26-Oct-04	Retrieval	9.9	9.7	85.9	3.4	373
	12-Aug-05	Deploym.	27.8	7.1	91.1	2.5	--
	7-Oct-05	Retrieval	14.5	8.9	87.8	2.8	--
Blackstone River Manville Dam (M-02)	4-Sep-04	Deploym.	25.5	7.4	90.6	2.3	483
	26-Oct-04	Retrieval	10.2	10.2	90.9	3.0	330
	12-Aug-05	Deploym.	29.1	6.9	89.9	3.1	--
	7-Oct-05	Retrieval	13.2	8.9	85.3	3.3	--
Wood River Reference Station (M-05)	4-Sep-04	Deploym.	22.8	8.1	94.3	1.0	122
	26-Oct-04	Retrieval	9.2	9.9	86.1	1.3	120
	12-Aug-05	Deploym.	23.9	8.0	95.1	0.8	--
	7-Oct-05	Retrieval	12.7	9.6	90.6	1.5	--

Figure 6-9: Invertebrates at the Blackstone River at Manville Dam and Wood River from Artificial Substrate Monitoring in 2004 and 2005

Invertebrate Taxa	Blackstone River Millville (M-03)		Blackstone River Manville Dam (M-03)		Wood River Reference Station (M-05)	
	2004	2005	2004	2005	2004	2005
Crustacea						
Amphipoda						
Gammarus sp.	76		187	5	14	6
Isopoda						6
Asellidae					17	
Gastropoda						
Valvatidae						
Valvata sp.		1				
Insecta						
Coleoptera						
Elmidae		8			1	
Diptera						
Chironomidae	18	42	122	328		12
Ephemeroptera (mayfly)						
Heptageniidae	4	3	3		16	13
Odonata		5				
Plecoptera (stonefly)						
Perlidae		4				
Trichoptera (caddisfly)						
Hydropsychidae	7		6		5	4
Total Abundance	**105**	**63**	**318**	**333**	**64**	**44**
Taxa Richness	**4**	**6**	**4**	**2**	**6**	**6**
Biotic Index (BI)	**4**	**7**	**4**	**1**	**8**	**7**
% Similarity	**75%**	**67%**	**75%**	**--**	**--**	**--**

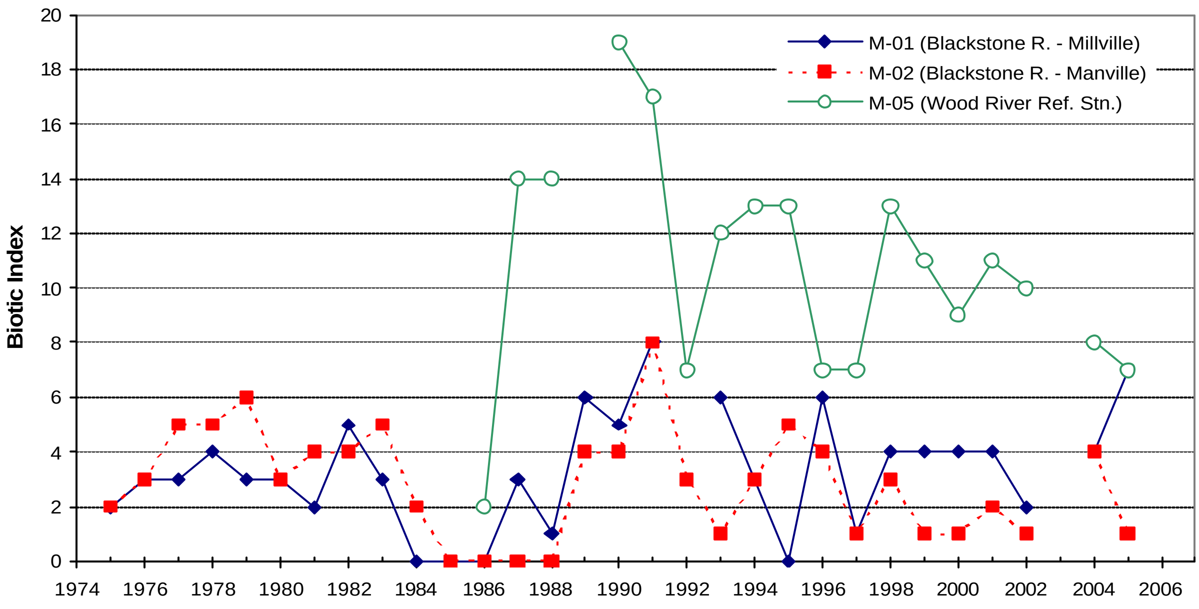


Figure 6-10: Biotic Index - Blackstone River and Wood River

7.0 VALLEY FALLS POND

Valley Falls Pond is located in the City of Central Falls approximately 500 m (1,600 feet) upstream of Valley Falls Dam (Figure 7-1 to 7-19). The pond is open to the Blackstone River and extends for almost 1 km (3,300 feet) to the west. The pond is surrounded by a marsh ('Valley Falls Marsh'). Presently, the pond is listed on the 303(d) for impairments of pathogens, phosphorus, nutrients, hypoxia, excess algal growth, biodiversity, and lead.

The goal of the Valley Falls Pond assessment was to obtain the information needed to ultimately allow for the removal of the pond from the 303(d) list. Two management approaches were considered: (1) Increasing the flow of Blackstone River water through the pond, and (2) Managing Valley Fall Pond as a wetland/pond system. The evaluation of these two management alternatives required the collection of field data to enhance the historical data to focus on the primary impairment of the system from nutrient enrichment (loss of biodiversity, phosphorus, low dissolved oxygen and excess algal growth) as well as impairment by pathogens and lead. The analysis focused on wetland and pond functions as they relate to system hydrodyamics and external (Blackstone River) versus internal (watershed, recycling) sources of nutrients and secondary nutrient parameters (dissolved oxygen, algae, etc.). In addition, both the concentrations and sources of lead and pathogens were addressed.

7.1 Methodology

The study assessed the wetland system, bathymetry, hydrology, water quality, algal composition, sediments, and the surrounding watershed.

7.1.1 Wetland System Assessment

The evaluation of the management of Valley Falls Pond as a wetland/pond system required an assessment of the emergent wetland and channels. The entire system is referred to as Valley Falls Marsh, which includes Valley Falls Pond. Freshwater wetlands forming around and growing into depositional basins tributary to main river channels are common particularly to rivers with dams and impoundments. Aerial photographs were used to map the wetlands of the Valley Falls Marsh and to prepare a vegetation map. The distribution of dominant plant assemblages were confirmed with a site walkover on September 13, 2005. Further, the walkover wetland survey was conducted to determine physical limits of the wetland system, functional value, hydraulic regime, major wetland plants/assemblages, and wildlife (including birds).

7.1.2 Bathymetry

A bathymetric map of Valley Falls Pond was constructed using depth data collected by a handheld acoustic depth-sounder on September 28, 2005. A total of 76 soundings were obtained. Sounding locations were recorded with a GPS unit. The location of the shoreline was obtained from RIGIS database. The bathymetric data were adjusted to the low-water depth at Station P-02 (0.5 m), which is controlled by Valley Falls Dam.

7.1.3 Hydrology

The water elevation was continuously recorded within Valley Falls Pond to assess the water exchange between Valley Falls Pond and the Blackstone River. Measurements were made at 10-minute intervals using a recording water elevation meter, with a vented pressure transducer, which automatically corrects for changes in atmospheric pressure. The gauge was deployed in the northwestern corner of the pond

(Station WL-01). Depth measurements at Station P-02 during the deployment period were used to check instrument calibration. The meter was installed from August 10 to December 6, 2004 and again from April 19 to September 28, 2005. The meter was removed during the winter to avoid damage from ice. In addition, anecdotal information was collected from the abutting neighbors including variability in elevation of the pond water surface and presence of aquatic vegetation in the summer.

7.1.4 Watershed Assessment

The watershed area was assessed using topographic maps and a visual site survey. In addition, sources of contaminants were sought by a site walkover and inquiries at the City of Central Falls and Town of Lincoln and local residents. These sources included stormwater drainage pipes, septic systems, small stream/surface water inflows, and other sources of contaminants draining into the pond.

7.1.5 Water Sampling

A total of 11 survey events were conducted in Valley Falls Pond. The events were concentrated during the summer of 2004 and 2005 (July to September), with additional events in December 2004 and April 2005. Sampling and measurements were conducted at three stations in Valley Falls Pond (P-01, P-02, P-03) and at a station on the Blackstone River (P-04) located approximately 100 m (330 feet) upstream of the entrance to Valley Falls Pond (Figure 7-1). In-situ measurements (dissolved oxygen, pH, temperature, specific conductance, turbidity, Secchi depth) were collected during all of these events. Water samples were collected during seven of these events. Five of the events were dry weather surveys; two events were wet weather surveys. The wet weather events were conducted shortly after a storm when maximum wet weather inflow into the pond is believed to have occurred. Pathogen samples were collected during an additional dry weather event. Samples were collected from the center of the water column (mid-water depth) and analyzed for the following constituents:

- Pathogens (fecal coliform and enterococci)
- Nutrients (total phosphorus, orthophosphate, ammonia, particulate organic carbon and nitrogen, total dissolved nitrogen)
- Chlorophyll *a* and Pheophytin *a*
- Metals (dissolved lead and copper)
- Hardness

In the data tables, data are reported to the reporting limit (RL). Values below (and also above for pathogens) are flagged as <[RL] (and >[RL]). For mathematical calculations of means, the approach described in Section 3.1.2 was used.

It is noted that the lead and copper data from sampling events POND-02, 03, and 04 were edited during quality control. Specifically, samples from these events had been analyzed by the ICP Method 200.7 with a RL for dissolved lead of 5 ug/l and a method detection limit (MDL) of 0.23 ug/l; for dissolved copper, the RL was 15 ug/l and the MDL was 3.2 ug/l. Samples from the later events (POND-06, 09, 11) were analyzed by ICP-MS Method 200.8 with a more sensitive RL of 0.1 ug/l for dissolved lead and a MDL of 0.04 ug/l; for dissolved copper, the RL was 1 ug/l and the MDL was 0.4 ug/l. Dissolved lead and copper concentrations in samples analyzed by ICP Method 200.7 tended to be higher and had greater variability in the duplicate samples (see also discussion in Section 3.1.3); these data are attached in Table B-8 of Appendix B.

7.1.6 Phytoplankton

Phytoplankton samples were collected on August 12, 2005 to address in part the concern about excess algal growth in Valley Falls Pond. The algal count included phytoplankton and periphyton counts. Phytoplankton samples were collected at Stations P-01 and P-03 at a depth of 0.3 m (1 foot) from the middle of the water column. Samples were collected by filling bottles with 500 ml of natural water. The samples were preserved with 1% Lugols solution immediately after collection.

Enumeration: Duplicate samples were composited at the laboratory and an aliquot was placed in a settling chamber. After settling, the supernatant was removed and the sample transferred to an inverted microscope fitted with phase contrast objectives. All algal species were identified and enumerated at magnifications of 100X, 200X and 400X until a minimum of 100 natural counting units, distributed among the three magnifications, was obtained. A natural counting unit was defined as individual cell, colony, filament, trichome or coenobia, depending on the species. A minimum of 20 fields were counted at each magnification. Species abundance was reported as number of natural counting units per milliliter.

Biovolume: Biovolume was determined by measuring individual cells of each species. The biovolume of individual cells was computed using equations for basic geometric shapes such as sphere, cube or cylinder that best fit the cell shape. Individual cell biovolumes were multiplied by the number of cells in the natural counting unit, which was then multiplied by the density of natural counting units to determine the biovolume per milliliter for each species.

Trophic State Index (TSI): One measure of trophic state is based upon the total biovolume of all species combined, in a sample. A Trophic State Index based upon phytoplankton biovolume has been developed from a data set of several hundred lakes located throughout several states (Sweet, 1986, Report to EPA). The index was derived in a similar fashion as Carlson-derived indices (1977) for Secchi depth, chlorophyll *a* concentration, and total phosphorus concentration (employed below). The biovolume index ranges from 1 for ultraoligotrophic lakes to 100 for hypereutrophic lakes. The index is defined as:

$$\text{TSI (biovolume)} = (\text{Log-base 2} \quad (B+1)) * 5$$

where B is the phytoplankton biovolume in cubic micrometers per milliliter divided by 1,000.

7.1.7 Sediment

Surface sediment samples were collected at Stations P-01 and P-03a (a station approximately 15 m [50 feet] to the north of P-03) using a handheld box corer. The upper sediment layer of the core was subsampled for macroalgae (upper 0-2 cm), metals (0-4 cm), grain size (0-4 cm), nutrients (0-2 cm, 2-4 cm), and chlorophyll *a* (0-2 cm). The boat was not anchored to avoid disturbance of the black fine-grained mud at the bottom of the pond. Metal analyses consisted of total copper and lead. Nutrient analyses consisted of total organic carbon, nitrogen, and phosphorus.

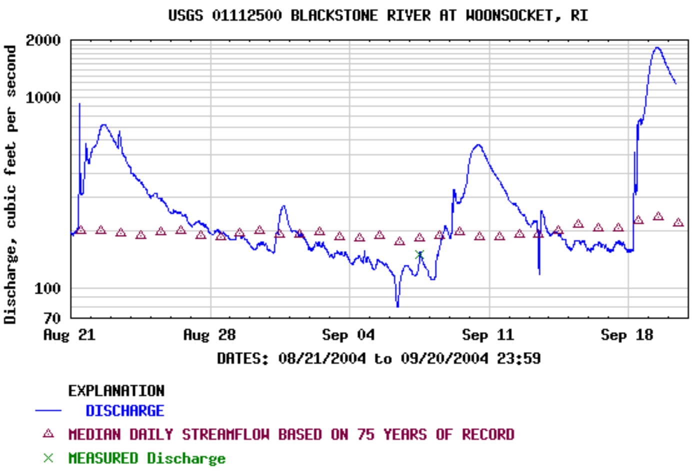
In addition, an uncapped 3 m (10 foot) long PVC pipe with an outside diameter of 2 inches was used to probe the soft sediment depth along a transect extending from the east (Blackstone River) to the western end of Valley Falls Pond. The measurement locations were recorded with a GPS unit.

Macroalgae in the samples (0-2 cm) were sieved in the laboratory with 500 um and 300 um sieves. The organic particles were analyzed under a dissecting microscope to determine if the particles consisted of wetland plants versus algae; phytoplankton were unrecognizable due to their rapid decomposition.

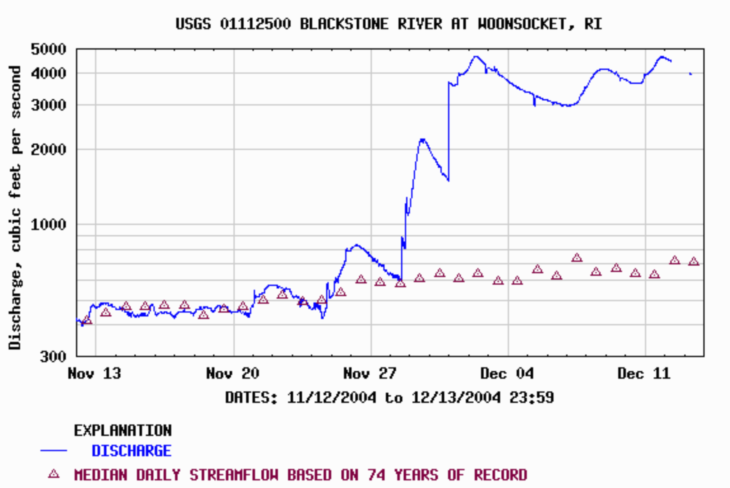
7.2 Field Observations

Following are selected field observations from the 11 survey events of Valley Falls Pond. Graphs with the flow rate of the Blackstone River at the USGS monitoring station in Woonsocket are included as reference for several of the events.

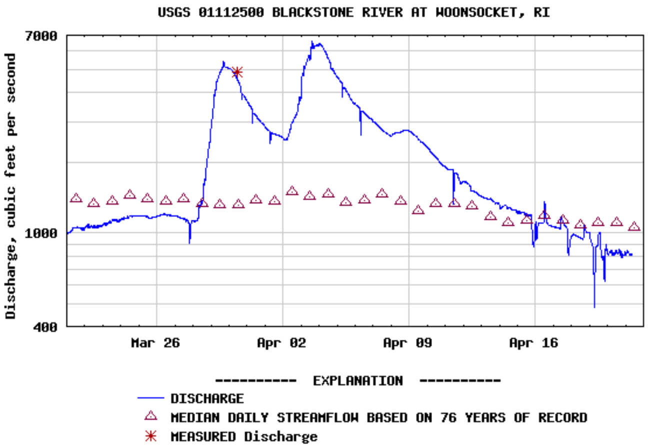
Event POND-01 (August 10, 2004): Valley Falls Pond was close to its shallowest water depth of 0.5 m (1.6 feet) at Station P-02. The flow at the USGS Woonsocket gage was 158 cfs. The weather was sunny and calm. Duckweed *(Spirodela polyrhiza)* grew on the edges of the pond. Aquatic vegetation included further purple loosestrife and water lilies.



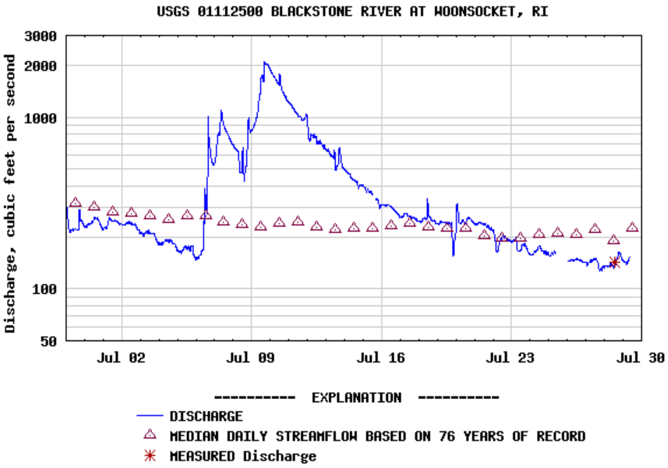
Event POND-02 (September 17, 2004): The water depth in Valley Falls Pond was low (0.5 m [1.6 feet] at Station P-02), similar to the August 10 sampling. The flow at the USGS Woonsocket gage was 175 cfs. The weather was sunny and calm. The water was mostly free of aquatic plants. Duckweed grew on the edges of the pond. In the western section, there were patches of Duckweed and some Gray fanwort *(Cabomba caroliniana)* in the open water as well. The pH and the dissolved oxygen concentrations were distinctly higher in the western (innermost) part of the pond (Station P-01) as compared to the central part (P-02) and eastern (outermost) part (P-03) of the pond, suggesting a decrease in flushing with distance from the Blackstone River. This observation corresponded with higher duckweed concentrations along the edges of the pond in the western section. The pH between Station P-01 and P-02 was transitional, i.e., it gradually decreased along a transect from P-01 (pH of 9.2) toward P-02 (pH of 7.5). Measurements of the pH along this transect were conducted twice for confirmation.



Event POND-03 (December 6, 2004): The water elevation in Valley Falls Pond was approximately 0.35 m to 0.4 m (1.1 to 1.3 feet) higher than during Events POND-01 and POND-02 in the summer. The flow at the USGS Woonsocket gage was approximately 3,000 cfs. The higher water depth and flow rate was due to high rainfall on November 28 and December 2, 2004. The weather was cloudy and cold. The vegetated island in the central part of Valley Falls Pond was partially submerged. The water was mostly free of aquatic plants. A thin sheet of ice had formed in the westernmost corners of the pond.

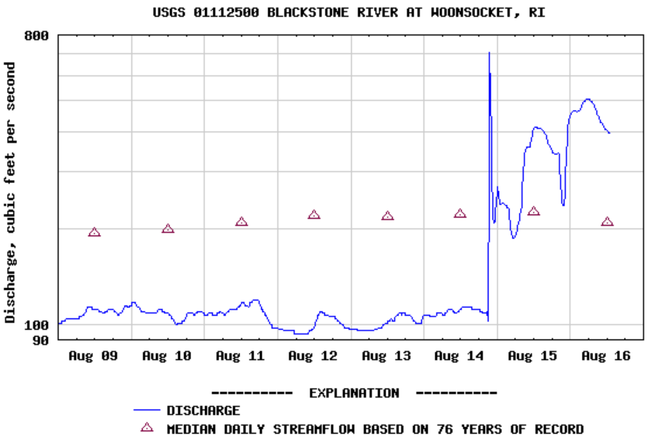


Event POND-04 (April 19, 2005): The water elevation in Valley Falls Pond was approximately 0.1 m (4 inches) higher than during Events POND-01 and POND-02 in the summer. The flow at the USGS Woonsocket gage was approximately 1,000 cfs. The flow had been high two to three weeks prior to this event, reaching 6,000 cfs at the Woonsocket gage. The water elevation in Valley Falls Pond appeared to have been higher in the preceding weeks by approximately 1 m (3 feet), as shown by markings on the reeds in the wetland. The weather was sunny and calm. The vegetated island in the central part of Valley Falls Pond was partially submerged. Wetland vegetation had not grown back yet. The water was also free of rooted and floating aquatic plants.



Event POND-05 (July 12, 2005): The water elevation in Valley Falls Pond at Station P-02 was approximately 0.7 m (2.3 feet). The flow at the USGS Woonsocket gage was approximately 700 cfs. The flow had reached 2,000 cfs in Woonsocket three days prior to this event. The weather was sunny and calm. There was a film of green algae on the surface along the fringes of the pond.

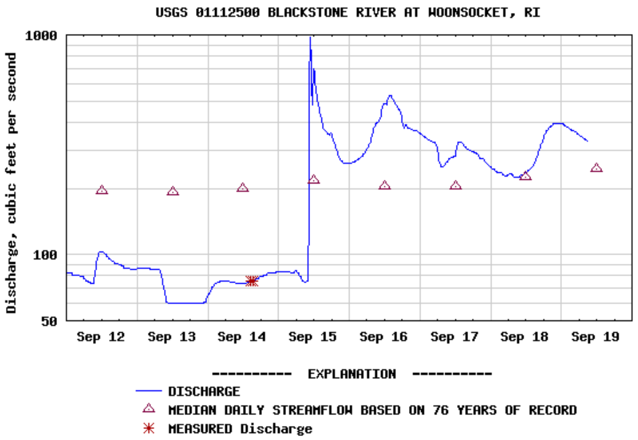
Event POND-06 (July 28, 2005): The water depth at Station P-02 was approximately 0.5 m (1.6 feet), similar to the previous summer surveys. The flow at the USGS Woonsocket gage was approximately 140 cfs, also similar to the previous summer. The flow in Woonsocket had been below 200 cfs for 12 days. The weather was sunny and calm. There were water lily patches on the pond. Some duckweed was floating on the surface.



Event POND-07 (August 12, 2005): The water elevation in Valley Falls Pond was low (0.5 m), after a long dry period. The flow at the USGS Woonsocket gage was approximately 100 cfs. The weather was sunny and calm. There was duckweed floating on the surface and coontail growing in the inner part of Valley Falls Pond (west of Station P-02) (Figures 7-8 and 7-9). Phytoplankton samples were collected from the water column mid-depth at Stations P-01 and P-03a (the station was approximately 15m to the west of P-03). Also, sediment samples were collected at Stations P-01 and P-03a for macroalgae, metals, grain size, nutrients, and chlorophyll *a*.

Event POND-08 (August 14, 2005): No activities on Valley Falls Pond (only Scott Pond).

Event POND-09 (August 15, 2005): This survey was a wet weather event. Rain fell between approximately 18:00h on August 14 and 3:00h on August 15, 2005. Rainfall in Worcester was 1.15 inches, in Woonsocket 1.07 inches, and in Lincoln 0.93 inches. Peak rainfall occurred around midnight in Rhode Island. Field sampling in Valley Falls Pond occurred 10 hours after the peak. The flow at the USGS Woonsocket gage increased from 100 cfs to 400 cfs. The weather was cloudy and cool. There were water lily patches and floating duckweed on the pond.



Event POND-10 (September 13, 2005): The Valley Falls Marsh was characterized during this event. In addition, the sediment thickness was measured with a 2-inch diameter PVC pipe.

Event POND-11 (September 16, 2005): This survey was the second wet weather event. Rain fell between approximately 10:00h and 13:00h on the previous day. Rainfall was 0.94 inches in Worcester and 0.83 inches in Lincoln. The event was preceded by a two-week dry period. Field sampling in Valley Falls Pond occurred 21 hours after the peak event. The flow at the USGS Woonsocket gage increased from 80 cfs (prestorm) to 1,000 cfs during the storm peak. The flow rate at the Pawtucket station at the time of sampling was approximately 400 cfs. The weather was cloudy, with short showers at noon and later in the afternoon. There were water lily patches and floating duckweed (spirodela tolyrhiza) on the pond, as well as clusters of coontail *(Ceratophyllum demersum)*. Dissolved oxygen was comparatively low in the pond with lowest elevations measured at Station P-01 (3.9 mg/l). The dissolved oxygen concentrations at Stations P-02 and P-03 were 4.6 mg/l and 5.4 mg/l, respectively. The dissolved oxygen concentration in the river was 6.6 mg/l.

Event POND-12 (September 28, 2005): The primary purpose for the event was to recover the water elevation meters in the ponds. The weather was sunny and calm. While on site, vertical in-situ water quality profiles were also collected. Two days before, 0.30 inches of rain fell in Worcester and Lincoln (RI), and 1.02 inches at Providence Airport. The rainstorm was preceded by a 5-day dry period. As during Event POND-11, there were water lily patches and floating duckweed *(Spirodela tolyrhiza)* on the pond, as well as clusters of coontail *(Ceratophyllum demersum)*. Dissolved oxygen was comparatively low in the river at 6.6 mg/l, but higher in Valley Falls Pond.

7.3 Results

7.3.1 Wetland System Assessment

7.3.1.1 Overview

The wetland complex associated with Valley Falls Pond and the Blackstone River floodplain (i.e., “Valley Falls Marsh”) encompasses approximately 1 km^2 (250 acres) between the John Street and Broad Street bridges. The majority of the 0.17 km^2 (43 acres) Valley Falls Pond lies in the City of Central Falls

(Figure 7-1). The relatively shallow pond was reportedly expanded and deepened by Irish immigrants in the 1800's to increase the holding capacity for water-powered textile mills along the Blackstone (Nadeau, 2005). The wetlands north of the pond and bordering the western bank of the Blackstone River are contained within the Town of Lincoln. Wetlands bordering the eastern bank of the river are located in the Town of Cumberland.

The wetland and open water complex lies in a broad well-defined floodplain valley bordered by extensive commercial and residential developments in Central Falls and Cumberland. The entire wetland complex is contained within the 100-year floodplain of the Blackstone River (Figure 7-26). The western edge of the wetland complex is defined by development along Lonsdale Avenue and by fill associated with an early 1900's railroad corridor which was never completed. The corridor was reportedly used for municipal dumping until the 1950's. A broader area of fill, presumably associated with past dumping, lies near the northwest corner of Valley Falls Pond. This area includes an osprey nest platform installed by a local utility company in 1996 and remains unoccupied (Figure 7-10). A narrow break in the former railroad corridor of approximately 20 m (65 feet) along the western edge of the pond provides a hydraulic connection to additional open water and wetland habitat. North of this location, the rail corridor isolated a long narrow wetland along Lonsdale Avenue, which was likely part of the floodplain wetland prior to its construction. The granular fill associated with the rail bed and other dumping activities appears to be extensively used by turtles for nesting habitat (Figure 7-11).

Several radio towers occupy a large mowed wet meadow along the eastern bank of the Blackstone River and just south of the John Street bridge). The wetlands found along the eastern side of the Blackstone River floodplain are generally similar in vegetation types and landscape setting. Therefore, the entire wetland complex was included in the functional evaluation. Just north or upstream of the John Street bridge crossing lies the 0.1 km^2 (24 acre) Lonsdale Marsh restoration area. This area of formerly filled wetland was the location of the Lonsdale Twin Drive-In, which was recently restored to wetland habitat by the Army Corps of Engineers.

The pond and wetland complex includes a diversity of habitat types with a good interspersion of vegetated wetlands and open water. The amount of standing water is enhanced by the presence of several remnant meander scars from former channel locations (Figure 7-12).

7.3.1.2 Hydraulic regime

According to the 1981 Rhode Island Soil Survey (Rector, 1981), soils in the vegetated wetlands of the Marsh consist of Carlisle muck and Rumney fine sandy loam. Carlisle soils are very poorly drained organic soils formed in deep organic deposits within low-lying outwash plains. Rumney soils are poorly drained and formed in recent alluvium of river floodplains. Due to the seasonally high water table, both soil types are considered hydric (Figure 7-27). The typical water regime of vegetated wetlands within the study area ranges from intermittently exposed zones associated with beds of submerged aquatic plants, semi-permanently flooded zones within emergent marshes and seasonally flooded zones within wooded wetlands and wet meadows. As part of the 100-year floodplain, the entire area is periodically flooded during periods of unusually high flows in the Blackstone River, such as during the flood on October 16, 2005.

The wetland to the north of the pond is also bisected by the remains of a former drainage channel, which extends from the Blackstone River to the wetland area west of the rail corridor (Figure 7-13). There are twin dilapidated 24-inch diameter corrugated metal pipes under the rail corridor (Figure 7-14). The origin of the former channel is unknown. The accumulation of sediment along with the growth of vegetation has severely limited the hydraulic capacity of the former drainage channel along most of its length. According to the Town of Lincoln, the intended purpose of the drainage channel is not known (Kim Wiegand, Town Engineer, personal communication, October 17, 2005).

7.3.1.3 Functional value

A functional evaluation based on the US Army Corps of Engineers 1995 descriptive approach was performed. The wetland complex provides a variety of important functions and values including:

- Groundwater recharge/discharge
- Floodflow alteration
- Fish habitat
- Sediment / Toxicant retention
- Nutrient removal/retention/transformation
- Production export
- Shoreline stabilization
- Wildlife habitat
- Endangered species habitat
- Recreation
- Education / Scientific value
- Uniqueness / Heritage value
- Visual Quality / Aesthetics.

The landscape setting of a broad floodplain valley and the lack of a restrictive layer in the overlying soil provides the opportunity for the wetland complex to interact with the regional groundwater including recharge potential during high river flows and discharge to support base flows in the river system during low flow periods. The landscape setting, large size and extent of development within the immediate watershed of the wetland complex all contribute to the floodflow alteration function. The wetland/pond complex is known to support 15 species of fish including white perch, fallfish and tessellated darter based on a 1994 survey by the Rhode Island Division of Fish and Wildlife as reported in Enser (1997; Appendix F). This function as fish habitat is enhanced by the size and diversity of available sub-habitats within the wetland/pond system, e.g., open water, submerged aquatic vegetation, flooded emergent wetland, etc.. Water quality improvement functions (including sediment/toxicant retention and nutrient removal/retention/transformation) are enhanced by the basin morphology and dense emergent vegetation which result in reduced velocities, diffuse flow and extended retention of flood waters. These functions are also enhanced by the ability of flood waters to enter the sediments during recharge periods. In addition, the opportunity is enhanced by the developed nature of the watershed which includes sources of upstream pollutants. The production export function is enhanced by the productivity and size of the wetland complex and connection to a perennially flowing outlet. Shoreline stabilization is provided by the root systems contained within the well-vegetated banks of the river and pond. No signs of unusual erosion were observed.

A relatively long-term survey of avian species has shown the areas to be utilized by a wide variety of bird species and to be an important stop-over for mitigating passerines and waterfowl. Several documented species are State-listed. The entire wetland/pond complex is identified as rare species habitat by RIDEM (Figure 7-28). The habitat value is also enhanced by the diversity and interspersion of wetland types, size of available habitats, and relationship with open water.

Socio-economic and quality-of-life values including recreation, education/scientific value, uniqueness/heritage value, and visual quality/aesthetics are all enhanced by the uniqueness of the natural setting within a developed landscape, active recreation and education opportunities promoted by the

Blackstone Tourism Council, ongoing wildlife surveys and the areas important historical ties to the origin of the industrial revolution within the country (Figures 7-15 and 7-16). The site is intended to be a major natural area in the Blackstone River Valley Natural Heritage Corridor. The study area has been referred to as the most valuable marsh in Northern Rhode Island (R. Enser, 2004).

7.3.1.4 Major Wetland Types

According to the classification system of wetlands from the U.S. Fish and Wetland Service (Cowardin et al., 1979), the majority of the wetland/pond complex is classified as Palustrine. Submerged aquatic bed vegetation (dominated by long-leaved pondweed, *Potamogeton nodosus;* Figure 7-17) and unvegetated open water areas associated with the Blackstone River channel are classified as Riverine lower perennial aquatic bed rooted vascular (R2AB3) and Riverine lower perennial streambed-sand (R2SB4), respectively (Figure 7-29). The relatively shallow open water areas found within Valley Falls Pond along with several deeper remnant meander scars are classified as Palustrine unconsolidated bottom-organic (PUB4).

The main pond basin appears to be generally unvegetated or sparsely vegetated by water weed (*Elodea candandensis*) and coontail (*Ceratophyllum demersum*). The pond also contains a few aquatic bed zones (PAB3) dominated by yellow water lily (*Nuphar lutea*) (Figure 7-18). Free floating duckweed (*Spirodela polyhiza*) was common throughout the open water zones. The lack of extensive submerged aquatic beds within the pond may be related to water quality impairments or herbivory by the reported large population of carp. The most common vegetated wetland type within the study area is Palustrine emergent marsh dominated by persistent vegetation (PEM1). A narrow zone of nonpersistent emergent marsh (PEM2) is found within several of the meander scars and fringing the pond edge in many locations. The nonpersistent wetland zones are dominated by pickerelweed (*Pontederia cordata*), Arrow arum (*Peltandra virginica*), and arrowhead (*Sagittaria* sp.) (Figure 7-19). The zones of persistent emergent vegetation include shallow marshes dominated by cattail (*Typha latiflolia*), purple loosestrife (*Lythrum salicaria*) or common reed (*Phragmities australis*) or wet meadows dominated by bluejoint (*Calamagrotis canadensis*), various sedges (*Carex* sp.), reed canary grass (*Phalaris arundinacea*), and wool grass (*Scirpus cyperinus*) (Figures 7-20 to 7-22). Both buttonbush (*Cephalanthus occidentalis*) and water-willow (*Decodon verticillatus*) are found along the marsh/open water edge in many locations increasing cover habitat for waterfowl broods (Figure 7-23). The wetland/pond complex also includes areas classified as Palustrine scrub-shrub (PSS1) and forested wetland (PFO1). Areas of shrub swamp include a wide variety of wetland shrubs such as arrowwood (*Viburnum dentatum*), silky dogwood (*Cornus amomum*), speckled alder (*Alnus rugosa*), high bush blueberry (*Vaccinium corymbosum*), and buttonbush. Areas of forested wetland include both early successional forest dominated by grey birch (*Betula populafolia*) and more mature forests which include red maple (*Acer rubrum*), silver maple (*Acer pensylvanicum*), green ash (*Fraxinus pennsylvanica*), and basswood *(Tilia americana)* (Figures 7-24 and 7-25). The young forested wetlands dominated by dense stands of grey birch are typically found on better drained portions of the sandier alluvial floodplain soils. Catalpa trees (*Catalpa* sp.), which have escaped from cultivation, are common along the river bank. Other invasive species including purple loosestrife and *Phragmities* are likely expanding within the wetland system, reducing habitat value.

7.3.1.5 Observed Wildlife

Available information on the wildlife associated with Valley Falls Pond and the Valley Falls Marsh is limited. Agencies contacted included the following: RIDEM (Richard Enser, Nancy Freeman), the U.S Army Corps of Engineers, (Michael Penko), the Town of Lincoln (Kim Wiegand), Blackstone Valley Tourism Council (Patricia MacApline), Audubon Society (Eugenia Marks), Charter Environmental, Inc. (Bob Delhome), and Save the Bay (Brigitte Kubis). The most extensive recent work was conducted by

Richard Enser who collected 25 years worth of bird observations between the 1977 and the 1996 (Appendix F). The Audubon Society is not monitoring the marsh. Birds observed by Patricia MacApline (Education Coordinator of the Blackstone Valley Tourism Council that run tours past Valley Falls Pond) include Canada goose, osprey, red-tailed hawk, belted kingfisher, swans, snowy egret, and turns (Nadeau, 2005).

The following species, or their signs, were observed during a September 2005 site visit:

- *Birds:* Chickadee, great blue heron, red-winged blackbird, osprey, broad-wing hawk, belted kingfisher, wood duck, mallard, mute swan, green heron, willow flycatcher, yellow throat, yellow warbler, swamp sparrow, cormorant, ring-billed gull, spotted sandpiper, Carolina wren, tuffed titmouse, crow, cedar wax wing.
- *Mammals:* Coyote, white tail deer, muskrat, beaver.
- *Reptiles/Amphibians:* Garter snake, bull frog, green frog, painted turtle.
- *Fish:* Small mouth bass, white sucker.

7.3.2 Bathymetry

Valley Falls Pond is uniformly shallow. The minimum water depth is controlled by Valley Falls Dam. The lowest water depth in most of the pond is 0.5 m (1.6 feet) (Figure 7-30), including a portion in the vicinity of the Blackstone River. The water depths in the westernmost portion of the pond in the vicinity of Station P-01 is approximately 0.1 m (4 inches) shallower. Also, water depths shoal along the edges of the pond.

There is no sill between the river and the pond. Due to the elevation of the spillway on Valley Falls Dam, the pond cannot dry up, unless the flow stopped in the Blackstone River for an extended period. Such a scenario is not likely and there is no record of this occurring.

7.3.3 Hydrology

The rate and volume of water exchange between the Blackstone River and Valley Falls Pond is a critical management parameter relative to each of the 303(d) impairments. Increases in the flow in the Blackstone River increased the water elevation in the pond by up to 0.8 m (2.6 feet) during the measurement periods in 2004 and 2005 (Figure 7-31 in Section 7). The elevation can increase further, however, as was the case during the large flood event on October 16, 2005, which resulted in flooding of Valley Falls Marsh; unfortunately the water elevation meter had already been recovered at the time for protection from ice. Large-scale flooding of the marsh is not common, however (Len Nadeau, local resident, personal communication, January 16, 2006).

Flushing of the pond is driven by changes in water elevation in the Blackstone River. As there is no restriction to water flow between the river and pond, pond levels will change in tandem with river levels. Rapid sequential rises and falls in river levels will tend to cause a turnover of water in Valley Falls Pond. These events occurred relatively frequently and are seen as "spikes" in the stage record (Figure 7-31). These spikes result primarily from rain events. The effect on water quality of the pond, due to flushing by river waters is determined in significant part by the quality of the Blackstone River water entering during flooding. In addition, there is likely exchange of water within the pond due to circulation of river water associated with peripheral channel flows during high river flows.

The very limited water elevation changes in the summer and early fall of 2005 and the relatively low water levels may have been the reason for the low dissolved oxygen concentrations measured on September 16, 2005 (Event POND-11). The flushing rate of the pond decreases with distance from the Blackstone River. The westernmost (innermost) part of the pond is flushed the least.

7.3.4 Watershed Assessment

Sources of inflow to Valley Falls Pond from the surrounding watershed are small. The urban areas surrounding the pond are sewered. There are no streams entering the pond. Surface water runoff is limited to non-point source runoff. The contributing drainage area is small. There may be groundwater discharges to Valley Falls Pond from the nearby Scott Pond which is kept artificially at a 5 m (15 foot) higher elevation than Valley Falls Pond; the rates of such groundwater discharges (if any) are currently unknown.

The only point source observed discharging to the Valley Falls Pond was NBC CSO Outfall #007. The outfall is located at the intersection of Aetna Street and Richmond Street in Central Falls. Both, dry weather flow (0.2 cfs) and wet weather flows (up to 4 cfs), were observed in 2005 (see Section 5 for more detail). Fecal coliform concentrations in the discharge were high (16,000 MPN/100 ml) in both the dry and wet weather flows. The dissolved lead concentration was elevated (3.6 ug/l) in one of the wet weather discharges.

7.3.5 Water Quality

7.3.5.1 Nutrients and related Parameters

Valley Falls Pond and the Blackstone River in its vicinity are classified as B1 waters (RIDEM, 2000). Relative to nutrient-related water quality, Valley Falls Pond is currently on the 303(d) list of impaired waters due to loss of biodiversity, phosphorus, low dissolved oxygen and excess algal growth. All of these issues relate directly to nutrient enrichment and are symptoms of eutrophication resulting from overfertilization by phosphorus.

The water quality was assessed along a longitudinal transect from the inner portion of the main basin to the pond to the entrance to the river. An additional sampling site was located upstream of the pond in the Blackstone River. Overall, there was no clear gradient in the phosphorus, chlorophyll *a* pigments (expressed as the sum of chlorophyll *a* and pheophytin *a*) from the river station to the head of the pond (Figure 7-32). The Secchi depth in the pond was always low. While the Secchi depth was at times greater than the shallow water depth of Valley Falls Pond, the disk was barely visible at the bottom indicting that the pond water was very turbid. During 4 of the 7 surveys, the Secchi depth within the pond was less than 0.55 m (1.8 feet), compared to an average of 1.5 m (5 feet) with a range of 0.9 to 2.3 m (3 to 7.5 feet) in the Blackstone River (Figure 7-33). This observation was also reflected in the turbidity measurements in the pond which reached 24 NTU. On average, the turbidity in the pond was 4 times higher than in the Blackstone River. In addition, dissolved oxygen levels within the pond were lower than in the river. These latter measurements indicate that the pond may serve as a depositional basin, where organic matter decay results in oxygen depletion.

All of the water quality indicators showed levels typical of phosphorus enrichment and eutrophic conditions. Chlorophyll pigment concentrations within the pond and river were very high, averaging 21 and 29 ug/l, respectively (Figure 7-34). As stated above, the Secchi depths were low. These values are consistent with the very high total phosphorus levels, 0.26 mg/l (pond) and 0.21 mg/l (river) and the periodically low oxygen levels within the pond (3.9 mg/l). Secchi depth, chlorophyll, temperature data from this study correspond to data collected by the URI Watershed Watch (Figures 7-35 to 7-38). The nutrient enrichment has not resulted in odors, as odors have not been noticed by abutting neighbors (Nadeau, personal communication, January 18, 2006).

Given that the water within Valley Falls Pond originates from the Blackstone River and that water exchange is dominated by alterations in river level and flows, it is clear that the trophic status of the pond is controlled primarily by the water quality of the Blackstone River. However, even under the eutrophic conditions of the pond, the Valley Falls Marsh appears to be highly productive and is currently operating as a healthy wetland system. The association of Valley Falls Pond with the large surrounding wetland also provides a mechanism for the organic enrichment of the pond, even without the Blackstone River loadings. Transport of organic matter off of emergent wetlands into adjacent basins as flood water recedes or during plant senescence in the fall is well-documented. While it is unlikely that this process is currently the cause of the conditions within the pond, it is likely that it would result in some moderate level of "impairment" if the river loading were significantly reduced. It is for this reason that wetland/pond systems are managed at a higher nutrient and organic matter loading than typical pond systems. However, Valley Falls Pond is currently far above any standard for nutrient related health. For example, total phosphorus concentrations of <0.02 mg/l in ponds and lakes are considered typical of mesotrophic conditions. In comparison, the total phosphorus concentrations in Valley Falls Pond are more than an order of magnitude higher, well within the hypereutrophic range.

7.3.5.2 Pathogens

The regulatory standard for fecal coliform for Class B1 waters (geometric mean of 200 col/100 ml) was exceeded only during one of the eight sampling events (Figure 7-32). Specifically, on December 6, 2004, the geometric mean of the fecal coliform concentrations at Stations P-01, P-02, and P-03 was 422 col/100 ml. The fecal coliform concentration in the Blackstone River was 240 col/100ml (and 1,600 col/100 ml in the duplicate sample) on the same day. These concentrations may have been a result of high rainfall that occurred approximately a week before the sampling event. The water elevation in the pond was still almost twice above its low elevation. Therefore, the likely source for the elevated fecal coliform concentration was the Blackstone River.

A second source appears to be NBC CSO #007, located in the southwestern corner of Valley Falls Pond, as observed during the reconnaissance survey (see Section 5). The relative contribution of the outfall is not known at this time.

The proposed regulatory standard for enterococci is 54 col/100 ml (steady state geometric mean density) for Class B1 waters. The mean of 54 col/100 ml was not exceeded during any of the sampling events (Figure 7-32). Only one of all 19 samples collected exceeded the proposed standard concentration. That sample was collected at Station P-01 during the wet weather survey on September 16, 2005; the enterococci concentration was 180 col/100 ml.

7.3.5.3 Dissolved Copper and Lead

The dissolved copper and lead data were compared individually against the acute and chronic criteria (Table 7-32). Only one of the individual samples, collected at Station P-01 on July 28, 2005, exceeded the chronic criteria for dissolved lead. The mean dissolved copper and lead concentrations measured in Valley Falls Pond (Stations P-01 to P-03) and the Blackstone River (Station P-04) met the respective water quality criteria (Figure 7-33).

However, given the open water exchange between the Blackstone River and Valley Falls Pond, elevated metal concentrations in the river will consequently result in increases in the metals concentration in the pond (as long as the flow rate in the river increases to allow for inflow to the pond). According to the data from the more extensive dry and wet weather surveys (Section 3 and 4), the river at times violates for copper and lead. It is likely that, relative to the Blackstone River, metal-rich bottom sediments in the pond and inflow from NBO Outfall #007 are only very minor sources of dissolved metals in the pond water.

7.3.6 Phytoplankton

The algal community compositions at Stations P-01 and P-03 in Valley Falls Pond were similar (Figure 7-39). Both stations were dominated by chlorophytes (green algae), specifically by *Characium* sp., *Oocystis submarina* and *Gloeocystis vesiculosa* colonies. Small unidentified flagellates and unicellular cyanobacteria were also abundant. Due to their small size, flagellates and unicellular cyanobacteria were relatively minor contributors to the total biovolume, however (Figure 7-40). Chlorophytes were the dominant group in terms of biovolume, contributing 60% of the total volume at Station P-01 and 72% at Station P-03 (Figure 7-41). Due to their larger cell size, diatoms (bacillariophyceae) were the second greatest contributor to biovolume.

The total biovolume was about three times greater at Station P-01, even though Stations P-01 and P-03 were relatively similar in terms of species composition. The algal community included a large number of species that are typically found in shallow and soft-water environments.

It is possible to calculate a trophic state index (TSI) of Carlson (1977) based upon the biovolume for comparison to the water quality based index. TSI values of Carlson (1977) provide for a determination of trophic status based upon water quality parameters associated with eutrophication, Secchi depth, chlorophyll *a* pigments and total phosphorus (Figure 7-42). The calculated TSI values range from less than 0 to greater than 100, where each 10 units represents a doubling in transparency or a halving of total phosphorus. Suggested TSI limits to classical trophic state terminology are:

Ultra-Oligotrophy	0-20
Oligotrophy	10-40
Mesotrophy	40-50
Eutrophy	50-70
Hypereutrophy	>70

Using the data collected on August 12, 2005 the TSI ranged from 51 to 59 for Valley Falls Pond (Figure 7-41), which reflect eutrophic conditions (Figure 7-9). The biovolume TSI values are best used in combination with the water quality TSI values as interpreting algal trophic state from transparency values alone is difficult, because of the potential interference of non-algal turbidity and dissolved water color. All of the water quality measurements in Valley Falls Pond and adjacent Blackstone River show eutrophic to hypereutrophic conditions. The total phosphorus levels of >0.2 mg/l were more than 10 fold higher than the threshold for eutrophic trophic status. Similarly, the chlorophyll *a* and Secchi depth values both were well within the eutrophic range. The overall water quality TSI for the pond and river were 72 and 67, respectively. However, it should be noted that Valley Falls Pond, operating as an open water basin held within a large wetland complex, is expected to be somewhat nutrient and organic matter enriched.

It appears that all of the water quality and biovolume indicators of trophic status would classify Valley Falls Pond, and the upstream Blackstone River station as well, within the eutrophic range. Even as a wetland/pond it appears that these several lines of evidence support the classification of Valley Falls Pond as impaired by nutrients, and its placement on the 303(d) list.

7.3.7 Sediment

Valley Falls Pond appears to be a depositional basin for both water column particulates and organic matter and wetland detritus. The surface sediment in the pond consists of soft, organic-rich mud. The upper 4 cm contain 97% silt and clay and 3% fine sand (Figure 7-43). In addition, the sediment contains plant debris from the adjacent wetland. The soft sediment layer extends to approximately 1 m (3.1 feet) in the eastern and central part of the pond, and to 0.5 to 0.8 m (1.6 to 2.6 feet) in the western part of the pond (Figure 7-44 and 7-45). At Station 8 in the eastern part of the pond, the soft sediment thickness of 2 m (6 feet) was twice as large as at the surrounding stations. This depth could indicate a former Blackstone River channel, as suggested by the position of the oxbow. The soft sediment depth at the entrance to the oxbow was also nearly 2 m (6 feet).

The high organic carbon concentration of the surficial sediments, 18% by weight (0-2cm) and 11% by weight (2-4 cm) is indicative of a depositional basin operating in an organic matter rich environment (Figure 7-10). These high organic carbon concentrations are paralleled by high nitrogen (1.7%, 0.9%) and phosphorus (0.32%, 0.27%) concentrations. The high levels of all three of these constituents of plant/algae/phytoplankton is expected based upon a wetland/water-column source of the organic matter (as opposed to wastewater). The moderate levels of chlorophyll *a* within the surface sediments further suggests an input of organic matter from the wetland or water column, rather than in-situ production at the sediment surface. This latter observation is consistent with the poor transparency of the overlying waters.

The algal composition of the upper 2 cm of the sediment column consists to roughly 50% of wetland plants and to 50% of macroalgae (Figure 7-11). Results are considered an estimate because of the fragmented nature of the plant material. It should be noted that the remnants of higher plants tend to persist much longer than macroalgae and phytoplankton. Phytoplankton tend to degrade within days to weeks and macroalgae in weeks to a few months. In contrast, fragments of higher plants, especially if they contain lignin, can persist for years. These data indicate that plant material from the extensive wetlands and possibly from the Blackstone River, are entering the pond sediments. However, integrating all of the sediment data indicate that plant detritus, algae and phytoplankton are the predominant source of organic matter to the sediments.

The soft sediments in Valley Falls Pond contain high concentrations of metals. All heavy metals analyzed exceed nearly all guideline values for sediment quality (Figure 7-12). All measured metal concentrations are well above the background concentrations in Rhode Island soils, suggesting anthropogenic sources. Data from Dr. John King at URI (unpublished data) show that the concentrations remain high throughout the entire soft sediment layer to a depth of approximately 1 m (3 feet).

7.4 Summary

Valley Falls Pond is presently eutrophic. All of the water quality and phytoplankton biovolume indicators of trophic status would classify Valley Falls Pond and the upstream Blackstone River as well within the eutrophic range. Even as a wetland/pond it appears that these several lines of evidence support the classification of Valley Falls Pond as impaired by nutrients, and its placement on the 303(d) list.

Valley Falls Pond is influenced by the Blackstone River, but at the same time it functions as a semi-separate system. The pond is flushed primarily as a result of fluctuations in the water elevation in the river. Some additional flushing occurs from stormwater runoff from the Valley Falls Marsh and from discharges of NBC CSO #007 in the southeastern corner of the pond. It is also possible that groundwater inflow along the western shore is enhanced by groundwater flows from Scott Pond, but this has not been quantified.

Valley Falls Pond acts as a depositional basin accumulating fine-grained sediments and organic matter derived from the high level of algae and phytoplankton growth, associated with its eutrophic status of its waters, and detritus from the surrounding wetlands. The fine-grained sedimentary materials in Valley Falls Pond are likely largely derived from the Blackstone River, because it is the main sediment source. Due to the absence of currents in the pond, suspended particles are allowed to settle out of the water column. The consequence of this deposition is the accumulation of nitrogen and phosphorus and the accumulation of 0.5 to 2.0 m (1.5 to 7 feet) of unconsolidated material. It is likely that the high rate of organic matter deposition results in a high rate of sediment oxygen demand that is causing the periodic oxygen depletion within the pond. However, it also appears that the water within the pond is sufficiently shallow to have adequate ventilation to prevent anoxia.

Pathogen concentrations are generally low but can increase as a result of flooding of the pond by the Blackstone River. During larger flood events, the pathogen concentrations in the pond are expected to be the same as the concentration in the river. This seemed to be the case during the December 6, 2004 sampling event. Elevated pathogen loads also appear to be supplied by the NBC CSO #007 during both dry and wet weather, although the data are based on three reconnaissance sampling events only. Another small pathogen source is local wildlife, namely turtles and local birds. Regularly observed during the field surveys were swans, ducks, egrets, and cormorants. In addition, some pathogens likely enter the pond from runoff of the Valley Falls Marsh.

As for pathogens, dissolved metal concentrations in the pond have to be similar to the metal concentrations in the Blackstone River during flood events. Dissolved copper concentrations were generally similar in Valley Falls Pond and the Blackstone River station (Figure 7-33). However, the dissolved lead concentration was always higher than in the river. Hardness was also high. Only one sample violated the chronic criterion for lead. It is noted that for historic data, the process of sample collection must be considered as the sediments are easily stirred up by even a shallow draft boat and especially any type of outboard engine, which potentially results in the release of metal-enriched interstitial waters from the sediment column.

The Blackstone River is the predominant source of phosphorus to Valley Falls Pond and the rate of loading to the pond is primarily through water exchange with the Blackstone River. River-pond water exchange is controlled by alterations in river level and flows associated with storm events and flow recession. Therefore, the trophic status of the pond is controlled primarily by the water quality of the Blackstone River. However, even under the eutrophic conditions of the pond, the Valley Falls Marsh appears to be highly productive and be currently operating as a healthy wetland system. The association of Valley Falls Pond with the large surrounding wetland also provides a mechanism for the organic enrichment of the pond, even without the Blackstone River loadings. Transport of organic matter off of emergent wetlands into the adjacent depositional basin as flood water recedes or during plant senescence in the fall are the likely processes. While it is unlikely that the wetlands are the cause of the present eutrophic-hypereutrophic conditions within the pond, it is likely that it would result in some moderate level of "impairment" if the Blackstone River loading were significantly reduced. It is for this reason that wetland/pond systems are managed at a higher nutrient and organic matter loading than typical pond systems and that the present pond appears to support important fish habitat. Nevertheless, Valley Falls Pond is currently far above any standard for nutrient related health. For example, Pond waters are presently 10 times higher than the threshold total phosphorus level indicating eutrophic conditions (0.02 mg/l) in lakes and ponds.

It is clear that management options for removing Valley Falls Pond from the 303(d) list for impairments related to phosphorus enrichment must include both improvements of the Blackstone River waters which dominate the loading to the pond and an acknowledgement that the pond is operating not as a "classic" freshwater pond or lake, but as an open water basin within a significant wetland system. The observations of the healthy status of the Valley Falls Marsh and the relatively modest oxygen depletions and the status of fish habitats in the pond under its currently high rates of organic matter inputs, supports the contention that wetland ponds are less sensitive to nutrient enrichment than "classic" ponds and lakes.

It is our understanding that the biodiversity impairment determination for Valley Falls Pond was made by extrapolation of the biological data from the Manville station along the Blackstone River to the pond (Connie Carey, RIDEM, personal communication, August 10, 2006). The findings of this study support this determination for the pond. As for nutrients, improvements to the biodiversity in the pond will be tied to improvements of the water quality in the Blackstone River.

The available metals data do not support listing the pond for lead on the 303(d) list. On the other hand, the pond could be listed for the same metals as the Blackstone River, given that it the primary source of water in the pond.

The available data allow a screening of some potential management options for Valley Falls Pond. Given the intimate association of the pond to the Blackstone River, attempts to reduce the organic matter and phosphorus loading to the pond by isolation or restriction of inflow does not appear feasible given the diversity of wetland types requiring a complex range of wetting and drying cycles. The periodic flooding levels within the wetlands are critical to maintaining the variety of plant communities and wetland function and could likely not be replicated. Further, it appears that the Valley Falls Marsh may be serving to remove nutrients and organic matter from the river waters which contact them, thus serving to "improve" conditions in downstream waters.

Another potential management option for improving Valley Falls Pond would be to increase the flushing of Pond waters by creating a flow-through pond, rather than a tributary basin to the Blackstone River. Construction of a channel with a control structure between the western end of the pond and the Blackstone River, possibly in the vicinity of the radio tower would create flow through the pond. However, while this would increase water exchange, it does not appear that it would improve the water quality. Water quality within the pond appears to be currently dominated by the nutrient and organic matter enriched nature of the inflowing River waters. Increasing the input of River waters with their present quality would not cause any significant improvement and may even result in higher rates or organic matter deposition within the pond. In addition, it could lead to resuspension and transport of the soft metal-rich bottom sediments from the pond into the Blackstone River.

7.5 Recommendations

Following are recommendations for follow-up activities for Valley Falls Pond:

- *Improve the water quality in the Blackstone River:* Phosphorus enrichment of Valley Falls Pond is presently dominated by exchanges with the nutrient and organic matter enriched eutrophic waters of the Blackstone River.

- *Role of pond in Blackstone River system:* Valley Falls Pond appears to be removing/retaining nutrients and organic matter originating within its adjacent wetlands and from the inflowing river waters. The pond also acts as a depositional basin for fine-grained sediments transported by the Blackstone River. Therefore, the pond appears to be operating to improve water quality conditions of downstream river waters. An analysis of the extent of this improvement is necessary prior to any management of the basin configuration (dredging) or water exchange between the pond and the Blackstone River.

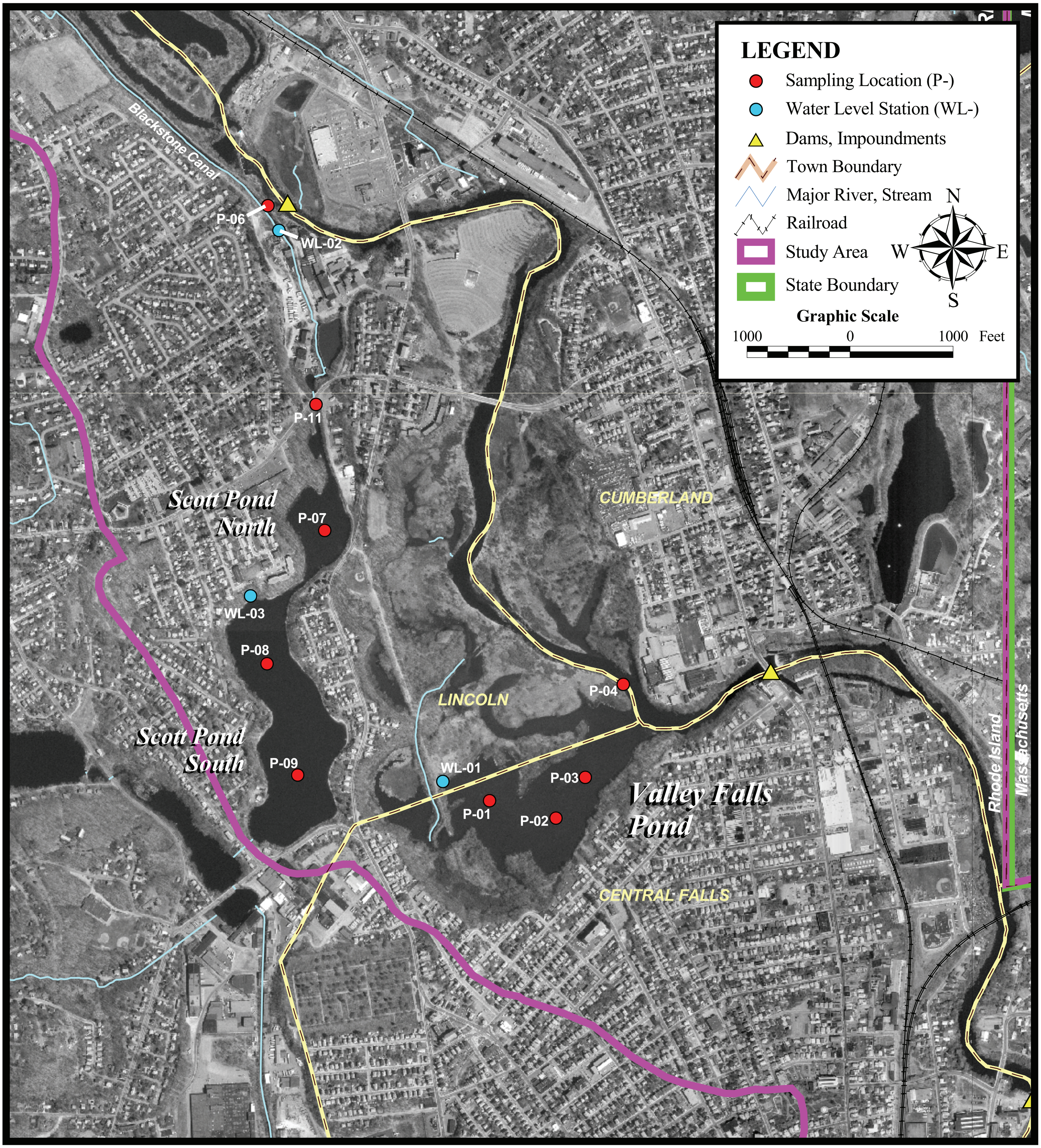
- *Effect of deepening on dissolved oxygen:* While the pond basin is accumulating fine-grained sediments, organic matter and nutrients, management options that require deepening of the basin need to consider that the present quality of the pond is linked in part to its vertical mixing. The shallow waters tend to be well-ventilated with only modest levels of oxygen depletion. Typically, as water depth increases, a system's ability to maintain oxygen levels is reduced.

- *Flow-through channel:* Creating a flow-through channel of Blackstone River water would not appear to improve conditions in Valley Falls Pond, due to the eutrophic nature of the river waters. However, if management of Scott Pond indicates that a surface water outflow would be desirable, an analysis of discharging to Valley Falls Pond rather than the Moshassuck River would be important. It appears that the surface waters of Scott Pond are of higher quality than of Valley Falls Pond and therefore would serve as a "higher quality" source of water. The extent to which this would improve Valley Falls Pond's phosphorus enrichment cannot be ascertained from existing information, as the present groundwater flow between the ponds is unknown (i.e., the volume of flow may not change if present recharged groundwater from Scott Pond is already entering Valley Falls Pond).

- *Outfall NBC CSO #007*: This outfall should be investigated in more detail to determine its loading of pathogens, metals, and nutrients to the pond. Mitigation measures should be considered, as appropriate.

- *Metals in sediment:* The contribution of dissolved metals in the sediment of Valley Falls Pond to the water quality is not known.

- *Shorefront to Valley Falls Pond:* Stormwater and wastewater from streets along Valley Falls Pond are largely collected. Only a small number of houses are located at a lower elevation than the closest street with stormwater and sewer pipes (i.e., Shawmut Avenue). This includes houses on Temple Street and Arrow Street. However, the resident at 44 Temple Street stated on October 6, 2005 that she has a pump that transports the wastewater to the drain on Shawmut Street. She did not know if that is the case also for the other houses. Her house was built around the year 2000. The total volume of stormwater entering Valley Falls Pond is expected to be very small. Some of the houses at lower elevations have septic systems. It is recommended to identify these houses and assess potential discharges from the septic system and other sources to the pond.



The Louis Berger Group, Inc.

Rhode Island DEM

Source: RIGIS, MASSGIS

File: bw-report-07.apr

Blackstone River Water Quality

Figure 7-1

VALLEY FALLS POND AND SCOTT POND STATIONS

Figure 7-2: Valley Falls Dam, controlling the elevation in Valley Falls Pond (7/14/04).

Figure 7-3: Valley Falls Pond – entrance (8/10/04)

Figure 7-4: Island in center of VFP, looking west (8/10/04).

Figure 7-5: Water lilies - western end of VFP (8/10/04).

Figure 7-6: Purple loosestrife along VFP (8/10/04).

Figure 7-7: Oxbow with water lilies.

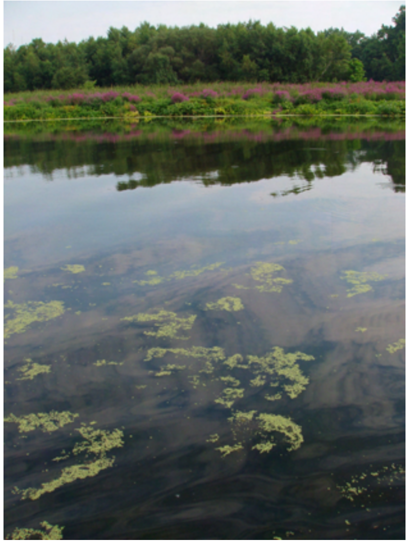


Figure 7-8: Coontail in VFP (8/12/05).

Figure 7-11: Turtle nesting in VF Marsh along edges of the Pond (9/13/05).

Figure 7-9: Dense algal growth in VFP (9/27/05).

Figure 7-12: Meander scar in VF Marsh (9/13/05).

Figure 7-10: Upland fill in VF Marsh (9/13/05).

Figure 7-13: Former drainage channel (9/13/05).

Figure 7-14: Twin culverts (9/13/05).

Figure 7-17: Aquatic bed with pond weeds (9/13/05).

Figure 7-15: Blackstone River Tourisms Council tour.

Figure 7-18: Aquatic bed with water lily along VFP (9/13/05).

Figure 7-16: Fisherman on Blackstone River near VFP.

Figure 7-19: Nonpersistent emergent vegetation in VF Marsh (9/13/05).

Figure 7-20: Emergent marsh fringing edge of VFP (9/13/05).

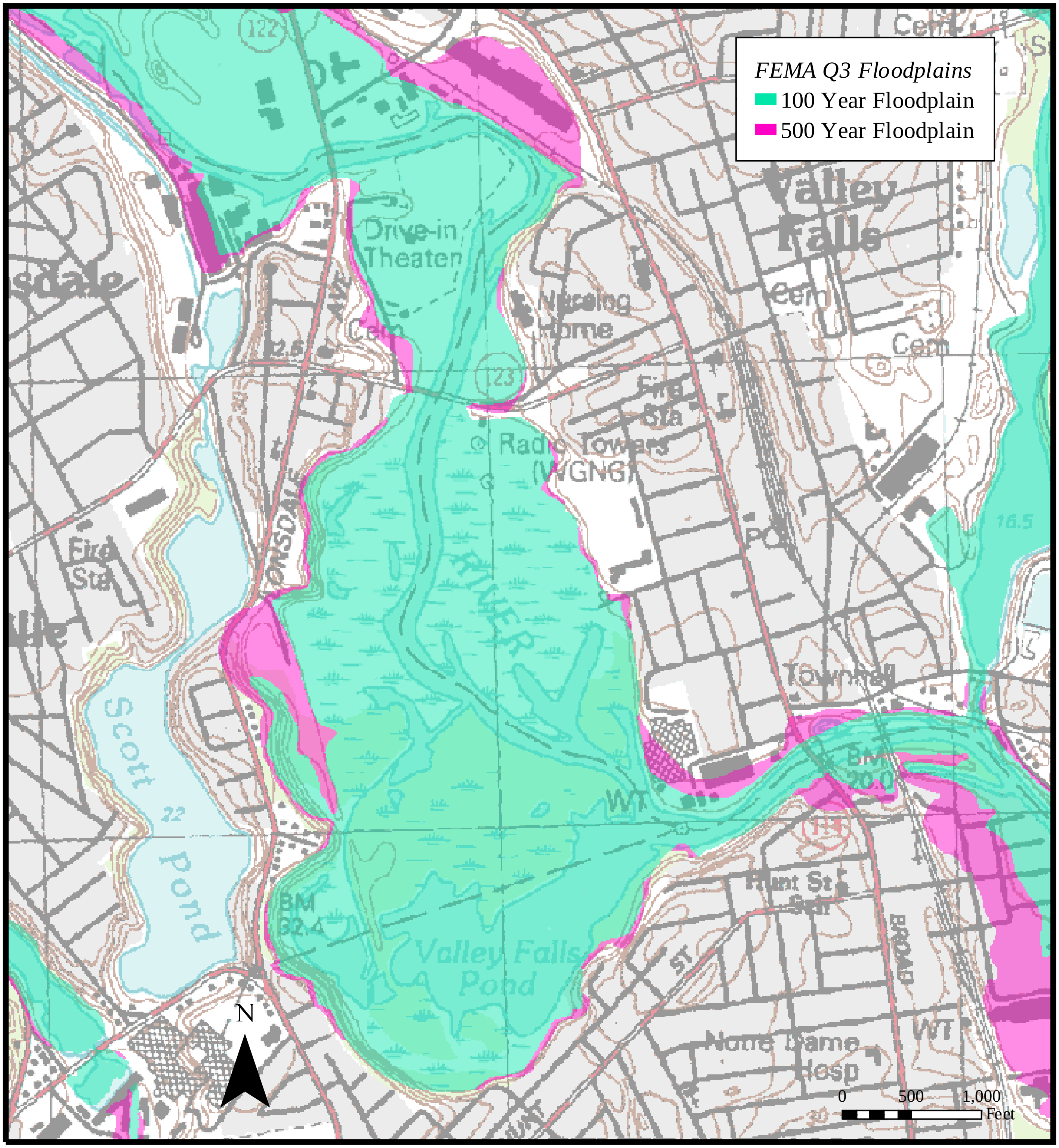
Figure 7-23: Water willow along edge of VFP (9/13/05).

Figure 7-21: *Phragmites* in marsh zone along VFP (9/13/05).

Figure 7-24: Stand of gray birch along Blackstone River bank (9/13/05).

Figure 7-22: Wet meadow dominated by sedges in VF Marsh (9/13/05).

Figure 7-25: Wooded swamp near rail corridor in VF Marsh (9/13/05).



The Louis Berger Group, Inc.

Rhode Island DEM

Source: FEMA, RIGIS

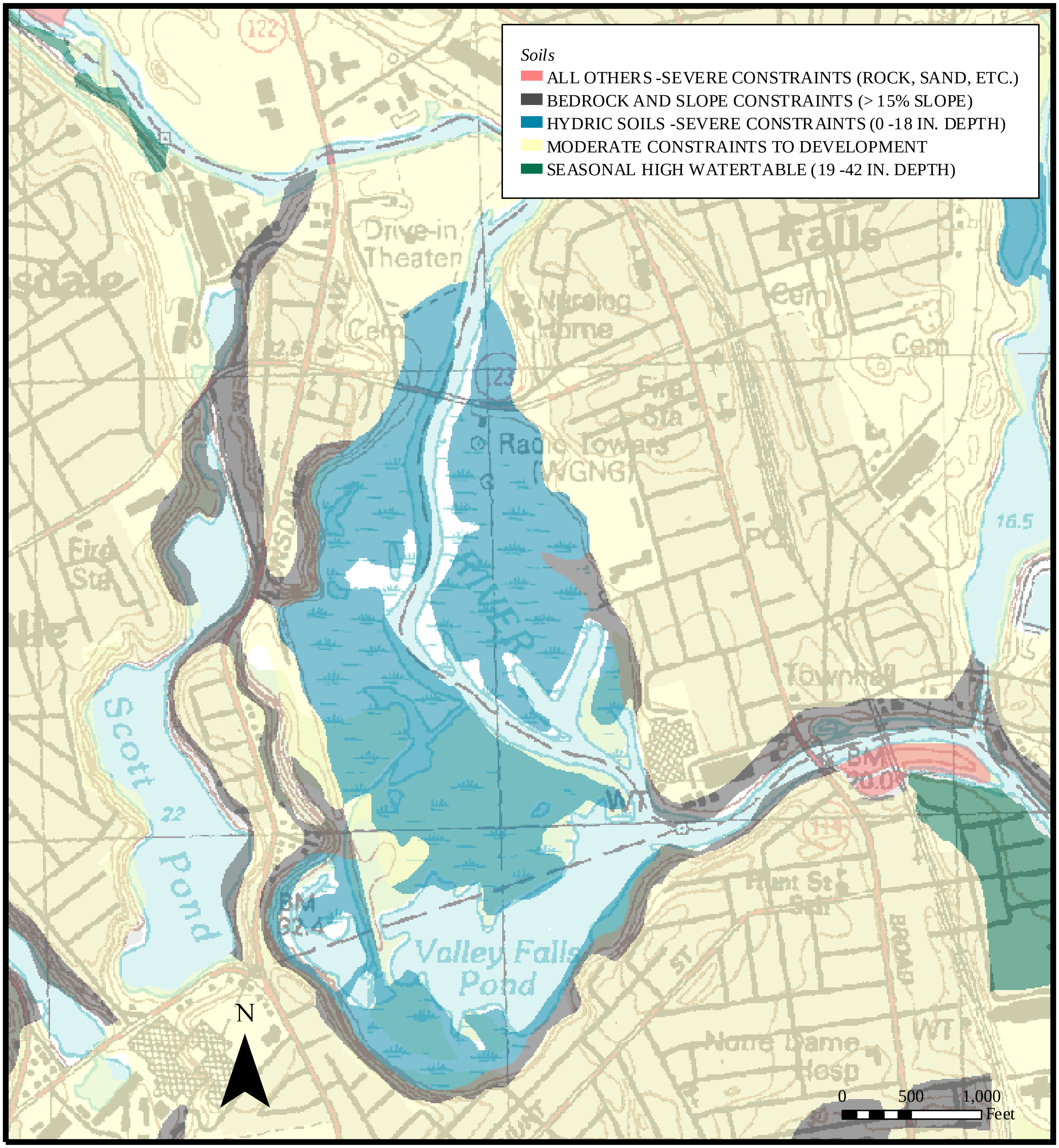
FEMAQ3.mxd

2005-10-14

Blackstone River Water Quality

Figure 7-26

FEMA Q3 FLOODPLAINS



The Louis Berger Group, Inc.

