River Rescue

Year One Data Report

Blackstone River
Moshassuck River
Woonasquatucket River
Pawtuxet River

Rhode Island Sea Grant

River Rescue
Citizens Bank

Coastal Resources Center

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RIVER RESCUE DATA REPORT

YEAR ONE
(OCTOBER 1990 - AUGUST 1991)

Blackstone River
Moshassuck River
Woonasquatucket River
Pawtuxet River

July, 1992

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River Rescue Sponsored by: Citizens Bank
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ACKNOWLEDGMENTS

The River Rescue project has been successful because of the efforts of many people. First, the volunteers themselves, who have contributed their time on evenings, early mornings and weekends to collect the data presented in this report. Several researchers at the University of Rhode Island provided analytical support for the program. Thanks to Dr. Raymond Wright, Dr. James Quinn, Dr. James Latimer, Dr. Scott Nixon and Ms. Betty Buckley for this help. URI graduate student David Avery performed the nutrient analyses and helped with training River Rescue volunteers. His assistance was essential to the program's success.

Citizens Bank provided funding for the River Rescue program and several staff people at Citizens were major contributors to the program's first year. Thanks to Faye Sanders, Linda Tissiere and Bob Oberg for their ideas and support.

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INTRODUCTION

During the first year of River Rescue, volunteers monitored the Blackstone, Moshassuck, Woonasquatucket and Pawtuxet Rivers. These urban rivers have received industrial and domestic wastes for more than a century, and are the largest source of point source pollution to Narragansett Bay. During the last ten years, millions of dollars have been spent to improve the condition of these rivers and even greater amounts are planned for the future.

River Rescue was designed to meet three overall objectives. First, it was important that the volunteers collect credible and useful water quality information. The data would be considered useful if state and local resource managers accepted and used the data in their planning process. Second, River Rescue hoped to educate the public about the historic and present value of the rivers and their watersheds. Rhode Island's citizens are generally well educated about the state's marine and estuarine resources, but the freshwater resources have often been ignored. Protection and improvement of Providence's urban rivers depends on an educated citizenry, committed to the needs of the rivers. This education process leads to the third objective, to foster stewardship for these long neglected resources. Citizens and businesses living and working along the rivers should join together in watershed alliances to manage and preserve them.

The River Rescue monitoring program was designed with these objectives in mind. The questions addressed by the monitoring program during the first year were:

1. What is the current water quality of the four rivers?
2. What are the sources of pollution to the rivers?
3. How has the water quality changed over time?
4. What is the total load of pollutants that these rivers send to Narragansett Bay?

Volunteers were assigned to three activities. Master Monitors collected chemical water quality data every other week at six stations on the four rivers. The chemical data was supplemented by land use data collected by River Rescue River Captain volunteers. These volunteers walked, canoed and drove along the rivers and through the watersheds, documenting the location of pipes, debris and land uses that could potentially affect the water quality of the rivers. CSO volunteers monitored combined sewer overflows, watching for dry weather discharges from these structures.

MONITORING RESULTS
October 1990-August 1991

River Rescue stations were located near the mouth of each river (at the farthest downstream point that was not tidally influenced) to evaluate the rivers' contribution of pollutants to the Providence River and Narragansett Bay. Upstream stations were also monitored on the Blackstone and Woonasquatucket Rivers to evaluate water quality changes within the rivers themselves. Stations are located at the mouth of the Blackstone River at Slater Park in Pawtucket (B-1) and upstream at Blackstone, Massachusetts (B-2). Woonasquatucket River stations were located near the mouth at Valley Street in Providence (W-1) and at Route 44 in North Providence (W-2). Stations were also located on the Moshassuck River at Charles Street (M-1) and on the Pawtuxet River just upstream of the dam at Broad Street in Cranston (P-1). Figure A (at the end of the text) shows the location of the six sampling stations.

Volunteers visited the station every other week starting on October 1, 1990. Data collected through August 31, 1991, is discussed in this report. Complete listings of the data can be found in Appendix A. Total suspended solids and nutrient analyses were performed in Dr. Scott Nixon's laboratory by GSO graduate student David Avery, metals were analyzed in Dr. Ray Wright's laboratory, and petroleum hydrocarboans were analyzed in Dr. Jim Quinn's laboratory at the University of Rhode Island. Laboratory methods are summarized in Appendix B. Field sampling methods used by the volunteers are described in Appendix C.

Information supplied by River Rescue mappers and CSO monitors is summarized in Appendices D and E. This information was used to interpret the River Rescue water quality data. The maps indicated areas where the rivers were visibly degraded. They confirmed the location of old mill dams which can significantly reduce the river's velocity, slowing the rivers' natural ability to degrade organic material. The dams also allow pollutants associated with particulate material to settle to the bottom. Shoreline maps also indicated potential sources of runoff pollution which can affect the river's condition. CSO reports provided information about the size and frequency of wet weather discharges from the overflow points. These discharges can significantly affect the condition of the rivers after a storm.

The following section summarizes the results of the first year of River Rescue sampling. Figures referenced in the discussion are at the end of the text. The discussion covers each of the major parameters sampled by River Rescue water quality monitors. Whenever possible, data have been compared to state and federal water quality standards to assist with the interpretation of the results. Unfortunately, such "bench mark" values do not exist for all the chemicals included in the River Rescue testing program. Since one year of sampling can not be used to assess long-term changes in the rivers' conditions, comparisons of River Rescue results to historical studies of these rivers were included, where appropriate (see Appendix F for the data used in the comparisons).

Total Suspended Solids

Water samples for TSS analysis were collected from the mouth of each river in conjunction with the sampling for total saturated petroleum hydrocarbons. Figure 1 shows the measured TSS concentrations and the river flow at the mouth of the river on the same day. Flows were extrapolated from the most downstream USGS gage to the mouth using drainage area ratios.

TSS was not well correlated to flow at any of the stations. The Blackstone River is regulated, and instantaneous TSS measurements are affected by sudden releases of water from the dams. Water levels have been observed to rise several feet in the span of a half hour at the Slater Mill site. Flows in the Pawtuxet River are also affected by discharges from the sewage treatment plants. The gage is located above the Cranston discharge and the sewage flow was not incorporated in the flow calculation. The lower Moshassuck River is densely urbanized and responds quickly to storm events. The peak TSS concentration measured in February could have been caused by short, intense rain just prior to sampling. About 1/2 inch of rain was reported on that day at Greene airport. The May peak was not related to rain and may have been caused by disturbed bottom sediments.

Dissolved Oxygen and Temperature

Fish and other aquatic organisms use oxygen dissolved in the water to respire. The Environmental Protection Agency (EPA) has determined that a concentration of 5 milligrams of oxygen per liter of water (5 mg/l) is the minimum safe level for most aquatic organisms. The State of Rhode Island has adopted this level as the oxygen standard for all four rivers evaluated by River Rescue.

Figure 2 shows the results of the River Rescue oxygen testing. Figure 3 shows the air and water temperatures measured at the stations at the same time the oxygen was measured. Since water loses its capacity to dissolve oxygen as it warms, the oxygen level of the rivers naturally declines during the warmer months of the year. The graphs show the expected seasonal changes in oxygen concentrations. The Pawtuxet River regularly dipped below the 5 mg/l standard during the warm months of October and July and August. The other stations stayed above the standard at all times of the year.

The Pawtuxet River is affected by sewage discharged from three municipal wastewater treatment plants immediately upstream of River Rescue station P-1. The decomposition of organic material in these wastes uses up the oxygen in the water. During the summer when concentrations would naturally be low due to the warm water, oxygen levels at the mouth of the Pawtuxet fall below the 5 mg/l standard. Oxygen depletion in the Pawtuxet River degrades habitat for aquatic organisms in the lower river. The State of Rhode Island is currently working with the three major municipalities to improve the quality of their discharges. Studies are also underway to address the runoff pollution entering the river from urban stormdrains.

Nutrients

Nitrogen and phosphorus, chemicals essential to healthy plants, are the key ingredients in lawn and garden fertilizers. In water, nitrogen and phosphorus nourish aquatic plants such as algae and aquatic weeds. Although plant life is essential to a balanced aquatic ecosystem, excessive levels of nitrogen and phosphorus will produce an overabundance of plants. In rivers over enriched with nutrients, lush weeds choke the river's flow and destroy bottom habitats. In lakes and estuaries, excess nutrients can produce blooms of algae. When massive amounts of algae bloom and decay, they can remove oxygen from the water which can cause fish kills. Some algae are also toxic to fish and shellfish.

Algae blooms and weed infestations are the physical symptoms of a "eutrophic" waterbody. Eutrophication, a waterbody's natural aging process, is accelerated by the influence of humans. Sewage introduced to waters by discharges from municipal treatment plants and leachate from septic tanks introduce excess nutrients to waters. Runoff of fertilizer from lawns and farms can also introduce significant amounts of nitrogen and phosphorus after rain events.

Figures 4 and 5 show the average dissolved nitrogen and phosphorus concentrations measured at the six stations. The error bars show one standard deviation. These data show a general decrease in nutrient concentrations from the upstream Woonasquatucket and Blackstone River stations to the downstream stations. The Pawtuxet River had the highest concentrations of nitrogen and phosphorus. This is caused in large part by sewage discharges from Cranston, Warwick and West Warwick and runoff flow from I-95 and I-295 which flow into the river upstream of station P-1. These concentrations should decrease in the years ahead, as advanced treatment is added to the waste treatment plants and steps are taken to address the runoff pollution.

Measured dissolved inorganic nitrogen and phosphorus concentrations are plotted with river flow in Figures 6 and 7. The point source dominated Pawtuxet River showed an inverse relationship between flow and concentration. The other river stations showed little correlation between flow and nutrient concentrations.

Figures 8 and 9 show the mass (pounds) of dissolved inorganic nitrogen and phosphorus dumped into the Providence River and Narragansett Bay each day by the four rivers. These charts clearly show that the Blackstone and Pawtuxet Rivers dominate the loadings. The load of nutrients is the product of the concentration of the nutrient in the river and the volume of river water flowing into the Bay (the river's flow). On the average, the four tributaries contribute over 90 percent of the freshwater to the Providence River. The Blackstone River has the highest average daily flow, followed in order by the Pawtuxet River, Woonasquatucket River and Moshassuck River. When multiplied times the nutrient concentrations, the larger flows result in a much larger daily load.

The 1990/1991 River Rescue nutrient data were compared to biweekly data collected in 1982 and 1983 by Scott Nixon (in prep.). The data used for these comparisons is included in Appendix D. Figures 17 and 18 show the change in pollutant concentrations over this time period. Although the Blackstone, Woonasquatucket, Moshassuck and Pawtuxet Rivers continue to be highly polluted, phosphorus concentrations in all four rivers have decreased by at least 50 percent. Nitrogen concentrations have decreased in all but the Pawtuxet. These improvements are probably caused by better CSO maintenance in Providence and perhaps by lower concentrations of phosphorus in laundry detergents.

Metals

High concentrations of metals are toxic to living organisms. Industrial discharges have introduced metals to the Blackstone, Woonasquatucket, Moshassuck and Pawtuxet Rivers for almost a century. Metals are also introduced to the rivers by runoff from highways and city streets.

The Environmental Protection Agency has analyzed the toxicity of metals to a variety of aquatic organisms. Toxic substances affect organisms in two general ways. High levels of chemicals will kill organisms immediately. EPA has established "acute" criteria designed to protect aquatic organisms from short term exposures to high concentrations of metals. Chemicals can also have a long term effect, where the toxicity develops after the organism has been exposed for some time to a lower concentration. EPA has developed "chronic" criteria to protect organisms from these long term, low level exposures. Acute criteria are always higher than the chronic criteria.

River Rescue volunteers collected samples that were analyzed for lead, copper, cadmium, chromium and nickel. These data are displayed in Figures 10-14. In general, metals concentrations are very high in the rivers, with consistent violations of chronic criteria for copper and lead. The Blackstone River (B-1 and B-2) and the Pawtuxet River also violated the acute criteria in most of the copper samples.

The Blackstone River delivers the highest loading of all four metals to the Providence River followed closely by the Pawtuxet River. As was evident in the nutrient loadings, this is in large part due to the larger flows of these two rivers.

The River Rescue metals data were compared to seasonal data collected in 1985 and 1986 during the SINBADD cruises. The data used for the comparisons is included in Appendix D. Figures 17 and 18 show the results of the comparisons. Concentrations of chromium, cadmium and nickel have significantly improved in the Moshassuck, Woonasquatucket and Blackstone Rivers. Copper and lead concentrations have decreased in the Moshassuck and Woonasquatucket Rivers, but increased slightly in the Blackstone. These improvements are testimony to the success of the Narragansett Bay Commission's (NBC) pretreatment program, CSO maintenance program and aggressive pursuit of illegal discharges to the sewer system and the rivers.

The Pawtuxet River shows less improvement than the rivers in the NBC drainage area. Toxic metals are being addressed in new permits for the Cranston, Warwick and West Warwick wastewater treatment facilities. Upgraded treatment facilites will be online at these plants in the next five to ten years.

Petroleum Hydrocarbons[1]

Petroleum hydrocarbons receive a lot of media attention, especially following large oil spills such as the 1989 EXXON VALDEZ spill in Alaska. However, chronic inputs of oil from sewage treatment plants and rain runoff from urban roads also contribute large amounts of oil to the aquatic environment. Petroleum hydrocarbons have been extensively studied in Narragansett Bay where sediment core samples indicate that oil is introduced to the Bay throughout its watershed, with highest concentrations in the metropolitan area near Providence. The Providence Fields Point treatment plant with its combination of sanitary sewers and storm sewers, is a major source of oil to the bay during both wet and dry conditions.

Once in the aquatic environment, more than half of the oil settles to the bottom, where it becomes incorporated into the sediments and persists for several years. Sedimentation of

[1] A complete discussion of the petroleum hydrocarbon results can be found in, "Non-Aromatic Petroleum and Natural Hydrocarbons Entering Narragansett Bay from Four Tributaries Under Dry Weather Conditions", J.S. Latimer, Cormier, S.A. and Quinn, J.G., Final Report to the River Rescue Program, May 11, 1992.

particulate forms of the oil, evaporation, and microbial activity remove most compounds in the water column within a few weeks or days. However, toxic portions of the oil can persist in the water column for several months.

It is expensive to analyze for petroleum hydrocarbons, and these analyses are not routinely included in most water quality monitoring programs. However, the River Rescue program was designed to specifically address the water quality issues of the four major urban rivers flowing through Providence. These issues include petroleum hydrocarbons. Therefore, during the first year of the River Rescue sampling effort, volunteers collected biweekly petroleum hydrocarbon samples from the mouth of each river (B-1, W-1, M-1 and P-1). This dataset provides information on the significance of petroleum hydrocarbons in each of the four rivers and information on the rivers' loading of hydrocarbons to the Providence River and Narragansett Bay. Archived samples will be analyzed in the future for other organic chemicals. Petroleum hydrocarbon sampling will not continue into the second year, but as analyses continue on the samples, the results will be reported to the River Rescue volunteers.

Figure 15 shows the total average petroleum hydrocarbons concentrations measured by River Rescue in the four rivers. The Moshassuck River had the highest concentrations, followed by the Blackstone and Pawtuxet Rivers. The Woonasquatucket River had the lowest average concentrations.

The overall concentrations of total petroleum hydrocarbons ranged from a minimum of 2 µg/L in the Pawtuxet River to a maximum of 170 µg/L in the Moshassuck River. Most of the samples, however, were in the 10 to 30 µg/L range. There are no state or federal water quality criteria for petroleum hydrocarbons. Scientists disagree on a safe level, suggesting that levels as low as 10 ug/l and as high as 100 ug/l are toxic to aquatic organisms.

The average load of petroleum hydrocarbons introduced to the Providence River and Narragansett Bay by the rivers is shown in Figure 16. As for the other pollutants studied, the Blackstone River dominates as the largest source of hydrocarbons to the Bay. Following the Blackstone was the Pawtuxet River with 22 percent of the total. Finally, the Moshassuck and the Woonasquatucket each contributed approximately 5 percent of the total load of petroleum hydrocarbons.

The River Rescue results are compared to 1985/1986 samples in Figures 17 and 18. Petroleum concentrations have improved by 25 percent in the Moshassuck, 28 percent in the Blackstone, 50 percent in the Pawtuxet and 75 percent in the Woonasquatucket River. These improvements are difficult to explain.

CONCLUSIONS

Environmental monitoring requires patience and stamina. The real world will not behave like a controlled experiment, and the results of any water quality monitoring project are always confounded by weather, hydrologic conditions, spills and accidents, and many other factors. During the first year of the River Rescue water quality monitoring project, a lot was accomplished. But there is still a great deal more to learn.