Rhode Island DEM

Source: USDA/NRCS, RIGIS

Soils.mxd

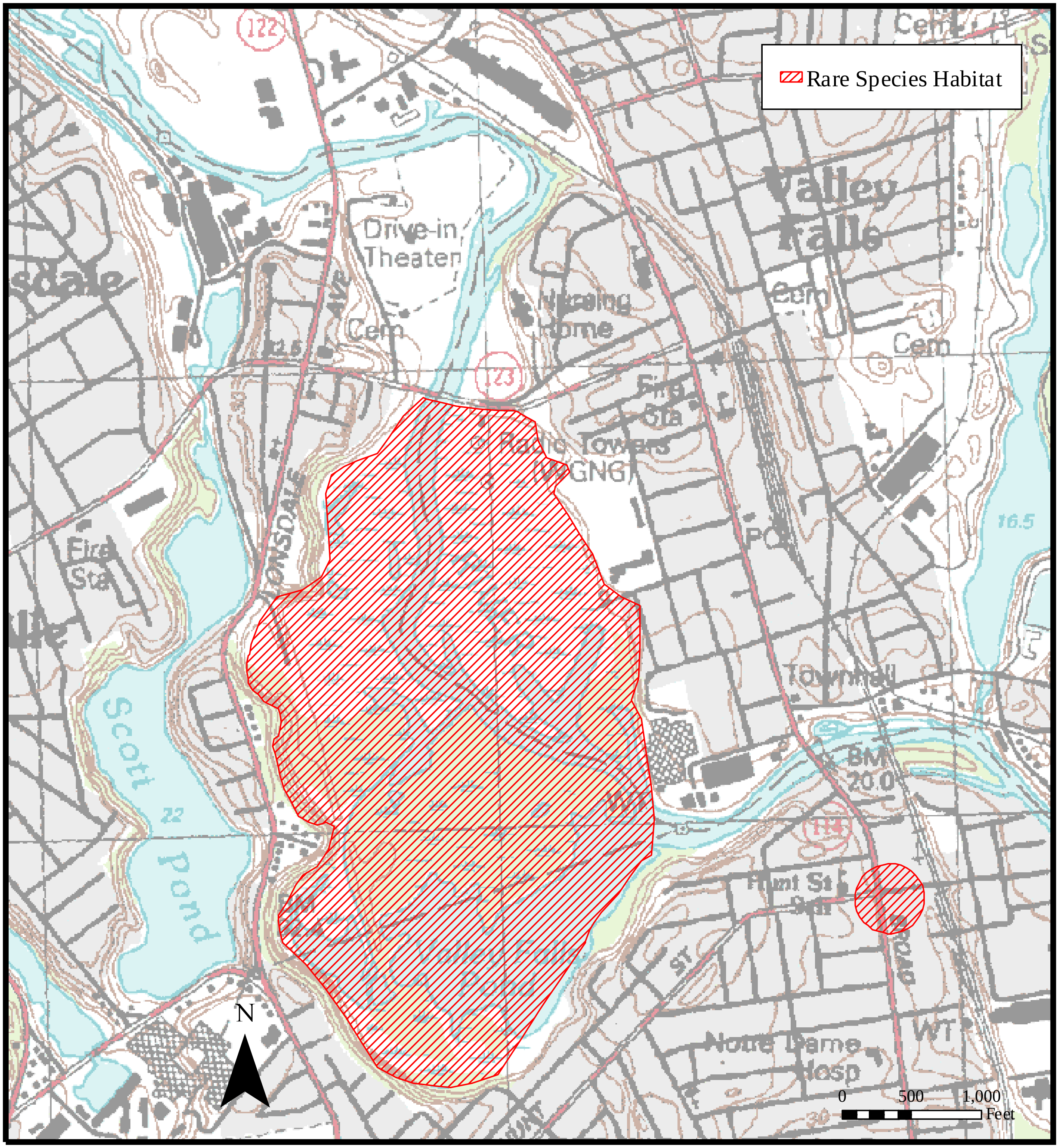
2005-10-14

Blackstone River Water Quality

Figure 7-27

SOIL CONSTRAINTS

(Soil Survey Geographic [SSURGO] Database)



The Louis Berger Group, Inc.

Rhode Island DEM

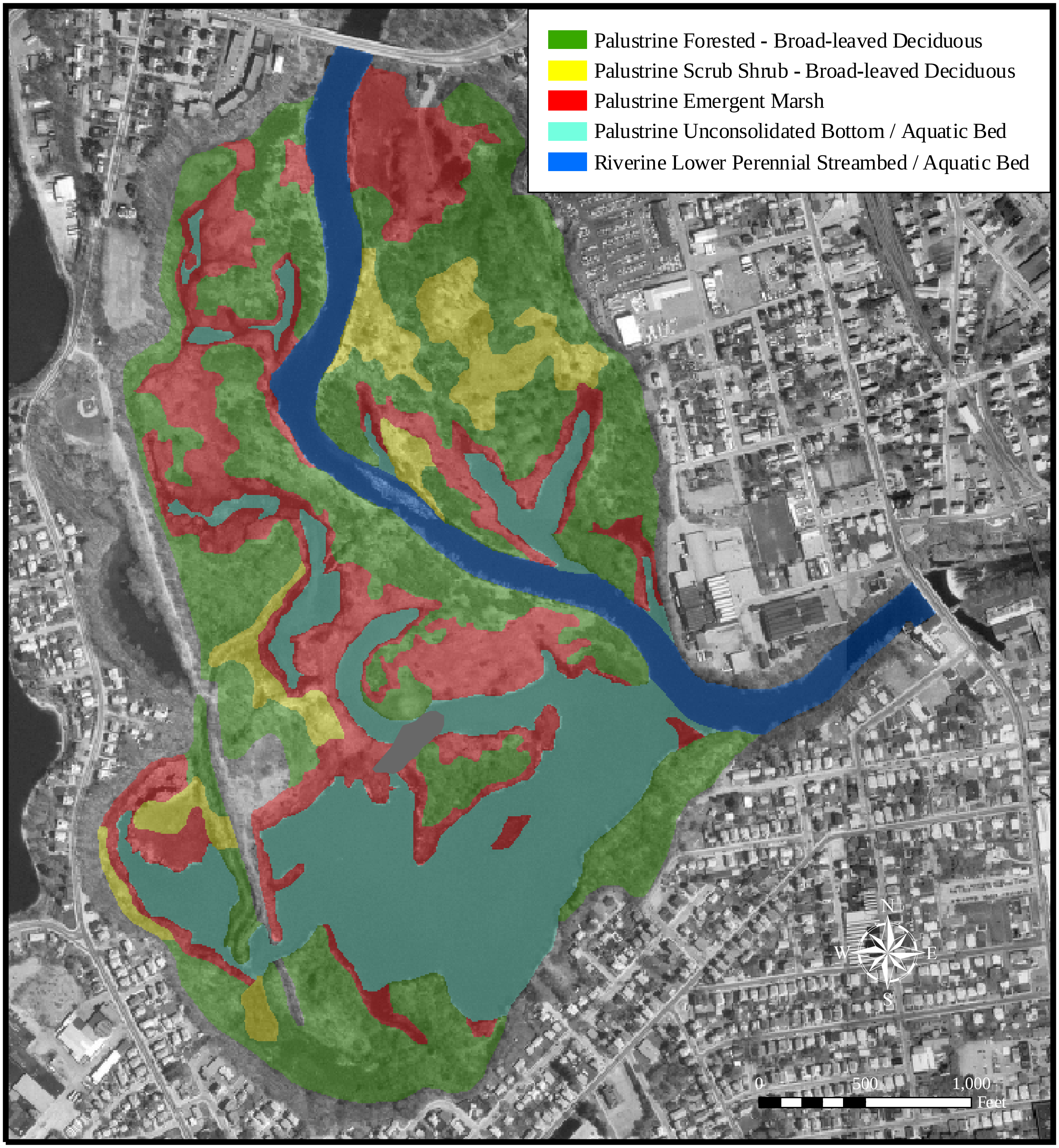
Source: FEMA, RIGIS

Habitat.mxd	2005-10-14

Blackstone River Water Quality

Figure 7-28

ESTIMATED HABITAT & RANGE OF RARE SPECIES & NOTEWORTHY NATURAL COMMUNITIES



The Louis Berger Group, Inc.

Rhode Island DEM

Based on 1999 Aerial Photograph

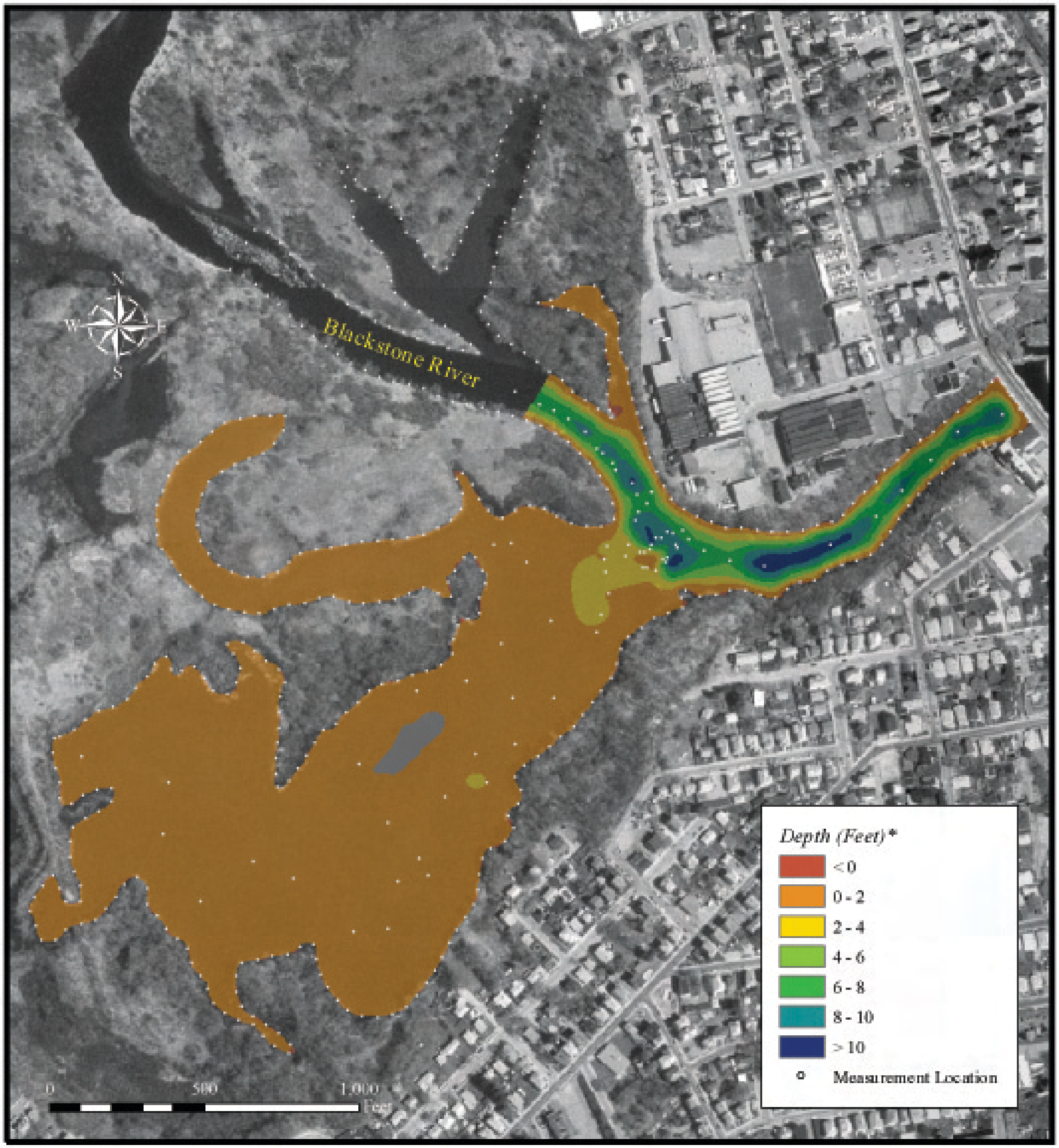
BathymetryValleyF.mxd

2006-01-31

Blackstone River Water Quality

Figure 7-29

WETLAND VEGETATION IN VALLEY FALLS MARCH



The Louis Berger Group, Inc.

Rhode Island DEM

Source: RIGIS, The Louis Berger Group

BathymetryValleyF.mxd

2006-01-31

Blackstone River Water Quality

Figure 7-30

VALLEY FALLS POND BATHYMETRY

** Bathymetry is based on lowest Blackstone River flow.*

Figure 7-31: Water Depths in Valley Falls Pond, and Water Elevations in Blackstone Canal and Scott Pond.
Gages were deployed at Stations WL-01 to WL-03 (see Figure 7-1 for station locations).

Figure 7-32: Water Quality in Valley Falls Pond

																																Regulatory Standards				
Station *(1)*	Name	Time	Water Depth	Secchi Depth	Survey Water Depth	Temperature	Conductivity	Dissolved Oxygen	pH (Field)	pH (lab)	Turbidity	Fecal Coliform	Enterococci	Ortho-phosphate	Total Phosphorus	Ammonia	Nitrate	DIN	Total Dissolved Nitrogen	DON	Particulate Organic Carbon	Particulate Organic Nitrogen	C/N	TON	TN	Chlorophyll *a*	Pheophytin *a*	Ratio Chl *a* / (Chl *a* + Pheo *a*)	Dissolved Copper *(4)*	Dissolved Lead *(4)*	Hardness *(4)*	Dissolved Copper - Acute Criteria	Dissolved Copper - Chronic Criteria	Dissolved Lead - Acute Criteria	Dissolved Lead - Chronic Criteria	Comments
		h	m	m	m	ºC	uS/cm	mg/l			NTU	col/100 ml		mg/l P		mg/l N								mg/l N		ug/l	ug/l		ug/l	ug/l	mg/l	ug/l	ug/l	ug/l	ug/l	
Event POND-01: August 10, 2004 *(Dry Weather)*																																				*(5)*
P-01	VFP - west	12:08	0.95	>0.9	0.2	*ed*	412	12.4	*ed*		7.6	8		0.135	0.23	0.02	0.01	0.02	0.63	0.61	2.49	0.32	9.16	0.93	0.95	0.69	1.69	0.29								
					0.5			12.8																												
P-02	VFP - central	12:20	0.52	>0.5	0.2	25.6	417	12.2	*ed*		14.3	<2		0.145	0.48	0.04	0.14	0.18	0.81	0.63	3.04	0.41	8.63	1.04	1.22	4.70	12.58	0.27								
					0.3			11.8																												
					0.5			11.8																												
P-03	VFP - east	12:35	0.55	>0.5	0.2	24.8	427	13.6	*ed*		11.2	2		0.127	0.29	0.04	0.60	0.64	1.52	0.87	2.09	0.28	8.83	1.15	1.79	4.06	4.78	0.46								
					0.3			13.2																												
					0.5			13.2																												
P-04	Blackstone River - up	12:42	2.75	1.5	0.2	22.8	448	8.2	*ed*		2.5	110		0.122	0.43	0.01	1.77	1.78	2.11	0.32	1.29	0.21	7.27	0.53	2.31	12.39	5.06	0.71								
					0.5			8.2																												
					2.5			8.2																												
P-05	(duplicate of VFP-04)				0.5							80		0.117	0.30	0.01	1.76	1.77	2.15	0.38	1.40	0.23	7.10	0.61	2.38	13.57	1.13	0.92								
Event POND-02: September 17, 2004 *(Dry Weather)*																																				*(3)*
P-01	VFP - west	12:08	0.50	>0.5	0.2	22.7	412	11.4	9.3	9.2	5.9	2	12	0.057	0.30	0.01	0.01	0.02	0.75	0.73	2.70	0.36	8.64	1.09	1.11	4.14	3.56	0.54			61					
					0.3																															
					0.5	22.7	409	11.4																												
P-02	VFP - central	12:33	0.50	>0.5	0.2	22.9	405	6.5	7.2	7.5	9.2	14	18	0.086	0.39	0.24	0.36	0.61	1.17	0.57	2.28	0.33	8.12	0.89	1.50	9.24	2.69	0.77	*ed*	*ed*	25					
					0.3																															
					0.4	22.9	404	6.5																												
P-03	VFP - east	12:58	0.50	>0.5	0.2	22.3	400	7.5	7.2	7.5	7.5	5	10	0.092	0.25	0.21	0.65	0.86	1.22	0.36	2.76	0.38	8.44	0.74	1.61	6.65	4.25	0.61	*ed*	*ed*	57					
					0.3																															
					0.5	22.3	397	7.5																												
P-04	Blackstone River - up	13:30	2.80	2.3	0.2	20.8	375	8.3	7.4	7.4	1.4	36	10	0.088	0.13	0.07	1.42	1.48	1.69	0.21	0.58	0.08	8.04	0.29	1.78	7.57	3.20	0.70	*ed*	*ed*	55					
					0.5																															
					1.0	20.2	397	8.1																												
					2.0	20.1	396	8.1																												
P-05	(duplicate of P-04)				0.5					7.3		44	<2	0.088	0.19	0.07	1.47	1.54	1.85	0.32	0.58	0.09	7.86	0.40	1.94	6.53	1.94	0.77	*ed*	*ed*	46					
Event POND-03: December 6, 2004 *(Dry Weather)*																																				
P-01	VFP - west	10:58	0.84	>0.8	0.2	3.2	177	10.8	8.1		5.6	300	30	0.048	0.10	0.13	0.46	0.59	0.83	0.24	2.37	0.28	9.73	0.52	1.11	6.30	0.65	0.91	*ed*	*ed*	43					
					0.4	3.2	177	10.7																												
					0.7	3.2	177	10.7																												
P-02	VFP - central	10:52	0.90	>0.9	0.2	3.2	173	12.0	7.8		4.0	500	36	0.057	0.10	0.15	0.53	0.68	1.03	0.36	1.17	0.16	8.50	0.52	1.19	11.39	<0.05	1.00	*ed*	*ed*	39					
					0.4	3.2	173	12.0																												
					0.7	3.2	173	12.0																												
P-03	VFP - east	12:01	0.90	>0.9	0.2	3.1	175	11.9	8.0		4.0	500	21	0.056	0.11	0.12	0.50	0.62	0.87	0.25	1.35	0.19	8.31	0.44	1.06	6.94	<0.05	0.99	*ed*	*ed*	39					
					0.4	3.1	174	11.9																												
					0.8	3.1	173	11.9																												
P-04	Blackstone River - up	12:18		1.3	0.2	4.4	177	13.1	7.9		4.3	240	69	0.063	0.10	0.17	0.65	0.82	1.10	0.28	0.67	0.07	10.63	0.35	1.17	3.11	1.29	0.71	*ed*	*ed*	38					
					1.0	4.4	177	13.1																												
					4.5	4.4	177	13.1																												
P-05	(duplicate of P-04)				1.0							1,600	56	0.063	0.10	0.17	0.64	0.81	1.14	0.33	0.72	0.08	10.76	0.41	1.22	2.89	1.53	0.65	*ed*	*ed*	38					

Figure 7-32 *(cont.)*: Water Quality in Valley Falls Pond

																																Regulatory Standards				
Station *(1)*	Name	Time	Water Depth	Secchi Depth	Survey Water Depth	Temperature	Conductivity	Dissolved Oxygen	pH (Field)	pH (lab)	Turbidity	Fecal Coliform	Enterococci	Ortho-phosphate	Total Phosphorus	Ammonia	Nitrate	DIN	Total Dissolved Nitrogen	DON	Particulate Organic Carbon	Particulate Organic Nitrogen	C/N	TON	TN	Chlorophyll a	Pheophytin a	Ratio Chl a / (Chl a + Pheo a)	Dissolved Copper *(4)*	Dissolved Lead *(4)*	Hardness *(4)*	Dissolved Copper - Acute Criteria	Dissolved Copper - Chronic Criteria	Dissolved Lead - Acute Criteria	Dissolved Lead - Chronic Criteria	Comments
		h	m	m	m	ºC	uS/cm	mg/l			NTU	col/100 ml		mg/l P		mg/l N								mg/l N		ug/l	ug/l		ug/l	ug/l	mg/l	ug/l	ug/l	ug/l	ug/l	
Event POND-04: April 19, 2005 *(Dry Weather; sunny, calm)*																																				
P-01	VFP - west	9:15	0.60	0.45	0.2							7	16																							
					0.3	14.9	356	11.6	*ed*	8.0	12.2			0.021	0.16	0.01	0.00	0.01	0.39	0.38	6.27	0.77	9.47	1.15	1.16	25.56	19.55	0.57	*ed*	*ed*	49					
					0.6																															
P-02	VFP - central	9:20	0.65	0.51	0.2							4	<1																							
					0.3	15.1	360	12.7	*ed*	8.0	10.1			0.012	0.14	0.01	0.35	0.35	0.67	0.31	3.68	0.62	6.94	0.93	1.28	67.05	<0.05	1.00	*ed*	*ed*	50					
					0.6																															
P-03	VFP - east	9:30	0.68	0.54	0.2							80	2																							
					0.3	14.4	363	12.0	*ed*	7.9	10.6			0.014	0.14	0.01	0.49	0.50	0.70	0.20	3.47	0.60	6.75	0.80	1.30	72.03	<0.05	1.00	*ed*	*ed*	50					
					0.6																															
P-04	Blackstone River - up	9:38	3.80	2.10	0.2	12.9	381	10.2				22	<1																							
					1.0	12.9	382	10.4	*ed*	7.8	3.0			0.025	0.07	0.45	0.95	1.41	1.60	0.19	0.79	0.10	9.12	0.29	1.70	7.60	0.72	0.91	*ed*	*ed*	44					
					2.0	12.9	382	10.4																												
P-05	(duplicate of P-04)				1.0					7.6		13	5	0.025	0.07	0.45	0.96	1.41	1.59	0.18	0.78	0.10	9.15	0.28	1.69	8.75	0.06	0.99	*ed*	*ed*	47					
Event POND-05: July 12, 2005 *(Dry Weather; sunny, calm)*																																				
P-01	VFP - west	9:30	0.70	>0.70	0.2							<200	11																							
					0.3	25.5	415	n/a	7.8		6.5																									
					0.6																															
P-02	VFP - central	10:30	0.70	>0.70	0.2							<200	6																							
					0.3	25.3	410	n/a	7.9		10.0																									
					0.6																															
P-03	VFP - east	10:20	0.70	>0.70	0.2							<200	24																							
					0.3	24.8	390	n/a	7.9		10.1																									
					0.6																															
P-04	Blackstone River - up	10:05		1.30	0.2																															
					1.0				7.6		4.8																									
	BR - down *(2)*	11:30			0.1	23.6	342	n/a	7.9		4.4	<200	19																							
P-05	(duplicate of P-04)				1.0							<200	70																							
Event POND-06: July 28, 2005 *(Dry Weather; sunny, calm)*																																				*(6)*
P-01	VFP - west	8:15	0.55	0.50	0.2	25.4	485	5.8				20	*ed*																							
					0.3				8.4		15.6			0.156	0.39	0.05	0.19	0.24	0.69	0.45	1.84	0.33	6.61	0.77	1.01	12.37	11.27	0.52	3.4	**2.4**	70	9.60	6.60	43.71	1.70	
					0.4	25.4	484	6.0																												
P-02	VFP - central	8:32	0.51	0.48	0.2	24.9	483	6.0				<20	*ed*																							
					0.3				8.2		24.4			0.145	0.45	0.11	0.29	0.40	0.80	0.40	1.90	0.32	6.84	0.72	1.12	11.97	14.94	0.44	3.6	1.4	66	9.09	6.28	40.97	1.60	
					0.4	24.9	483	5.7																												
P-03	VFP - east	8:41	0.45	>0.45	0.2	25.1	480	5.4			15.1	<20	2																							
					0.3				8.0					0.161	0.33	0.09	0.32	0.41	0.80	0.39	1.80	0.30	7.05	0.69	1.09	10.19	8.05	0.56	3.7	1.2	66	9.09	6.28	40.97	1.60	
					0.4	25.0	479	4.9																												
P-04	Blackstone River - up	9:50	2.77	1.10	0.2	25.3	499	5.3				110	2																							
					1.0	25.2	499	5.1	8.0		3.3			0.120	0.19	0.05	0.93	0.98	1.25	0.27	1.63	0.27	7.07	0.54	1.52	13.23	52.20	0.20	4.3	<0.10	65	8.96	6.20	40.28	1.57	
					2.0	25.2	499	**4.9**																												
					2.5	25.2	499	**4.7**																												
P-05	(duplicate of P-04)				1.0							230	1	0.119	0.20	0.05	0.97	1.02	1.42	0.40	1.75	0.30	6.84	0.70	1.72	38.14	17.87	0.68	4.5	<0.10	67	9.22	6.36	41.65	1.62	

Figure 7-32 *(cont.)*: Water Quality in Valley Falls Pond

																																Regulatory Standards				
Station *(1)*	Name	Time	Water Depth	Secchi Depth	Survey Water Depth	Temperature	Conductivity	Dissolved Oxygen	pH (Field)	pH (lab)	Turbidity	Fecal Coliform	Enterococci	Ortho-phosphate	Total Phosphorus	Ammonia	Nitrate	DIN	Total Dissolved Nitrogen	DON	Particulate Organic Carbon	Particulate Organic Nitrogen	C/N	TON	TN	Chlorophyll *a*	Pheophytin *a*	Ratio Chl *a* / (Chl *a* + Pheo *a*)	Dissolved Copper *(4)*	Dissolved Lead *(4)*	Hardness *(4)*	Dissolved Copper - Acute Criteria	Dissolved Copper - Chronic Criteria	Dissolved Lead - Acute Criteria	Dissolved Lead - Chronic Criteria	Comments
		h	m	m	m	ºC	uS/cm	mg/l			NTU	col/100 ml		mg/l P		mg/l N								mg/l N		ug/l	ug/l		ug/l	ug/l	mg/l	ug/l	ug/l	ug/l	ug/l	
Event POND-07: August 12, 2005 *(Dry Weather; sunny, calm)*																																				
P-01	VFP - west	11:03	0.50		0.3	*ed*	567	**4.3**	8.3		13.6	Collection of sediment samples for grain size, macroalgae, CNP, and chlorophyll. Also, collection of phytoplankton from water column.																								
P-02	VFP - central	12:10	0.50		0.3		538		8.6		9.2																									
P-03	VFP - east	9:30	0.50		0.3		544		8.3		7.7																									
P-04	Blackstone- up				0.3		543		8.2		3.3																									
Event POND-08: August 14, 2005 *(no activities in Valley Falls Pond)*																																				
Event POND-09: August 15, 2005 *(Wet weather; cloudy, post-rain event)*																																				
P-01	VFP - west	10:18	0.50	0.45	0.2 0.3 0.4	25.6 25.7	526 526	5.4 5.4	7.8		13.8	<20	51	0.123	0.42	0.10	0.09	0.20	0.75	0.55	2.36	0.33	8.37	0.88	1.08	16.13	4.29	0.79	2.0	0.68	81	11.02	7.48	51.30	2.00	
P-02	VFP - central	11:10	0.60	>0.60	0.2 0.3 0.5	25.4 25.4	534 534	6.7 6.6	8.0		8.2	<20	<10	0.104	0.27	0.07	0.59	0.66	1.09	0.43	2.05	0.32	7.49	0.75	1.41	28.74	<0.05	1.00	3.3	0.43	77	10.51	7.16	48.53	1.89	
P-03	VFP - east	11:20	0.60	>0.60	0.2 0.3 0.5	25.7 25.6	534 534	5.4 5.4	8.0		10.8	<20	41	0.144	0.32	0.12	0.29	0.41	0.91	0.51	2.66	0.37	8.44	0.87	1.28	8.13	12.36	0.40	2.7	0.84	79	10.76	7.32	49.92	1.95	
P-04	Blackstone River - up	11:30	3.20	0.90	0.2 1.0 2.0 3.0	26.1 26.1 26.1 26.1	541 541 542 542	5.4 5.2 5.2 5.1	7.6		4.2	1,100	98	0.097	0.20	0.18	1.27	1.45	1.87	0.42	1.76	0.31	6.59	0.73	2.18	62.30	15.07	0.81	5.1	0.15	77	10.51	7.16	48.53	1.89	
P-05	(duplicate of P-04)				1.0							2,400	86	0.096	0.21	0.18	1.27	1.45	1.86	0.41	1.48	0.28	6.22	0.69	2.14	29.13	10.04	0.74	5.1	0.13	77	10.94	7.46	58.54	2.28	
Event POND-10: September 13, 2005 *(Dry weather, after long dry period)*																																				
P-01	VFP - west	13:55	0.40	>0.40	0.2	28.2		*ed*	*ed*		21.8	Valley Falls Marsh Assessment; Sediment thickness survey																								
P-02	VFP - central	13:37	0.50	>0.50	0.2	27.5		*ed*	*ed*		14.6																									
P-03	VFP - east	14:15	0.50	>0.50	0.2	26.5		*ed*	*ed*		10.3																									
P-04	Blackstone	11:45	1.30	>1.3	0.2	24.5		*ed*	*ed*		1.9																									
Event POND-11: September 16, 2005 *(Wet Weather; cool, drizzle at times, one day after a rainstorm)*																																				
P-01	VFP - west	10:49	0.55	0.50	0.2 0.3 0.4	23.4 23.4	452 451	**3.9** **3.8**	7.0		17.1	140	180	0.039	0.22	0.01	0.03	0.03	0.53	0.49	4.89	0.88	6.49	1.37	1.41	10.26	2.20	0.82	2.7	0.66	76	10.38	7.08	47.84	1.86	
P-02	VFP - central	10:50	0.60	0.50	0.2 0.3 0.5	23.1 23.2	496 494	**4.6** **4.6**	7.0		12.5	40	20	0.052	0.22	0.04	0.63	0.66	1.15	0.49	4.54	0.76	6.96	1.25	1.91	21.22	4.68	0.82	3.5	0.83	78	10.63	7.24	49.22	1.92	
P-03	VFP - east	10:45	0.60	0.55	0.2 0.3 0.5	22.8 22.8	518 517	5.4 5.3	6.9		8.3	300	<10	0.092	0.24	0.11	1.03	1.14	1.67	0.53	2.83	0.47	7.00	1.01	2.14	6.96	8.05	0.46	3.7	0.57	78	10.63	7.24	49.22	1.92	
P-04	Blackstone River - up	10:01	2.00	1.4	0.2 1.0 2.0	22.7 22.7 22.7	575 576 576	6.6 6.4 6.2	7.1		3.5	230	20	0.321	0.39	0.51	2.86	3.38	3.49	0.12	1.15	0.17	8.01	0.28	3.66	15.56	7.47	0.68	5.8	0.12	78	10.63	7.24	49.22	1.92	
P-05	(duplicate of P-04)				1.0							220	30	0.321	0.41	0.51	2.88	3.39	3.40	0.01	1.21	0.16	9.04	0.17	3.56	14.98	7.01	0.68	5.5	<0.10	77	10.51	7.16	48.53	1.89	

Figure 7-32 *(cont.)*: Water Quality in Valley Falls Pond

																																Regulatory Standards				
Station *(1)*	Name	Time	Water Depth	Secchi Depth	Survey Water Depth	Temperature	Conductivity	Dissolved Oxygen	pH (Field)	pH (lab)	Turbidity	Fecal Coliform	Enterococci	Ortho-phosphate	Total Phosphorus	Ammonia	Nitrate	DIN	Total Dissolved Nitrogen	DON	Particulate Organic Carbon	Particulate Organic Nitrogen	C/N	TON	TN	Chlorophyll *a*	Pheophytin *a*	Ratio Chl *a* / (Chl *a* + Pheo *a*)	Dissolved Copper *(4)*	Dissolved Lead *(4)*	Hardness *(4)*	Dissolved Copper - Acute Criteria	Dissolved Copper - Chronic Criteria	Dissolved Lead - Acute Criteria	Dissolved Lead - Chronic Criteria	Comments
		h	m	m	m	ºC	uS/cm	mg/l			NTU	col/100 ml		mg/l P		mg/l N								mg/l N		ug/l	ug/l		ug/l	ug/l	mg/l	ug/l	ug/l	ug/l	ug/l	
Event POND-12: September 28, 2005 *(Dry Weather)*																																				
P-01	VFP - west	10:05	0.40	0.30	0.3	18.7	449	6.6			23.5	Recovery of water level meters, In-situ measurements; no samples collected.																								
P-02	VFP - central	9:58	0.50	0.50	0.2	18.6	468	7.3			13.4																									
					0.4	18.1	464	7.8																												
P-03	VFP - east	9:54	0.50	0.50	0.2	18.7	463	7.1			8.3																									
					0.4	17.8	460	7.3																												
P-04	Blackstone River - up		2.30	2.0	0.2	18.1	504	7.7			3.9																									
					1.0	18.1	504	8.2																												
					2.0	18.1	504	8.3																												

ed Data removed after QA review.
(1) Stations from sampling event POND-01 were called *'VFP-___'* on the Chain-of-Custody. These stations were renamed as '*P-___* ' thereafter.
(2) Samples collected at BR Tourism Council pier downstream of Valley Falls Pond.
(3) Two samples were analyzed for Fecal Coliform and Enteroccoci for all VFP samples of Sampling Event 2.
(4) Metals were analyzed by Mitkem for Events POND-01 to POND-05, and by STL for Events POND-06 to POND-12. Hardness was analyzed by Mitkem for Events POND-01 to POND-06, and by STL for Events POND-08 to POND-12. The metals data from Mitkem were edited due to questions regarding adequate detection limits. Data are provided as Appendix, however.

7.8 Exceeds Acute Criteria
5.5 Exceeds Chronic Criteria (metals), or regulatory standards for bacteria, or lower than dissolved oxygen minimum, respectively.

Figure 7-33: Summary of Water Quality in Valley Falls Pond - In- situ Parameters, Pathogens, Metals

						In-situ Parameters *(1)*												**Pathogens** *(1)*				**Metals** *(1)*							
						Dis-solved Oxygen		**Tempe-rature**		**Conduc-tivity**		**pH**		**Secci Depth**		**Turbidity**		**Fecal Coliform**		**Entero-cocci** *(2)*		**Dissolved Copper**			**Dissolved Lead**			**Hardness**	
Event (POND-___)	**Sampling Date**	**Dry Weather**	**Wet Weather**	**Flow of Blackstone River Flow at Woonsocket** *(3)*	**Water Depth in Valley Falls Pond** *(Stn. P-02)*	Blackstone River	Valley Falls Pond	Blackstone River	Valley Falls Pond	Blackstone River	Valley Falls Pond	Blackstone River	Valley Falls Pond	Blackstone River	Valley Falls Pond	Blackstone River	Valley Falls Pond	Blackstone River	Valley Falls Pond - *MEAN*	Blackstone River	Valley Falls Pond - *MEAN*	Blackstone River	Valley Falls Pond - *MEAN*	Valley Falls Pond - *MAX.*	Blackstone River	Valley Falls Pond - *MEAN*	Valley Falls Pond - *MAX.*	Blackstone River	Valley Falls Pond
				cfs	m	mg/l		ºC		uS/cm				m		NTU		col/100 ml				ug/l			ug/l			mg/l	
01	8/10/2004	●		158	0.52	8.2	12.6	22.8	25.2	448	419			1.5	>0.5	2.5	11.0	110	3										
02	9/17/2004	●		175	0.50	8.3	8.5	20.8	22.6	389	405	7.4	7.9	2.3	>0.5	1.4	7.5	36	5	10	13	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	55	48
03	12/6/2004	●		3,000	0.90	13.1	*11.5*	4.4	3.2	177	*175*	7.9	8.0	1.3	>0.8	4.3	4.5	**240**	**422**	**69**	28	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	38	40
04	4/19/2005	●		1,000	0.65	10.3	12.1	12.9	14.8	382	360	7.8	8.0	2.1	0.5	3.0	11.0	22	13	<1	3	*ed*	*ed*	*ed*	*ed*	*ed*	*ed*	44	50
05	7/12/2005	●		700	0.70			23.6	25.2	342	405	7.8	7.9	1.3	>0.7	4.8	8.9	<200	<200	19	19								
06	7/28/2005	●		140	0.50	5.2	5.6	25.3	25.1	499	482	8.0	8.2	1.1	>0.5			110	<20	2	2	4.3	3.6	3.7	<0.10	1.67	**2.4**	65	67
07	8/12/2005	●		100	0.50					543	550	8.2	8.4			3.3	10.2												
08	8/14/2005	●																											
09	8/15/2005		●	400	0.60	5.3	5.8	26.1	25.6	542	531	7.6	7.9	0.9	>0.5	4.2	10.9	**1,100**	<20	**98**	27	5.1	2.7	3.3	0.15	0.65	0.84	77	79
10	9/13/2005	●		75	0.50			24.5	27.4					>1.3	>0.5	1.9	15.6												
11	9/16/2005		●	400	0.50	6.5	4.6	22.7	23.1	576	488	7.1	7.0	1.4	0.5	3.5	12.6	**230**	119	20	32	5.8	3.3	3.7	0.12	0.69	0.83	78	77
12	9/28/2005	●		135	0.50	8.0	7.2	18.1	18.4	504	459			2.0	0.4	3.9	15.0												

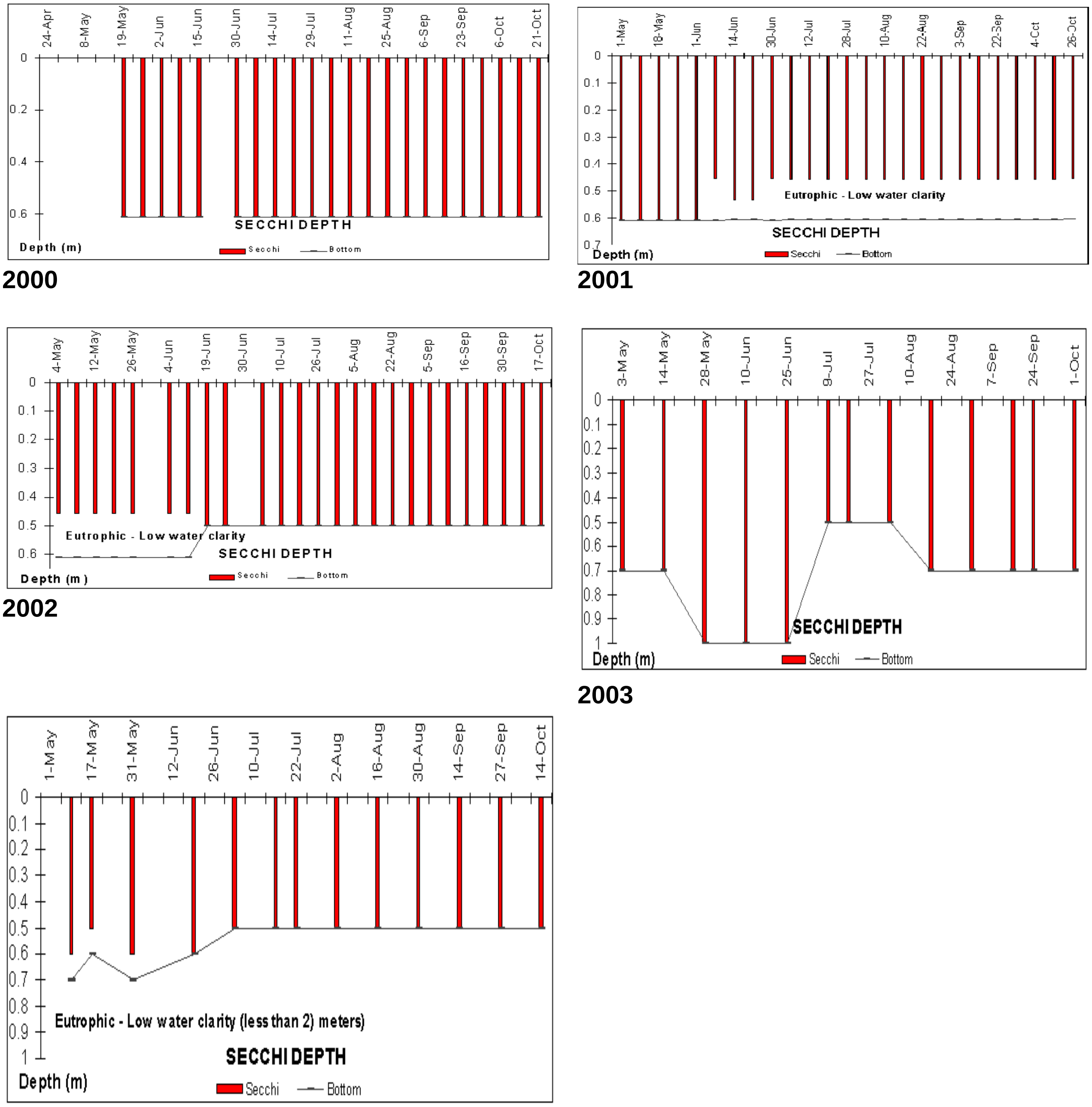
(1) For Valley Falls Pond, the mean values of Stations P-01 to P-03 are listed: geometric mean for pathogens; arithmetic mean for metals and in-situ parameters.
(2) The proposed regulatory standard for enterococci is 54 col/100 ml (steady state geometric mean density) for Class B waters.
(3) Approximate flow at the USGS Woonsocket gage at the time of sampling in Valley Falls Pond.
ed Edited during Quality Control.

7.8 Exceeds Acute Criteria
5.5 Exceeds Chronic Criteria (metals), or regulatory standard for bacteria (FC)

Figure 7-34: Summary of Water Quality in Valley Falls Pond - Nutrients, Pigments

Event (POND-___)	Sampling Date	Dry Weather	Wet Weather	Nutrients *(1)*																								Pigments *(1)*					
				Ortho-phosphate		Total Phos-phorus		Ammonia		Nitrate		DIN		Total Diss. Nitrogen		DON		Partic. Organic Carbon		Partic. Organic Nitrogen		C/N		TON		Total Nitrogen		Chloro-phyll a		Pheo-phytin *a*		Ratio Chl / (Chl+ Pheo)	
				Blackstone River	Valley Falls Pond	Blackstone River	Valley Falls Pond	Blackstone River	Valley Falls Pond	Blackstone River	Valley Falls Pond	Blackstone River	Valley Falls Pond	Blackstone River	Valley Falls Pond	Blackstone River	Valley Falls Pond	Blackstone River	Valley Falls Pond	Blackstone River	Valley Falls Pond	Blackstone River	Valley Falls Pond	Blackstone River	Valley Falls Pond	Blackstone River	Valley Falls Pond	Blackstone River	Valley Falls Pond	Blackstone River	Valley Falls Pond	Blackstone River	Valley Falls Pond
				mg/l P		mg/l P		mg/l N		mg/l N		mg/l N		mg/l N		mg/l N		mg/l		mg/l N				mg/l N		mg/l N		ug/l		ug/l			
01	8/10/2004	●		0.122	0.136	0.43	0.33	0.01	0.03	1.77	0.25	1.78	0.28	2.11	0.99	0.32	0.71	1.29	2.54	0.21	0.33	7.27	8.87	0.53	1.04	2.31	1.32	12.39	3.15	5.06	6.35	0.71	0.34
02	9/17/2004	●		0.088	0.078	0.13	0.31	0.07	0.16	1.42	0.34	1.48	0.50	1.69	1.05	0.21	0.55	0.58	2.58	0.08	0.36	8.04	8.40	0.29	0.91	1.78	1.41	7.57	6.68	3.20	3.50	0.70	0.64
03	12/6/2004	●		0.063	0.054	0.10	0.10	0.17	0.13	0.65	0.50	0.82	0.63	1.10	0.91	0.28	0.28	0.67	1.63	0.07	0.21	10.63	8.85	0.35	0.49	1.17	1.12	3.11	8.21	1.29	0.65	0.71	0.97
04	4/19/2005	●		0.025	0.018	0.07	0.13	0.45	0.12	0.95	0.45	1.41	0.57	1.60	0.84	0.19	0.27	0.79	3.55	0.10	0.52	9.12	8.07	0.29	0.80	1.70	1.36	7.60	43.06	0.72	10.13	0.91	0.87
05	7/12/2005	●																															
06	7/28/2005	●		0.120	0.154	0.19	0.39	0.05	0.08	0.93	0.27	0.98	0.35	1.25	0.76	0.27	0.41	1.63	1.85	0.27	0.32	7.07	6.83	0.54	0.73	1.52	1.08	13.23	11.51	52.20	11.42	0.20	0.51
07	8/12/2005	●																															
08	8/14/2005	●																															
09	8/15/2005		●	0.097	0.123	0.20	0.34	0.18	0.10	1.27	0.32	1.45	0.42	1.87	0.92	0.42	0.50	1.76	2.36	0.31	0.34	6.59	8.10	0.73	0.83	2.18	1.25	62.30	17.67	15.07	8.33	0.81	0.73
10	9/13/2005	●																															
11	9/16/2005		●	0.321	0.061	0.39	0.23	0.51	0.05	2.86	0.56	3.38	0.61	3.49	1.12	0.12	0.51	1.15	4.09	0.17	0.70	8.01	6.82	0.28	1.21	3.66	1.82	15.56	12.82	7.47	4.98	0.68	0.70
12	9/28/2005	●																															
Mean				**0.120**	**0.089**	**0.21**	**0.26**	**0.21**	**0.10**	**1.41**	**0.38**	**1.61**	**0.48**	**1.87**	**0.94**	**0.26**	**0.46**	**1.12**	**2.66**	**0.17**	**0.40**	**8.11**	**7.99**	**0.43**	**0.86**	**2.05**	**1.34**	**17.40**	**14.73**	**12.14**	**6.48**	**0.67**	**0.68**
Minimum				0.025	0.018	0.07	0.10	0.01	0.03	0.65	0.25	0.82	0.28	1.10	0.76	0.12	0.27	0.58	1.63	0.07	0.21	6.59	6.82	0.28	0.49	1.17	1.08	3.11	3.15	0.72	0.65	0.20	0.34
Maximum				0.321	0.154	0.43	0.39	0.51	0.16	2.86	0.56	3.38	0.63	3.49	1.12	0.42	0.71	1.76	4.09	0.31	0.70	10.63	8.87	0.73	1.21	3.66	1.82	62.30	43.06	52.20	11.42	0.91	0.97

(1) For Valley Falls Pond, the mean values of Stations P-01 to P-03 are listed; for the Blackstone River, data from Station P-04 are listed.



2000

2001

2002

2003

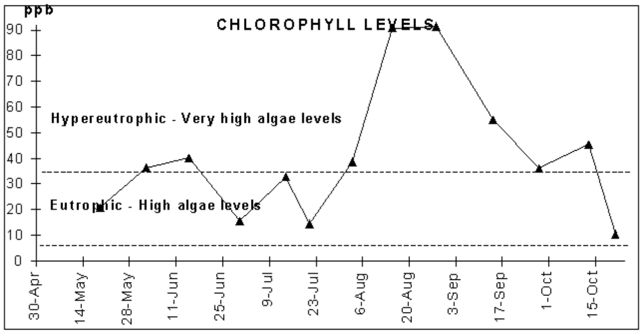
2004

Figure 7-35: Secchi Depth in Valley Falls Pond (m)

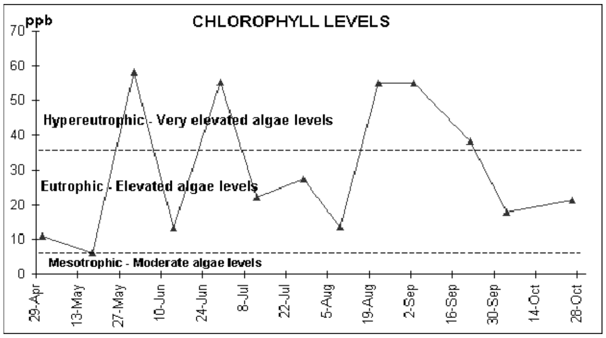
Water Clarity as Measured by Secchi Depth

Oligotrophic:	> 4 meters (> 13.1 feet), excellent water clarity
Mesotrophic:	2-4 meters (6.6-13.1 feet), moderate water clarity
Eutrophic:	< 2 meters (< 6.6 feet), low water clarity

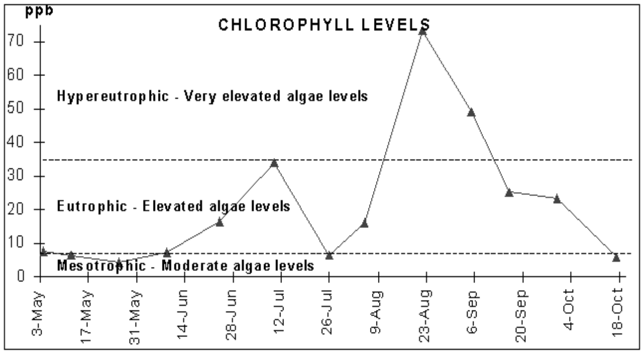
Source: University of Rhode Island, Watershed Watch Program
(with permission from Linda Green, Program Director, February 2, 2006)



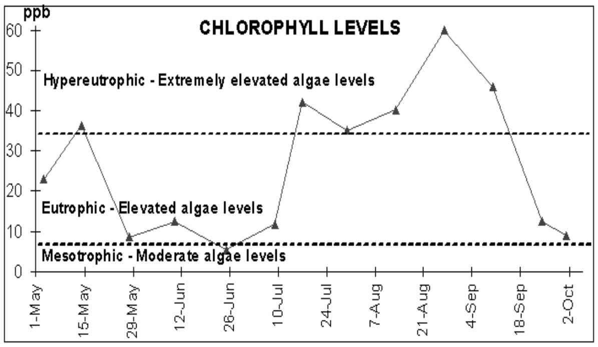
2000



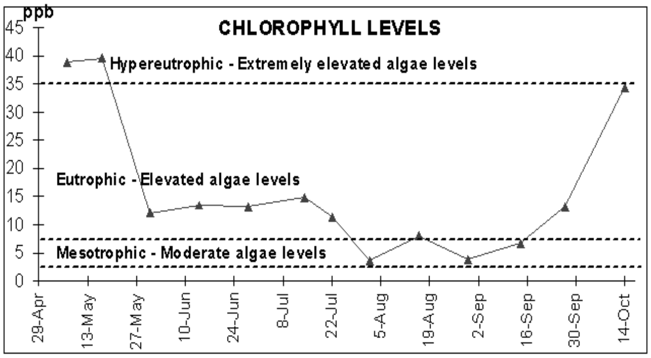
2001



2001



2003

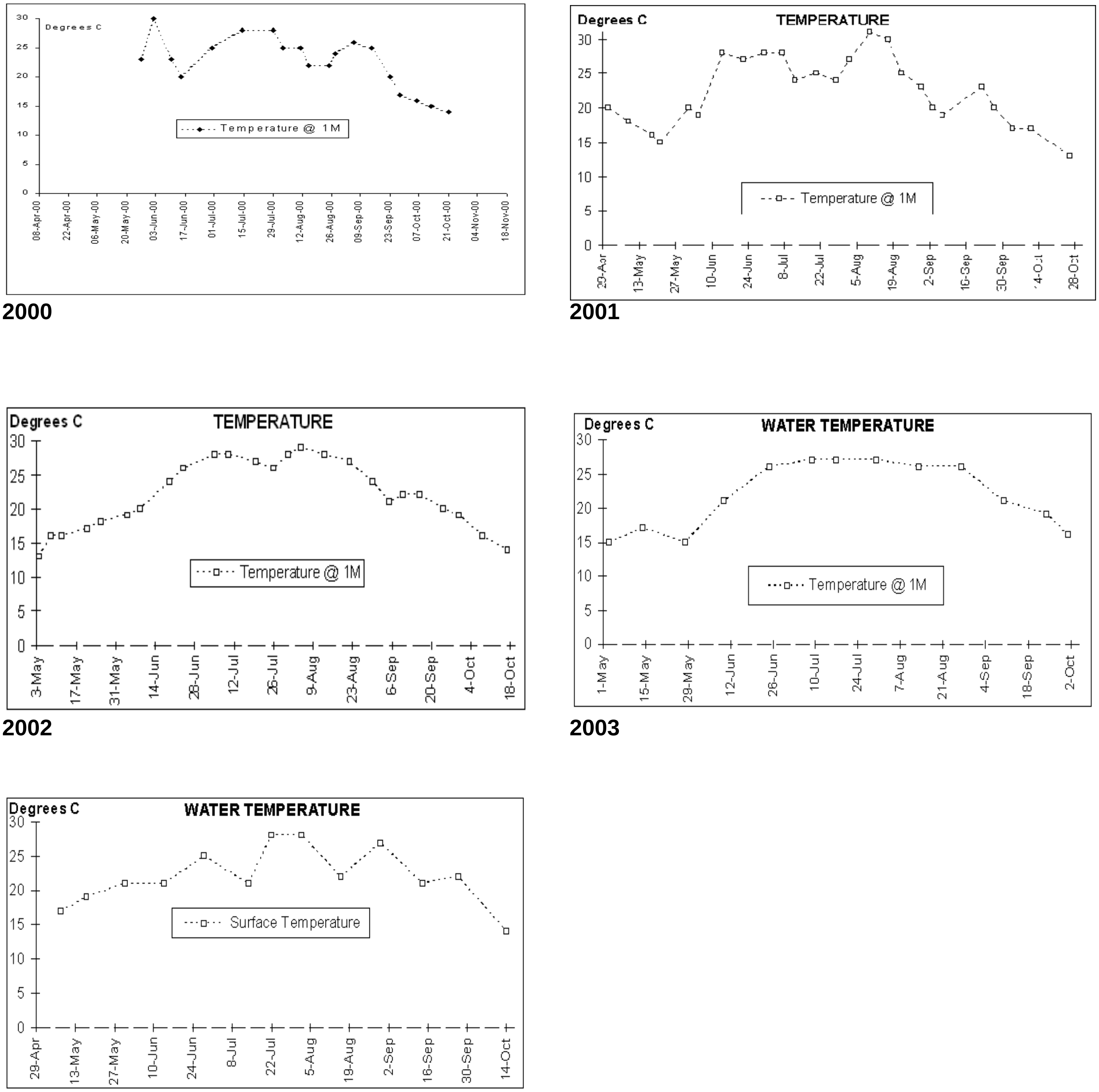


2004

Figure 7-36: Chlorophyll *a* in Valley Falls Pond (ppb)

Algae Concentration as Measured by Chlorophyll Levels
Oligotrophic < 2.6 ppb, low algae levels
Mesotrophic 2.6-7.2 ppb, moderate algae levels
Eutrophic > 7.2 ppb, elevated algae levels; indicates an algae bloom
Hypereutrophic > 35 ppb, extremely high algae levels; "pea soup" conditions

Source: University of Rhode Island, Watershed Watch Program (
with permission from Linda Green, Program Director, February 2, 2006)



2000

2001

2002

2003

2004

Figure 7-37: Temperature in Valley Falls Pond (ºC)

Source: University of Rhode Island, Watershed Watch Program
(with permission from Linda Green, Program Director, February 2, 2006)

Figure 7-38: Water Quality in Valley Falls Pond (URI Watershed Watch)

	2000				**2001**			
Parameter	**May**	**July**	**Oct.**	**Mean**	**May**	**July**	**Oct.**	**Mean**
pH	7.1	7.7	7.1	7.3	7.2	7.7	7.6	7.5
Alkalinity (mg/l)					33.9	32.6	32.6	33.0
Chloride (mg/l)	60	80	60	67	85		76	81
Fecal Coliform (col/100 ml)	200	37	25	57	12	3	33	11
E.coli (col/100 ml)	200	23	25	24	12	3	33	11
Dissolved Phosphorus (mg/l)	0.093	0.121	0.175	0.130	0.122	0.109	0.125	0.119
Total Phosphorus (mg/l)	0.367	0.390	0.218	0.325	0.286	0.184	0.225	0.232
Nitrate (mg/l N)	0.83	0.24	1.23	0.77	1.88	0.61	2.00	1.50
Ammonia (mg/l N)					0.32		0.05	0.19
Total-Nitrogen (mg/l N)	1.99			1.99	3.05	1.13	2.68	2.29
Chlorophyll (ug/l)					Range: 6.1 - 58.2			30.3
Trophic State Index								61 / 83
Mean Trophic Status				E				E / E

	2002				**2003**			
Parameter	**May**	**July**	**Oct.**	**Mean**	**May**	**July**	**Oct.**	**Mean**
pH	7.2	9.8	7.3	8.1	7.3	7.2	7.4	7.3
Alkalinity (mg/l)	18.9	33.7	33.1	28.5	23.1	26.1	33.7	27.6
Chloride (mg/l)	71		80	76				
Fecal Coliform (col/100 ml)	120	23	102	66	30	96	33	46
E.coli (col/100 ml)	100	23	88	59	31	96	33	46
Dissolved Phosphorus (mg/l)	0.038	0.190	0.147	0.125	0.018	0.036	0.044	0.033
Total Phosphorus (mg/l)	0.149	0.203	0.194	0.182	0.173	0.216	0.201	0.197
Nitrate (mg/l N)	1.08	0.78	1.66	1.18	0.26	<0.05	0.38	0.22
Ammonia (mg/l N)	0.14				0.16		0.02	0.09
Total-Nitrogen (mg/l N)	1.45	0.66	2.24	1.45	1.09	1.33	1.58	1.33
Chlorophyll (ug/l)	Range: 4.2 - 73.4			21.2	Range: 5.4 - 60.1			26.3
Trophic State Index				58 / 79				61
Mean Trophic Status				E / H				E

	2004				**2005**			
Parameter	**May**	**July**	**Oct.**	**Mean**	**May**	**July**	**Oct.**	**Mean**
pH	6.9	9.8	7.5	8.0				
Alkalinity (mg/l)								
Chloride (mg/l)								
Fecal Coliform (col/100 ml)	56	3	22	15	12	12	40	18
E.coli (col/100 ml)								
Dissolved Phosphorus (mg/l)	0.048	0.055	0.034	0.046				
Total Phosphorus (mg/l)	0.192	0.155	0.153	0.167				
Nitrate (mg/l N)	0.32	0.17	0.62	0.37				
Ammonia (mg/l N)	0.18		<0.03	0.10				
Total-Nitrogen (mg/l N)	1.21	1.42	1.48	1.37				
Chlorophyll (ug/l)	Range : 3.5 - 39.6			16.3				
Trophic State Index				56				
Mean Trophic Status				E				

Detection Limits
Dissolved Phosphorus: MDL = 0.003 mg/l (2001-2003); 0.004 mg/L (2004)
Total Phosphorus: MDL = 0.003 mg/L (2001-2004)
Nitrate (as N): MDL = 0.015 mg/l (2001); 0.02 mg/l (2002); 0.05 g/l (2003), 0.03 mg/L (2004)
Ammonia-Nitrogen: MDL = 0.02 mg/l (2001, 2002); 0.03 mg/l (2004), 0.01 mg/l (2003)
Total Nitrogen: MDL = 0.03 mg/l (2001); 0.05 mg/l (2003); 0.02 mg/l (2004)

Trophic Level
H: Hypertrophic
E: Eutrophic

<___: Below detection limit

Figure 7-39: Density of Phytoplankton in Valley Falls Pond and Scott Pond on August 12, 2005

			Density (No. of natural counting units / ml)			
		Natural	**Valley Falls Pond**		**Scott Pond**	
Group	**Species**	**Counting Unit**	**P-01**	**P-03**	**P-07**	**P-12**
Bacillariophyceae	Cyclotella meneghiniana	unicell	497	83		
	Navicula sp.	unicell		6		
	Nitzschia sp.	unicell		6		
	Pennales	unicell			12	14
	Synedra sp.	unicell		6		
Chlorophyceae	Actinastrum hantzschii	coenobia/unicell	29	22		
	Ankistrodesmus falcatus var. mirabilis	unicell	29	6		
	Characium sp.	unicell	1,872	354		
	Chlamydomonas sp.	unicell				28
	Chlamydomonas sp. (palmelloid)	colony			25	
	Closteriopsis longissima	unicell	22	11		
	Coelastrum cambricum	coenobia/unicell	29		12	
	Coelastrum sphaericum	coenobia/unicell	7	11		
	Cosmarium punctulatum var. subpunctulatum	unicell			12	14
	Crucigenia apiculata	coenobia/unicell	15	6	6	
	Dictyosphaerium pulchellum	colony			98	
	Elakothrix gelatinosa	colony	146	22		
	Gloeocystis vesiculosa	colony	409	155	55	
	Kirchneriella contorta	coenobia/unicell			295	110
	Kirchneriella elongata	coenobia/unicell	7			
	Kirchneriella lunaris	coenobia/unicell			49	28
	Kirchneriella sp.	coenobia/unicell			492	
	Lobomonas sp.	unicell				28
	Micractinium pusillum	colony	29	22		
	Oocystis pusilla	coenobia/unicell	234	177		
	Oocystis submarina	coenobia/unicell	556	309	74	28
	Pediastrum duplex var. clathratum	coenobia/unicell	7	6		
	Pediastrum duplex var. gracilimum	coenobia/unicell	7			
	Pediastrum duplex var. reticulatum	coenobia/unicell	7	6		
	Pediastrum tetras	coenobia/unicell		6		
	Scenedesmus brasiliensis	coenobia/unicell		22		
	Scenedesmus denticulatus	coenobia/unicell	15	44		
	Scenedesmus dimorphus	coenobia/unicell				7
	Scenedesmus opoliensis	coenobia/unicell	58	44		
	Scenedesmus quadricauda	coenobia/unicell	175	88	98	
	Scenedesmus sp.	coenobia/unicell	1,755	442	98	
	Schroederia setigera	unicell			98	276
	Staurastrum paradoxum	unicell	95	61	6	
	Staurastrum tetracerum	unicell		28		
	Tetraedron limneticum	unicell	7			
	Tetraedron trigonum	unicell	29	22		
	Tetrastrum staurogeniaeforme	coenobia/unicell	29			
	Treubaria setigerum	unicell			664	21
	unid. Chlorophyte flagellate	unicell		22	25	
	unid. Chlorophyte unicell	unicell				138
	unid. Unicell (Gloeocystis)	unicell			443	193
Chyrsophyceae	Ochromonas sp.	unicell				55
Cryptophyceae	Campylomonas reflexa	unicell		22	25	
	Chroomonas nordstedtii	unicell	58	22	1,477	
	Cryptomonas ovata	unicell	88	44	37	
Cyanobacteria	Anabaena sp.	trichome	7			
	Aphanizomenon flos-aquae	trichome			6	
	Gloeocapsa sp.	colony		22		
	Oscillatoriales (?Geitlerinema)	trichome	7			
	Pseudanabaena/Limnothrix sp.	trichome			6	3,038
	unid. Cyanobacteria unicell	unicell	468	619	1,182	2,210
Euglenophyceae	Phacus lemmermannii	unicell	15			
	Trachelomonas varians	unicell		22		
	Trachelomonas volvocina	unicell	88			
not assigned	unid. Chrysophyte/Xanthophyte flagellate	unicell	468	442		3,646
	unid. Flagellate A	unicell	585		788	
	unid. Flagellate B	unicell				55
	unid. Unicell	unicell	585	707	1,969	884

Figure 7-40: Biovolume of Phytoplankton in Valley Falls Pond and Scott Pond on Aug. 12, 2005

		Biovolume (cubic microns / ml)			
		Valley Falls Pond		**Scott Pond**	
Group	**Species**	**P-01**	**P-03**	**P-07**	**P-12**
Bacillariophyceae	Cyclotella meneghiniana	995,025	133,527	0	0
	Navicula sp.	0	2,651	0	0
	Nitzschia sp.	0	608	0	0
	Pennales	0	0	2,805	3,778
	Synedra sp.	0	8,749	0	0
Chlorophyceae	Actinastrum hantzschii	11,906	11,339	0	0
	Ankistrodesmus falcatus var. mirabilis	8,524	2,406	0	0
	Characium sp.	17,610	2,053	0	0
	Chlamydomonas sp.	0	0	0	5,423
	Chlamydomonas sp. (palmelloid)	0	0	27,247	0
	Closteriopsis longissima	24,722	9,830	0	0
	Coelastrum cambricum	47,037	0	15,641	0
	Coelastrum sphaericum	6,418	7,686	0	0
	Cosmarium punctulatum var. subpunctulatum	0	0	45,054	53,803
	Crucigenia apiculata	11,783	1,803	4,983	0
	Dictyosphaerium pulchellum	0	0	4,032	0
	Elakothrix gelatinosa	45,622	2,747	0	0
	Gloeocystis vesiculosa	646,774	119,674	33,307	0
	Kirchneriella contorta	0	0	3,182	5,108
	Kirchneriella elongata	7,464	0	0	0
	Kirchneriella lunaris	0	0	5,311	2,391
	Kirchneriella sp.	0	0	59,632	0
	Lobomonas sp.	0	0	0	8,027
	Micractinium pusillum	26,800	24,856	0	0
	Oocystis pusilla	67,439	117,728	0	0
	Oocystis submarina	501,521	294,242	30,714	24,064
	Pediastrum duplex var. clathratum	286,598	23,054	0	0
	Pediastrum duplex var. gracilimum	86,245	0	0	0
	Pediastrum duplex var. reticulatum	33,967	2,063	0	0
	Pediastrum tetras	0	17,747	0	0
	Scenedesmus brasiliensis	0	17,992	0	0
	Scenedesmus denticulatus	14,460	13,960	0	0
	Scenedesmus dimorphus	0	0	0	4,698
	Scenedesmus opoliensis	52,484	19,729	0	0
	Scenedesmus quadricauda	50,076	10,018	21,396	0
	Scenedesmus sp.	84,517	14,881	4,941	0
	Schroederia setigera	0	0	1,444	11,345
	Staurastrum paradoxum	78,604	43,072	3,045	0
	Staurastrum tetracerum	0	24,506	0	0
	Tetraedron limneticum	17,879	0	0	0
	Tetraedron trigonum	2,456	2,817	0	0
	Tetrastrum staurogeniaeforme	9,738	0	0	0
	Treubaria setigerum	0	0	92,941	2,798
	unid. Chlorophyte flagellate	0	19,991	20,987	0
	unid. Chlorophyte unicell	0	0	0	44,093
	unid. Unicell (Gloeocystis)	0	0	80,496	9,133
	Ochromonas sp.	0	0	0	18,445
	Campylomonas reflexa	0	10,825	16,019	0
	Chroomonas nordstedtii	8,314	1,914	298,408	0
	Cryptomonas ovata	166,147	98,080	53,309	0
Cyanobacteria	Anabaena sp.	15,801	0	0	0
	Aphanizomenon flos-aquae	0	0	7,032	0
	Gloeocapsa sp.	0	862	0	0
	Oscillatoriales (?Geitlerinema)	30,262	0	0	0
	Pseudanabaena/Limnothrix sp.	0	0	792	166,359
	unid. Cyanobacteria unicell	2,627	3,205	5,359	12,723
Euglenophyceae	Phacus lemmermannii	159,040	0	0	0
	Trachelomonas varians	0	46,852	0	0
	Trachelomonas volvocina	42,851	0	0	0
not assigned	unid. Chrysophyte/Xanthophyte flagellate	1,716	1,228	0	75,464
	unid. Flagellate A	2,087	0	4,815	0
	unid. Flagellate B	0	0	0	131,698
	unid. Unicell	2,664	2,431	14,090	36,870
Total	Total phytoplankton biovolume	3,567,180	1,115,126	856,982	616,223

Figure 7-41: Biovolume of major Taxonomic Groups, the percent Contribution to Total Biovolume and the Trophic State Index at Stations in Valley Falls Pond and Scott Pond on August 12, 2005 (*)

	Biovolume							
	Valley Falls Pond Stations				**Scott Pond Stations**			
	P-01		**P-03**		**P-07**		**P-12**	
Major Taxonomic Groups	microns/ml	%	microns/ml	%	microns/ml	%	microns/ml	%
Bacillariophyceae	995,025	28	145,535	13	2,805	0	3,778	1
Chlorophyceae	2,140,647	60	804,194	72	454,351	53	170,885	28
Chyrsophyceae	0	0	0	0	0	0	18,445	3
Cryptophyceae	174,461	5	110,819	10	367,736	43	0	0
Cyanobacteria	48,690	1	4,067	0	13,183	2	179,083	29
Euglenophyceae	201,890	6	46,852	4	0	0	0	0
not assigned	6,467	0	3,659	0	18,905	2	244,032	40
Total	3,567,180	100	1,115,126	100	856,982	100	616,223	100
Trophic State Index (*)	59		51		49		46	

(*) The Biovolume and Trophic State Index may be too low, as Scott Pond had been treated with copper sulfate on July 20, 2005. High dissolved copper concentrations and comparatively low turbidity in Scott Pond on August 12 indicate that the algal concentrations in the pond was still reduced from the treatment.

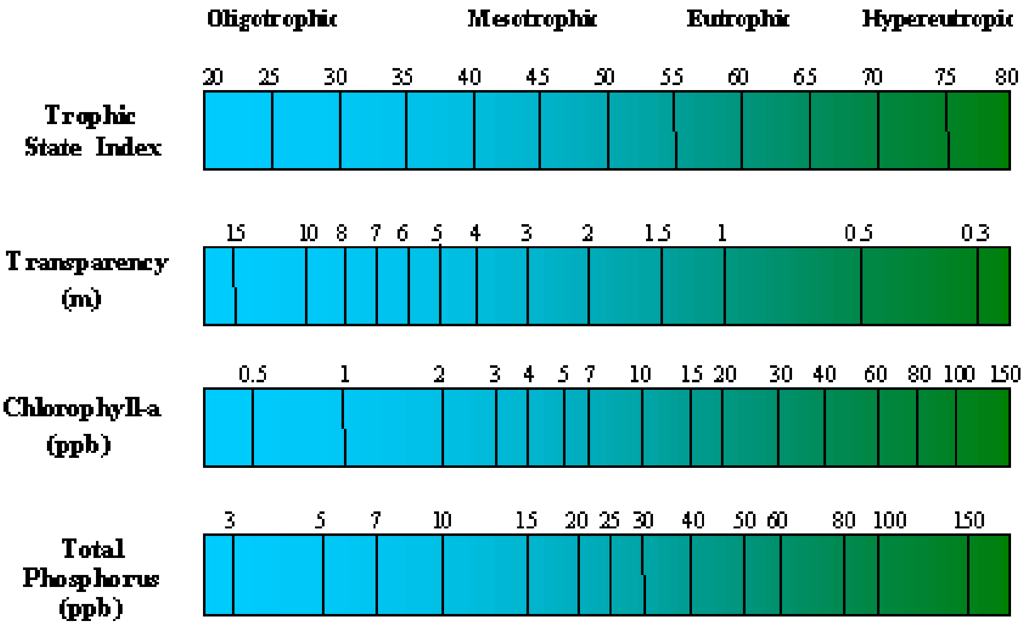


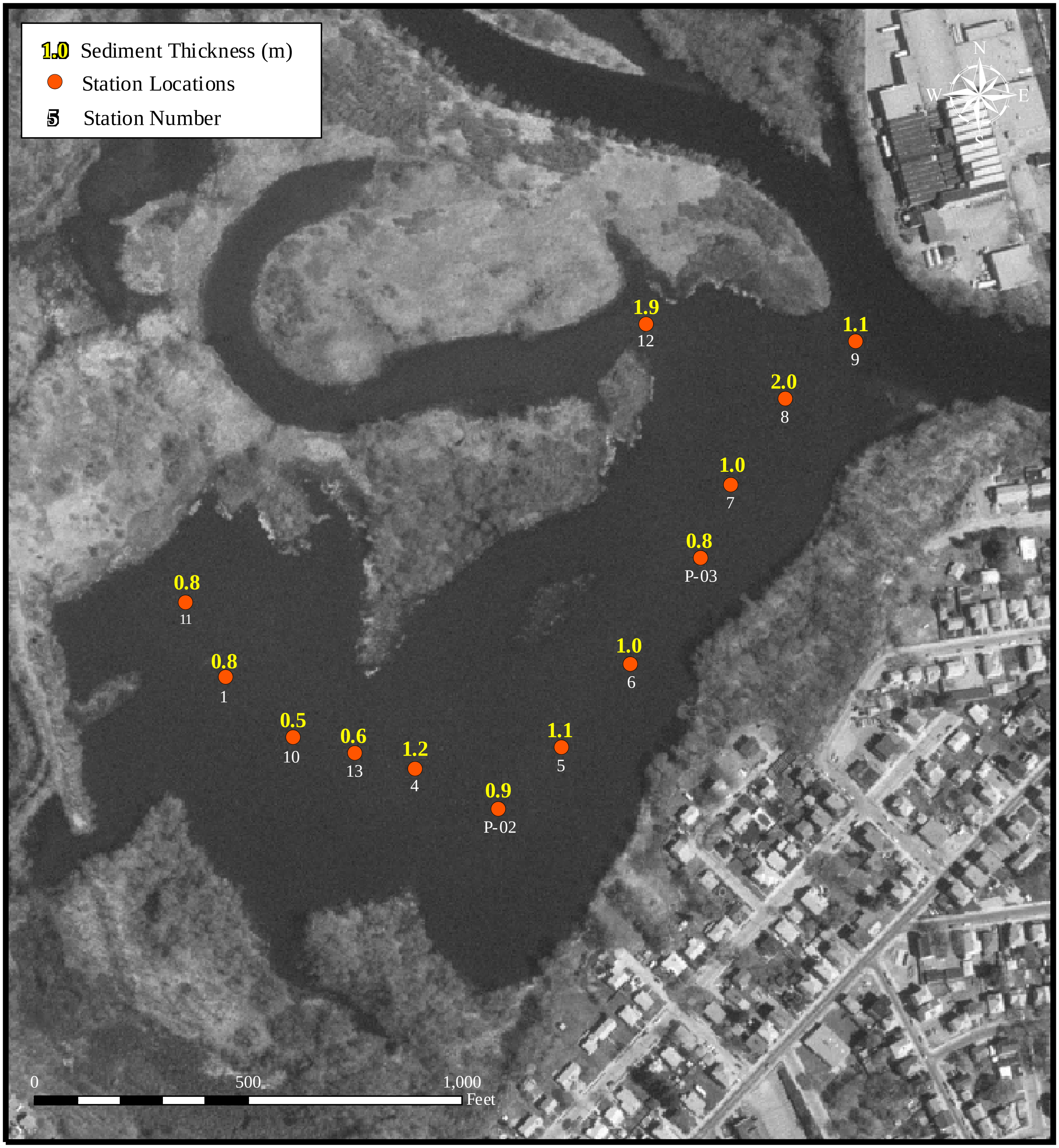
Figure 7-42 Carlson Trophic State Index (Minnesota Pollution Control Agency, 1988).

Figure 7-43: Sediment Grain Size in Valley Falls Pond and Scott Pond

Sample No.	Grain Size (% of total sample)									
	Sieve Size		**Coarse Sand**	**Medium Sand**		**Fine Sand**			**Silt/Clay (or Fines)**	
	Mesh	from	#4	#10	#20	#40	#60	#100	<#200	
		to	#10	#20	#40	#60	#100	#200		
	inch	from	0.187	0.0787	0.0331	0.0165	0.0098	0.0059	<0.0029	
		to	0.0787	0.0331	0.0165	0.0098	0.0059	0.0029		
	mm	from	4.75	2.00	0.84	0.419	0.249	0.150	<0.074	
		to	2.00	0.84	0.419	0.249	0.150	0.074		Sum
Valley Falls Pond										
P-01	%			0.2	0.4	0.5	0.9	2.3	95.7	100.0
P-03	%			0.0	0.1	0.2	0.3	1.5	97.9	100.0
Scott Pond										
P-07	%			0.2	3.4	2.5	1.6	1.8	90.5	100.0
P-08	%			0.1	0.9	1.8	1.3	2.7	93.1	100.0
P-09	%			0.2	7.8	5.5	4.5	7.1	75.1	100.0

(*) Size differentiation into coarse, medium, fine sand/fines is done according to ASTM standards, which is coarser than the differentiation using the Wentworth Sieve Scale for grades of sediment. The ASTM scale was also used in samples analyzed by the Corps of Engineers (USACE, 1995b).

Sampling Date: August 12, 2005



The Louis Berger Group, Inc.

Rhode Island DEM

Blackstone River Water Quality

Figure 7-44

SOFT SEDIMENT THICKNESS IN VALLEY FALLS POND

SedimentThickness.mxd

2006-01-31

Figure 7-45: Soft Sediment Thickness in Valley Falls Pond

Station	Latitude	Longitude	Water Depth	Soft Sediment Thickness (*)
			m	m
9	41º 53.879' N	71º 23.682' W	0.70	1.1
8	41º 53.857' N	71º 23.718' W	0.75	2.0
7	41º 53.824' N	71º 23.746' W	0.60	1.0
P-03	41º 53.796' N	71º 23.762' W	0.50	0.8
6	41º 53.755' N	71º 23.798' W	0.60	1.0
5	41º 53.723' N	71º 23.834' W	0.55	1.1
P-02	41º 53.699' N	71º 23.866' W	0.45	0.9
4	41º 53.715' N	71º 23.909' W	0.50	1.2
13	halfway between Stns. 4 and 10		0.50	0.6
10	41º 53.727' N	71º 23.972' W	0.40	0.5
P-01a	41º 53.750' N	71º 24.007' W	0.50	0.8
P-01b			0.50	0.9
11	41º 53.779' N	71º 24.027' W	0.40	0.8
12a	Beginning of oxbow in NE corner of Valley Falls Pond		0.30	2.1
12b			0.30	1.6

(*) Note: A hollow 2" diameter PVC rod was pushed into the sediment to the extent possible. The same person performed this test at all stations.

Figure 7-46: Organic Composition of Surface Sediments from Valley Falls Pond and Scott Pond

Station	**Depth** (cm)	**Sediment Volume** (cm^3)	**Sediment Dry Weight** (g)	**Water** (%)	**Dry Bulk Density** (g/cm^3)	**Total Organic Carbon** (% by weight)	**Total Organic Nitrogen** (% by weight)	**Total Organic Phosphorus** (% by weight)	**C/N Ratio**	**Carbon** (mg/cm^3 total sediment)	**Nitrogen** (mg/cm^3 total sediment)	**Phosphorus** (mg/cm^3 total sediment)	**Chlorophyll a** (ug/g dry weight) (*)	***Std Dev***	**Phaeopigment** (ug/g dry weight) (*)	***Std Dev***	**Chlorophyll a** (ug/cm^3 sediment) (*)	***Std Dev***	**Phaeopigment** (ug/cm^3 sediment) (*)	***Std Dev***
Valley Falls Pond																				
P-01	0-2	29.45	22.11	82.2%	0.18	18.6	1.7	0.29	13.04	33.23	2.97	0.52	20.4	*8.0*	52.0	*6.8*	3.6	*1.4*	9.3	*1.2*
	2-4	29.45	23.10	80.8%	0.23	9.7	0.8	0.28	14.44	22.13	1.79	0.64	--	--	--	--	--	--	--	--
P-03	0-2	29.45	22.46	76.7%	0.21	17.5	1.6	0.34	12.48	36.29	3.39	0.71	17.5	*6.7*	57.1	*9.7*	3.6	*1.4*	11.9	*2.0*
	2-4	29.45	26.16	76.2%	0.32	12.3	1.0	0.25	14.10	39.77	3.29	0.81	--	--	--	--	--	--	--	--
Scott Pond																				
P-07	0-2	29.45	19.14	89.4%	0.09	19.5	1.8	0.25	12.59	18.03	1.67	0.23	60.3	*9.3*	205.6	*13.5*	5.6	*0.9*	19.0	*1.2*
	2-4	29.45	19.34	88.9%	0.09	16.9	1.5	0.25	13.28	15.32	1.35	0.23	--	--	--	--	--	--	--	--
P-08	0-2	29.45	18.49	93.1%	0.06	16.8	1.5	0.25	13.29	10.51	0.92	0.16	233.9	*25.6*	680.8	*142.6*	14.6	*1.6*	42.5	*8.9*
	2-4	29.45	18.82	91.6%	0.08	12.3	1.0	0.25	13.86	10.16	0.86	0.21	--	--	--	--	--	--	--	--
P-09	0-2	29.45	18.12	93.1%	0.06	9.7	0.8	0.24	14.13	5.61	0.46	0.14	298.0	*39.8*	621.5	*71.4*	17.3	*2.3*	36.1	*4.1*
	2-4	29.45	19.56	91.5%	0.09	16.7	1.5	0.24	13.21	14.73	1.30	0.21	--	--	--	--	--	--	--	--

(*) Average value based on three replicate analyses.
-- Not sampled.

Sampling date: August 12, 2005

Figure 7-47: Algal Composition of Surface Sediments in Valley Falls Pond and Scott Pond

			500 Micron Fraction					300 Micron Fraction				
Station	**Depth** (cm)	**Original Sample Volume** (cm^3)	**Dry Weight** (mg)	**Carbon** (%)	**Nitrogen** (%)	**Wetland Plants** (%)	**Macroalgae** (%)	**Dry Weight** (mg)	**Carbon** (%)	**Nitrogen** (%)	**Wetland Plants** (%)	**Macroalgae** (%)
Valley Falls Pond												
P-01	0-2	29.45	50	10.2	0.8	47%	53%	60	16.5	1.5	56%	44%
Scott Pond												
P-08	0-2	29.45	70	30.5	2.3	44%	56%	60	15.6	1.1	67%	33%
P-09	0-2	29.45	30	2.1	0.1	65%	36%	20	1.7	0.1	50%	50%

Sampling Date: August 12, 2005

Figure 7-48: Metals and Grain Size of Surface Sediments in Valley Falls Pond and Scott Pond

Station	Latitude	Longitude	Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Mercury	Silver	Zinc	Manganese	Iron
			mg/kg (dry weight)										
Valley Falls Pond (0-4 cm)													
P-01	41º 53.749' N	71º 24.012' W	26.9	44.9	617	622	578	155	2.50				
P-03	41º 53.755' N	71º 23.797' W	16.5	38.7	439	454	370	112	2.40				
Scott Pond (0-4 cm)													
P-07	41º 54.176' N	71º 24.366' W	20.9	8.8	150	249	454	93	0.75				
P-08	41º 53.977' N	71º 24.453' W	40.4	21.3	334	315	993	227	0.83				
P-09	41º 53.776' N	71º 24.414' W	31.5	19.2	250	260	872	194	0.96				
Valley Falls Pond (0-153 cm) *(3)*													
0-10 cm	Station was in the center of the pond.			39.8	302	345	308	115		3.6	1,389	517	25,620
10-30 cm				50.1	505	516	453	145		4.7	2,664	703	29,850
30-50 cm				51.0	607	463	454	114		3.3	4,127	1,209	22,800
50-70 cm				86.3	1,025	621	628	123		3.1	7,423	1,976	63,200
70-90 cm				17.5	925	513	603	57		0.8	2,842	474	26,267
90-110 cm				4.8	872	475	740	96			876	271	22,300
110-130 cm				0.1	26	12	7	7		0.2	32	197	10,000
130-153 cm				0.2	13	7	3	6		0.2	22	115	6,050
GUIDELINES													
NOAA SQuiRTs - Aquatic Organisms *(2)*													
Threshold Effects Level (TEL)			5.9	0.6	37.3	35.7	35.0	18.0	0.17		123		
Probable Effects Level (PEL)			17.0	3.5	90.0	197.0	91.3	35.9	0.49		315		
Upper Effects Level (UEL)			17.0	3.0	95.0	86.0	127.0	43.0	0.56		520		
Ontario Guidelines - Aquatic Organisms *(4)*													
Low Effects Level (LEL)			6.0	0.6	26.0	16.0	31.0	16.0	0.20		120		
Severe Effects Level (SEL)			33.0	10.0	110.0	110.0	250.0	75.0	2.00		820		
Background Concentrations in Rhode Island Soils *(1)*													
Average			2.7		9.2	13.6	33.5	6.8			42		
Std. Dev.			2.9		9.7	28.2	55.5	9.3			73		

(1) RIDEM (1995) *Background levels of high priority pollutants metals in Rhode Island.*

(2) NOAA (1999) *Screening Quick Reference Tables.*

(3) Dr. John King, URI (unpublished data)

(4) Province of Ontario (1993) *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario.*

8.0 SCOTT POND AND BLACKSTONE CANAL

Scott Pond is located entirely within the Town of Lincoln, Rhode Island. The pond is connected to the Blackstone River through the remnant Blackstone Canal (Figure 7-1). Water enters the canal just upstream of the Ashton Dam. Photographs of the canal and the pond are presented in Figures 8-1 to 8-18.

Scott Pond consists of two main basins: a northern basin (herein termed 'Scott Pond North') and a larger southern basin ('Scott Pond South'). The two basins are connected by a shallow and narrow channel (Figure 8-10). The only surface water inflow is via the Blackstone Canal (Figure 8-1) with enters the pond at the Front Street Bridge (Figures 8-8 and 8-9). Historically there was also a water exchange between Scott Pond and the Moshassuck River through a boat lock. The primary land use in the watershed to Scott Pond is residential development (Figure 8-11).

Scott Pond is identified on the 303(d) list as being impaired from excess algal growth, chlorophyll *a*, low dissolved oxygen, and phosphorus. All of these ecological issues are associated with nutrient enrichment (eutrophication). The pond is anoxic at depth in the summer. During our survey, the pond was observed being used for recreational fishing and boating. The present assessment investigated the dynamics of Scott Pond as a basis for managing the pond.

8.1 History

The construction of the Blackstone Canal was completed in year 1828. The canal was built primarily for the purpose of barge transportation, but it was also used for water regulation and power production. Originally, the canal extended for 72 km (45 miles) from Providence, Rhode Island, to Worchester, Massachusetts. The canal was 10.7 m (35 feet) wide at the top, 5.5 m (18 feet) wide at the bottom, and 1.2 to 1.8 m (4 to 6 feet) deep (Kerr, 1990). It had 45 locks and a system of reservoirs. The canal existed only for 20 years before closing in 1849. The main reason for closure was competition from the Providence and Worcester Railroad that opened in 1847.

In Rhode Island, the largest remnant section of the canal extends from the Ashton Dam to Scott Pond. This section runs parallel to the western shore of the Blackstone River within the Town of Lincoln. In Lonsdale, it extends through the former Lonsdale Bleachery (now the Lonsdale Industrial Park) into Scott Pond.

Historically, Scott Pond was part of the Blackstone Canal system. There were two locks that connected Scott Pond to the Saylesville Pond, an impoundment on the Moshassuck River (Rick Greenwood, RI Historical Preservation and Heritage Commission, personal communication, August 11, 2004). From there, the Blackstone Canal went in and out of the Moshassuck River connecting with Narragansett Bay and Providence in the south. With the closure of the canal, the locks were filled in and presently there is no surface water discharge from Scott Pond to the Moshassuck River. However, given the 4.6 m (15 foot) higher water elevation in Scott Pond, it is clear that subsurface flow is occurring.

Until approximately the 1930s, water from the canal was used for power generation at the Lonsdale Bleachery. The tailrace of the power-generating facility entered the Blackstone River on the northern side of the bleachery. At present, there is no flow through the remaining bleachery facilities.

8.2 Methodology

The study assessed the bathymetry, hydrology, water quality, algal composition, and sediments of Scott Pond and its relationship to the surrounding watershed and the Blackstone Canal.

8.2.1 Bathymetry

A bathymetric map of Scott Pond was constructed using depth data collected by a handheld acoustic depth-sounder along multiple transects across the pond. A total of 414 soundings were obtained. Sounding locations were recorded with a GPS unit. Surveys were conducted on August 14, August 15, and September 16, 2005. The location of the shoreline was obtained from the RIGIS database. The bathymetric data were adjusted to the elevation of a sill that crosses the Blackstone Canal underneath the Front Street bridge, dividing the canal from the pond (at Station P-11 on Figure 7-1). When the water elevation of Scott Pond reaches the sill elevation, the pond is considered full. The sill elevation set the zero-foot elevation for the bathymetry survey.

8.2.2 Water Elevation

The water elevation was continuously recorded in the Blackstone Canal and Scott Pond to allow for the assessment of the hydraulic connection between the two waterbodies. Specifically, the deployment locations were as follows (Figure 7-1):

- *Blackstone Canal (Station WL-02):* Approximately 40 m (130 feet) to the south of the weir at the former Lonsdale Bleachery

- *Scott Pond (Station WL-03):* At the northern shore of the northern part of Scott Pond.

The meters were installed for approximately four months in 2004 (August 10 to December 6) and five months in 2005 (April 19 to September 28). The meters recorded water levels at 10-minute intervals and were vented to automatically correct for changes in atmospheric pressure. The meters were not installed during the winter to avoid damage from ice. Data from both the Blackstone Canal and the Scott Pond stations were adjusted to the sill elevation (as a common datum) to reflect the water elevation relative to the sill underneath the Front Street bridge.

8.2.3 Watershed Assessment

The watershed area was assessed using topographic maps and a visual site survey. In addition, sources of contaminants were sought by a site walkover and inquiries at the Town of Lincoln and local residents. These sources included stormwater drainage pipes, septic systems, small stream/surface water inflows, and other potential contaminant sources draining into the pond.

8.2.4 Water Sampling

A total of 11 survey events were conducted in Scott Pond. The events were concentrated during the summer of 2004 and 2005 (July to September), with additional events in December 2004 and April 2005. Sampling and measurements were conducted at two stations in Scott Pond South (P-08 and P-09), one station in Scott Pond North (P-07), and a station at the inflow to Scott Pond underneath the Front Street bridge (P-11) (Figure 7-1). During the first event, a sample was also collected at the weir near the Lonsdale Bleachery (W-34; also identified as Station P-06 in lab data sheets). In-situ measurements (dissolved oxygen, pH, temperature, specific conductance, turbidity, Secchi depth) were collected during all 11 events. Water samples were collected during seven of these events of which five were dry weather events and two were wet weather events. The wet weather events were conducted shortly after a storm when maximum wet weather inflow into the pond was believed to have occurred. Pathogen samples were collected during an additional dry weather event (July 12, 2005).

Water samples from Scott Pond were typically collected at the following depths:

Station No.	Location	Sampling Depths		
Station P-07	Scott Pond North	0.5 m	7 m	
Station P-08	Scott Pond South (northern section)	1 m	7 m	13 m
Station P-09	Scott Pond South (southern section)	1 m	7 m	10 m

Samples were analyzed for the same constituents as samples collected in Valley Falls Pond (see Section 7.1.5). In the data tables, data are reported to the reporting limit (RL). Values below (and also above for pathogens) are flagged as <[RL] (and >[RL]). For mathematical calculations of means, the approach described in Section 3.1.2 was used.

It is noted that the lead and copper data from sampling events POND-02, 03, and 04 were edited during quality control. Specifically, samples from these events had been analyzed by the ICP Method 200.7 with a reporting limit (RL) for dissolved lead of 5 ug/l and a method detection limit (MDL) of 0.23 ug/l; for dissolved copper, the RL was 15 ug/l and the MDL was 3.2 ug/l. Samples from the later events (POND-06, 09, 11) were analyzed by ICP-MS Method 200.8 with a more sensitive RL of 0.1 ug/l for dissolved lead and a MDL of 0.04 ug/l; for dissolved copper, the RL was 1 ug/l and the MDL was 0.4 ug/l. Dissolved lead and copper concentrations in samples analyzed by ICP Method 200.7 tended to be higher and had greater variability in the duplicate samples (see also discussion in Section 3.1.3); these data are attached in Table B-9 of Appendix B.

Aside from Event POND-01 on August 10, 2004, the water quality of the Blackstone Canal at the weir near the Lonsdale Bleachery (Station W-34) was determined during selected dry weather (DW) and wet weather (WW) events (see Sections 3 and 4); those data were considered also in this section:

DW-07	July 21, 2005
DW-09	August 11, 2005
WW-01	July 8, 2005
WW-03	October 8/9, 2005
WW-04	October 22/23, 2005

8.2.5 Phytoplankton

In addition to the chlorophyll *a* samples collected in each of the surveys, phytoplankton samples were collected on August 12, 2005 to address the concern about excess algal growth in Scott Pond. The algal count included phytoplankton and periphyton counts. Samples were collected in the center of Scott Pond North (P-07) and in the center of Scott Pond South (P-12, located in-between Stations P-08 and P-09). Approximately 50% of the volume of the total sample was collected from a water depth of 30 cm (1 foot). The remaining 50% of the sample was collected from the middle of the oxygenated upper zone using a Niskin sampler (i.e., at 1.5 m). The thickness of the oxygenated zone was established prior to sampling by taking dissolved oxygen readings throughout the water column of the pond. At each station, a 500 ml water sample was collected and immediately preserved with 1% Lugols solution. The enumeration procedure and the determination of the biovolume and Trophic State Index followed the same procedure as for Valley Falls Pond (see Section 7.1.6).

8.2.6 Sediment

Surface sediment samples were collected at Stations P-07, P-08, and P-09 using a handheld box corer. The undisturbed upper sediment layer was subsampled for macroalgae (upper 0-2 cm), metals (0-4 cm), grain size (0-4 cm), nutrients (0-2 cm, 2-4 cm), and chlorophyll *a* (0-2 cm). Metal analyses consisted of total copper and lead. Nutrient analyses consisted of total organic carbon, nitrogen, and phosphorus.

Macroalgae in the samples were sieved in the laboratory with 500 um and 300 um sieves. The organic particles were analyzed under a dissecting microscope to determine if the particles consisted of wetland plants versus algae.

The water depth in Scott Pond did not permit probing of the sediment with a long pole to assess the thickness of the soft sediment in the central parts of the pond, as had initially been planned.

8.3 Field Observations

Following are selected field observations from the 11 survey events of Scott Pond.

Event POND-01 (August 10, 2004): At the weir near the Lonsdale Bleachery (Station W-34), water flow in the canal was not noticeable in either direction. However, water was observed flowing toward Scott Pond at the narrow section near the entrance of the former industrial building now occupied by the Michael London & Co. Water was also flowing into Scott Pond over the sill underneath the Front Street bridge (Station P-11). The flow rate was approximately 5 cfs (Figure 8-19). The elevation of the water surface of Scott Pond North was approximately 0.3 to 0.6 m (1 to 2 feet) below the sill elevation. The weather was sunny and calm. Sparse vegetation along the shoreline of Scott Pond indicated that the water elevation had been approximately 0.6 m (2 feet) higher in the past. The water surface in Scott Pond North was noticeably greenish even though the pond had been treated with copper sulfate on July 12, 2004 (Figure 8-15).

Event POND-02 (September 16, 2004): Water was flowing into Scott Pond from the Blackstone Canal over the sill underneath the Front Street bridge (Station P-11). The flow rate was approximately 10 cfs. The elevation of the water surface of Scott Pond North was approximately 20 to 30 cm (0.6 to 1 foot) below the sill elevation. The weather was cloudy. High humidity resulted in occasional precipitation. The total precipitation measured by NOAA in Lincoln for the day was 0.07 inches. The water in Scott Pond was noticeably greenish (Figure 8-12). The water of Scott Pond North was further covered with bands of algae (Figure 8-14).

Event POND-03 (December 6, 2004): Water was flowing into Scott Pond from the Blackstone Canal over the sill underneath the Front Street bridge (Station P-11). The flow rate was approximately 5 cfs. The elevation of the water surface of Scott Pond North was approximately 0.6 m (2 feet) below the sill elevation. The weather was cloudy and cold. There was minor snowfall in the afternoon. The total precipitation measured by NOAA in Lincoln for the day was 0.02 inches. The water in Scott Pond North was comparatively clear without the high algal density observed in September.

Event POND-04 (April 19, 2005): The boards at the overflow structure for the Blackstone Canal had been worked on. One board was found on the berm. The top board of the weir was new, suggesting that boards were being replaced. It is possible that boards had been worked on during the large flood event 2 to 3 weeks previously (see graphs of Woonsocket gage in Section 7.2). Based on mud markings on shoreline vegetation, it appeared that the canal had been higher by approximately 35 cm (1 foot) prior to the survey event, possibly during the previous flood event. At Station P-11, water flowed from the canal into the pond at a rate of approximately 5 cfs. The water elevation of Scott Pond North was 18 cm ± 3 cm (7 inches ± 2 feet) below the sill elevation. There was another location in the canal near the Michael London & Company entrance where there was a drop by approximately an inch. Therefore, the canal station WL-02 had a water elevation that was approximately 20 cm ±5 cm (8 inches ± 2 inches) higher than the water elevation in Scott Pond on April 19, 2005. These values were used for adjusting the water elevation meters to the common datum at the sill at Front Street Bridge. The weather was sunny and calm. The water in Scott Pond North was comparatively clear without the high algal density observed in September 2004. Scott Pond North was anoxic at depth. Scott Pond South was not yet anoxic at depth.

Event POND-05 (July 12, 2005): The water elevation in Scott Pond was high. Water flowed into the pond at a slow rate from the canal underneath the Front Street bridge. There was no noticeable difference in elevation between the sill underneath the bridge and the pond surface. The water elevation was approximately 20 cm above the sill elevation. The weather was sunny and calm. The water in Scott Pond North was greenish (color of 'pea soup'). Water samples for pathogen analyses were collected along the shore rather than from the center of the pond. Stations were as follows:

- P-07a: Scott Pond North – at boat ramp to the northeast of P-07
- P-08b: Scott Pond South – at private mooring to the northwest of P-08
- P-09b: Scott Pond South – near fire station to the south of P-09

Event POND-06 (July 28, 2005): The water elevation in Scott Pond was high. At Station P-11, water flowed from the canal into the pond at a rate of approximately 10 cfs. The weather was sunny and calm. The water in Scott Pond was clearer than it was two weeks earlier due to treatment of the pond with copper sulfate on July 20, 2005 (Mike Gagnon, Town of Lincoln, letter, August 26, 2005). Both parts of the pond were anoxic at depth.

Event POND-07 (August 12, 2007): The water elevation in Scott Pond was approximately 0.6 m (2 feet) lower than during POND-06 (July 28, 2005). The weather was sunny and calm. The water in Scott Pond was very clear, probably still due to the treatment with copper sulfate on July 20, 2005. Both parts of the pond were anoxic at depth. Phytoplankton samples were collected from the water column at Stations P-7 and P-12 (located between Stations P-08 and P-09). Sediment samples were collected at P-07, P-08, and P-09.

Event POND-08 (August 14, 2005): The pond was at the same elevation as two days before (i.e., low). The weather was sunny and warm.

Event POND-09 (August 15, 2005): This event was a wet weather event. Rain fell between approximately 18:00h on August 14 and 3:00h on August 15. The rainfall amount in Lincoln was 0.93 inches. The rainfall peak in Rhode Island occurred around midnight. During the survey on the following morning, there was inflow of water into the pond from the canal at a rate of approximately 4 cfs underneath the Front Street bridge. The water elevation of Scott Pond was approximately 0.6 to 0.75 m (2 to 2.5 feet) below the sill. The water in Scott Pond was clear. Both parts of the pond were anoxic at depth.

Event POND-10 (September 13, 2005): No activities on Scott Pond (only Valley Falls Pond).

Event POND-11 (September 16, 2005): This event was the second wet weather event. Rain fell between approximately 10:00h and 13:00h on the day before the event. The rainfall amount in Lincoln was 0.83 inches. There was a two-week dry period prior to the storm. On the day of the sampling event, the weather was cloudy with short showers at noon and in the afternoon. Water flowed into the pond from the canal at a rate of approximately 5 cfs underneath the Front Street bridge. The pond elevation was approximately 0.6 to 0.75 m (2 to 2.5 feet) below the sill elevation. The water in Scott Pond was very turbid and greenish in color in Scott Pond South. Scott Pond North was less turbid, possibly a result of the inflow of Blackstone River water from the rainstorm. Also in Scott Pond South, the turbidity in the water column was lowest in the middle part of the water column; it increased again at the bottom sampling depth.

Event POND-12 (September 28, 2005): Water was flowing into Scott Pond from the Blackstone Canal over the sill underneath the Front Street bridge (Station P-11). The flow rate was approximately 4 cfs. The water elevation of Scott Pond was approximately 0.75 to 0.9 m (2.5 to 3 feet) below the sill. Approximately 0.3 inches of rain fell in Lincoln two days before the sampling event. The weather was sunny and calm. The water in Scott Pond was very turbid, particularly in Scott Pond South, as reflected by the turbidity values and the Secchi depth. Scott Pond North was less turbid. Scott Pond North was near anoxic below 5 m (16 feet); Scott Pond South was near anoxic below 6 m (20 feet).

8.4 Results

8.4.1 Bathymetry

The bathymetry of the Blackstone Canal (Figure 8-1) was not investigated, but in many areas it appears to only be a few feet deep.

The deepest part of Scott Pond North is located in the southeast with a maximum recorded depth of 11.5 m (38 feet) (Figure 8-20). The deepest part of Scott Pond South is located in its northern portion with depths reaching 17.4 m (57 feet). The connecting passage between Scott Pond North and Scott Pond South is approximately 7.6 m (25 feet) wide and up to approximately 1.5 m (5 feet) deep. The passage maintained a depth of at least 0.8 meter of water throughout the study period. These depths are based on a filled pond. Water depths can decrease by up to approximately 0.9 m (3 feet) as a result of water elevation changes (Figure 7-31).

8.4.2 Hydrology

8.4.2.1 Blackstone Canal Hydrology

Presently, water flows from the Blackstone River into the Blackstone Canal just upstream of the Ashton Dam. The connection between the river and the canal is partially blocked by large rocks (Figure 8-2). Water seeps through the rock blockage during low flow conditions. During high flow conditions, water also flows over the rocks. The width of the canal is similar to its original width between the Ashton Dam and the Lonsdale Bleachery in the south. Within the property of the Lonsdale Bleachery, the canal first narrows considerably, then widens again adjacent to the former mill pond on the site. Near the southern end of the mill pond, it extends through a former control structure into another small pond within the bleachery site. The southern end of this pond connects to Scott Pond via a narrow channel underneath the Front Street bridge (Figures 8-8 and 8-9).

There are two weirs in this remnant section of the canal that drain the Blackstone River:

- *Ashton Dam area, north of Quinnville:* Weir approximately 100 m (330 feet) from the start of this canal section, located approximately 50 m (165 feet) to the south of the Ashton Dam (Figures 8-3 and 8-4).

- *Lonsdale Bleachery:* Weir approximately 100 m (330 feet) to the north of the former bleachery, downstream of the Pratt Dam on the Blackstone River (Figure 8-5).

Water can be regulated by placing or removing 6x6 square boards in front of each weir. Altering the number of boards has the effect of lowering or increasing the water elevation in the canal. These two weirs are intermittently operated by the Town of Lincoln in a manner to avoid flooding along the canal (Michael Gagnon, Highway Superintendent, Town of Lincoln, personal communication, August 17, 2005). There is no set schedule for adjusting the number of boards and records have not been kept. Typically, the town removes boards in the spring to accommodate the spring floods and replaces the boards in the summer to maintain the water elevation in Scott Pond. In addition, boards may be removed at other times to accommodate flood waters after a large rainstorm. There is no plan to regulate the water elevation in the canal for the sole purpose of management of Scott Pond.

In addition to the weirs, there is an overflow structure from the canal into the Blackstone River in the vicinity of Old River Road in Lincoln, between the intersections of River Road and Dexter Rock Road. This structure cannot be regulated. This and other water control structures were built in the early 1920s by the Lonsdale Company as they adapted the canal for use by the former bleachery (Rick Greenwood, Rhode Island Historical Preservation and Heritage Commission, personal communication, August 12, 2004).

At the weir near the Lonsdale Bleachery the measured changes in water elevations of the Blackstone Canal were relatively small, approximately 35 cm (1 foot; Figure 7-31). The elevations on this figure are reported relative to the elevation of the sill underneath the Front Street bridge. Rainstorms during the measurement periods in 2004 and 2005 resulted in short-term spikes of only 0.1 m (0.3 feet) at the Blackstone Canal station. By comparison, these same rain storms increased the water elevation in Valley Falls Pond by up to 0.6 m (2 feet). Information about the removal or placement of boards at the weir during the measurement period is not available.

8.4.2.2 Scott Pond Hydrology

The only surface water inflow entering Scott Pond is the Blackstone Canal; there are no streams. Scott Pond does not have any surface water outflow. During operation of the Blackstone Canal, there were two locks that connected Scott Pond to the Saylesville Pond, an impoundment on the Moshassuck River (Rick Greenwood, RI Historical Preservation and Heritage Commission, personal communication, August 11, 2004). With the closure of the canal, the locks were filled in. More recently, Scott Pond drained to Saylesville Pond along the Moshassuck River through a pipe in the southwest corner of Scott Pond[1]. However, this connection does not exist anymore. It appears that water leaves Scott Pond through groundwater recharge, given the 4.6 m (15 foot) higher water elevation in Scott Pond versus the adjacent Moshassuck River.

---

[1] Note: The road atlas still shows a connection between Saylesville Pond [part of the Moshassuck River] and Scott Pond [American Map, 2003]).

Water was observed flowing into the pond from the Blackstone Canal during each survey. The typical flow rate was approximately 5 cfs. During the pond surveys, the water level in Scott Pond was lower than the water level in the Blackstone Canal at the sill under the Front Street Bridge. The difference in elevation upstream of the sill (Blackstone Canal) and downstream of the sill (Scott Pond) varied from approximately 0 to 0.75 m (0 to 2.5 feet). Water was never observed flowing from Scott Pond into the Blackstone Canal. This observation is supported by the continuous records of water elevation from Scott Pond and the Blackstone Canal (Figure 7-31), which show that water levels in the canal were always higher than in the pond. Even at times when the water elevation in Scott Pond rose above the sill elevation, the water elevation in the Blackstone Canal was still a few centimeters higher. Flow from Scott Pond back into the Blackstone River is conceivable only when a very large storm results in the discharge of a large volume of water into Scott Pond discharges to the Blackstone Canal, resulting from a rise of the water elevation in the pond relative to the canal. Such an event is unlikely.

Also, flow from the pond into the canal, due to a lowering of the canal water level (by management of weir boards) is not likely, as the levels in Scott Pond are virtually always lower than the sill between the canal and pond at Front Street. The only possible mechanism which would allow flow from Scott Pond to the canal would be during the few days per year when water levels in the pond and canal are both higher than the sill, and there was a quick decrease in the elevation in the canal through outflow at the weir (altering the boards). A short period with a return flow from the pond to the canal would ensue under such circumstances, conceivably resulting in the discharge of a few inches of surface water from the pond. However, such events are expected to be rare and have not been observed by officials from the Town of Lincoln (Kim Wiegand, Town Engineer, personal communication, January 26, 2006).

Therefore, based upon the data, it appears that Scott Pond is the terminal discharge location for the adjacent remnant of the Blackstone Canal and that water flows in from the canal virtually year-around.

Water also enters Scott Pond from its surrounding watershed through groundwater discharge. The shoreline of Scott Pond is comparatively steep. The pond is at an elevation of 23 m (75 feet) NGVD; the surrounding land is at an elevation of approximately 34 m (110 feet) NGVD. The elevation difference creates a hydraulic gradient that results in seepage of groundwater into the pond. One local resident from Scott Pond South stated that there were underground springs. An estimate of the inflow of groundwater was determined based on the watershed information using a water balance method. In this approach a topographically determined watershed was used (Figure 8-20), resulting in the following surface areas:

- Water Surface: 0.185 km^2 (45.6 acres), and
- Watershed: 0.468 km^2 (116 acres). This area does not include the area of the pond.

Annual precipitation was based upon data collected by the Woonsocket Water Treatment Facility, which showed average annual precipitation of 48.7 inches per year (1960-2005). In rural and forested watersheds this annual precipitation would yield an annual aquifer recharge rate of 33.2 inches per year based upon USGS estimates for southeastern Massachusetts. However, given the urban nature of the Scott Pond watershed, where impervious surfaces lead to (a) stormwater runoff directly to the pond via stormwater pipes or as nonpoint source runoff, and (b) collection and rapid infiltration to groundwater via catch basins and pervious surfaces adjacent to the impervious surfaces, the water entering the pond from the watershed approaches the annual precipitation rate. We assume, based on the size of the watershed and the vegetated border of the pond (Figure 8-20), as well as the limited number of outfalls discharging to the pond (see Section 8.4.3.2 below), that much the rainfall within the watershed infiltrates into the ground with the possible exception of larger, more intense rainstorms. The USGS aquifer recharge estimate (33.2 in/yr) is also a fairly good approximation for the net atmospheric input to the pond surface (precipitation minus evaporation). Based upon the surface area for Scott Pond, the annually averaged daily freshwater input to the pond (direct rain over pond, groundwater inflow, surface water runoff) most likely approaches 2,210 m^3/day (78,000 cubic feet/day), but not less than 1,510 m^3/day (53,000 cubic feet/day). This input represents the volume of freshwater entering Scott Pond from its surrounding watershed and the net precipitation directly to the surface waters of Scott Pond. To maintain the observed water levels, this is also the amount of water that must leave the pond through groundwater each day (on average over a year). Of course, the total volume leaving on average each day will also include the average volume entering from the Blackstone Canal. Input from the watershed, alone (groundwater inflow and surface water runoff), most likely approaches 1,586 m^3/day, but not less than 1,081 m^3/day. The range is due to the uncertainty of the direct stormwater discharge volume to the pond.

This watershed inflow can be compared to the observed inflows from the Blackstone Canal at the Front Street Bridge of 12,233 m^3/day (432,000 cf/day), based upon 5 cfs. These data indicate that Scott Pond is dominated hydrologically by the Blackstone Canal (85% of inflow) and not its local watershed/rainfall (15% of input). Therefore, the water elevation in Scott Pond is closely tied to the water elevation in the Blackstone Canal indicating that the canal is the primary source of water in the pond (Figure 7-31).

The predominance of the canal inflow to pond levels can be seen in the relation between water levels, where spikes in the water elevation in the canal resulted in rapid increases of the water elevation in the pond. However, a second pattern also was seen in the fall of 2004 and summer of 2005 water level data. The water elevations in the pond gradually decreased from above the sill elevation to approximately 0.6 m (2 feet) below the sill elevation. Particularly in the fall of 2004, there was no correlation between the generally unchanged water elevations in the canal and the decreasing elevations in Scott Pond. This necessarily results from the inflows being less than the outflows from the pond.

Water outflow from Scott Pond is through subsurface flow. While a buried pipe or a collapsed culvert cannot be completely ruled out, discharge through groundwater is presently deemed the most likely mechanism. The water elevation in Scott Pond is quite high relative to adjacent downgradient surface waterbodies. According to the 1998 USGS topographic map, Scott Pond is at an elevation of 23 m (75 feet) NGVD; the adjacent Valley Falls Pond to the east and Saylesville Pond along the Moshassuck River to the west are both at 18.3 m (60 feet). These elevations were surveyed in 1949, and photo-updated in 1998. Scott Pond is separated from these waterbodies by approximately 100 m (330 feet) at the closest points. The large surface water elevation difference of 4.6 m (15 feet) creates a hydraulic gradient toward the lower waterbodies, although more information is needed about the soil types to predict the flow using Darcy's Law. However, a survey along the shore of Scott Pond indicated sandy sediments, which would provide for high hydraulic conductivities. In addition, changes in the groundwater table may result in increased seepage rates to these adjacent watersheds in the summer and fall, as suggested by the water level data from the pond (Figure 7-31). Aside from groundwater seepage, the only other loss of water from Scott Pond is via evaporation.

In summary, the hydrologic analysis of Scott Pond indicates three key points:

- Surface water is nearly continuously flowing from the Blackstone Canal into Scott Pond.
- The predominant source of water to Scott Pond is from the Blackstone Canal, not its watershed.
- Freshwater outflow is mainly through subsurface flow, generated by the steep hydraulic gradient from Scott Pond to downgradient Saylesville Pond and Valley Falls Pond.

8.4.3 Watershed Assessment

8.4.3.1 Blackstone Canal Watershed

The predominant land use in the area surrounding the investigated Blackstone Canal section is residential development. The main exception is the Lonsdale Bleachery that presently has a number of commercial and industrial uses. The investigated section of the Blackstone Canal is located entirely within the Town of Lincoln. The area is sewered, including the Lonsdale Bleachery. The percentage of residences that are not connected to the sewer system was not determined.

Stormwater flows into the Blackstone Canal from individual sources in Lincoln were not investigated during this study. The stormwater volume is smaller than from other parts of the Blackstone River watershed as the watershed boundary extends only to approximately 1 km (0.6 miles) toward the west from the canal.

8.4.3.2 Scott Pond Watershed

The predominant land use in the area surrounding Scott Pond is also residential development. In addition, some commercial developments exist to the northwest of the northern part of the pond, and a few small industrial developments exist along its northeastern side. The area surrounding Scott Pond is sewered, although not all houses are connected to the system. These houses apparently have septic systems instead. No information exists about the status of these systems.

There are a number of pipes and culverts that enter the pond. In addition, roadway runoff is allowed to enter the pond at specific points as well as via non-point source runoff. Dry weather flow was not observed at any of these locations. Specifically, the main stormwater entry points consist of the following (see Figure 5-12 for location):

- **OF-404:** Corrugated metal pipe near Walker Avenue, 18 inches in diameter. Stormwater runoff from the neighborhood discharges into two manholes at the end of Walker Avenue, from where it discharges into Scott Pond via a pipe that extends down the steep slope toward the pond.

- **OF-405:** Corrugated metal pipe near Walker Street, 12 inches in diameter. The pipe is located directly behind the fire station. It appears to discharge primarily runoff from Walker Street.

- **OF-406:** Clay pipe near Walker Street, 12 inches in diameter. It is located approximately 50 m (165 feet) to the east of OF-405. The pipe does not appear to be active.

- **OF-407:** Concrete culvert near Walker Street, 0.9 m (3 feet) wide and 0.6 m (2 feet) high (Figure 8-12). The large culvert appears to drain stormwater from Walker Street. It is not known if other streets or other sources also drain through this large structure.

Other stormwater sources entering the pond include the following:

- *Franklin Street:* The drain at the end of Franklin Street. Discharge from this drain has created a small delta in the pond, presumably as a result of erosion of the steep slope.

- *Lonsdale Avenue - North:* Stormwater runoff from Lonsdale Avenue enters the northern part of Scott Pond at a low point in the road near the intersection with Lower Road.

- *Streets on eastern side of Scott Pond South.* Streets between Scott Pond and Lonsdale Avenue dip toward the southern part of Scott Pond. Stormwater drains from these streets and adjoining residences directly into the pond via overland flow. This runoff may include stormwater from adjacent sections of Lonsdale Avenue.

These direct surface water inflows of stormwater provide transport pathways for nutrients (particularly phosphorus), pathogens, and metals. While small in the hydrologic balance of Scott Pond, they may play a greater role in the health of the pond systems, although still less than the Blackstone Canal.

8.4.4 Vegetation and Wildlife

The Blackstone Canal is part of the Blackstone River State Park, and therefore covered with trees and other vegetation along much of its length. Water plants were observed growing inside the shallow canal. Ducks and Canadian geese were observed at times (Figure 8-16).

The steep slopes of Scott Pond are largely covered by trees and other vegetation. Aquatic vegetation was not observed along the shore of the pond. The central portions of the pond are too deep for aquatic vegetation.

8.4.5 Water Quality

Water quality data for Scott Pond and the Blackstone Canal are presented in Figure 8-21, with summaries in Figures 8-22 to 8-23. Vertical profiles for temperature and dissolved oxygen are presented in Figures 8-24 and 8-25. Other key parameters are graphically shown in Figures 8-26 to 8-42. Water quality data for outfalls OF-405 and OF-407 are included in Figure 5-17 in Section 5.

8.4.5.1 Blackstone Canal Water Quality

The Blackstone Canal is classified as Class B1 waters. The water quality is dominated by the Blackstone River. During wet weather, stormwater runoff from the Town of Lincoln contributes to the water quality in the canal. Only a few samples were collected in the Blackstone Canal (Stations W-34 and P-11). Station P-11 data are included in figures with Section 8. Station W-34 data are presented in figures in Section 3 (Dry Weather) and Section 4 (Wet Weather).

Nutrients and related parameters: Nutrient concentrations at the two Canal stations were generally similar to the concentrations in the Blackstone River. While the long residence time of the water in the canal is conducive to eutrophic conditions, specifically in the summer, the limited available data are not sufficient to assess its status at this time.

Pathogens: Dry weather fecal coliform and enterococci concentrations exceeded the respective standards approximately half of the time. During wet weather, the standards were exceeded nearly all the time.

Lead and copper: Dissolved lead and copper concentrations were within regulatory standards at both stations.

8.4.5.2 Scott Pond Water Quality

Nutrients and related Parameters

Scott Pond is classified as a Class B waterbody, and is listed on the 303(d) list as being impaired for excess algal growth, chlorophyll *a*, low dissolved oxygen, and phosphorus; the measurements collected during this study are consistent with the prior assessment of impairment. All of these impairments stem from the overenrichment of Scott Pond waters by phosphorus. Phosphorus enters the pond from the Blackstone Canal inflow and from the surrounding watershed, primarily through stormwater inflows. Another important source of phosphorus to phytoplankton blooms within Scott Pond is through phosphorus released from the bottom sediments, particularly when bottom waters become anoxic. Anoxic conditions were observed below the thermocline during the summer months in both years (Figures 4-24 and 8-25). The thermocline was on average approximately 1 m (3 feet)) shallower in Scott Pond North (Station P-07), than at the northern station of Scott Pond South (P-08). The thermocline at the southern station of Scott Pond South (P-09) was at a similar depth as at Station P-08, except for the September 28, 2005 survey, where the thermocline was 1 m (3 feet) deeper at Station P-09.

The enrichment of Scott Pond by nutrients has created eutrophic conditions in pond waters. Specifically, during summer the total phosphorus levels in surface waters ranged from 0.050 to 0.424 mg/l with a mean of 0.144 mg/l in Scott Pond North, and from 0.015 to 0.093 mg/l with a mean of 0.057 mg/l in Scott Pond South. The phosphorus levels were generally greater in Scott Pond North than in Scott Pond South and higher still in the inflowing waters from the Blackstone Canal (0.069 to 0.377 mg/l with a mean of 0.164 mg/l). The gradient in total phosphorus is even more clear in the geometric means, which are often used when observations contain a few very high or low values which can skew the average, such as the 8/15/07 surface value in Scott Pond North. The geometric means for the Blackstone Canal, Scott Pond North and South are 0.143, 0.110, and 0.035 mg/l, respectively. These observed average total phosphorus concentrations throughout Scott Pond were above the 0.024 mg/l noted to indicate eutrophic conditions in the Carlson Trophic Status Index and above the nutrient criteria specified in Rhode Island's Water Quality Regulations[2].

It appears that the Blackstone Canal is a major source of phosphorus to Scott Pond. Based upon the estimated freshwater inflow rate from the canal and the observed geometric mean concentration of 0.143 mg/l (as P), the annual phosphorus input would be 1,400 lbs/yr (as P). This must be taken as an approximate value given the limited inflow sampling that was undertaken, but as the flows and concentrations at the inflow station (P-11) were relatively constant it should be a useful approximation.

Another important aspect of the phosphorus dynamics within Scott Pond relates to the periodic anoxia of its bottom waters both in Scott Pond North and South. The anoxia itself is an indicator of eutrophication and prevents utilization of much of the bottom for infaunal animal habitat. The anoxia is produced by the organic matter production in the surface waters falling into the bottom waters and consuming oxygen during decay during the period of summer stratification. At present, the organic matter deposition is sufficient to consume oxygen from bottom waters during stratification faster than the rate of resupply. Anoxia was observed in both summers of 2004 and 2005 during the routine water column surveys. During anoxia, inorganic phosphorus is released from the sediments due to dissolution of iron oxyhydroxide which sorb phosphorus under oxic conditions. This release is generally many times the

---

[2] "Average Total Phosphorus shall not exceed 0.025 mg/l in any lake, pond, kettlehole or reservoir, and average Total P in tributaries at the point where they enter such bodies of water shall not cause exceedance of this phosphorus criteria, except as naturally occurs, unless the Director determines, on a site-specific basis, that a different value for phosphorus is necessary to prevent cultural eutrophication."

rate of release from remineralization of organic matter during the same time period. The bottom waters of each basin showed this release in their high orthophosphate concentrations in summer (Scott Pond North, 0.230 to 0.665 mg/l [as P]; Scott Pond South, 0.236 to 0.553 mg/l [as P]); these concentrations were many fold higher than the surface water concentrations. While much of this inorganic phosphorus is held in the bottom waters until fall overturn, some is brought into the surface waters during summer through wind-driven shallow mixing events and diffusion.

It is clear that while the Blackstone Canal is an important source of new phosphorus to Scott Pond, recycling of phosphorus from bottom sediments facilitated by anoxic release from sediments has an important contribution.

The water column surveys also documented the eutrophic nature of Scott Pond with surface water chlorophyll *a* concentrations typically approximately 20 ug/l during summer, which result in a green color of the pond waters and in elevated turbidity. The "bands of algae" observed on the surface of Scott Pond North during the September 16, 2004 survey (Figures 8-12 and 8-14) are further indication of the nutrient-enriched nature of Scott Pond. The chlorophyll *a* concentrations were well over the threshold for eutrophication under the Carlson Trophic Status Index of approximately 7 ug/l. Similarly, the Secchi depths were much shallower than the 2-m threshold. All of the eutrophication indicators and the anoxia of the bottom waters clearly support the classification of Scott Pond as eutrophic and its position on the 303(d) list.

Stormwater, to the extent that non-point source runoff or transport via pipes directly to pond waters occurs, represents another potentially important source of phosphorus to Scott Pond. Stormwater represents a portion of the 1,586 to 1,081 m^3/day (average daily) of water entering from the watershed. While the watershed has relatively high density residential development, the upland bordering the pond is generally well vegetated (Figure 8-20). It appears that most of the watershed surface supports vegetation. In addition, it is likely that much of the impermeable surface within the watershed "drains" to infiltration basins or to vegetated buffer where groundwater recharge occurs. However, runoff to Scott Pond occurs in some areas. Since runoff from high density residential development generally contains elevated total phosphorus (0.38 mg/l; RIDEM, 2007), this represents an important source for pond waters. However, even if direct runoff accounts for 25% of the watershed freshwater input to Scott Pond, this would represent only 121 to 83 lbs P/yr, less than 10% of the total phosphorus load entering from the Blackstone Canal.

Restoration of the ecological resources within Scott Pond will require management of phosphorus. Management will need to focus on both the inputs from the Blackstone Canal and the summer time release from pond sediments and likely have to address the inputs through the direct stormwater discharges (which are important for pathogens too, see below), as well. It can be concluded that without phosphorus management, the phytoplankton blooms and resulting turbidity and anoxia will continue into the foreseeable future.

Pathogens

The regulatory standard for fecal coliform for Class B waters (geometric mean of 200 col/100 ml) was exceeded only in Scott Pond North during the two wet weather events. Enterococci concentrations were also high in Scott Pond North at that time, exceeding the proposed standard. Concentrations in Scott Pond South were much lower and remained well within the regulatory limit. The high concentrations in Scott Pond North were contributed from the Blackstone Canal as indicated by the even higher pathogen concentrations at Station P-11 underneath Front Street bridge. Fecal coliform concentrations at that station were 9,000 col/100 ml during both wet weather events; enterococci concentrations were 430 and

240 col/100 ml, respectively. Fecal coliform concentrations in the Blackstone River station in the vicinity of Valley Falls Pond (Station P-04) were also elevated during the during these surveys with fecal coliform concentrations of 1,100 and 230 col/100 ml and enterococci concentrations of 86 and 30 col/100 ml, respectively, suggesting that the pathogen could have been contributed by the Blackstone River, via the Blackstone Canal.

Elevated pathogen concentrations at the Blackstone Canal Station P-11 were also observed during some of the dry weather surveys of the pond. The pond, however, was generally within the regulatory standard at that time with the exception of an elevated enterococci concentration in Scott Pond South on September 16, 2004. The fecal coliform concentration at that time was comparatively low, however. It appears that the enterococci concentrations from that day are questionable, because the duplicate sample differed by one order of magnitude from the original sample, and because the fecal coliform data were all below the detection limit of <2 col/100 ml.

The limited pathogen data suggest that Scott Pond South appears to meet the regulatory standard during dry weather. There are no dry weather discharges entering the pond with the exception of maybe some subsurface groundwater springs. Scott Pond North probably meets the regulatory standard most of the time, although it is more directly influenced by discharges from the Blackstone Canal, which has pathogen concentrations that can exceed the regulatory standard even during dry weather conditions. During wet weather conditions, high pathogen loading from the Blackstone Canal leads to exceedances in Scott Pond North. Scott Pond South may also be impacted by the canal as the water elevation in the pond can rise quickly as shown by the rapid response of the water elevations in the pond after a rain storm (Figure 7-31). Other important sources of pathogens entering the pond are direct stormwater discharges, such as the observed outfalls and non-point discharges from large roadway runoff at various locations surrounding the pond (Figure 8-12). Pathogen loads in stormwater from residential development are well documented. However, the relative importance of the Blackstone Canal versus direct stormwater inflows cannot be determined at this time. Birds were observed on the pond only occasionally (Figure 8-16)

The sources of the pathogens in the Blackstone Canal are not known. Potential sources consist of (a) Blackstone River water entering the canal at the Ashton Dam, (b) stormwater discharges from the Town of Lincoln entering the Blackstone Canal, or (c) illicit discharges from the Lonsdale Bleachery. The relative contribution from local sources in the Town of Lincoln that also discharge to the Blackstone Canal is not known at this time. The Lonsdale Bleachery is the least likely source as it is connected to the sewer system (Cindy Hannus, RIDEM, personal communication, January 27, 2006). Nevertheless the facilities contain multiple old pipes that have not all been identified. Several buildings are built directly over, or adjacent to, the canal and should be assessed for potential contribution to pathogen loading.

Dissolved Copper and Lead

Scott Pond was treated for algal growth on July 12, 2004 and July 20, 2005. In 2005, 300 pounds of the pesticides (copper sulfate) were applied (Michael Gagnon, Highway Superintendent, Town of Lincoln, personal communication, August 26, 2005). The effect was clearly reflected in the dissolved copper concentrations in the oxygenated upper layer of the pond during subsequent months. The copper concentration in the underlying anoxic zone did not increase as much, specifically in 2005, as a result of the lack of vertical mixing in the pond during the summer and fall.

The chronic criteria for dissolved copper in Scott Pond ranged between 4.5 and 6.6 ug/l with a mean of 5.1 ug/l (for Events POND-06, 09, 11). The acute criteria ranged from 6.3 to 9.6 ug/l with a mean of 7.3 ug/l (Figure 8-20). One week after the treatment of the pond on July 28, 2005, the copper concentrations in the surface water of both Scott Pond North and South exceeded 40 ug/l (Figure 8-22). The copper concentrations in the oxygen-deficient deep waters remained below 5 ug/l.

The dissolved lead concentrations in the oxygenated surface water as well as in the frequently oxygen-depleted deep and bottom water of Scott Pond North and South were within regulatory limits.

The dissolved copper and lead concentrations measured in the Blackstone Canal at the point of inflow to the Scott Pond North were within the regulatory criteria, with the exception of the lead concentration on August 15, 2005, as discussed above.

The oxygen status of the bottom waters can have important implications to the release or non-release of heavy metals from the pond sediments. Metals may be immobilized by oxidized forms of iron and manganese and then released under anoxic conditions. In addition, if sulfides are present under anoxic conditions, heavy metals such as Cd, Zn and Pb are bound tightly. The role of the cycling of bottom waters between fully oxic and anoxic conditions on metal sequestration in this system is not clear at present.

8.4.6 Phytoplankton

The algal community composition in Scott Pond North (Station P-07) was dominated by the cryptomonad *Chroomonas nordstedtii* in terms of both density and biovolume (Figures 7-39 and 7-40). Total biovolume was mostly composed of chlorophytes and cryptomonads. Scott Pond South (Station P-12) was numerically dominated by trichomes of cyanobacteria belonging to either *Pseudananbaena* or *Limnothrix*, which are difficult to distinguish in preserved material. Small unicellular cyanobacteria were also abundant. The *Pseudanabaena/Limnothrix* cyanobacteria and a moderately sized unidentified flagellate were the greatest contributors to biovolume at Station P-12.

The algal community included a large number of species that are typically found in shallow and soft-water environments. Total biovolume in Scott Pond (Stations P-07 and P-12) was slightly lower than in Valley Falls Pond (Stations P-01 and P-03), and the community composition was distinct. Except for Station P-12, cyanobacteria were a minor constituent of the total algal biovolume.

It is possible to calculate a trophic state index (TSI) of Carlson (1977) based upon the biovolume for comparison to the water quality based index. Using the data collected on August 12, 2005 the Index ranged from 46 to 49 for Scott Pond (Figures 7-41). A trophic state index of 50 or greater is generally considered to indicate eutrophic conditions. In Scott Pond, the phytoplankton composition at both Scott Pond stations bordered on eutrophic conditions.

The TSI assesses the amount of plant material in a waterbody. Aside from the algal composition, other indices are also used to determine the trophic state of a pond: water transparency (Secchi Depth), algal chlorophyll *a*, and total phosphorus. Given the clearly eutrophic status of Scott Pond based on the water quality indicators, the lower TSI value based upon biovolume received further investigation. The chlorophyll *a* concentrations of the pond surveys indicated that the July 28, 2005 survey had significantly lower concentrations (5-10 fold) than the other summer surveys. It was then noted that Scott Pond was treated with copper sulfate to remove "algae" on July 20, 2005, approximately 1 week prior to the chlorophyll sampling and one month prior to the biovolume sampling. Water samples collected on August 15, 2005, three days after the collection of the phytoplankton samples, contained significantly elevated copper concentrations relative to pretreatment conditions. This treatment clearly affected the chlorophyll levels, community composition and biovolume. Integrating this treatment information indicates that the TSI based upon the biovolume data alone is an underestimate of the level of eutrophication in Scott Pond. However, given that the results still border on a eutrophic classification (and are underestimates), it appears that the eutrophic classification based upon the water quality data is correct.

8.4.7 Sediment

The shallow water sediments along the perimeter of Scott Pond consist of predominantly sand. In the deep central parts of Scott Pond North and South, the surface sediments (upper 4 cm) consist predominantly of soft, organic-rich black silt and clay (Figures 7-43; 8-17 and 8-18). The silt/clay concentration in Scott Pond North was 91%, in the northern portion of Scott Pond South it was 93%, and in the southern portion of Scott Pond South it was 75%. The remainder of the sediment consisted of fine and medium sand. The thickness of the soft sediment layer is not known. The predominance of sand in the shallow waters may be important to the exfiltration of pond waters to the aquifer along the southernmost shoreline.

The water content and low bulk density of the sediments in the Scott Pond basins of $\geq$89% and 0.06-0.09 g/cm^2 respectively, is consistent with their fine-grained unconsolidated nature and their high organic carbon content, 10 to 20% (by weight) (Figure 7-46). The sediments are also high in nitrogen and phosphorus, which is expected from the high organic matter content. Similarly, the sediment organic matter appears to be related to phytoplankton deposition, given the very high chlorophyll *a* levels (60-300 ug/g dry weight) in surficial sediments. All of the sediment characteristics are consistent with an organically-enriched sediment resulting from phytoplankton deposition, indicative of an eutrophic aquatic system.

The algal composition of the upper 2 cm of the sediment column consisted to 44 to 65% of wetland plants with the remainder being macroalgae. Results are considered an estimate because of the fragmented nature of the plant material (Figure 7-47). It should be noted that the remnants of higher plants tend to persist much longer than macroalgae and phytoplankton. Phytoplankton tend to degrade within days to weeks and macroalgae in weeks to a few months. In contrast, fragments of higher plants, especially if they contain lignin, can persist for years. These data indicate that plant material enter the pond sediments from the margins of Scott Pond, and possibly from the Blackstone Canal. However, integrating all of the sediment data indicates that algae and phytoplankton are the predominant source of organic matter to the sediments.

The soft sediments in the deepest portion of Scott Pond contained high concentrations of heavy metals. All metals analyzed exceeded most guideline values for sediment quality (Figure 7-48). All measured metal concentrations were well above the background concentrations in Rhode Island soils, suggesting anthropogenic sources. The general similarity of the concentrations in Valley Falls Pond and central portions of Scott Pond, coupled with the fact that the Blackstone Canal is the predominant source of water to the pond suggests that the soft sediment in Scott Pond originated from industrial activities in the Blackstone Valley.

8.5 Summary

The data and analysis presented in the above, relative to Scott Pond, have important implications to the future management of Scott Pond, as well as firmly establishing its present habitat quality and tropic status. The major points and issues are as follows:

- Scott Pond is an eutrophic freshwater pond at the terminus of a remnant of the Blackstone Canal and its local watershed. Water flows in from the Blackstone Canal and out through groundwater. As a result, the pond operates as a depositional basin, which is enriched in phosphorus and which shows classic symptoms of eutrophication: high total phosphorus levels, high chlorophyll *a* levels, low transparency and high phytoplankton biovolumes. In addition, the bottom waters of both the Scott Pond North and Scott Pond South become seasonally anoxic. Based upon the data and the Carlson Trophic State Index, Scott Pond is clearly eutrophic and is properly listed on the 303(d) list as impaired by low dissolved oxygen, excess algal growth/chlorophyll-*a*, and phosphorus (RIDEM, 2003). Management will be required for the restoration of this impaired aquatic resource.

- The hydrologic balance of Scott Pond is dominated by inflow from the Blackstone Canal (85%), with the watershed and direct atmospheric deposition accounting for 11% and 4%, respectively. Freshwater outflow appears to be through the subsurface most likely to the Moshassuck River and possibly Valley Falls Pond. Pond water enters the aquifer on the southern shore due to a 4.3 m (15 foot) hydraulic head and steep hydraulic gradient that exists between Scott Pond and these adjacent surface waterbodies. The apparent sandy sediments and steep hydraulic gradient, are consistent with outflow through groundwater.

- The Blackstone Canal is a source of nutrients to Scott Pond. The total phosphorus concentration in the water flowing into Scott Pond is typically higher than the surface water concentrations of the pond. Based upon the rates of inflow and concentrations, it appears that the annual input of phosphorus from the canal is approximately 1,400 kg/yr. Scott Pond is operating in a manner analogous to an impoundment on a river, except that the water exits through the subsurface. Impoundments typically are depositional basins, which can become enriched in nutrients and have depletion of bottom water oxygen.

- The watershed to Scott Pond is likely an important, though secondary, source of phosphorus to pond waters. Stormwater was not measured as a part of the present analysis. However, stormwater can contain high levels of phosphorus, as well as nitrogen and pathogens. Given the direct stormwater discharges to Scott Pond, it is almost certain that this is a relevant source.

- Scott Pond has a significant amount of phosphorus release from the bottom sediments due to the periodic anoxia of the bottom waters. During stratification in summer, there is sufficient organic matter input to the sediments to deplete the bottom waters of oxygen. The result is a rapid release of inorganic phosphate from the sediments, which can be seen in the very high concentrations (0.230 - 0.665 mg/l [as P]), several times higher than in the overlying oxic surface waters. This recycled nitrogen plays a role in meeting the phytoplankton demand for phosphorus and maintaining the eutrophic conditions of the pond.

- At present, management of eutrophic conditions within Scott Pond merely addresses turbidity and has short-term effects (weeks, at best). Periodic summer time water treatment with copper sulfate is the current management method. However, the current treatment results in high dissolved copper concentrations in pond waters, well above the regulatory limits. Further, it does not address the fundamental problem of excess phosphorus, and therefore would be needed into the foreseeable future; this approach is undesirable due to the high copper loading. A better approach would be to develop a more effective phosphorus management approach (see Section 8.6 [Recommendations] below).

- Both the oxygenated surface waters and anoxic bottom waters of Scott Pond met the standards for dissolved lead. The standards for dissolved copper were greatly exceeded in the surface waters of the pond due to treatment of the pond with copper sulfate. The bottom water met the standard for dissolved copper.

- Scott Pond also met the standard for pathogens during dry weather. During dry weather, the pond received pathogen loads from the Blackstone Canal. Only Scott Pond North exceeded the standard during wet weather, but the inflowing canal water likely also affects Scott Pond South during large wet weather events.

8.6 Recommendations

Following are recommendations for follow-up activities for Scott Pond and the Blackstone Canal:

- *Pathogen concentrations*: The Blackstone Canal contained high pathogen concentrations during wet weather and at times during dry weather, affecting the pathogen concentration in Scott Pond North. The existing data are inadequate to determine the source of the pathogens in the canal. It is recommended to collect samples for pathogens at several stations along the Blackstone Canal from its northern extent at the Ashton Dam to the southern point at the sill underneath Front Street bridge. At the same time, a survey should be conducted along this stretch to identify any point sources as well as large non-point sources that may contribute to the canal and help explain this observation.

- *Phosphorus loadings:* Essential to determining the most effective management method for reducing the eutrophication of Scott Pond is an assessment of the relative sources of phosphorus to support phytoplankton in pond waters. Specifically, this entails the amount of phosphorus loading from the watershed through direct stormwater discharges, the amount of phosphorus released from the bottom sediments during oxic and anoxic conditions, and a refinement of the inflowing load from the Blackstone Canal. Based upon available information, it is clear that the Blackstone Canal is the major "external" source of phosphorus to the pond, likely accounting for >90% of the external P load. It should be noted that although external sources (predominantly the Blackstone Canal) ultimately control the eutrophication of the pond, internal recycling plays a role in the present eutrophication status. Controlling internal recycling would likely ameliorate the present need for copper sulfate additions, which only address the outcome of phosphorous enrichment (i.e. phytoplankton blooms). A phosphorus management plan should be developed that addresses both in-pond and external source reduction as mitigation for the impairment of the pond system. Both are needed as the phosphorous already cycling within the pond needs to be controlled to reduce the present eutrophic state and the external load needs to be managed to reduce the amount of phosphorous "build-up" over time. In some instances, measures to control the internal recycling can be performed to reduce the results of eutrophication, while the external loading is addressed; in some instances the external loading needs to be performed first as the P load is sufficiently high as to quickly re-establish eutrophic conditions (i.e., effect on internal recycling control measures last only a few years). However, in the case of Scott Pond, preventing the need for copper sulfate additions should be factored into the management decision. In preparing the management plan, consideration should be given to collection of additional data:

phosphorus water column profiles in winter to compare against summer values to determine the amount of phosphorus that builds up in the hypolimnion and released with fall mixing and to assess seasonal variability in phosphorus loading; cores for the determination of phosphorus flux from the sediment into the water column; and phosphorus concentrations of stormwater entering the pond to compare against the data for the Blackstone Canal inflow.

- *Surface water outflow:* While the Blackstone Canal appears to predominate the "external" phosphorus loadings, an analysis as part of Recommendation #2 above, to determine the potential effect on the phosphorus balance of having a surface water discharge restored to the southern end of the pond should be conducted. However, the concern for this recommendation would be the potential additional phosphorus loading to downgradient waters.

- *Blackstone Canal flow:* One mechanism for reducing the phosphorus loading to Scott Pond from the Blackstone Canal would be to reduce the volumetric inflow. The effectiveness of this approach would depend on the relative importance of the canal versus other sources (see Recommendation #2 above). However, even if the canal is the dominant phosphorus source, it is not clear that reducing inflow would result in a sufficiently high Pond water elevation to support present habitats. The present high groundwater outflow from the pond during the study period appeared to result in relatively rapid lowering of the pond elevation at low canal inflow rates. A better assessment of the effect of the canal inflow on maintaining pond levels would be relatively simple to attain. It would be needed before including alteration of inflow rates in the management plan.

- *Discharges from the Lonsdale Bleachery to the Blackstone Canal:* As part of the rehabilitation of the Lonsdale Bleachery, the buildings adjacent to the Blackstone Canal should be inspected closely to assure that there are no illicit discharges to the canal. Dye tests should be performed as appropriate, as some of the discharge points could be below the water surface in the Blackstone Canal or are covered by the buildings constructed right above the canal.

- *Improve the water quality in the Blackstone River:* Improving the water quality of the Blackstone River should also improve the water quality in Scott Pond.

Figure 8-1: Blackstone Canal, near southern weir (7/12/05).

Figure 8-2: Blackstone Canal, at inflow near Ashton Dam (7/14/04).

Figure 8-3: Blackstone Canal, northern weir, looking toward the canal (7/14/04).

Figure 8-4: Blackstone Canal, northern weir, looking toward the Blackstone River (7/14/04).

Figure 8-5: Blackstone Canal, southern weir, looking toward the canal (8/10/04).

Figure 8-6: Blackstone Canal, southern weir, looking toward the Blackstone River (7/14/04).

Figure 8-7: Blackstone Canal, former Lonsdale Bleachery building over the canal.

Figure 8-10: Passage between South North and South basins.

Figure 8-8: Blackstone Canal, sill at Front Street bridge (8/10/04)

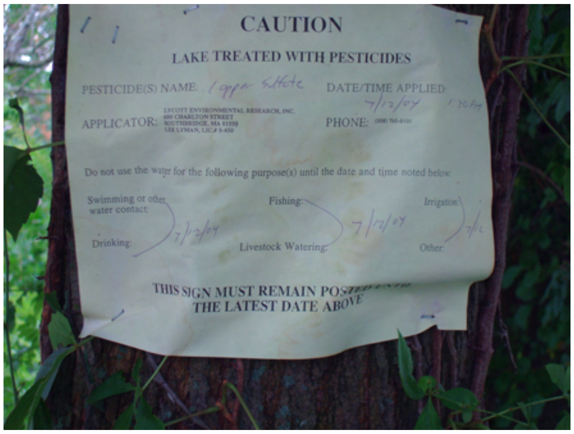
Figure 8-11: Scott Pond South, eastern shore (8/10/04).

Figure 8-9: Blackstone Canal, sill at Front Street bridge (7/12/05).

Figure 8-12: Scott Pond South, outfall OF-407 on southern shore (9/16/04).

Figure 8-13: Scott Pond North, green-colored eutrophic water (7/14/04).

Figure 8-14: Scott Pond North, band of algae on surface water (9/16/04).



CAUTION

LAKE TREATED WITH PESTICIDES

PESTICIDE(S) NAME: Copper Sulfate
DATE/TIME APPLIED: 7/12/04 1:30 PM

APPLICATOR: LYCOTT ENVIRONMENTAL RESEARCH, INC.
600 CHARLTON STREET
SOUTHBRIDGE, MA 01550
LEE LYMAN, LIC# S-450
PHONE:

Do not use the water for the following purpose(s) until the date and time noted below:

Swimming or other water contact:
Drinking: 7/12/04
Fishing:
Livestock Watering: 7/12/04
Irrigation:
Other: 7/12

THIS SIGN MUST REMAIN POS
THE LATEST DATE ABOVE

Figure 8-15: Scott Pond, Caution sign after treatment with copper sulfate (7/12/04).

Figure 8-16: Scott Pond South, Canadian geese.

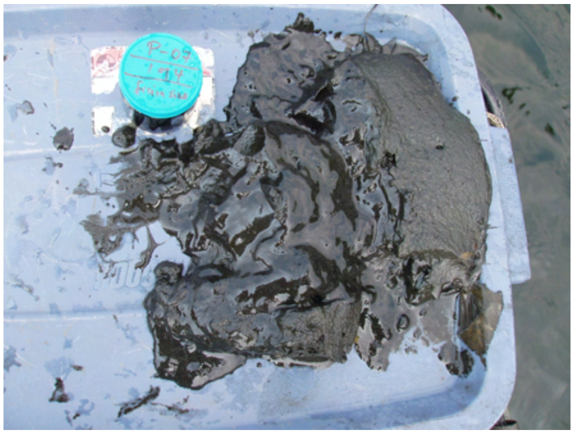


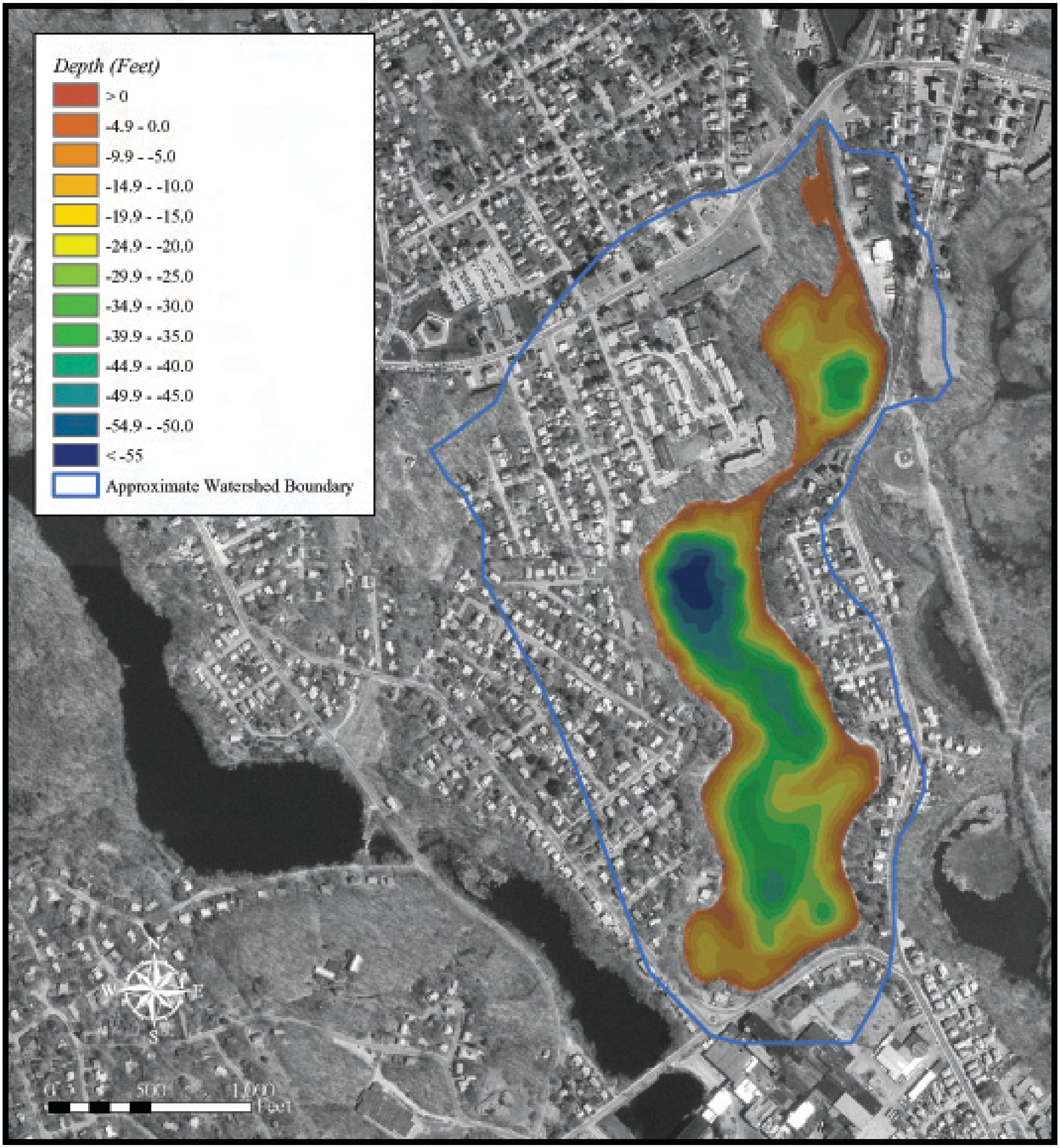
Figure 8-17: Scott Pond North, fine-grained surface sediment (Station P-07).

Figure 8-18: Scott Pond South, fine-grained surface sediment (Station P-08).

Figure 8-19: Flow Rate and Elevation of Blackstone Canal underneath Front Street Bridge (Station P-11), Town of Lincoln

Sampling Event	**Date**	**Flow Rate** (cfs) (estimate)	**Elevation of Scott Pond relative to the Sill Level underneath Front Street Bridge**
POND-01	Aug. 10, 2004	5	1 to 2 feet below
POND-02	Sep. 16, 2004	10	0.6 – 1.0 feet below
POND-03	Dec. 6, 2004	5	2 feet below
POND-04	Apr. 19, 2005	5	0.6 feet (+/- 1 inch) below
POND-05	June 12, 2005	n/a	1 foot above
POND-06	July 28, 2005	10	0.3 to 0.6 feet above
POND-07	Aug. 12, 2005	n/a	2 feet below
POND-08	Aug. 14, 2005	n/a	2 feet below
POND-09	Aug. 15, 2005	4	2 to 2.5 feet below
POND-11	Sep. 16, 2005	5	2 to 2.5 feet below
POND-12	Sep. 28, 2005	4	2.5 to 3 feet below

n/a Not estimated



The Louis Berger Group, Inc.