Next year, River Rescue will expand its coverage of the four rivers. Upstream stations will be added on the Pawtuxet and Moshassuck Rivers to help define sources of pollution and changes in water quality along the rivers themselves. Stations will also be added in the Providence and Seekonk Rivers to better define the extent of the rivers' impact on Narragansett Bay. Monthly monitoring will continue at the six original stations.

River mappers will concentrate on the Pawtuxet River and streams tributary to the Woonasquatucket, Moshassuck and Blackstone Rivers. Volunteers will also be encouraged to become "pipe detectives", carefully examining discharges from pipes along the urban rivers during a variety of weather conditions. This information will help define sources of pollution to the urban rivers.

During 1992, River Rescue will work closely with Rhode Island environmental officials as efforts are taken to address the water quality of the Blackstone, Woonasquatucket, Moshassuck and Pawtuxet Rivers. Volunteers will be encouraged to become advocates for these sometimes forgotten rivers, and get involved in the decisions that are key to the rivers' improved condition. River Rescue will also act as a catalyst, motivating businesses and citizens living and working along the rivers to care about these important resources and strive to improve their condition.

RIVER RESCUE MONITORING SUMMARY

	YEAR 1	YEAR 2
Number of Water Quality Stations	6	10
Sampling Frequency	Biweekly	Monthly
Rivers Covered	Moshassuck Woonasquatucket Blackstone Pawtuxet	Moshassuck Woonasquatucket Blackstone Pawtuxet Ten Mile
Parameters	Dissolved Oxygen TSS Nutrients Metals Hardness (1) Petroleum Hydrocarbons	Dissolved Oxygen TSS Nutrients Metals Hardness pH (2)
Other Monitoring Projects	CSO Monitors River Mappers (4) River Clean-ups	(3) River Mappers Pipe Detectives River Clean-ups

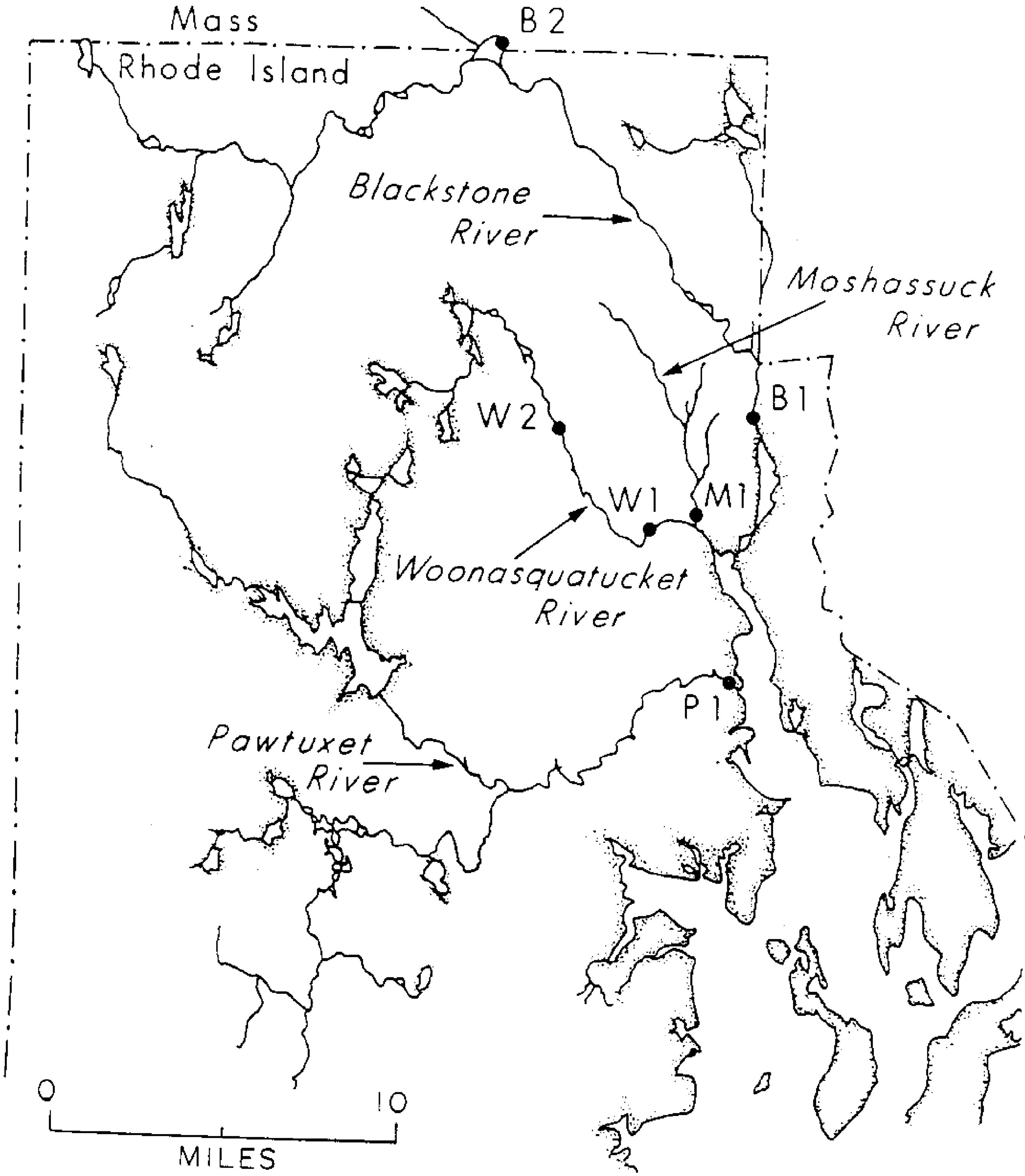
Explanation of Changes:

(1) Measurements for pH were made at the four downstream stations during Year 1. For Year 2, we added pH kits to the equipment for each volunteer.

(2) A very extenisve petroleum hydrocarbon data set was collected during the first year of River Rescue. We hope to resample the rivers for petroleum hydrocarbons during the third year of the porgram.

(3) CSO monitors found very few problems with the combined sewer overflows in Providence. We decided to stop CSO monitoring, and spend more time doing pipe detective work.

(4) Pipe detectives are assigned to segments of the urban river stretches. They examine the pipes along this segment during a variety of weather conditions to determine whether the pipes ever discharge.



RIVER RESCUE SAMPLING STATIONS

Figure A. Northern Rhode Island map showing River Rescue sampling stations.

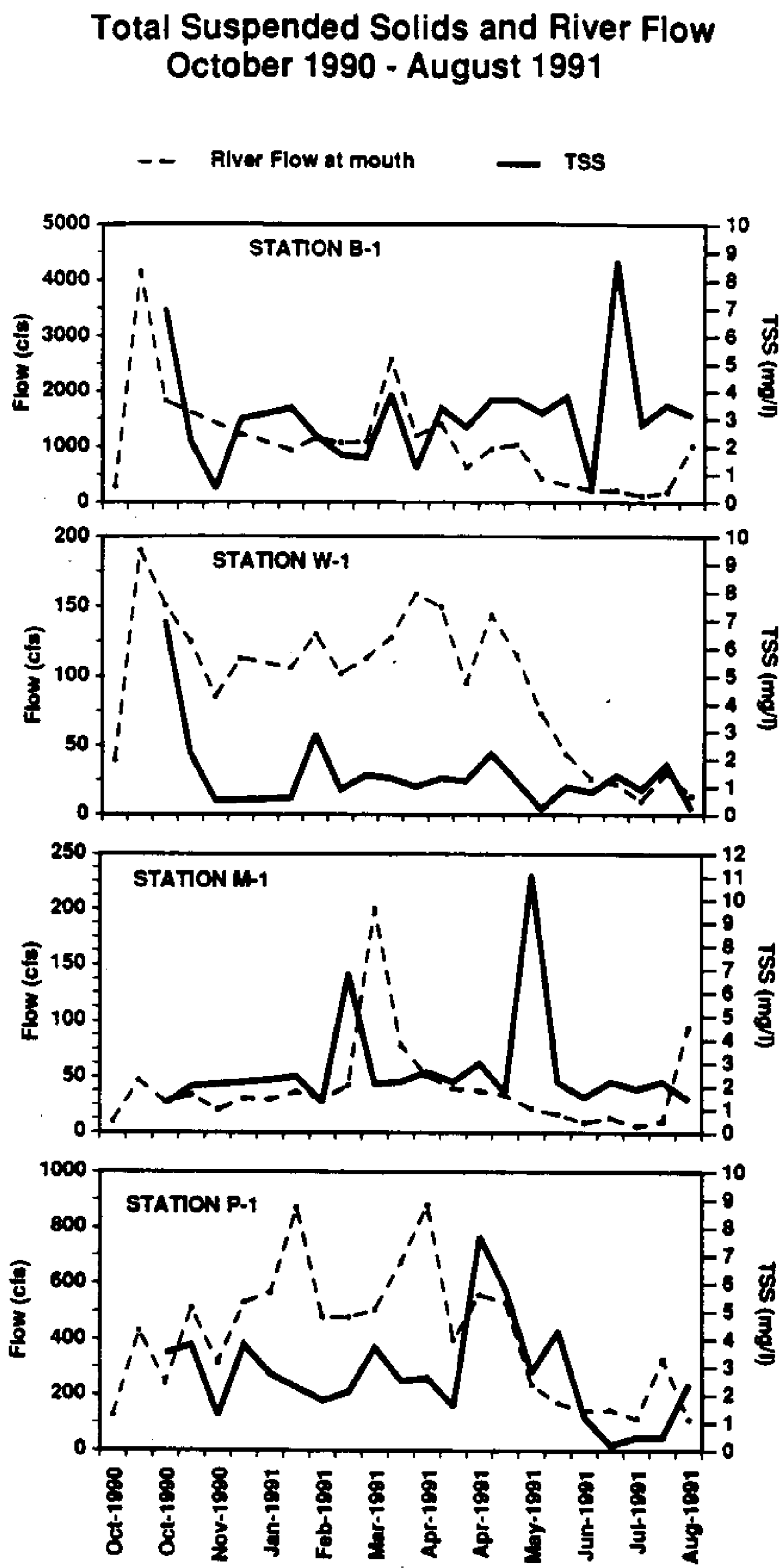


Figure 1. Average daily river flow and total suspended solids at the mouth of each river.

Dissolved Oxygen Concentrations
October 1990 - August 1991

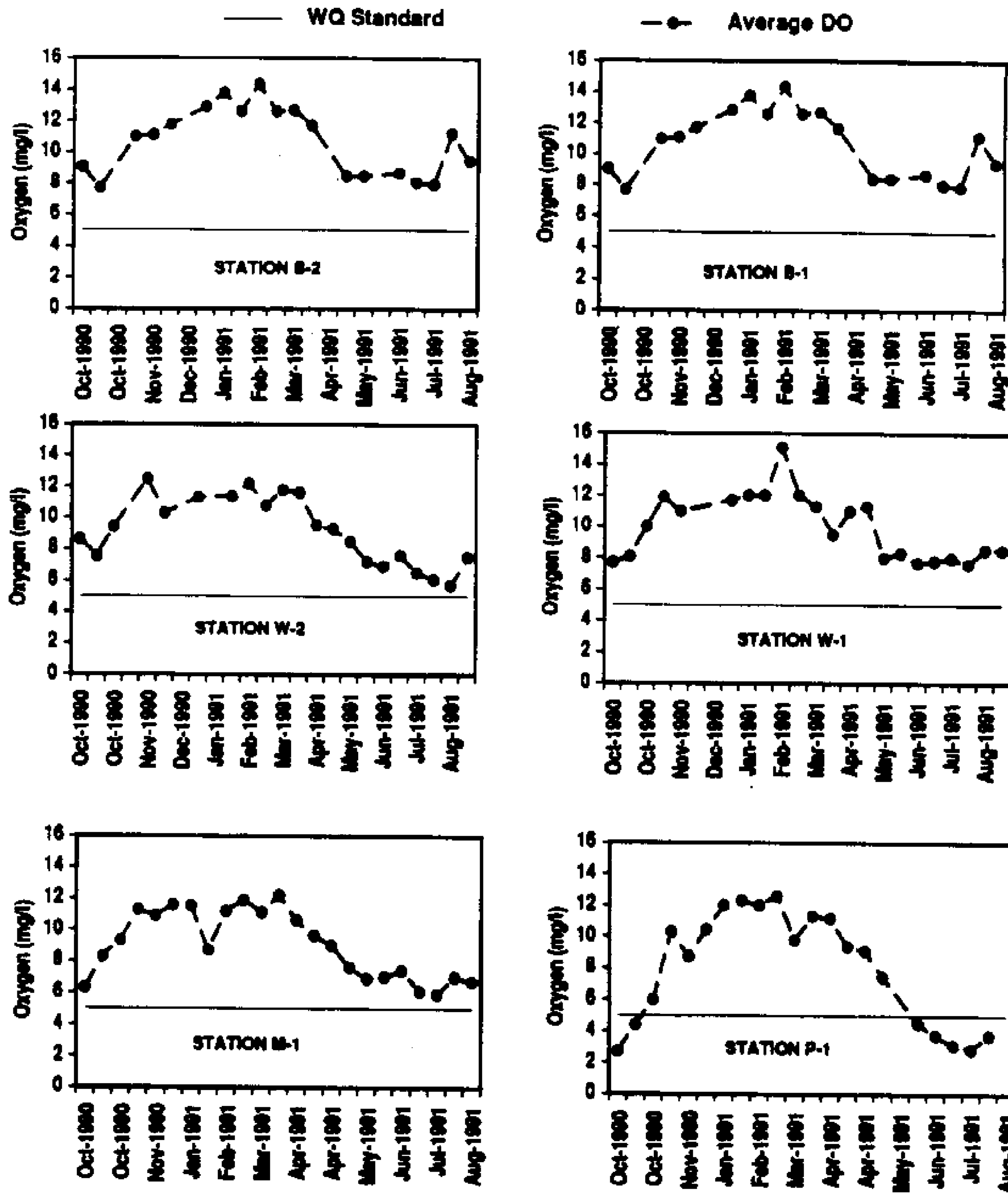


Figure 2. Average measured dissolved oxygen concentration compared to 5 mg/L water quality standard.

Water and Air Temperatures
October 1990 - August 1991

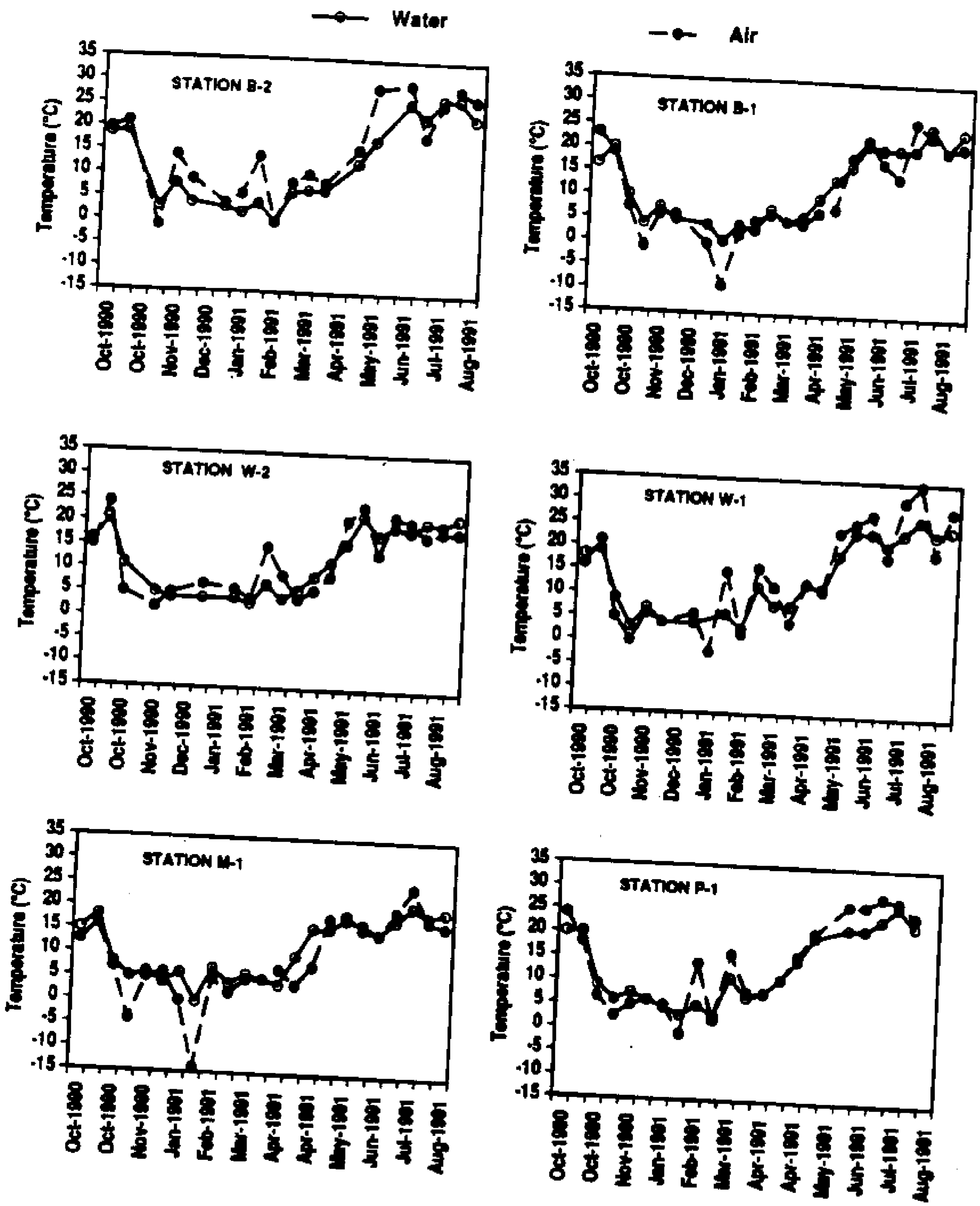


Figure 3. Air and water temperatures measured at each sampling station.