Rhode Island DEM

Source: RIGIS, The Louis Berger Group

BathymetryScottPond.mxd

2006-06-19

Blackstone River Water Quality

Figure 8-20
Scott Pond Bathymetry and Approximate Watershed Boundary

Figure 8-21: Water Quality in Scott Pond

																																Regulatory Standards				
Station (5)		Time	Water Depth	Secchi Depth	Survey Water Depth	Temperature	Conductivity	Dissolved Oxygen	pH (field)	pH (lab)	Turbidity	Fecal Coliform	Enterococci	Ortho-phosphate	Total Phosphorus	Ammonia	Nitrate	DIN	Total Dissolved Nitrogen	DON	Particulate Organic Carbon	Particulate Organic Nitrogen	C/N	TON	TN	Chlorophyll *a*	Pheophytin *a*	Ratio Chl *a* / (Chl *a* + Pheo *a*)	Dissolved Copper	Dissolved Lead	Hardness	Dissolved Copper - Acute Criteria	Dissolved Copper - Chronic Criteria	Dissolved Lead - Acute Criteria	Dissolved Lead - Chronic Criteria	Comments
		h	m	m	m	ºC	uS/cm	mg/l			NTU	col/100 ml		mg/l P		mg/l N								mg/l N		ug/l	ug/l		ug/l	ug/l	mg/l	ug/l	ug/l	ug/l	ug/l	
Event POND-01: August 10, 2004 *(Dry Weather)*																																				
W-34	Blackstone Canal	13:53	1.7		0.2	22.4	420	8.2	8.2		3.1	110		0.063	0.217	0.004	1.103	1.107	1.46	0.35	1.84	0.29	7.49	0.64	1.75	13.37	6.08	0.69								
(4)	weir - south				1.2			8.2																												
P-07	Scott Pond North	14:40	5.0	1.2	0.2	25.9	390	13.2	9.6																											
					0.5				9.6		5.7	4		0.009	0.147	0.004	0.174	0.178	0.80	0.62	2.34	0.42	6.57	1.03	1.21	26.11	<0.05	1.00								
					1.5	23.2	381	9.7																												
					3.0	21.1	377	**2.7**																												
					4.5	14.8	421	**0.5**	6.9		8.3			0.230	0.443	1.638	0.003	1.641	2.02	0.38	2.70	0.41	7.65	0.79	2.43	120.78	<0.05	1.00								
P-08	Scott Pond South	15:45	17.0		0.2	26.2	365					<2																								
	- northern part				1.0	26.2	364	9.8	8.9		4.0			0.005	0.073	0.006	0.002	0.008	0.50	0.49	1.65	0.28	6.85	0.77	0.78	7.60	<0.05	0.99								
					2.8	24.4	362	9.4																												
					3.7	24.2	361	8.2																												
					4.6	21.6	353	**1.0**																												
					5.5	14.8	348	**1.0**																												
					6.4	11.8	341	**0.8**																												
					7.0						3.2			0.140	0.422	1.156	0.003	1.159	1.54	0.38	2.03	0.34	6.98	0.72	1.88	9.16	25.26	0.27								
					8.2	8.1	356	**0.4**																												
					11.0	7.3	354	**0.4**																												
					13.0						2.3			0.371	0.632	2.235	0.005	2.240	18.67	16.43	1.20	0.20	7.17	16.62	18.86	4.11	5.83	0.41								
					14.3	6.0	368	**0.4**																												
P-09	Scott Pond South	15:05	10.7	1.1	0.2	25.3	365	10.8				<2																								
	- southern part				1.0				9.3		4.2			<0.003	0.040	0.007	0.004	0.011	0.45	0.44	2.28	0.34	7.85	0.78	0.79	19.01	1.60	0.92								
					1.8	24.7	364	10.4																												
					2.7	24.4	362	10.0																												
					3.7	24.1	360	8.5																												
					4.6	22.3	355	**1.0**																												
					5.5	19.9	345	**1.0**																												
					6.4	13.3	353	**1.0**																												
					7.0	10.0	361	**0.6**	7.9		6.5			0.029	0.176	0.921	0.002	0.923	1.23	0.31	2.26	0.37	7.23	0.67	1.59	15.68	22.01	0.42								
					8.2	8.8	357	**0.4**																												
					9.2	8.7	356	**0.4**																												
					10.0	8.0	356	**0.2**	6.9		3.7			0.322	0.348	2.112	0.004	2.116	2.30	0.18	1.88	0.31	7.08	0.49	2.61	6.98	9.19	0.43								
					11.0	7.5	356	**0.2**																												
P-10	(duplicate of P-08 [1 m])				1.0																															

Figure 8-21 *(cont.)*: Water Quality in Scott Pond

																																Regulatory Standards				
Station *(5)*		Time	Water Depth	Secchi Depth	Survey Water Depth	Temperature	Conductivity	Dissolved Oxygen	pH (field)	pH (lab)	Turbidity	Fecal Coliform	Enterococci	Ortho-phosphate	Total Phosphorus	Ammonia	Nitrate	DIN	Total Dissolved Nitrogen	DON	Particulate Organic Carbon	Particulate Organic Nitrogen	C/N	TON	TN	Chlorophyll *a*	Pheophytin *a*	Ratio Chl *a* / (Chl *a* + Pheo *a*)	Dissolved Copper	Dissolved Lead	Hardness	Dissolved Copper - Acute Criteria	Dissolved Copper - Chronic Criteria	Dissolved Lead - Acute Criteria	Dissolved Lead - Chronic Criteria	Comments
		h	m	m	m	ºC	uS/cm	mg/l			NTU	col/100 ml		mg/l P		mg/l N								mg/l N		ug/l	ug/l		ug/l	ug/l	mg/l	ug/l	ug/l	ug/l	ug/l	
Event POND-02: September 16, 2004 *(Dry Weather)*																																				
P-07	Scott Pond North	10:53	11.0	0.4	0.2	21.0	399	14.4				<2	<2																							
		-11:30			0.5				9.7		42.0			0.002	0.130	<0.001	0.003	0.004	0.33	0.33	8.05	1.51	6.21	1.84	1.85	26.99	<0.05	1.00	*ed*	*ed*	46	6.47	4.61	27.5	1.07	*(1)*
					1.0	20.8	394	12.0																												
					2.0	20.5	395	10.8																												
					3.0	20.2	395	5.8																												
					4.0	18.6	394	**1.2**																												
					5.0	12.8	513	**0.7**																												
					6.0	9.2	605	**0.7**																												
					8.0	6.0	940	**0.7**	7.4		8.5			0.638	0.945	3.774	0.003	3.777	5.37	1.60	1.76	0.27	7.61	1.87	5.64	143.99	<0.05	1.00	*ed*	*ed*	50	6.99	4.95	30.1	1.17	
					10.0	5.7	1174	**0.5**																												
P-08	Scott Pond South - northern part	12:49	14.5	1.2	0.2	22.7	354	10.6				<2	26																							
		-13:40			1.0	22.5	354	10.5	9.1		5.6			0.004	0.093	0.003	0.002	0.005	0.37	0.36	2.10	0.28	8.81	0.64	0.65	31.13	<0.05	1.00	*ed*	*ed*	25	3.64	2.74	13.9	0.54	*(1)*
					2.0	22.4	353	10.2																												
					3.0	22.4	352	9.8																												
					4.0	22.2	352	8.6																												
					5.0	21.0	350	**1.7**																												
					6.0	14.6	352	**0.7**																												
					7.0				6.7		5.5			0.033	0.176	0.621	0.001	0.622	0.95	0.33	1.50	0.28	6.34	0.61	1.23	11.99	6.72	0.64	*ed*	*ed*	43	6.07	4.35	25.5	0.99	
					8.0	9.4	351	**0.5**																												
					10.0	7.0	348	**0.4**																												
					12.0	6.8	348	**0.4**																												
					13.0				6.5		3.5			0.431	0.484	2.723	0.005	2.728	3.05	0.32	1.32	0.23	6.78	0.55	3.28	12.50	11.13	0.53	*ed*	*ed*	38	5.40	3.92	22.2	0.87	
P-09	Scott Pond South - southern part	12:08	10.8		0.2	22.5	353	10.8				<2	94																							
		-12:38			1.0	22.5	355	10.4	9.4		4.8			0.002	0.069	<0.001	0.001	0.002	0.39	0.39	2.12	0.28	8.72	0.67	0.67	8.94	<0.05	1.00	*ed*	*ed*	42	5.93	4.27	24.8	0.97	*(1)*
					2.0	22.4	354	10.2																												
					4.0	22.4	354	9.8																												
					5.0	20.7	348	**1.5**																												
					6.0	16.3	344	**1.3**																												
					7.0				7.4		4.8			0.033	0.171	0.598	0.001	0.599	0.93	0.33	1.86	0.34	6.43	0.67	1.27	7.37	5.18	0.59	*ed*	*ed*	44	6.20	4.44	26.1	1.02	
					8.0	9.1	356	**0.8**																												
					10.0	7.4	365	**0.8**	6.7		3.3			0.336	0.608	1.410	0.002	1.412	2.82	1.40	1.61	0.28	6.64	1.69	3.10	12.51	7.95	0.61	*ed*	*ed*	42	5.93	4.27	24.8	0.97	
P-11	Scott Pond North Inflow	14:59	0.2		0.1	19.4	418	7.0	7.1		4.6	<2	136	0.150	0.377	0.019	1.991	2.010	2.48	0.47	1.24	0.16	9.19	0.62	2.63	8.14	2.93	0.74	*ed*	*ed*	54	7.83	5.51	37.3	1.45	
P-10	(duplicate of P-08 [1 m])											2	2	<0.003	0.051	<0.001	0.006	0.007	0.41	0.40	2.16	0.29	8.75	0.69	0.70	20.31	<0.05	1.00	*ed*	*ed*	42	6.18	4.45	27.1	1.05	*(1)*

Figure 8-21 *(cont.)*: Water Quality in Scott Pond

																																Regulatory Standards				
Station *(5)*		**Time**	**Water Depth**	**Secchi Depth**	**Survey Water Depth**	**Temperature**	**Conductivity**	**Dissolved Oxygen**	**pH (field)**	**pH (lab)**	**Turbidity**	**Fecal Coliform**	**Enterococci**	**Ortho-phosphate**	**Total Phosphorus**	**Ammonia**	**Nitrate**	**DIN**	**Total Dissolved Nitrogen**	**DON**	**Particulate Organic Carbon**	**Particulate Organic Nitrogen**	**C/N**	**TON**	**TN**	**Chlorophyll *a***	**Pheophytin *a***	**Ratio Chl *a* / (Chl *a* + Pheo *a*)**	**Dissolved Copper**	**Dissolved Lead**	**Hardness**	**Dissolved Copper - Acute Criteria**	**Dissolved Copper - Chronic Criteria**	**Dissolved Lead - Acute Criteria**	**Dissolved Lead - Chronic Criteria**	**Comments**
		h	m	m	m	ºC	uS/cm	mg/l			NTU	col/100 ml		mg/l P		mg/l N								mg/l N		ug/l	ug/l		ug/l	ug/l	mg/l	ug/l	ug/l	ug/l	ug/l	
Event POND-03: December 6, 2004 (Dry Weather)																																				
P-07	Scott Pond North	13:55	8.9	1.7	0.2	5.5	223	7.5				23	10																							
					0.5				7.5		1.6			0.110	0.136	0.405	0.393	0.798	1.01	0.21	0.60	0.08	8.33	0.29	1.09	2.27	4.05	0.36	*ed*	*ed*	41	5.80	4.18	24.2	0.94	
					1.0	5.5	224	7.4																												
					4.0	5.5	224	7.3																												
					6.0	5.5	225	7.2																												
					7.0	5.6		5.3			2.3			0.728	0.568	2.420	0.184	2.604	2.83	0.23	0.50	0.07	8.77	0.30	2.90	8.17	5.17	0.61	*ed*	*ed*	48	6.73	4.78	28.8	1.12	
P-08	Scott Pond South - northern part	14:29		2.0	0.2	6.8	221	5.4			1.1	<2	13																							
					1.0	6.8		5.4	7.6		0.8			0.113	0.131	0.844	0.072	0.916	1.19	0.28	0.59	0.08	8.16	0.36	1.27	2.11	5.65	0.27	*ed*	*ed*	41	5.80	4.18	24.2	0.94	
					7.0	6.8		4.7			0.9			0.108	0.159	0.828	0.071	0.899	1.19	0.29	1.05	0.18	6.84	0.47	1.37	1.44	7.16	0.17	*ed*	*ed*	41	5.80	4.18	24.2	0.94	
					10.0	6.8		4.7						0.107	0.130	0.827	0.070	0.897	1.35	0.46	0.63	0.09	7.86	0.55	1.44	2.24	5.55	0.29	*ed*	*ed*	42	5.93	4.27	24.8	0.97	
P-09	Scott Pond South - southern part	15:08		3.3	0.2	6.8		5.4				<2	6																							
					1.0	6.8		5.4						0.103	0.138	0.820	0.072	0.892	1.19	0.30	0.60	0.09	7.42	0.39	1.28	1.52	5.98	0.20	*ed*	*ed*	41	5.80	4.18	24.2	0.94	
					7.0	6.7		5.4						0.103	0.137	0.818	0.071	0.889	1.35	0.46	0.87	0.15	6.89	0.61	1.50	1.75	4.96	0.26	*ed*	*ed*	41	5.80	4.18	24.2	0.94	
P-11	Scott Pond North Inflow	13:21	0.2		0.1	2.8	172	10.4	7.6		1.8	50	2	0.081	0.106	0.025	0.520	0.545	0.75	0.21	0.43	0.06	9.09	0.27	0.81	4.50	0.62	0.88	*ed*	*ed*	42	5.93	4.27	24.8	0.97	
P-10	(duplicate of P-07 [0.5 m])													0.110	0.145	0.408	0.391	0.799	1.18	0.39	1.07	0.18	6.97	0.57	1.36	2.62	3.39	0.44	*ed*	*ed*	42	5.93	4.27	24.8	0.97	

Figure 8-21 *(cont.):* Water Quality in Scott Pond

																																Regulatory Standards				
Station *(5)*		Time	Water Depth	Secchi Depth	Survey Water Depth	Temperature	Conductivity	Dissolved Oxygen	pH (field)	pH (lab)	Turbidity	Fecal Coliform	Enterococci	Ortho-phosphate	Total Phosphorus	Ammonia	Nitrate	DIN	Total Dissolved Nitrogen	DON	Particulate Organic Carbon	Particulate Organic Nitrogen	C/N	TON	TN	Chlorophyll *a*	Pheophytin *a*	Ratio Chl *a* / (Chl *a* + Pheo *a*)	Dissolved Copper	Dissolved Lead	Hardness	Dissolved Copper - Acute Criteria	Dissolved Copper - Chronic Criteria	Dissolved Lead - Acute Criteria	Dissolved Lead - Chronic Criteria	Comments
		h	m	m	m	ºC	uS/cm	mg/l			NTU	col/100 ml		mg/l P		mg/l N								mg/l N		ug/l	ug/l		ug/l	ug/l	mg/l	ug/l	ug/l	ug/l	ug/l	
Event POND-04: April 19, 2005 *(Dry Weather; sunny, calm)*																																				
P-07	Scott Pond North	10:40	8.4	1.6	0.2	14.4	388	*ed*				<1	10																							
		-11:05			0.5				10.6	9.9	1.7			0.006	0.050	0.013	0.173	0.187	0.52	0.34	2.68	0.47	6.61	0.81	1.00	20.64	<0.05	1.00	*ed*	*ed*	46	6.47	4.61	27.5	1.07	
					1.0	13.9	387	*ed*																												
					2.0	10.7	409	*ed*																												
					3.0	5.5	583	*ed*																												
					4.0	4.2	629	*ed*																												
					5.0	4.2	724	*ed*																												
					6.0	4.2	876	*ed*																												
					7.0	4.2	960	*ed*	-	6.9	-			0.189	0.299	2.006	0.016	2.022	2.46	0.44	1.61	0.29	6.42	0.73	2.75	8.87	5.41	0.62	*ed*	*ed*	54	7.52	5.29	32.8	1.28	
P-08	Scott Pond South	11:40	17.1	1.5	0.2	14.2	375	*ed*				<1	21																							
	- northern part	-12:05			1.0	13.7	373	*ed*	10.8	10.0	2.2			0.008	0.100	0.016	0.187	0.203	0.66	0.45	2.31	0.43	6.32	0.88	1.08	35.59	8.90	0.80	*ed*	*ed*	42	5.93	4.27	24.8	0.97	
					2.0	13.4	376	*ed*																												
					3.0	11.6	368	*ed*																												
					4.0	8.1	367	*ed*																												
					5.0	6.5	372	*ed*																												
					6.0	5.7	377	*ed*																												
					7.0				8.3	7.4	1.3			0.073	0.108	0.694	0.394	1.088	1.31	0.22	0.63	0.09	8.02	0.31	1.40	6.03	3.33	0.64	*ed*	*ed*	42	5.93	4.27	24.8	0.97	
					8.0	5.3	382	*ed*																												
					10.0	5.1	384	*ed*																												
					11.0				8.1	7.2	1.3			0.078	0.124	0.729	0.388	1.118	1.38	0.27	0.55	0.08	8.47	0.34	1.46	5.13	2.99	0.63	*ed*	*ed*	38	5.40	3.92	22.2	0.87	
					12.0	5.0	387	*ed*																												
					15.0	4.7	394	*ed*																												
P-09	Scott Pond South	12:15	12.7	1.5	0.2	14.6	373	*ed*				<1	7																							
	- southern part	-12:35			1.0	13.5	374	*ed*	10.7	10.1	1.9			0.008	0.062	0.019	0.189	0.208	0.59	0.39	1.66	0.29	6.58	0.68	0.89	24.36	<0.05	1.00	*ed*	*ed*	42	5.93	4.27	24.8	0.97	
					2.0	12.8	371	*ed*																												
					3.0	11.1	367	*ed*																												
					4.0	8.9	364	*ed*																												
					5.0	6.2	373	*ed*																												
					6.0	5.7	377	*ed*																												
					7.0				8.3	7.3	0.8			0.074	0.109	0.735	0.388	1.124	1.32	0.20	0.62	0.09	8.06	0.29	1.41	6.60	2.92	0.69	*ed*	*ed*	42	5.93	4.27	24.8	0.97	
					8.0	5.3	382	*ed*																												
					10.0	5.2	385	*ed*	7.9	7.2	1.1			0.086	0.136	0.838	0.323	1.161	1.39	0.23	0.60	0.09	8.10	0.32	1.48	4.32	2.32	0.65	*ed*	*ed*	43	6.07	4.35	25.5	0.99	
P-11	Scott Pond North Inflow	13:30			0.1	14.4	445	*ed*		8.4	5.4	<1	2	0.011	0.069	0.009	0.530	0.539	0.78	0.24	2.27	0.40	6.72	0.64	1.18	46.81	1.29	0.97	*ed*	*ed*	80	10.89	7.40	50.6	1.97	
P-10	(duplicate of **P-08 [7m]**)									9.8				0.005	0.054	0.007	0.158	0.165	0.51	0.34	1.62	0.29	6.61	0.63	0.79	17.35	2.48	0.88	*ed*	*ed*	44	6.20	4.44	26.1	1.02	

Figure 8-21 *(cont.)*: Water Quality in Scott Pond

																																Regulatory Standards				
Station *(5)*		Time	Water Depth	Secchi Depth	Survey Water Depth	Temperature	Conductivity	Dissolved Oxygen	pH (field)	pH (lab)	Turbidity	Fecal Coliform	Enterococci	Ortho-phosphate	Total Phosphorus	Ammonia	Nitrate	DIN	Total Dissolved Nitrogen	DON	Particulate Organic Carbon	Particulate Organic Nitrogen	C/N	TON	TN	Chlorophyll a	Pheophytin a	Ratio Chl a / (Chl a + Pheo a)	Dissolved Copper	Dissolved Lead	Hardness	Dissolved Copper - Acute Criteria	Dissolved Copper - Chronic Criteria	Dissolved Lead - Acute Criteria	Dissolved Lead - Chronic Criteria	Comments
		h	m	m	m	ºC	uS/cm	mg/l			NTU	col/100 ml		mg/l P		mg/l N								mg/l N		ug/l	ug/l		ug/l	ug/l	mg/l	ug/l	ug/l	ug/l	ug/l	
Event POND-05: July 12, 2005 *(Dry Weather; sunny, calm)*																																				
P-07	Scott Pond North	11:45			0.3	26.6	465		10.1		35.5	<200	2																							
P-08	Scott Pond South, northern part	12:55			0.3	27.0	435		10.0		2.6	<200	<1																							
P-09	Scott Pond South, southern part	13:20			0.3	26.8	426		10.1		4.0	<200	<1																							
P-11	Scott Pond North Inflow	12:00			0.1	23.8	371		7.9		6.8	800	64																							
Event POND-06: July 28, 2005 *(Dry Weather; sunny, calm)*																																				*(3)*
P-07	Scott Pond North	12:05	8.4	7.4	0.2	27.5	420	7.9																												
					0.5				8.8		2.5	20	<1	0.007	0.061	0.050	0.012	0.062	0.33	0.27	2.14	0.30	8.38	0.57	0.63	2.64	4.06	0.39	***47.0***	0.93	50	6.99	4.95	30.1	1.17	*(2)*
					1.0	27.1	418	8.2																												
					2.0	24.0	427	8.4																												
					3.0	17.8	444	**4.1**																												
					4.0	12.2	479	**1.2**																												
					5.0	9.0	634	**0.9**																												
					6.0	7.3	798	**0.8**																												
					7.0	5.9	968	**0.6**	7.3		2.7			0.643	0.696	2.872	0.008	2.880	2.99	0.11	1.45	0.21	7.90	0.33	3.21	17.38	4.14	0.81	2.2	1.2	55	7.65	5.37	33.5	1.31	
					8.0	5.6	1053	**0.6**																												
P-08	Scott Pond South - northern part	11:38 -12:05	15.1	2.5	0.2	27.1	407	8.3	9.3		2.5	<20	<1																							
					1.0	27.1	407	7.9						0.004	0.026	0.006	0.003	0.008	0.28	0.27	1.08	0.15	8.64	0.42	0.42	1.40	0.08	0.95	***42.0***	0.80	46	6.47	4.61	27.5	1.07	*(2)*
					2.0	27.0	407	7.2																												
					3.0	25.5	406	8.2																												
					4.0	20.1	385	**4.7**																												
					5.0	15.8	375	**1.3**																												
					6.0	11.2	377	**1.0**																												
					7.0	8.5	382	**0.9**	8.2		3.0			0.037	0.078	0.505	0.043	0.547	0.83	0.28						23.53	21.26	0.53	3.7	<0.10	43	6.07	4.35	25.5	0.99	
					8.0	7.1	376	**0.9**																												
					10.0	6.1	390	**0.9**																												
					12.0	5.8	391	**0.9**																												
					13.0				7.4		2.0			0.265	0.315	1.530	0.002	1.532	1.67	0.14						3.47	3.95	0.47	2.2	0.48	44	6.20	4.44	26.1	1.02	
P-09	Scott Pond South - southern part	10:47	13.1	3.1	0.2	26.9	406	8.3	9.3		2.3	<20	<1																							
					1.0	26.9	406	7.5						0.003	0.030	0.005	0.009	0.014	0.28	0.27	1.29	0.17	9.05	0.44	0.45	1.57	0.17	0.90	***43.0***	0.83	44	6.20	4.44	26.1	1.02	*(2)*
					2.0	26.8	406	7.1																												
					3.0	26.8	405	6.9																												
					4.0	20.1	384	**4.5**																												
					5.0	11.7	374	**1.9**																												
					6.0	10.8	378	**1.1**																												
					7.0			**1.0**			3.1			0.050	0.093	0.612	0.009	0.620	0.90	0.28	2.39	0.31	8.89	0.60	1.22	38.65	29.16	0.57	3.3	0.17	45	6.33	4.53	26.8	1.04	
					8.0	7.2	388	**0.8**																												
					10.0	6.3	392	**0.8**																												
					12.0			**0.7**			7.3			0.553	0.673	3.370	0.066	3.437	3.81	0.37	7.59	0.99	8.90	1.37	4.80	12.91	1.83	0.88	<1.0	<0.10	46	6.47	4.61	27.5	1.07	
P-11	Scott Pond North Inflow	13:20			0.1	25.8	467	8.3	7.6		5.5	300	32	0.047	0.134	0.171	0.406	0.577	0.91	0.33						3.64	8.96	0.29	3.6	1.0	57	7.91	5.54	34.8	1.36	
P-10	(duplicate of **P-07 [0.5 m]**)													0.008	0.055	0.046	0.056	0.102	0.53	0.43	2.14	0.29	8.59	0.72	0.82	3.21	1.19	0.73	***47.0***	0.92	49	6.86	4.87	29.5	1.15	

Figure 8-21 *(cont.)*: Water Quality in Scott Pond

																																Regulatory Standards				
Station *(5)*		Time	Water Depth	Secchi Depth	Survey Water Depth	Temperature	Conductivity	Dissolved Oxygen	pH (field)	pH (lab)	Turbidity	Fecal Coliform	Enterococci	Ortho-phosphate	Total Phosphorus	Ammonia	Nitrate	DIN	Total Dissolved Nitrogen	DON	Particulate Organic Carbon	Particulate Organic Nitrogen	C/N	TON	TN	Chlorophyll a	Pheophytin a	Ratio Chl a / (Chl a + Pheo a)	Dissolved Copper	Dissolved Lead	Hardness	Dissolved Copper - Acute Criteria	Dissolved Copper - Chronic Criteria	Dissolved Lead - Acute Criteria	Dissolved Lead - Chronic Criteria	Comments
		h	m	m	m	ºC	uS/cm	mg/l			NTU	col/100 ml		mg/l P		mg/l N								mg/l N		ug/l	ug/l		ug/l	ug/l	mg/l	ug/l	ug/l	ug/l	ug/l	
Event POND-07: August 12, 2005 *(Dry Weather; sunny, calm)*																																				
P-07	Scott Pond North	13:30	6.3		0.2	28.0		7.4	8.4		0.8	*Collection of sediment samples for grain size, macroalgae, CNP, and chlorophyll. Also, collection of phytoplankton from water column at P-07 and P-12.*																								
					1.0	28.0		7.2																												
					2.0	26.0		6.5																												
					2.5	23.0		5.5																												
					3.0	18.2		**3.3**																												
					4.0	14.1		**0.5**																												
					5.0	9.8		**0.5**																												
					6.0	8.2		**0.5**																												
P-08	Scott Pond South - northern part	14:15	14.6	3.0	0.2						0.8																									
P-09	Scott Pond South - southern part	15:00	12.6		0.2																															
P-12	Scott Pond South - center	15:30		3.7	0.2	28.2		7.5	8.6		0.4																									
					1.0			7.4																												
					3.0			5.8																												
					4.0			**1.9**																												
					5.0			**1.1**																												
Event POND-08: August 14, 2005 *(Bathymetry event)*																																				
P-07	Scott Pond North	9:44	10.5	2.7	0.2	28.6	447	7.8	8.2		0.6																									
					1.0	28.2	447	7.7																												
					2.0	25.6	444	7.2																												
					3.0	18.2	469	**3.2**																												
					4.0	13.9	501	**0.8**																												
					5.0	8.5	740	**0.5**																												
					6.0	6.9	876	**0.3**																												
					8.0	5.6	1169	**0.4**																												
					10.0	5.8	1268	**0.3**																												
P-08	Scott Pond South - northern part	10:10	16.3	4.0	0.2	28.5	416	7.4	8.2		0.4																									
					1.0	28.3	417	7.0																												
					2.0	28.0	417	6.9																												
					3.0	25.9	408	5.7																												
					4.0	21.7	384	**2.7**																												
					5.0	13.5	385	**0.7**																												
					6.0	11.1	385	**0.4**																												
					8.0	7.1	394	**0.3**																												
					10.0	6.3	399	**0.3**																												
P-09	Scott Pond South - southern part	10:27	11.1	3.7	0.2	28.4	418	7.3	8.2		0.1																									
					1.0	28.1	417	7.2																												
					2.0	27.9	417	7.1																												
					3.0	27.4	415	6.9																												
					4.0	22.8	389	**3.1**																												
					5.0	17.8	384	**1.3**																												
					6.0	12.8	382	**0.4**																												
					8.0	7.3	401	**0.3**																												
					10.0	6.6	421	**0.2**																												

Figure 8-21 *(cont.):* Water Quality in Scott Pond

																																Regulatory Standards				
Station *(5)*		**Time**	**Water Depth**	**Secchi Depth**	**Survey Water Depth**	**Temperature**	**Conductivity**	**Dissolved Oxygen**	**pH (field)**	**pH (lab)**	**Turbidity**	**Fecal Coliform**	**Enterococci**	**Ortho-phosphate**	**Total Phosphorus**	**Ammonia**	**Nitrate**	**DIN**	**Total Dissolved Nitrogen**	**DON**	**Particulate Organic Carbon**	**Particulate Organic Nitrogen**	**C/N**	**TON**	**TN**	**Chlorophyll a**	**Pheophytin a**	**Ratio Chl a / (Chl a + Pheo a)**	**Dissolved Copper**	**Dissolved Lead**	**Hardness**	**Dissolved Copper - Acute Criteria**	**Dissolved Copper - Chronic Criteria**	**Dissolved Lead - Acute Criteria**	**Dissolved Lead - Chronic Criteria**	**Comments**
		h	m	m	m	ºC	uS/cm	mg/l			NTU	col/100 ml		mg/l P		mg/l N								mg/l N		ug/l	ug/l		ug/l	ug/l	mg/l	ug/l	ug/l	ug/l	ug/l	
Event POND-09: August 15, 2005 *(Wet Weather; cloudy, post-rain event)*																																				*(3)*
P-07	Scott Pond North	16:00	9.0	2.0	0.2	26.7	435	7.5																												
					0.5				7.8		1.8	5,000	52	0.123	0.424	0.105	0.091	0.195	0.75	0.55	2.36	0.33	8.37	0.88	1.08	16.13	4.29	0.79	***18.0***	0.65	53	7.39	5.21	32.1	1.25	*(2)*
					1.0	26.8	435	7.5																												
					2.0	26.7	430	7.3																												
					3.0	19.1	441	**2.9**																												
					4.0	14.3	580	**0.4**																												
					5.0	11.2	789	**0.3**																												
					6.0			**0.3**																												
					7.0	7.3	1005	**0.3**	7.1		5.9			0.577	0.700	2.734	0.002	2.736	2.96	0.22	1.90	0.32	6.96	0.54	3.28	61.74	2.08	0.97	2.3	1.0	61	8.44	5.87	37.6	1.46	
P-08	Scott Pond South	14:59	15.2	3.5	0.2	27.1	413	6.7	7.8		1.1	<20	<10																							
	- northern part				1.0	27.2	414	6.8						0.005	0.017	0.014	0.008	0.023	0.31	0.29	0.40	0.07	6.99	0.35	0.38	1.16	0.38	0.75	4.8	0.26	46	6.47	4.61	27.5	1.07	*(2)*
					2.0	27.2	415	6.7																												
					3.0	27.0	415	6.3																												
					4.0	23.8	388	**3.7**																												
					5.0	18.4	385	**0.8**																												
					6.0	12.7	385	**0.2**																												
					7.0	9.9	386	**0.2**	7.7		2.8			<0.003	0.037	0.346	<0.001	0.346	0.62	0.27	1.48	0.22	7.94	0.49	0.83	5.45	11.85	0.32	3.5	0.40	47	6.60	4.70	28.1	1.10	
					13.0				7.1		2.9			0.236	0.285	1.700	0.001	1.701	1.95	0.25	1.31	0.20	7.62	0.45	2.15	11.16	5.08	0.69	1.8	0.47	46	6.47	4.61	27.5	1.07	
P-09	Scott Pond South		13.1	3.1	0.2	27.1	414	6.6	7.9		0.9	80	20																							
	- southern part				1.0	27.2	415	6.6						0.004	0.015	0.016	0.007	0.023	0.42	0.39	0.42	0.07	7.30	0.46	0.48	3.20	0.93	0.77	***25.0***	0.58	49	6.86	4.87	29.5	1.15	*(2)*
					2.0	27.2	415	6.5																												
					3.0	27.2	415	6.6																												
					4.0	21.9	405	**2.7**																												
					5.0	15.9	395	**0.6**																												
					6.0	12.8	383	**0.2**																												
					7.0	10.1	390	**0.1**	7.7		6.0			0.028	0.081	0.863	0.001	0.864	1.19	0.32	2.08	0.30	8.15	0.62	1.48	12.02	63.29	0.16	4.5	0.57	46	6.47	4.61	27.5	1.07	
					12.0				7.1		5.0			0.220	0.284	1.739	0.001	1.740	2.03	0.29	1.86	0.29	7.38	0.58	2.32	30.09	60.66	0.50	1.9	0.46	46	6.47	4.61	27.5	1.07	
P-11	Scott Pond North Inflow	12:32			0.1	25.3	521		7.8		7.5	9,000	430	0.049	0.130	0.094	0.436	0.530	0.96	0.43	2.14	0.34	7.25	0.77	1.30	15.03	5.53	0.73	3.8	1.50	67	9.22	6.36	41.6	1.62	
P-10	(duplicate of **P-07 [0.5 m]**)													0.005	0.041	0.024	0.025	0.049	0.40	0.35	0.96	0.16	7.18	0.51	0.56	7.28	6.62	0.52	***17.0***	0.68	54	7.52	5.29	32.8	1.28	
Event POND-10: September 13, 2005 *(no activities in Scott Pond - only Valley Falls Pond)*																																				

Figure 8-21 *(cont.)*: Water Quality in Scott Pond

																																Regulatory Standards				
Station (5)		Time	Water Depth	Secchi Depth	Survey Water Depth	Temperature	Conductivity	Dissolved Oxygen	pH (field)	pH (lab)	Turbidity	Fecal Coliform	Enterococci	Ortho-phosphate	Total Phosphorus	Ammonia	Nitrate	DIN	Total Dissolved Nitrogen	DON	Particulate Organic Carbon	Particulate Organic Nitrogen	C/N	TON	TN	Chlorophyll *a*	Pheophytin *a*	Ratio Chl *a* / (Chl *a* + Pheo *a*)	Dissolved Copper	Dissolved Lead	Hardness	Dissolved Copper - Acute Criteria	Dissolved Copper - Chronic Criteria	Dissolved Lead - Acute Criteria	Dissolved Lead - Chronic Criteria	Comments
		h	m	m	m	ºC	uS/cm	mg/l			NTU	col/100 ml		mg/l P		mg/l N								mg/l N		ug/l	ug/l		ug/l	ug/l	mg/l	ug/l	ug/l	ug/l	ug/l	
Event POND-11: September 16, 2005 *(Wet Weather; cool, drizzle at times, one day after a rainstorm)*																																				
P-07	Scott Pond North	15:16	10.1	1.2	0.2	23.5	416	10.0																												
					0.5				8.6		3.5	230	160	0.006	0.059	0.033	0.128	0.161	0.59	0.43	3.19	0.50	7.46	0.93	1.09	11.23	1.28	0.90	**7.3**	0.51	51	7.13	5.04	30.8	1.20	
					1.0	23.5	416	9.8																												
					2.0	22.1	437	**3.0**																												
					3.0	21.2	446	**1.0**																												
					4.0	19.7	457	**0.6**																												
					5.0	11.6	698	**0.5**																												
					6.0	8.0	855	**0.5**																												
					7.0	6.8	980	**0.5**	7.4		4.8			0.665	0.832	3.450	0.002	3.452	3.48	0.02	1.60	0.25	7.39	0.28	3.73	77.35	9.84	0.89	2.1	0.57	57	7.91	5.54	34.8	1.36	
					8.0	6.1	1118	**0.5**																												
					9.0	6.0	1192	**0.5**																												
P-08	Scott Pond South - northern part	15:31	14.6	0.5	0.2	24.2	398	10.0																												
					1.0	24.2	399	10.4	8.8		11.8	<20	20	0.006	0.032	0.019	0.008	0.028	0.34	0.32	4.46	0.95	5.50	1.26	1.29	72.31	<0.05	1.00	***14.0***	0.31	48	6.73	4.78	28.8	1.12	
					2.0	23.9	402	10.4																												
					3.0	23.1	402	9.0																												
					4.0	22.5	401	7.0																												
					5.0	20.5	384	**0.6**																												
					6.0	14.1	353	**0.5**																												
					7.0	9.9	387	**0.5**	7.5		2.0			0.013	0.046	0.562	0.001	0.563	0.86	0.30	1.05	0.16	7.72	0.46	1.02	17.19	12.76	0.57	3.5	0.12	47	6.60	4.70	28.1	1.10	
					8.0	8.0	388	**0.5**																												
					9.0	7.0	392	**0.5**																												
					10.0	6.6	392	**0.5**																												
					13.0				6.8		5.9			0.321	0.399	2.333	0.002	2.335	2.48	0.14	1.08	0.18	7.07	0.32	2.65	21.81	14.30	0.60	2.0	0.50	45	6.33	4.53	26.8	1.04	
P-09	Scott Pond South - southern part	15:43	10.5	0.5	0.2	24.1	400	11.0																												
					1.0	24.1	400	10.6	9.1		14.4	20	<10	0.003	0.030	0.009	0.003	0.012	0.36	0.35	4.38	0.96	5.30	1.31	1.33	102.29	<0.05	1.00	***14.0***	0.34	48	6.73	4.78	28.8	1.12	
					2.0	24.1	400	10.6																												
					3.0	22.9	402	9.2																												
					4.0	22.6	401	8.0																												
					5.0	20.6	381	**0.6**																												
					6.0	14.4	378	**0.5**																												
					7.0	10.4	368	**0.4**	7.7		1.8			0.010	0.042	0.099	0.002	0.101	0.43	0.33	0.95	0.14	8.01	0.47	0.57	16.08	10.24	0.61	**5.0**	<0.10	45	6.33	4.53	26.8	1.04	
					8.0	8.4	394	**0.4**																												
					9.0	7.3	395	**0.4**																												
					10.0	6.8	398	**0.4**																												
					12.0				6.8		3.4			0.306	0.377	2.416	0.001	2.417	2.57	0.16	1.61	0.24	7.87	0.39	2.81	67.05	18.49	0.78	1.9	0.52	46	6.47	4.61	27.5	1.07	
P-11	Scott Pond North Inflow	11:46			0.1	21.8	452	5.9	7.2		5.9	9,000	240	0.053	0.115	0.130	1.416	1.546	2.32	0.77	2.01	0.27	8.72	1.04	2.59	11.46	9.44	0.55	4.0	0.42	60	8.31	5.79	36.9	1.44	
P-10	(duplicate of **P-07 [0.5 m]**)													0.004	0.058	0.021	0.132	0.153	0.54	0.38	3.04	0.46	7.74	0.84	1.00	15.88	1.86	0.90	**7.4**	0.54	53	7.39	5.21	32.1	1.25	

Figure 8-21 *(cont.)*: Water Quality in Scott Pond

																																Regulatory Standards				
Station (5)		Time	Water Depth	Secchi Depth	Survey Water Depth	Temperature	Conductivity	Dissolved Oxygen	pH (field)	pH (lab)	Turbidity	Fecal Coliform	Enterococci	Ortho-phosphate	Total Phosphorus	Ammonia	Nitrate	DIN	Total Dissolved Nitrogen	DON	Particulate Organic Carbon	Particulate Organic Nitrogen	C/N	TON	TN	Chlorophyll a	Pheophytin a	Ratio Chl a / (Chl a + Pheo a)	Dissolved Copper	Dissolved Lead	Hardness	Dissolved Copper - Acute Criteria	Dissolved Copper - Chronic Criteria	Dissolved Lead - Acute Criteria	Dissolved Lead - Chronic Criteria	Comments
		h	m	m	m	ºC	uS/cm	mg/l			NTU	col/100 ml		mg/l P		mg/l N								mg/l N		ug/l	ug/l		ug/l	ug/l	mg/l	ug/l	ug/l	ug/l	ug/l	
Event POND-12: September 28, 2005 *(Dry Weather)*																																				
P-07	Scott Pond North	11:45	11.0	1.4	0.2	21.0	449	8.3																												
					0.5						3.8																									
					1.0	20.1	447	9.2																												
					2.0	19.9	448	8.6																												
					3.0	19.7	448	7.3																												
					4.0	18.6	473	**3.3**																												
					5.0	11.5	753	**1.4**																												
					6.0	7.4	919	**1.1**																												
					7.0	6.6	1046	**1.1**																												
					8.0	6.0	1156	**1.1**																												
					9.0	6.0	1206	**1.1**																												
					10.0	6.0	1149	**1.1**																												
P-08	Scott Pond South - northern part	12:08	16.5	0.6	0.2	21.7	397	10.6																												
					1.0	20.7	397	10.6			11.8																									
					2.0	20.5	395	10.6																												
					3.0	20.5	395	10.4																												
					4.0	20.5	395	10.2																												
					5.0	20.4	396	10.0																												
					6.0	12.3	373	**1.8**																												
					7.0	10.5	383	**1.0**																												
					8.0	8.1	384	**1.0**																												
					9.0	7.6	386	**1.0**																												
					10.0	6.9	387	**1.0**																												
P-09	Scott Pond South - southern part	12:27	10.6	0.6	0.2	21.6	397	11.0																												
					1.0	20.7	394	10.4			16.4																									
					2.0	20.6	395	10.6																												
					3.0	20.5	395	10.4																												
					4.0	20.5	395	10.4																												
					5.0	20.4	393	10.0																												
					6.0	20.3	374	**1.4**																												
					7.0	10.1	385	**1.0**																												
					8.0	8.5	379	**1.0**																												
					9.0	7.0	393	**1.0**																												
					10.0	6.9	394	**1.0**																												
P-11	Scott Pond North Inflow	13:00			0.1	17.8	44	6.0			3.1																									

ed Edited during Quality Control.
(1) Copper sulfate treatment on July 12, 2004 by Lycott Environmental, Inc. (Source: Sign on tree at boat launch at Scott Pond North).
(2) Copper sulfate treatment (300 pds) on July 20, 2005 (Source: M. Gagnon, Town of Lincoln, letter, August 26, 2005).
(3) Metals were analyzed by Mitkem for Events POND-01 to POND-05, and by STL for Events POND-06 to POND-12. Hardness was analyzed by Mitkem for Events POND-01 to POND-06, and by STL for Events POND-08 to POND-12. The metals data from Mitkem were edited due to questions regarding adequate detection.
(4) This station was originally called VFP-06 but is identical to dry weather monitoring station W-34.
(5) Stations from sampling event POND-01 were called *'VFP-___'* on the Chain-of-Custody. These stations were renamed as *'P-___'* thereafter.

7.8 Exceeds Acute Criteria
5.5 Exceeds Chronic Criteria (metals), or regulatory standards for bacteria, or lower than dissolved oxygen minimum, respectively.

Figure 8-22: Summary of Water Quality in Scott Pond - In- situ Parameters, Pathogens, Metals

Event (POND-___)	Sampling Date	Dry Weather	Wet Weather	Flow into Pond from Blackstone Canal *(est.)*	Depth of Diss. Oxygen <5 mg/l (appr.)		Depth of Diss. Oxygen <1 mg/l (appr.)		Secchi Depth		Turbidity (surface water)			Pathogens						Dissolved Copper *(2)*							Dissolved Lead						
														Fecal Coliform *Surface Water*			Enterococci *(3)* *Surface Water*			*Surface Water*				*Deep/ Bottom Water*			*Surface Water*				*Deep/ Bottom Water*		
					Scott P.- North	Scott P.- South	Scott P.- North	Scott P.- South	Scott P.- North	Scott P.- South	Inflow	Scott P.- North	Scott P.- South	Inflow	Scott P.- North	*Scott P.- South - Geom.MEAN*	Inflow	Scott P.- North	*Scott P.- South - Geom. MEAN*	Inflow	Scott P.- North	Scott P.- South - *MEAN*	Scott P.- South -*MAX.*	Scott P.- North	Scott P.- South - *MEAN*	Scott P.- South -*MAX.*	Inflow	Scott P.- North	Scott P.- South - *MEAN*	Scott P.- South -*MAX.*	Scott P.- North	Scott P.- South - *MEAN*	Scott P.- South -*MAX.*
				cfs	m		m							col/100 ml						ug/l							ug/l						
01	8/10/2004	●		5	3.0	4.0	4.5	4.5	1.2	1.1		5.7	4.1		4	<2																	
02	9/16/2004	●		10	3.5	4.5	4.5	6.0	0.4	1.2	4.6	42.0	5.3	<2	<2	<2	**136**	<2	**49**	*ed*							*ed*						
03	12/6/2004	●		5	--	*(1)*	--	--	1.7	2.7	1.8	1.6	1.1	50	23	<2	2	10	9														
04	4/19/2005	●		5	5.0	--	7.5	--	1.6	1.5	5.4	1.7	2.1	<1	<1	<1	2	10	12														
05	7/12/2005	●									6.8	35.5	3.3	**800**	<200	<200	**64**	2	<1														
06	7/28/2005	●		10	3.0	4.0	4.5	6.0	7.4	2.8	5.5	2.5	2.4	**300**	20	<20	32	<1	<1	3.6	***47.0***	***42.5***	***43.0***	2.2	2.5	3.7	1.0	0.93	0.82	0.83	1.2	0.18	0.48
07	8/12/2005	●			3.0	3.5	4.0	5.0		3.4		0.8	0.6																				
08	8/14/2005	●			3.0	3.5	4.0	5.0	2.7	3.9		0.6	0.3																				
09	8/15/2005		●	4	3.0	4.0	4.0	5.0	2.0	3.3	7.5	1.8	1.0	**9,000**	**5,000**	39	**430**	**52**	19	3.8	***18.0***	***14.9***	***25.0***	2.3	2.9	4.5	1.5	0.65	0.42	0.58	1.0	0.48	0.57
10	9/13/2005	●																															
11	9/16/2005		●	5	2.0	4.5	3.0	5.0	1.2	0.5	5.9	3.5	12.6	**9,000**	**230**	19	**240**	**160**	13	4.0	***7.3***	***14.0***	***14.0***	2.1	3.1	5.0	0.42	0.51	0.33	0.34	0.57	0.31	0.52
12	9/28/2005	●		4	4.0	--	5.5	7.0	1.4	0.6	3.1	3.8	14.1																				

(1) Dissolved oxygen concentrations were mostly 5.4 mg/l at Stations P-08 and P-09, with two concentrations at 4.7 mg/l below a depth of 7 m at Station P-08.

(2) Copper sulfate treatment on July 12, 2004 by Lycott Environmental, Inc. (Source: Sign on tree at boat launch at Scott Pond North).
Copper sulfate treatment (300 pds) on July 20, 2005. (Source: M. Gagnon, Town of Lincoln, letter, August 26, 2005).

(3) The proposed regulatory standard for enterococci is 33 col/100 ml (steady state geometric mean density) for Class B waters; the maximum concentration is 107 col/100 ml.

ed Edited during Quality Control.

7.8 Exceeds Acute Criteria

5.5 Exceeds Chronic Criteria (metals), or regulatory standard for bacteria (FC)

Figure 8-23: Summary of Water Quality in Scott Pond - Nutrients, Pigments

Event (POND-___)	Sampling Date (2	Dry Weather	Wet Weather	Flow into Pond from Blackstone Canal *(est.)*	Orthophosphate					Total Phosphorus					Ammonia					Nitrate					DIN				
					Surface Water			***Deep/ Bottom Water***		***Surface Water***			***Deep/ Bottom Water***		***Surface Water***			***Deep/ Bottom Water***		***Surface Water***			***Deep/ Bottom Water***		***Surface Water***			***Deep/ Bottom Water***	
					Inflow	**Scott P.- North**	**Scott P.- South -** *MEAN*	**Scott P.- North**	**Scott P.- South -** *MEAN*	**Inflow**	**Scott P.- North**	**Scott P.- South -** *MEAN*	**Scott P.- North**	**Scott P.- South -** *MEAN*	**Inflow**	**Scott P.- North**	**Scott P.- South -** *MEAN*	**Scott P.- North**	**Scott P.- South -** *MEAN*	**Inflow**	**Scott P.- North**	**Scott P.- South -** *MEAN*	**Scott P.- North**	**Scott P.- South -** *MEAN*	**Inflow**	**Scott P.- North**	**Scott P.- South -** *MEAN*	**Scott P.- North**	**Scott P.- South -** *MEAN*
				cfs	mg/l P					mg/l P					mg/l N					mg/l N					mg/l N				
01	8/10/2004	●		5	0.063	0.009	0.003	0.230	0.216	0.217	0.147	0.057	0.443	0.395	0.004	0.004	0.007	1.638	1.606	1.103	0.174	0.003	0.003	0.004	1.107	0.178	0.010	1.641	1.610
02	9/16/2004	●		10	0.150	0.002	0.003	0.638	0.208	0.377	0.130	0.081	0.945	0.360	0.019	<0.001	0.002	3.774	1.338	1.991	0.003	0.002	0.003	0.002	2.010	0.004	0.004	3.777	1.340
03	12/6/2004	●		5	0.081	0.110	0.108	0.728	0.106	0.106	0.136	0.135	0.568	0.142	0.025	0.405	0.832	2.420	0.824	0.520	0.393	0.720	0.184	0.071	0.545	0.798	0.904	2.604	0.895
04	4/19/2005	●		5	0.011	0.006	0.008	0.189	0.078	0.069	0.050	0.081	0.299	0.119	0.009	0.013	0.018	2.006	0.749	0.530	0.173	0.188	0.016	0.373	0.539	0.187	0.206	2.022	1.123
05	7/12/2005	●																											
06	7/28/2005	●		10	0.047	0.007	0.004	0.643	0.226	0.134	0.061	0.028	0.696	0.290	0.171	0.050	0.006	2.872	1.504	0.406	0.012	0.006	0.008	0.030	0.577	0.062	0.011	2.880	1.534
07	8/12/2005	●																											
08	8/14/2005	●																											
09	8/15/2005		●	4	0.049	0.123	0.005	0.577	0.121	0.130	0.424	0.016	0.700	0.172	0.094	0.105	0.015	2.734	1.162	0.436	0.091	0.008	0.002	0.001	0.530	0.195	0.023	2.736	1.163
10	9/13/2005	●																											
11	9/16/2005		●	5	0.053	0.006	0.005	0.665	0.163	0.115	0.059	0.003	0.832	0.216	0.130	0.033	0.014	3.450	1.353	1.416	0.128	0.006	0.002	0.002	1.546	0.161	0.020	3.452	1.354
12	9/28/2005	●		4																									
Mean					**0.065**	**0.038**	**0.019**	**0.524**	**0.160**	**0.164**	**0.144**	**0.057**	**0.640**	**0.242**	**0.065**	**0.102**	**0.127**	**2.699**	**1.219**	**0.915**	**0.139**	**0.133**	**0.031**	**0.069**	**0.979**	**0.226**	**0.168**	**2.730**	**1.288**
Minimum					0.011	0.002	0.003	0.189	0.078	0.069	0.050	0.003	0.299	0.119	0.004	<0.001	0.002	1.638	0.749	0.406	0.003	0.002	0.002	0.001	0.530	0.004	0.004	1.641	0.895
Maximum					0.150	0.123	0.108	0.728	0.226	0.377	0.424	0.135	0.945	0.395	0.171	0.405	0.832	3.774	1.606	1.991	0.393	0.720	0.184	0.373	2.010	0.798	0.904	3.777	1.610

Figure 8-23 *(cont.)*: Summary of Water Quality in Scott Pond - Nutrients, Pigments

					Total Dissolved Nitrogen					DON					Particulate Organic Carbon					Particulate Organic Nitrogen					C/N				
					Surface Water			***Deep/ Bottom Water***		***Surface Water***			***Deep/ Bottom Water***		***Surface Water***			***Deep/ Bottom Water***		***Surface Water***			***Deep/ Bottom Water***		***Surface Water***			***Deep/ Bottom Water***	
Event (POND-___)	**Sampling Date** *(2*	**Dry Weather**	**Wet Weather**	**Flow into Pond from Blackstone Canal** *(est.)*	**Inflow**	**Scott P.- North**	**Scott P.- South** - *MEAN*	**Scott P.- North**	**Scott P.- South** - *MEAN*	**Inflow**	**Scott P.- North**	**Scott P.- South** - *MEAN*	**Scott P.- North**	**Scott P.- South** - *MEAN*	**Inflow**	**Scott P.- North**	**Scott P.- South** - *MEAN*	**Scott P.- North**	**Scott P.- South** - *MEAN*	**Inflow**	**Scott P.- North**	**Scott P.- South** - *MEAN*	**Scott P.- North**	**Scott P.- South** - *MEAN*	**Inflow**	**Scott P.- North**	**Scott P.- South** - *MEAN*	**Scott P.- North**	**Scott P.- South** - *MEAN*
				cfs	mg/l N					mg/l N					mg/l N					mg/l N									
01	8/10/2004	●		5	1.46	0.80	0.48	2.02	5.94	0.35	0.62	0.47	0.38	4.33	1.84	2.34	1.97	2.70	1.84	0.29	0.42	0.31	0.41	0.31	7.49	6.57	7.35	7.65	7.12
02	9/16/2004	●		10	2.48	0.33	0.38	5.37	1.94	0.47	0.33	0.38	1.60	0.60	1.24	8.05	2.11	1.76	1.57	0.16	1.51	0.28	0.27	0.28	9.19	6.21	8.77	7.61	6.55
03	12/6/2004	●		5	0.75	1.01	1.19	2.83	1.30	0.21	0.21	0.29	0.23	0.40	0.43	0.60	0.60	0.50	0.85	0.06	0.08	0.09	0.07	0.14	9.09	8.33	7.79	8.77	7.20
04	4/19/2005	●		5	0.78	0.52	0.63	2.46	1.35	0.24	0.34	0.42	0.44	0.23	2.27	2.68	1.99	1.61	0.60	0.40	0.47	0.36	0.29	0.09	6.72	6.61	6.45	6.42	8.16
05	7/12/2005	●																											
06	7/28/2005	●		10	0.91	0.33	0.03	2.99	1.80	0.33	0.27	0.27	0.11	0.27		2.14	1.19	1.45	4.99		0.30	0.02	0.21	0.65		8.38	8.85	7.90	8.90
07	8/12/2005	●																											
08	8/14/2005	●																											
09	8/15/2005		●	4	0.96	0.75	0.37	2.96	1.45	0.43	0.55	0.34	0.22	0.28	2.14	2.36	0.41	1.90	1.68	0.34	0.33	0.07	0.32	0.25	7.25	8.37	7.15	6.96	7.77
10	9/13/2005	●																											
11	9/16/2005		●	5	2.32	0.59	0.04	3.48	1.59	0.77	0.43	0.34	0.02	0.23	2.01	3.19	4.42	1.60	1.17	0.27	0.50	0.96	0.25	0.18	8.72	7.46	5.40	7.39	7.67
12	9/28/2005	●		4																									
Mean					**1.38**	**0.62**	**0.44**	**3.16**	**2.19**	**0.40**	**0.39**	**0.36**	**0.43**	**0.91**	**1.66**	**3.05**	**1.81**	**1.65**	**1.82**	**0.25**	**0.52**	**0.30**	**0.26**	**0.27**	**8.08**	**7.42**	**7.39**	**7.53**	**7.62**
Minimum					0.75	0.33	0.03	2.02	1.30	0.21	0.21	0.27	0.02	0.23	0.43	0.60	0.41	0.50	0.60	0.06	0.08	0.02	0.07	0.09	6.72	6.21	5.40	6.42	6.55
Maximum					2.48	1.01	1.19	5.37	5.94	0.77	0.62	0.47	1.60	4.33	2.27	8.05	4.42	2.70	4.99	0.40	1.51	0.96	0.41	0.65	9.19	8.38	8.85	8.77	8.90

Figure 8-23 *(cont.)*: Summary of Water Quality in Scott Pond - Nutrients, Pigments

Event (POND-___)	Sampling Date (2	Dry Weather	Wet Weather	Flow into Pond from Blackstone Canal *(est.)*	TON					Total Nitrogen					Chlorophyll a					Pheophytin a					Ratio Chl / (Chl/Pheo)				
						Surface Water		***Deep/ Bottom Water***			***Surface Water***		***Deep/ Bottom Water***			***Surface Water***		***Deep/ Bottom Water***			***Surface Water***		***Deep/ Bottom Water***			***Surface Water***		***Deep/ Bottom Water***	
					Inflow	Scott P.- North	Scott P.- South - *MEAN*	Scott P.- North	Scott P.- South - *MEAN*	Inflow	Scott P.- North	Scott P.- South - *MEAN*	Scott P.- North	Scott P.- South - *MEAN*	Inflow	Scott P.- North	Scott P.- South - *MEAN*	Scott P.- North	Scott P.- South - *MEAN*	Inflow	Scott P.- North	Scott P.- South - *MEAN*	Scott P.- North	Scott P.- South - *MEAN*	Inflow	Scott P.- North	Scott P.- South - *MEAN*	Scott P.- North	Scott P.- South - *MEAN*
				cfs	mg/l N					mg/l N					ug/l					ug/l									
01	8/10/2004	●		5	0.64	1.03	0.78	0.79	4.63	1.75	1.21	0.79	2.43	6.24	13.37	26.11	13.31	120.78	8.98	6.08	<0.05	0.81	<0.05	15.57	0.69	1.00	0.96	1.00	0.38
02	9/16/2004	●		10	0.62	1.84	0.66	1.87	0.88	2.63	1.85	0.66	5.64	2.22	8.14	26.99	20.04	143.99	11.09	2.93	<0.05	<0.05	<0.05	7.75	0.74	1.00	1.00	1.00	0.59
03	12/6/2004	●		5	0.27	0.29	0.38	0.30	0.54	0.81	1.09	1.28	2.90	1.44	4.50	2.27	1.82	8.17	1.81	0.62	4.05	5.82	5.17	5.89	0.88	0.36	0.24	0.61	0.24
04	4/19/2005	●		5	0.64	0.81	0.78	0.73	0.32	1.18	1.00	0.99	2.75	1.44	46.81	20.64	29.98	8.87	5.52	1.29	<0.05	4.46	5.41	2.89	0.97	1.00	0.90	0.62	0.65
05	7/12/2005	●																											
06	7/28/2005	●		10		0.57	0.43	0.33	0.99		0.63	0.44	3.21	3.01	3.64	2.64	1.49	17.38	19.64	8.96	4.06	0.13	4.14	14.05	0.29	0.39	0.93	0.81	0.61
07	8/12/2005	●																											
08	8/14/2005	●																											
09	8/15/2005		●	4	0.77	0.88	0.41	0.54	0.54	1.30	1.08	0.43	3.28	1.70	15.03	16.13	2.18	31.74	14.68	5.53	4.29	0.66	2.08	35.22	0.73	0.79	0.76	0.97	0.42
10	9/13/2005	●																											
11	9/16/2005		●	5	1.04	0.93	1.29	0.28	0.41	2.59	1.09	1.31	3.73	1.76	11.46	11.23	87.30	77.35	30.53	9.44	1.28	<0.05	9.84	13.95	0.55	0.90	1.00	0.89	0.64
12	9/28/2005	●		4																									
Mean					**0.66**	**0.91**	**0.67**	**0.69**	**1.18**	**1.71**	**1.14**	**0.84**	**3.42**	**2.54**	**14.71**	**15.14**	**22.30**	**58.33**	**13.18**	**4.98**	**3.42**	**2.37**	**5.33**	**13.62**	**0.69**	**0.78**	**0.83**	**0.84**	**0.51**
Minimum					0.27	0.29	0.38	0.28	0.32	0.81	0.63	0.43	2.43	1.44	3.64	2.27	1.49	8.17	1.81	0.62	<0.05	0.13	<0.05	2.89	0.29	0.36	0.24	0.61	0.24
Maximum					1.04	1.84	1.29	1.87	4.63	2.63	1.85	1.31	5.64	6.24	46.81	26.99	87.30	143.99	30.53	9.44	4.29	5.82	9.84	35.22	0.97	1.00	1.00	1.00	0.65

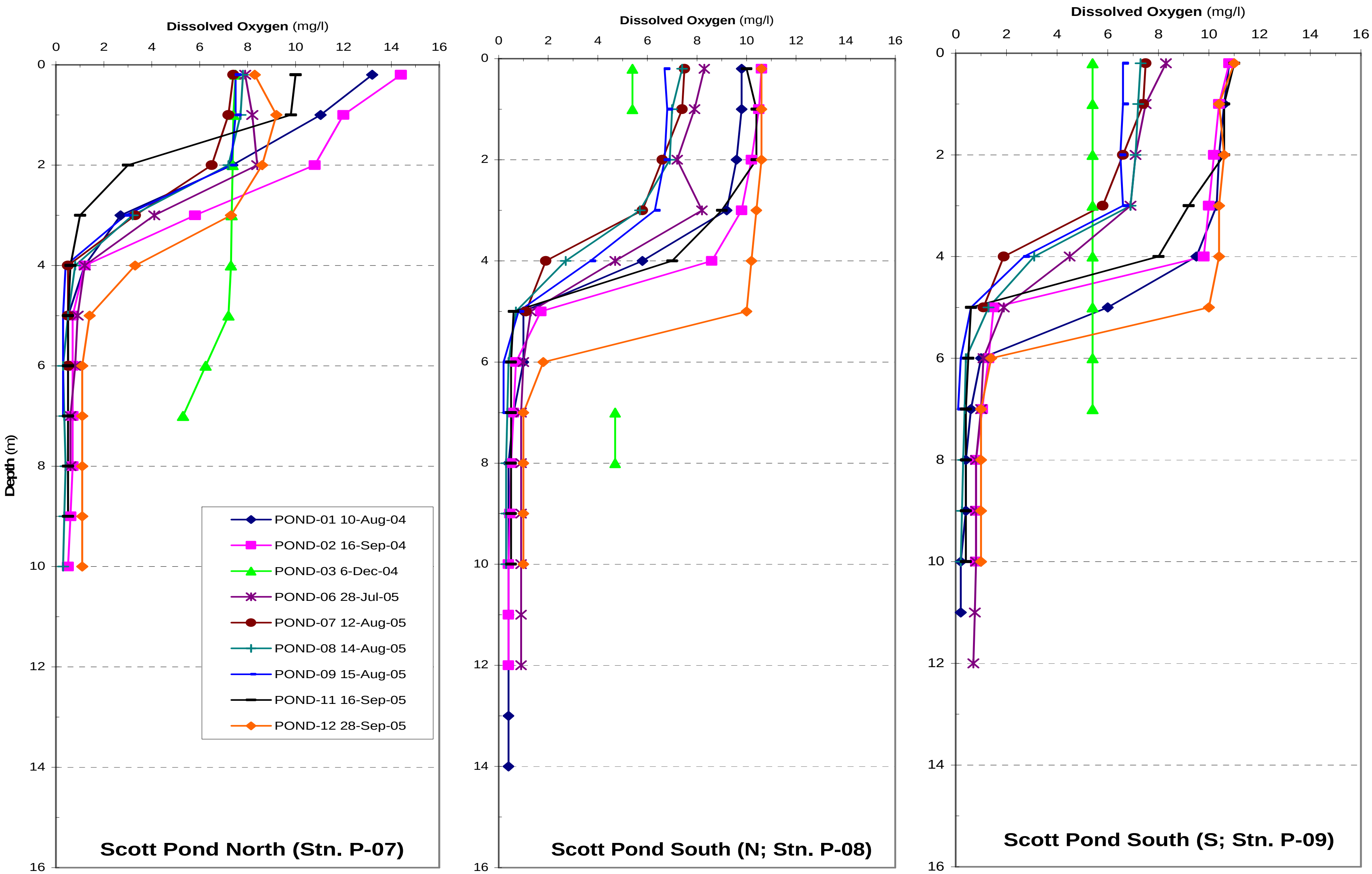


Figure 8-24: Dissolved oxygen with depth in Scott Pond North and South.

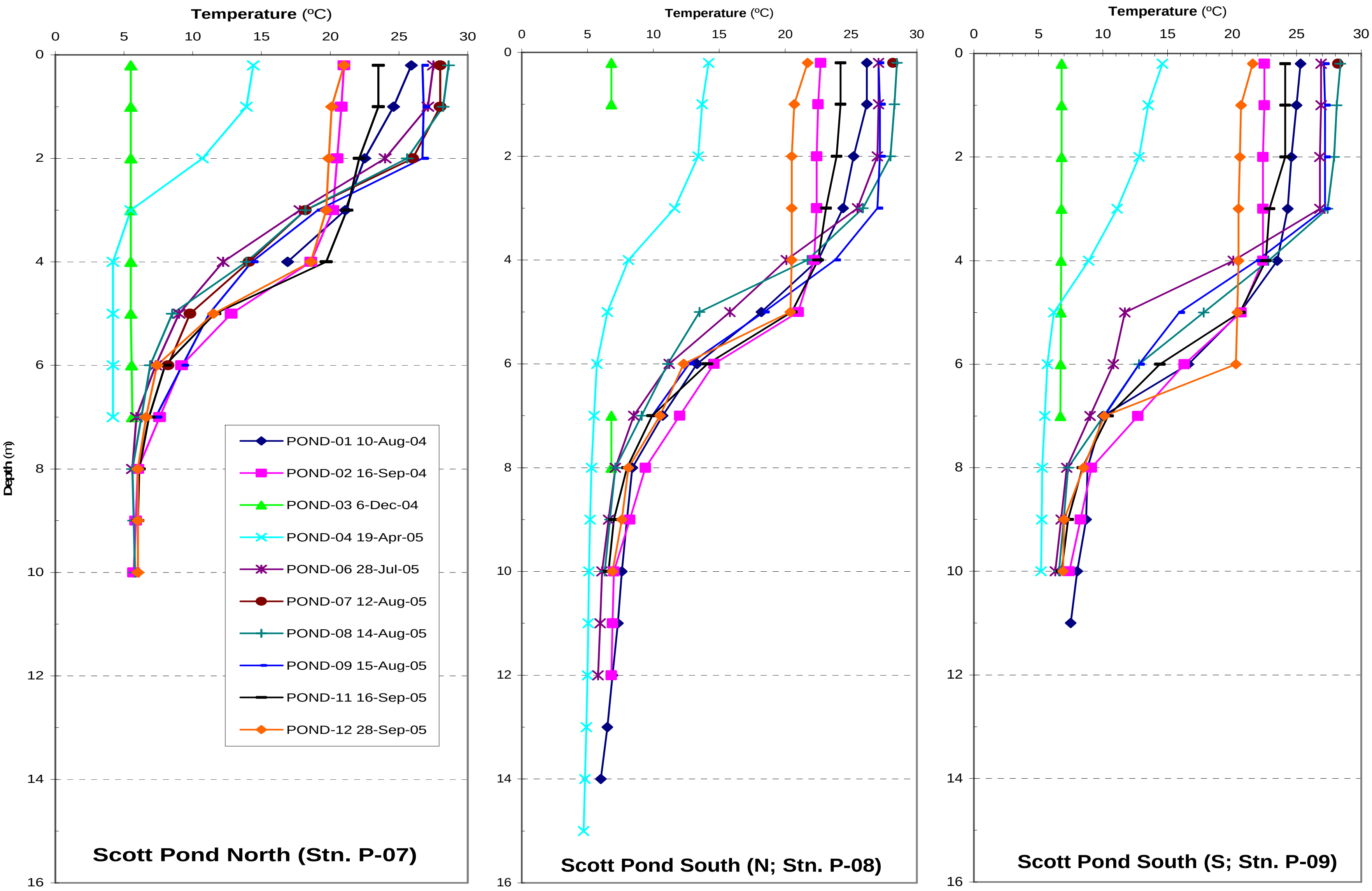


Figure 8-25: Temperature with depth in Scott Pond North and South.