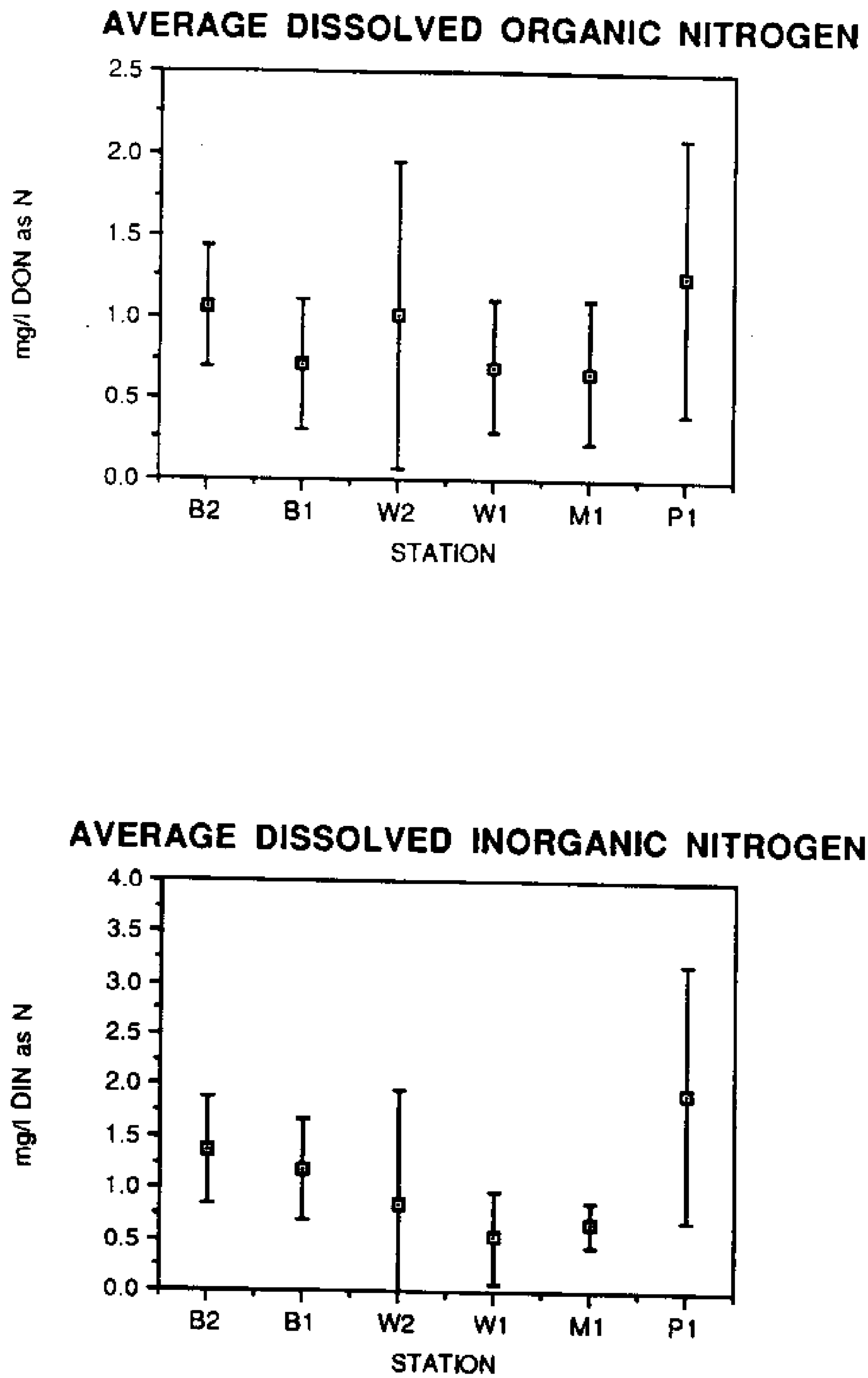
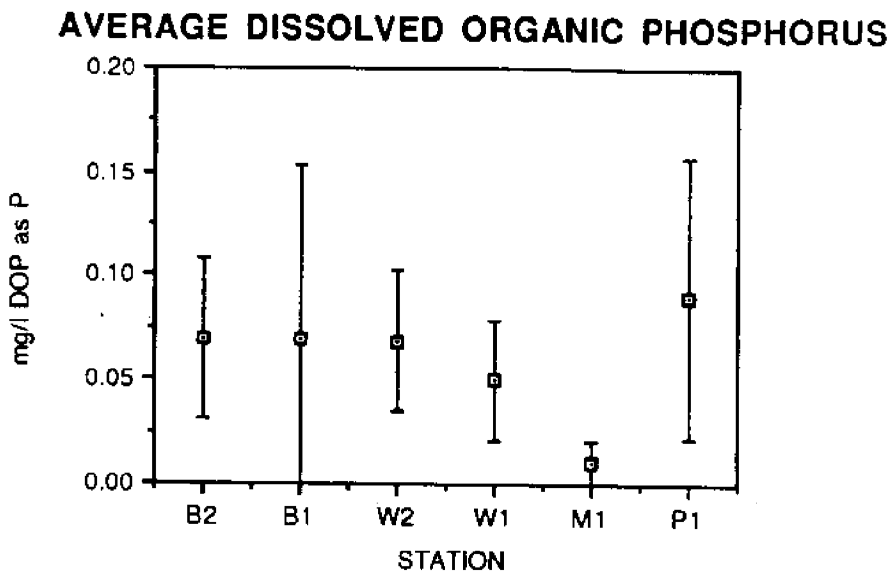


Figure 4. Average DIN and DON concentrations with error bars showing one standard deviation. River Rescue data from October 1990 through August 1991.



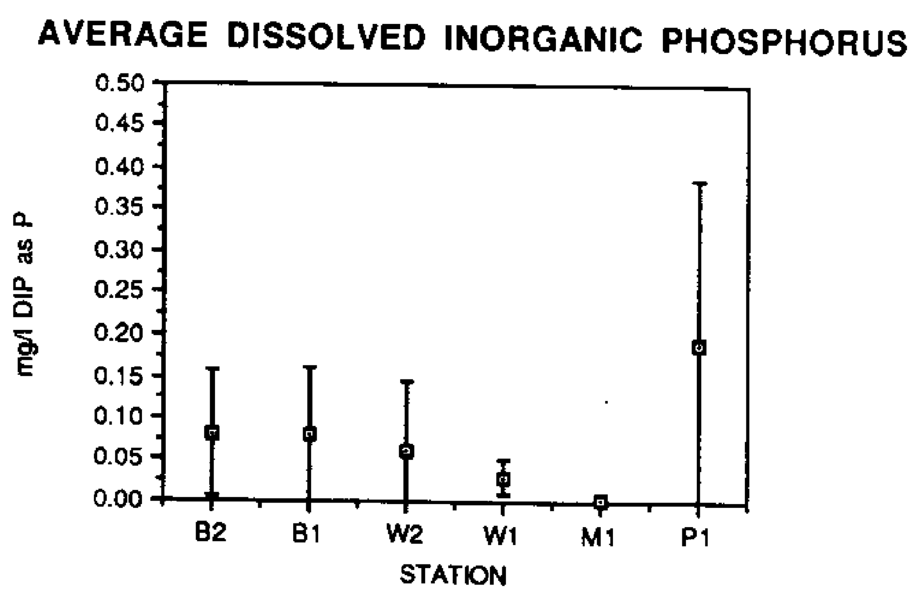


Figure 5. Average DOP and DIP concentrations with error bars showing one standard deviation. River Rescue data from October 1990 through August 1991.

Dissolved Inorganic Nitrogen and River Flow
October 1990 - August 1991

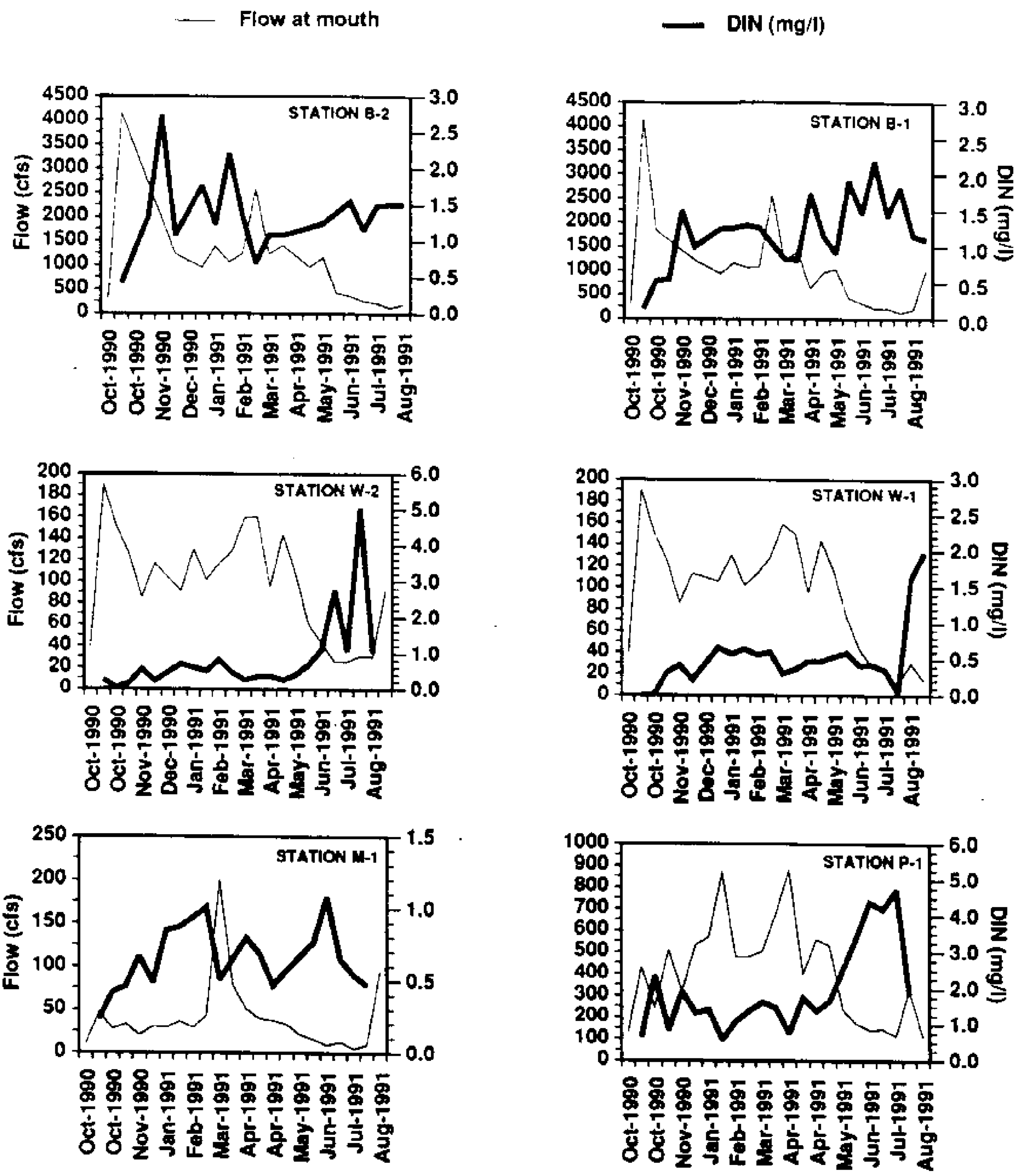


Figure 6. Total dissolved inorganic nitrogen concentrations at River Rescue stations plotted with average daily river flow at the mouth of each river.

Dissolved Inorganic Phosphorus and River Flow
October 1990 - August 1991

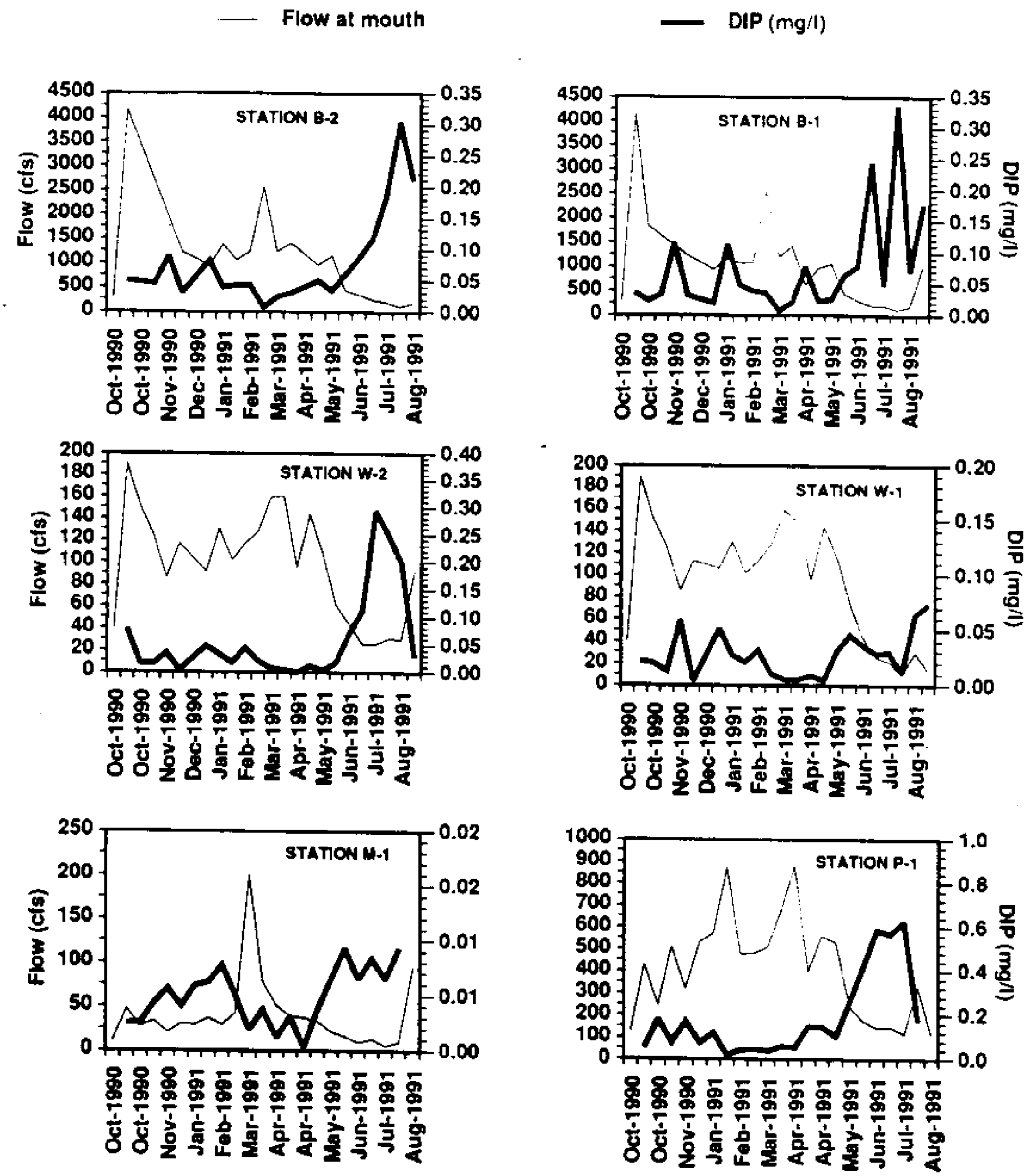


Figure 7. Total dissolved inorganic phosphorus concentrations at River Rescue stations plotted with average daily river flow at the mouth of each river.