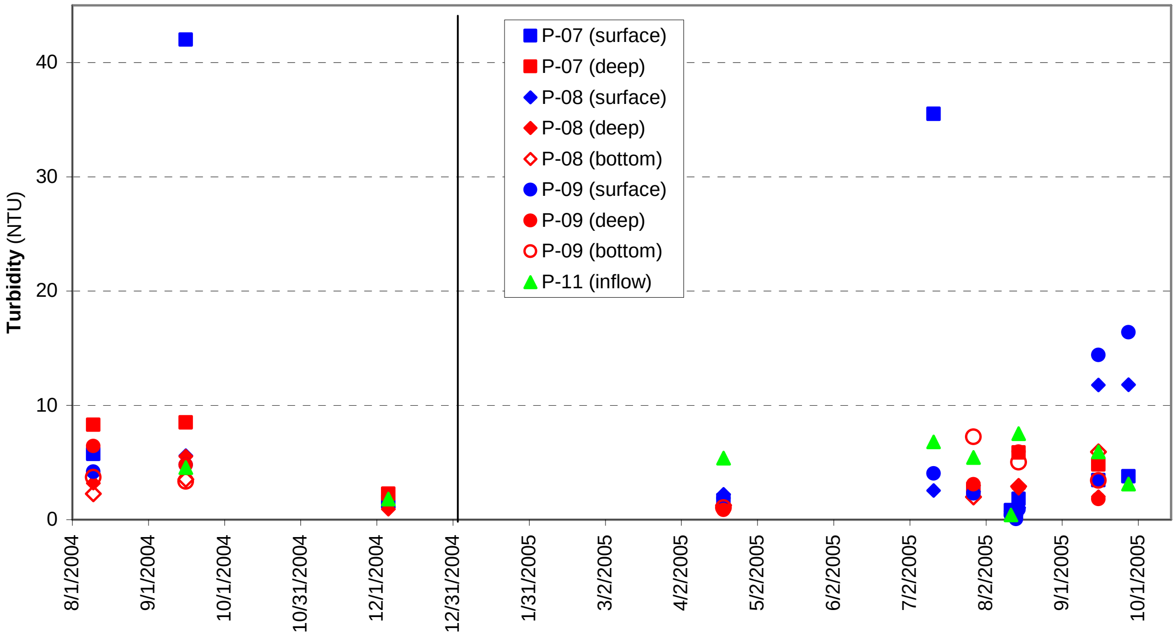


Figure 8-26: Turbidity in Scott Pond

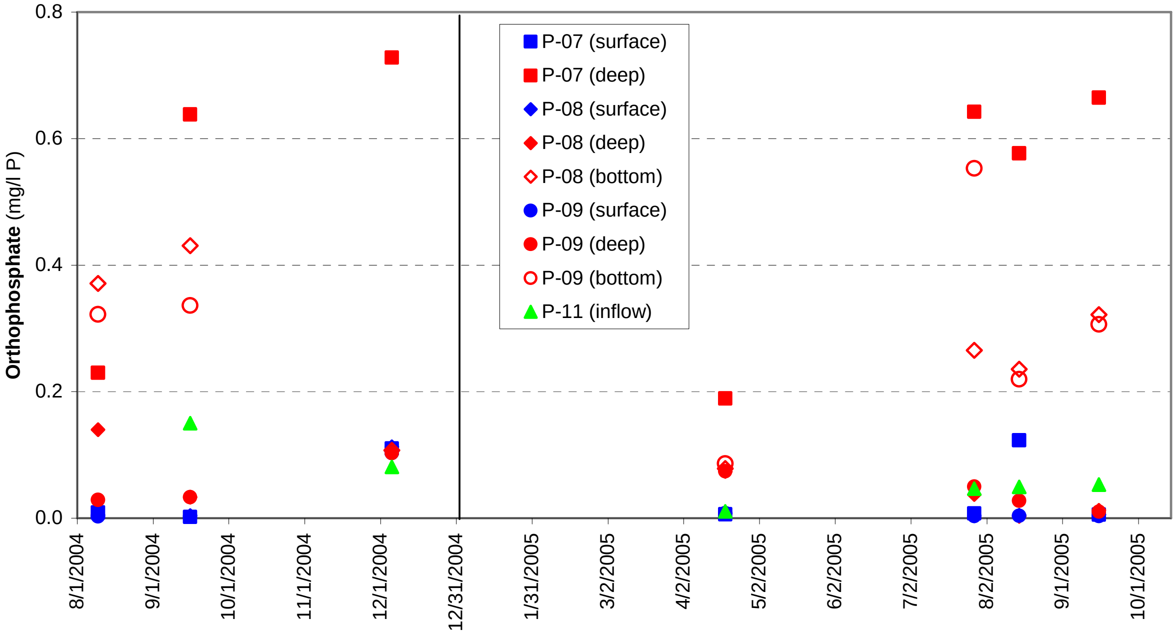


Figure 8-27: Orthophosphate in Scott Pond

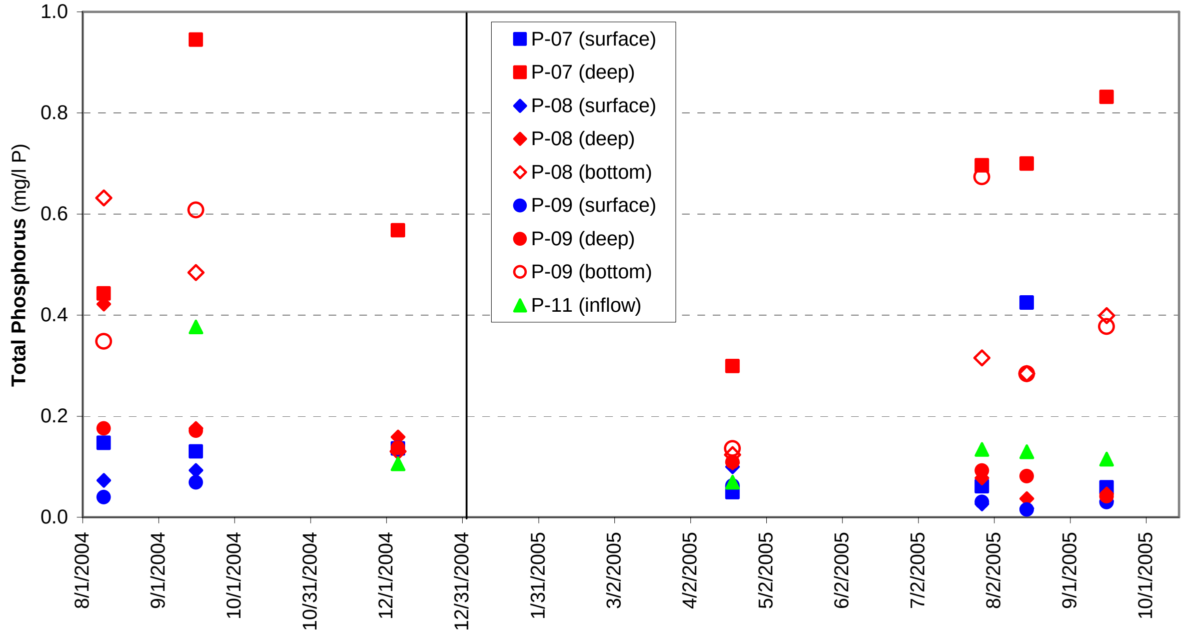


Figure 8-28: Total Phosphorus in Scott Pond

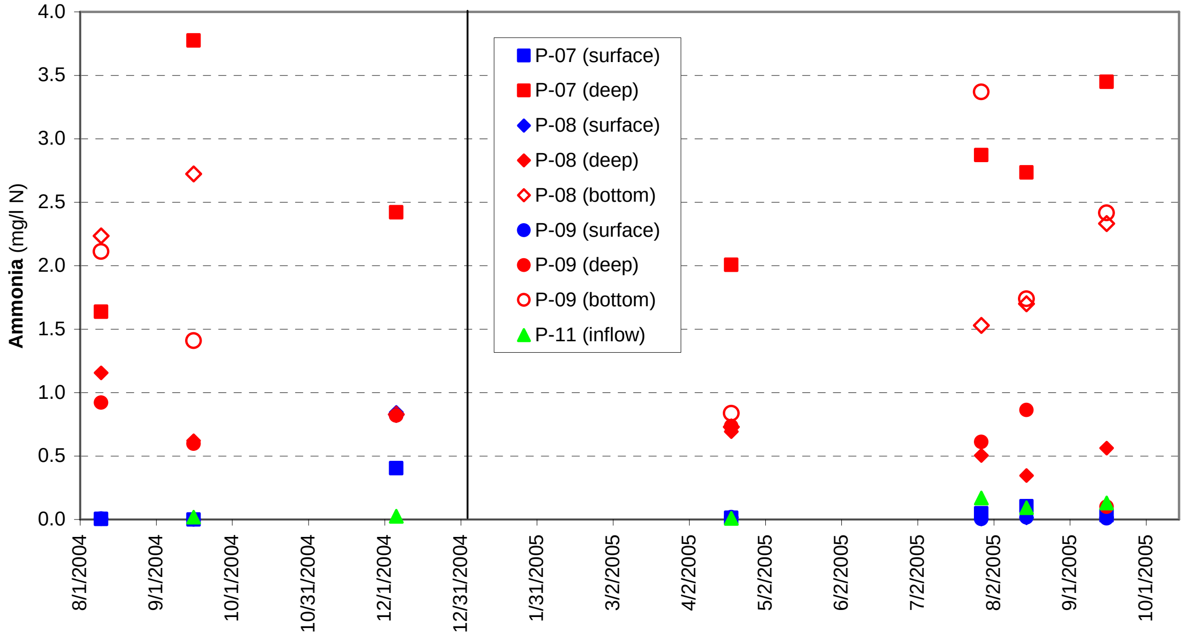


Figure 8-29: Ammonia in Scott Pond

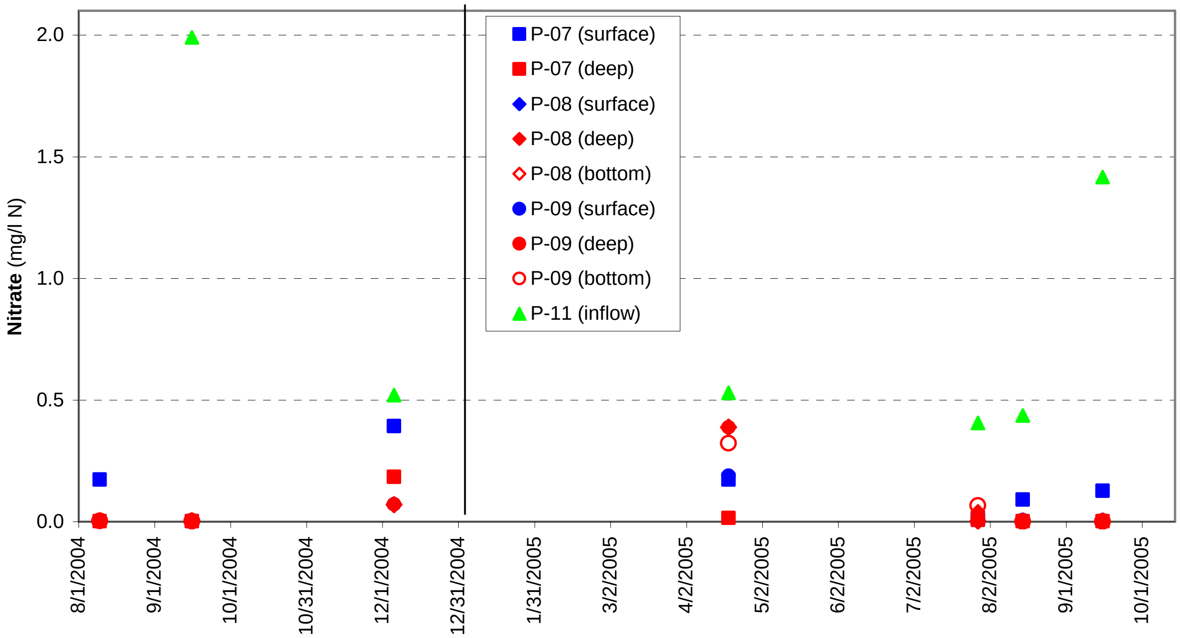


Figure 8-30: Nitrate in Scott Pond

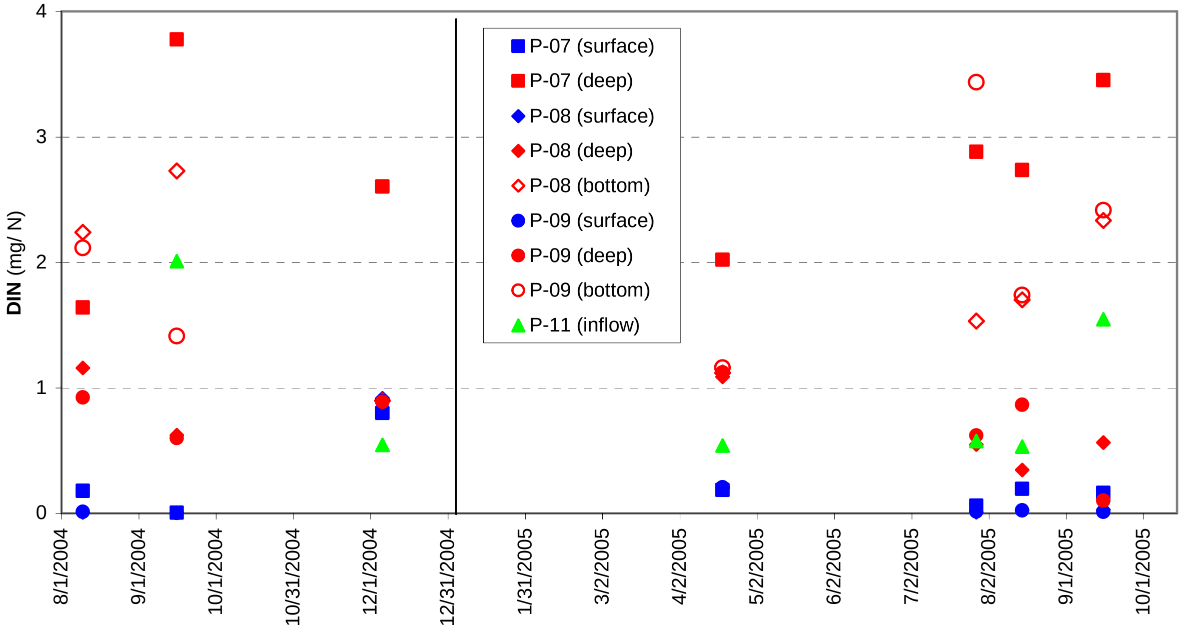


Figure 8-31: Dissolved Inorganic Nitrogen in Scott Pond

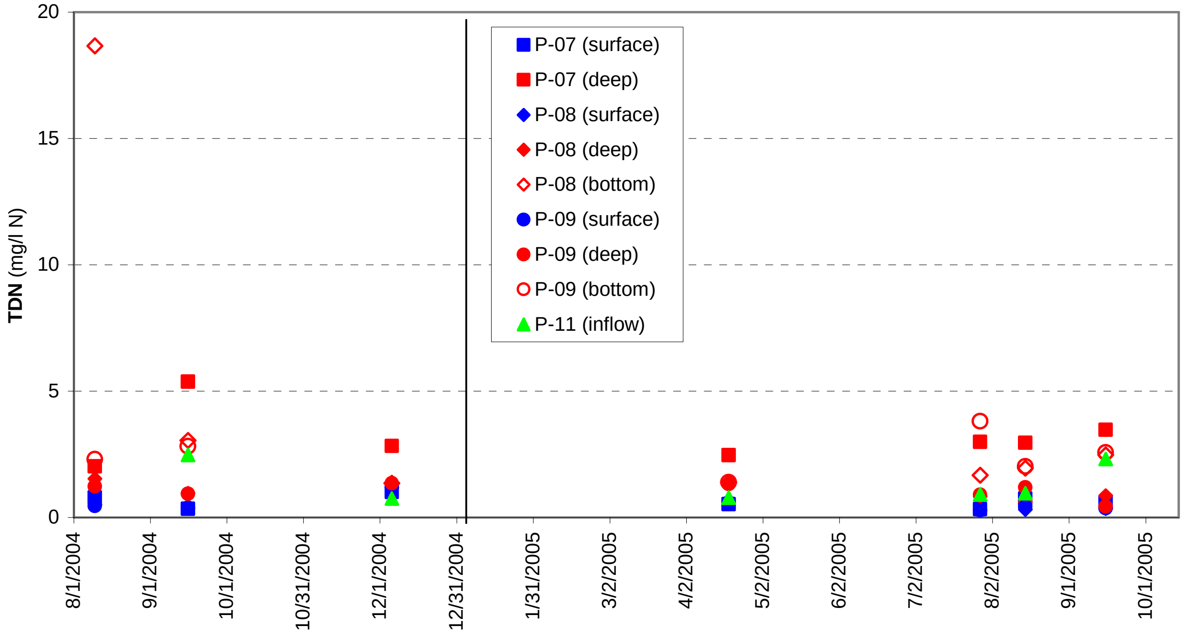


Figure 8-32: Total Dissolved Nitrogen in Scott Pond

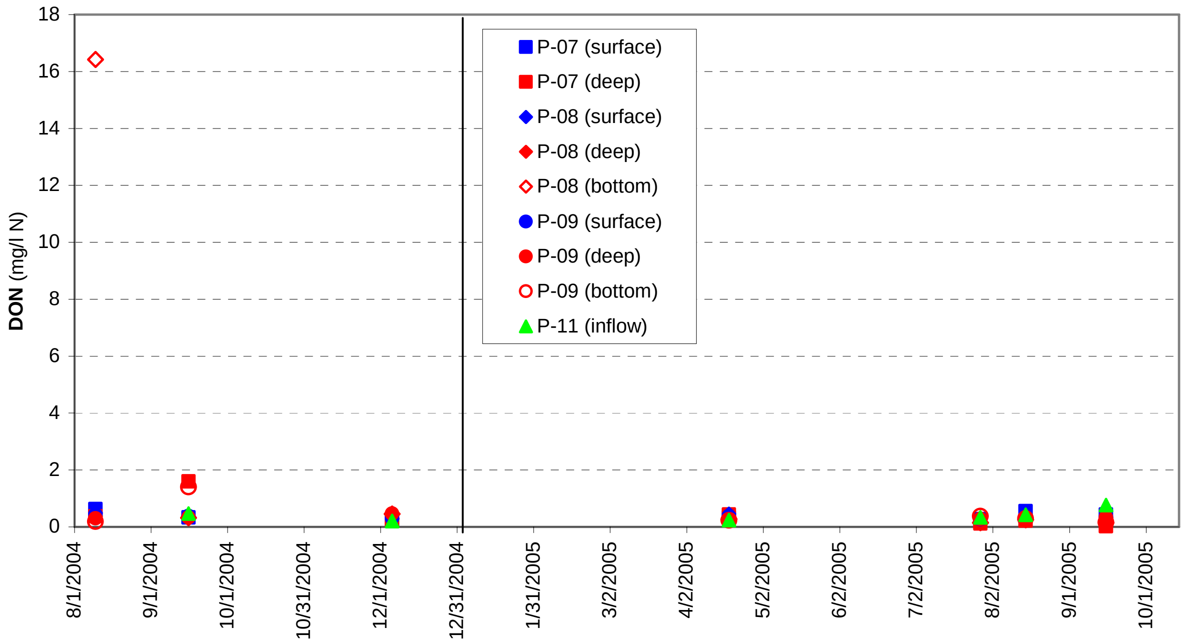


Figure 8-33: Dissolved Organic Nitrogen in Scott Pond

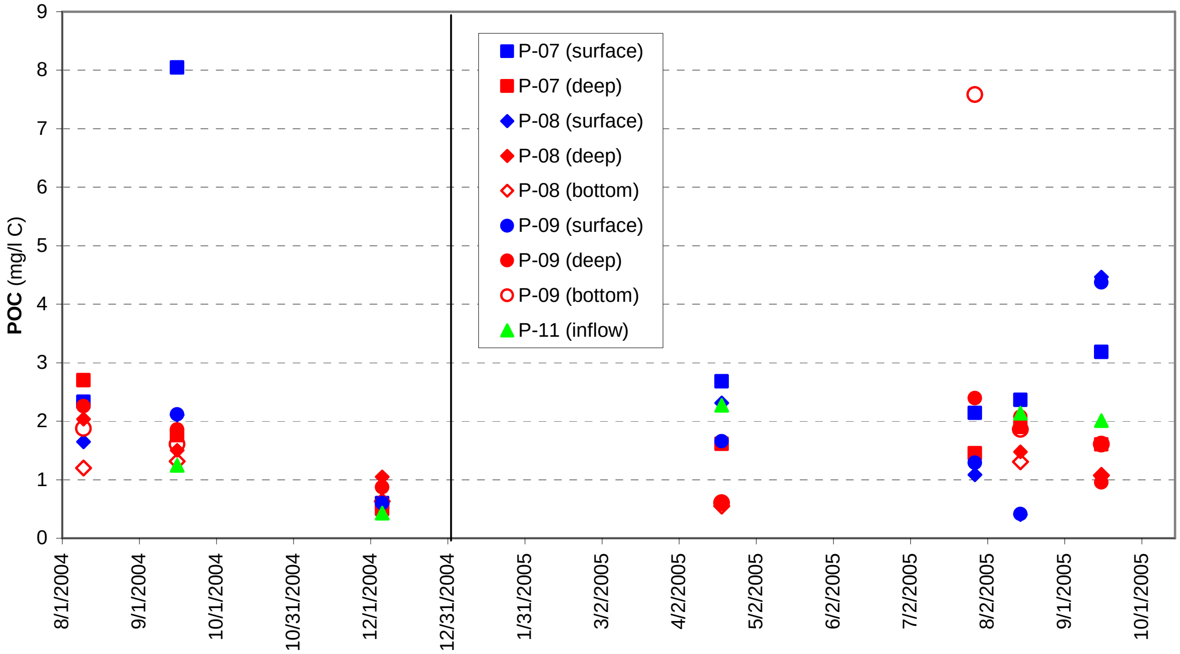


Figure 8-34: Particulate Organic Carbon in Scott Pond

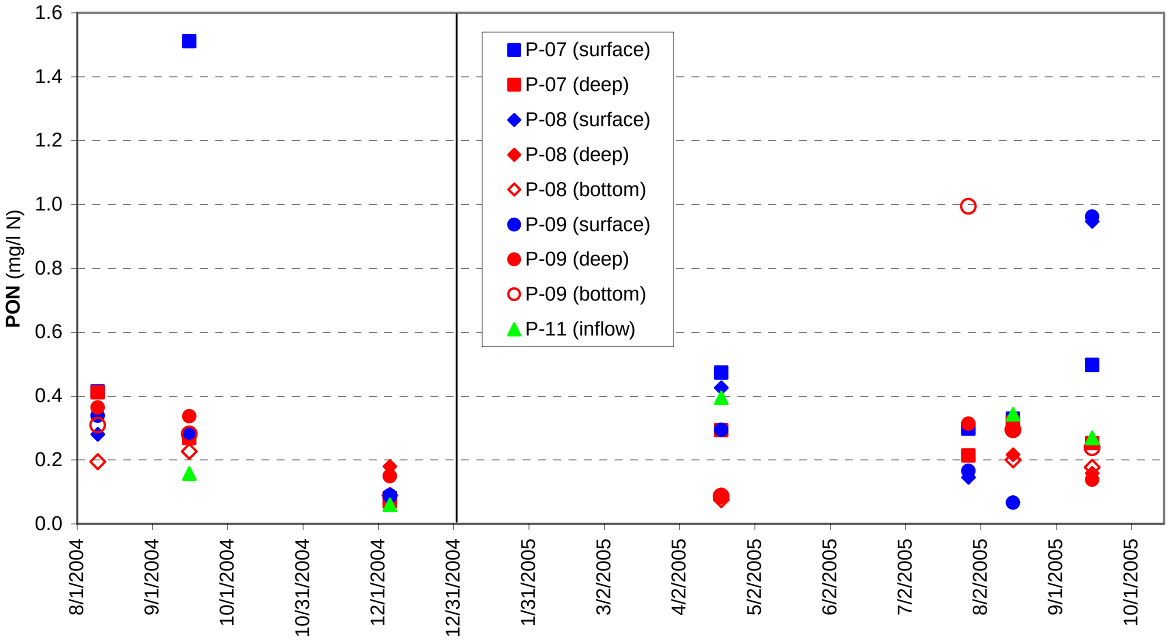


Figure 8-35: Particulate Organic Nitrogen in Scott Pond

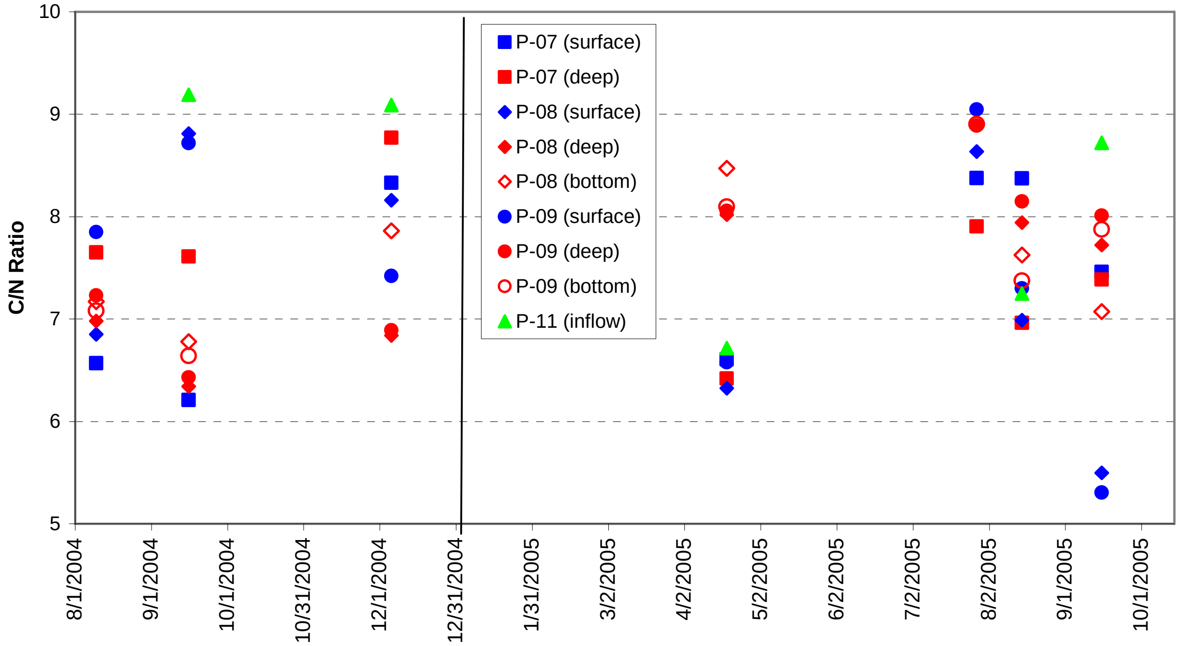


Figure 8-36: C/N Ratio in Scott Pond

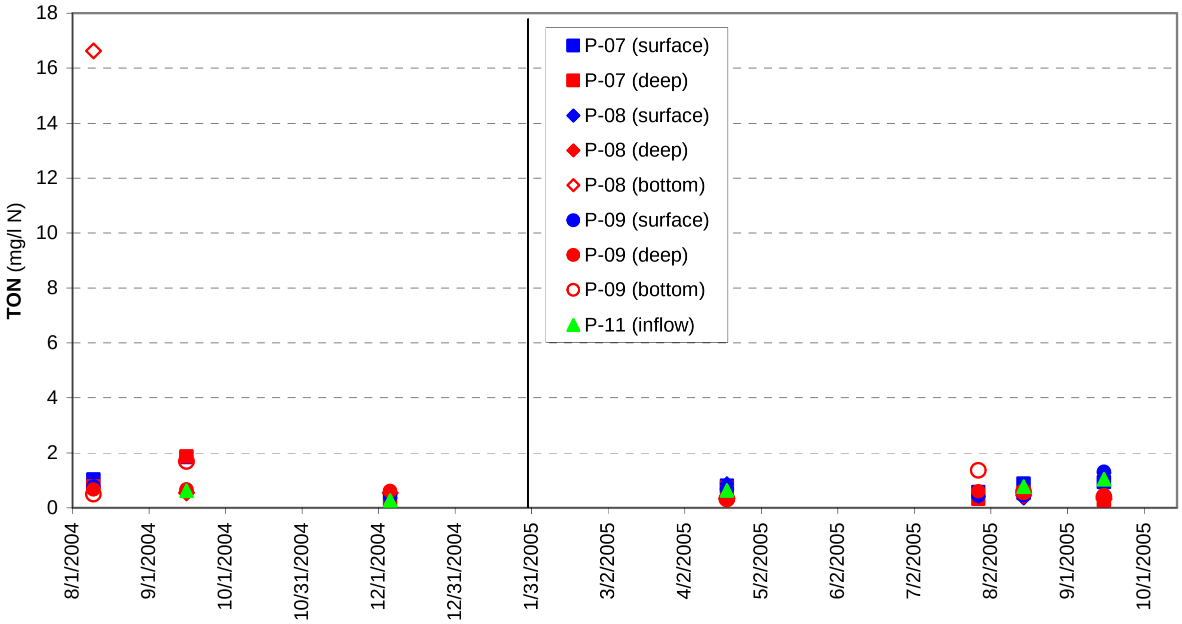


Figure 8-37: Total Organic Nitrogen in Scott Pond

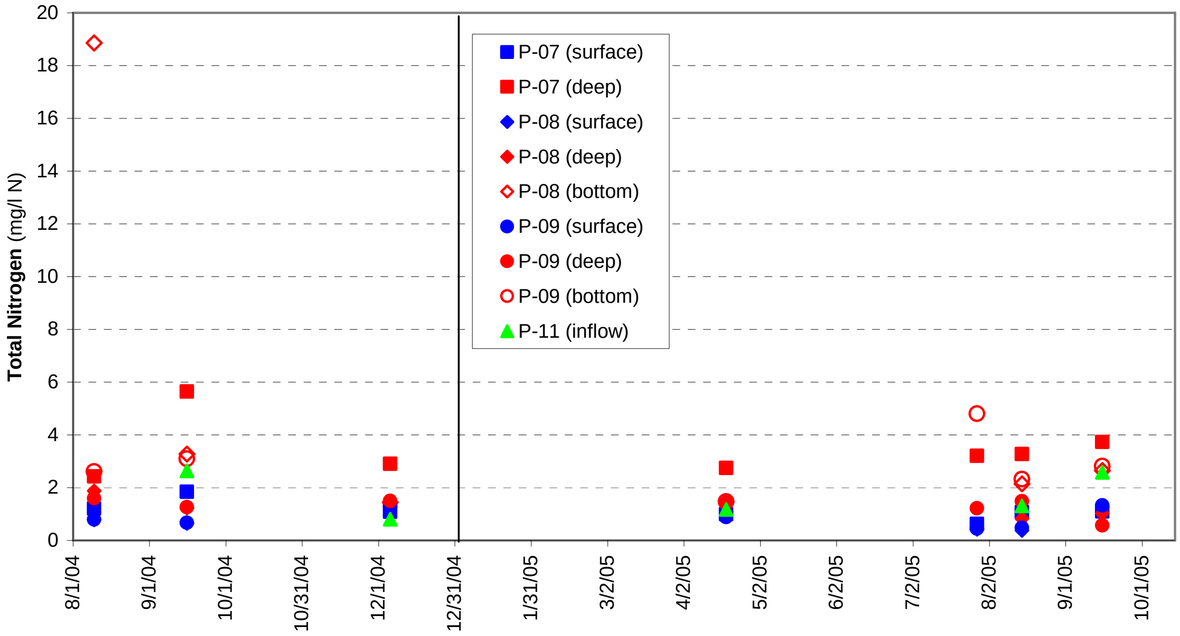


Figure 8-38: Total Nitrogen in Scott Pond

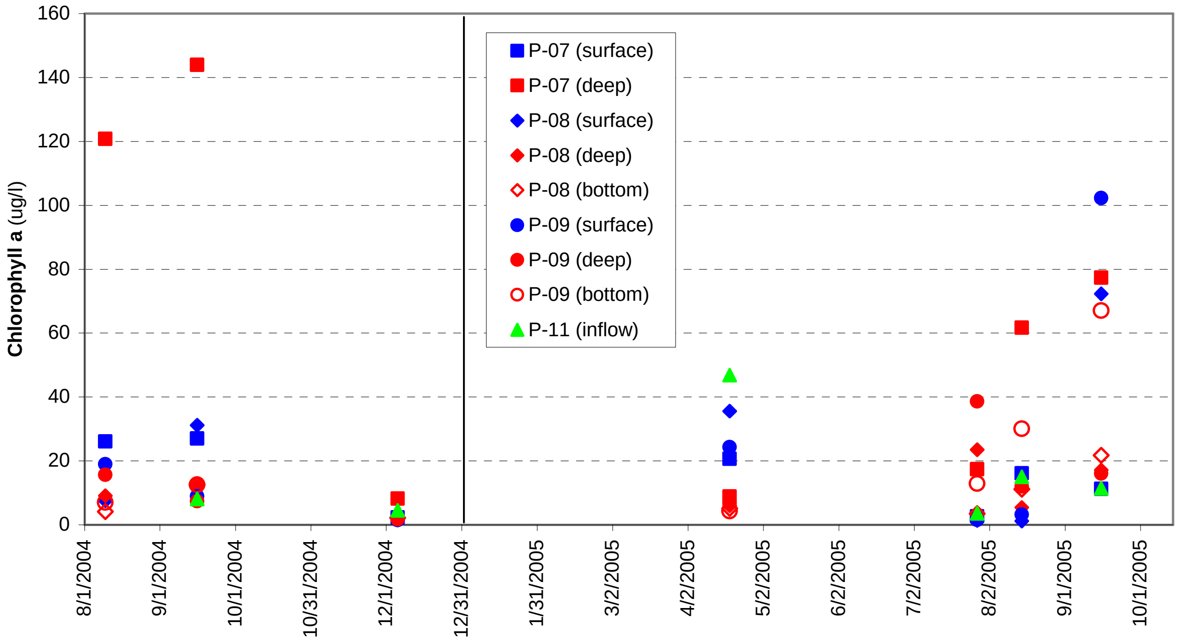


Figure 8-39: Chlorophyll in Scott Pond

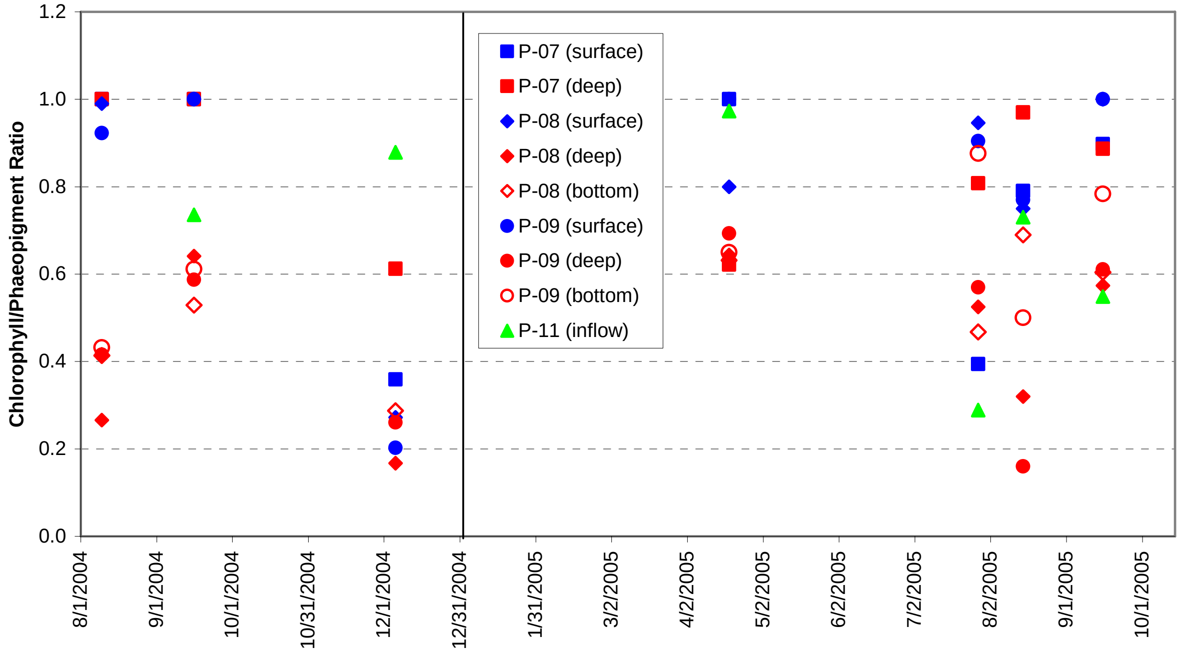


Figure 8-40: Chlorophyll/Phaeopigment Ratio in Scott Pond

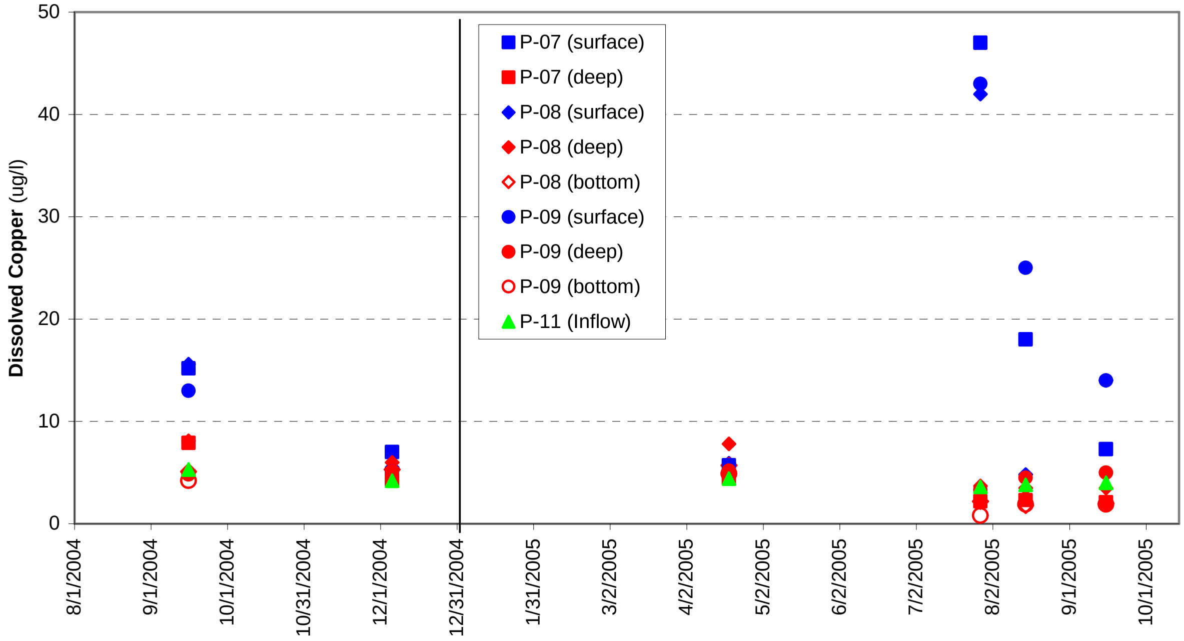


Figure 8-41: Dissolved Copper in Scott Pond

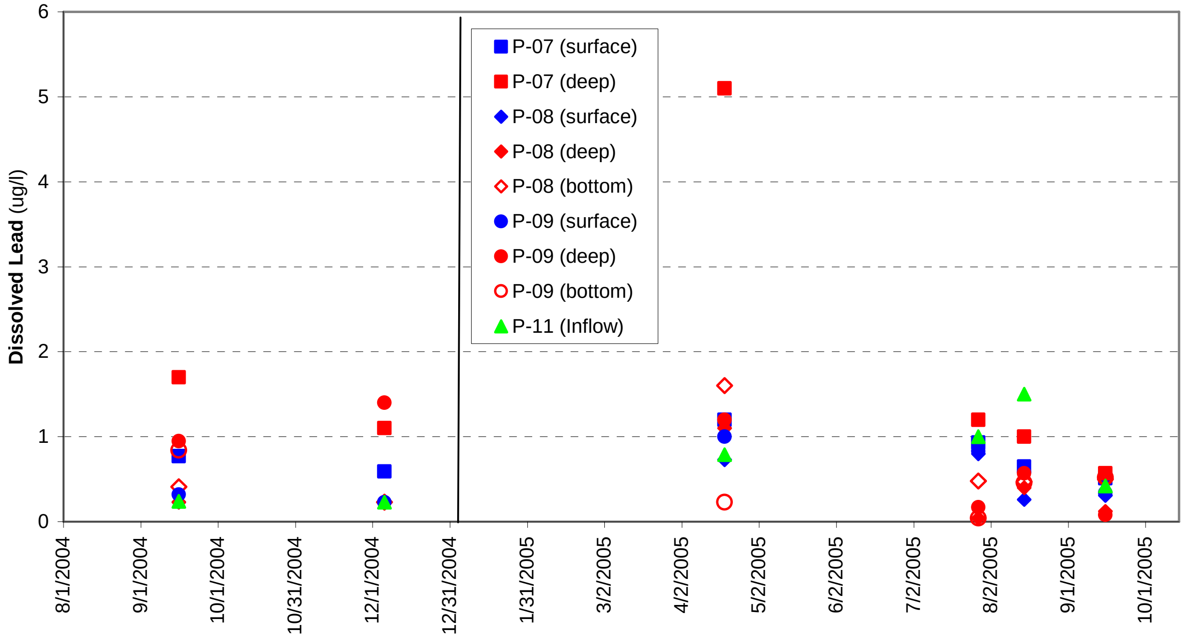


Figure 8-42: Dissolved Lead in Scott Pond

9.0 SUMMARY AND RECOMMENDATIONS FOR TMDL DEVELOPMENT

9.1 Issues of No Concern for TMDL Development

Fecal Coliform

- Reach 2: There are no major sources in this reach.

- Abbott Run Brook: Not a significant source.

Dissolved Copper

- Dry Weather: No exceedances of the acute dissolved copper criteria.

- Dry Weather: No exceedances of the chronic criteria in the watershed other than at the primary stations.

- Dry Weather: The Branch River contributed copper at less than 5% on average at its point of confluence with the Blackstone River. Its contribution to the Blackstone River is not significant.

- Dry Weather: Abbott Run Brook contributed copper at 4.5% at its point of confluence with the Blackstone River. This contribution was considered small.

- Dry Weather: The Mill and Peters Rivers provided only about 1.7 to 0.5%, respectively, to the copper load in the Blackstone River. This is not significant. There was no obvious increase of dissolved copper in either river.

- Wet Weather: No significant sources within Reaches 2 and 3, although some of the outfalls exceeded the regulatory criteria for copper.

Dissolved Lead

- No exceedances of the acute dissolved lead criteria in dry or wet weather.

- Dry Weather: The Mill River provided on average 0.02 lbs/day to the Blackstone (0.25 lbs/day at Station W-02), while the Peters River provided on average 0.002 lbs/day to the Blackstone. Their impact on the Blackstone is considered small.

- Wet Weather: No significant sources within Reaches 2 and 3.

9.2 Issues of Concern for TMDL Development

Fecal Coliform

- Surprisingly, in the 14 years covered between the BRI and this study, the pattern of fecal coliform is very similar for both wet and dry weather. This suggests that there were neither significant reductions in the discharge of fecal coliform nor new sources in this time frame.

- The contribution of pathogens from Massachusetts is important. For wet weather, the mean concentration in each storm exceeded 500 MPN/100 ml. During dry weather, 7 samples out of 17 exceeded 200 MPN/100 ml at the State line (W-01).

- Many of the outfalls sampled during the reconnaissance survey exceeded the regulatory limit for fecal coliform, particularly during wet weather.

Dissolved Copper

- Dry Weather: The contribution of dissolved copper from Massachusetts is important. The largest number of exccedances of dry weather criteria occurred at the State line (W-01), where concentrations of over 50% of the surveys exceeded the criteria.

- Dry Weather: Exceedances of dissolved copper at the lower Blackstone River stations are a direct result of the high concentrations at the State line that carry through to the mouth of the river.

- Wet Weather: Dissolved copper is expected to be conservative for the length of Reach 1 and the time period of a typical storm signal. Therefore, a balance has significance. For dissolved copper, on average, the mass of dissolved copper at the end of the reach is accountable through all monitored inputs. There do not appear to be significant sources of copper in addition to the sources that were monitored.

- Wet Weather: Most of the load at Station W-02 (91% of 110% at Station W-02) is attributable to Massachusetts (W-01).

- Wet Weather: For the Mill River, there was only one slight exceedance of the acute criterion. For the Peters River, during Storm WW-02, the chronic criteria were exceeded slightly, and the acute criteria were exceeded during a few of the sampling runs. The source appeared to be in Massachusetts. There were no exceedances during Storms WW-03 and WW-04.

- Wet Weather: The dissolved copper load from the Branch River was elevated (21%) during Storm WW-04.

- Dry Weather: For copper, the profile for the BRI was similar to that observed in the BTMDL. In general, concentrations during the BTMDL were lower and the ranges between maximum and minimum were smaller than the BRI study. There appears to be a measurable reduction in copper above W-01 over the 14 years. This change can also be seen in the downstream stations.

Dissolved Lead

- Dry Weather: For the Branch River, the exceedances of the chronic criteria during dry weather (3 of the 4 surveys) are more a result of the lowest hardness values (17 to 23 mg/l) recorded in the river.

- Wet Weather: Dissolved lead is considered conservative for the length of Reach 1 and in the time period of a typical storm signal. Therefore, a balance has significance. For dissolved lead, on average, approximately 97%, of the load observed at the end of the reach, were identified with the monitored inputs. There did not appear to be any significant sources of lead in addition to the monitored sources.

- Wet Weather: Approximately 84% of the load at W-02 was contributed by Massachusetts (W-01). Sources in Rhode Island included the Branch River and Mill River.

- Dry Weather: For lead, the concentrations reported in the BTMDL are considerably lower than those reported in the BRI. This may be a direct result of the improved technology being used in the laboratory now as compared with 14 years ago.

9.3 Recommended Studies and Actions

Fecal Coliform

- On the Peters River, unlike the Mill River, sources above the State line are important and do represent a significant portion of the fecal coliform load in the lower stations (W-15 and W-16). If remediation was anticipated along the Peters River, the sources in Massachusetts need to be identified.

- Wet weather observations on the Branch River, although not conclusive, suggest a possible source upstream of W-23. This source should be identified.

- There is a source of fecal coliform along the Mill River between Stations W-11 and W-12. This source discharges during both dry and wet weather conditions. There is an immediate impact on the Mill River that results in concentrations from less than 100 MPN/100 ml at Station W-11 to as high as 9,000 MPN/100 ml at Station W-12. The mass balance suggests that the wet weather contribution of the Mill River is approximately 11% of the fecal coliform mass relative to Blackstone River station W-02. The elimination of this source on the Mill River would have an impact on Station W-02, but alone would not bring W-02 into compliance. Possible wet weather sources for pathogens are outfalls OF-704 which contained high coliform concentrations during the reconnaissance survey, and Outfall OF-703 (not monitored so far).

- The brook near Ann&Hope (Station W-35) runs under a parking lot before discharging into a small channel that flows into the Blackstone River. The exact extent of the watershed is unknown. Station W-35 had the highest mean fecal coliform and enterococci concentrations (7,444 and 956 MPN/100 ml) in the study for the four dry weather sampling events. There is an obvious source in the drainage area that results in high concentrations important to the area immediately downstream of its emergence from underground. Further investigation is warranted to determine the source of the pathogens. In addition, the station should be sampled during wet weather. However, the brook's pathogen contribution to the Blackstone River are likely comparatively minor as suggested by the brook's much lower flow rate during dry weather; however, the flow rate during wet weather is not known and should be investigated.

- There is an obvious source of fecal coliform between W-04 and W-05. The source discharges in both dry and wet weather. The pathogen sources have already been identified in previous CSO engineering studies. Mass and concentrations identified in this study should be compared to those measured and/or estimated in earlier studies. If these fecal coliform values are similar, the source of the fecal coliform identified in this study is assumed to be included in the future CSO abatement program. If not, the sources need to be identified and should be eliminated or significantly reduced. These sources are significant. This study has shown that fecal coliform doubles in this reach during wet weather.

- In wet weather, the Front Street Drain (W-32) was a consistent source of fecal coliform. Similar to Station W-35, the extent of the watershed is unknown. The problem appears to occur only during wet weather. The mass balance indicated that W-32 contributed on average approximately 5% of the fecal coliform mass relative to Blackstone River station W-02.

- There are numerous outfalls in the RI watershed, specifically in the Woonsocket area. The reconnaissance sampling clearly shows that pathogen concentrations in the discharges from some of these outfalls are high. Although likely minor sources individually with regard to load, efforts should be made to characterize the key outfalls further. Results from the reconnaissance sampling should be used to develop additional sampling efforts, and subsequent remediation approaches.

Dissolved Copper

- Wet weather contributions from the Branch River are not consistent across Storms WW-03 and WW-04. Contributed copper loads were 2.6% and 21%, respectively. This higher load during Storm WW-04 is of concern but remediation should be considered only if further investigation confirms this single observation. Dry weather copper contributions from the Branch River were consistently low.

- Selected outfalls should be monitored for exceedances of the copper criteria, based on results from the reconnaissance survey (see suggestions in Table 5-17).

Dissolved Lead

- During one of the dry weather events, chronic criteria were exceeded in the Mill River and Cherry Brook. However, without supporting evidence no remedial action is warranted. Continued monitoring of these sites is recommended, including Outfalls OF-703 and OF-704 along the Mill River.

- The Branch River contributed lead at over 40% (0.07/0.16 lbs/day W-23/W-01) on average at its point of confluence with the Blackstone River during dry weather. The contributions from the Branch River were consistent (concentrations observed were 0.67, 0.62, 0.29, 0.40 µg/l) and significant. The origin of the lead should be further investigated. Wet weather contributions from the Branch River were not of concern.

- Selected outfalls should be monitored for exceedances of the lead criteria, based on results from the reconnaissance survey (see suggestions in Table 5-17).

10.0 REFERENCES

BBL (Blausland, Bouck & Lee, Inc.), 2003, RI/FS, Data Base Summary Report, Peterson/Puritan OU2. (December 2003).

BBL (Blausland, Bouck & Lee, Inc.), 2006, Revised Data Base Summary Report. Remedial Investigation and feasibility Study for the Peterson/Puritan Superfund Site, Operable Unit 2, Cumberland and Lincoln, Rhode Island (February 2006).

American Map, 2003, Street Atlas Rhode Island.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Rivers: Periphyton, Benthic Macroinvertebrates, and Fish. Second Edition. EPA 841-B-99-002. Office of Water, US Environmental Protection Agency, Washington, DC. 151p and appendices.

Beck, W. M. Jr. 1954. Studies in Stream Pollution Biology: a simplified ecological classification of organisms. Quarterly Journal of the Florida Academy of Sciences. 17(4)211-227.

Berger (The Louis Berger Group, Inc.), 2004, *Water Quality – Blackstone River*. Final Report 1: Existing Data. Prepared for the Rhode Island Department of Environmental Management, Office of Water Resources, 2 volumes (January 2004).

Brown University, 2003, The Blackstone River. A comprehensive study of storm runoff and drainage on the Cumberland side between the Ashton & Pratt Dams. Center for Environmental Studies. http://envstudies.brown.edu/classes/es192/2003/blackstone/projectoverview.htm

Cairns, J., Jr. and J.R. Pratt. 1993. A history of biological monitoring using benthic macroinvertebrates. In: Rosenberg, D.M. and V.H. Resh (editors). Freshwater Biomonitoring and Benthic Macroinvertebrates. Chapman and Hall, New York.

Carlson, R.E. 1977. A trophic state index for lakes. Limnol. Oceangr. 22:361-369.

City of Central Falls, 2004, Flow Monitoring Areas – map. Provided by the Department of Public Works Office in July 2004.

Cowardin L.M., V. Carter, F.C. Golet, and E.T. LaRoe, 1979, *Classifications of Wetlands and Deepwater Habitats of the United States.* FWS/OBS-79/-31. US Fish and Wildlife Service Washington DC.

da Silva, S., 2002, *Establishment and Field Testing of a Rapid Bioassessment Screening of Rhode Island Freshwater Benthic Macroinvertebrates, 2001 Results.* Prepared for the Rhode Island Department of Environmental Management.

Enser, R., 1997, Birding the Lower Blackstone River Valley, Rhode Island. In: *Bird Observer of Eastern Massachusetts.* 462 Trapelo Road, Belmont, MA.

Enser, R., 2004, RI Natural Heritage Program Coordinator, Marshes of Eden. Article published in *The Times*, July 12 2004.

ESS (ESS, Inc.), 2002, Quality Assurance Project Plan for Taxonomic Identification of Benthic Macroinvertebrates. Submitted to the USEPA on September 30, 2002.

Gould, M., 1998, *Establishment and Filed Testing of a Rapid Bioassessment Screening of Rhode Island Freshwater Benthic Macroinvertebrates, 1998 Results*, 1998. Prepared for the Rhode Island Department of Environmental Management.

Hilsenhoff, W.L., 1987, An improved Biotic Index of organic stream pollution. *Great Lakes Entomol*., v. 20, p. 31-39.

Kerr, M., 1990, The Blackstone River. Rhode Island Sea Grant Fact Sheet. http://seagrant.gso.uri.edu/factsheets/blackstone_river.html.

King, J., et al., 1995, *A study of the sediments of Narragansett Bay. Volume 1: The surface sediments of Narragansett Bay*. Final Report submitted to the Narragansett Bay Project.

London & Co, 1953, *D. London and Company, Lonsdale, Rhode Island*. Site engineering map. Surveyed on December 3, 1953; revised from Department files on March 13, 1959. Provided by John Faile, Water Department, Town of Lincoln.

Mandaville, S.M., 2000, Benthic Macroinvertebrates in Freshwaters-Taxa Tolerance Values, Metrics and Protocols. Project H-1 Soil and Water Conservation Society of Metro Halifax. Master Homepage: http://chebucto.ca/Science/SWCS/SWCS.html.

Mason, W.T., Jr., 1973, An Introduction to the Identification of Chironomid Larvae. Analytical Quality Control Laboratory, National Environmental Research Center, U.S. EPA, Cincinnati, Ohio, 89p.

Merritt, R.W. and K.W. Cummins, 1996, *An Introduction to the Aquatic Insects of North America.* 3rd Edition. Kendall/Hunt Publishing

Minnesota Pollution Control Agency (http://www.pca.state.mn.us/water/lakeacro.html. After Moore, L. and K. Thornton, [Ed]. 1988. Lake and Reservoir Restoration Guidance Manual. USEPA. EPA 440/5-88-002.

Nadeau, J.B., 2005, Former site of drive-in yields another world. In *The Woonsocket Call,* Jul. 18, 2005. http://www.zwire.com/site/news.cfm?newsid=14875858&BRD=1712&PAG=461&dept_id=24361&rfi=6.

NOAA (National Oceanographic and Atmospheric Administration), 1977, Technical Memorandum NWS Hydro-35, U.S. Department of Commerce, Weather Bureau.

NOAA (National Oceanographic and Atmospheric Administration), 1999, Screening Quick Reference Tables.

NOAA (National Oceanographic and Atmospheric Administration), 2004, http://www.erh.noaa.gov/box/dailystns.shtml.

North Smithfield (Town of North Smithfield), 2003, North Smithfield Stormwater Outfalls (provided by the Town Planning Office).

Pawtucket (City of Pawtucket), 1975, Pawtucket Existing Sewerage Facilities (provided by the City's Engineering Office).

Peckarsky, B.L., P.R. Fraissinet, M.A. Penton, and D.J. Conklin, Jr., 1990, *Freshwater Macroinvertebrates of Northeastern North America*. Cornell University Press. 442p.

Pennak R.W., 1989, *Freshwater Invertebrates of the United States*, 3rd Edition. Protozoa to Mollusca. John Wiley & Sons, Inc., 803p.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes, 1989, Rapid bioassessment protocols for use in streams and rivers. Benthic macroinvertebrates and fish. USEPA/444/4-89-001. Office of Water Regulation Standards, US Environmental Protection Agency, Washington, DC., 162p.

Pomeroy, S., 2000, Establishment and Filed Testing of a Rapid Bioassessment Screening of Rhode Island Freshwater Benthic Macroinvertebrates, 1999 Results and 2000 Results. Prepared for the Rhode Island Department of Environmental Management.

Province of Ontario, 1993, Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario, http://www.ec.gc.ca/ceqg-rcqe/English/Sediment/default.cfm.

Rector, D.D., 1981, *Soil Survey of Rhode Island.* U.S. Department of Agriculture, Natural Resources Conservation Service (formerly Soil Conservation Service).

RIDEM (Rhode Island Department of Environmental Management), 1995, Background levels of high priority pollutants metals in Rhode Island.

RIDEM (Rhode Island Department of Environmental Management), 2000, Water Quality Regulations. Promulgated August 6, 1997; amended March 25, 1999 and June 23, 2000. Regulation EVM 112-88.97.1.

RIDEM (Rhode Island Department of Environmental Management), 2000, Blackstone River Watershed-specific Stormwater Permitting. Final Report. Submitted to the U.S. Environmental Protection Agency. December 2000.

RIDEM (Rhode Island Department of Environmental Management), 2003, State of Rhode Island, 2002 303(d) List of Impaired Waters.

RIDEM (Rhode Island Department of Environmental Management), 2006, Woonasquatucket River - Fecal Coliform Bacteria and Dissolved Metals, Total Maximum Daily Loads (December 2006), http://www.dem.ri.gov/programs/benviron/water/quality/rest/pdfs/woondrft.pdf.

RIDEM (Rhode Island Department of Environmental Management), 2007. Total Maximum Daily Load for Dissolved Oxygen and Phosphorus for Mashapaug Pond, Rhode Island.

RIDOT (Rhode Island Department of Transportation), 1963, Interstate Route 295, Mendon Road to Mass State Line, Grading and Drainage STA 234+00 to STA 246+50. Prepared by J.L. Hayden Consulting Engineers.

Smith, D.G., 1995, *Keys to the Freshwater Macroinvertebrates of Massachusetts.* 2nd ed. 241p.

Stewart K.W. and P.B. Stark, 2002, *Nymphs of North American Stonefly Genera*. Second Edition. The Caddis Press. Columbus, Ohio. xii+510p.

Sweet, J. W. 1986. Survey and Ecological Analysis of Oregon and Idaho Phytoplankton. Final Report to EPA, Seattle, WA. 47p.

Thorp, J.H. and A.P. Covich (eds.), 1991, *Ecology and Classification of North American Freshwater Invertebrates*. Academic Press, New York. 911p.

Town of Cumberland, 2005, Stormwater Monitoring Project Plan. Submitted to RIDEM in June 2005.

Town of North Smithfield, 2003, *North Smithfield Stormwater Outfalls.* Prepared by the Town of North Smithfield with parcel mapping provided by Applied Geographics, Inc. (September 2003).

USACE (U.S. Army Corps of Engineers), 1997, *Blackstone River Watershed Reconnaissance Investigation Massachusetts and Rhode Island.* Main Report and Appendices, 2 volumes.

USACE (U.S. Army Corps of Engineers, New England District), 1999, *Wetland Functions and Values A Descriptive Approach. The Highway Methodology Workbook Supplement.* NAEEP-360-1-30a, Concord, MA.

USEPA (U.S. Environmental Protection Agency), 1970, *Blackstone River Time of Travel, 1964 and 1970, Worchester, MA – Pawtucket, RI.* USEPA Region 1, Surveillance and Analysis Division, Needham Heights, MA.

USEPA (U.S. Environmental Protection Agency), 1990, Macroinvertebrate field and laboratory methods for evaluating the biological integrity of surface waters, EPA 600/4-90-030. Aquatic Biology Branch and Development and Evaluation Branch, Quality Assurance Research Division, Environmental Monitoring Systems Laboratory, Cincinnati, Ohio.

Wiggins G.B., 1996, *Larve of the North American Caddisfly Genera (Trichoptera).* 2nd edition, University of Toronto Press.

Winner, R. W., Boesel, M. W., and M. P. Farrell, 1980, Insect community structure as an index of heavy-metal pollution in lotic systems. Canadian Journal of Fisheries and Aquatic Sciences: 37, 647-655.

Woonsocket (City of Woonsocket), 2004, *Storm Line Plans*. Department of Public Works. Updated January 2004 (provided by the City's Engineering Office)

Wright, R.M., P. Nolan, D. Pincumbe, E. Hartman, and O.J. Viator, 2001, *The Blackstone River Initiative: Water Quality Analysis of the Blackstone River Under Wet and Dry Weather Conditions.* Prepared for the USEPA New England, Boston, MA.

Wright, R., Viator, O. and Michaelis, B., 2004, Dry Weather Water Quality Sampling and Modeling Blackstone River Feasibility Study, Phase 1: Water Quality Evaluation and Modeling of the Massachusetts Blackstone River, Prepared for the U.S. Army Corps of Engineers, University of Rhode Island, Kingston, RI.

11.0 APPENDICES

Appendix A

Precipitation Data

Note: Rainfall data from the Woonsocket Water Treatment Facility were recorded between 8:00 am of the previous morning to 8:00 am of the day of the recorded value.

Rainfall data from the NOAA stations represent the period between 1am and 1 am (EST) of the following day.

Table A-1

Monthly Precipitation (inches)

Water Division, City of Woonsocket

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
1960	3.64	5.63	3.30	4.14	3.93	0.91	6.46	1.98	7.57	3.30	3.12	4.50	**48.5**
1961	3.20	3.80	4.16	5.92	4.16	2.65	3.00	2.77	7.42	2.33	3.18	3.81	**46.4**
1962	3.93	5.79	2.32	3.60	2.35	4.26	2.17	3.40	3.27	9.89	4.42	3.50	**48.9**
1963	3.38	3.43	3.90	1.67	2.76	3.91	3.85	1.50	3.90	1.68	7.13	2.72	**39.8**
1964	5.42	3.52	2.63	4.98	0.53	1.31	3.27	1.68	2.76	2.14	3.13	5.60	**37.0**
1965	2.15	3.23	2.26	2.34	1.23	2.23	2.35	2.27	2.64	2.66	2.35	1.64	**27.4**
1966	4.29	3.53	2.16	0.98	3.48	1.71	3.84	2.07	4.60	2.83	4.52	2.34	**36.4**
1967	1.74	3.16	5.09	4.31	8.50	3.65	5.11	4.63	4.16	2.27	3.44	6.73	**52.8**
1968	4.12	1.03	8.85	1.76	3.33	9.12	0.71	2.28	3.55	2.17	6.73	5.98	**49.6**
1969	2.11	9.84	3.53	5.57	4.94	0.90	4.22	2.90	5.03	2.28	6.94	9.96	**58.2**
1970	0.99	6.60	4.29	4.11	3.37	3.40	1.59	4.06	2.17	3.15	5.10	4.98	**43.8**
1971	2.33	4.66	3.03	2.89	3.96	1.40	2.61	2.23	2.39	4.10	5.95	2.56	**38.1**
1972	2.33	5.95	7.27	3.92	5.19	7.77	3.78	2.90	5.35	4.30	8.39	7.74	**64.9**
1973	3.48	3.06	2.62	6.53	3.96	4.72	2.76	3.43	4.82	3.15	2.03	9.14	**49.7**
1974	3.74	2.84	5.98	4.53	3.29	2.67	1.72	4.08	8.55	3.46	1.93	5.66	**48.5**
1975	5.76	3.29	3.98	3.15	1.67	2.69	2.63	4.45	6.99	7.00	6.29	6.00	**53.9**
1976	6.57	3.27	3.10	2.76	2.71	1.70	5.54	8.20	2.35	5.30	0.71	3.22	**45.4**
1977	4.34	2.96	5.11	3.81	2.61	3.57	2.76	3.61	7.04	7.39	4.58	7.09	**54.9**
1978	10.01	2.52	3.45	2.49	6.45	2.10	2.06	6.07	2.19	3.04	2.19	4.30	**46.9**
1979	11.99	3.71	2.73	4.87	6.00	1.13	2.74	9.52	3.72	3.21	4.46	1.62	**55.7**
1980	1.45	1.01	6.91	5.48	1.69	4.14	7.33	1.54	0.80	3.93	3.64	0.88	**38.8**
1981	0.76	6.87	0.73	4.22	2.76	3.12	3.50	0.60	5.00	5.43	3.75	7.58	**44.3**
1982	3.67	3.56	2.94	4.66	2.01	12.12	3.78	1.85	2.00	3.62	4.95	1.84	**47.0**
1983	4.98	4.12	9.82	10.37	3.74	2.91	2.20	3.18	1.71	4.72	9.27	4.81	**61.8**
1984	2.22	6.97	7.41	5.82	5.61	7.59	4.41	0.70	2.28	4.55	2.94	2.97	**53.5**
1985	1.07	1.42	2.40	1.13	4.58	4.69	2.91	5.69	2.68	1.66	9.28	1.34	**38.9**
1986	3.73	2.42	3.58	1.36	1.88	7.79	4.55	7.12	0.85	2.44	4.70	8.00	**48.4**
1987	5.20	0.60	1.71	10.07	1.80	1.58	2.11	2.99	6.31	3.56	2.78	2.07	**40.8**
1988	2.44	3.47	4.02	2.97	3.08	0.67	6.68	1.71	2.35	2.74	7.97	0.83	**38.9**
1989	0.95	2.42	2.73	4.20	4.51	5.67	4.22	8.43	4.57	7.37	5.77	1.44	**52.3**
1990	5.02	3.66	2.20	5.36	6.90	1.11	4.21	10.03	1.79	9.99	2.92	5.95	**59.1**
1991	3.62	2.29	5.56	3.37	3.67	2.08	4.55	6.79	6.50	3.58	6.13	2.40	**50.5**
1992	4.77	2.39	4.66	3.33	1.04	5.44	3.22	5.31	4.72	1.96	5.24	9.78	**51.9**
1993	2.99	4.50	7.56	5.27	1.27	1.78	2.52	1.25	5.14	3.31	4.06	7.33	**47.0**
1994	6.08	3.43	7.34	2.58	3.91	1.49	1.79	6.91	5.04	0.40	5.50	4.70	**49.2**
1995	3.76	2.67	3.12	2.54	3.13	1.88	3.62	1.65	3.29	8.80	5.60	2.17	**42.2**
1996	8.12	3.56	3.24	6.86	4.14	2.38	6.66	4.38	6.79	7.47	3.50	8.29	**65.4**
1997	4.08	1.92	4.74	7.45	2.82	0.71	1.55	4.71	2.33	2.20	6.41	3.33	**42.3**
1998	6.21	5.05	6.37	4.52	5.71	12.06	5.32	3.49	1.85	4.74	2.60	1.78	**59.7**
1999	8.08	4.21	6.78	1.21	5.17	0.50	2.51	1.21	7.19	5.18	3.05	3.05	**48.1**
2000	4.28	3.38	5.31	6.04	3.82	5.55	5.04	2.92	3.83	2.22	4.05	5.60	**52.0**
2001	2.55	2.78	10.59	1.79	3.24	6.85	3.12	5.08	1.80	0.89	0.92	3.15	**42.8**
2002	2.99	2.56	4.28	3.46	6.03	4.25	1.73	3.85	4.54	3.73	6.49	6.50	**50.4**
2003	2.57	4.91	5.38	4.44	3.74	7.30	3.80	3.92	5.24	7.29	2.14	7.25	**58.0**
2004	1.79	1.98	2.09	9.43	3.30	0.94	3.01	7.10	6.47	1.67	5.27	4.73	**47.8**
2005	6.00	3.10	6.12	6.25	5.31	1.00	4.03	4.02	2.52	15.71	4.13	4.15	**62.3**
AVG	4.02	3.63	4.51	4.32	3.68	3.64	3.51	3.92	4.09	4.24	4.56	4.59	**48.7**
MAX	11.99	9.84	10.59	10.37	8.50	12.12	7.33	10.03	8.55	15.71	9.28	9.96	**65.4**
MIN	0.76	0.60	0.73	0.98	0.53	0.50	0.71	0.60	0.80	0.40	0.71	0.83	**27.4**

Source: Woonsocket Water Treatment Facility

Table A-2

Precipitation data for 2004

Source: NOAA Station in Worcester, MA

Date	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1				1.58		0.23	0.02	0.10				1.11
2	0.07		0.06	0.08	0.12	0.13				0.11		
3	0.15	0.47		0.01	0.61						0.05	
4	0.29		0.06	0.15	0.20			0.02			0.85	
5	0.26		0.07	0.01	0.02			0.76				
6		0.92	0.18									0.02
7		0.05			0.03							0.58
8			0.19				0.26		0.70			0.12
9			0.02		0.31	0.26			1.43			0.09
10						0.16	0.37		0.07			0.71
11												0.23
12	0.10		0.04	0.15				0.04			0.15	
13	0.02			2.18			0.43	0.05				0.02
14			0.01	0.17		0.01	0.04			0.04		
15	0.02		0.01	0.15			0.03	0.79		1.01		
16			0.40		0.08			0.41	0.07	0.24		
17			0.02			0.01			0.16			0.04
18	0.14		0.06		0.52	0.02	0.16		2.53	0.04		
19			0.03			0.20	0.19			0.63		0.10
20			0.17					0.13			0.25	0.03
21		0.01	0.26					2.46			0.06	
22				0.04	0.02					0.01		0.01
23				0.79	0.03		0.41					1.25
24					0.43		2.39				0.55	
25				0.06		0.07				0.01	0.29	
26				1.00	0.21	0.12						0.09
27			0.23	0.20	0.29		0.41					0.02
28	0.23				0.38		0.16		1.89		1.59	
29						0.07	0.01		0.62			
30								0.26	0.06	0.15		
31			1.56		0.02			0.05				
Days with rain	9	4	17	14	15	11	13	11	9	9	8	15
Total rainfall	**1.28**	**1.45**	**3.37**	**6.57**	**3.27**	**1.28**	**4.88**	**5.07**	**7.53**	**2.24**	**3.79**	**4.42**
Minimum rainfall	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.06	0.01	0.05	0.01
Maximum rainfall	0.29	0.92	1.56	2.18	0.61	0.26	2.39	2.46	2.53	1.01	1.59	1.25

Data are recorded from 1 am to 1 am EST.

Table A-3

Precipitation data for 2005

Source: NOAA Station in Worcester, MA

Date	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1			0.07	0.02	0.06		0.04	0.03				
2	0.04			1.27	0.18			0.04			0.01	
3	0.38	0.18		0.75								
4	0.29	0.13		0.01								0.17
5	0.13							0.08				
6	1.09						1.68				0.30	
7				0.15	0.68		0.01			0.25		
8	0.69		0.61	0.12		0.69	2.49			3.03		
9		0.07					0.09	0.02		0.66	0.35	0.63
10		0.62								1.45	0.33	
11	0.06	0.11	0.10							0.99		
12	0.44		0.51			0.01				0.20		
13	0.01		0.24							0.43		
14	0.85	0.21				0.26		0.60		2.00		
15		0.60			0.21			0.57	0.94	3.32	0.11	
16	0.03	0.31			0.29	0.20			0.58		0.72	1.22
17	0.15					0.13	0.07		0.38		0.20	
18										0.06		
19	0.09				0.05		0.28					
20	0.01			0.15					0.15			
21		0.45		0.12				0.34			0.21	
22	0.31	0.01		0.04	0.13	0.02	0.03			0.55	1.23	
23	0.85	0.02	0.08	1.50	0.24					0.52		
24		0.13	0.36	0.81	0.52			0.12		0.40	0.31	
25		0.07		0.17	0.75					1.66		0.66
26	0.41				0.34				0.30	0.01		0.61
27	0.01			0.86	0.19		0.30					
28	0.01	0.11	1.34	0.04		0.27		0.09				
29			0.82			0.19			0.48	0.03	0.05	0.32
30				0.48	0.04			0.36			0.94	
31					0.03		0.03	0.39				0.14
Days with rain	19	14	9	15	14	8	10	11	6	16	12	7
Total rainfall	**5.85**	**3.02**	**4.13**	**6.49**	**3.71**	**1.77**	**5.02**	**2.64**	**2.83**	**15.56**	**4.76**	**3.75**
Minimum rainfall	0.01	0.01	0.07	0.01	0.03	0.01	0.01	0.02	0.15	0.01	0.01	0.14
Maximum rainfall	1.09	0.62	1.34	1.50	0.75	0.69	2.49	0.60	0.94	3.32	1.23	1.22

Data are recorded from 1 am to 1 am EST.

Table A-4

Precipitation data for 2004

Source: City of Woonsocket - Water Treatment Plant

Date	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1				2.11		0.33			0.08	0.10		0.13
2	0.01			1.20	0.15	0.11	0.45	0.22		0.01		0.30
3	0.15				0.88	0.02	0.17				0.04	
4	0.13	0.69	0.13									
5	0.69		0.02	0.13				1.30	0.01		1.09	
6	0.15		0.36				1.16					
7		1.22	0.06			0.14		0.02				0.18
8		0.03	0.05						0.30			1.00
9			0.16						0.88			
10					0.36	0.09			0.19			0.15
11							0.01					0.60
12	0.08											0.01
13			0.02	0.54			0.05	2.11			0.84	0.02
14				2.75			0.36	0.09			0.05	0.02
15	0.03			0.58			0.02	1.67		0.20		
16				0.08				0.13	0.09	0.82		
17			0.52		0.04			0.05	0.06	0.01		0.02
18	0.01	0.01	0.09			0.08			0.83			
19	0.21		0.04		0.24		0.04		1.75	0.28		
20										0.08		0.28
21			0.43								0.45	0.09
22		0.03						1.45				
23				0.72	0.01					0.06		0.03
24				0.14	0.55		0.50					1.09
25					0.09		0.14			0.03	0.52	
26				0.49	0.01		0.01				0.33	
27			0.20	0.57	0.40							0.81
28	0.15			0.12			0.05		0.06			
29	0.18				0.57	0.17	0.05		2.06		1.95	
30									0.16	0.02		
31			0.01					0.06		0.06		
Days with rain	11	5	13	12	11	7	13	10	12	11	8	15
Total rainfall	**1.79**	**1.98**	**2.09**	**9.43**	**3.30**	**0.94**	**3.01**	**7.10**	**6.47**	**1.67**	**5.27**	**4.73**
Minimum rainfall	0.01	0.01	0.01	0.08	0.01	0.02	0.01	0.02	0.01	0.01	0.04	0.01
Maximum rainfall	0.69	1.22	0.52	2.75	0.88	0.33	1.16	2.11	2.06	0.82	1.95	1.09

Data are recorded between 8:00am of the previous day and 8:00 am of the day of the recording.

Table A-5

Precipitation data for 2005

Source: City of Woonsocket - Water Treatment Plant

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1			0.44	0.02	0.63	0.01	0.26		0.24			0.70
2			0.02	0.57	0.13		0.01	0.01				
3	0.03			2.55	0.08							
4	0.73	0.41		0.02								0.03
5												0.14
6	0.66						0.03	0.23				
7	0.43				0.40		2.05				0.15	
8	0.01		0.02	0.42	1.05		0.01			0.31		
9	0.86		0.97		0.02		1.13	0.02		2.91		0.14
10	0.01	0.22					0.01			0.05	0.83	1.04
11		0.54								0.11		
12	0.45		0.34							0.16		
13	0.17		0.67			0.02				0.32		
14	0.12									0.53	0.02	
15	0.67	1.15				0.46		1.07	0.07	6.80		
16					0.10	0.01		0.01	1.16	1.05	0.06	0.41
17	0.07	0.19				0.25			0.19		0.39	
18									0.03	0.01		
19					0.17	0.01	0.21					
20	0.11						0.28					
21		0.17	0.04	0.12					0.03			
22		0.12			0.03			0.45			1.44	
23	1.16	0.02		0.05	0.01	0.05	0.02			1.12	0.67	
24	0.15		0.45	1.15	0.11					0.01	0.12	
25		0.28		0.47	0.98					0.92	0.07	
26	0.10			0.01	1.07					1.10		0.77
27	0.27			0.06	0.13				0.38			0.36
28			0.21	0.73	0.20		0.02	0.11		0.01		
29			2.95	0.06	0.17	0.03		0.96				
30			0.01	0.02		0.16		1.16	0.42	0.30	0.38	0.56
31					0.03							
Days with rain	17	9	11	14	17	9	11	9	8	16	10	9
Total rainfall	**6.00**	**3.10**	**6.12**	**6.25**	**5.31**	**1.00**	**4.03**	**4.02**	**2.52**	**15.71**	**4.13**	**4.15**
Minimum rainfall	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.01	0.02	0.03
Maximum rainfall	1.16	1.15	2.95	2.55	1.07	0.46	2.05	1.16	1.16	6.80	1.44	1.04

Data are recorded between 8:00am of the previous day and 8:00 am of the day of the recording.

Appendix B

Laboratory QA/QC for Metal Analyses

Interlaboratory Comparisons

MITKEM Metals Data, edited due to Quality Concerns:

These data are presented here for completeness, but were edited in the data tables and not used in the water quality analyses in the report. See Section 3.1.2 for further discussion on the reason for removing these data.