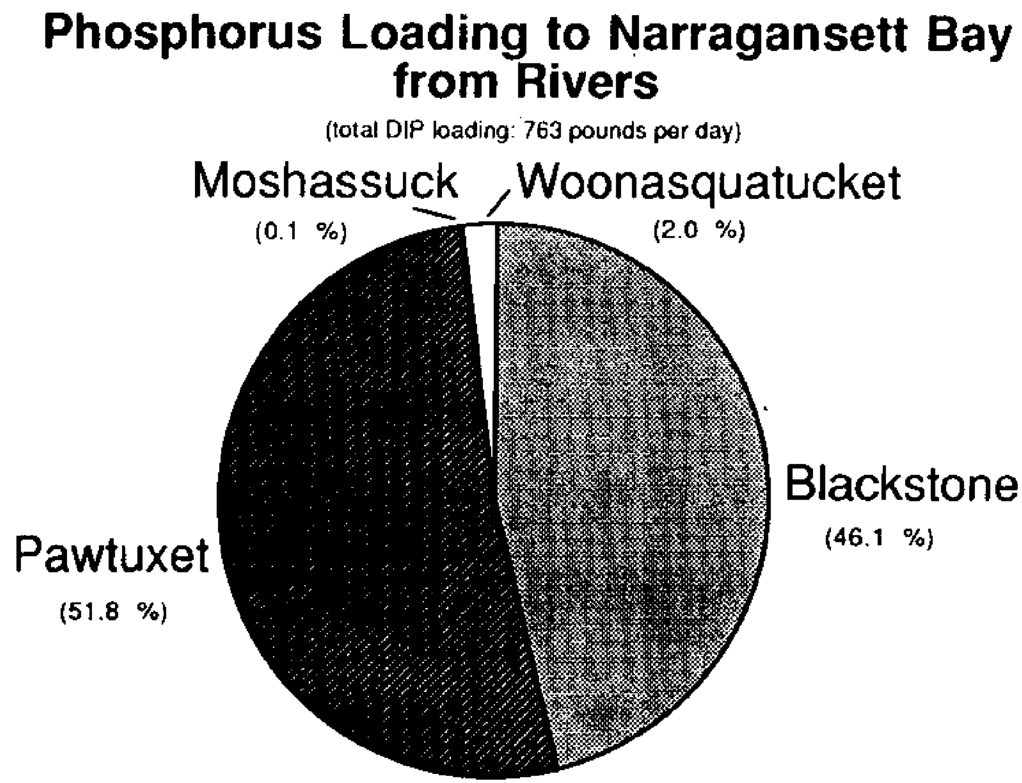


Figure 8. Total dissolved inorganic phosphorus loading to Narragansett Bay from the four rivers, October 1990 through August 1991.

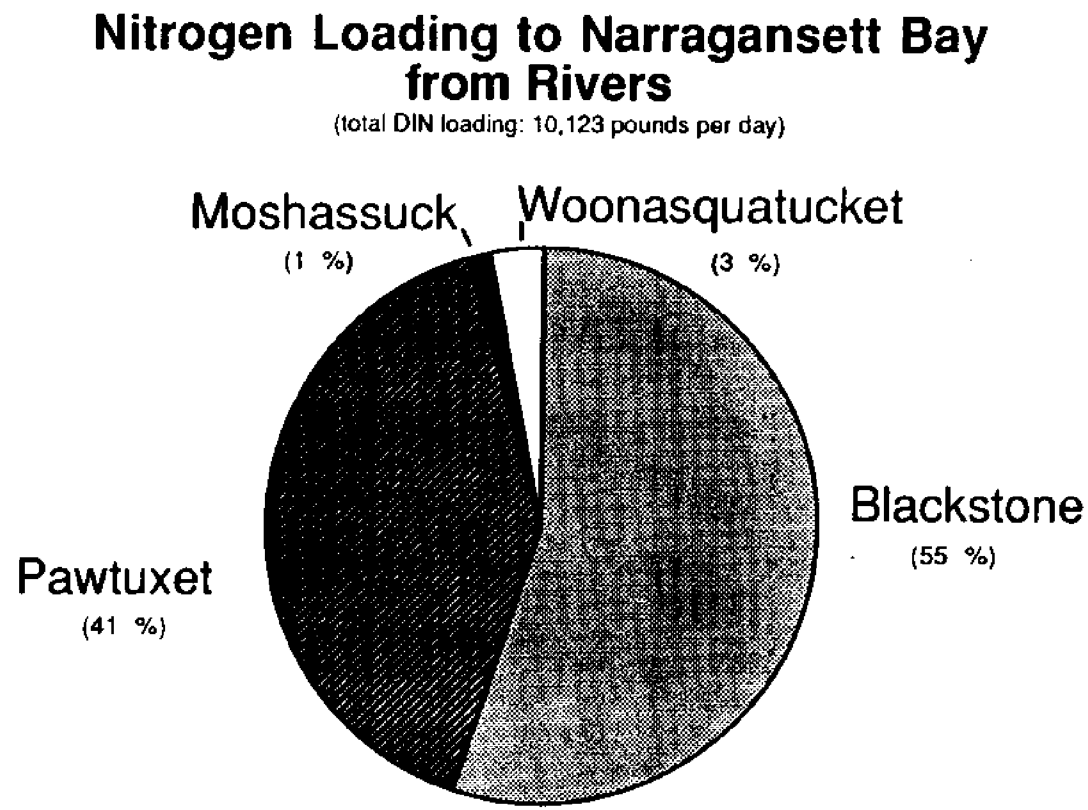


Figure 9. Total dissolved inorganic nitrogen loading to Narragansett Bay from the four rivers, October 1990 through August 1991.

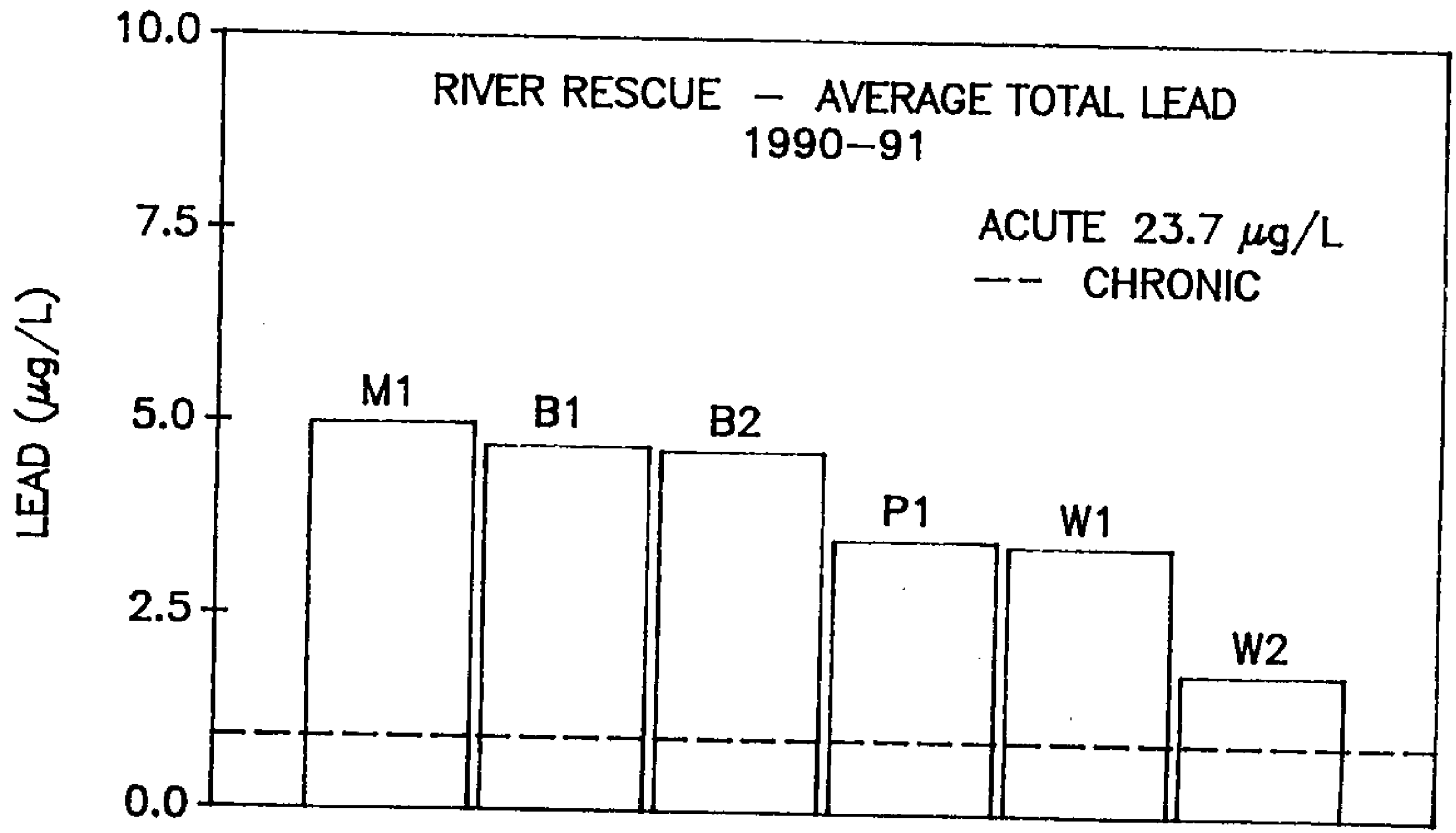


Figure 10. Average total lead concentrations at River Rescue stations compared to the acute and chronic water quality criteria calculated with the average measured water hardness.

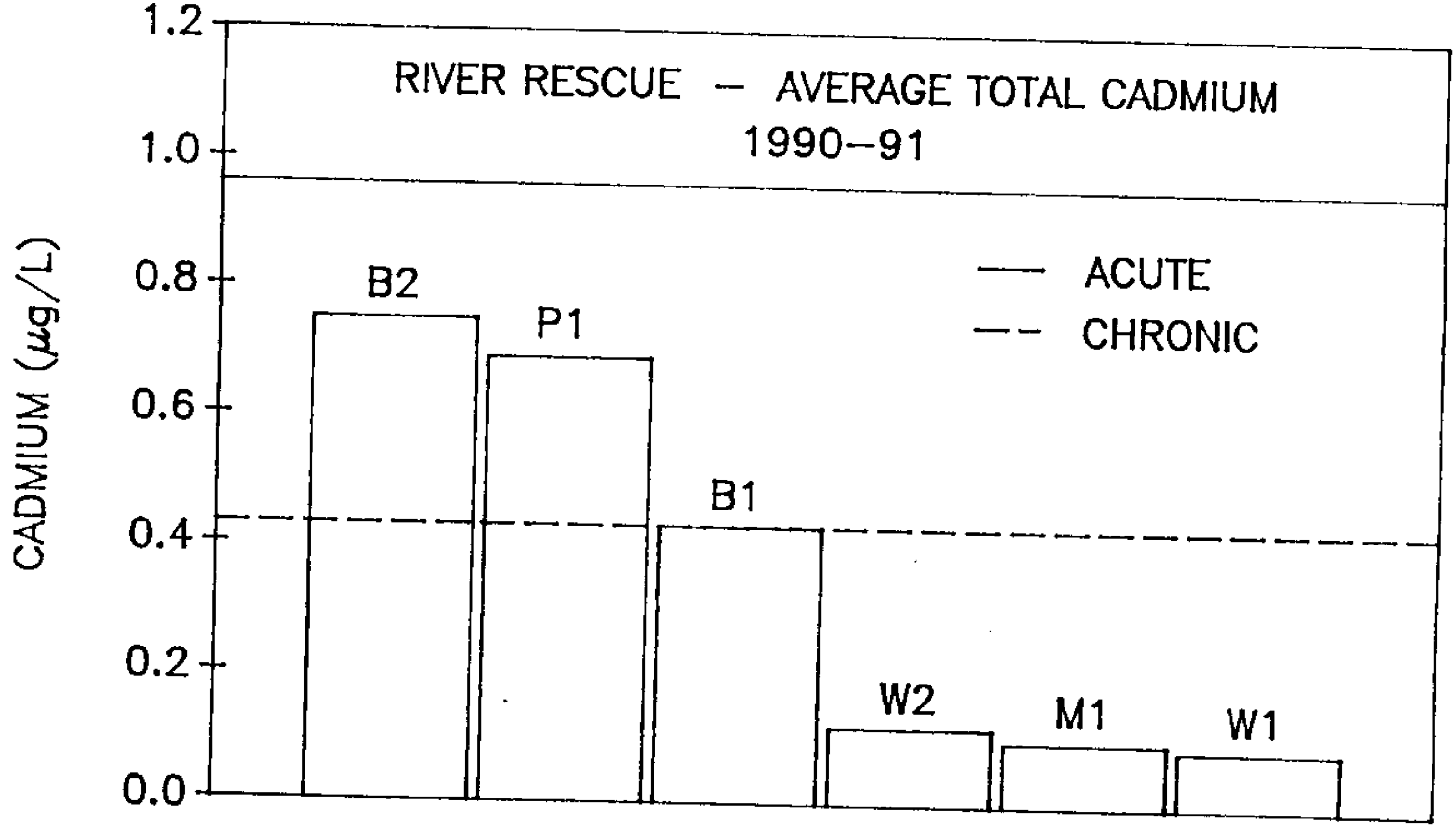


Figure 11. Average total cadmium concentrations at River Rescue stations compared to the acute and chronic water quality criteria calculated with the average measured water hardness.

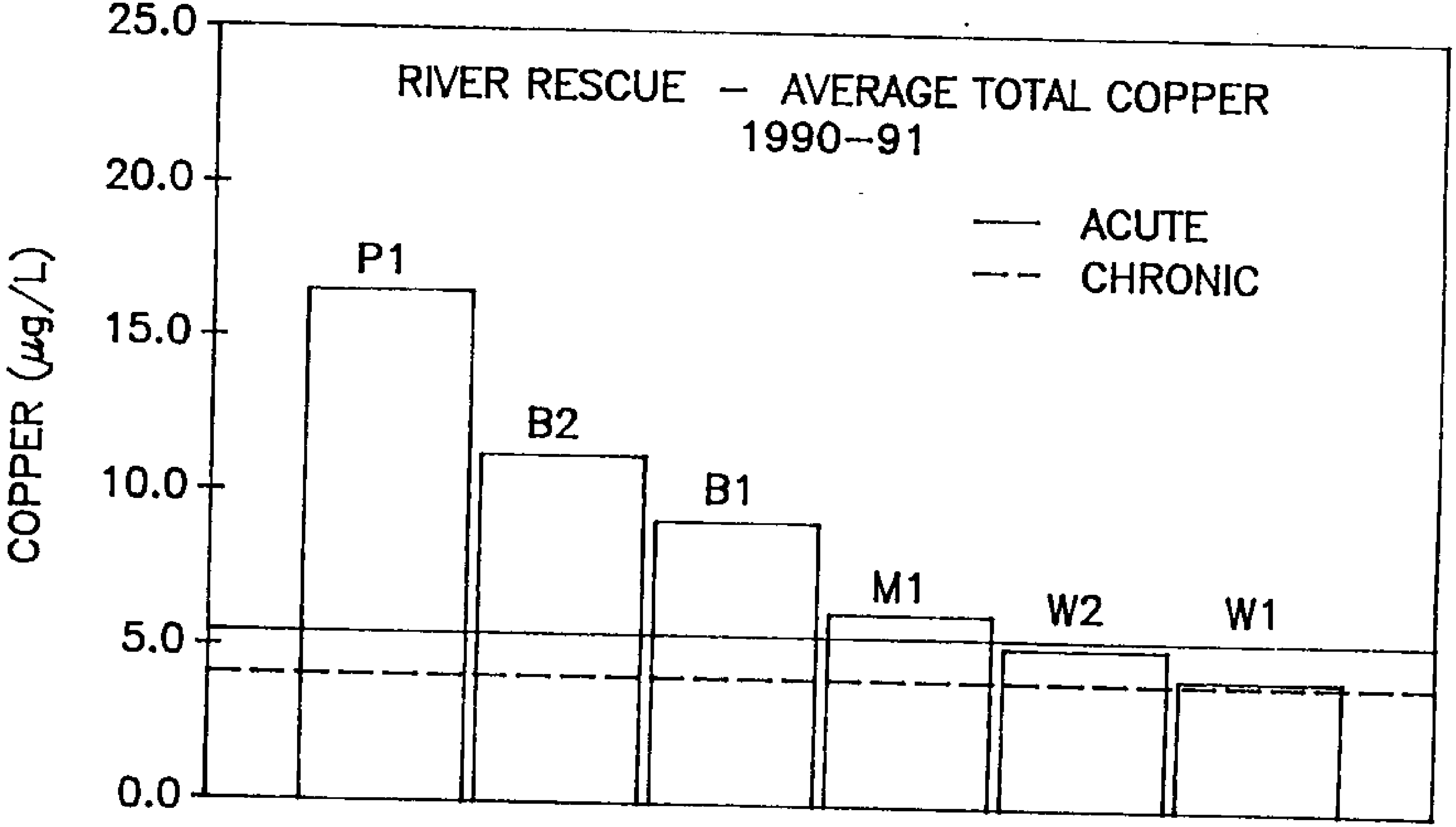


Figure 12. Average total copper concentrations at River Rescue stations compared to the acute and chronic water quality criteria calculated with the average measured water hardness.

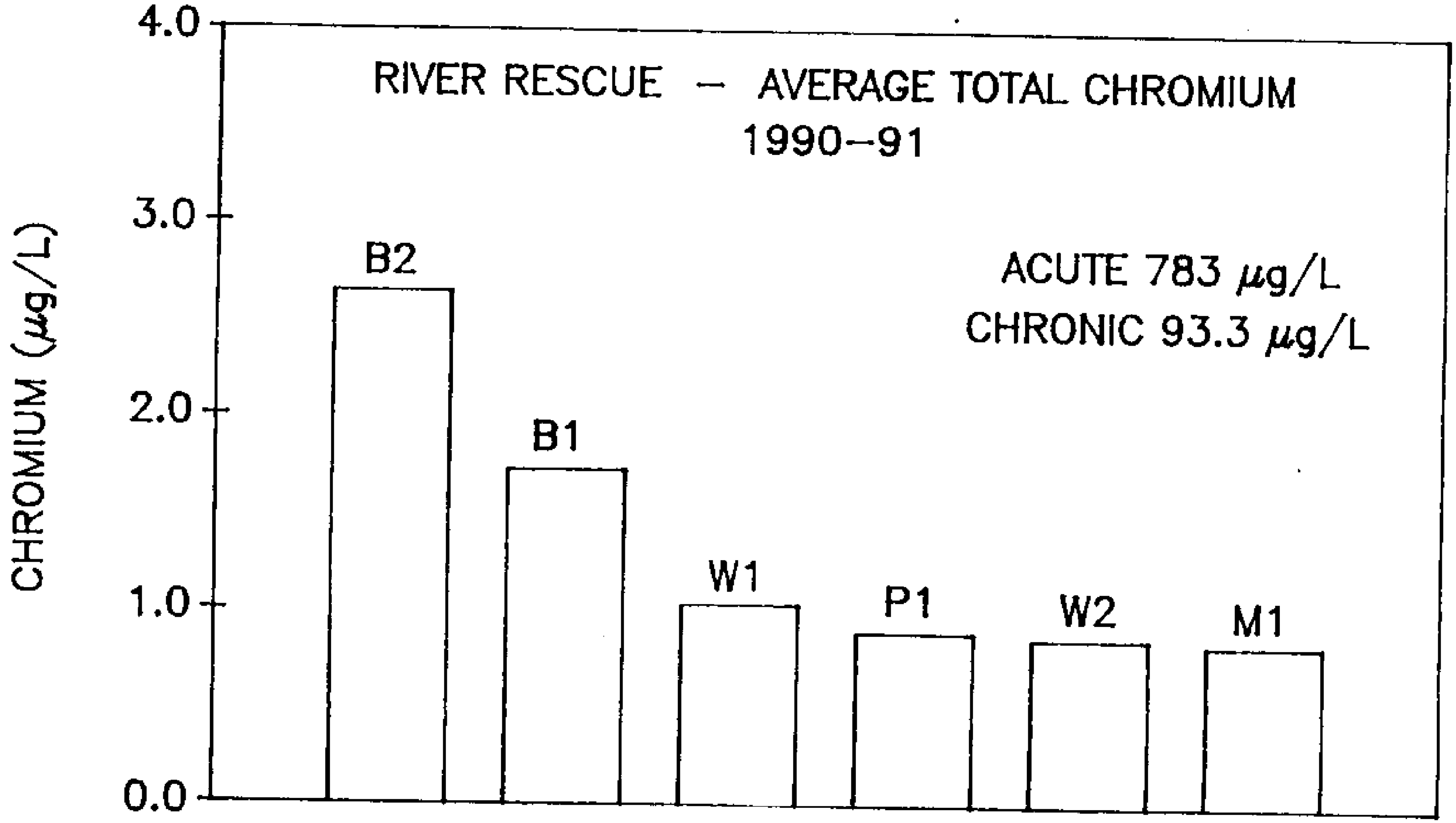


Figure 13. Average total chromium concentrations at River Rescue stations compared to the acute and chronic water quality criteria calculated with the average measured water hardness.

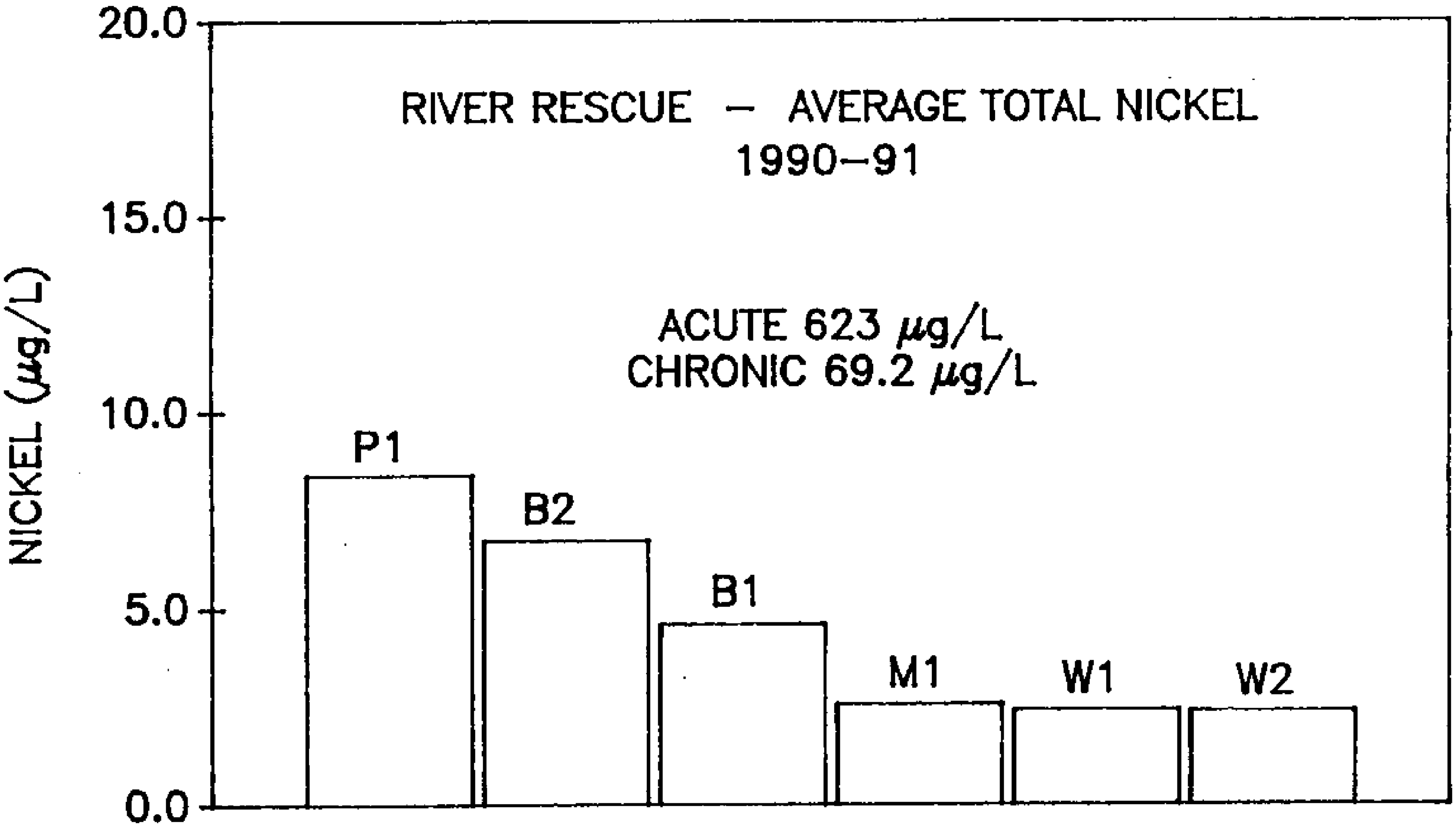


Figure 14. Average total nickel concentrations at River Rescue stations compared to the acute and chronic water quality criteria calculated with the average measured water hardness.

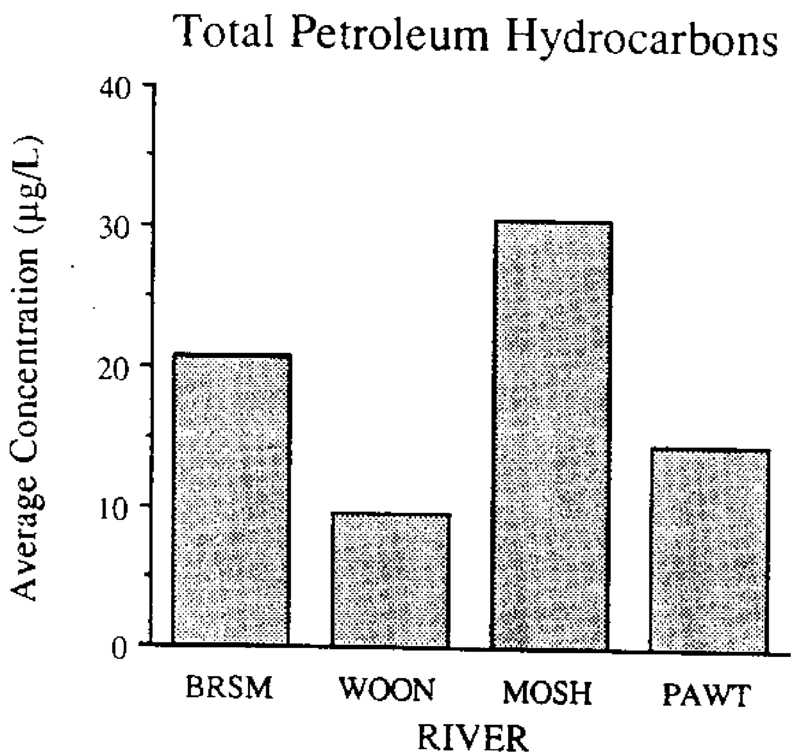


Figure 15. Average total petroleum hydrocarbon concentrations at the mouth of the Blackstone, Woonasquatucket, Moshassuck and Pawtuxet Rivers, October 1990-August 1991.

Σ PHC TRANSPORT (KG/D) Total = 64 KG/D

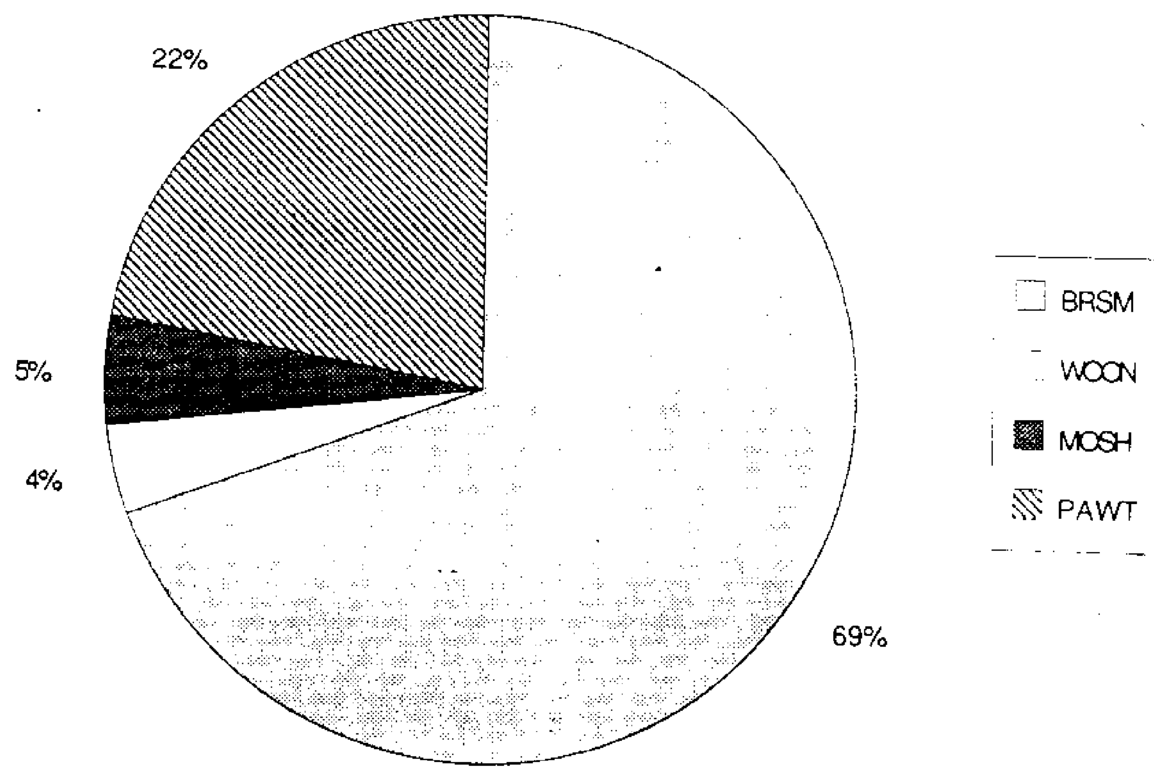


Figure 16. Total petroleum hydrocarbon loading to Narragansett Bay from the four rivers, October 1990-August 1991.

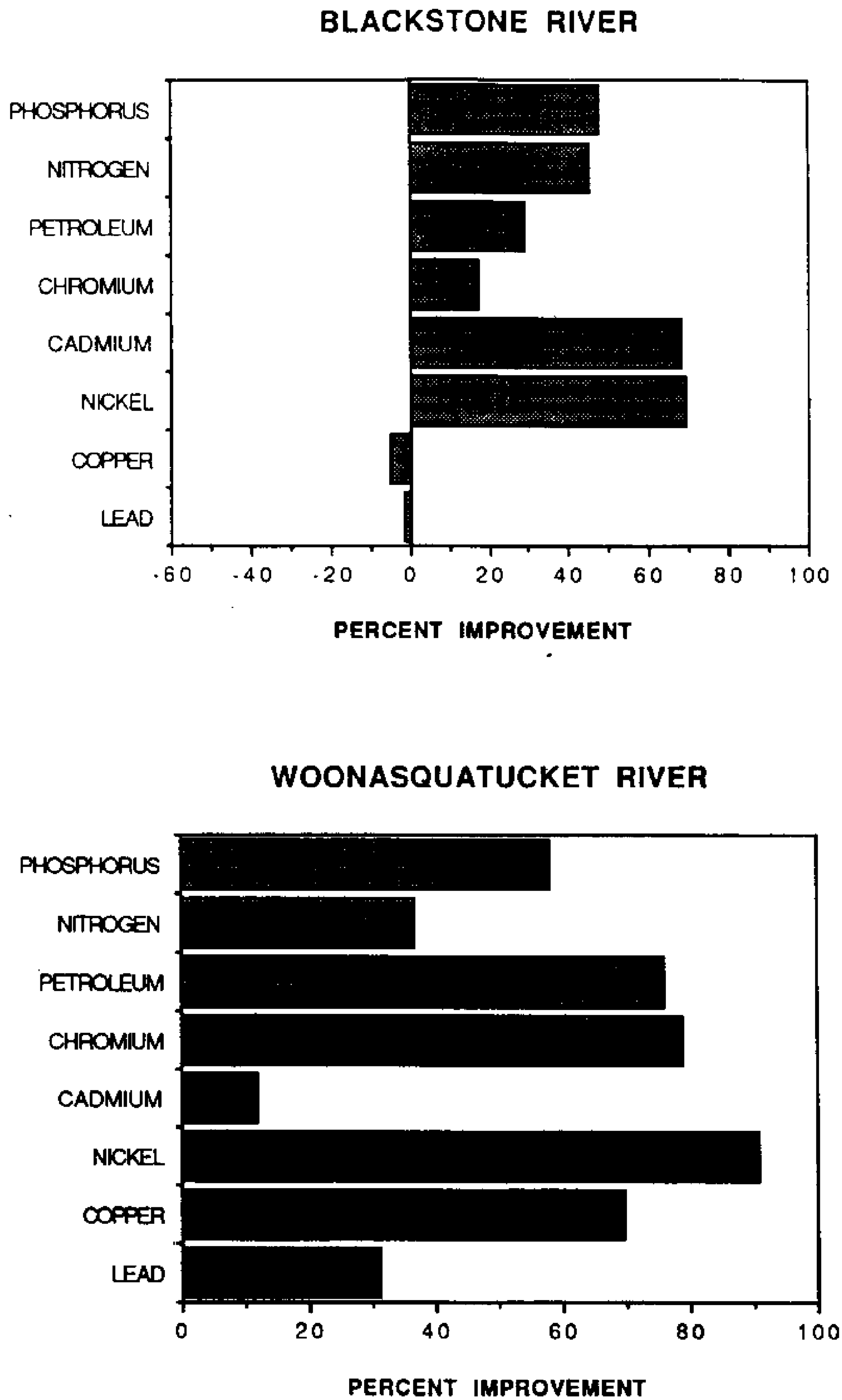


Figure 17. Comparison of average River Rescue pollutant concentrations to historical studies for the Blackstone and Woonasquatucket Rivers.