Laboratory Statements regarding Reporting Limits

Mitkem: Reporting Limit for TKN of 0.1 mg/l
STL: Reporting Limit for Dissolved Copper of 1.0 ug/l
STL: Reporting Limit for Dissolved Lead of 0.1 ug/l

Table B-1: Laboratory Comparison for Dry Weather Concentrations - Dissolved Copper (ug/l)

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Location	Mitkem / Microinorganics / STL Comparison																																				
						20-Apr-05 Mitkem	20-Apr-05 Microinorg.	Hardness (mg/l)	Acute Criteria	Chronic Criteria	11-May-05 Mitkem	11-May-05 Microinorg.	Hardness (mg/l)	Acute Criteria	Chronic Criteria	23-May-05 Mitkem	23-May-05 Microinorg.	Hardness (mg/l)	Acute Criteria	Chronic Criteria	21-Jul-05 Mitkem	21-Jul-05 Microinorg.	21-Jul-05 STL	Hardness (mg/l)	Acute Criteria	Chronic Criteria	3-Aug-05 Mitkem	3-Aug-05 STL	Hardness (mg/l)	Acute Criteria	Chronic Criteria	11-Aug-05 Mitkem	11-Aug-05 Microinorg.	11-Aug-05 STL	Hardness (mg/l)	Acute Criteria	Chronic Criteria	14-Sep-05 Microinorg.	14-Sep-05 STL	Hardness (mg/l)	Acute Criteria	Chronic Criteria
					Event No. (DW-__)	2					3					4					7						8					9						11				
W-01	Reach 1	●			Millville (***MA/RI*** *border*)	***8.1*** B	3.25	47	6.6	4.7	***8.2*** B	3.81	41	5.8	4.2	**5.6** B	2.96	48	6.7	4.8	***11.9*** B		**7.1**	53	7.4	5.2	**10.7** B	**7.6**	70	9.6	6.6	***12.4*** B		**7.5**	61	8.4	5.9		***10.0***	72	9.9	6.8
W-23			●		Branch River																<3.2		2.0	**18**	2.7	2.1						<3.2	1.12	1.4	22	3.2	2.5	0.71 B	1.5	26	3.8	2.8
W-21		●			Singleton Street																**6.4** B		4.7	53	7.4	5.2						6.6 B		5.4	61	8.4	5.9		6.6	72	9.9	6.8
W-22		●			Below Thundermist Dam																**6.4** B		5.1	53	7.4	5.2						6.1 B		5.5	61	8.4	5.9		6.3	72	9.9	6.8
W-11			●		Mill River (***MA/RI*** *border*)																<3.2	1.30	2.9	35	5.0	3.7						3.4 B	0.75 J	1.7	42	5.9	4.3	0.68 B	2.0	48	6.7	4.8
W-12			●		Mill River (pre-culvert entry)																<3.2		2.3	35	5.0	3.7						<3.2	0.53 J	1.2	42	5.9	4.3	0.89 B	2.3	48	6.7	4.8
W-13			●		Mill River (confluence w/ BR)																<3.2		2.5	35	5.0	3.7						4.8 B	0.78 J	1.7	42	5.9	4.3	1.58	1.6	48	6.7	4.8
W-14			●		Peters River (***MA/RI*** *border*)																<3.2	0.70 b	2.4	56	7.8	5.5						<3.2		0.89	74	10.1	6.9		1.9	76	10.4	7.1
W-15			●		Peters River (pre-culvert entry)																<3.2		1.9	56	7.8	5.5						3.3 B		1.8	74	10.1	6.9		2.5	76	10.4	7.1
W-16			●		Peters River (confluence w/ BR)																			56	7.8	5.5						<3.2		1.5	74	10.1	6.9		2.0	76	10.4	7.1
W-17		●			Hamlet Avenue																**5.3** B		4.1	53	7.4	5.2						6.5 B		5.1	61	8.4	5.9		6.6	72	9.9	6.8
W-24				●	Woonsocket WWTF																7.9 B	6.26	8.0	160	20.9	13.4													7.9	150	19.7	12.7
W-02	Reach 2	●			Manville Dam	**6.2** B	2.31	47	6.6	4.7	***7.1*** B	2.36	41	5.8	4.2	**5.5** B	2.34	48	6.7	4.8	**5.5** B	3.22	5.1	53	7.4	5.2	8.0 B	5.6	70	9.6	6.6	8.6 B		5.5	61	8.4	5.9		**7.1**	72	9.9	6.8
W-03		●			George Washington Hwy Bridge	**5.5** B	2.61	47	6.6	4.7	**5.1** B	2.42	41	5.8	4.2	**6.5** B	2.39	48	6.7	4.8	4.9 B		4.9	53	7.4	5.2	7.5 B	6.3	70	9.6	6.6	8.2 B		5.5	61	8.4	5.9		6.2	72	9.9	6.8
W-04	Reach 3	●			Lonsdale Ave	**5.7** B	2.67	47	6.6	4.7	3.9 B	2.49	41	5.8	4.2	**5.7** B	2.13	48	6.7	4.8	**5.4** B	3.50	4.7	53	7.4	5.2	7.2 B	5.8	70	9.6	6.6	7.2 B		5.4	61	8.4	5.9		5.9	72	9.9	6.8
W-25		●			Broad Street																**5.9** B	2.76	3.8	53	7.4	5.2						**4.6** B		5.4	61	8.4	5.9		5.2	72	9.9	6.8
W-26			●		Abbott Run Brook																<3.2		1.3	34	4.9	3.6							0.64 J	0.7	72	9.9	6.8	0.37 B	0.95	30	4.3	3.2
W-05		●			Slaters Mill Dam	4.7 B	2.37	47	6.6	4.7	4.1 B	2.24	41	5.8	4.2	**5.0** B	2.29	48	6.7	4.8	5.0 B		4.7	53	7.4	5.2	6.6 B	5.0	70	9.6	6.6	6.2 B		4.5	61	8.4	5.9		5.1	72	9.9	6.8
W-31	1			●	Cherry Brook																<3.2	2.36	3.2	43	6.1	4.4						<3.2		1.6	85	11.5	7.8		2.8	84	11.4	7.7
W-32				●	Front Street Drain																<3.2	1.82	2.0	71	9.7	6.7						<3.2		0.72	72	9.9	6.8		1.5	73	10.0	6.8
W-33				●	Sylvestre Pond Outflow																<3.2	1.98	3.4	42	5.9	4.3						<3.2		1.5	51	7.1	5.0		1.6	44	6.2	4.4
W-34	2			●	Blackstone Canal at Lonsdale																**6.7** B		3.8	51	7.1	5.0						4.0 B		3.6	64	8.8	6.1					
QA QC Sample Comparison																																										
W-02	1 2				Sample Analysis	**6.2** B	2.31	47	6.6	4.7	**7.1** B	2.36	41	5.8	4.2	**5.5** B	2.34	48	6.7	4.8																						
W-02					Field Duplicate	5.5 B	2.07	47	6.6	4.7	**6.5** B	2.31	41	5.8	4.2	**5.4** B	2.32	48	6.7	4.8																						
W-02					Lab Duplicate (of sample analysis)						**6.9** B		41	5.8	4.2																											
W-01	1				Sample Analysis	**8.1** B		47	6.6	4.7																	**10.7** B		68	9.3	6.4											
W-01					Field Duplicate																																					
W-01					Lab Duplicate (of sample analysis)	**6.4** B		47	6.6	4.7																	**9.2** B		68	9.3	6.4											
W-11	1				Sample Analysis (W-11)																<3.2		2.9	35	5.0	3.7						3.4 B	0.75 J	1.7	42	5.9	4.3	0.68 B	2.0	48	6.7	4.8
W-41					Field Duplicate of W-11																<3.2		2.0	35	5.0	3.7						<3.2	0.78 J	2.0	42	5.9	4.3	0.72 B	1.9	48	6.7	4.8
W-11					Lab Duplicate of W-11																												0.53						2.0	48	6.7	4.8
W-14	1				Sample Analysis (W-14)																<3.2		2.4	56	7.8	5.5						<3.2		0.9	74	10.1	6.9		1.9	76	10.4	7.1
W-42					Field Duplicate of W-14																<3.2		2.2	56	7.8	5.5						<3.2		1.2	74	10.1	6.9		2.4	76	10.4	7.1
W-14					Lab Duplicate of W-14																																			76	10.4	7.1
W-04	2 3				Sample Analysis (W-04)																**5.4** B	3.50	4.7	53	7.4	5.2	7.2 B	5.8	72	9.9	6.8	7.2 B		5.4	61	8.4	5.9		5.9	72	9.9	6.8
W-43					Field Duplicate of W-04																**5.5** B	3.46	**5.4**	53	7.4	5.2	6.5 B	5.8	71	9.7	6.7	5.8 B		5.3	61	8.4	5.9		5.7	72	9.9	6.8
W-04					Lab Duplicate of W-04																	3.38										6.2 B							5.9	72	9.9	6.8

🟩	STL data	B	Below the Reporting Limit (RL) but above the Method Detection Limit (MDL.).
🟧	Mitkem data	<3.2	Below the Detection Limit.
🟨	Microinorganics data		
8.2	Value exceeds Chronic Criteria.		
9.5	Value exceeds Acute Criteria.		

Table B-2: Laboratory Comparison for Dry Weather Concentrations - Dissolved Lead (ug/l)

						Mitkem / Microinorganics / STL Comparison																																				
Station No.	**Reach**	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location**	**20-Apr-05 Mitkem**	**20-Apr-05 Microinorg.**	Hardness (mg/l)	Acute Criteria	Chronic Criteria	**11-May-05 Mitkem**	**11-May-05 Microinorg.**	Hardness (mg/l)	Acute Criteria	Chronic Criteria	**23-May-05 Mitkem**	**23-May-05 Microinorg.**	Hardness (mg/l)	Acute Criteria	Chronic Criteria	**21-Jul-05 Mitkem**	**21-Jul-05 Microinorg.**	**21-Jul-05 STL**	Hardness (mg/l)	Acute Criteria	Chronic Criteria	**3-Aug-05 Mitkem**	**3-Aug-05 STL**	Hardness (mg/l)	Acute Criteria	Chronic Criteria	**11-Aug-05 Mitkem**	**11-Aug-05 Microinorg.**	**11-Aug-05 STL**	Hardness (mg/l)	Acute Criteria	Chronic Criteria	**11-Sep-05 Microinorg.**	**11-Sep-05 STL**	Hardness (mg/l)	Acute Criteria	Chronic Criteria
					Event No. (DW-__)	2					3					4					7						8					9						11				
W-01	Reach 1	●			Millville *(**MA/RI** border)*	**2.0** B	0.413	47	28.1	1.10	0.75 B	0.40	41	24.2	0.94	<0.23	0.46	48	28.8	1.12	<0.23		0.24 B	53	32.1	1.25	<0.23	0.18	70	43.7	1.70	<0.23		0.28	61	37.6	1.46		0.37	72	45.1	1.76
W-23			●		Branch River																<0.23		**0.67** B	**18**	9.6	0.37						0.24 B	0.47	**0.77**	22	12.0	0.47	0.19 B	0.39	26	14.5	0.57
W-21		●			Singleton Street																0.23 B		0.29 B	53	32.1	1.25						<0.23		0.11	61	37.6	1.46		0.27	72	45.1	1.76
W-22		●			Below Thundermist Dam																<0.23		0.47 B	53	32.1	1.25						<0.23		0.10	61	37.6	1.46		0.25	72	45.1	1.76
W-11			●		Mill River *(**MA/RI** border)*																<0.23	0.42	**0.89** B	35	20.3	0.79						<0.23	0.15 B	0.48	42	24.8	0.97	0.14 B	0.19	48	28.8	1.12
W-12			●		Mill River (pre-culvert entry)																<0.23		0.66 B	35	20.3	0.79						**1.5** B	<0.04	0.11	42	24.8	0.97	<0.04	0.24	48	28.8	1.12
W-13			●		Mill River (confluence w/ BR)																<0.23		**0.80** B	35	20.3	0.79						<0.23	<0.08	0.31	42	24.8	0.97	<0.08	0.29	48	28.8	1.12
W-14			●		Peters River *(**MA/RI** border)*																<0.23	0.22	0.55 B	56	34.2	1.33						<0.23		0.08	74	46.5	1.81		0.43	76	47.8	1.86
W-15			●		Peters River (pre-culvert entry)																<0.23		0.44 B	56	34.2	1.33						<0.23		0.12	74	46.5	1.81		0.19	76	47.8	1.86
W-16			●		Peters River (confluence w/ BR)																											<0.23		0.10	74	46.5	1.81		0.18	76	47.8	1.86
W-17		●			Hamlet Avenue																<0.23		0.27 B	53	32.1	1.25						<0.23		0.09	61	37.6	1.46		0.22	72	45.1	1.76
W-24				●	Woonsocket WWTF																<0.23	<0.08	0.08 B	160	107.3	4.18													0.10	150	100.1	3.90
W-02	Reach 2	●			Manville Dam	**1.5** B	0.324	47	28.1	1.10	0.49 B	0.35	41	24.2	0.94	<0.23	0.42	48	28.8	1.12	<0.23	0.26	0.22 B	53	32.1	1.25	0.64 B	0.08	70	43.7	1.70	<0.23		0.05	61	37.6	1.46		0.38	72	45.1	1.76
W-03		●			George Washington Hwy Bridge	**1.3** B	0.294	47	28.1	1.10	0.75 B	0.32	41	24.2	0.94	<0.23	0.39	48	28.8	1.12	<0.23		0.18 B	53	32.1	1.25	<0.23	0.09	70	43.7	1.70	<0.23		<0.04	61	37.6	1.46		0.13	72	45.1	1.76
W-04	Reach 3	●			Lonsdale Ave	1.1 B	0.352	47	28.1	1.10	0.76 B	0.36	41	24.2	0.94	<0.23	0.36	48	28.8	1.12	<0.23	0.26	0.14 B	53	32.1	1.25	<0.23	<0.04	70	43.7	1.70	<0.23		<0.04	61	37.6	1.46		0.14	72	45.1	1.76
W-25		●			Broad Street																<0.23	0.33	0.25 B	53	32.1	1.25						<0.23		0.05	61	37.6	1.46		0.17	72	45.1	1.76
W-26			●		Abbott Run Brook																<0.23		0.23 B	34	19.6	0.76							0.16 B	0.05	72	45.1	1.76	0.10 B	0.21	30	17.0	0.66
W-05		●			Slaters Mill Dam	0.97 B	0.327	47	28.1	1.10	0.92 B	0.29	41	24.2	0.94	<0.23	0.38	48	28.8	1.12	<0.23		0.25 B	53	32.1	1.25	<0.23	0.05	70	43.7	1.70	<0.23		<0.04	61	37.6	1.46		0.12	72	45.1	1.76
W-31	1			●	Cherry Brook																<0.23	**1.23**	**2.30** B	43	25.5	0.99						0.31 B		0.55	85	54.1	2.11		0.36	84	53.4	2.08
W-32				●	Front Street Drain																<0.23	0.17 b	0.35 B	71	44.4	1.73						<0.23		<0.04	72	45.1	1.76		0.08	73	45.8	1.78
W-33				●	Sylvestre Pond Outflow																<0.23	0.43	0.38 B	42	24.8	0.97						0.57 B		0.28	51	30.8	1.20		0.36	44	26.1	1.02
W-34	2			●	Blackstone Canal at Lonsdale																0.51 B		0.74 B	51	30.8	1.20						<0.23		0.83	64	39.6	1.54					
QA QC Sample Comparison																																										
W-02	1 2				Sample Analysis	**1.5** B	0.324	47	28.1	1.10	0.49 B	0.35	41	24.2	0.94	<0.23	0.42	48	28.8	1.12																						
W-02					Field Duplicate	0.84 B	0.282	47	28.1	1.10	0.57 B	0.33	41	24.2	0.94	<0.23	0.41	48	28.8	1.12																						
W-02					Lab Duplicate (of sample analysis)						**1.1** B		41	24.2	0.94																											
W-01	1				Sample Analysis	**2.0** B		47	28.1	1.10																	<0.23		70	43.7	1.70											
W-01					Field Duplicate																																					
W-01					Lab Duplicate (of sample analysis)	**1.7** B		47	28.1	1.10																	0.26 B		70	43.7	1.70											
W-11	1				Sample Analysis (W-11)																<0.23		**0.89** B	35	20.3	0.79						<0.23	0.15 B	0.48	42	24.8	0.97	0.14 B	0.19	48	28.8	1.12
W-41					Field Duplicate of W-11																<0.23		0.65 B	35	20.3	0.79						0.95 B	0.15 B	0.26	42	24.8	0.97	0.15 B	0.21	48	28.8	1.12
W-11					Lab Duplicate of W-11																												0.12 B							48	28.8	1.12
W-14	1				Sample Analysis (W-14)																<0.23		0.55 B	56	34.2	1.33						<0.23		0.08	74	46.5	1.81		0.43	76	47.8	1.86
W-42					Field Duplicate of W-14																<0.23		0.63 B	56	34.2	1.33						<0.23		0.14	74	46.5	1.81		**1.90**	76	47.8	1.86
W-14					Lab Duplicate of W-14																																					
W-04	2 3				Sample Analysis (W-04)																<0.23	0.26	0.14 B	53	32.1	1.25	<0.23	<0.04	70	43.7	1.70	<0.23		<0.04	61	37.6	1.46		0.14	72	45.1	1.76
W-43					Field Duplicate of W-04																<0.23	0.21	0.25 B	53	32.1	1.25	<0.23	0.04	70	43.7	1.70	<0.23		<0.04	61	37.6	1.46		0.13	72	45.1	1.76
W-04					Lab Duplicate of W-04																	0.24										<0.23								72	45.1	1.76

🟩	STL data
🟧	Mitkem data
🟨	Microinorganics data
8.2	Value exceeds Chronic Criteria.

B	Below the Reporting Limit (RL) but above the Method Detection Limit (MDL.).
<3.2	Below the Detection Limit.

Table B-3: Laboratory Comparison for Storm Data: Dissolved Copper (ug/l)

					WW-02 (September 16, 2005)										WW-03 (October 8/9, 2005)										WW-04 (October 22/23, 2005)													
Station No.	**Blackstone River**	**Tributary**	**WWTF/outfall/other**	**Location**	**STL**	**Microinorg.**	Hardness (mg/l)	Acute Criteria	Chronic Criteria	**STL**	**Microinorg.**	Hardness (mg/l)	Acute Criteria	Chronic Criteria	**STL**	**Microinorg.**	Hardness (mg/l)	Acute Criteria	Chronic Criteria	**STL**	**Microinorg.**	Hardness (mg/l)	Acute Criteria	Chronic Criteria	**STL**	**Microinorg** *(1)*	**Microinorg** *(2) unfiltered*	**Microinorg** *(2) filtered*	Hardness (mg/l)	Acute Criteria	Chronic Criteria	**STL**	**Microinorg** *(1)*	**Microinorg** *(2) unfiltered*	**Microinorg** *(2) filtered*	Hardness (mg/l)	Acute Criteria	Chronic Criteria
				Run No.	Run 1					Run 2					Run 2					Run 7					Run 2							Run 4						
W-01	●			Millville, MA											7.9		62	8.6	6.0	8.2		36	5.1	3.7	7.4				38	5.4	3.9	6.2				32	4.6	3.4
W-23		●		Branch River											6.2	2.6	24	3.5	2.6	2.5	2.1	19	2.8	2.2	9.5	5.9	8.7	10.1	12	1.8	1.5	4.3	2.9	3.3	4.6	14	2.1	1.7
W-21	●			Singleton Street											10.0		58	8.0	5.6	6.5		45	6.3	4.5	7.1		7.2	7.7	29	4.2	3.1	5.6		6.5	5.5	28	4.1	3.0
W-22	●			Below Thundermist Dam											10.0		58	8.0	5.6	6.0		44	6.2	4.4	9.1		7.9	9.1	29	4.2	3.1	5.9		5.5	5.4	31	4.5	3.3
W-11		●		Mill River (MA/RI border)	2.0	2.0	42	5.9	4.3	2.0	0.7	42	5.9	4.3	1.9	1.7	36	5.1	3.7	1.8	1.0	37	5.3	3.8	2.9	2.4			29	4.2	3.1	4.9	1.6			26	3.8	2.8
W-12		●		Mill River (pre-culvert entry)	4.4	3.4	26	3.8	2.8	4.1	1.5	30	4.3	3.2	1.8	1.1	39	5.5	4.0	2.1	1.6	38	5.4	3.9	2.7	1.6			30	4.3	3.2	3.4	1.5			27	3.9	2.9
W-13		●		Mill River (confluence w/ BR)	5.0	3.5	17	2.5	2.0	2.8		36	5.1	3.7	3.5	3.3	38	5.4	3.9	2.3	1.7	35	5.0	3.7	2.7	1.8			26	3.8	2.8	2.8	1.6			25	3.6	2.7
W-14		●		Peters River (MA/RI border)	4.4		5	0.7	0.6	2.4		68	9.3	6.4	2.1		64	8.8	6.1	2.1		26	3.8	2.8	3.5				48	6.7	4.8	3.1				46	6.5	4.6
W-15		●		Peters River (pre-culvert entry)	2.2		21	3.1	2.4	3.3		9	1.4	1.1	2.5		52	7.3	5.1	2.8		29	4.2	3.1	3.9				43	6.1	4.4	2.8				39	5.5	4.0
W-16		●		Peters River (confluence w/ BR)	3.5		21	3.1	2.4	3.7	3.0	25	3.6	2.7	2.6		54	7.5	5.3																			
W-17	●			Hamlet Avenue											7.9		56	7.8	5.5	5.8		45	6.3	4.5	4.3				30	4.3	3.2	4.4				31	4.5	3.3
W-24			●	Woonsocket WWTF											12.0		280	35.5	21.6																			
W-02	●			Manville Dam											5.9		64	8.8	6.1	4.7		45	6.3	4.5	4.4				32	4.6	3.4	4.0				30	4.3	3.2
W-03	●			George Washington Hwy Bridge											5.3		61	8.4	5.9	4.4		38	5.4	3.9	4.4				32	4.6	3.4	4.4				34	4.9	3.6
W-04	●			Lonsdale Ave											4.8		60	8.3	5.8	5.2		44	6.2	4.4	4.6				34	4.9	3.6	5.0				35	5.0	3.7
W-25	●			Broad Street											4.4		29	4.2	3.1	5.5		24	3.5	2.6	5.0				36	5.1	3.7	4.7				34	4.9	3.6
W-26		●		Abbott Run Brook											1.0	0.8	66	9.1	6.3	1.3	0.7	50	7.0	5.0	1.3	0.6			33	4.7	3.5	1.3	0.6			37	5.3	3.8
W-05	●			Slaters Mill Dam											4.2		58	8.0	5.6	5.2		54	7.5	5.3	4.8				32	4.6	3.4	4.9				32	4.6	3.4
W-31			●	Cherry Brook											5.2		34	4.9	3.6	4.4		37	5.3	3.8	4.1		3.7	4.1	36	5.1	3.7	3.9		3.0	4.1	32	4.6	3.4
W-32			●	Front Street Drain											5.7		44	6.2	4.4	4.1		60	8.3	5.8	3.8				34	4.9	3.6	3.0				33	4.7	3.5
W-33			●	Sylvestre Pond Outflow											3.1		36	5.1	3.7	2.4		18	2.7	2.1	1.9				48	6.7	4.8	2.0				47	6.6	4.7
W-34			●	Blackstone Canal at Lonsdale											4.4		63	8.7	6.0	4.4		62	8.6	6.0	4.4				39	5.5	4.0	4.1				35	5.0	3.7
QA/QC Sample Comparison																																						
W-12				Sample Analysis							1.5	30	4.3	3.2																								
W-12				Field Duplicate																																		
W-12				Lab Duplicate (of sample analysis)							1.5	30	4.3	3.2																								
W-23				Sample Analysis																	2.1	19	2.8	2.2														
W-23				Field Duplicate																																		
W-23				Lab Duplicate (of sample analysis)																	2.2	19	2.8	2.2														
W-26				Sample Analysis																						0.6			33	4.7	3.5							
W-26				Field Duplicate																																		
W-26				Lab Duplicate (of sample analysis)																						0.6			33	4.7	3.5							
W-11				Sample Analysis (W-11)	2.0		42	5.9	4.3	2.0	0.7	42	5.9	4.3		1.7	36	5.1	3.7		1.0	37	5.3	3.8	2.9				29	4.2	3.1	4.9	1.6			26	3.8	2.8
W-41				Field Duplicate of W-11						1.6	0.6	41	5.8	4.2	3.2	2.7	45	6.3	4.5		0.7				3.1				26	3.8	2.8	2.9	1.5			28	4.1	3.0
W-11				Lab Duplicate of W-11	2.1																																	
W-14				Sample Analysis (W-14)						2.4		68	9.3	6.4	2.1		64	8.8	6.1						3.5				48	6.7	4.8	3.1				46	6.5	4.6
W-42				Field Duplicate of W-14						2.1		66	9.1	6.3	2.8		78	10.6	7.2						5.0				47	6.6	4.7	3.5				47	6.6	4.7
W-14				Lab Duplicate of W-14											2.2		64	8.8	6.1																			
W-04				Sample Analysis (W-04)																					4.6				34	4.9	3.6	5.0				35	5.0	3.7
W-43				Field Duplicate of W-04											5.0		61	8.4	5.9						4.7				34	4.9	3.6	4.9				40	5.7	4.1
W-04				Lab Duplicate of W-04																																		

(1) Analyses by Microinganics right after sampling, parallel to STL's analysis.

(2) Rerun in April by Microinorganics (for verification).

🟦 Laboratory value appears low.

Table B-4: Laboratory Comparison for Storm Data: Dissolved Lead (ug/l)

					WW-02 (September 16, 2005)										WW-03 (October 8/9, 2005)										WW-04 (October 22/23, 2005)													
Station No.	Blackstone R.	Tributary	WWTF/outfall	Location	STL	Microinorg.	Hardness (mg/l)	Acute Criteria	Chronic Criteria	STL	Microinorg.	Hardness (mg/l)	Acute Criteria	Chronic Criteria	STL	Microinorg.	Hardness (mg/l)	Acute Criteria	Chronic Criteria	STL	Microinorg.	Hardness (mg/l)	Acute Criteria	Chronic Criteria	STL	Microinorg (1)	Microinorg. (2) *unfiltered*	Microinorg. (2) *filtered*	Hardness (mg/l)	Acute Criteria	Chronic Criteria	STL	Microinorg (1)	Microinorg (2) *unfiltered*	Microinorg (2) *filtered*	Hardness (mg/l)	Acute Criteria	Chronic Criteria
				Run No.	Run 1					Run 2					Run 2					Run 7					Run 2							Run 4						
W-01	●			Millville, MA											0.21		62	38.2	1.49	0.35		36	20.9	0.81	1.50				38	22.2	0.87	2.20	0.37			32	18.3	0.71
W-23		●		Branch River											0.28	0.21	24	13.3	0.52	0.37	0.48	19	10.2	0.40	5.00	2.43	0.70	4.35	12	6.0	0.24	4.30	2.31	0.65	3.75	14	7.2	0.28
W-21	●			Singleton Street											1.00		58	35.5	1.38	0.98		45	26.8	1.04	30.0		5.08	27.2	29	16.4	0.64	26.0		19.2	22.8	28	15.8	0.61
W-22	●			Below Thundermist Dam											0.30		58	35.5	1.38	0.49		44	26.1	1.02	8.70		1.29	8.03	29	16.4	0.64	7.60		1.46	6.86	31	17.7	0.69
W-11		●		Mill River (MA/RI border)	0.25	0.10	42	24.8	0.97	0.18	<0.05	42	24.8	0.97	0.18	0.21	36	20.9	0.81	0.12	0.16	37	21.6	0.84	1.20	0.49			29	16.4	0.64	2.20	0.66			26	14.5	0.57
W-12		●		Mill River (pre-culvert entry)	0.83	0.66	26	14.5	0.57	0.66	0.30	30	17.0	0.66	0.24	0.20	39	22.9	0.89	0.13	1.09	38	22.2	0.87	0.34	0.30			30	17.0	0.66	1.50	0.41			27	15.1	0.59
W-13		●		Mill River (confluence w/ BR)	1.50	1.06	17	9.0	0.35	0.21		36	20.9	0.81	0.49	0.61	38	22.2	0.87	0.41	0.85	35	20.3	0.79	0.50	0.41			26	14.5	0.57	1.30	0.65			25	13.9	0.54
W-14		●		Peters River (MA/RI border)	1.10		5	2.0	0.08	0.26		68	42.3	1.65	0.13		64	39.6	1.54	0.16		26	14.5	0.57	2.30				48	28.8	1.12	2.40				46	27.5	1.07
W-15		●		Peters River (pre-culvert entry)	0.19		21	11.4	0.44	0.34		9	4.2	0.17	0.22		52	31.5	1.23	0.13		29	16.4	0.64	1.10				43	25.5	0.99	1.10				39	22.9	0.89
W-16		●		Peters River (confluence w/ BR)	0.48		21	11.4	0.44	0.91	0.72	25	13.9	0.54	0.16		54	32.8	1.28																			
W-17	●			Hamlet Avenue											0.21		56	34.2	1.33	0.42		45	26.8	1.04	1.20				30	17.0	0.66	1.50				31	17.7	0.69
W-24			●	Woonsocket WWTF											0.15		280	194.1	7.56																			
W-02	●			Manville Dam											0.30		64	39.6	1.54	0.26		45	26.8	1.04	1.20				32	18.3	0.71	1.30				30	17.0	0.66
W-03	●			George Washington Hwy Bridge											0.19		61	37.6	1.46	0.30		38	22.2	0.87	1.40				32	18.3	0.71	1.30				34	19.6	0.76
W-04	●			Lonsdale Ave											0.16		60	36.9	1.44	0.24		44	26.1	1.02	1.30				34	19.6	0.76	1.40				35	20.3	0.79
W-25	●			Broad Street											0.14		29	16.4	0.64	0.24		24	13.3	0.52	1.60				36	20.9	0.81	1.50				34	19.6	0.76
W-26		●		Abbott Run Brook											0.19	0.16	66	41.0	1.60	0.18	0.18	50	30.1	1.17	0.74	0.17			33	19.0	0.74	0.51	0.11			37	21.6	0.84
W-05	●			Slaters Mill Dam											0.18		58	35.5	1.38	0.16		54	32.8	1.28	1.30				32	18.3	0.71	1.30				32	18.3	0.71
W-31			●	Cherry Brook											0.75		34	19.6	0.76	1.00		37	21.6	0.84	5.30		2.23	5.24	36	20.9	0.81	6.90		3.93	6.77	32	18.3	0.71
W-32			●	Front Street Drain											1.40		44	26.1	1.02	0.66		60	36.9	1.44	1.60				34	19.6	0.76	1.30				33	19.0	0.74
W-33			●	Sylvestre Pond Outflow											1.20		36	20.9	0.81	1.10		18	9.6	0.37	0.79				48	28.8	1.12	0.96				47	28.1	1.10
W-34			●	Blackstone Canal at Lonsdale											0.26		63	38.9	1.52	0.22		62	38.2	1.49	1.50				39	22.9	0.89	1.20				35	20.3	0.79
QA/QC Sample Comparison																																						
W-12	Sample Analysis										0.30	30	17.0	0.66																								
W-12	Field Duplicate																																					
W-12	Lab Duplicate (of sample analysis)										0.29	30	17.0	0.66																								
W-23	Sample Analysis																				0.48	19	10.2	0.40														
W-23	Field Duplicate																																					
W-23	Lab Duplicate (of sample analysis)																				0.52	19	10.2	0.40														
W-26	Sample Analysis																									0.17			33	19.0	0.74							
W-26	Field Duplicate																																					
W-26	Lab Duplicate (of sample analysis)																									0.18			33	19.0	0.74							
W-11	Sample Analysis (W-11)									0.18	<0.05	42	24.8	0.97		0.21	36	20.9	0.81		0.16	37	21.6	0.84	1.20				29	16.4	0.64	2.20	0.66			26	14.5	0.57
W-41	Field Duplicate of W-11									0.08	<0.08	41	24.2	0.94	0.21	0.37	45	26.8	1.04		0.09				1.90				26	14.5	0.57	3.00	1.18			28	15.8	0.61
W-11	Lab Duplicate of W-11																																					
W-14	Sample Analysis (W-14)									0.26		68	42.3	1.65	0.13		64	39.6	1.54						2.30				48	28.8	1.12	2.40				46	27.5	1.07
W-42	Field Duplicate of W-14									0.12		66	41.0	1.60	0.13		78	49.2	1.92						4.60				47	28.1	1.10	3.80				47	28.1	1.10
W-14	Lab Duplicate of W-14														0.13																							
W-04	Sample Analysis (W-04)																								1.30				34	19.6	0.76	1.40				35	20.3	0.79
W-43	Field Duplicate of W-04														0.21		61	37.6	1.46						1.40				34	19.6	0.76	1.40				40	23.5	0.92
W-04	Lab Duplicate of W-04																																					

(1) Analyses by Microinganics right after sampling, parallel to STL's analysis.
(2) Rerun in April by Microinorganics (for verification).

▨ Value appears high. Laboratory error suspected. Data removed from data tables used in study.
🟧 Value appears PARTICULARLY high. Laboratory error suspected. Results were doublechecked. Data removed from data tables used in the study.
🟦 Lab value appears low.

Table B-5: Dry Weather Concentrations - Dissolved Copper and Copper *(Mitkem lab)* *(Data were not used)*

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Location	**Dissolved Copper Concentrations** (ug/l)							**Dissolved Lead Concentrations** (ug/l)						
						16-Mar-05	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05 *(3)*	16-Mar-05 *(3)*	20-Apr-05	11-May-05	23-May-05	9-Jun-05	27-Jun-05	21-Jul-05 *(3)*
					Event No. (DW-__)	1	2	3	4	5	6	7	1	2	3	4	5	6	7
W-01	Reach 1	●			Millville *(**MA/RI** border)*	*7.8*	*8.1*	*8.2*	**5.6**	*8.7*	**6.6**	*11.9*	0.47	**2.0**	0.75	<0.23	<0.23	0.85	<0.23
W-23			●		Branch River							**<3.2**							<0.23
W-21		●			Singleton Street							**6.4**							0.23
W-22		●			Below Thundermist Dam							**6.4**							<0.23
W-11			●		Mill River *(**MA/RI** border)*	**5.1**				*5.6*		<3.2	0.35				0.38		<0.23
W-12			●		Mill River (pre-culvert entry)	**4.3**				4.3		<3.2	0.24				0.37		<0.23
W-13			●		Mill River (confluence w/ BR)	**3.8**						<3.2	0.72						<0.23
W-14			●		Peters River *(**MA/RI** border)*	3.3				4.2		<3.2	<0.23				0.24		<0.23
W-15			●		Peters River (pre-culvert entry)	<3.2				3.8		<3.2	<0.23				0.51		<0.23
W-16			●		Peters River (confluence w/ BR)	<3.2							<0.23						
W-17		●			Hamlet Avenue	***12.7***				**6.0**		**5.3**	**4.7**				0.48		<0.23
W-24				●	Woonsocket WWTF							7.9							<0.23
W-02	Reach 2	●			Manville Dam	**6.0**	**6.2**	*7.1*	**5.5**	***10.9***	3.6	**5.5**	0.24	**1.5**	0.49	<0.23	0.93	<0.23	<0.23
W-03		●			George Washington Hwy Bridge	*8.6*	**5.5**	**5.1**	**6.5**	***15.7***	<3.2	4.9	<0.23	**1.3**	0.75	<0.23	**1.5**	<0.23	<0.23
W-04	Reach 3	●			Lonsdale Ave	**6.3**	**5.7**	3.9	**5.7**	*8.1*	<3.2	**5.4**	0.79	1.1	0.76	<0.23	0.30	<0.23	<0.23
W-25		●			Broad Street							**5.9**							<0.23
W-26			●		Abbott Run Brook							<3.2							<0.23
W-05		●			Slaters Mill Dam	**5.1**	4.7	4.1	**5.0**	*9.9*	**6.2**	5.0	0.34	0.97	0.92	<0.23	**1.3**	<0.23	<0.23
W-31	1			●	Cherry Brook							<3.2							<0.23
W-32				●	Front Street Drain							<3.2							<0.23
W-33				●	Sylvestre Pond Outflow							<3.2							<0.23
W-34	2			●	Blackstone Canal at Lonsdale							**6.7**							0.51
W-35	3			●	Brook near Ann&Hope														
W-02	1 2	(=W-02)			Duplicate		**5.5**	*6.5*	**5.4**		<3.2			0.84	0.57	<0.23		<0.23	
W-05	3	(=W-05)			Duplicate	*8.0*							0.54						
W-01	1	(=W-01)			Duplicate	**6.8**							0.59						
W-41		(=W-11)			Duplicate							<3.2							<0.23
W-42		(=W-14)			Duplicate							<3.2							<0.23
W-43	2 3	(=W-04)			Duplicate							**5.5**							<0.23

Mean Hardness (mg/l)															
	Blackstone River	47	47	41	48	51	60	53	47	47	41	48	51	60	53
	Branch River	0	0	0	0	0	0	18	0	0	0	0	0	0	18
	Mill River	35				37		35	35				37		35
	Peters River	45				49		56	45				49		56
	Abbott Run Brook	0	0	0	0	0	0	34	0	0	0	0	0	0	34

Reporting Limit: Dissolved Cu: 15 ug/l; Dissolved Pb: 5 ug/l.
Method Detection Limit: Dissolved Cu: 3.2 ug/l; Dissolved Pb: <0.23 ug/l . Data were reported to the Method Detection Limit.

7.8	Exceeds Acute Criteria	4.7	Outlier
5.5	Exceeds Chronic Criteria	**<3.2**	Below MDL.

Table B-6: Storm WW-01 - Dissolved Copper Concentrations (ug/l) *(Mitkem lab)* *(Data were not used)*

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm WW-01 (July 8 - 12, 2005) (*Mitkem* *[1])*														
						8-Jul			9-Jul				10-Jul		11-Jul		12-Jul	**Statistics** (Runs 2-12)		
						8:30 - 10:15h	16:40 - 18:25h	21:00 - 23:15h	0:10 - 2:30h	6:20 - 7:50h	14:30 - 16:15h	20:30 - 22:40h	6:40 - 8:10h	15:15 - 16:30h	8:40 - 10:00h	14:50 -15:30h	8:40 - 10:00h	**Minimum**	**Maximum**	**Mean**
					Run No.	1	2	3	4	5	6	7	8	9	10	11	12			
W-01	Reach 1	●			Millville, MA	***10.8***	***10.0***	***16.2***	4.2	***8.6***	***10.1***	***13.5***	***8.9***	***6.7***	***7.6***		7.5	4.2	16.2	**9.3**
W-23			●		Branch River		***4.3***	<3.2										4.3	4.3	**3.0**
W-21		●			Singleton Street		***9.7***	5.8										5.8	9.7	**7.8**
W-22		●			Below Thundermist Dam		***6.9***	5.3										5.3	6.9	**6.1**
W-11			●		Mill River (MA/RI border)	3.7	<3.2	<3.2	***8.5***			<3.2						<3.2	8.5	3.3
W-12			●		Mill River (pre-culvert entry)	3.3	***6.7***	<3.2	***6.2***			<3.2						<3.2	6.7	4.0
W-13			●		Mill River (confluence w/ BR)	***23.8***	***12.6***	5.5	5.2			3.3						3.3	12.6	**6.7**
W-14			●		Peters River (MA/RI border)	<3.2	4.1	4.3	5.2			<3.2						<3.2	5.2	3.8
W-15			●		Peters River (pre-culvert entry)	<3.2	3.9	3.4	4.0			<3.2						<3.2	4.0	3.2
W-16			●		Peters River (confluence w/ BR)													0.0	0.0	
W-17		●			Hamlet Avenue		5.6	5.3										5.3	5.6	**5.5**
W-24				●	Woonsocket WWTF					***9.9***			***9.3***					9.3	9.9	**9.6**
W-02	Reach 2	●			Manville Dam	***9.2***	***11.9***	***13.1***	4.6	***6.9***	3.7	***7.7***	***7.6***	***6.2***	***7.6***		5.4	3.7	13.1	**7.5**
W-03		●			George Washington Hwy Bridge	***9.2***	6.4	***8.6***	4.8	4.5	3.9	***5.7***	***6.2***	***6.5***	5.6	5.9	5.3	3.9	8.6	**5.8**
W-04	Reach 3	●			Lonsdale Ave	***7.8***	6.3	***7.1***	***17.7***	4.7	3.8	5.5	***5.5***	***6.0***	***7.4***	5.7	7.5	3.8	17.7	**7.0**
W-25		●			Broad Street	5.7	4.6	5.1										4.6	5.1	4.9
W-26			●		Abbott Run Brook	<3.2	<3.2	***5.9***										<3.2	5.9	**3.8**
W-05		●			Slaters Mill Dam	6.9	5.0	6.5	***13.1***	***7.3***	5.0	***5.6***	***8.2***	***10.4***	6.0	5.8	5.4	5.0	13.1	**7.1**
W-31	1			●	Cherry Brook		***7.3***	***7.5***										7.3	7.5	**7.4**
W-32				●	Front Street Drain		***103***	***12.6***										12.6	103.0	**57.8**
W-33				●	Sylvestre Pond Outflow		3.5	3.3										3.3	3.5	3.4
W-34	2			●	Blackstone Canal at Lonsdale	4.4	3.5	4.4										3.5	4.4	4.0
W-35	3			●	Brook near Ann&Hope													0.0	0.0	
W-02	1 2	(=W-02)			Duplicate	5.4	5.8	5.1	7.0	4.8	3.3	7.1	6.4	7.9	6.7					
W-05	3	(=W-05)			Duplicate															
W-01	1	(=W-01)			Duplicate															
W-41		(=W-11)			Duplicate			<3.2	3.9			<3.2								
W-42		(=W-14)			Duplicate			<3.2	3.8			<3.2								
W-43	2 3	(=W-04)			Duplicate															

[1] Samples for Storm WW-01 were analyzed by Mitkem at a higher Reporting Limit than Storms WW-02 to WW-04 by other laboratories. Thus, WW-01 data were not used.
Data shown in are reported in this table to the Method Detection Limit.

18 Concentrations are uncharacterically high.

7.7 Exceedance of Chronic Criteria (based on mean concentrations of hardness and copper per station).

8.1 Exceedance of Acute Criteria (based on mean hardness per waterbody), and typically also of chronic criteria.

Table B-7: Storm WW-01 - Dissolved Lead Concentrations (ug/l) *(Mitkem lab)* *(Data were not used)*

Station No.	Reach	Blackstone River	Tributary	WWTF/outfall/other	Sampling Dates and Times	Storm WW-01 (July 8 - 12, 2005) (*Mitkem* [1])												Statistics (Runs 2-12)		
						8-Jul			9-Jul				10-Jul		11-Jul		12-Jul			
						8:30 - 10:15h	16:40 - 18:25h	21:00 - 23:15h	0:10 - 2:30h	6:20 - 7:50h	14:30 - 16:15h	20:30 - 22:40h	6:40 - 8:10h	15:15 - 16:30h	8:40 - 10:00h	14:50 -15:30h	8:40 - 10:00h	Minimum	Maximum	Mean
					Run No.	1	2	3	4	5	6	7	8	9	10	11	12			
W-01	Reach 1	●			Millville, MA	3.20	0.36	<0.23	<0.23	0.58	**1.70**	**2.20**	0.28	1.10	0.93		1.10	<0.23	2.20	0.85
W-23			●		Branch River		<0.23	<0.23										<0.23	<0.23	0.12
W-21		●			Singleton Street		2.40	<0.23										<0.23	2.40	**1.26**
W-22		●			Below Thundermist Dam		0.80	<0.23										<0.23	0.80	0.46
W-11			●		Mill River (MA/RI border)	<0.23	<0.23	<0.23	0.52			<0.23						<0.23	0.52	0.22
W-12			●		Mill River (pre-culvert entry)	<0.23	0.50	<0.23	<0.23			<0.23						<0.23	0.50	0.22
W-13			●		Mill River (confluence w/ BR)	<0.23	2.30	<0.23	0.35			0.45						<0.23	2.30	0.81
W-14			●		Peters River (MA/RI border)	<0.23	<0.23	<0.23	<0.23			0.61						<0.23	0.61	0.24
W-15			●		Peters River (pre-culvert entry)	<0.23	0.42	<0.23	<0.23			0.35						<0.23	0.42	0.25
W-16			●		Peters River (confluence w/ BR)													0.00	0.00	
W-17		●			Hamlet Avenue		0.75	<0.23										<0.23	0.75	0.44
W-24	Reach 2			●	Woonsocket WWTF					<0.23			<0.23					<0.23	<0.23	0.12
W-02		●			Manville Dam	1.00	*ed*	<0.23	0.23	1.10	<0.23	2.10	0.87	1.10	0.90		1.10	<0.23	2.10	0.85
W-03		●			George Washington Hwy Bridge	0.59	<0.23	<0.23	<0.23	0.33	<0.23	0.69	0.51	1.30	1.20	0.99	1.00	<0.23	1.30	0.59
W-04	Reach 3	●			Lonsdale Ave	0.73	<0.23	<0.23	1.60	0.60	<0.23	<0.23	0.82	1.40	0.75	0.79	0.79	<0.23	1.60	0.66
W-25		●			Broad Street	<0.23	<0.23	<0.23										<0.23	<0.23	0.12
W-26			●		Abbott Run Brook	<0.23	<0.23	<0.23										<0.23	<0.23	0.12
W-05		●			Slaters Mill Dam	<0.23	<0.23	<0.23	0.81	<0.23	<0.23	<0.23	3.80	1.60	0.67	0.97	0.35	<0.23	3.80	0.80
W-31	1			●	Cherry Brook		7.00	<0.23										<0.23	7.00	**3.51**
W-32				●	Front Street Drain		8.90	<0.23										<0.23	8.90	**4.51**
W-33				●	Sylvestre Pond Outflow		<0.23	<0.23										<0.23	<0.23	0.12
W-34	2			●	Blackstone Canal at Lonsdale	0.48	<0.23	<0.23										<0.23	<0.23	0.12
W-35	3			●	Brook near Ann&Hope													0.00	0.00	
W-02	1 2	(=W-02)			Duplicate	1.50	<0.32	<0.23	0.80	0.53	<0.23	1.90	0.51	1.10	1.10					
W-05	3	(=W-05)			Duplicate															
W-01	1	(=W-01)			Duplicate															
W-41		(=W-11)			Duplicate			<0.23	0.23			<0.23								
W-42		(=W-14)			Duplicate			<0.23	<0.23			<0.23								
W-43	2 3	(=W-04)			Duplicate															

[1] Samples for Storm WW-01 were analyzed by Mitkem at a higher Reporting Limit than Storms WW-02 to WW-04 by other laboratories. Thus, WW-01 data were not used.
Data shown in are reported in this table to the Method Detection Limit.

0.61	Concentration of duplicate samples differ considerably from original sample.
8.9	Concentrations are uncharacterically high.
ed	Edited due to likely laboratory error.
1.8	Exceedance of Chronic Criteria (based on mean concentrations of hardness and copper per station).
8.1	Exceedance of Acute Criteria (based on mean hardness per waterbody).

Table B-8: Dissolved Copper and Lead Concentrations in Valley Falls Pond *(Mitkem Lab)*
(Data were not used)

									Regulatory Standards			
Station *(1)*	**Name**	**Time**	**Water Depth**	**Secchi Depth**	**Survey Water Depth**	**Dissolved Copper** *(6)*	**Dissolved Lead** *(6)*	**Hardness** *(6)*	**Dissolved Copper - Acute Criteria**	**Dissolved Copper - Chronic Criteria**	**Dissolved Lead - Acute Criteria**	**Dissolved Lead - Chronic Criteria**
		h	m	m	m	ug/l	ug/l	mg/l	ug/l	ug/l	ug/l	ug/l
Event POND-02: September 17, 2004 *(Dry Weather)*												
P-01	VFP - west	12:08	0.50	>0.5	0.2 0.3 0.5			61				
P-02	VFP - central	12:33	0.50	>0.5	0.2 0.3 0.4	**3.6**	**3.2**	25	3.64	2.74	13.88	0.54
P-03	VFP - east	12:58	0.50	>0.5	0.2 0.3 0.5	**6.3**	**3.2**	57	7.91	5.54	34.84	1.36
P-04	Blackstone River - up	13:30	2.80	2.3	0.2 0.5 1.0 2.0	**5.7**	<0.23	55	7.65	5.37	33.49	1.31
P-05	(duplicate of P-04)				0.5	**6.0**	<0.23	46	6.47	4.61	27.47	1.07
Event POND-03: December 6, 2004 *(Dry Weather)*												
P-01	VFP - west	10:58	0.84	>0.8	0.2 0.4 0.7	***7.9***	**2.7**	43	6.07	4.35	25.48	0.99
P-02	VFP - central	10:52	0.90	>0.9	0.2 0.4 0.7	***6.2***	<0.23	39	5.53	4.01	22.86	0.89
P-03	VFP - east	12:01	0.90	>0.9	0.2 0.4 0.8	***4.6***	<0.23	39	5.53	4.01	22.86	0.89
P-04	Blackstone River - up	12:18		1.3	0.2 1.0 4.5	**4.2**	<0.23	38	5.40	3.92	22.20	0.87
P-05	(duplicate of P-04)				1.0	**4.3**	0.72	38	5.40	3.92	22.20	0.87
Event POND-04: April 19, 2005 *(Dry Weather; sunny, calm)*												
P-01	VFP - west	9:15	0.60	0.45	0.2 0.3 0.6	**5.7**	**3.4**	49	6.86	4.87	29.47	1.15
P-02	VFP - central	9:20	0.65	0.51	0.2 0.3 0.6	**5.1**	**2.3**	50	6.99	4.95	30.14	1.17
P-03	VFP - east	9:30	0.68	0.54	0.2 0.3 0.6	**5.7**	**2.9**	50	6.99	4.95	30.14	1.17
P-04	Blackstone River - up	9:38	3.80	2.10	0.2 1.0 2.0	**4.9**	1.1	44	6.20	4.44	26.14	1.02
P-05	(duplicate of P-04)				1.0	**5.3**	0.79	47	6.60	4.70	28.13	1.10

7.8 Exceeds Acute Criteria
5.5 Exceeds Chronic Criteria (metals).

Table B-9: Dissolved Copper and Lead Concentrations in Scott Pond *(Mitkem Lab)*

(Data were not used)

									Regulatory Standards				
Station *(5)*		**Time**	**Water Depth**	**Secchi Depth**	**Survey Water Depth**	**Dissolved Copper**	**Dissolved Lead**	**Hardness**	**Dissolved Copper - Acute Criteria**	**Dissolved Copper - Chronic Criteria**	**Dissolved Lead - Acute Criteria**	**Dissolved Lead - Chronic Criteria**	**Comments**
		h	m	m	m	ug/l	ug/l	mg/l	ug/l	ug/l	ug/l	ug/l	
Event POND-02: September 16, 2004 *(Dry Weather)*													
P-07	Scott Pond North	10:53	11.0	0.4	0.2								
		-11:30			0.5	***15.2***	0.77	46	6.47	4.61	27.5	1.07	*(1)*
					8.0	***7.9***	**1.70**	50	6.99	4.95	30.1	1.17	
					10.0								
P-08	Scott Pond South	12:49	14.5	1.2	0.2								
	- northern part	-13:40			1.0	***15.6***	<0.23	25	3.64	2.74	13.9	0.54	*(1)*
					7.0	***8.1***	<0.23	43	6.07	4.35	25.5	0.99	
					13.0	**5.1**	0.41	38	5.40	3.92	22.2	0.87	
P-09	Scott Pond South	12:08	10.8		0.2								
	- southern part	-12:38			1.0	***13.0***	0.32	42	5.93	4.27	24.8	0.97	*(1)*
					7.0	**4.8**	0.95	44	6.20	4.44	26.1	1.02	
					10.0	4.2	0.84	42	5.93	4.27	24.8	0.97	
P-11	Scott Pond North Inflow	14:59	0.2		0.1	5.3	0.24	54	7.52	5.29	32.8	1.28	
P-10	(duplicate of P-08 [1 m])					***12.8***	0.35	42	5.93	4.27	24.8	0.97	*(1)*
Event POND-03: December 6, 2004 (Dry Weather)													
P-07	Scott Pond North	13:55	8.9	1.7	0.2								
					0.5	***7.0***	0.59	41	5.80	4.18	24.2	0.94	
					7.0	4.3	1.1	48	6.73	4.78	28.8	1.12	
P-08	Scott Pond South	14:29		2.0	0.2								
	- northern part				1.0	**5.5**	<0.23	41	5.80	4.18	24.2	0.94	
					7.0	***6.0***	<0.23	41	5.80	4.18	24.2	0.94	
					10.0	**5.3**	<0.23	42	5.93	4.27	24.8	0.97	
P-09	Scott Pond South	15:08		3.3	0.2								
	- southern part				1.0	**5.1**	<0.23	41	5.80	4.18	24.2	0.94	
					7.0	**5.1**	**1.4**	41	5.80	4.18	24.2	0.94	
P-11	Scott Pond North Inflow	13:21	0.2		0.1	4.2	<0.23	42	5.93	4.27	24.8	0.97	
P-10	(duplicate of P-07 [0.5 m])					**5.6**	<0.23	42	5.93	4.27	24.8	0.97	
Event POND-04: April 19, 2005 *(Dry Weather; sunny, calm)*													
P-07	Scott Pond North	10:40	8.4	1.6	0.2								
		-11:05			0.5	**5.7**	1.2	46	6.47	4.61	27.5	1.07	
					7.0	4.4	**5.1**	54	7.52	5.29	32.8	1.28	
P-08	Scott Pond South	11:40	17.1	1.5	0.2								
	- northern part	-12:05			1.0	**5.9**	0.73	42	5.93	4.27	24.8	0.97	
					7.0	***7.8***	**1.1**	42	5.93	4.27	24.8	0.97	
					11.0	***5.7***	**1.6**	38	5.40	3.92	22.2	0.87	
					15.0								
P-09	Scott Pond South	12:15	12.7	1.5	0.2								
	- southern part	-12:35			1.0	**5.7**	1.0	42	5.93	4.27	24.8	0.97	
					7.0	**5.2**	**1.2**	42	5.93	4.27	24.8	0.97	
					10.0	**4.9**	<0.23	43	6.07	4.35	25.5	0.99	
P-11	Scott Pond North Inflow	13:30			0.1	4.4	0.79	80	10.89	7.40	50.6	1.97	
P-10	(duplicate of **P-08 [7m]**)					**4.9**	**1.2**	44	6.20	4.44	26.1	1.02	

(1) Copper sulfate treatment on July 12, 2004 by Lycott Environmental, Inc. (Source: Sign on tree at boat launch at Scott Pond North).

7.8 Exceeds Acute Criteria
5.5 Exceeds Chronic Criteria (metals), or regulatory standards for bacteria, or lower than dissolved oxygen minimum, respectively.

Appendix C

Storm Drain Information

Figure C-1	Aerial photograph with storm drains mapped by the City of Woonsocket *(enclosed in pocket in the back of the report).*
Figure C-2	Map of very rough watershed boundaries for larger point sources in the Town of Cumberland. These boundaries are meant to be used for meant ONLY as a guide for more detailed watershed assessments as needed. See Figures 5-6 to 5-11 for corresponding outfall ID numbers.
Figure C-3	Map with location of NBC CSO entering Valley Falls Pond in the City of Central Falls (numbered in this study as Outfall OF-501 [NBC CSO#007]).
Figure C-4	Map with locations of other NBC CSOs entering the Blackstone River within the City of Central Falls. These outfalls were not studied.
Figure C-5	Map with locations of other NBC CSOs entering the Blackstone River within the City of Pawtucket. These outfalls were not studied.

Figure C-1

Stormlines in the City of Woonsocket

(Source: City of Woonsocket)

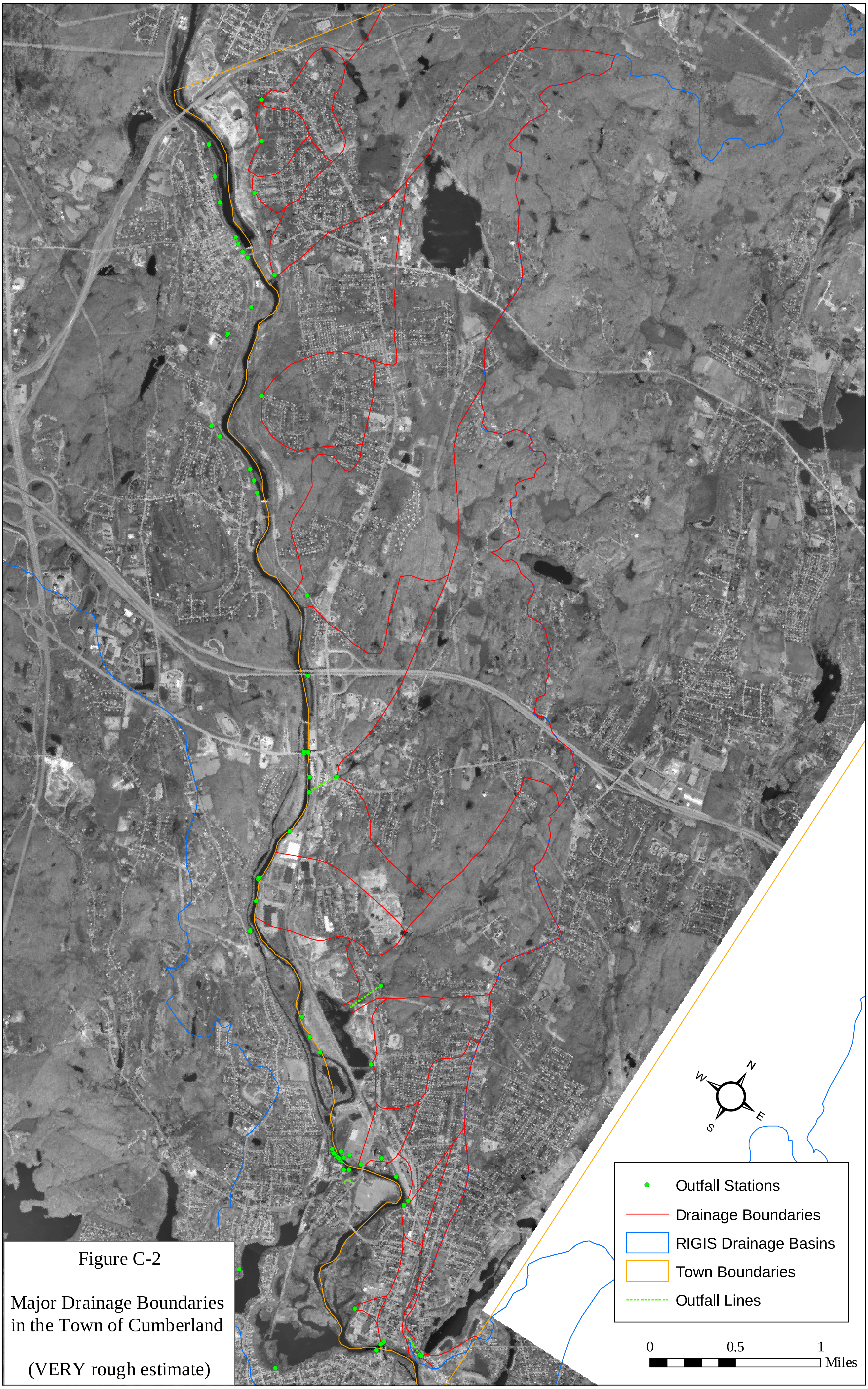
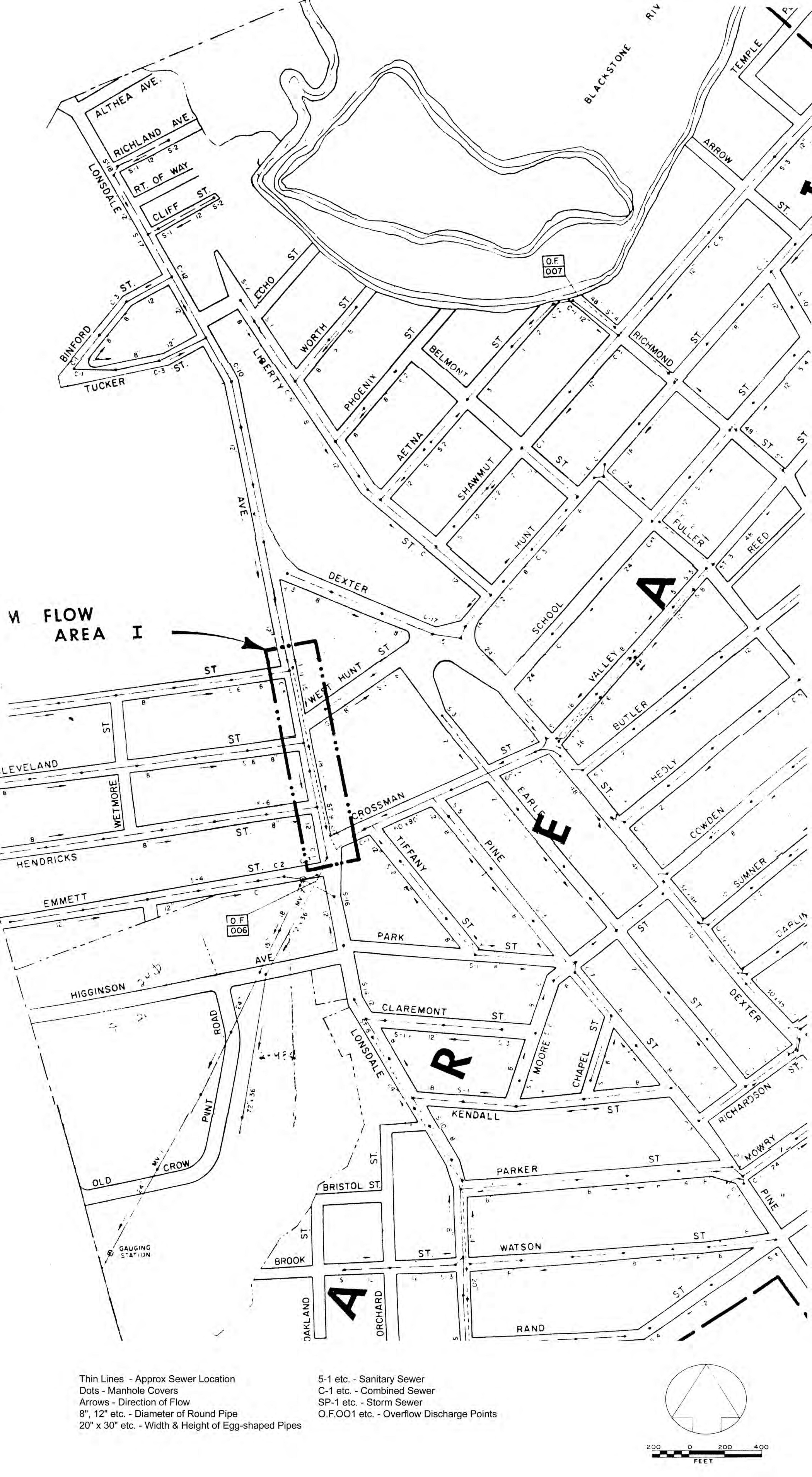


Figure C-2

Major Drainage Boundaries in the Town of Cumberland

(VERY rough estimate)



Thin Lines - Approx Sewer Location
Dots - Manhole Covers
Arrows - Direction of Flow
8", 12" etc. - Diameter of Round Pipe
20" x 30" etc. - Width & Height of Egg-shaped Pipes

5-1 etc. - Sanitary Sewer
C-1 etc. - Combined Sewer
SP-1 etc. - Storm Sewer
O.F.OO1 etc. - Overflow Discharge Points

Thin Lines - Approx Sewer Location
Dots - Manhole Covers
Arrows - Direction of Flow
8", 12" etc. - Diameter of Round Pipe
20" x 30" etc. - Width & Height of Egg-shaped Pipes
5-1 etc. - Sanitary Sewer
C-1 etc. - Combined Sewer
SP-1 etc. - Storm Sewer
O.F.OO1 etc. - Overflow Discharge Points

CITY OF PAWTUCKET, RHODE ISLAND
STUDY OF SEWERAGE IMPROVEMENTS

PAWTUCKET EXISTING SEWERAGE FACILITIES

WATERMAN ENGINEERING CO.
E. PROVIDENCE, RHODE ISLAND
NOVEMBER 1975

ANDERSON-NICHOLS & CO., INC.
VERNON - BOSTON - [illegible]
PLATE

LEGEND

BVDC INTERCEPTOR	=	BV	———
SANITARY SEWER	=	S	— — —
COMBINATION SEWER	=	C	- - - -
STORM DRAIN	=	ST	— - — -
CITY BOUNDARY			— — - —
OVERFLOW LOCATION		O.F. 000	
BVDC FLOW ENTRY LOCATION		⬡ 0	

Appendix D

Water Quality Data from Outfalls to the Blackstone River and Scott Pond

Table D-1	Data, organized by sampling date and time

Table D-1: Water Quality of Point Sources to the Blackstone River and Scott Pond

Report ID (OF-___)	Laboratory/ Field ID	Other Field/Lab ID or Town ID	Date	Time	North Smithfield	Blackstone (MA)	Woonsocket	Cumberland	Lincoln	Central Falls	Pawtucket	Location	Dry Weather	Wet Weather	Flow (estimate) cfs	Temperature ºC	Conductivity uS/ cm	Dissolved Oxygen mg/l	pH	Turbidity NTU	Fecal Coliform col/ 100 ml	Dissolved Copper ug/l	Dissolved Lead ug/l	Hardness mg/l	Comments
OUTFALL-01a: October 6, 2005 (Dry weather)																									
311	OF-311		10/6/05	10:01				●				Outfall, Abbot Run Brook - West	☐		0.50							1.3	<0.10	54	
317	OF-317		10/6/05	11:07				●				Brook near Ann & Hope	☐		0.25							3.1	0.10	43	
304	OF-304		10/6/05	13:16				●				Okonite outfall	☐		0.5 - 1.0							4.0	<0.10	91	
324	OF-324		10/6/05	13:50				●				John Dean Memorial Blvd	☐		0.05							6.3	**2.10**	43	
OUTFALL-01b: October 7, 2005 (Dry weather)																									
601	OF-4-10		10/7/05	10:22		●						Fox Brook	☐		0.5 - 1.0	17.9	319	8.2	7.2	0.2	**800**	1.4	<0.10	49	
219	OF-5-04	W-31	10/7/05	11:09			●					Cherry Brook	☐		0.75	17.3	540	7.0	6.9	0.9	**300**	4.2	0.23	87	
231	OF-5-16	W-32	10/7/05	11:35			●					Front Street outfall	☐		2.0	13.9	450	9.3	6.9	0.3	70	1.2	<0.10	66	
262	OF-6-23	W-33	10/7/05	12:06			●					Sylvestre Pond outflow	☐		1.0	20.3	324	7.8	6.6	2.6	**230**	1.6	0.60	40	
263	OF-6-24		10/7/05	12:15			●					Davison Avenue	☐		0.15	20.3	442	8.3	7.2	0.4	**500**	1.9	0.38	55	
334	OF-334		10/7/05	13:06				●				Brook near Manville Dam	☐		2.0	19.4	377	8.1	7.2	0.8	**220**	3.2	0.19	54	
333	OF-333		10/7/05	13:27				●				Sneech Brook	☐		0.5	19.9	424	7.0	6.6	0.8	**1,300**	1.6	<0.10	76	
304	OF-304		10/7/05	13:45				●				Okonite outfall	☐		0.5 - 1.0	22.9	305	7.7	7.0	5.1	130	3.8	<0.10	62	
324	OF-324		10/7/05	13:50				●				John Dean Memorial Blvd	☐		0.001										
302	OF-302		10/7/05	14:05				●				near Panda Restaurant	☐		0.001						**>16,000**				
317	OF-317		10/7/05	14:07				●				Brook near Ann & Hope	☐		0.5	23.7	266	5.1	6.7	5.4	**16,000**	***12.0***	0.14	41	
451	P-06		10/7/05	14:30					●			Blackstone Canal weir	☐		0.4	19.1	511	8.3	6.8	2.2	<20	2.5	0.10	82	
501	OF-501		10/7/05	14:52						●		NBC CSO #007	☐		0.1 - 0.2	16.9	554	7.1	6.6	0.3	**16,000**	1.6	0.10	130	
311	OF-311		10/7/05	15:00								Outfall, Abbot Run Brook - West	☐		0.30	18.9	227	7.0	6.5	3.0	500	1.5	0.11	37	
	OF-901		10/7/05	14:07								*Duplicate of OF-317*	☐								**>16,000**	***11.0***	0.15	39	
	OF-902		10/7/05	14:52								*Duplicate of OF-501*	☐								**16,000**	1.5	0.14	140	
OUTFALL-02: October 8, 2005 (Wet weather)																									
311	OF-311		10/8/05	13:47				●				Outfall, Abbot Run Brook - West		●	1.20	20.9	107	7.3	7.3	18.5	**>16,000**	***14.0***	**2.3**	17	
312	OF-312		10/8/05	13:50				●				Outfall, Abbot Run Brook - East		●	<0.5										
501	OF-501		10/8/05	14:00						●		NBC CSO #107		●	0.50	17.8	390	7.1	6.6	3.2	**16,000**	3.4	0.47	94	
407	OF-407		10/8/05	14:10					●			Scott Pond, Walker Street		●	0.005	22.0	69	8.6	7.4	33.0	**2,400**	***17.0***	**5.2**	22	(A)
406	OF-406		10/8/05	14:12					●			Scott Pond, Walker Street		●	n/f										
301	OF-301		10/8/05	14:20				●				Canal from wetland		●	n/f										
317	OF-317		10/8/05	14:22				●				Brook near Ann & Hope		●	0.3 - 0.5	22.2	151	7.8	6.9	8.4	**>16,000**	***23.0***	0.76	26	
318	OF-318		10/8/05	14:25				●				Ann & Hope, south of parking lot		●	0.27	22.7	51	8.2	6.0	19.4	**9,000**	***14.0***	**1.7**	5	

Table D-1 *(cont.)*: **Water Quality of Point Sources to the Blackstone River and Scott Pond**

Report ID (OF-___)	Laboratory/ Field ID	Other Field/Lab ID or Town ID	Date	Time	North Smithfield	Blackstone (MA)	Woonsocket	Cumberland	Lincoln	Central Falls	Pawtucket	Location	Dry Weather	Wet Weather	Flow (estimate) cfs	Temperature ºC	Conductivity uS/cm	Dissolved Oxygen mg/l	pH	Turbidity NTU	Fecal Coliform col/100 ml	Dissolved Copper ug/l	Dissolved Lead ug/l	Hardness mg/l	Comments
302	OF-302		10/8/05	14:28				●				near Panda Restaurant		●	0.13	20.9	115	8.2	6.4	69.2	**>16,000**	***14.0***	**11.0**	19	
304	OF-304		10/8/05	14:38				●				Okonite outfall		●	1.25	22.0	268	8.2	7.4	7.3	170	5.5	0.38	73	
324	OF-324		10/8/05	14:52				●				John Dean Memorial Blvd		●	0.41	20.9	99	7.8	6.8	12.1	**>16,000**	***11.0***	0.85	14	
325	OF-325		10/8/05	15:08				●				Scott Brook at Ashton Mill		●	2.00	20.9	189	8.5	7.1	18.5	**>16,000**	6.3	0.94	34	
330	OF-330		10/8/05	15:12				●				Ashton Mill		●	n/f										
331	OF-331		10/8/05	15:12				●				Ashton Mill		●	n/f										
326/327	OF-326/327		10/8/05	15:25				●				Route 116 bridge		●	0.045	22.3	101	8.1	7.6	5.0	**>16,000**	4.0	0.86	16	(1)
333	OF-333		10/8/05	15:46				●				Sneech Brook		●	2.00	19.7	395	7.3	7.0	6.5	**2,400**	2.2	0.11	83	
448	OF-335	BLA-06W	10/8/05	16:02					●			Manville Hill Road bridge		●	0.42	22.8	26	7.9	7.2	12.8	**>16,000**	**8.2**	**3.2**	11	
334	OF-334		10/8/05	16:27								Brook near Manville Dam		●	2.50	20.3	269	8.7	7.1	1.2	**800**	3.8	0.37	41	
258	OF-6-19		10/8/05	16:49			●					NW of Hamlet Street		●	0.25	21.0	37	8.2	7.0	6.8	**>16,000**	***12.0***	**3.3**	9	
263	OF-6-24		10/8/05	16:56			●					Davison Avenue		●	2.50	21.9	53	8.1	6.5	5.1	**>16,000**	**7.1**	**2.4**	8	
247	OF-6-13		10/8/05	17:47			●					just west of mouth of Mill River		●	3.50	21.6	132	7.4	6.7	8.1	**>16,000**	**8.9**	**4.6**	23	
235	OF-6-03		10/8/05	18:00			●					River Island Park		●	0.03	21.9	125	7.4	7.0	24.4	**2,200**	**8.5**	**2.0**	23	
601	OF-4-10		10/8/05	18:40		●						Fox Brook		●	3.00	19.8	223	7.6	6.9	3.2	**2,200**	1.9	0.36	43	
262	OF-6-23		10/8/05	19:15			●					Sylvestre Pond outflow		●	6.00	21.0	263	8.3	6.7	3.5	**1,300**	2.2	0.74	38	
	OF-903		10/8/05	19:15			●					*Duplicate of OF-262*									**800**	2.2	0.74	39	
OUTFALL-03: November 14, 2005 (Dry weather)																									
422	OF-422		11/14/05	11:05					●			Albion Mill	☐		0.05	11.9	299	10.6	8.1	2.2	20	<1.0	<0.10	56	(2)
423	OF-423		11/14/05						●			Albion Mill	☐		n/f										
424	OF-424		11/14/05						●			Albion Mill	☐		n/f										
425	OF-425		11/14/05						●			Albion Mill	☐		n/f										
426	OF-426		11/14/05						●			Albion Mill	☐		n/f										
427	OF-427		11/14/05	11:40					●			Brushwood Drive	☐		1.2	12.3	580	9.8	7.6	0.3	20	1.5	<0.10	80	
445	BLA10W		11/14/05						●			north of Albion Dam	☐		n/f										
446	BLA11W		11/14/05						●			north of Albion Dam	☐		inflow!!										
428	OF-428	BLA12W	11/14/05	11:50					●			Brook just downstream of Albion Dam	☐		1.2	12.1	390	8.6	7.3	0.9	<20	2.7	0.30	49	
429	OF-429	no. No.	11/14/05						●			New River Road, E of Mussey Brook	☐		n/f										
443	OF-443	BLA09W	11/14/05	12:15					●			Pipe to Mussey Brook from Kennedy Blvd	☐		0.26	12.1	650	9.1	7.4	0.05	<20	1.5	<0.10	130	(3)
430	OF-430		11/14/05	12:10					●			Mussey Brook	☐		2.00	10.8		9.3	7.5	0.2	<20	1.8	<0.10	100	
238	OF-6-06		11/14/05				●					Bernon Street bridge - North	☐		n/f										

Table D-1 *(cont.)*: **Water Quality of Point Sources to the Blackstone River and Scott Pond**

Report ID (OF-___)	Laboratory/ Field ID	Other Field/Lab ID or Town ID	Date	Time	North Smithfield	Blackstone (MA)	Woonsocket	Cumberland	Lincoln	Central Falls	Pawtucket	Location	Dry Weather	Wet Weather	Flow (estimate) cfs	Temperature ºC	Conductivity uS/ cm	Dissolved Oxygen mg/l	pH	Turbidity NTU	Fecal Coliform col/ 100 ml	Dissolved Copper ug/l	Dissolved Lead ug/l	Hardness mg/l	Comments
239	OF-6-05		11/14/05				●					Bernon Street bridge - North	☐		n/f										
235	OF-6-03		11/14/05				●					River Island Park	☐		n/f										
236	OF-6-25		11/14/05				●					Front Street	☐		n/f										
244	OF-6-10		11/14/05				●					north of railroad crossing	☐		n/f										
243	OF-6-08		11/14/05				●					Truman Drive	☐		n/f										
242	OF-6-32		11/14/05	12:25			●					Truman Drive	☐		0.08	14.7		8.7	7.4	4.6	130	5.3	0.51	260	
227	OF-5-24		11/14/05				●					Sayles Street bridge - Northeast	☐		n/f										
225	OF-5-11		11/14/05				●					Sayles Street bridge - East	☐		n/f										
226	OF-5-12		11/14/05				●					River Street	☐		n/f										
204	OF-4-03		11/14/05				●					Auto salvage yard	☐		submerg.										
205	OF-4-08		11/14/05	13:30			●					Cold Spring Park	☐		0.05	14.6	589	7.8	7.1	0.6	40	1.8	**3.4**	100	
266	OF-8-02		11/14/05	14:09			●					CVS Distribution Center	☐		0.5	12.6	522	9.8	7.5	1.0	<20	2.9	0.10	83	
353	OF-353		11/14/05	14:37				●				route 295	☐		1	14.1		9.0	7.6	0.1	<20	4.5	<0.10	140	
304	OF-304		11/14/05	14:50				●				Okonite outfall	☐		0.40	15.9	412	8.5		1.5	**>16,000**	3.5	0.29	110	
324	OF-324		11/14/05	15:00				●				John Dean Memorial Blvd	☐		0.30	13.8	734	7.8	7.6	4.3	**9,000**	***16.0***	0.27	96	
317	OF-317		11/14/05	15:35				●				Brook near Ann & Hope	☐		0.70	14.4	438	7.5	7.5	0.0	**>16,000**	2.0	<0.10	79	
311	OF-311		11/14/05	15:45				●				Outfall, Abbot Run Brook - West	☐		0.20	14.4	310	7.5	7.7	0.4	140	1.6	<0.10	61	
	OF-905		11/14/05	15:45				●				*Duplicate of OF-311*									170	1.8	<0.10	62	
OUTFALL-04: November 29, 2005 (Dry weather)																									
422	OF-422		11/29/05	9:07					●			Albion Mill	☐		0.05										
423	OF-423		11/29/05						●			Albion Mill	☐		n/f										
424	OF-424		11/29/05						●			Albion Mill	☐		n/f										
425	OF-425		11/29/05						●			Albion Mill	☐		n/f										
426	OF-426		11/29/05						●			Albion Mill	☐		n/f										
443	BLA-09W		11/29/05	10:35					●			Pipe entering Mussey Brook	☐		1.3	11.0	630	9.3	8.0	0.12	**300**	1.6	<0.10	120	
430	OF-430		11/29/05						●			Mussey Brook	☐		4										
431	OF-431	BLA08W	11/29/05	10:45					●			Brook at Northern Lincoln Elem. School	☐		1.2	10.3	472	10.3	7.8	0.7	80	2.0	0.18	73	clear
432	OF-432		11/29/05						●			Pipe discharging to OF-431	☐		n/f										
433	OF-433	BLA07W	11/29/05						●			South of Manville Hill Road bridge	☐		n/f										
434	OF-434		11/29/05						●			South of Manville Hill Road bridge	☐		n/f										
336	OF-336		11/29/05					●				South of Manville Hill Road bridge	☐		n/f										

Table D-1 *(cont.)*: **Water Quality of Point Sources to the Blackstone River and Scott Pond**

Report ID (OF-___)	Laboratory/ Field ID	Other Field/Lab ID or Town ID	Date	Time	North Smithfield	Blackstone (MA)	Woonsocket	Cumberland	Lincoln	Central Falls	Pawtucket	Location	Dry Weather	Wet Weather	Flow (estimate) cfs	Temperature ºC	Conductivity uS/cm	Dissolved Oxygen mg/l	pH	Turbidity NTU	Fecal Coliform col/100 ml	Dissolved Copper ug/l	Dissolved Lead ug/l	Hardness mg/l	Comments
448	OF-335	BLA06W	11/29/05						●			Manville Hill Road bridge	☐		0.05										(4)
447		BLA05W	11/29/05						●			Spring Street	☐		n/f										
435	OF-435	BLA04W	11/29/05	10:59					●			Winter Street	☐		0.15	10.9	471	10.2	8.0	5.5	**2,400**	2.3	0.20	74	
436	OF-436	BLA03W	11/29/05						●			Pother Street	☐		n/f										
437	OF-437	BLA02W	11/29/05	11:10					●			Vose Street	☐		0.10	9.0	720	10.7	7.8	0.1	40	2.8	0.10	91	
438	OF-438	BLA01W	11/29/05	11:28					●			northern Manville	☐		0.10	11.5	395	10.3	7.6	1.0	20	2.6	0.10	66	(5,6)
440	OF-440		11/29/05						●			Route 99	☐		n/f										
441	OF-441		11/29/05				●		●			Crookfall Brook	☐		25										
819	OF-7-01		11/29/05				●					Burnside Avenue	☐		n/f										
818	OF-7-02		11/29/05				●					southwest of Mill Street bridge	☐		n/f										
817	OF-7-03		11/29/05				●					Mill Street bridge	☐		n/f										
W-15	W-15		11/29/05				●					Peters River, at Elm Street	☐		35										(15)
815	OF-7-05		11/29/05	13:48			●					River Haven Condominium	☐		0.1	14.3	597	9.7	7.5	0.3	<20	1.7	<0.10	80	
814	OF-7-06		11/29/05				●					across from River Haven Condominum	☐		n/f										
813	OF-7-07		11/29/05				●					River Haven Condominium	☐		n/f										
812	OF-7-08		11/29/05				●					across from River Haven Condominum	☐		n/f										
811	OF-7-09		11/29/05				●					across from River Haven Condominum	☐		n/f										
810	OF-7-10		11/29/05				●					across from River Haven Condominum	☐		n/f										
809	OF-7-11		11/29/05				●					across from River Haven Condominum	☐		n/f										
808	OF-7-12		11/29/05				●					across from River Haven Condominum	☐		n/f										
807	OF-7-13		11/29/05				●					Wood Avenue	☐		n/f										
806	OF-7-14		11/29/05				●					Wood Avenue	☐		n/f?										
805	OF-7-16		11/29/05				●					Salisbury Street	☐		n/f?										
804	OF-7-15		11/29/05				●					Havelock Street - East	☐		n/f										
803	OF-7-17		11/29/05	14:19			●					Diamond Hill Road	☐		n/f										
802	OF-7-18		11/29/05	14:23			●					Diamond Hill Road	☐		1.5	9.6	330	10.5	7.7	1.2	40	2.0	0.27	66	
W-14	W-14		11/29/05	14:43			●					Peters River, near MA/RI border	☐		32.5	7.8	314	10.0	7.1	0.8	20	1.2	0.18	42	
704	OF-7-19		11/29/05				●					East School Street	☐		n/f										
W-11	W-11		11/29/05	15:13			●					Mill River, near MA/RI border	☐		135	4.5	259	14.2	7.2	4.8	170	1.6	0.35	27	
701	OF-7-20		11/29/05	15:30			●					north of Privilege Street	☐		0.03	10.5	248	9.0	6.9	8.0	20	1.0	<0.10	37	
	OF-905		11/29/05	14:43			●					*Duplicate of W-14*									40	1.4	0.23	46	

Table D-1 *(cont.)*: **Water Quality of Point Sources to the Blackstone River and Scott Pond**

Report ID (OF-___)	Laboratory/ Field ID	Other Field/Lab ID or Town ID	Date	Time	North Smithfield	Blackstone (MA)	Woonsocket	Cumberland	Lincoln	Central Falls	Pawtucket	Location	Dry Weather	Wet Weather	Flow (estimate) cfs	Temperature ºC	Conductivity uS/ cm	Dissolved Oxygen mg/l	pH	Turbidity NTU	Fecal Coliform col/ 100 ml	Dissolved Copper ug/l	Dissolved Lead ug/l	Hardness mg/l	Comments
OUTFALL-05: November 30, 2005 (Wet weather)																									
266	OF-8-02		11/30/05	6:38			●					CVS Distribution Center		●	6		62		7.1	11.1	**220**	4.8	0.70	4	
802	OF-7-18		11/30/05	6:45			●					Diamond Hill Road		●	5		174		7.0	8.4	110	2.5	1.1	24	
805	OF-7-16		11/30/05	6:50			●					Salisbury Street		●	2		70		7.1	9.2	**2,200**	4.9	**2.2**	3	
704	OF-7-19		11/30/05	7:00			●					Prince Street		●	0.5		59		6.9	16.8	**2,400**	5.7	**7.2**	5	
244	OF-6-10		11/30/05	7:08			●					north of railroad crossing		●	0.2		79		7.1	15.5	130	5.4	**3.4**	4	
243	OF-6-08		11/30/05	7:10			●					Truman Drive		●	0.4		1,347		7.0	24.8	**1,700**	***17.0***	**8.1**	4	
242	OF-6-32		11/30/05	7:18			●					Truman Drive		●	0.2		496		6.8	9.5	**3,000**	***12.0***	**3.7**	51	
235	OF-6-03		11/30/05	7:31			●					River Island Park		●	0.1		159		7.1	39.4	**800**	5.4	**1.4**	8	
263	OF-6-24		11/30/05	7:47			●					Davison Avenue		●	1		298		7.0	19.6	**2,400**	6.6	**3.5**	27	
247	OF-6-13		11/30/05	7:50			●					just west of mouth of Mill River		●	?										(7)
258	OF-6-19		11/30/05	7:55			●					NW of Hamlet Street		●	?										(7)
231	OF-5-16		11/30/05	8:10			●					Front Street outfall		●	5		271		7.0	7.7	**16,000**	3.1	**1.5**	36	
230	OF-5-15		11/30/05	8:15			●					South main Street bridge		●	0.3										(8)
205	OF-4-08		11/30/05	8:33			●					Cold Spring Park		●	0.2		458		6.8	20.6	**270**	5.3	**5.7**	38	
201	OF-4-01		11/30/05	8:45			●					Main Street / Gaskill Street		●	5		277		7.0	2.2	110	1.8	0.19	44	(9)
437	OF-437		11/30/05	9:00					●			Vose Street		●	0.3		519		6.8	2.0	**500**	2.7	0.40	65	
440	OF-440		11/30/05	9:05					●			Route 99		●	n/f										(10)
334	OF-334		11/30/05	9:09				●				Brook near Manville Dam		●	7		236		7.1	1.6	**700**	1.6	0.40	36	
448	OF-335		11/30/05	9:16					●			Manville Hill Road bridge		●	0.05		206		7.2	58.6	**3,000**	**9.2**	**4.3**	10	(11)
435	OF-435		11/30/05	9:25					●			Winter Street		●	0.3		283		7.0	25.2	**>16,000**	5.1	**1.7**	35	
443	BLA-09W		11/30/05	9:34					●			Pipe entering Mussey Brook		●	1		535		6.8	0.08	<20	1.7	0.12	110	(12)
422	OF-422		11/30/05	9:40					●			Albion Mill		●	0.3						**1,700**	1.4	<0.10	57	
428	OF-428	BLA12W	11/30/05	9:50					●			Brook just downstream of Albion Dam		●	7		295		7.0	1.0	**230**	3.3	0.61	36	
333	OF-333		11/30/05	9:56				●				Sneech Brook		●	6		559		7.0	2.1	**800**	2.3	0.28	67	
325	OF-325		11/30/05	10:04				●				Scott Brook at Ashton Mill		●	12		309		7.2	0.3	200	1.5	0.18	54	
324	OF-324		11/30/05	10:12				●				John Dean Memorial Blvd		●	0.5		542		7.0	11.5	**>16,000**	4.1	0.25	87	
304	OF-304		11/30/05	10:16				●				Okonite outfall		●	0.8		275		7.2	79.3	**>16,000**	4.3	1.3	75	
323	OF-323		11/30/05	10:20				●				Hope Global			submerg.										
302	OF-302		11/30/05	10:25				●				near Panda Restaurant		●	2		209		7.4	23.2	**1,700**	**6.8**	0.76	46	(9)
301	OF-301		11/30/05	10:36				●				Canal from wetland		●	4		251		7.2	1.3	<20	2.9	0.41	57	

Table D-1 *(cont.)*: **Water Quality of Point Sources to the Blackstone River and Scott Pond**

Report ID (OF-___)	Laboratory/ Field ID	Other Field/Lab ID or Town ID	Date	Time	North Smithfield	Blackstone (MA)	Woonsocket	Cumberland	Lincoln	Central Falls	Pawtucket	Location	Dry Weather	Wet Weather	Flow (estimate) cfs	Temperature °C	Conductivity uS/ cm	Dissolved Oxygen mg/l	pH	Turbidity NTU	Fecal Coliform col/ 100 ml	Dissolved Copper ug/l	Dissolved Lead ug/l	Hardness mg/l	Comments
318	OF-318		11/30/05	10:44				●				Ann & Hope, south of parking lot		●	0.5		45		7.3	11.9	500	**6.7**	1.1	4	
317	OF-317		11/30/05	10:50				●				Brook near Ann & Hope		●	6		332		6.7	16.1	**>16,000**	**7.1**	**2.0**	44	
316	OF-316		11/30/05	10:55				●				River Street		●	0.3		158		7.2	34.7	**3,000**	**9.2**	**4.2**	9	
413	OF-413		11/30/05	11:05					●			Lonsdale Bleachery		●	0.5		312		6.8	20.7	130	3.2	**1.5**	62	
405	OF-405		11/30/05	11:10					●			Scott Pond, Walker Street		●	0.5		62		6.8	24.3	**5,000**	**7.3**	**9.4**	5	
406	OF-406		11/30/05	11:11					●			Scott Pond, Walker Street		●	n/f										(13)
407	OF-407		11/30/05	11:13					●			Scott Pond, Walker Street		●	0.02										(13)
501	OF-501		11/30/05	11:34					●			NBC CSO #007		●	3.5		218		6.7	16.7	**>16,000**	5.9	**3.6**	38	
311	OF-311		11/30/05	11:42				●				Outfall, Abbot Run Brook - West		●	6		58		7.1	18.6	**5,000**	**7.0**	**2.4**	4	
312	OF-312		11/30/05	11:42				●				Outfall, Abbot Run Brook - East		●	0.7										
412	OF-412		11/30/05	12:40					●			Lonsdale Bleachery		●	n/f										(13)
418	OF-418		11/30/05	12:40					●			Lonsdale Bleachery		●	n/f										(13)
402	OF-402		11/30/05	12:40					●			Lonsdale Bleachery		●	n/f										(13)
417	OF-417		11/30/05	12:40					●			Lonsdale Bleachery		●	n/f										(13)
321	OF-321		11/30/05	12:55				●				Bike path at Stop&Shop		●	0.30										(14)
	OF-906		11/30/05	8:10			●					*Duplicate of OF-231*		●							**9,000**	3.5	**1.7**	36	
	OF-907		11/30/05	9:50					●			*Duplicate of OF-428*		●							**2,400**	3.5	0.66	36	
	OF-908		11/30/05	10:50				●				*Duplicate of OF-317*		●							**>16,000**	**6.9**	**2.0**	43	

(A) Runoff seemed to come of Walker Street.
(1) The sample is a composite of OF-326 and OF-327 (the two drains from the Cumberland side of the bridge. Each drain had a flow of 0.022 cfs.
(2) Small oil sheen near pipe
(3) Sample OF-443 was labeled OF-431 in Chain-of Custody and Laboratory Reports. Correction is noted on Data CD.
(4) Discharge point to river; no flow upgradient by rail tracks.
(5) Sampled upslope from CMP, prior to flowing into the channel toward OF-438..
(6) Sample OF-438 accidentally labeled OF-429 for MITKEM lab (fecal coliform). .
(7) 50% submerged, no distinct flow visible.
(8) Site inaccesible.
(9) STL sample submitted as separate batch (Lab Batch ID: 360-995)
(10) Not raining at time of survey.
(11) Sample collected upgradient of railtrack. At the wall adjacent to the Manville Dam downgradient, the flow was 0.4 cfs, reflecting an additional source to the outfall.
(12) Sample OF-443 accidentally labeled as OF-438 for MITKEM and STL labs.
(13) Raining at the time of the survey.
(14) Overflow of retention pond for Stop&Shop.

Appendix E

Biodiversity Assessment using Rapid Bioasssessment Protocol Monitoring

Complete report prepared by ESS, Inc.

ESS
Group, Inc.

December 27, 2005

Mr. Bernward Hay
Louis Berger Group, Inc.
75 Second Avenue, Suite 700
Needham, Massachusetts 02494

Re: ***Blackstone River Macroinvertebrate Sampling and Analysis***
ESS Project No. B357-000

Dear Mr. Hay:

ESS Group, Inc. (ESS) is pleased to present the report for the "Blackstone River Macroinvertebrate Sampling and Analysis Project". This report is the culmination of two years worth of macroinvertebrate sampling and data analysis, which took place in 2004 and 2005. ESS sampled the Blackstone River downstream of the Manville Dam, in Lincoln Rhode Island on August 30, 2004 and on September 2, 2005. The reference station for the Southern New England Coastal Plains and Hills Ecoregion (The Wood River) was sampled on August 20, 2004 and August 19, 2005. All work was performed in accordance with the Quality Assurance Project Plan (QAPP) that was submitted by ESS to the United States Environmental Protection Agency (US EPA) on October 2, 2002 for the RIDEM project entitled Taxonomic Identification of Benthic Macroinvertebrates, Rhode Island (ESS, 2002). A copy of this QAPP is on file with RIDEM's Office of Water Resources (OWR).

The purpose of this survey, as we understood it, was to determine the quality of the macroinvertebrate community and habitat at the study site in a manner consistent with the methods used for macroinvertebrate sampling by RIDEM as part of their routine statewide biomonitoring program.

1.0 STUDY APPROACH AND METHODS

ESS sampled aquatic macroinvertebrates from the Blackstone River within the fast run/riffle habitat located downstream of the Manville dam, but upstream of the Manville Hill Road bridge (Figure 1, Photos 1 and 2 (Attachment 1)). Aquatic invertebrates were also sampled from the Wood River reference station for the Southern New England Coastal Plains and Hills Ecoregion, downstream of the dam and Old Nooseneck Road (Figure 2, Photos 3 and 4 (Attachment 1)).

The monitoring of the macroinvertebrate community at the Blackstone River study site (hereafter known as "the study site") was conducted according to the US EPA's Rapid Bioassessment Protocols (RBPs) "Single Habitat Approach" (Barbour et al., 1999).

The mapped location and description of the study site was supplied by Louis Berger Group, Inc. at the start of the study.

Habitat Assessment

Habitat quality was assessed at both the study site and the reference station on Wood River by completing a Habitat Assessment Field Data Sheet for High Gradient Streams, which was similar to data sheets recommended by the US EPA (Barbour et al., 1999). Habitat quality was assessed in both 2004 and 2005. Completed assessment sheets for both years are provided as Attachment 2.

The habitat assessment process involves rating ten habitat parameters as optimal, sub-optimal, marginal, or poor based on the US EPA-developed criteria. A brief summary of the parameters evaluated and the criteria upon which the assessment is based, follows:

1. Instream Cover – Assesses the quantity and variety of natural structures in the stream such as cobbles, large rocks, fallen trees, logs, snags and undercut banks, which serve as shelter, nursery or feeding areas to aquatic organisms.
2. Epifaunal Substrate – Assesses the extent and quality of riffle and run habitat, which offers a diversity of habitat, through variety of particle sizes, to aquatic organisms.
3. Embeddedness – Assesses the extent to which rocks (gravel, cobbles, and boulders) and snags are covered or sunken into the fine sediments of the stream bottom, which impacts the surface area available to macroinvertebrates.
4. Channel Alteration – Assesses the extent of change to the shape of a stream channel. Such changes can include channelization, dredging and artificial embankments, which affect the quantity and quality of natural habitat for aquatic organisms.
5. Sediment Deposition – Assesses the amount of sediment that has accumulated in pools and other changes that have occurred to the stream bottom as a result of deposition.
6. Frequency of Riffles/Velocity-Depth Combinations – Assesses the presence or absence of four depth patterns, namely slow-deep, slow-shallow, fast-deep, fast-shallow. Variety of habitat is key; the more of these depth patterns present in a stream reach the more stable the aquatic environment.
7. Channel Flow Status – Assesses the degree to which the channel is filled with water, which affects the amount of suitable substrate and other habitat available to aquatic organisms.
8. Bank Vegetative Protection – Assesses the amount of vegetative protection afforded to the right and left banks of the stream. The greater the percentage of the stream bank covered with a variety of native vegetation at a variety of growth heights, the greater the ability of the bank to resist erosion, the greater the control of instream scouring and the more shading for the stream. Each bank is evaluated separately and the cumulative score is used.
9. Bank Stability – Assesses the extent of and potential for bank erosion. Each bank is evaluated separately and the cumulative score is used.
10. Riparian Vegetative Zone Width – Assesses the width of natural vegetation from the edge of the stream bank out through the riparian zone. A relatively undisturbed riparian zone supports a healthy system; narrow riparian zones occur when roads, parking lots, fields, lawns and buildings are near the stream bank. Each bank is evaluated separately and the cumulative score is used.

As specified by the US EPA methodology, the habitat assessment also included physical characterization and in-field measurement of water quality parameters. This information was not incorporated into habitat assessment scores but served as further insight into the ability of the stream to support a healthy aquatic community. Physical characterization included documenting:

- surrounding land use;
- subsystem classification;
- presence or absence of dams, local water erosion & potential sources of non-point source (NPS) pollution;
- width, depth and flow;
- inorganic and organic substrate types; and
- presence of odors, oils and deposits.

A physical characterization data sheet comparable to that recommended by the US EPA was completed for both the study site and the reference station on Wood River and is provided in Attachment 1. In addition, a map depicting the entire sampling reach and in-stream physical features such as riffles, falls, fallen trees, pools, bends and other important structures was sketched in the field for each stream segment. These field sketches can be found on the habitat assessment sheets in Attachment 2.

Water quality parameters measured in the field included:

- dissolved oxygen (mg/L and % saturation);
- pH (SU);
- specific conductance (μmhos/cm);
- turbidity (NTU);
- temperature (°C); and
- flow (cfs).

Each water quality parameter was measured in accordance with the project-specific QAPP (ESS, 2002).

Macroinvertebrate Sampling

The single habitat assessment approach to sampling as detailed by the US EPA (Barbour et al., 1999) was adopted for this study. This approach entailed sampling benthic macroinvertebrates from riffle/run communities at the selected stream segments. Sampling was conducted in accordance with the methods detailed in the project's QAPP (ESS, 2002). The following key tasks were completed:

- Selection of a representative 100-meter section of stream at each stream segment;
- Kick sampling within a series of riffles (working upstream) for a total cumulative duration of 3 minutes;
- Transfer of sample to a glass jar;

- Preservation of sample in 70% ethanol solution;
- Labeling inside and outside of sample jar accordingly; and
- Completion of the relevant section of the US EPA "Benthic Macroinvertebrate Log-In Sheet" (Barbour et al., 1999), which details the date the sample was collected, who it was collected by, the number of containers filled by the sample, the preservative used, the identification code for the stream segment and the name and location of the stream.

Laboratory Processing of Samples

Macroinvertebrate samples were processed by ESS in accordance with the methods detailed in the project's QAPP (ESS, 2002). Necessary deviations from the QAPP are described in Section (2) of this report. The following key tasks were performed:

- Review of US EPA "Benthic Macroinvertebrate Log-In Sheet" to verify all samples arrived in acceptable condition;
- Completion of US EPA "Benthic Macroinvertebrate Log-In Sheet" by recording the date the sample was received in the laboratory;
- Rinsing of samples to remove preservative and fine sediment;
- Distribution of rinsed material onto a grid lined tray;
- Removal of a randomly selected section of material, hereafter called a "sub-sample";
- Removal of large, rare or unique organisms from the remainder of the material on the grid lined tray (these were later identified and reported as supplemental data for each stream segment);
- Sorting of sub-samples under a microscope and removal of benthic macroinvertebrates from the debris;
- Repeating the removal and sorting steps for additional randomly selected sub-samples until a minimum of 100 macroinvertebrates were collected;
- Placement of macroinvertebrates into pre-labeled glass vials preserved in 70% ethanol based on initial taxonomic classification as (1) Oligochaetes (worms) and Chironomids (midges), (2) Crustaceans and Mollusks, and (3) other remaining organisms;
- Completion of the relevant sections of the US EPA "Laboratory Bench Sheet" detailing the sub-sampling/sorting information, the number of grids sorted, time expenditure, the number of organisms found and the presence of any large or obviously abundant organisms. Completed laboratory bench sheets for each stream segment are provided in Attachment 3;
- Storage of sorted debris for each sub-sample and unsorted sample debris into separate containers, labeled accordingly, both preserved in 70% ethanol; and
- Shipment of worm and midge samples to ARC and crustacean and mollusk samples to Mr. Doug Smith for further taxonomic identification.

Invertebrate Identification

ESS: Invertebrate Identification

ESS scientists conducted the taxonomic identification and enumeration of all the benthic macroinvertebrates previously stored in the "others" vials. These taxa included, but were not limited to Ephemeroptera (mayflies), Trichoptera (caddisflies), Diptera (true-flies), Coleoptera (beetles), and Megaloptera (fishflies, dobsonflies and alderfiles). The macroinvertebrates from each stream segment were counted and identified to genus/species level or lowest practical taxonomic level with the use of a dissecting microscope, a fiber optic lamp, and standard dissecting tools. Taxonomic keys that were relied upon enabled accurate identification to genus level in most instances (Merritt and Cummins, 1996; Peckarsky et al., 1990; Pennak, 1989; and Wiggins, 1998).

Each taxon found in a sample was recorded and enumerated on a laboratory bench notebook and then transcribed to the relevant section of the US EPA Laboratory Bench Sheet. Completion of the bench sheet also required the life stage of the macroinvertebrate to be noted (i.e. immature, pupae or adult), as well as the taxonomic certainty rating ranging from "most certain" to "least certain". Any difficulties encountered during identification were also noted on the bench sheets.

ARC and Mr. Doug. Smith: Invertebrate Identification

The contract labs for this study, namely ARC and Mr. Doug Smith, performed the taxonomic identification for the samples delivered to their laboratories in accordance with the methods detailed in the QAPP for this study (ESS, 2002) (except where otherwise noted in Section (2) of this report). Following identification, all contractor-identified samples were returned to ESS along with the tabulated results for each sample. These data have been incorporated into the results presented in this report.

Data Analysis

Habitat Assessment Data Analysis

The "habitat assessment matrix" approach was developed for the RBPs in Plafkin et al, 1989, but has since been modified to include additional assessment parameters for high gradient streams. The approach weights various habitat parameters to emphasize those parameters that are most biologically significant. All parameters are evaluated for each stream segment studied and rated on a numerical scale of 0 to 20 (highest). The ratings are then totaled and compared to the score of the appropriate reference station. This provides a final habitat ranking in the form of a "percent comparability measure". Scores increase as habitat quality increases.

Subsequent analysis of the habitat assessment score was also based on methods introduced by US EPA RBPs (Plafkin et al., 1989). The score for the study site was compared to the reference station specific to Southern New England Coastal Plains and Hills ecoregion, i.e. the Wood River station. The ratio between the score for the study site and the score for the reference station provided a percent comparability measure. The study site was then classified on the basis of its similarity to expected conditions (as represented by the reference station). Table 1 illustrates the ranges of percent comparability ratings and the assessment categories (classifications) assigned to each range, which were adopted for this study.

Macroinvertebrate Data Analysis

Macroinvertebrate data was analyzed by employing a number of US EPA approved metrics as detailed by the US EPA RBPs (Plafkin et al., 1989). The metrics employed during this study are listed in Table 2a, along with a discussion for each, covering its method of calculation, its range of possible values and its usefulness as an assessment tool.

In accordance with data analysis techniques used by Plafkin et al., 1989, select metrics (introduced in Table 2a) were used to develop an empirical value representative of the macroinvertebrate community at the study site. Table 3, taken from the US EPA RBPs (Plafkin et al., 1989), illustrates the method by which metric results for stream segments are scored upon percent comparability to reference station metric results. These calculations result in the development of the one empirical value to be carried forward into subsequent analysis.

The empirical values calculated for the study site were then compared to the empirical value for the reference station for the Southern New England Coastal Plains and Hills ecoregion, i.e. the Wood River at Barberville in Hopkinton (Figure 2). The study site was then classified on the basis of its similarity to expected conditions (as represented by the reference station). Table 4, taken from the US EPA RBPs (Plafkin et al., 1989), illustrates the ranges of percent comparability ratings and the assessment categories (classifications) assigned to each range, which were adopted for this study.

2.0 DEVIATIONS FROM THE QAPP

ESS adhered to the Quality Assurance/Quality Control (QA/QC) as outlined in the QAPP for "Taxonomic Identification of Benthic Macroinvertebrates, Rhode Island" (ESS, 2002). Any deviations from established QA/QC acceptance criteria or established procedures are discussed below:

- The grid-lined trays used throughout the study to sub-sample material collected, were not the size proposed in the QAPP (18x13x1 inch), but instead 10x7x2.5 inches and 11.5x8x2 inches. The trays utilized were considered sufficient for the task and were the closest attainable to the proposed size;
- The grid-lined trays were not divided into eight delineated sections, but instead sixteen. When the need arose, material was removed from only one-quarter of these sections. The large numbers of macroinvertebrates in some samples necessitated greater division of the sample in order to obtain the targeted 100-organism sub-sample and not substantially more organisms;
- Chironomids and Oligochaetes were identified by ARC to sub-family or tribe and order level respectively. This was the lowest practical taxonomic level for these groups for this study. Identification to sub-family, tribe and order levels could be carried out without mounting organisms onto slides as proposed in the QAPP;
- US EPA Laboratory Bench Sheets (Barbour et al., 1999) were not completed by contract labs (ARC and Mr. Doug Smith) for this study, only by ESS. Resulting data was supplied

to ESS from ARC and Mr. Doug Smith on bench sheets of their own design and was incorporated into data tables for the report;

- The bottom of the laboratory bench sheet (Total number of organisms and Total number of taxa) was not completed since the bench sheets did not contain all organisms identified (ARC and Mr. Doug Smith data was not included on these sheets);
- The metrics employed for data analysis during the study differed slightly from those listed in the proposal submitted to Louis Berger Group, Inc. on August 4, 2004. One proposed metric "Number of intolerant taxa" was deemed redundant and omitted, because taxa tolerance values were incorporated into the "Hilsenhoff Biotic Index" metric, which is a much more advanced measure of macroinvertebrate tolerance values in the community. The Hilsenhoff Biotic Index is also the metric proposed by Plafkin et al., (1989) for the bioassessment approach advocated for "Rapid Bioassesment Protocol III".

3.0 RESULTS

The results of the habitat assessment carried out at the Blackstone River study site in 2004 and 2005 and the subsequent data analysis are provided in Table 5. The habitat scores for the study site in 2004 (152) and 2005 (154) were each assessed according to its percent comparability rating to the reference station score for that year i.e. 175 in both 2004 and 2005. Percent comparability calculations suggest that the habitat of the Blackstone River study site is "Supporting" according to the US EPA assessment categorizations (Table 1).

Water quality data recorded at the study site and the reference station are presented in Table 6. In general, the study site exhibited good water quality, in most cases being comparable to the reference station. Dissolved oxygen levels were high and turbidity was low, although turbidity was slightly higher at the study site in 2005 compared to 2004. However, specific conductance levels were high in 2004 and 2005 compared to the reference station which could be indicative of anthropogenic sources of pollution. In addition, the temperature of the water at the study site was a few degrees higher than that observed at the reference station in both 2004 and 2005, which could be due to the slightly closer proximity of the study site to the dam on the Blackstone River, as compared to the proximity of the dam to the reference station on the Wood River.

Tables 7 and 8 present the raw macroinvertebrate data for the study site and the reference station in 2004 and 2005 respectively. These data reflect the actual number of macroinvertebrates in a known fraction of each sample, i.e. the sub-sample. The fraction of each sample sorted to acquire a 100-organism sub-sample is also presented. Macroinvertebrate taxa are organized alphabetically under their relevant class, order, or family.

Tables 9 and 10 present the calculated number of macroinvertebrates per 3-minute kick sample for the study site and the reference station in 2004 and 2005 respectively. These data resulted from multiplying the raw data for each station by the inverse of the fraction of sample sorted. The data are arranged such that "number of taxa per kick sample" has been recorded. The total number of macroinvertebrates per 3-minute kick sample is calculated and presented at the bottom of the tables.

Table 11 provides summary statistics calculated for both the study site and the reference station in 2004 and 2005. A discussion of each metric can be found in Table 2a. In 2004 and 2005 the study site was generally comparable to the reference station for many of the metrics calculated, although the scores were typically indicative of relatively poor water and/or habitat quality at the study site. In 2004 total taxa richness and EPT taxa richness were actually slightly higher at the study site than at the reference station. However, in 2005 these two metrics were much lower at the study site compared to the reference station, which is indicative of relatively poor water and habitat quality. In addition, the Hilsenhoff Biotic Index was higher at the study site and was classified as "good" compared to "very good" at the reference station in both 2004 and 2005, which suggests that a greater degree of organic pollution exists at the study site than at the reference station (Hilsenhoff, 1987). The percentage of Hydropsychidae caddisflies was greater at the study site than at the reference station in 2004 and 2005. Hydropsychidae are perceived to be pollution-tolerant relative to other more pollution sensitive Trichopterans (Barbour et al., 1999), therefore this is also indicative of environmental stress at the study site.

The metrics calculated for the study site in 2004 and 2005 were improved in nearly every case compared to metrics calculated from 1998 through to 2001 (Berger, 2004). Taxa richness and "percent dominant taxon" in 2004 and 2005 were both markedly improved compared to the 1998 to 2001 set of results, which may, in part, be due to the less detailed taxonomic identification achieved in those previous studies. The only metric to score worse in 2004 and 2005 compared to metrics calculated from 1998 to 2001 was the EPT to chironomid ratio. This metric was lower in 2004 (and then lower again in 2005) than was observed at any time from 1998 to 2001, which indicates that the population was more skewed towards chironomids in 2004 and 2005 than was previously observed. Chironomids are generally more tolerant than EPT taxa (Plafkin et al., 1989) which suggests that the study site may be currently under more environmental stress than in previous years.

The ratio of scrapers to filterers was lower in 2004 and 2005 than was observed in 1998, 2000 or 2001 (Berger, 2004). These lower numbers indicate a macroinvertebrate community more dominated by filter feeders than has been previously observed at the study site. Domination by filter feeders is indicative of an overabundance of suspended fine particulate organic matter and also of filamentous algae and aquatic mosses, which are both associated with organic enrichment (Plafkin et al., 1989). This may suggest that there was an increase in organic enrichment at the study site over the past few years, a conclusion that is supported by the fact that the Hilsenhoff Biotic Index value increased (worsened) slightly at the study site in 2005 compared to 2004. The increase in filter feeders appears to have been progressive since 2000, although there was a slight decrease in 2005 compared to 2004.

Also of note, there were no shredders found at the study site in 2005 which was consistent with data collected from 2000, although some shredders were found at the study site in 1998, 1999, 2001 and 2004. Shredders are good indicators of toxic effects and are particularly sensitive to riparian zone impacts (Plafkin et al., 1989).

Table 12 presents the results of the assessment of the macroinvertebrate community for the study site according to the approach advocated for by RBP III (Plafkin et al., 1989). The full calculations for determining the site's "percent comparability" in 2004 and 2005 can be found in Table 13 and Table 14 respectively. Table 12 also presents the assigned US EPA biological condition category for the study site in 2004 and 2005, based on the percent comparability score (i.e., non-impaired, slightly impaired, moderately impaired, or severely impaired).

4.0 CONCLUSIONS

The study site was classified as "Slightly Impaired" in both 2004 and 2005, with percent comparability scores of 79.2% and 60.9% respectively (Table 12). The percent comparability scores ranged between 21.0% and 68.8% from 1994 to 2001 (Berger, 2004). The results of this study indicate that, overall, the macroinvertebrate community at the study site in 2004 is the healthiest it has been since biomonitoring began in 1994. The results of this study also suggest that the health of the macroinvertebrate community declined slightly in 2005 compared to 2004. However, this was matched by a similar decline at the reference station in 2005, so that overall the biological condition category remained the same. In addition, the apparent differences in the metrics (Table 11) and the percent comparability scores from 2004 to 2005 can easily be attributed to natural variation associated with weather patterns, population dynamics, or other dynamic forces. Additional data would need to be collected (using comparable sampling and data analysis techniques) in order to begin to understand natural trends in the macroinvertebrate community at the study site and thus be able to distinguish between natural changes and those potentially caused by anthropogenic impacts.

5.0 REFERENCES

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. US EPA 841-B-99-002. US Environmental Protection Agency; Office of Water; Washington, D.C.

ESS, 2002. Quality Assurance Project Plan for Taxonomic Identification of Benthic Macroinvertebrates. September 30, 2002.

Hilsenhoff, W.L., 1987. An Improved Biotic Index of Organic Stream Pollution. Great Lakes Entomol. 20:31-39.

Berger (The Louis Berger Group, Inc.), 2004. Water Quality – Blackstone River, Final Report 1: Existing Data. Prepared for the Rhode Island Department of Environmental Management (January 2004).

Mandaville, S.M., 2000. Benthic Macroinvertebrates in Freshwaters-Taxa Tolerance Values, Metrics and Protocols. Project H-1 Soil and Water Conservation Society of Metro Halifax. Master Homepage: http://chebucto.ca/Science/SWCS/SWCS.html.

Merritt, R.W., and K.W. Cummins. 1996. An Introduction to the Aquatic Insects of North America, 3rd Edition. Kendall/Hunt Publishing.

Peckarsky, B.L., P.R. Fraissinet, M.A. Penton and D.J. Conklin, Jr., 1990. Freshwater Macroinvertebrates of Northeastern North America. Cornell University Press.

Pennak, R.W., 1989. Fresh-Water Invertebrates of the United States, 3rd Edition. Protozoa to Mollusca. John Wiley & Sons, Inc.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers. Benthic macroinvertebrates and fish. US EPA/444/4-89-001. Office of Water Regulation Standards, US Environmental Protection Agency, Washington, DC. 162 pp.

Smith, D.G., 1995. Keys to the freshwater macroinvertebrates of Massachusetts. 2nd ed. 241 pp.

Wiggins, G.B., 199. Larve of the North American Caddisfly Genera (Trichoptera) 2nd edition. University of Toronto Press.

Please contact the undersigned at (401) 330-1224 if you have any questions.

Sincerely,

ESS GROUP, INC.

Jennifer M. Sheppard Environmental Scientist	Carl Nielsen, CLM Senior Water Resource Scientist

Attachments: Tables
Figures
Attachment 1 - Photographic Log
Attachment 2 - Habitat Assessment Data Sheets
Attachment 3 - Lab Bench Sheets

Tables

TABLE 1.
Percent Comparability Evaluation for Habitat Assessment Scores (Plafkin et al., 1989).

U.S. EPA Assessment Category	Percent of Comparability
Comparable to Reference	_ > 90%
Supporting	75-88%
Partially Supporting	60-73%
Non-Supporting	_ < 58%

TABLE 2a
Metrics Employed for Macroinvertebrate Data Analysis

Total Taxa Richness	
Description	A measure of diversity within a sample. Increasing diversity correlates with increasing health of the macroinvertebrate assemblage and suggests that niche space, habitat and food source are adequate to support survival and propagation of many species (Barbour et al., 1999).
Calculation	All macroinvertebrates are separated into presumed species/genus groups; the number of distinct taxa is counted.
Range of values	21 to 32 (2004 & 2005) for this data set
Usefulness	Ranked as a "best candidate richness measure metric" by Barbour et al., 1999. However, in practice many taxa are identified only to genus level, which can result in an underestimate of taxa richness (Rosenberg & Resh 1993). This metric is employed in the bioassessment approach advocated for "Rapid Bioassessment Protocol III" (Plafkin et al., 1989).
EPT Taxa Richness	
Description	This metric is based on the observation that, in general, the majority of taxa in these three orders are pollution sensitive. Therefore, generally a high EPT taxa richness indicates healthy water quality.
Calculation	All Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) are separated from the other macroinvertebrates by order; the number of distinct taxa is then counted.
Range of values	9 to 15 for this data set (2004 & 2005)
Usefulness	Ranked as a "best candidate richness measure metric" by Barbour et al., 1999. This metric is employed in the bioassessment approach advocated for "Rapid Bioassessment Protocol III" (Plafkin et al., 1989).
EPT Abundance	
Description	This metric is based on the observation that, in general, the majority of taxa in these three orders are pollution sensitive. Therefore, generally a high EPT abundance indicates a healthy aquatic environment.
Calculation	All Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) are separated from the other macroinvertebrates by order; the total number of individuals in these orders is then counted.
Range of values	232 to 1256 for this data set (2004 & 2005)
Usefulness	Secondary in usefulness to the "EPT taxa richness" metric as it covers the same ground. This metric is not employed in the bioassessment approach advocated for "Rapid Bioassessment Protocol III" (Plafkin et al., 1989).

TABLE 2a
Metrics Employed for Macroinvertebrate Data Analysis (Continued)

Hilsenhoff Biotic Index (modified 1998)	
Description	This index weights the relative abundance of each taxon in terms of its pollution tolerance in determining a community score. A low HBI is generally indicative of a healthy aquatic environment
Calculation	Specimens are identified to genus or species and numbers of each taxon are counted; tolerance values are obtained from published tables (tolerance values used in this study are illustrated in Table 2b). The formula for calculating the biotic index is (Sum of (a x b/c)) where (a) = number of individuals within a species, (b) = tolerance value of a species, (c) = total number of organisms in the sample.
Range of values	0-(dependent on number of organisms at each tolerance level) (3.67 to 5.15 for this data set) (2004 & 2005)
Usefulness	Ranked as an "additional potential tolerance/intolerance measure metric" by Barbour et al., 1999. This metric is oriented toward detection of organic pollution, so may be unreliable in cases where inorganic pollutants impact a stream segment. This metric is employed in the bioassessment approach advocated for "Rapid Bioassessment Protocol III" (Plafkin et al., 1989).
Shannon Weaver Diversity Index	
Description	The rationale behind this metric is that species diversity decreases with decreasing water quality. This metric encompasses both species richness and the distribution of individuals among the species (species composition).
Calculation	Numbers in each species are counted. The formula for calculating the index is (Sum of ($p_i \log_2 p_i$)) where p_i = the proportion of individuals in the i^{th} species.
Range of values	0-(dependent on number of macroinvertebrates) (2.31 to 2.76 for this data set) (2004 & 2005).
Usefulness	Can work as a stand-alone measure of aquatic environment health. This metric is not employed in the bioassessment approach advocated for "Rapid Bioassessment Protocol III" (Plafkin et al., 1989). In practice many taxa are identified only to genus level, which can result in an underestimate of diversity.
Percent Contribution of Dominant Taxon	
Description	Measures the dominance of the single most abundant taxon. The percent contribution of the numerically dominant taxon to the total number of organisms is an indication of community balance at the lowest positive taxonomic level (assumed to be genus or species). A community dominated by relatively few taxa would indicate environmental stress

TABLE 2a
Metrics Employed for Macroinvertebrate Data Analysis (Continued)

Percent Contribution of Dominant Taxon	
Calculation	The formula for calculating the metric is ((a/b) x 100). Where a = the number of individuals in the dominant taxon, b = the total number of individuals recorded at that stream segment.
Range of values	1% - 100% (12.8% to 29.5% for this data set) (both years)
Usefulness	Ranked as a "best candidate tolerance/intolerance measure metric" by Barbour et al., 1999. However some unstressed habitats also are dominated by a few taxa (Barbour et al., 1999), which places the reliability of the metric into question. This metric is employed in the bioassessment approach advocated for "Rapid Bioassessment Protocol III" (Plafkin et al., 1989).
Ratio of EPT Abundance to Chironomid Abundance	
Description	The rationale behind this metric is that Chironomidae are perceived to be pollution-tolerant relative to pollution sensitive Ephemeroptera, Plecoptera and Trichoptera. Compared with a non-stressed habitat, a stressed habitat reflects an imbalance between these groups. Skewed populations having a disproportionate number of the generally tolerant Chironomidae may indicate environmental stress (Plafkin et al., 1989).
Calculation	All specimens of Ephemeroptera, Plecoptera and Trichoptera are determined to order and counted; the number of Chironomidae are determined. The number of EPT are divided by the number of Chironomids.
Range of values	0.0001 – infinity (1.88 to 3.31 for this data set) (both years)
Usefulness	The metric was not identified as a candidate metric by Barbour et al., 1999. In addition there is some inbuilt unreliability to the index with the known variety of pollution tolerance of the Chironomidae (Plafkin et al 1989), i.e. not all species of Chironomids are pollution tolerant. This metric is employed in the bioassessment approach advocated for "Rapid Bioassessment Protocol III" (Plafkin et al., 1989).

TABLE 2a
Metrics Employed for Macroinvertebrate Data Analysis (Continued)

Percent Hydropsychidae to Total Trichoptera	
Description	The rationale behind this metric is that Hydropsychidae are perceived to be pollution-tolerant relative to other more pollution sensitive Trichopterans (Barbour et al., 1999). Compared with a non-stressed habitat, a stressed habitat may reflect an imbalance between these groups. Skewed populations having a disproportionate number of Hydropsychidae may indicate environmental stress.
Calculation	All specimens of Hydropsychidae are determined and counted, all specimens of Trichoptera other than Hydropsychidae are determined and counted. The number of Hydropsychidae are divided by the number of other Trichoptera and multiplied by 100.
Range of values	0.0001 – 100% (65.9% - 98.5% for this data set) (both years)
Usefulness	Ranked as an "additional potential tolerance/intolerance measure metric" by Barbour et al., 1999. This metric is not employed in the bioassessment approach advocated for "Rapid Bioassessment Protocol III" (Plafkin et al., 1989).
Ratio of Shredders to Total Number of Macroinvertebrates	
Description	The rationale behind this metric is that shredder organisms and their microbial food base are sensitive to toxicants and to modifications to the riparian zone (Plafkin et al., 1989). The focus of the approach as identified by Plafkin, is on a comparison to the reference community, which should have an abundance and diversity of shredders representative of the particular area under study.
Calculation	Specimens are identified and numbers of each taxon counted; those in the shredder functional feeder group are determined using published studies (See Table 4 for a list of the feeding groups assigned to each identified taxon for this study). The number of shredders is divided by the total number of remaining macroinvertebrates.
Range of values	Dependent upon numbers of macroinvertebrates in the sample (0.000052 to 0.2288 for this data set)
Usefulness	Ranked as an "additional potential feeding measures metric" by Barbour et al., 1999. There is some question as to the applicability of functional designations when applied at the generic level, among ages of a specific taxon or in different regions etc (Rosenberg & Resh 1993). This metric is employed in the bioassessment approach advocated for "Rapid Bioassessment Protocol III" (Plafkin et al., 1989).

TABLE 2a
Metrics Employed for Macroinvertebrate Data Analysis (Continued)

Ratio of Scrapers to Filterers	
Description	This ratio reflects the riffle/run community food base. Predominance of a particular feeding group may indicate an unbalanced community responding to an overabundance of a particular food source. Scrapers increase with increased abundance of diatoms and decrease as filamentous algae and aquatic mosses increase, which provide good attachment sites for filterers. In addition, the organic enrichment often responsible for overabundance of filamentous algae provides particulate matter, which is also utilized by filterers. Therefore, dominance of filterers in a community may reflect organic enrichment (Rosenberg & Resh 1993).
Calculation	Specimens are identified and numbers of each taxon counted; those in the scraper and filterer functional feeder groups are determined using published studies (See Table 2b for a list of the feeding groups assigned to each identified taxon for this study). The total number of scrapers found is divided by the total number of filterers.
Range of values	Dependent upon numbers of macroinvertebrates in the sample (0.05 to 3.00 for this data set) (2004 & 2005)
Usefulness	There is some question as to the applicability of functional designations when applied at the generic level, among ages of a specific taxon or in different regions, etc. (Rosenberg & Resh 1993). In addition there is some inbuilt unreliability to the index due to the fact that some scraper organisms are in fact pollution tolerant e.g. Physid Snails (Plafkin et al. 1989). This metric is employed in the bioassessment approach advocated for "Rapid Bioassessment Protocol III" (Plafkin et al., 1989), but is not identified by Barbour et al. (1999) as a candidate metric.

TABLE 2a
Metrics Employed for Macroinvertebrate Data Analysis (Continued)

Community Loss Index	
Description	This metric measures the loss of benthic species between a reference station and the station of comparison. The rationale behind the metric is that the communities will become more dissimilar as stress increases at the station of comparison (Rosenberg & Resh, 1993).
Calculation	(The total number of taxa at the reference station) minus (total number of taxa common to both stations)/(total number of taxa at station of comparison)
Range of values	0-infinity (0 to 0.71 for this data set) (2004 & 2005)
Usefulness	This metric is employed in the bioassessment approach advocated for "Rapid Bioassessment Protocol III" (Plafkin et al., 1989), but is not identified by Barbour et al. (1999) as a candidate metric.

Table 2b.

Tolerance values and feeding habits for all macroinvertebrates identified within 100-organism sub-samples from the Blackstone River at Manville Dam and the Reference Station for the Southern New England Coastal Plains and Hills Ecoregion, during 2004 and 2005.

Invertebrate Taxa	Tolerance Values (taken from Mandaville 2002)	Feeding Habit (taken from Mandaville 2002 & Merritt & Cummins 1996)
Bivalvia (Pelecypoda)		
Pisidiidae (Sphaeriidae)		
Musculium sp.	6	Collector Filterer
Pisidium sp.	6	Collector Filterer
Crustacea		
Amphipoda		
Gammarus sp.	6	Collector Gatherer
Hyalella azteca	8	Collector Gatherer
Decapoda		
Orconectes sp.	6	Collector Gatherer
Gastropoda		
Valvatidae		
Valvata sp.	8	Scraper
Hirudinea		
Arhynchobdellida		
Erpobdellidae	10	Predator
Insecta		
Coleoptera		
Ancyronyx sp. (Larvae)	5	Collector Gatherer
Microcylloepus sp. (Larvae)	3	Collector Gatherer
Optioservus sp. (Larvae)	4	Scraper
Oulimnius sp. (Larvae)	4	Scraper
Oulimnius sp. (Adult)	4	Scraper
Promoresia sp. (Larvae)	2	Scraper
Promoresia sp. (Adult)	2	Scraper
Diptera		
Antocha sp. (Larvae)	3	Collector Gatherer
Antocha sp. (Pupae)	N/A	N/A
Bezzia sp.	6	Predator
Chironomidae (Pupae)	N/A	N/A
Chironomini	8	Collector Gatherer
Hemerodromia sp. (Pupae)	6	N/A
Hemerodromia sp.	6	Predator
Orthocladiinae	5	Collector Gatherer
Simulium sp.	5	Collector Filterer
Tanypodinae	7	Predator
Tanytarsini	6	Collector Gatherer
Tipula sp.	6	Shredder
Ephemeroptera		
Acentrella sp.	4	Collector Gatherer
Attenella sp.	1	Collector Gatherer
Baetis sp.	6	Collector Gatherer
Centroptilum sp.	2	Collector Gatherer
Heterocloeon sp.	2	Scraper
Paraleptophlebia sp.	1	Collector Gatherer
Stenacron sp.	3	Scraper
Stenonema sp.	3	Scraper
Megaloptera		
Corydalus sp.	0	Predator
Nigronia sp.	4	Predator
Plecoptera		
Acroneuria sp.	0	Predator
Trichoptera		
Brachycentidae	2	Shredder
Brachycentrus sp.	1	Collector Filterer
Ceraclea sp.	3	Collector Gatherer
Ceratopysche sp.	5	Collector Filterer
Cheumatopsyche sp.	5	Collector Filterer
Chimarra sp.	4	Collector Filterer
Glossosoma sp.	0	Scraper
Hydropsychidae (Pupae)	N/A	N/A
Hydropsyche sp.	4	Collector Filterer
Hyrdroptila sp.	6	Scraper
Lepidostoma sp.	1	Shredder
Leucotrichia sp.	6	Scraper
Macrostemum sp.	3	Collector Filterer
Mayatrichia sp.	6	Scraper
Micrasema sp.	2	Shredder
Ochrotrichia sp.	6	Collector Gatherer
Oecetis sp.	5	Predator
Nematoda	5	Various
Nemertea	8	Predator
Oligochaeta		
Lumbriculidae	5	Collector Gatherer
Naididae	8	Collector Gatherer
Tubificida	10	Collector Gatherer
Tubificidae	10	Collector Gatherer
Turbellaria	4	Predator

TABLE 3.

Bioassessment Approach for Rapid Bioassessment Protocol III (Plafkin et al., 1989).

Metric	Biological Condition Scoring Criteria			
	6*	4*	2*	0*
Taxa Richness (a)	>80%	60-80%	40-60%	<40%
Hilsenhoff Biotic Index (b)	>85%	70-85%	50-70%	<50%
Ratio of Scrapers/Filterers (a,c)	>50%	35-50%	20-35%	<20%
Ratio of EPT and Chironomid Abundance (a)	>75%	50-75%	25-50%	<25%
% Contribution of Dominant Taxon (d)	<20%	20-30%	30-40%	>40%
EPT Index (a)	>90%	80-90%	70-80%	<70%
Community Loss Index (e)	<0.5	0.5-1.5	1.5-4.0	>4.0
Ratio of Shredders/Total (a,c)	>50%	35-50%	20-35%	<20%

(a) Score is a ratio of study site to reference site x 100.
(b) Score is a ratio of reference site to study site x 100.
(c) Determination of Functional Feeding Group is independent of taxonomic grouping.
(d) Scoring criteria evaluate actual percent contribution, not percent comparability to the reference station.
(e) Range of values obtained. A comparison to the reference station is incorporated in these indices.
* The scores for each metric fall under one of these four numbers, these numbers are added up to result in the representative empirical value for each stream segment.

TABLE 4.

Percent Comparability Evaluation for Macroinvertebrate Bioassessment Scores (Plafkin et al., 1989)

% Comparability to Reference Score	Biological Condition Category
>83%	Non-impaired
54-79%	Slightly impaired
21-50%	Moderately impaired
<17%	Severely impaired

Table 5.
Habitat Assessment Score and EPA Assigned Assessment Category for the Blackstone River at Manville Dam based on a comparison with the Reference Site for the Southern New England Coastal Plains and Hills Ecoregion, 2004 and 2005.

Site	Habitat Score*	Percent of Comparability to Reference Site	EPA Assessment Category
Blackstone River at Manville dam, 2004	152	86.9	Supporting
Wood River Reference Station 2004	**175**		
Blackstone River at Manville dam, 2005	154	88.0	Supporting
Wood River Reference Station 2005	**175**		

* Habitat assessment methodology used for this study was comparable to that of the"EPA Rapid Bioassessment Protocols for Use in Streams and Rivers".

Table 6.
Water quality results for the Blackstone River at Manville Dam and the Reference Station for the Southern New England Coastal Plains and Hills Ecoregion, during 2004 and 2005.

Site	Date	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Saturation)	Turbidity (NTU)	pH (SU)	Specific Conductance (μmhos/cm)	Flow (cfs)
Blackstone River at Manville Dam	8/30/2004	25.1	7.8	94.8	3.5	7.2	452.0	90.00
	9/2/2005	23.5	7.7	90.5	6.2	7.1	477.8	60.00
Wood River Reference Station	8/20/2004	22.0	8.4	93.4	4.3	6.3	98.4	124.80
	8/19/2005	21.1	9.1	102.0	4.7	7.4	88.1	67.20

Table 7.

Numbers of macroinvertebrates identified from a known fraction (sub-sample) of the 3-minute kick sample for the Blackstone River at Manville Dam, and the Reference Station for the Southern New England Coastal Plains and Hills Ecoregion, during 2004.

Invertebrate Taxa	**Manville Dam**	**Reference station**
	1/4	**1/4**
Bivalvia (Pelecypoda)		
Pisidiidae (Sphaeriidae)		
Musculium spp.	14	
Pisidium sp.	3	4
Crustacea		
Amphipoda		
Hyalella azteca		2
Decapoda		
Orconectes sp.	1	
Insecta		
Coleoptera		
Ancyronyx sp. (Larvae)	2	
Microcylloepus sp. (Larvae)		2
Optioservus sp. (Larvae)		5
Oulimnius sp. (Adult)		2
Promoresia sp. (Larvae)		45
Promoresia sp. (Adult)		5
Diptera		
Antocha sp. (Larvae)	17	
Antocha sp. (Pupae)	4	
Bezzia sp.		1
Chironomidae (Pupae)	4	
Chironomini	12	7
Hemerodromia sp. (Pupae)	2	
Hemerodromia sp.	2	
Orthocladiinae	27	40
Simulium sp.		3
Tanypodinae	1	7
Tanytarsini	43	4
Tipula sp.	1	1
Ephemeroptera		
Acentrella sp.	9	
Attenella sp.		6
Baetis sp.	18	
Centroptilum sp.		8
Heterocloeon sp.	1	
Paraleptophlebia sp.	1	
Stenacron sp.	1	
Stenonema sp.	6	13
Megaloptera		
Corydalus sp.		1
Nigronia sp.		1
Trichoptera		
Brachycentidae		6
Brachycentrus sp.		5
Ceraclea sp.		1
Ceratopysche sp.	58	36
Cheumatopsyche sp.	44	4
Chimarra sp.	64	
Glossosoma sp.		1
Hydropsychidae (Pupae)	3	
Hydropsyche sp.	75	12
Hydroptila sp.	1	
Leucotrichia sp.	3	
Macrostemum sp.	3	2
Mayatrichia sp.		1
Micrasema sp.		9
Ochrotrichia sp.	1	
Oecetis sp.		5
Nematoda		1
Nemertea	1	
Oligochaeta		
Tubificida	2	
Turbellaria	13	

Table 8.
Numbers of Macroinvertebrates identified from a known fraction (sub-sample) of the 3-minute kick sample for the Blackstone River at Manville Dam, and the Reference Station for the Southern New England Coastal Plains and Hills Ecoregion, during 2005.

Invertebrate Taxa	**Manville Dam**	**Reference station**
	1/8	**1/4**
Bivalvia (Pelecypoda)		
Pisidiidae (Sphaeriidae)		
Musculium sp.	4	1
Pisidium sp.	14	
Crustacea		
Amphipoda		
Gammarus sp.	2	
Gastropoda		
Valvatidae		
Valvata sp.	1	
Hirudinea		
Arhynchobdellida		
Erpobdellidae	1	
Insecta		
Coleoptera		
Microcylloepus sp. (Larvae)	1	6
Optioservus sp. (Larvae)		3
Oulimnius sp. (Adult)		2
Promoresia sp. (Larvae)		44
Promoresia sp. (Adult)		3
Diptera		
Chironomidae (Pupae)	1	
Chironomini	11	3
Orthocladiinae	6	10
Simulium sp.	1	4
Tanypodinae		2
Tanytarsini	37	7
Ephemeroptera		
Acentrella sp.	1	
Attenella sp.		1
Baetis sp.	13	2
Centroptilum sp.		2
Heterocloeon sp.	8	
Stenonema sp.		23
Plecoptera		
Acroneuria sp.	1	1
Trichoptera		
Brachycentrus sp.		1
Ceratopysche sp.	50	19
Cheumatopsyche sp.	45	
Chimarra sp.	2	
Hydropsychidae (Pupae)	2	1
Hydropsyche sp.	35	4
Lepidostoma sp.		2
Macrostemum sp.		1
Oecetis sp.		1
Oligochaeta		
Lumbriculidae		1
Naidinae		4
Tubificinae		1
Turbellaria	6	

Table 9.
Total number of macroinvertebrates per 3-minute kick sample for the Blackstone River at Manville Dam, and the Reference Station for the Southern New England Coastal Plains and Hills Ecoregion, during 2004.

Invertebrate Taxa	**Manville Dam**	**Reference station**
Bivalvia (Pelecypoda)		
Pisidiidae (Sphaeriidae)		
Musculium spp.	56	
Pisidium sp.	12	16
Crustacea		
Amphipoda		
Hyalella azteca		8
Decapoda		
Orconectes sp.	4	
Insecta		
Coleoptera		
Ancyronyx sp. (Larvae)	8	
Microcylloepus sp. (Larvae)		8
Optioservus sp. (Larvae)		20
Oulimnius sp. (Adult)		8
Promoresia sp. (Larvae)		180
Promoresia sp. (Adult)		20
Diptera		
Antocha sp. (Larvae)	68	
Antocha sp. (Pupae)	16	
Bezzia sp.		4
Chironomidae (Pupae)	16	
Chironomini	48	28
Hemerodromia sp. (Pupae)	8	
Hemerodromia sp.	8	
Orthocladiinae	108	160
Simulium sp.		12
Tanypodinae	4	28
Tanytarsini	172	16
Tipula sp.	4	4
Ephemeroptera		
Acentrella sp.	36	
Attenella sp.		24
Baetis sp.	72	
Centroptilum sp.		32
Heterocloeon sp.	4	
Paraleptophlebia sp.	4	
Stenacron sp.	4	
Stenonema sp.	24	52
Megaloptera		
Corydalus sp.		4
Nigronia sp.		4
Trichoptera		
Brachycentidae		24
Brachycentrus sp.		20
Ceraclea sp.		4
Ceratopysche sp.	232	144
Cheumatopsyche sp.	176	16
Chimarra sp.	256	
Glossosoma sp.		4
Hydropsychidae (Pupae)	12	
Hydropsyche sp.	300	48
Hydroptila sp.	4	
Leucotrichia sp.	12	
Macrostemum sp.	12	8
Mayatrichia sp.		4
Micrasema sp.		36
Ochrotrichia sp.	4	
Oecetis sp.		20
Nematoda		4
Nemertea	4	
Oligochaeta		
Tubificida	8	
Turbellaria	52	
Total Number	**1748**	**960**

Table 10.
Total number of macroinvertebrates per 3-minute kick sample for the Blackstone River at Manville Dam, and the Reference Station for the Southern New England Coastal Plains and Hills Ecoregion, during 2005.

Invertebrate Taxa	**Manville Dam**	**Reference station**
Bivalvia (Pelecypoda)		
Pisidiidae (Sphaeriidae)		
Musculium sp.	32	4
Pisidium sp.	112	
Crustacea		
Amphipoda		
Gammarus sp.	16	
Gastropoda		
Valvatidae		
Valvata sp.	8	
Hirudinea		
Arhynchobdellida		
Erpobdellidae	8	
Insecta		
Coleoptera		
Microcylloepus sp. (Larvae)	8	24
Optioservus sp. (Larvae)		12
Oulimnius sp. (Adult)		8
Promoresia sp. (Larvae)		176
Promoresia sp. (Adult)		12
Diptera		
Chironomidae (Pupae)	8	
Chironomini	88	12
Orthocladiinae	48	40
Simulium sp.	8	16
Tanypodinae		8
Tanytarsini	296	28
Ephemeroptera		
Acentrella sp.	8	
Attenella sp.		4
Baetis sp.	104	8
Centroptilum sp.		8
Heterocloeon sp.	64	
Stenonema sp.		92
Plecoptera		
Acroneuria sp.	8	4
Trichoptera		
Brachycentrus sp.		4
Ceratopysche sp.	400	76
Cheumatopsyche sp.	360	
Chimarra sp.	16	
Hydropsychidae (Pupae)	16	4
Hydropsyche sp.	280	16
Lepidostoma sp.		8
Macrostemum sp.		4
Oecetis sp.		4
Oligochaeta		
Lumbriculidae		4
Naididae		16
Tubificidae		4
Turbellaria	48	
Total Number	**1936**	**596**

Table 11.
Summary statistics for the Blackstone River at Manville Dam and The Reference Station for the Southern New England Coastal Plains and Hills Ecoregion, 2004 and 2005. Based on Metrics Recommended by EPA Rapid Bioassessment Protocols.

Site Code	Total Taxa Richness	EPT Taxa Richness	EPT Abundance per Kick Sample	Hilsenhoff Biotic Index		Shannon Weaver Diversity Index	% Contribution of Dominant Taxon	Ratio of EPT to Chironomid Abundance	% Hydropsychidae to Total Trichoptera	Ratio Shredders/Total Number of Invertebrates*	Ratio Scrapers/ Filterers	Community Loss Index
				Index	Water Quality							
Blackstone River at Manville dam, 2004	32	15	1152	4.81	Good	2.64	17.2	3.31	72.6	0.2288	0.05	0.63
Wood River Reference Station 2004	31	14	436	3.85	Very Good	2.76	18.8	1.88	65.9	0.0667	1.09	0.00
Blackstone River at Manville dam, 2005	21	9	1256	5.15	Good	2.31	12.8	2.86	98.5	0.000052	0.08	0.71
Wood River Reference Station 2005	26	12	232	3.67	Very Good	2.48	29.5	2.64	86.2	0.0134	3.00	0.00

* In the case where 0 shredders were found at a site, a value of 0.1 was substituted for the sake of ratio calculations

Table 12.
Assessment of the Macoinvertebrate Community For The Blackstone River At Manville Dam
Using the Bioassessment Approach Advocated for Rapid Bioassessment Protocol (3) (Plafkin et al 1989).

Site	Ecoregion	% Comparability of Study Site Biological Condition Score to Reference Station Biological Condition Score	Assigned Biological Condition Category
Blackstone River at Manville Dam, 2004	SNECPH	79.2%	Slightly impaired
Blackstone River at Manville Dam, 2005	SNECPH	60.9%	Slightly impaired
Wood River Reference Station 2004 and 2005	**SNECPH**	**Reference Site for Southern New England Coastal Plains and Hills Ecoregion**	

SNECPH = Southern New England Coastal Plains and Hills

Table 13.

Relative Percentile Comparability Calculations for 2004 Data, Using the Bioassessment Approach Advocated for Rapid Bioassessment Protocol (3) (Plafkin et al 1989).

Southern New England Coastal Plains and Hills Ecoregion (Reference Station: Wood River - Barberville Baseline Station)

Site	Metric	Metric Result for Study Site	Metric Result for Reference Station	% Comparability of Study Site to Reference Station[f]	Biological Condition Score for Study Site[g]	Biological Condition Score for Reference Station[g]	% Comparability of Study Site Score to Reference Station Score
Blackstone River at Manville Dam	Taxa Richness[a]	32	31	103.2	6	6	**79.2%**
2004	Hilsenhoff Biotic Index[b]	4.81	3.85	80.0	4	6	
	Ratio Scrapers/Filtering Collector[a,c]	0.05	1.09	4.6	0	6	
	Ratio EPT and Chironomid abundances[a]	3.31	1.88	176.1	6	6	
	% Contribution of Dominant Taxon[d]	17.2	18.8		6	6	
	EPT Index[a]	15	14	107.1	6	6	
	Community Loss Index[e]	0.63	0		4	6	
	Ratio of Shredders/Total[a,c]	0.2288	0.0667	343.0	6	6	
					Total Score	**Total Score**	
					38	**48**	

a = Score is a ratio of study site to reference site x 100
b = Score is a ratio of reference site to study site x 100
c = Determination of Functional Feeding Group is independent of taxonomic grouping
d = Scoring criteria evaluate actual percent contribution, not percent comparability to the reference station
e = Range of values obtained. A comparison to the reference station is incorporated in these indices
f = Not always relevant, some metrics are scored on actual percent contribution or have the reference station incorporated into the indices
g = Scoring Criteria taken from USEPA Rapid Bioassessment Protocols (RBP-3) Plafkin et al

Table 14.

Relative Percentile Comparability Calculations for 2005 Data, Using the Bioassessment Approach Advocated for Rapid Bioassessment Protocol (3) (Plafkin et al 1989).

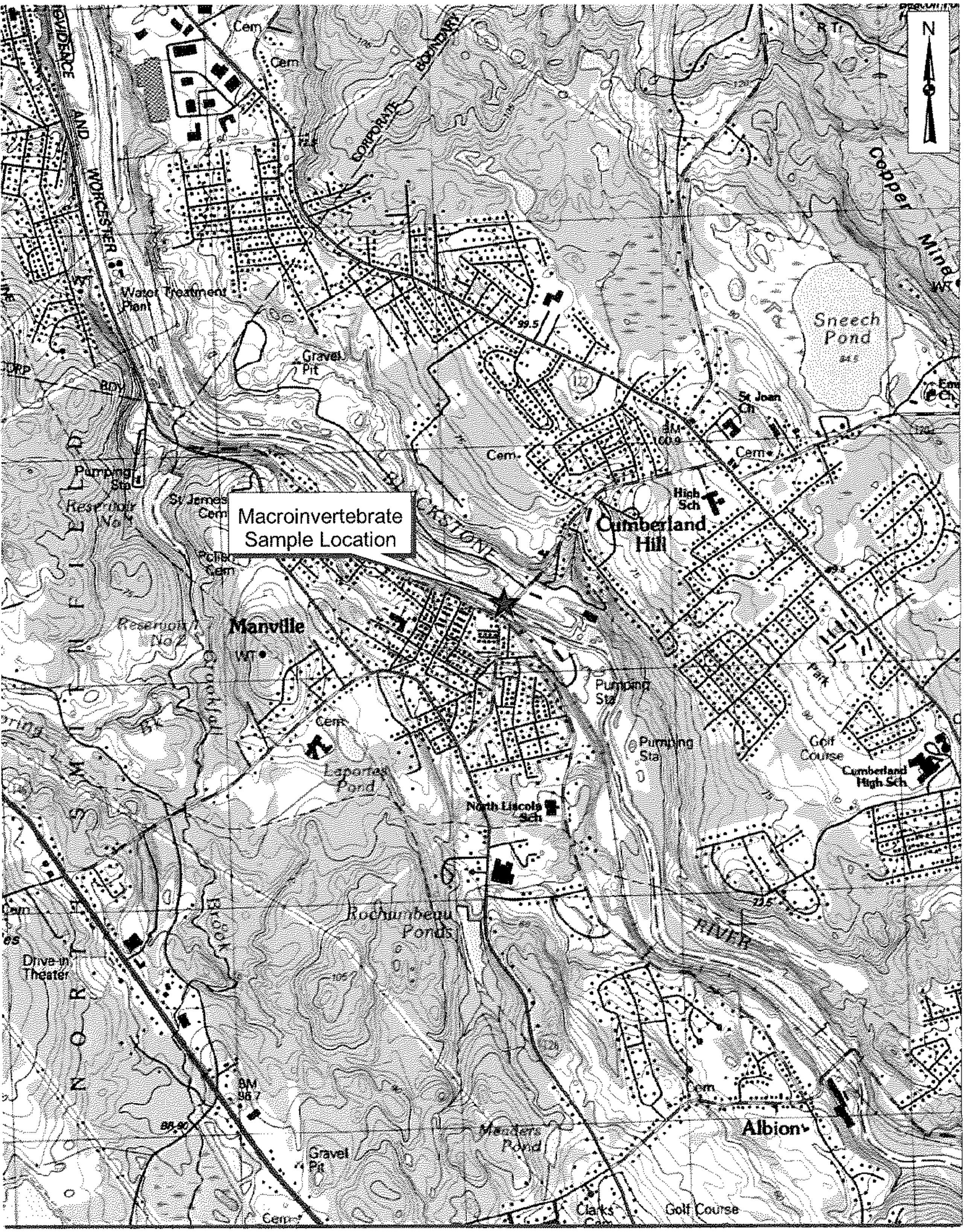
Southern New England Coastal Plains and Hills Ecoregion (Reference Station: Wood River - Barberville Baseline Station)

Site	Metric	Metric Result for Study Site	Metric Result for Reference Station	% Comparability of Study Site to Reference Station[f]	Biological Condition Score for Study Site[g]	Biological Condition Score for Reference Station[g]	% Comparability of Study Site Score to Reference Station Score
Blackstone River at Manville Dam	Taxa Richness[a]	21	26	80.8	6	6	60.9%
2005	Hilsenhoff Biotic Index[b]	5.15	3.67	71.3	4	6	
	Ratio Scrapers/Filterering Collector[a,c]	0.08	3.00	2.7	0	6	
	Ratio EPT and Chironomid abundances[a]	2.86	2.64	108.3	6	6	
	% Contribution of Dominant Taxon[d]	12.8	29.5		6	4	
	EPT Index[a]	9	12	75.0	2	6	
	Community Loss Index[e]	0.71			4	6	
	Ratio of Shredders/Total[a,c]	0.000052	0.0134	0.4	0	6	
					Total Score	**Total Score**	
					28	**46**	

a = Score is a ratio of study site to reference site x 100
b = Score is a ratio of reference site to study site x 100
c = Determination of Functional Feeding Group is independent of taxonomic grouping
d = Scoring criteria evaluate actual percent contribution, not percent comparability to the reference station
e = Range of values obtained. A comparison to the reference station is incorporated in these indices
f = Not always relevant, some metrics are scored on actual percent contribution or have the reference station incorporated into the indices
g = Scoring Criteria taken from USEPA Rapid Bioassessment Protocols (RBP-3) Plafkin et al

Figures

Location: G:\GIS-Projects\B357\Berger.apr Layout: Site Locus



Macroinvertebrate Sample Location

ESS Group, Inc.