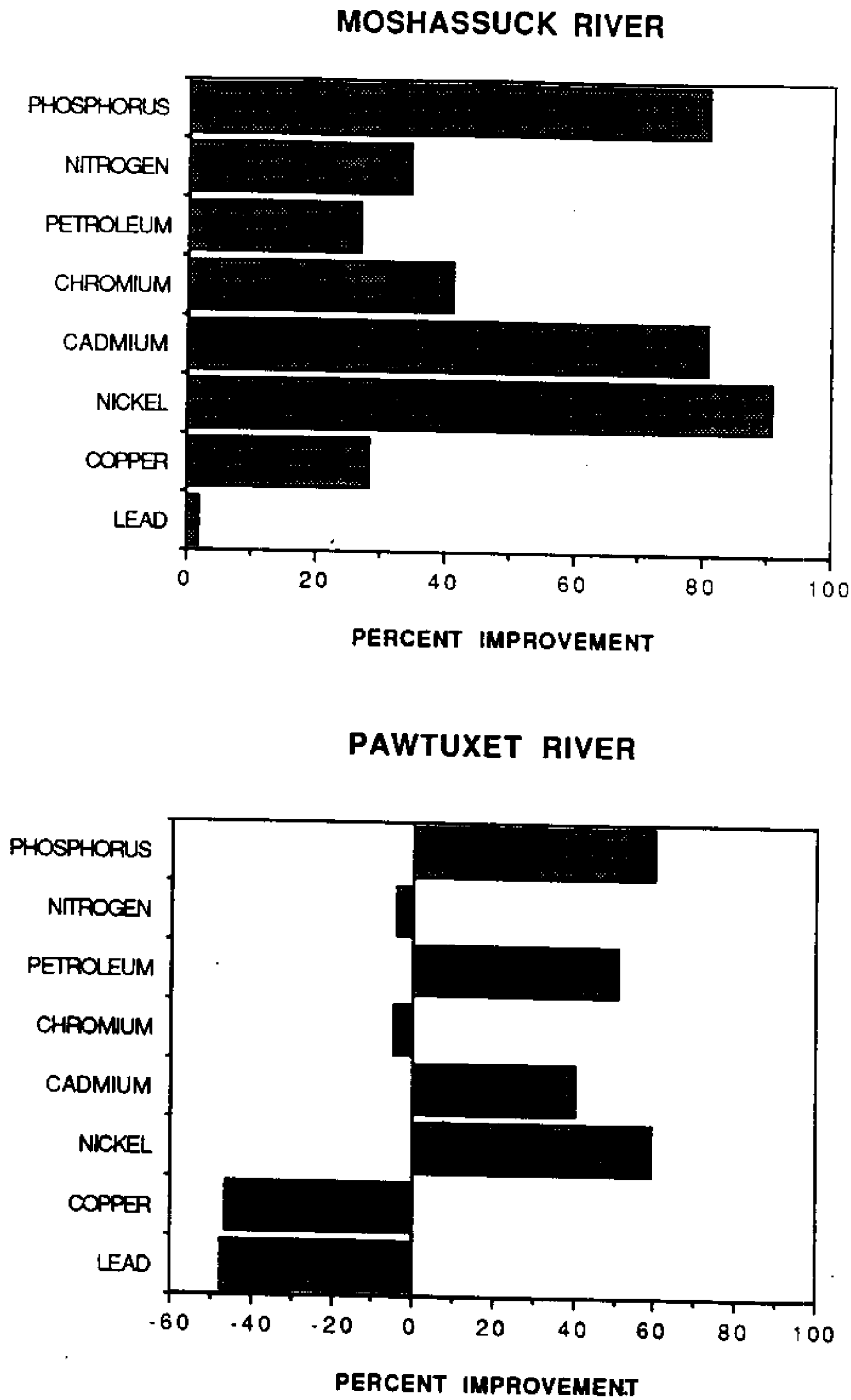


Figure 18. Comparison of average River Rescue pollutant concentrations to historical studies for the Moshassuck and Pawtuxet Rivers.

APPENDIX A

River Rescue Water Quality Data
Year One (October 1990 - August 1991)

KEY TO COLUMN HEADINGS

Rainfall at Greene Airport	total inches of rain on sampling date
cumulative rain 5 day	rain on sampling day plus four previous days
flow at gauge	average daily flow from USGS records for sampling day (preliminary numbers)
flow at mouth	flow at mouth of river calculated with drainage area ratios Blackstone Flow at mouth = flow at gauge x 472/416 Woon Flow at mouth = flow at gauge x 51.9/38.2 Mosh Flow at mouth = flow at gauge x 23.7/23.3 Pawt Flow at mouth = flow at gauge x 232/201
time	time sampling began
pH	pH estimated with HACH kit
hardness (kit)	hardness measured with LaMotte kit
DO1, DO2	replicate dissolved oxygen measurements, Lamotte kit
DOAVG	average dissolved oxygen measurement
DOSAT	dissolved oxygen saturation at the measured water temperature
%SAT	(DOAVG/DOSAT)*100
WATER T, AIR T	measured water and air temperatures in Centigrade
TSS	total suspended solids
D NOx	dissolved nitrate plus nitrite
D NO2	dissolved nitrite (calculated as D NOx - D NO3)
D NO3	dissolved nitrate
D NH4	dissolved ammonia
DIN	dissolved inorganic nitrogen (D NOx + D NH4)
tot dis N	total dissolved nitrogen (DIN + DON)
DON	dissolved organic nitrogen
TKN	total nitrogen analyzed with a persulfate digestion
DIP	dissolved inorganic phosphorus
tot dis P	total dissolved phosphorus
DOP	dissolved organic phosphorus
PART PHOS	particulate phosphorus (retained on Gelman A/E Glass fiber filters)
TOT P	total phosphorus
Total Ca, Total Mg	Calcium and Magnesium analyzed in Dr. Wright's lab
calculated hardness	(2.497*Ca) + (4.118*Mg)

NOTE: nutrient concentrations given in micro Moles/liter

BLACKSTONE/SLATER MILL

DATE	RAINFALL AT GREENE AIRPORT (INCHES)	cumulative rain 5 day inches	BLACK. FLOW AT GAUGE (CFS)	BLACK. FLOW AT MOUTH * (CFS)	TIME	water level (in)	DO 1 (mg/l)	DO 2 (mg/l)	DO AVG (mg/l)	DO SAT (mg/l)
1-Oct-90	0.01	0.05	245	278	16:00		8.2	8.2	8.2	9.2
15-Oct-90	0.00	2.60	3660	4153	7:30		7.8	8.2	8	9.1
29-Oct-90	0.00	0.35	1610	1827	7:40		10.9	11	10.95	11.3
13-Nov-90	0.00	1.12			7:20		11.9	11.9	11.9	13.1
26-Nov-90	0.00	0.19			7:30		11.2	11.2	11.2	12.0
10-Dec-90	0.00	0.31	1080	1225	7:30		12.4	12.2	12.3	12.8
7-Jan-91	0.00	0.10	822	933	8:00		13.2	13.2	13.2	13.1
22-Jan-91	0.00	0.11	1020	1157	9:15		13.6	13	13.3	14.4
4-Feb-91	0.00	0.20	944	1071	7:30		14.2	14.4	14.3	13.1
19-Feb-91	0.42	0.51	957	1086	7:30	66	13.2	13.4	13.3	13.5
4-Mar-91	0.85	2.00	2270	2576	7:30	57	11.6	11.4	11.5	12.0
18-Mar-91	1.26	1.84	1060	1203	7:30	63.5	12	11.8	11.9	12.8
1-Apr-91	t	0.36	1240	1407	7:30	62.5	11	11.1	11.05	12.4
15-Apr-91	0.26	0.36	546	620	7:30	70	9.6	9.5	9.55	11.3
29-Apr-91	0.00	0.00	848	962	7:30	67	9.2	9	9.1	10.3
13-May-91	0.00	0.66	913	1036	7:30	64.5	7.8	8	7.9	9.7
28-May-91	0.02	0.05	381	432	7:45	72.5	6.8	6.8	6.8	8.7
10-Jun-91	0.00	0.00	274	311	7:30	77.5	7.2	7.2	7.2	8.9
24-Jun-91	0.00	0.02	186	211	7:15	76	7.4	7.2	7.3	8.9
8-Jul-91	0.00	0.11	183	208	7:30	78.5	6.9	6.9	6.9	8.9
22-Jul-91	0.00	0.00	104	118	7:30	79	5.4	5	5.2	8.1
5-Aug-91	0.00	0.86	163	185	7:30	78	6.6	nm	6.6	8.9
19-Aug-91	2.51	2.55	885	1004	7:30	76	6.4	6.2	6.3	8.3
# samples	22	23	21	21		14	45		23	23
mean	0.24	0.62	923	1048		70.6	9.8		9.7	10.9
st dev	0.60	0.83	825	936		7.2	2.7		2.7	2.0

BLACKSTONE/SLATER MILL

DATE	% SAT	H2O T	AIR T	TSS	D NOx	D NO2	D NO3	D NH4	DIN	tot dis N
	%	(C)	(C)	(mg/l)	(um/l as N)	(um/l as N)	(um/l as N)	(um/l as N)	(um/l as N)	(um/l as N)
1-Oct-90	89.29	16.5	23							
15-Oct-90	87.99	20	19		8.72	0.34	8.38	0.87	9.59	72.530
29-Oct-90	97.01	10	7.5	7	36.72	0.25	36.47	0.57	37.29	60.630
13-Nov-90	90.79	4	-1	2.2	37.56	0.73	36.83	0.74	38.3	86.210
26-Nov-90	93.40	7.5	6	0.5	60.12	3.8	56.32	46.26	106.38	128.910
10-Dec-90	96.32	5	6	3	42.96	0.27	42.69	28.2	71.16	121.680
7-Jan-91	100.71	4	0	3.4	56.34	1.97	54.37	33	89.34	176.430
22-Jan-91	92.24	0.5	-9	2.4	45.57	0.72	44.85	43.92	89.49	113.640
4-Feb-91	109.10	4	2	1.7	50.79	1.07	49.72	41.67	92.46	141.031
19-Feb-91	98.81	3	5	1.6	45.25	0.21	45.04	44.98	90.23	140.891
4-Mar-91	95.91	7.5	6.5	3.9	42.61	0.19	42.42	31.84	74.45	99.166
18-Mar-91	93.19	5	5	1.2	46.14	0.7	45.44	12.92	59.06	111.446
1-Apr-91	88.78	6	4.5	3.4	43.74	0.19	43.55	14.78	58.52	99.103
15-Apr-91	84.60	10	7	2.7	92.98	0.27	92.71	30.78	123.76	149.113
29-Apr-91	88.30	14	8	3.7	64.14	3.21	60.93	17.8	81.94	74.776
13-May-91	81.74	17	19	3.7	61.54	0.29	61.25	3.1	64.64	107.936
28-May-91	77.77	22	23	3.2	131.56	8.03	123.53	5.01	136.57	156.316
10-Jun-91	80.76	21	18	3.8	102.81	0.54	102.27	0.99	103.8	207.262
24-Jun-91	81.88	21	15	0.6	129.09	0.57	128.52	27.21	156.3	222.01
8-Jul-91	77.40	21	27	8.7	100.47	0.45	100.02	0.57	101.04	193.67
22-Jul-91	64.09	26	24	2.8	126.24	2.19	124.05	3.39	129.63	217.96
5-Aug-91	74.03	21	21	3.5	58.41	5.97	52.44	23.49	81.9	165.47
19-Aug-91	76.24	25	22	3.1	65.1	1.05	64.05	12.99	78.09	144.69
# samples	23	23	23	21	22	22	22	22	22	22
mean	87.84	12.7	11.2	3.1	65.86	1.50	64.36	19.32	85.18	135.95
st dev	10.19	8.2	9.8	1.9	33.37	2.06	32.66	16.44	34.32	47.07

BLACKSTONE/SLATER MILL

DATE	DON	DIP	tot dis P	DOP	PART P	TOT P	Total Ca	Total Mg	hardness
	(um/l as N)	(um/l as P)	(um/l as P)	(um/l as P)	(um/l as P)	(UM/L AS P)	mg/l as Ca	mg/l as Mg	calculated
1-Oct-90					4.95		9.5	2.00	32.0
15-Oct-90	62.940	1.14	2.500	1.360	7.57	10.070	2.2	1.00	9.6
29-Oct-90	23.340	0.75	1.100	0.350	3.35	4.450	3.9	2.00	18.0
13-Nov-90	47.910	1.05	2.850	1.800	2.86	5.710	3.6	2.40	18.9
26-Nov-90	22.530	3.71	4.750	1.040	4.53	9.280	6.0	2.00	23.2
10-Dec-90	50.520	1.01	2.198	1.188	2.10	4.298	4.6	2.00	19.7
7-Jan-91	87.090	0.62	2.828	2.208	2.75	5.578	6.2	2.00	23.7
22-Jan-91	24.150	3.69	3.788	0.098	4.30	8.088	4.0	1.90	17.8
4-Feb-91	48.571	1.54	3.827	2.287	5.00	8.827	6.0	1.80	22.4
19-Feb-91	50.661	1.25	1.697	0.447	2.72	4.417	6.6	1.90	24.3
4-Mar-91	24.716	1.14	2.72	1.580	6.15	8.870			
18-Mar-91	52.386	0.22	1.69	1.470	3.56	5.250	7.6	1.90	26.8
1-Apr-91	40.583	0.67	2.72	2.050	2.73	5.450	9.2	2.19	32.0
15-Apr-91	25.353	2.48	8.44	5.960	2.97	11.410	11.5	2.44	38.8
29-Apr-91	-7.164	0.74	1.82	1.080	2.09	3.910	8.9	1.79	29.6
13-May-91	43.296	0.81	2.72	1.910	2.82	5.540	8.4	1.85	28.6
28-May-91	19.746	2.08	2.92	0.840	3.44	6.360	11.8	2.42	39.4
10-Jun-91	103.462	2.49	6.913	4.423	2.16	9.073	12.4	2.89	42.9
24-Jun-91	65.710	7.83	9.383	1.553	1.72	11.103	14.3	3.08	48.4
8-Jul-91	92.630	1.56	5.185	3.625	3.19	8.375	14.5	2.62	47.0
22-Jul-91	88.330	10.83	12.705	1.875	2.00	14.705	16.1	2.86	52.0
5-Aug-91	83.570	2.25	15.13	12.880	2.48	17.610	12.4	2.50	41.3
19-Aug-91	66.600	5.73	8.86	3.130	4.07	12.930			
# samples	22	22	22	22	23	22	21	21	21
mean	50.77	2.44	4.85	2.42	3.46	8.24	8.56	2.17	30.30
st dev	28.48	2.62	3.81	2.71	1.43	3.65	4.01	0.47	11.62

BLACKSTONE/SLATER MILL

DATE	Cr (ug/l)	Ni (ug/l)	Cu (ug/l)	Pb (ug/l)	Cd (ug/l)
1-Oct-90	1.6	6.1	13	2.7	0.35
15-Oct-90	4.1	6.2	17.5	12.4	0.64
29-Oct-90	1.5	3.4	10.4	5.5	0.4
13-Nov-90	1.5	3.4	7.4	3.5	0.35
26-Nov-90	1.3	3.7	7.1	4.1	0.37
10-Dec-90	1.5	4.9	8.5	3.2	0.48
7-Jan-91	1.3	4.2	9.9	11.2	0.48
22-Jan-91	1	3.5	5	2.1	0.35
4-Feb-91	1.2	3.4	7.4	2.8	0.38
19-Feb-91	0.8	3.7	7.4	5.2	0.46
4-Mar-91					
18-Mar-91	0.6	3.3	5.7	1.9	0.3
1-Apr-91	6	2.7	7.5	3.2	0.53
15-Apr-91	1.1	5.2	6.5	4.2	0.43
29-Apr-91	2.4	4.6	8.1	7.1	0.66
13-May-91	2.4	4	8.3	5.1	0.49
28-May-91	1.5	5	9	5.9	0.44
10-Jun-91	1.2	5.3	11.9	5	0.43
24-Jun-91	1.5	6.6	12.8	3.2	0.45
8-Jul-91	1	4.7	9	5.1	0.26
22-Jul-91	1.2	6.7	9.3	1.4	0.33
5-Aug-91	1.5	5.7	10.1	3.6	0.43
19-Aug-91					
# samples	21	21	21	21	21
mean	1.7	4.6	9.1	4.7	0.43
st dev	1.2	1.2	2.9	2.8	0.10