Engineers
Scientists
Consultants

BLACKSTONE RIVER
MACROINVERTEBRATE
SAMPLE & ANALYSIS
Lincoln, Rhode Island

Scale: 1" = 2,000'

Source: 1) RIGIS, USGS DRG, 1975

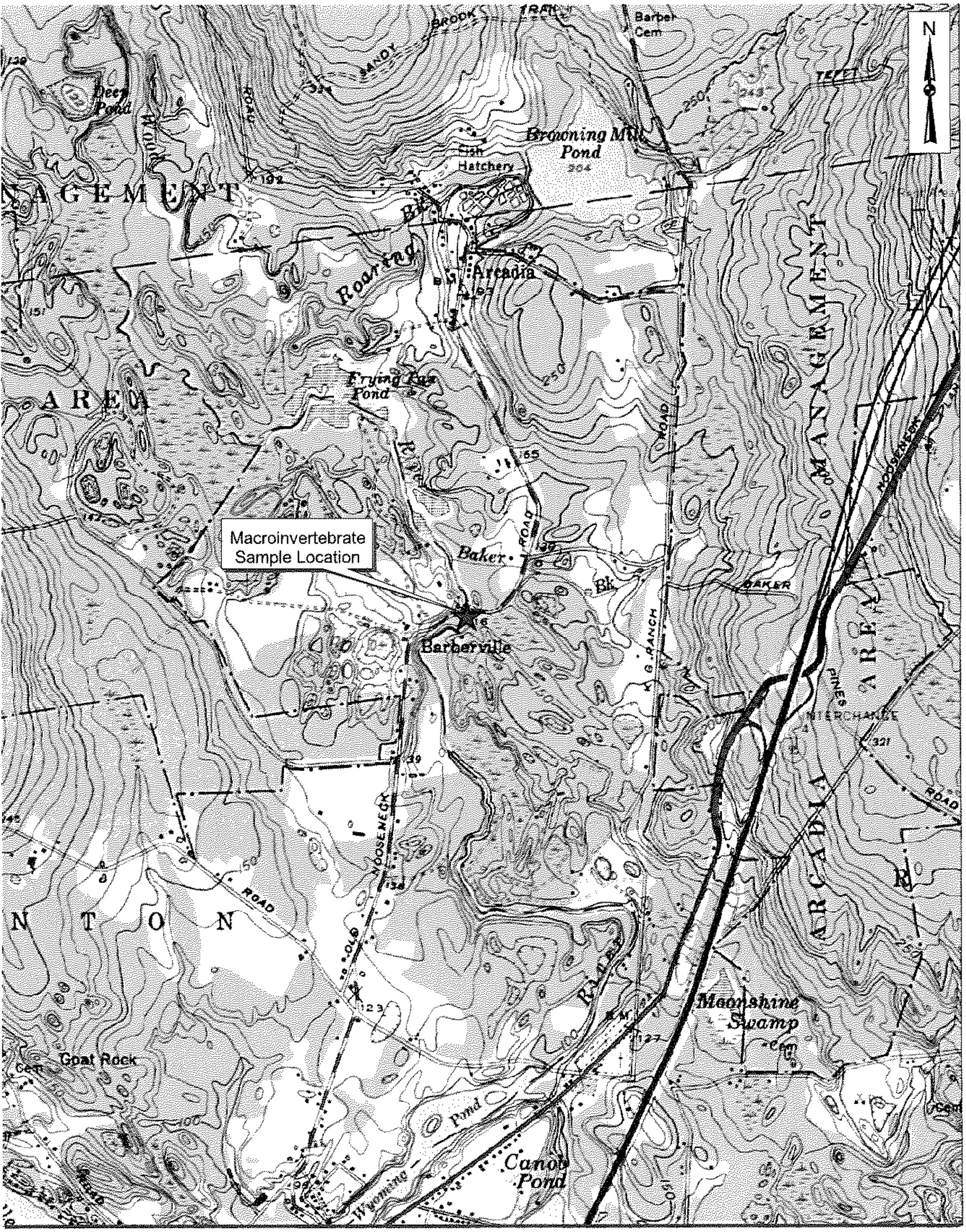
LEGEND

★ Blackstone River Sample Location

Site Locus Map (Blackstone River)

Figure 1

Location: G:\GIS-Projects\B357\Berger.apr Layout: Site Locus - Hopkinton



ESS Group, Inc.
Engineers
Scientists
Consultants

BLACKSTONE RIVER
MACROINVERTEBRATE
SAMPLE & ANALYSIS
Hopkinton, Rhode Island

Scale: 1" = 2,000'

Source: 1) RIGIS, USGS DRG, 1975

LEGEND

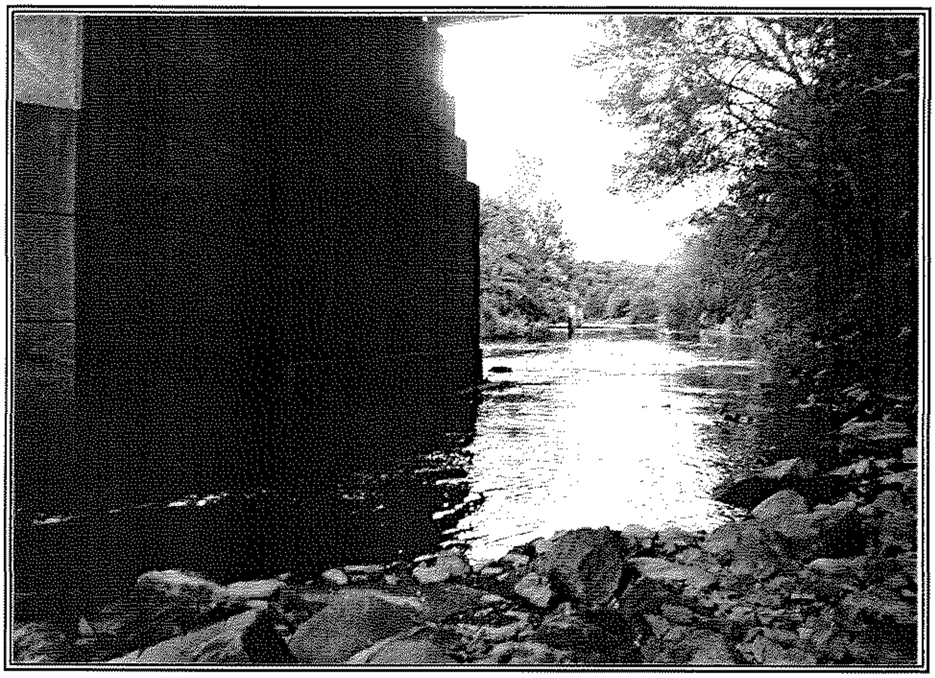
★ Reference Station
Sample Location

Site Locus Map
(Reference Station)

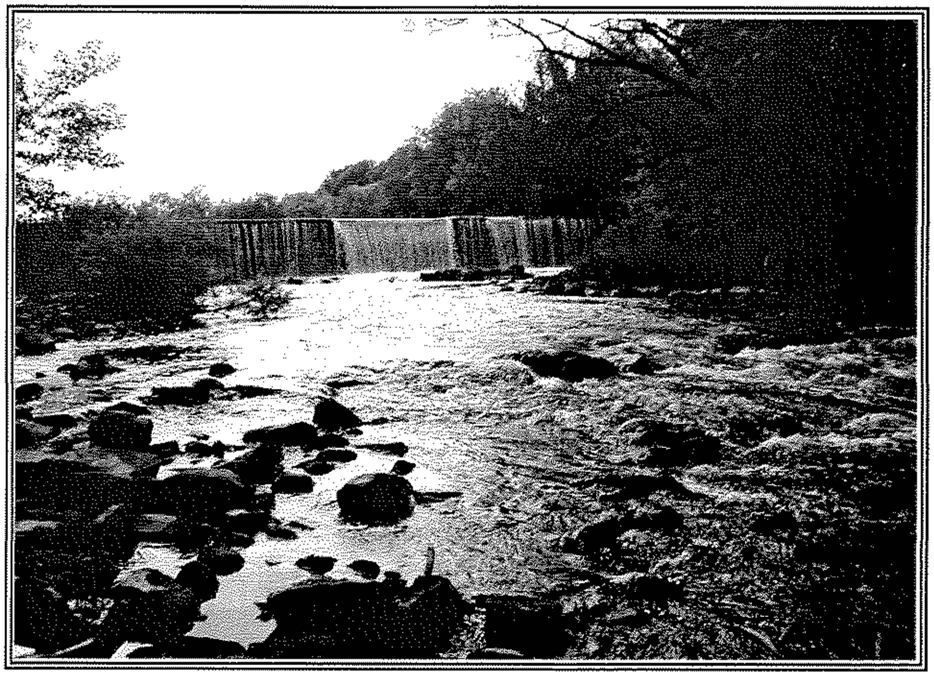
Figure
2

Attachment 1

Photographic Log



Photograph No. 1:
Blackstone River (at Manville Dam) looking downstream



Photograph No. 2:
Blackstone River (at Manville Dam) looking upstream

ESS Group, Inc.

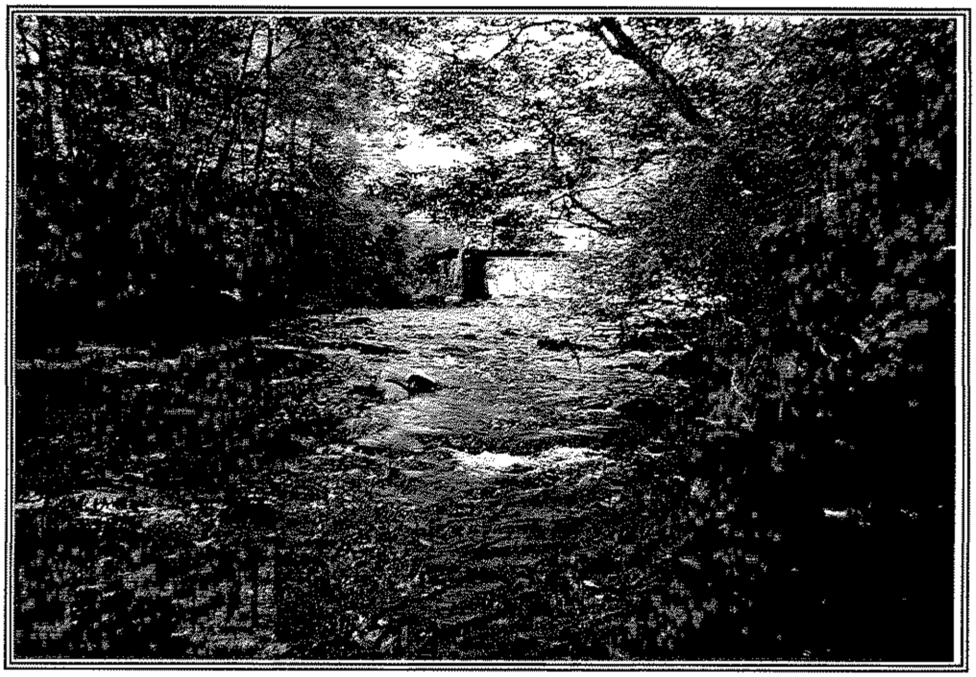
Photographic Log

Macroinvertebrate Sample Locations
Rhode Island, 2004 and 2005

Sheet 1 of 2

PROJECT NO.
B357-000

Photograph No. 3:
Wood River- Reference station looking downstream



Photograph No. 4:
Wood River- Reference station looking upstream

ESS Group, Inc.	**Photographic Log** Macroinvertebrate Sample Locations Rhode Island, 2004 and 2005	Sheet 2 of 2 PROJECT NO. B357-000

Attachment 2

Habitat Assessment Data Sheets

HABITAT ASSESSMENT FIELD DATA SHEET

SARIS NO. Manville Dam

RIVER BASIN Blackstone

RIVER MILE

ECOREGION REFERENCE SITE WOOD RIVER (Station 15)

DATE 8/30/04

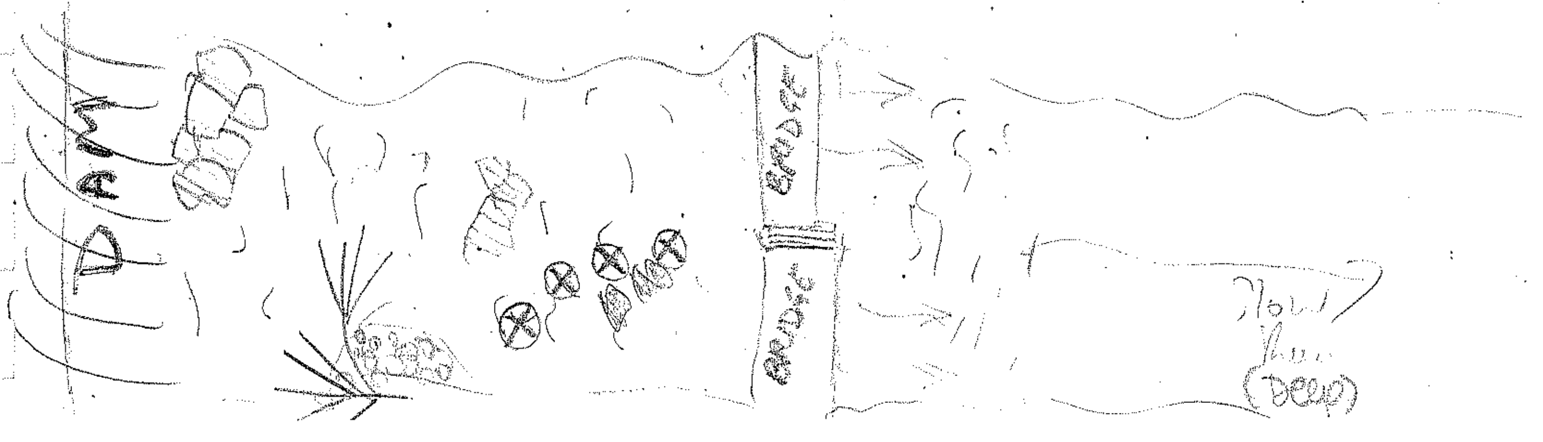
INVESTIGATOR Sheppard

DESCRIBE SITE LOCATION Sampled u/s of Bridge d/s of the dam

Comments: Very Rocky, Slippy hard to sample!

Riffle/Run Prevalent Streams are those in moderate to high-gradient landscapes that sustain water velocities of approximately 30 cm/sec or greater. Natural streams have substrates primarily composed of coarse sediment particles (i.e., gravel or larger) or frequent coarse particulate aggregations along stream reaches.

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
1. Instream Cover (Fish)	A mix of snags, submerged logs, undercut banks, rubble, or other stable habitat in greater than 50% of the sample area	30-50% of area with a mix of stable habitat; adequate habitat for maintenance of populations.	10-30% of area with a mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% of area with a mix of stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE 18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Epifaunal Substrate	Well-developed riffle and run; riffle is as wide as stream and length extends two times the width of stream; abundance of cobble. (Boulders prevalent in headwater streams).	Riffle is as wide as stream but length is less than two times width; abundance of cobble; boulders and gravel common.	Run area may be lacking; riffle not as wide as stream and its length is less than 2 times the stream width; gravel or bedrock prevalent; some cobble present.	Riffles or runs virtually nonexistent; bedrock prevalent; cobble lacking.
SCORE 20	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE 18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	New embankments present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted.
SCORE 8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 20	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0



Manville Dam

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
6. Frequency of Riffles (or bends) / Velocity-Depth Combinations	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important; All 4 velocity/depth patterns present.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15. Only 3 of 4 velocity/depth patterns present (i.e., slow [<0.3 m/s]-deep [>0.5 m]; slow-shallow; fast-deep; fast-shallow).	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25. Only 2 velocity/depth patterns present; usually lacking deep areas.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25. Dominated by one velocity/depth pattern.
SCORE 18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE 5 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 5 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE 10 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 10 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE 1 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 2 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score 152

12/13/95

Physical Characterization/Water Quality Field Data Sheet

STATION: Manville Dam STREAM NAME: Blackstone River RIVER MILE: ______ DATE: 8/30/04

RIVER BASIN: Blackstone STREAM CLASSIFICATION: NO INVESTIGATORS: Sheppard

RECONN | HABITAT | [✓ INVERTEBRATE] | FISH | FLOW | WQ

DESCRIBE LOCATION: ______

STREAM CHARACTERIZATION

■ Subsystem Classification
- ___ Tidal
- ✓ Lower Perennial
- ___ Upper Perennial
- ___ Intermittent

■ Stream Type
- ___ Coldwater
- ✓ Warmwater

RIPARIAN ZONE/INSTREAM FEATURES

■ Predominant Surrounding Land Use
- ✓ Forest
- ___ Field/Pasture
- ___ Agricultural
- ✓ Residential
- ___ Commercial
- ___ Industrial
- ___ Other

■ Channelized ✓ Y ___ N

■ Dam Present ✓ Y ___ N

■ Local Water Erosion
- ✓ None
- ___ Moderate
- ___ Heavy

■ Local Watershed NPS Pollution
- ___ No evidence
- ___ Some potential sources
- ✓ Obvious sources

■ High Water Mark 1.5 m

■ Velocity ___ m/sec

■ Estimated Stream Width 9 m

■ Estimated Stream Depth

Riffle 0.35 m

Run ___ m

Pool ___ m

■ Estimated Fish Reach Length ___ m

■ Canopy Cover
- ✓ Partly open
- ___ Partly shaded
- ___ Shaded

SEDIMENT/SUBSTRATE

■ Odors
- ___ Normal
- ✓ Sewage
- ___ Petroleum
- ___ Chemical
- ✓ Anaerobic
- ___ None
- ___ Other

■ Oils
- ✓ Absent
- ___ Slight
- ___ Moderate
- ___ Profuse
- ___ Relict shells
- ___ Other

■ Deposits
- ___ Sludge
- ___ Sawdust
- ___ Paper fiber
- ___ Sand

■ Are the underside of stones not deeply embedded black? ___ Y ✓ N

INORGANIC SUBSTRATE COMPONENTS			ORGANIC SUBSTRATE COMPONENTS		
Substrate Type	Diameter	Percent Composition in Sampling Area	Substrate Type	Characteristic	Percent Composition in Sampling Area
Bedrock			Detritus	sticks, wood, coarse plant materials (CPOM)	
Boulder	>256mm (10 in)	40%			
Cobble	64-256mm (2.5-10 in)	50%			
Gravel	2-64mm (0.1-2.5 in)	10%	Muck-mud	black, very fine organic (FPOM)	
Sand	0.06-2mm (gritty)				
Silt	0.004-0.06mm		Marl	grey, shell fragments	
Clay	<0.004mm (slick)				

WATER QUALITY

■ Temperature ___ °C

■ Specific Conductance ___

■ Dissolved Oxygen ___

■ pH ___

■ Turbidity

■ Instrument(s) Used

Hydrolab H2O No. ___

Hydrolab SRV3 No. ___

■ Other ______

■ Water Odors
- ___ Normal/None
- ✓ Sewage
- ___ Petroleum
- ___ Chemical
- ___ Fish
- ✓ Other Anaerobic

■ Water Surface Oils
- ___ Slick
- ___ Sheen
- ___ Globs
- ___ Flecks
- ✓ None

■ Turbidity (if not measured)
- ✓ Clear
- ___ Slightly turbid
- ___ Turbid
- ___ Opaque
- ___ Water color

Massachusetts DEP Preliminary Biological Monitoring and Assessment Protocols for Wadable Rivers and Streams

SOP	Method 004
Revision No.	1
Date	December 13, 1995
Page	8 of 10

HABITAT ASSESSMENT FIELD DATA SHEET

3 photos here

SARIS NO. Louis Berger Site

RIVER BASIN

RIVER MILE

ECOREGION REFERENCE SITE WOOD RIVER (PAW-47)

DATE 9/2/05

INVESTIGATOR Sheppard

DESCRIBE SITE LOCATION downstream of Manville Dam - all Big boulders

Comments: + cobble with gravel foundeep.

Riffle/Run Prevalent Streams are those in moderate to high-gradient landscapes that sustain water velocities of approximately 30 cm/sec or greater. Natural streams have substrates primarily composed of coarse sediment particles (i.e., gravel or larger) or frequent coarse particulate aggregations along stream reaches.

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
1. Instream Cover (Fish)	A mix of snags, submerged logs, undercut banks, rubble, or other stable habitat in greater than 50% of the sample area	30-50% of area with a mix of stable habitat; adequate habitat for maintenance of populations.	10-30% of area with a mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% of area with a mix of stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE 18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Epifaunal Substrate	Well-developed riffle and run; riffle is as wide as stream and length extends two times the width of stream; abundance of cobble. (Boulders prevalent in headwater streams).	Riffle is as wide as stream but length is less than two times width; abundance of cobble; boulders and gravel common.	Run area may be lacking; riffle not as wide as stream and its length is less than 2 times the stream width; gravel or bedrock prevalent; some cobble present.	Riffles or runs virtually nonexistent; bedrock prevalent; cobble lacking.
SCORE 19	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE 20	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	New embankments present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted.
SCORE 10	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 20	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Massachusetts DEP Preliminary Biological Monitoring and Assessment Protocols for Wadable Rivers and Streams

SOP	Method 004
Revision No.	1
Date	December 13, 1995
Page	9 of 10

Louis G

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
6. Frequency of Riffles (or bends) / Velocity-Depth Combinations SCORE 17	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important; All 4 velocity/depth patterns present.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15. Only 3 of 4 velocity/depth patterns present (i.e., slow [<0.3 m/s]-deep [>0.5 m]; slow-shallow; fast-deep; fast-shallow).	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25. Only 2 velocity/depth patterns present; usually lacking deep areas.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25. Dominated by one velocity/depth pattern.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Flow Status SCORE 15	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Vegetative Protection (score each bank) Note: determine left or right side by facing downstream. SCORE 5 (LB) SCORE 5 (RB)	More than 90% of the streambank surfaces covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Bank Stability (score each bank) SCORE 10 (LB) SCORE 10 (RB)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone) SCORE 2 (LB) SCORE 3 (RB)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score 154

Massachusetts DEP | Physical Characterization/Water Quality Field Data Sheet

STATION: Louis B STREAM NAME: Blackstone RIVER MILE: ______ DATE: 9/2/05

RIVER BASIN: ______ STREAM CLASSIFICATION: NO INVESTIGATORS: Sheppard

RECONN | HABITAT | [✓ INVERTEBRATE] | FISH | FLOW | WQ

DESCRIBE LOCATION: Fast rapids - v. hard to sample - Rocks so Big - used my hands to wipe over rocks mostly

STREAM CHARACTERIZATION

■ Subsystem Classification
- ___ Tidal
- ✓ Lower Perennial
- ___ Upper Perennial
- ___ Intermittent

■ Stream Type
- ___ Coldwater
- ✓ Warmwater

RIPARIAN ZONE/INSTREAM FEATURES

■ Predominant Surrounding Land Use
- ✓ Forest
- ___ Field/Pasture
- ___ Agricultural
- ✓ Residential
- ✓ Commercial
- ✓ Industrial
- ___ Other

■ Channelized ✓ Y ___ N
■ Dam Present ✓ Y ___ N

■ Local Water Erosion
- ✓ None
- ___ Moderate
- ___ Heavy

■ Local Watershed NPS Pollution
- ___ No evidence
- ___ Some potential sources
- ✓ Obvious sources

■ High Water Mark 1.5 m
■ Velocity ___ m/sec

■ Estimated Stream Width 9 m
■ Estimated Stream Depth
Riffle 0.8 m
Run ___ m
Pool ___ m
■ Estimated Fish Reach Length ___ m
■ Canopy Cover
- ✓ Partly open
- ___ Partly shaded
- ___ Shaded

SEDIMENT/SUBSTRATE

■ Odors
- ___ Normal
- ✓ Sewage
- ___ Petroleum
- ___ Chemical
- ___ Anaerobic
- ___ None
- ___ Other

■ Oils
- ✓ Absent
- ___ Slight
- ___ Moderate
- ___ Profuse
- ___ Relict shells
- ___ Other

■ Deposits
- ___ Sludge
- ___ Sawdust
- ___ Paper fiber
- ___ Sand

■ Are the underside of stones not deeply embedded black?
___ Y ✓ N

INORGANIC SUBSTRATE COMPONENTS		
Substrate Type	Diameter	Percent Composition in Sampling Area
Bedrock		
Boulder	>256mm (10 in)	25%
Cobble	64-256mm (2.5-10 in)	65%
Gravel	2-64mm (0.1-2.5 in)	10%
Sand	0.06-2mm (gritty)	
Silt	0.004-0.06mm	
Clay	<0.004mm (slick)	

ORGANIC SUBSTRATE COMPONENTS		
Substrate Type	Characteristic	Percent Composition in Sampling Area
Detritus	sticks, wood, coarse plant materials (CPOM)	5%
Muck-mud	black, very fine organic (FPOM)	
Marl	grey, shell fragments	

WATER QUALITY

■ Temperature ___ °C
■ Specific Conductance ___
■ Dissolved Oxygen ___
■ pH ___
■ Turbidity
■ Instrument(s) Used
Hydrolab H2O No. ___
Hydrolab SRV3 No. ___
■ Other ______

■ Water Odors
- ___ Normal/None
- ✓ Sewage
- ___ Petroleum
- ___ Chemical
- ___ Fish
- ___ Other

■ Water Surface Oils
- ___ Slick
- ___ Sheen
- ___ Globs
- ___ Flecks
- ✓ None

■ Turbidity (if not measured)
- ___ Clear
- ___ Slightly turbid
- ___ Turbid
- ___ Opaque
- ___ Water color

Attachment 3

Lab Bench Sheets

BENTHIC MACROINVERTEBRATE LABORATORY BENCH SHEET (FRONT)

page 1 of 2

STREAM NAME Blackstone River
LOCATION D/S of Dam
STATION # Mandeville Dam RIVERMILE ____
STREAM CLASS
LAT ____ LONG ____
RIVER BASIN Blackstone
STORET #
AGENCY
COLLECTED BY Sheppard DATE 9/2/05
LOT #
TAXONOMIST Sheppard DATE 11/28/05
SUBSAMPLE TARGET ☒ 100 ☐ 200 ☐ 300 ☐ Other ____

Enter Family and/or Genus and Species name on blank line.

Organisms		No.	LS	TI	TCR
Oligochaeta					
Hirudinea	Erpobdellidae	1	A	JS	2
Isopoda					
Amphipoda	Gammarus	2	A	JS	2
Decapoda					
Ephemeroptera	Baetis	13	I	JS	2
	Heterocloeon	8	I	JS	1
	Acentrella	1	I	JS	4
Plecoptera	Acroneuria	1	I	JS	2
Trichoptera	Chimarra	2	I	JS	1
	unknown	2	P	JS	2
	Hydropsyche	35	I	JS	1
	Cheumatopsyche	45	I	JS	1
	Ceratopsyche	48	I	JS	1
Hemiptera					

Organisms		No.	LS	TI	TCR
Megaloptera					
Coleoptera	Microcylloepus	1	I	JS	2
Diptera	Simulium	1	P	JS	2
Gastropoda	Valvata	1	A	JS	2
Pelecypoda	Musculium	4	A	JS	2
	pisidium	14	A	JS	3
Other	Turbellaria	6	A	JS	2

Taxonomic certainty rating (TCR) 1-5:1=most certain, 5=least certain. If rating is 3-5, give reason (e.g., missing gills). LS= life stage: I = immature; P = pupa; A = adult TI = Taxonomists initials

Total No. Organisms ____

Total No. Taxa ____

BENTHIC MACROINVERTEBRATE LABORATORY BENCH SHEET (BACK)

SUBSAMPLING/SORTING INFORMATION

Sorter Sheppard

Date 11/22/05

Number of grids picked: 1/8

Time expenditure 1.5 hrs No. of organisms 221

Indicate the presence of large or obviously abundant organisms:

Many Hydropsychidae

QC: ☐ YES ☐ NO **QC Checker** ______

# organisms originally sorted		(	# organisms recovered by checker		# organisms originally sorted	)		% sorting efficiency
☐	÷	(	☐	+	☐	)	=	☐

≥90%, sample passes ______

<90%, sample fails, action taken ______

TAXONOMY

ID Sheppard

Date 11/28/05

Explain TCR ratings of 3-5:
Acentrella:- tiny specimen/Bad condition
Pisidium:- tiny specimens

Other Comments (e.g. condition of specimens):

QC: ☐ YES ☐ NO **QC Checker** ______

Organism recognition ☐ pass ☐ fail
Verification complete ☐ YES ☐ NO

General Comments (use this space to add additional comments):

BENTHIC MACROINVERTEBRATE LABORATORY BENCH SHEET (FRONT)

page 1 of 2

STREAM NAME Blackstone River	LOCATION D/S of dam
STATION # Manville Dam RIVERMILE ______	STREAM CLASS
LAT ______ LONG ______	RIVER BASIN Blackstone
STORET #	AGENCY
COLLECTED BY Emily DATE 8/30/04	LOT #
TAXONOMIST Sheppard DATE 1/14/05	SUBSAMPLE TARGET ☑ 100 ☐ 200 ☐ 300 ☐ Other ____

Enter Family and/or Genus and Species name on blank line.

Organisms		No.	LS	TI	TCR
Oligochaeta					
Hirudinea					
Isopoda					
Amphipoda					
Decapoda	Orconectes	1	A	JS	2
Ephemeroptera	Stenonema	6	I	JS	2
	Stenacron	1	I	JS	2
	Acentrella	9	I	JS	2
	Baetis	18	I	JS	2
	Paraleptophlebia	1	I	JS	4
Plecoptera					
Trichoptera	Chimarra	63	I	JS	1
	Macrostemum	3	I	JS	1
	Hydropsyche	75	I	JS	1
	Leucotrichia	3	I	JS	1
	Cheumatopsyche	44	I	JS	1
	Ceratopsyche	58	I	JS	1
Hemiptera					

Organisms		No.	LS	TI	TCR
Megaloptera					
Coleoptera	Ancyronyx	2	I	JS	1
Diptera	Antocha	17	I	JS	2
	Antocha	4	P	JS	2
	Tipula	1	I	JS	2
	Hemerodromia	1	I	JS	2
	Hemerodromia	2	P	JS	2
Gastropoda					
Pelecypoda					
Other	Turbellaria	13	A	JS	2
	Ochrotrichia	1	I	JS	2
	Chironomidae	4	P	JS	2
	Hydropsyche	3	P	JS	2
	Heterocloeon	1	I	JS	2
	Hydroptila	1	I	JS	4

Taxonomic certainty rating (TCR) 1-5:1=most certain, 5=least certain. If rating is 3-5, give reason (e.g., missing gills). LS= life stage: I = immature; P = pupa; A = adult TI = Taxonomists initials

Total No. Organisms 332

Total No. Taxa 24

Man. Dam

BENTHIC MACROINVERTEBRATE LABORATORY BENCH SHEET (BACK)

SUBSAMPLING/SORTING INFORMATION

Sorter Sheppard

Date 12/27/04

Number of grids picked: 1/4

Time expenditure ~2hrs No. of organisms ~318

Indicate the presence of large or obviously abundant organisms:

Many hydropsychids, dipterans, chironomids, some clams

QC: ☐ YES ☐ NO QC Checker ____________

# organisms originally sorted		# organisms recovered by checker		# organisms originally sorted		% sorting efficiency
	÷ (		+		) =	

≥90%, sample passes ________

<90%, sample fails, action taken ____________

TAXONOMY

ID 1/14/05

Date Sheppard

Explain TCR ratings of 3-5:

Paraleptophlebia: - tiny bad specimen
Hydroptila: - v. early instar.

Other Comments (e.g. condition of specimens):

QC: ☐ YES ☐ NO QC Checker ____________

Organism recognition ☐ pass ☐ fail
Verification complete ☐ YES ☐ NO

General Comments (use this space to add additional comments):

Not a lot of debris, alot of diversity.

Appendix F

Birds of the Valley Falls Marshes, 1977-1996

Compiled by Richard W. Enser,
Rhode Island Department of Environmental Management

	s	S	F	W
___ Northern Mockingbird (n)	u	u	u	u
___ Brown Thrasher	u		u	

WAXWINGS - SHRIKES - STARLING

	s	S	F	W
___ Cedar Waxwing (n)	o	u	o	
___ Northern Shrike				x
___ European Starling (n)	c	c	c	c

VIREOS

	s	S	F	W
___ White-eyed Vireo	r		r	
___ Solitary Vireo	o		r	
___ Warbling Vireo (n)	c	c		
___ Red-eyed Vireo	o		o	

WARBLERS

	s	S	F	W
___ Blue-winged Warbler	r			
___ Tennessee Warbler	r			
___ Orange-crowned Warbler				r
___ Nashville Warbler	o			r
___ Northern Parula	o		r	
___ Yellow Warbler (n)	c	c	r	
___ Chestnut-sided Warbler	r		r	
___ Magnolia Warbler	o		r	
___ Cape May Warbler	r			
___ Black-throated Blue Warbler	r			
___ Yellow-rumped Warbler	u		c	
___ Black-throated Green Warbler	o		r	
___ Blackburnian Warbler	r		r	
___ Prairie Warbler	r		r	
___ Palm Warbler	o		o	
___ Bay-breasted Warbler	r		r	
___ Blackpoll Warbler	o		o	
___ Black-and-white Warbler	o		o	
___ American Redstart	o		o	
___ Ovenbird	o		r	
___ Northern Waterthrush	u			
___ Common Yellowthroat (n)	c	c	u	
___ Wilson's Warbler	o			
___ Canada Warbler	o			

TANAGERS - BUNTINGS - SPARROWS

	s	S	F	W
___ Scarlet Tanager	r		r	
___ Northern Cardinal (n)	c	c	c	u
___ Rose-breasted Grosbeak (n)	u	u	r	
___ Indigo Bunting	r	r		
___ Rufous-sided Towhee	o		u	
___ American Tree Sparrow	u		c	c
___ Chipping Sparrow	r		r	
___ Field Sparrow	o		u	u
___ Savannah Sparrow	u		u	
___ Sharp-tailed Sparrow			r	
___ Fox Sparrow	r		r	
___ Song Sparrow (n)	a	a	a	c
___ Lincoln's Sparrow	x			
___ Swamp Sparrow (n)	c	c	a	u
___ White-throated Sparrow	c		c	u
___ White-crowned Sparrow	r		o	
___ Dark-eyed Junco	o		u	o

BLACKBIRDS - FINCHES

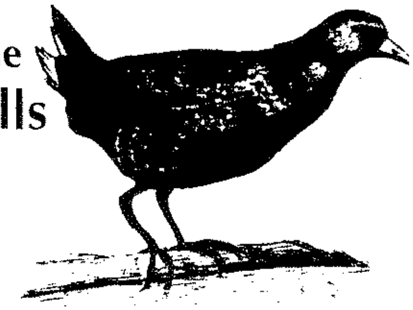
	s	S	F	W
___ Bobolink	r		o	
___ Red-winged Blackbird (n)	a	a	a	o
___ Eastern Meadowlark	r			
___ Rusty Blackbird	o		r	o
___ Common Grackle (n)	c	c	u	r
___ Brown-headed Cowbird	u		o	
___ Orchard Oriole	r			
___ Northern Oriole (n)	u	c	o	
___ Purple Finch	r		r	
___ House Finch	o	o	o	o
___ Common Redpoll			r	r
___ American Goldfinch (n)	c	u	c	u
___ House Sparrow	r	r	r	

NOTES

Date ____________ Time ____________ Total ____

Temp ______ Wind ________ Sky ____________

Birds of the Valley Falls Marshes



A checklist

The area covered by this checklist is a 250+ acre freshwater wetland complex along the floodplain of the lower Blackstone River within the municipalities of Lincoln, Cumberland, and Central Falls, Rhode Island. The Valley Falls Marshes have long been recognized as a valuable wildlife habitat. Large numbers of migrating waterfowl may be present during the spring and fall, and several uncommon species rely on this area for nesting habitat. This checklist is the result of field observations compiled during the period of 1977-1996. Names are in accordance with the Fifth Edition of the American Ornithologists Union Checklist as amended. Symbols used are defined as follows:

s - Spring	March - May
S - Summer	June - August
F - Fall	September - November
W - Winter	December - February

a - abundant	A common species which is usually numerous.
c - common	Certain to be seen in suitable habitat.
u - uncommon	Present, but not certain to be seen on every visit.
o - occasional	Seen only a few times during a season.
r - rare	Seen at intervals of 2-5 years.
x - accidental	Has been seen only once.

(n) - denotes nesting species

Compiled by Richard W. Enser in cooperation with the Rhode Island Nongame Wildlife Program, Division of Fish and Wildlife, 1808 Tower Hill Road, Wakefield, RI 02879

	s	S	F	W
LOONS - GREBES - CORMORANTS				
___ Common Loon	x			
___ Pied-billed Grebe	o		u	r
___ Great Cormorant				x
___ Double-crested Cormorant	u	r	u	r
BITTERNS - HERONS - IBIS				
___ American Bittern	r		r	
___ Least Bittern (n)	r	o		
___ Great Blue Heron	c	o	c	u
___ Great Egret	r			
___ Snowy Egret			r	
___ Tricolored Heron	x			
___ Green Heron (n)	u	c	o	
___ Black-crowned Night Heron	o	r	r	
___ Glossy Ibis	x			
SWANS - GEESE - DUCKS				
___ Mute Swan (n)	c	c	c	c
___ Snow Goose			x	
___ Brant			x	
___ Canada Goose (n)	c	u	c	u
___ Wood Duck (n)	c	c	a	o
___ Green-winged Teal (n)	c	r	c	o
___ American Black Duck (n)	c	o	c	o
___ Mallard (n)	a	u	a	c
___ Northern Pintail	r		r	
___ Blue-winged Teal	u		o	
___ Northern Shoveler	x		x	
___ Gadwall	o		o	o
___ American Wigeon	u		u	r
___ Canvasback	r			
___ Ring-necked Duck	o		r	
___ Common Goldeneye				x
___ Hooded Merganser	o		r	o
___ Common Merganser	o		r	u
___ Ruddy Duck			x	
VULTURES - HAWKS - FALCONS				
___ Turkey Vulture	o		o	
___ Osprey	o	r	u	
___ Northern Harrier	r		r	x
___ Sharp-shinned Hawk	r		o	o
___ Cooper's Hawk			r	
___ Northern Goshawk			r	
___ Red-shouldered Hawk			x	

	s	S	F	W
___ Red-tailed Hawk (n)	u	u	u	u
___ Rough-legged Hawk				x
___ American Kestrel (n)	o	o	u	r
___ Merlin	r		r	
___ Peregrine Falcon			r	
PHEASANT - GROUSE				
___ Ring-necked Pheasant	r	r	r	r
___ Ruffed Grouse	r		r	r
RAILS				
___ Virginia Rail (n)	u	o	o	
___ Sora (n)	u	o	r	
___ Common Moorhen			r	
___ American Coot	o		o	o
PLOVERS - SANDPIPERS				
___ Killdeer (n)	u	o	o	r
___ Greater Yellowlegs	r		r	
___ Solitary Sandpiper	o		r	
___ Spotted Sandpiper (n)	o	o		
___ Least Sandpiper	o			
___ Pectoral Sandpiper	r		r	
___ Common Snipe	o		o	r
___ American Woodcock (n)	u	o	r	
GULLS - TERNS				
___ Ring-billed Gull	c	u	c	c
___ Herring Gull	o	r	o	o
___ Great Black-backed Gull	u		u	u
___ Common Tern		x		
DOVES - CUCKOOS - OWLS - SWIFT HUMMINGBIRD - KINGFISHER				
___ Rock Dove (n)	o	o	o	o
___ Mourning Dove (n)	u	u	c	u
___ Black-billed Cuckoo	r	r		
___ Yellow-billed Cuckoo	x			
___ Eastern Screech-Owl (n)	o	o	o	r
___ Great Horned Owl (n)	r	r	r	r
___ Barred Owl			x	
___ Long-eared Owl				x
___ Short-eared Owl			x	
___ Common Nighthawk	r	r	r	
___ Chimney Swift	u	c	u	
___ Ruby-throated Hummingbird			r	

	s	S	F	W
___ Belted Kingfisher (n)	u	u	u	u
WOODPECKERS - FLYCATCHERS				
___ Red-headed Woodpecker	x		x	x
___ Yellow-bellied Sapsucker	r		r	
___ Downy Woodpecker (n)	c	u	c	u
___ Hairy Woodpecker (n)	o	o	r	o
___ Northern Flicker (n)	c	u	c	o
___ Pileated Woodpecker	x			
___ Eastern Wood-Pewee	r		r	
___ Willow Flycatcher (n)	u	u	o	
___ Least Flycatcher	r			
___ Eastern Phoebe	o		c	
___ Great Crested Flycatcher	o			
___ Western Kingbird			x	
___ Eastern Kingbird (n)	u	c	r	
SWALLOWS - JAYS and CROWS				
___ Tree Swallow (n)	c	c	u	
___ No. Rough-winged Swallow (n)	c	c		
___ Bank Swallow	u	u		
___ Barn Swallow	u	o	u	
___ Blue Jay (n)	c	c	c	u
___ American Crow (n)	c	c	c	c
___ Fish Crow	r			
TITMICE - NUTHATCHES - WRENS				
___ Black-capped Chickadee (n)	c	c	c	c
___ Tufted Titmouse (n)	c	u	c	u
___ Red-breasted Nuthatch			r	
___ White-breasted Nuthatch (n)	o	o	u	o
___ Brown Creeper	r		r	r
___ Carolina Wren (n)	u	u	u	u
___ House Wren (n)	c	u	u	
___ Winter Wren			r	r
___ Marsh Wren (n)	u	u	u	r
KINGLETS - THRUSHES - MIMICS				
___ Golden-crowned Kinglet			r	
___ Ruby-crowned Kinglet	r		u	x
___ Veery	r			
___ Swainson's Thrush	r		r	
___ Hermit Thrush	r		o	
___ Wood Thrush (n)	o	o		
___ American Robin (n)	c	c	c	r
___ Gray Catbird (n)	c	c	c	

12.0 Compact Disk

Folder 1	Copy of Report	
Folder 2	Laboratory data	(All laboratory data from the following laboratories: Mitkem, STL, Microinorganics, University of Massachusetts, Normandeau Associates, Inc,)
Folder 2	Storm Line Plans, City of Woonsocket, 2004	

Submitted by:

The Louis Berger Group, Inc.

in association with

University of Rhode Island
University of Massachusetts - School of Marine Science and Technology

Water Quality - Blackstone River

Final Report 2: Field Investigations

Addendum

August 8, 2008

History

The Louis Berger Group, Inc. (Berger) submitted its final report entitled *"Water Quality - Blackstone River; Final Report 2: Field Investigations"* to the Rhode Island Department of Environmental Management in February 2008. A Technical Advisory Committee and stakeholder meeting was held in the Town of Lincoln on March 20, 2008. Prior to the meeting, the report was distributed as hardcopy and or on CD members of the Technical Advisory (see distribution list in Attachment 1).

In addition, a meeting was held with the Blackstone River Data Group on April 10, 2008 in Uxbridge, Massachusetts. The list of participants is presented in Attachment 2.

RIDEM requested that all comments on the report be submitted by April 18, 2008. Two emails with comments were received (see Attachment 3). We greatly appreciated these comments from Mr. Gall and Ms. Hartman, as well as the time spent by all reviewers of our extensive report.

Following are our responses to these comments.

COMMENT 1: TIME OF TRAVEL *(John Gall)*

We believe that the time of travel may be significantly understated at very low flows.

The report says that at 200 cubic feet per second (CFS) at Woonsocket, the time of travel from the Mass/Rhode Island border to the outlet at Slater's mill is 15.7 hours, and that at a flow of 100 CFS at the Millbury USGS gage, the time of travel from Worcester to the Mass/Rhode Island line is 24.8 hours. Adding them together results in a time of travel of approximately 40 hours from Worcester to the outlet.

These results were defined by analysis of the time differential between peak rates of flow observed at various gauging locations. While this method presents a reasonable approximation of time of travel in systems with no storage, the Blackstone has storage behind its numerous dams that becomes significant at low flows. Under these conditions, the time of travel of the peak rate of flow can be far faster than that of the volume of flow.

We encountered the same issue in the original development of our HSPF model. Times of travel calculated using the USGS model of the system were very short, not dissimilar to the values presented in your report. After review with our technical advisory panel, we revised our river segmentation, and used the highly detailed river hydraulic model developed for FEMA flood studies to reconstruct our hydraulic representation of the river.

As a result of these efforts, we have developed a robust hydraulic model of the system that is well suited to estimating time of travel. Our analyses suggest, for example, that at 235 cfs at Woonsocket, the time of travel from Worcester to the outlet is almost 10 days, some 5 times slower than the report predicts. If the flow is lower – down in the range of 100 cfs at Woonsocket - the time of travel can exceed 20 days.

It is not clear to us how you will be using times of travel in your current work. If this is an important consideration, we would be most happy to sit down with you to discuss this comment in greater detail.

Response:

The time of travel portion of the BTMDL data report was completed prior to the USGS publishing its HSPF precipitation-runoff model for the Blackstone River watershed. USGS did provide 15-minute flow data to the Louis Berger Team for the Blackstone River and it's tributaries from Jan 1, 1996 to December 31, 2005. The temporary USGS gaging station data that was used for the USGS HSPF was also made available. It is sufficient to say that a considerable amount of flow data was used to calculate the travel times in Section 2 of the report, which goes into some detail on what was done to complete these calculations.

When the USGS HSPF model was published, the travel times of the BTMDL report were compared against the travel times that were generated by the USGS model. The travel times from both sources were very close to each other in their estimates.

Currently, the USGS and MADEP are planning to conduct a time of travel study on the Blackstone River that should resolve any issues concerning the travel times associated with low flows in the river. Until such time that this project is completed, RIDEM remains confident with the BTMDL travel time calculations. We will evaluate the necessity to modify these estimates once the USGS/MADEP time of travel study is completed and documentation is available for review.

COMMENT 2: PROPORTIONS OF WATERSHED IN MA AND RI *(John Gall)*

The report should present the fraction of the watershed in Massachusetts tributary to the Manville station.

The report provides numerous statistics reflecting the percentage of the river load at the Manville station that originates in Massachusetts. For example, in page i-2 it indicates that 71% of nitrates, 68 % of ammonia and 58 % of the annual phosphorus load measured at Manville comes from Massachusetts. And that 74 %, 84% and 84 % of the same constituents are contributed by Massachusetts during wet weather. This could be interpreted by some that Massachusetts is somehow far behind Rhode Island in managing these loads. Indeed, even one of your project participants "apologized" for being from Massachusetts because of the way these statistics were presented.

But, according to the report 75 % of the entire watershed is in Massachusetts. And on that basis, 81 % of the watershed tributary to the Manville station is in Massachusetts. When viewed in this light, it is more appropriate to say that we all contribute proportionately to loadings on the River. We would suggest adding information on the relative size of the watershed in order to provide a more balanced perspective on pollutant sources.

Response:
Below, please find an expanded Figure 2-1 from the report, which now includes approximate percentages of relevant subwatershed areas. Specifically, these areas are:

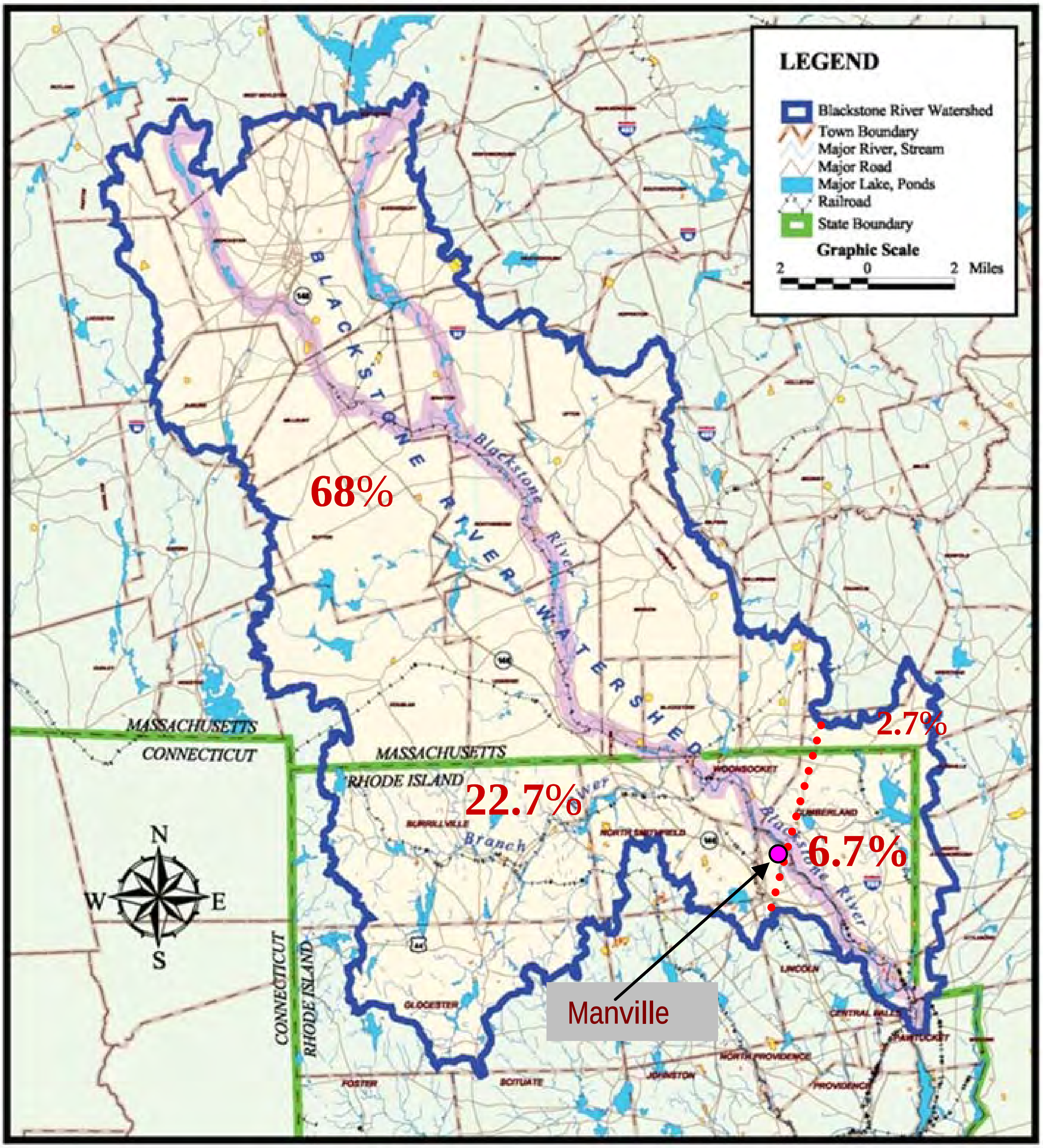
• MA:	Watershed of Blackstone River, Mill River and Peters River to MA/RI state line	68%
• RI:	Watershed of Blackstone River, from MA/RI state line to Manville Station (W-02)	22.7%
• RI:	Watershed between Manville Station and mouth of river (Slater Mill)	6.7%
• MA:	Contribution of Abbot Run Brook watershed within Massachusetts	2.7%

These values result in the following calculations:

- 75% of the Blackstone River watershed <u>at the Manville station</u> (W-02) is located in Massachusetts; 25% in Rhode Island.

- 77% of the Blackstone River watershed <u>within Rhode Island</u> is located upstream of the Manville station; 23% is located downstream.

Therefore, it is correct to state that if the load measured at the Manville station (W-02) was, for example, 75% contributed by Massachusetts's sources (and to 25% by Rhode Island sources), the contributions from Massachusetts and Rhode Island were proportional to their respective watershed. However, it is still true that the two states need to work together to reduce exceedances of specific contaminants in order to assure that Rhode Island can indeed achieve compliance.



The Louis Berger Group, Inc.

Rhode Island DEM

Source: RIGIS, MASSGIS

File: bw-report-07.apr

Blackstone River TMDL

Figure 2-1

BLACKSTONE RIVER WATERSHED

COMMENT 3: DISINFECTION REQUIREMENTS IN MASSACHUSETTS *(John Gall)*

Disinfection requirements in Massachusetts would suggest subdividing the pathogen data into two seasons.

As you may know, Massachusetts DEP requires effluent disinfection for discharges to Class B waters only during the swimming season, from April 1 through October 31. Several of your dry weather sampling events took place outside of this time frame, and it would thus be expected that pathogen loads during the winter season would be significantly different than those of the summer months. For the purpose of looking at relative loadings, this suggests that the data should be split into two seasons. Of course, the draft permit proposed for UBWPAD imposes year round disinfection, and that recently issued to Northbridge does the same.

Response:

Although MADEP establishes seasonal limits, Rhode Island does not adhere to seasonal pathogen criteria. The Blackstone River is a Class B1 water body from the Massachusetts-Rhode Island state line to the Slater Mill Dam in Pawtucket, RI. As such, the Rhode Island pathogen criteria is:
'Not to exceed a geometric mean value of 200 MPN/100ml and not more than 20% of the samples shall exceed a value of 500 MPN/100ml.

The Louis Berger Group was tasked to do water quality sampling for the Blackstone River to provide the RIDEM with the information to develop accurate and effective TMDLs for the Rhode Island portion of the watershed. One of the primary stations sampled was Station W-01, located in Millville, MA, upstream of the Tupperware Dam. This station was chosen as the last accessible point on the main stem of the Blackstone River prior to its crossing the MA-RI border. The fecal coliform data from Station W-01 was sampled for several constituents, one being fecal coliform. The station was sampled bi-weekly from May to November, and monthly from November to April. The dry weather data from the report for W-01 resulted in a geomean of 216 MPN/100ml. Thirty-five percent of the samples above the 500 MPN/100ml criteria, all of which occurred during the time when disinfection was not being done by the treatment facilities in Massachusetts.

While the fecal concentrations that are being discharged into the river from five of the six waste water treatment facilities may not exceed the pathogen criteria for Massachusetts, the data shows that there are still exceedances of the RI state criteria occurring during the months that effluent chlorination is not done by the Massachusetts facilities. The draft UBWPAD and final Northbridge NPDES permits specifically include year round disinfection and fecal limits to ensure compliance with Rhode Island's water quality standards. Though the seasonal permit limits help to explain the observed fecal coliform criteria violations, there is no regulatory basis to subdivide the pathogen data into two seasons for purposes of evaluating compliance with Rhode Island's fecal coliform criteria.

COMMENT 4: WASTEWATER DISCHARGERS - DECHLORINATION *(John Gall)*

Wastewater dischargers to the river routinely dechlorinate their effluent.

The discussion on page 4-15 suggests that residual chlorine in wastewater effluents could be a cause for pathogen die-off in reach 1. Since the time of the BRI, all dischargers on the river have initiated dechlorination, or have switched to disinfection process that leave no residual. It is thus unlikely that residual chlorine is causing the dieoff in this reach.

Response:

The report did speculate that residual disinfection was a contributing factor to the fecal coliform decline in Reach 1, based in part on observations documented in the BRI. However, as noted by the commenter, WWTFs have implemented dechlorination or alternative disinfection processes since the time that the BRI sampling was conducted.

Reach 1 is in the Rhode Island section of the watershed, and as such would be more likely influenced by the discharge from the Woonsocket WWTF. All Rhode Island treatment facilities are required to report to RIPDES those instances when their effluent may have residual chlorine. A check of RIPDES records for the Woonsocket WWTF showed that the plant was operating within de-chlorination permit limits during the period when the BTMDL dry surveys were conducted.

Therefore, we agree that residual disinfection is not likely the cause of the pathogen decline in Reach 1. Pathogen die-off is a natural occurrence in a river or stream system, and can be accelerated under certain conditions such as low temperatures in the winter. Exposure to sunlight (with its ultraviolet disinfection properties) may have the same effect, even in the warmer water of summertime.

COMMENT 5: HARDNESS FOR USE IN CRITERIA FOR METALS *(Elaine Hartman)*

The method of using hardness values in determining acute and chronic criteria is important as this is then translated into determining violations and subsequent listing or delisting and TMDL requirements. Averaging hardness over different stations and different dates may obscure the results. The Blackstone mainstem stations and tributaries are known for having a wide range of hardness values varying historically from 10 to over 60 mg/l. The BRI final report (used in this report for data comparison) attempted to provide more instantaneous values per station and over time for this very reason of site and time variability. This looks as if it may have been done for the wet weather chronic criteria, but not for the dry weather or wet weather acute.

*From pg 3-4: "Wet Weather***:** *For wet weather, the hardness for calculating acute and chronic criteria differed. For the calculation of the acute criteria, the average hardness of all stations on a waterbody for each run was used. For the Blackstone River, Stations W-01 to W-05, W-21, W-22, W-17, and W-25 along the mainstem were used."*

Response:

The water quality standards for toxics, including dissolved metals, set forth in Appendix B of the Rhode Island Department of Environmental Management Water Quality Regulations (DEM 2006) state that "to protect aquatic life, the one-hour average concentration of a pollutant should not exceed the acute criteria more than once every three years on the average. The four-day average concentration of a pollutant should not exceed the chronic criteria more than once every three years on the average. These aquatic life criteria shall be achieved in all waters, except mixing zones, regardless of the waters' classification. In addition, the acute and chronic aquatic life criteria for freshwaters shall not be exceeded at or above the lowest average 7 consecutive day low flow with an average recurrence frequency of once in 10 years (7Q10)".

DEM evaluated all hardness data from the Blackstone field investigations in order to determine appropriate hardness levels to use in calculating water quality criteria and establishing water quality goals for the TMDL. For the most part, there was little variation in hardness values observed along the Rhode Island reaches of the Blackstone, Peters and Mill Rivers from one station to the other (on the individual rivers) during any given dry weather survey. For this reason, the average hardness of all stations for a waterbody for each survey date was used to calculate the dry weather acute and chronic criteria. For the Blackstone River, this included all mainstem stations (W-01, to W-05, W-21, W-22, W-17, and W-25). The value of each sample result was compared against the calculated acute and chronic metals criteria to evaluate compliance.

During wet weather, there was a little more variation observed from station to station on a given waterbody - with a maximum change of 16 mg/l observed during the WW-3 wet weather survey. However, for the most part, the same can be said for wet weather as for dry weather, that there was little variation in hardness observed along the Rhode Island reaches of the Blackstone, Peters and Mill Rivers from one station to the other (on the individual rivers) during any given sampling run.

For wet weather, the acute criteria were calculated using the average hardness of all stations on a waterbody for each run. As with the dry weather surveys, the Blackstone mainstem stations (W-01, to W-05, W-21, W-22, W-17, and W-25) were used to calculate the average hardness for each run. For the evaluation of the wet weather metals data for exceedances, the value of each sample was compared against the calculated acute criteria. The chronic criteria were calculated for each station using the average hardness for each storm event.

COMMENT 6: SUMMARY TABLE OF FINDINGS *(Elaine Hartman)*

A one-page summary color table entitled Key Issues for TMDLs was distributed at the presentation and appeared to over summarize the results for pathogens, lead, and copper. This table should be clearly labeled whether the categories of: concern, smaller concern, and no concern, are based upon mg/l for fate and transport issues or are based upon criteria violations. It was stated at the meeting that the table actually mixed these two. Perhaps different summary tables should be prepared, one for concentration, one for loading, one for acute criteria violations, and one for chronic criteria violations. Tables of this form would be very helpful.

The data in the summary table and the information presented in the report summary should coincide.

If the data in the summary table lists the number of exceedences it should be listed with the number of total samples taken. As an example, the summary statement that the dissolved copper exceeded in 13 cases, is that out of 15 or out of 300. The exceedences should be done for each station. It was unclear if these were all at one stations or mixed tributaries and mainstem stations.

Response:

The table was developed solely for the purpose of discussion as part of a presentation to the Blackstone River Data Team on April 20, 2008. The table had not been reviewed and approved by RIDEM at that time. Also, the table was not part of the Final Report. The table should be modified as suggested by Ms. Hartman, if it is to be used again in the future. We may consider a revised table for a later document as part of the TMDL development for the Blackstone River.

COMMENT 7: EXPANSION OF THE EXECUTIVE SUMMARY *(Elaine Hartman)*

Given that the report is so lengthy the summary section becomes more important and should be more specific and inclusive in its presentation of data results.

Response:

The primary purpose of this study was to provide data and information as input to the development of the TMDL for the Blackstone River and its tributaries. As such, it is the basis for the development of appropriate TMDLs. A more detailed summary will be considered for the Final TMDL Report.

COMMENT 8: FLOWS AND TIME OF TRAVEL *(Elaine Hartman)*

More review is needed of the flows used to determine the loadings.

Time of travel differences between studies need to be resolved.

Response:

(See Response to Comment 1 above.)

COMMENT 9: LOADINGS BY WATERSHED AREA *(Elaine Hartman)*

Presentation of loadings based upon unit watershed area would provide information on proportionate loadings per subwatershed for management decisions.

Response:

(See Response to Comment 4 above.)

ATTACHMENT 1: PUBLIC REVIEW OF FINAL REPORT AND DISTRIBUTION LIST

RIDEM sent a mailing to all potentially interested individuals (identified as a stakeholder (S) or Technical Advisory Committee member (T) in the attached table) notifying them of the availability of the Final Data Report for public review comment, the posting of the document on DEM's website, http://www.dem.ri.gov/programs/benviron/water/quality/rest/index.htm, and the scheduling of a public meeting to discuss the findings on March 20, 2008 at Lincoln Town Hall. All members of the Technical Advisory Committee were also sent a copy of the Final Data Report on CD.

RIDEM and Berger also presented the Final Data Report findings to the Blackstone River Data Team at a meeting held at River Bend Farm in Massachusetts on April 10, 2008. Present at the meeting were Elizabeth Scott, RIDEM; Skip Viator, RIDEM; Bernard Hay, Louis Berger; Elaine Hartman, MADEP; Rob Breault, USGS; Jan Reitsma, John H. Chafee Blackstone River Natural Heritage Corridor; Cindy Delpapa, MADEP; Dave Newton, USEPA; Tammy Gilpatrick, Blackstone River Coalition; Donna Williams, Massachusetts Audubon Society/Blackstone River Coalition; & Peter Coffin, Blackstone River Coalition

Blackstone TMDL Technical Advisory Committee and Stakeholder List

Stk	TAC	Last Name	First Name	Company	JobTitle	Business City
S		Almond	T. Joseph	Town of Lincoln	Town Administrator	Lincoln
S		Annarummo	Michael	City of Woonsocket	Director of Public Works	Woonsocket
	T	Ardito	Tom	Narragansett Bay Estuarine Project	Outreach and Policy Coordinator	Narragansett
S		Aubin III	John	Town of Cumberland	Planning & Development	Cumberland
S		Bachand	Joe	NRCS	WRP Program Manager	Warwick
S		Badeau	Roger R.	20th District	RI State Senator	Woonsocket
S		Baldelli-Hunt	Lisa	49th District	Representative	Woonsocket
	T	Basile	Alfred	US EPA		Boston
S		Beaudoin	Therese	MA DEP		Worcester
	T	Beck	Eric	RIDEM		Providence
S		Bernardo	Richard	Town of Burrillville	Director of Public Works	Harrisville
S		Billington	Bob	Blackstone Valley Tourism Group		Pawtucket
	T	Boltrushek	Roger	US Filter Woonsocket WWTP		Woonsocket
	T	Breault	Rob	USGS		Lincoln
S		Brien	Jon D.	50th District	Representative	Woonsocket
S		Brodd	Alan	City of Woonsocket	Engineer	Woonsocket
S		Carney	John E.	City of Pawtucket	Director of Public Works	Pawtucket
	T	Cassidy	Michael	City of Pawtucket	Planning & Development	Pawtucket
S		Chimielewski	Michael	Synergics Inc		Newton
S		Church	Raymond C.	48th District	Representative	N. Smithfield
S		Cleary	Kevin	Town of Burrillville	Town Engineer	Harrisville
S		Coderre	Elaine A.	60th District	Representative	Pawtucket
	T	Coffin	Peter	Blackstone River Coalition		Mendon
	T	Cohen	Russ	Mass Dept of Fish and Game - Riverways	Rivers Advocate	Boston
S		Commons	Clay	RIDOH - Office of Drinking Water Quality		Providence
S		Connors	Daniel P.	19th District	RI State Senator	Cumberland
S		Cote	Marc A.	24th District	RI State Senator	Woonsocket
S		Cute	Kevin	CRMC		Wakefield
	T	Davis	Dan	MADEP DWM		Worcester
S		Debroisse	Mike	City of Woonsocket	Solid Waste	Woonsocket
S		Delpapa	Cindy	Mass Dept of Fish and Game - Riverways	Stream Ecologist	Boston
S		DeMarco	Gina	Northern RI Conservation District		Greenville
S		Doyle	James E.	City of Pawtucket	Mayor	Pawtucket
S		Doyle, II	James E.	8th District	RI State Senator	Pawtucket
S		Dudley	Christine	RIDEM	Division of Fish and Wildlife	West Kingston
	T	Dunn	Rick	MADEP		Worcester
S		Emond	Michael	US Filter Woonsocket WWTP		Woonsocket
	T	Ferguson	Wenley	Save The Bay		Providence
S		Firmin	Bryant	MADEP		Worcester
S		Fletcher	Robert J.	Federal Energy Regulatory Commission	Ecologist (OEP)	Washington
S		Flynn	Kevin	RI Department of Administration - Statewide Planning	cc: Nancy Hess	Providence
S		Fogarty	Paul W.	23rd District	RI State Senator	Harmony
S		Fugate	Grover	Coastal Resources Management Council	cc: Jim Boyd	Wakefield
S		Gilpatrick	Tammy	Blackstone River Coalition		Uxbridge
S		Goff	Raymond	Town of Glocester	Planning	Chepachet
S		Gorham	Nicholas	40th District	Representative	Greene
S		Green	Linda	URI Watershed Watch Program		Kingston
S		Hanson	Arthur	City of Central Falls	Planning & Development	Central Falls
	T	Hartman	Elaine	MADEP	TMDL	Worcester
S		Hess	Nancy	RI Department of Administration - Statewide Planning		Providence
S		Hidenfelter	Mindy	Blackstone River Watershed Council		Pawtucket
	T	Hunter	Johanna	Blackstone-Woonasquatucket American Heritage Rivers	River Navigator	Providence
S		Issa	Daniel J.	16th District	RI State Senator	Central Falls
	T	Janson	Roger	EPA New England, Region 1		Boston
S		Jeffers	Eugene	Town of Cumberland	Director of Public Works	Cumberland
S		Joubert	Lorraine	URI Natural Resources		Kingston
S		Kapsner	Pat	Trout unlimited-Narragansett Chapter		Pawtucket
S		Kravitz	Thomas	Town of Burrillville	Planning	Harrisville
	T	LeBlanc	Alison	RIDOT -Office of Environmental Programs		Providence
	T	Liberti	Angelo	RIDEM	Chief, Surface Water Protection	Providence
S		Lowe	Robert B.	Town of North Smithfield	Town Administrator	Slatersville

Blackstone TMDL Technical Advisory Committee and Stakeholder List *(continued)*

Stk	TAC	Last Name	First Name	Company	JobTitle	Business City
S		MacQueen	John	Town of Lincoln	Director of Public Works	Lincoln
	T	Mariscal	Juan	Water Resource Board	General Manager	Providence
S		Marseglia	Vin	Elizabeth Webbing Mills, Inc		Central Falls
S		Martin, III	John E.	WWTF -Burrillville	Superintendent	Harrisville
S		Mataleska	Karen	John H Chafee Blackstone River Nat'l Corridor	Park Ranger	Woonsocket
S		Mathews	Joel	City of Woonsocket	Planning & Development	Woonsocket
S		McBurney, III	John F.	15th District	RI State Senator	Pawtucket
S		McKee	Daniel	Town of Cumberland	Mayor	Cumberland
S		McManus	William J.	46th District	Representative	Lincoln
	T	Meharg	Dan	John H. Chafee Blackstone River National Heritage Corridor		Woonsocket
S		Menard	Rene R.	45th District	Representative	Manville
S		Menard	Susan	City of Woonsocket	Mayor	Woonsocket
	T	Millar	Scott	RIDEM, Office of Sustainable Watersheds	Chief	Providence
S		Montalbano	Joseph A.	17th District	RI State Senator	N. Providence
S		Moreau	Charles D.	City of Central Falls	Mayor	Central Falls
S		Mullen	William	USACOE		Concord
	T	Newton	Dave	EPA New England, Region 1	RPM Peterson Puritan SF Site	Boston
S		Nield, Jr.	Joseph	City of Central Falls	Director of Public Works	Central Falls
S		Oatley	John	Woonsocket WWTF	Superintendent	Woonsocket
S		O'Neill	Patrick J.	59th District	Representative	Pawtucket
S		Pacheco	Edwin R.	47th District	Representative	Pascoag
S		Pendergast	Raymond J.	Town of North Smithfield	Director of Public Works	Slatersville
S		Phillips	Michael A.	Town of North Smithfield	Planning	Slatersville
S		Picard	Roger A.	51st District	Representative	Woonsocket
	T	Pincumbe	Dave	EPA New England, Region 1		Boston
S		Pineault	Paul	Narragansett Bay Commission	Executive Director	Providence
	T	Pratt	J	Louis Berger		Needham
	T	Pryor	Don	Brown University	Center for Environmental Studies	Providence
	T	Ranaldi	Albert	Town of Lincoln	Town Planner	Lincoln
	T	Reitsma	Jan	John H. Chafee Blackstone River National Heritage Corridor		Woonsocket
	T	Rojko	Alice	MADEP	Planning	Worcester
S		Roylene Rides at the Door		Natural Resources Conservation Service	State Conservationist	Warwick
S		Rosenfield	Charles	Pawtucket Hydro		Woodstock
S		San Bento, Jr.	William	58th District	Representative	Pawtucket
	T	Scott	Elizabeth	RI DEM	Deputy Chief, Surface Water Prot.	Providence
S		Sette	Steven A.	Town of Glocester	President, Town Council	Chepachet
S		Shawver	Robert	RIDOT -Environmental and Intermodal Planning	Associate Chief Engineer	Providence
S		Silva	Agostinho F.	56th District	Representative	Central Falls
	T	Silva	Steve	USEPA Region 1		Boston
S		Singleton	Richard W.	52nd District	Representative	Cumberland
	T	Spaulding	Curt	Save The Bay		Providence
	T	Sturdevant Rees	Paula	UMass, Dept of Civil & Environmental Engineering	Assistant Professor	Amherst
	T	Swanson	Craig	ASA	Senior Principal	Narragansett
S		Tassoni, Jr.	John J.	22nd District	RI State Senator	Smithfield
S		Uva	Thomas	NBC		Providence
S		Vaudreuil	Kenneth A.	57th District	Representative	Cumberland
	T	Waldron	Chris	USGS		Northborough
	T	Walsh	Tom	Upper Blackstone WPAD		Millbury
	T	Welsh	Lynne	MA EOEA		W. Boylston
S		Wendland	Diane	John H. Chafee Blackstone River National Heritage Corridor	Landscape Architect	Woonsocket
	T	Weygand	Kim	Town of Lincoln	Town Engineer	Lincoln
S		Whitford	Alan D.	Town of Glocester	Director of Public Works	Chepachet
	T	Williams	Donna	Massachusetts Audubon Society/Blackstone River Coalition		Worcester
S		Winfield	Thomas J.	53rd District	Representative	Smithfield
	T	Winnett	Steve	EPA New England, Region 1		Boston
S		Wood	Michael	Town of Burrillville	Town Manager	Harrisville

ATTACHMENT 2: COMMENTS RECEIVED

From: Gall, John [mailto:GallJJ@cdm.com]
Sent: Thursday, April 03, 2008 2:01 PM
To: skip.viator@dem.ri.gov; elizabeth.scott@dem.ri.gov
Cc: Hay, Bernward; tom walsh
Subject: Louis Berger Report Comments

Elizabeth/Skip

The Upper Blackstone Water Pollution Abatement District asked us to review the Berger report on the Blackstone data, and to provide comments to you. Thanks for the opportunity. We would particularly like to thank RIDEM and the project participants, as the data collected have provided a useful addition to the data set we are using to calibrate the HSPF model we are developing of the Blackstone River.

In reviewing the material, we have the following comments:

We believe that the time of travel may be significantly understated at very low flows.

The report says that at 200 cubic feet per second (CFS) at Woonsocket, the time of travel from the Mass/Rhode Island border to the outlet at Slater's mill is 15.7 hours, and that at a flow of 100 CFS at the Millbury USGS gage, the time of travel from Worcester to the Mass/Rhode Island line is 24.8 hours. Adding them together results in a time of travel of approximately 40 hours from Worcester to the outlet.

These results were defined by analysis of the time differential between peak rates of flow observed at various gauging locations. While this method presents a reasonable approximation of time of travel in systems with no storage, the Blackstone has storage behind its numerous dams that becomes significant at low flows. Under these conditions, the time of travel of the peak rate of flow can be far faster than that of the volume of flow.

We encountered the same issue in the original development of our HSPF model. Times of travel calculated using the USGS model of the system were very short, not dissimilar to the values presented in your report. After review with our technical advisory panel, we revised our river segmentation, and used the highly detailed river hydraulic model developed for FEMA flood studies to reconstruct our hydraulic representation of the river.

As a result of these efforts, we have developed a robust hydraulic model of the system that is well suited to estimating time of travel. Our analyses suggest, for example, that at 235 cfs at Woonsocket, the time of travel from Worcester to the outlet is almost 10 days, some 5 times slower than the report predicts. If the flow is lower – down in the range of 100 cfs at Woonsocket - the time of travel can exceed 20 days.

It is not clear to us how you will be using times of travel in your current work. If this is an important consideration, we would be most happy to sit down with you to discuss this comment in greater detail.

The report should present the fraction of the watershed in Massachusetts tributary to the Manville station.

The report provides numerous statistics reflecting the percentage of the river load at the Manville station that originates in Massachusetts. For example, in page i-2 it indicates that 71% of nitrates, 68 % of ammonia and 58 % of the annual phosphorus load measured at Manville comes from Massachusetts.

And that 74 % , 84% and 84 % of the same constituents are contributed by Massachusetts during wet weather. This could be interpreted by some that Massachusetts is somehow far behind Rhode Island in managing these loads. Indeed, even one of your project participants “apologized” for being from Massachusetts because of the way these statistics were presented.

But, according to the report 75 % of the entire watershed is in Massachusetts. And on that basis, 81 % of the watershed tributary to the Manville station is in Massachusetts. When viewed in this light, it is more appropriate to say that we all contribute proportionately to loadings on the River. We would suggest adding information on the relative size of the watershed in order to provide a more balanced perspective on pollutant sources.

Disinfection requirements in Massachusetts would suggest subdividing the pathogen data into two seasons.

As you may know, Massachusetts DEP requires effluent disinfection for discharges to Class B waters only during the swimming season, from April 1 through October 31. Several of your dry weather sampling events took place outside of this time frame, and it would thus be expected that pathogen loads during the winter season would be significantly different than those of the summer months. For the purpose of looking at relative loadings, this suggests that the data should be split into two seasons. Of course, the draft permit proposed for UBWPAD imposes year round disinfection, and that recently issued to Northbridge does the same.

Wastewater dischargers to the river routinely dechlorinate their effluent.

The discussion on page 4-15 suggests that residual chlorine in wastewater effluents could be a cause for pathogen die-off in reach 1. Since the time of the BRI, all dischargers on the river have initiated dechlorination, or have switched to disinfection process that leave no residual. It is thus unlikely that residual chlorine is causing the dieoff in this reach.

This was a large effort that resulted in a significant document. I thought some of the graphical displays of data were particulalry ingenious and useful.

Don't hestitate to contact us if you have questions.

John Gall

From: Hartman, Elaine (DEP) [mailto:Elaine.Hartman@state.ma.us]
Sent: Friday, April 11, 2008 2:47 PM
To: Skip Viator
Cc: Dunn, Dennis (DEP)
Subject: Berger Report draft comments

Thank you for RIDEM's having Berger present the highlights from their study at the Blackstone Data Gap Committee Meeting. Due to the reports length and the time for submittal of comments I have only had the opportunity to review part of the report, so these comments may have been addressed in other areas of the report. I believe Elizabeth said at the meeting to forward the comments to you.

Preliminary comments:

The method of using hardness values in determining acute and chronic criteria is important as this is then translated into determining violations and subsequent listing or delisting and TMDL requirements. Averaging hardness over different stations and different dates may obscure the results. The Blackstone mainstem stations and tributaries are known for having a wide range of hardness values varying historically from 10 to over 60 mg/l. The BRI final report (used in this report for data comparison) attempted to provide more instantaneous values per station and over time for this very reason of site and time variability. This looks as if it may have been done for the wet weather chronic criteria, but not for the dry weather or wet weather acute.

From pg 3-4: “Wet Weather**:** For wet weather, the hardness for calculating acute and chronic criteria differed. For the calculation of the *acute criteria*, the average hardness of all stations on a waterbody for each run was used. For the Blackstone River, Stations W-01 to W-05, W-21, W-22, W-17, and W-25 along the mainstem were used.”

A one-page summary color table entitled Key Issues for TMDLs was distributed at the presentation and appeared to over summarize the results for pathogens, lead, and copper. This table should be clearly labeled whether the categories of: concern, smaller concern, and no concern, are based upon mg/l for fate and transport issues or are based upon criteria violations. It was stated at the meeting that the table actually mixed these two. Perhaps different summary tables should be prepared, one for concentration, one for loading, one for acute criteria violations, and one for chronic criteria violations. Tables of this form would be very helpful.

The data in the summary table and the information presented in the report summary should coincide.

If the data in the summary table lists the number of exceedences it should be listed with the number of total samples taken. As an example, the summary statement that the dissolved copper exceeded in 13 cases, is that out of 15 or out of 300. The exceedences should be done for each station. It was unclear if these were all at one stations or mixed tributaries and mainstem stations.

Given that the report is so lengthy the summary section becomes more important and should be more specific and inclusive in its presentation of data results.

More review is needed of the flows used to determine the loadings.

Time of travel differences between studies need to be resolved.

Presentation of loadings based upon unit watershed area would provide information on proportionate loadings per subwatershed for management decisions.

Elaine M. Hartman
Environmental Analyst
Massachusetts Department of Environmental Protection
Division of Watershed Management
627 Main Street, 2nd Floor
Worcester, MA 01608
Telephone: 508-767-2857