BLACKSTONE/BLACK.,MA

DATE	RAINFALL AT GREENE AIRPORT (INCHES)	cumulative rain 5 day inches	BLACK. FLOW AT GAUGE (CFS)	BLACK. FLOW AT MOUTH * (CFS)	TIME	DO 1 (mg/l)	DO 2 (mg/l)	DO AVG (mg/l)	DO SAT (mg/l)
1-Oct-90	0.01	0.05	245	277.98	15:45	9	9.1	9.05	9.372
15-Oct-90	0.00	2.60	3660	4152.69	11:30	7.8	7.6	7.7	9.276
29-Oct-90									
13-Nov-90	0.00	1.12	NA		10:00	10.8	11.2	11	13.46
25-Nov-90	0.00	0.19	NA		15:30	11.2	11	11.1	11.843
10-Dec-90	0.00	0.31	1080	1225.38	11:15	11.8	11.7	11.75	13.107
6-Jan-91	0.00	0.10	843	956.48	15:00	12.8	13	12.9	13.46
20-Jan-91	0.00	1.37	1220	1384.23	12:00	14	13.6	13.8	13.829
4-Feb-91	0.00	0.20	944	1071.08	15:30	12.4	12.8	12.6	13.107
17-Feb-91	t	1.07	1090	1236.73	15:30	14.4	14.3	14.35	14.621
4-Mar-91	0.85	2.00	2270	2575.58	15:00	12.8	12.4	12.6	12.293
17-Mar-91	0.00	0.58	1090	1236.73	15:00	12.6	12.8	12.7	12.139
1-Apr-91	t	0.36	1240	1406.92	15:00	11.6	11.8	11.7	12.139
15-Apr-91									
29-Apr-91	0.00	0.00	848	962.15	15:30	8.3	8.6	8.45	10.53667
12-May-91	0.00	0.66	1020	1157.31	14:30	8.3	8.6	8.45	9.467
28-May-91	0.02	0.05	381	432.29					
9-Jun-91	0.00	0.03	315	357.40		8.6	8.8	8.7	8.113626
22-Jun-91	0.01	0.48	226	256.42	1600	8.1	8	8.05	8.578221
8-Jul-91	0.00	0.11	183	207.63	10:00	8.05	7.85	7.95	7.968482
22-Jul-91	0.00	0.00	104	118.00	1600	11.1	11.3	11.2	7.968482
5-Aug-91	0.00	0.86	163	184.94	1400	9.4	9.6	9.5	8.578221
# samples	18	20	18	18		38		19	19
mean	0.05	0.61	940.11	1066.66		10.71		10.71	11.05
st dev	0.20	0.72	874.35	992.05		2.13		2.15	2.28

BLACKSTONE/BLACK.,MA

DATE	% SAT	WATER T	AIR T	D NOx	D NO2	D NO3	D NH4	DIN	tot dis N	DON
	%	(C)	(C)	(um/l as N)	(um/l as N)	(um/l as N)	(um/l as N)	(um/l as N)	(um/l as N)	(um/l as N)
1-Oct-90	96.56	18.5	19.5							
15-Oct-90	83.01	19	21	29.28	0.26	29.02	0.52	29.8	122.889	93.089
29-Oct-90										
13-Nov-90	81.72	3	-1	46.2	0.92	45.28	48.84	95.04	175.6	80.56
25-Nov-90	93.73	8	14	64.23	3.9	60.33	131.16	195.39	244.24	48.85
10-Dec-90	89.65	4	9	50.64	0.1	50.54	26.22	76.86	145.59	68.73
6-Jan-91	95.84	3	4	53.55	0.24	53.31	72.32	125.87	220.94	95.07
20-Jan-91	99.79	2	6	49.23	0.38	48.85	38.25	87.48	157.221	69.741
4-Feb-91	96.13	4	14	157.52	0.15	157.37	0.49	158.01	200.621	42.611
17-Feb-91	98.15	0	0	45.26	0.33	44.93	50.88	96.14	140.636	44.496
4-Mar-91	102.50	6.5	8.5	38.4	0.14	38.26	11.31	49.71	153.186	103.476
17-Mar-91	104.62	7	10.5	50.45	1.55	48.9	26.91	77.36	168.846	91.486
1-Apr-91	96.38	7	8.5	51.45	0.27	51.18	25.7	77.15	137.373	60.223
15-Apr-91										
29-Apr-91	80.20	13	16	72.02	0.33	71.69	12.23	84.25	101.936	17.686
12-May-91	89.26	18	29	65.2	0.26	64.94	23.34	88.54	178.006	89.466
28-May-91										
9-Jun-91	107.23	26	30	109.35	0.05	109.26	1.14	110.49	216.202	105.712
22-Jun-91	93.84	23	19	80.49	0.05	80.4	1.14	81.63	190.432	108.802
8-Jul-91	99.77	27	26	105.12	0.05	105.03	0.69	105.81	202.51	96.7
22-Jul-91	140.55	27	29	87.15	0.21	86.94	20.58	107.73	161.65	53.92
5-Aug-91	110.75	23	27	106.83	0.21	106.62	0.93	107.76	208.693	100.933
# samples	19	19	19	18	18	18	18	18	18	18
mean	97.88	12.58	15.26	70.13	0.52	69.60	27.37	97.50	173.70	76.20
st dev	13.19	9.55	9.94	32.45	0.92	32.62	33.17	36.96	37.49	26.50

BLACKSTONE/BLACK.,MA

DATE	DIP	tot dis P	DOP	PART PHOS	TOT P	Cr	Ni	Cu	Pb	Cd
	(um/l as P)	(um/l as P)	(um/l as P)	(um/l as P)	(UM/L AS P)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
1-Oct-90				5.90	5.9	1.7	12.2	13.1	4.9	0.46
15-Oct-90	1.61	3.644	2.034	6.55	10.194	4.2	8.6	20.6	9.6	1.13
29-Oct-90										
13-Nov-90	1.48	3.26	1.78	3.75	7.01	1.9	4.4	10.8	3.6	0.67
25-Nov-90	2.88	6.82	3.94	5.03	11.85	2.8	9.8	24.5		3.88
10-Dec-90	0.99	2.698	1.708	6.46	9.158	1.7	4.2	7.8	3.3	0.47
6-Jan-91	2.64	3.998	1.358	4.62	8.618	3.1	5.5	9.9	5.5	0.53
20-Jan-91	1.26	3.147	1.887	4.52	7.667	2.2	6.7	8.3	4	0.49
4-Feb-91	1.38	3.197	1.817	6.55	9.747					
17-Feb-91	1.39	2.11	0.72	2.97	5.08	1.7	4.2	7.5	3.5	0.52
4-Mar-91	0.22	2.68	2.46	4.73	7.41	4	3.9	11.6	6.2	0.55
17-Mar-91	0.78	1.89	1.11	2.18	4.07	1.2	4.9	6.5	2.3	0.41
1-Apr-91	0.99	4.16	3.17	2.88	7.04	6	3.8	9.6	3.1	0.76
15-Apr-91										
29-Apr-91	1.6	2.23	0.63	3.38	5.61	2.8	6.3	9.8	4.8	0.64
12-May-91	1.11	2.81	1.7	3.42	6.23	3.5	5.4	11.5	5.8	0.72
28-May-91										
9-Jun-91	2.79	7.703	4.913	2.48	10.183	2.2	6.8	9.9	5.3	3.49
22-Jun-91	3.78	7.883	4.103	2.19	10.073	1.9	7.4	10.6	5.3	0.54
8-Jul-91	5.97	10.305	4.335	4.07	14.375	2.5	7.3	9.7	4.6	0.5
22-Jul-91	9.84	11.655	1.815	3.47	15.125	1.5	7.6	8.3	1.6	0.36
5-Aug-91	6.81	8.88	2.07	3.85	12.73	2.6	11.8	11.8	5.4	0.46
# samples	18	18	18	19	19	18	18	18	17	18
mean	2.64	4.95	2.31	4.16	8.85	2.64	6.71	11.21	4.64	0.92
st dev	2.51	3.08	1.26	1.43	3.10	1.19	2.56	4.50	1.81	1.02

BLACKSTONE/BLACK.,MA

DATE	Ca	Mg	hardness
	(mg/l)	(mg/l)	calc
			(mg/l CaCO3)
1-Oct-90	11.5	2.30	38.2
15-Oct-90	4.3	2.00	19.0
29-Oct-90			
13-Nov-90	4.0	1.70	17.0
25-Nov-90	8.0	2.20	29.0
10-Dec-90	5.6	2.00	22.2
6-Jan-91	6.0	2.00	23.2
20-Jan-91	6.0	2.00	23.2
4-Feb-91			
17-Feb-91	8.0	2.00	28.2
4-Mar-91	5.5	1.80	21.1
17-Mar-91	9.6	2.30	33.4
1-Apr-91	8.1	2.20	29.3
15-Apr-91			
29-Apr-91	9.4	2.10	32.1
12-May-91	9.8	2.00	32.7
28-May-91			
9-Jun-91	13.3	2.72	44.4
22-Jun-91	13.4	2.51	43.8
8-Jul-91	14.3	2.83	47.4
22-Jul-91	14.8	2.96	49.1
5-Aug-91	13.5	2.60	44.4
# samples	18	18	18
mean	9.17	2.23	32.10
st dev	3.58	0.36	10.32

MOSHASSUCK/USGS GAGE

DATE	RAINFALL AT GREENE AIRPORT (INCHES)	cumulative rain 5 day inches	MOSH. FLOW AT GAUGE (CFS)	MOSH. FLOW AT MOUTH * (CFS)	TIME	pH (su) kit	DO 1 (mg/l)	DO 2 (mg/l)	DO AVG (mg/l)
1-Oct-90	0.01	0.05	9.7	9.9	8:00		6.4	6.2	6.3
15-Oct-90	0.00	2.60	46.0	46.8	7:34		8.6	8	8.3
29-Oct-90	0.00	0.35	27.0	27.5	8:00		9.4	9.2	9.3
13-Nov-90	0.00	1.12	33.0	33.6	7:25		11.1	11.5	11.3
26-Nov-90	0.00	0.19	20.0	20.3	7:30		11	10.8	10.9
10-Dec-90	0.00	0.31	30.0	30.5	7:30		12	11.2	11.6
7-Jan-91	0.00	0.10	29.0	29.5	7:25		11.8	11.2	11.5
23-Jan-91	0.00	0.11	36.0	36.6	7:05		8.6	8.8	8.7
4-Feb-91	0.00	0.20	29.0	29.5	7:30		11.2	11.2	11.2
19-Feb-91	0.42	0.51	42.0	42.7	7:30		11.8	12	11.9
4-Mar-91	0.85	2.00	197.0	200.4	7:30		11.2	11	11.1
18-Mar-91	1.26	1.84	77.0	78.3	7:30	7.05	12.4	12	12.2
1-Apr-91	t	0.36	50.0	50.9	11:30	7.20	10.4	10.8	10.6
15-Apr-91	0.26	0.36	39.0	39.7	7:30	7.05	9.6	9.6	9.6
29-Apr-91	0.00	0.00	37.0	37.6	7:30	7.05	9	9	9
13-May-91	0.00	0.66	33.0	33.6	7:25	7.20	7.7	7.5	7.6
28-May-91	0.02	0.05	21.0	21.4	7:45	7.15	7	6.8	6.9
10-Jun-91	0.00	0.00	16.0	16.3	7:30	7.10	7	7	7
24-Jun-91	0.00	0.02	9.2	9.4	7:30	7.15	7.7	7.1	7.4
8-Jul-91	0.00	0.11	13.0	13.2	7:25	7.30	6.2	6	6.1
22-Jul-91	0.00	0.00	5.5	5.6	7:30	7.40	6	5.8	5.9
5-Aug-91	0.00	0.86	9.9	10.1	7:30	7.25	7.2	6.8	7
20-Aug-91	0.14	2.67	93.0	94.6	7:30	7.50	6.8	6.6	6.7
# samples	22	23	23	23		12	46		23
mean	0.13	0.63	39.2	39.9		7.2	9.0		9.0
st dev	0.32	0.84	40.2	40.9		0.1	2.1		2.1

MOSHASSUCK/USGS GAGE

DATE	DO SAT (mg/l)	% SAT %	WATER T (C)	AIR T (C)	TSS (mg/l)	D NOx (um/l as N)	D NO2 (um/l as N)	D NO3 (um/l as N)	D NH4 (um/l as N)	DIN (um/l as N)
1-Oct-90	10.08	62.5	15	12.5						
15-Oct-90	9.47	87.7	18	16		16.42	0.28	16.14	0.3	16.72
29-Oct-90	11.84	78.5	8	7	1.3	29.52	0.78	28.74	0.44	29.96
13-Nov-90	12.77	88.5	5	-4	2.0	28.62	0.56	28.06	4.59	33.21
26-Nov-90	12.45	87.6	6	5		39.54	0.87	38.67	8.29	47.83
10-Dec-90	13.11	88.5	4	6		33.85	0.9	32.95	1.03	34.88
7-Jan-91	12.45	92.4	6	0	2.3	54.6	0.75	53.85	6.37	60.97
23-Jan-91	14.62	59.5	0	-14	2.4	57.3	0.71	56.59	5.3	62.6
4-Feb-91	12.14	92.3	7	5	1.3	58.02	0.79	57.23	9.06	67.08
19-Feb-91	13.11	90.8	4	2	6.8	57.78	0.94	56.84	14.6	72.38
4-Mar-91	12.45	89.2	6	5	2.1	30.99	0.48	30.51	5.26	36.25
18-Mar-91	12.77	95.5	5	5	2.2	46.52	0.73	45.79	0.29	46.81
1-Apr-91	13.11	80.9	4	7	2.6	54.37	0.77	53.6	2.65	57.02
15-Apr-91	11.29	85.0	10	4	2.2	43.78	1.02	42.76	5.27	49.05
29-Apr-91	9.87	91.2	16	8	3.0	33.13	0.56	32.57	0.59	33.72
13-May-91	9.87	77.0	16	18	1.7	31.43	1.04	30.39	9.81	41.24
28-May-91	9.47	72.9	18	19	11.1					
10-Jun-91	9.66	72.4	17	16	2.2	41.04	2.19	38.85	13.77	54.81
24-Jun-91	10.08	73.4	15	15	1.5	49.62	2.67	46.95	27.51	77.13
8-Jul-91	9.47	64.4	18	20	2.2	45.93	0.72	45.21	0.45	46.38
22-Jul-91	8.92	66.2	21	25	1.9	38.7	0.9	37.8	0.15	38.85
5-Aug-91	9.28	75.5	19	18	2.2	33.33	1.83	31.5	0.21	33.54
20-Aug-91	9.09	73.7	20	17	1.4					
# samples	23	23	23	23	19	20	20	20	20	20
mean	11.19	80.2	11	9	2.8	41.22	0.97	40.25	5.80	47.02
st dev	1.71	10.7	7	9	2.3	11.69	0.59	11.59	6.84	15.69

MOSHASSUCK/USGS GAGE

DATE	tot dis N	DON	TKN	DIP	tot dis P	DOP	PART PHOS	TOT P	Total Ca	Total Mg
	(um/l as N)	(um/l as N)	(um/l as N)	(um/l as P)	(um/l as P)	(um/l as P)	(um/l as P)	(um/l as P)	mg/l as Ca	mg/l as Mg
1-Oct-90									24	5.9
15-Oct-90	61.649	44.929		0.08	0.999	0.919	3.26	4.26	15	4.5
29-Oct-90	77.299	47.339		0.08	0.381	0.301	2.05	2.43		
13-Nov-90	57.500	24.290		0.14	0.620	0.480	1.89	2.51	14.5	4
26-Nov-90	69.180	21.350		0.18	0.560	0.380	4.25	4.81	17	5
10-Dec-90	67.623	32.743		0.13	0.650	0.520	2.65	3.30	17.5	4.5
7-Jan-91	80.290	19.320		0.19	0.398	0.208	2.63	3.03	15.5	4.9
23-Jan-91	114.831	52.231		0.2	0.647	0.447	2.78	3.43	15	3.2
4-Feb-91	89.801	22.721		0.25	0.367	0.117	2.02	2.39	17.5	4.5
19-Feb-91	134.281	61.901	88.303	0.16	0.457	0.297	2.68	3.14	18.5	6.3
4-Mar-91	43.316	7.066	53.853	0.06	0.4	0.340	5.35	5.75	8.8	2.5
18-Mar-91	44.556	-2.254		0.12	0.18	0.060	1.65	1.83	13.5	3.9
1-Apr-91	122.093	65.073		0.04	0.54	0.500	1.27	1.81	9.1	3.91
15-Apr-91	146.213	97.163		0.1	0.36	0.260	1.62	1.98	20.3	3.76
29-Apr-91	60.106	26.386		0.01	0.09	0.080	1.18	1.27	17.1	3.51
13-May-91	50.476	9.236		0.12	0.97	0.850	1.27	2.24	18.7	4.06
28-May-91	79.476	79.476			0.79	0.790	1.33	2.12	22.5	4.74
10-Jun-91	140.382	85.572		0.3	1.003	0.703	1.06	2.06	23.7	4.38
24-Jun-91	152.612	75.482		0.21	0.453	0.243	1.21	1.66	27.1	5.6
8-Jul-91	104.43	58.050		0.27	1.655	1.385	2.14	3.80	20.1	4.02
22-Jul-91	92.52	53.670		0.21	0.505	0.295	1.04	1.55	26.2	5.71
5-Aug-91	150.983	117.443		0.3	0.98	0.680	0.97	1.95		
20-Aug-91										
# samples	21	21	2	20	21	21	21	21	20	20
mean	92.36	47.58	71.08	0.16	0.62	0.47	2.11	2.73	18.08	4.44
st dev	36.68	31.76	24.36	0.08	0.35	0.32	1.13	1.16	4.98	0.94

MOSHASSUCK/USGS GAGE

DATE	calculated hardness mg CaCO3/L	Cr (ug/l)	Ni (ug/l)	Cu (ug/l)	Pb (ug/l)	Cd (ug/l)
1-Oct-90	84.2	0.5	2.5	3.1	2.1	0.04
15-Oct-90	56.0	0.9	1.5	5.3	7.1	0.04
29-Oct-90						
13-Nov-90	52.7	0.4	2	3.1	2.7	0.04
26-Nov-90	63.0	0.4	1.9	3.4	2.7	0.07
10-Dec-90	62.2	0.7	1.9	3.3	3.3	0.1
7-Jan-91	58.9					
23-Jan-91	50.6	0.8	2	2.6	2.3	0.06
4-Feb-91	62.2	0.5	2.5	4.6	2.2	0.07
19-Feb-91	72.1	0.6	3.8	11.5	9.3	0.28
4-Mar-91	32.3	1.3	3.7	10.6	15.4	0.13
18-Mar-91	49.8	0.3	1.9	2.3	1.9	0.03
1-Apr-91	38.8	0.5	0.7	4.6	2.3	0.06
15-Apr-91	66.2	3.9	1.6	10.1	2.5	0.07
29-Apr-91	57.2	0.4	1.3	3.7	2.9	0.11
13-May-91	63.4	1.5	3	12.8	2.8	0.15
28-May-91	75.7	1	4.8	15.2	10.3	0.29
10-Jun-91	77.2	0.2	2	3.8	1.9	0.03
24-Jun-91	90.7	0.5	3	4.2	4.5	0.11
8-Jul-91	66.7	0.9	5.3	9.1	12.8	0.13
22-Jul-91	88.9	0.5	2.8	5.1	5.6	0.13
5-Aug-91						
20-Aug-91						
# samples	20	19	19	19	19	19
mean	63.45	0.8	2.5	6.2	5.0	0.10
st dev	15.26	0.8	1.2	4.0	4.1	0.07

PAWTUXET/BROAD ST.

DATE	RAINFALL AT GREENE AIRPORT (INCHES)	cumulative rain 5 day inches	PAWTUXET FLOW AT GAUGE (CFS)	PAWTUXET FLOW AT MOUTH * (CFS)	TIME	pH (SU)	DO 1 (mg/l)	DO 2 (mg/l)	DO AVG (mg/l)
1-Oct-90	0.01	0.05	111	128	13:15		2.6	2.85	2.725
15-Oct-90	0.00	2.60	373	431	9:30	6.6	4.2	4.6	4.4
29-Oct-90	0.00	0.35	210	242	9:30	6.3	6.1	5.9	6
13-Nov-90	0.00	1.12	443	511	14:00	NM	10.6	10	10.3
26-Nov-90	0.00	0.19	274	316	9:00	6.6	8.6	8.8	8.7
10-Dec-90	0.00	0.31	461	532	9:30	6.75	10.3	10.6	10.45
6-Jan-91	0.00	0.10	493	569	2:00	6.7	12	12	12
21-Jan-91	0.11	0.15	755	871	10:00	6.7	12.4	12.2	12.3
3-Feb-91	0.00	0.30	415	479	13:00	6.7	11.9	12.1	12
18-Feb-91	0.04	1.01	416	480	13:00	6.75	12.6	12.6	12.6
3-Mar-91	0.61	1.23	438	506	13:15	6.7	9.8	9.7	9.75
18-Mar-91	1.26	1.84	586	676	16:30		11.4	11.2	11.3
1-Apr-91	t	0.36	763	881	16:30	6.7	11.2	11.1	11.15
15-Apr-91	0.26	0.36	345	398	16:15	6.7	9.4	9.3	9.35
29-Apr-91	0.00	0.00	485	560	16:20	6.7	9	9.1	9.05
13-May-91	0.00	0.66	460	531	16:15	6.6	7.4	7.4	7.4
28-May-91	0.02	0.05	205	237		6.7			
10-Jun-91	0.00	0.00	149	172	16:00	6.8	4.6	4.4	4.5
24-Jun-91	0.00	0.02	123	142	16:10	6.6	3.8	3.6	3.7
10-Jul-91	0.00	0.08	126	145	1600	6.7	3.2	3	3.1
21-Jul-91	0.00	0.00	99	114	1410	6.8	2.9	2.8	2.85
5-Aug-91	0.00	0.86	285	329	16:10	6.9	3.7	3.7	3.7
18-Aug-91	0.02	0.04	97	112		6.8			
# samples	22	23	23	23		20	42		21
mean	0.11	0.51	353	407		6.7	8.0		8.0
st dev	0.29	0.67	197	228		0.1	3.5		3.6

PAWTUXET/BROAD ST.

DATE	DO SAT	% SAT	H2O T	AIR T	TSS	D NOx	D NO2	D NO3	D NH4	DIN
	(mg/l)	%	(C)	(C)	(mg/l)	(um/l as N)	(um/l as N)	(um/l as N)	(um/l as N)	(um/l as N)
1-Oct-90	9.1	30.0	20	24						
15-Oct-90	9.1	48.4	20	18		44.7	0.28	44.42	0.9	45.6
29-Oct-90	11.6	51.9	9	6.5	3.5	81.96	0.28	81.68	85.8	167.76
13-Nov-90	12.4	82.8	6	2.5	3.8	39.54	2.15	37.39	21.36	60.9
26-Nov-90	12.0	72.6	7.5	5	1.25	64.56	4.55	60.01	72.48	137.04
10-Dec-90	12.4	84.0	6	6	3.8	41.22	0.17	41.05	53.22	94.44
6-Jan-91	12.9	92.7	4.5	5	2.75	44.58	3.44	41.14	56.16	100.74
21-Jan-91	13.5	91.4	3	-1	2.25	35.6	0.83	34.77	5.84	41.44
3-Feb-91	12.8	94.0	5	14	1.8	40.49	1.03	39.46	36.56	77.05
18-Feb-91	13.5	93.6	3	2	2.1	38.45	0.48	37.97	59.84	98.29
3-Mar-91	11.0	88.4	11	16	3.7	45.4	0.86	44.54	70.84	116.24
18-Mar-91	12.1	93.1	7	8	2.5	36.73	0.82	35.91	68.36	105.09
1-Apr-91	11.8	94.1	8	8	2.6	27.75	0.27	27.48	26.1	53.85
15-Apr-91	11.0	84.8	11	11	1.6	51.28	0.3	50.98	73.8	125.08
29-Apr-91	10.1	89.7	15	16	7.7	38.17	0.43	37.74	60.24	98.41
13-May-91	9.1	81.4	20	21	5.8	39.37	2.27	37.1	78.98	118.35
28-May-91					2.8					
10-Jun-91	8.7	51.5	22	27	4.3	77.82	1.17	76.65	166.29	244.11
24-Jun-91	8.7	42.3	22	27	1.2	128.01	0.75	127.26	185.61	313.62
10-Jul-91	8.4	36.8	24	29	0.2	165.42	0.54	164.88	133.71	299.13
21-Jul-91	8.0	35.8	27	28	0.5	147.72	4.14	143.58	189.81	337.53
5-Aug-91	8.6	43.1	23	25	0.5	94.39	8.73	85.66	36.72	131.11
18-Aug-91					2.4					
# samples	21	21	21	21	21	20	20	20	20	20
mean	10.8	70.6	13.0	14.2	2.7	64.16	1.67	62.48	74.13	138.29
st dev	1.9	23.6	8.0	9.8	1.8	40.10	2.12	39.59	54.84	89.43

PAWTUXET/BROAD ST.

DATE	tot dis N	DON	TKN	DIP	tot dis P	DOP	PART PHOS	TOT P
	(um/l as N)	(um/l as N)	(um/l as N)	(um/l as P)	(um/l as P)	(um/l as P)	(um/l as P)	(UM/L AS P)
1-Oct-90							5.10	5.1
15-Oct-90	212.099	166.499		1.65	4.481	2.831	4.27	8.751
29-Oct-90	110.919	-56.841		5.82	3.821	-1.999	4.53	8.351
13-Nov-90	128.93	68.03		2.49	5.89	3.4	4.42	10.31
26-Nov-90	198.5	61.46		5.54	8.83	3.29	5.79	14.62
10-Dec-90	173.25	78.81		2.38	4.388	2.008	5.00	9.388
6-Jan-91	144.13	43.39		3.91	3.588	-0.322	5.98	9.568
21-Jan-91	107.29	65.85		0.6	1.878	1.278	3.58	5.458
3-Feb-91	162.811	85.761		1.41	3.537	2.127	3.05	6.587
18-Feb-91	161.811	63.521	123.243	1.51	3.477	1.967	3.77	7.247
3-Mar-91	187.366	71.126	197.693	1.27	3.44	2.17	4.28	7.72
18-Mar-91	225.706	120.616	131.593	1.88	4.81	2.93	4.65	9.46
1-Apr-91	152.583	98.733		1.7	3.85	2.15	4.62	8.47
15-Apr-91	165.203	40.123		4.89	7.79	2.9	4.15	11.94
29-Apr-91	294.153	195.743		4.78	6.75	1.97	4.23	10.98
13-May-91	159.806	41.456		3.34	6.95	3.61	4.42	11.37
28-May-91								
10-Jun-91	346.232	102.122		13.53	17.723	4.193	2.97	20.693
24-Jun-91	381.742	68.122		18.99	22.403	3.413	3.52	25.923
10-Jul-91	491.21	192.08		18.3	23.395	5.095	2.21	25.605
21-Jul-91	527.27	189.74		20.22	29.615	9.395	2.03	31.645
5-Aug-91	222.763	91.653		5.61	9.28	3.67	1.77	11.05
18-Aug-91								
# samples	20	20	3	20	20	20	21	21
mean	227.69	89.40	150.84	5.99	8.79	2.80	4.02	12.39
st dev	120.24	61.00	40.79	6.35	7.92	2.19	1.13	7.30

PAWTUXET/BROAD ST.

DATE	Total Ca (mg/l)	Total Mg (mg/l)	Hardness (mg/l CaCO3)	Cr (ug/l)	Ni (ug/l)	Cu (ug/l)	Pb (ug/l)	Cd (ug/l)
1-Oct-90	13	2.2	41.5	0.6	14.7	8.7	0.8	0.41
15-Oct-90	7.4	2.2	27.5	1	7.7	6.8	4.9	0.22
29-Oct-90	7.6	2.2	28.0	0.7	8.6	7.4	3.2	0.36
13-Nov-90	7.2	1.8	25.4	0.8	5.4	13.1	4.8	0.34
26-Nov-90	6	1.9	22.8	0.6	5.4	5.4	2.4	0.29
10-Dec-90	6	1.4	20.7	0.6	4.1	11.7	2.3	0.27
6-Jan-91	4.3	2	19.0	0.8	4.9	6.4	2.8	0.34
21-Jan-91	4	1.7	17.0	0.5	3.7	6	2.1	0.26
3-Feb-91	6.4	1.6	22.6	0.4	6	4.3	1.2	0.27
18-Feb-91	5.7	1.4	20.0	0.2	4.9	4.5	1.6	0.27
3-Mar-91	5.5	1.7	20.7	0.2	3.5	5.1	1.6	0.28
18-Mar-91	6.2	1.5	21.7	0.3	4.3	4.9	2.3	0.22
1-Apr-91								
15-Apr-91	9.9	1.92	32.6	2.2	9.5	14.6	2.7	0.65
29-Apr-91	8.5	1.62	27.9	1.7	8.6	29.5	5.6	1.31
13-May-91	8.1	1.93	28.2	1.1	8.4	15	3	0.77
28-May-91								
10-Jun-91	16.1	1.78	47.5	0.6	8	24.1	3.2	0.72
24-Jun-91	19.6	1.91	56.8	1.8	12.3	39.9	5.9	1.44
10-Jul-91	17.1	2.71	53.9	1.6	25.4	75.5	7.8	2.29
21-Jul-91	17.7	2.23	53.4	1.2	13.9	30.8	8.4	2.45
5-Aug-91								
18-Aug-91								
# samples	19	19	19	19	19	19	19	19
mean	9.3	1.9	30.9	0.9	8.4	16.5	3.5	0.69
st dev	4.9	0.3	13.0	0.6	5.3	17.7	2.2	0.69

WOONASQUATUCKET/VAL ST.

DATE	RAINFALL AT GREENE AIRPORT (INCHES)	cumulative rain 5 day inches	WOONASQ. FLOW AT GAUGE (CFS)	WOONASQ. FLOW AT MOUTH * (CFS)	TIME	DO 1 (mg/l)	DO 2 (mg/l)	DO AVG (mg/l)	DO SAT (mg/l)
1-Oct-90	0.01	0.05	29	39	17:30	7.6	7.8	7.7	9.5
15-Oct-90	0.00	2.60	140	190	17:30	8	8.2	8.1	9.3
29-Oct-90	0.00	0.35	111	151	17:30	10	10	10	11.6
13-Nov-90	0.00	1.12	92	125	17:30	12	11.8	11.9	13.5
26-Nov-90	0.00	0.19	63	86	17:30	11	11	11	12.1
12-Dec-90	0.00	0.26	83	113	17:00				
6-Jan-91	0.00	0.10	78	106	12:30	11.6	11.8	11.7	13.1
21-Jan-91	0.11	0.15	96	130	10:30	12.0	12.0	12.0	
3-Feb-91	0.00	0.30	75	102	13:30	12.2	11.8	12.00	12.4
18-Feb-91	0.04	1.01	83	113	13:30	15	15.2	15.10	13.5
3-Mar-91	0.61	1.23	94	128	13:30	12.2	11.8	12	10.8
17-Mar-91	0.00	0.58	117	159	12:30	11.4	11.2	11.3	11.8
1-Apr-91	0.00	0.36	110	149	17:15	9	10	9.5	11.8
14-Apr-91	0.00	0.10	70	95	12:30	11	11	11	10.5
28-Apr-91	0.00	0.00	106	144	12:45	11.2	11.4	11.3	10.9
12-May-91	0.00	0.66	85	115	12:30	7.8	8.2	8	9.3
27-May-91	0.03	0.03	54	73	12:30	8.6	8	8.3	8.4
10-Jun-91	0.00	0.00	32	43	17:15	7.9	7.5	7.7	8.4
23-Jun-91	0.01	0.49	19	26	11:15	7.4	8.2	7.8	8.8
8-Jul-91	0.00	0.11	16	22	17:30	8	8	8	8.4
21-Jul-91	0.00	0.00	7	10	11:05	7.6	7.6	7.6	8.0
4-Aug-91	0.79	0.86	22	30	10:30	8.5	8.6	8.55	8.4
18-Aug-91	0.02	0.04	10	14	10:30	8.5	8.5	8.5	8.3
# samples	23	23	23	23		22	22	22	21
mean	0.07	0.46	69	94		9.9	10.0	10.0	10.4
st dev	0.20	0.60	39	53		2.1	2.0	2.1	1.887255

WOONASQUATUCKET/VAL ST.

DATE	% SAT	WATER T	AIR T	TSS	D NOx	D NO2	D NO3	D NH4	tot dis N
	%	(C)	(C)	(mg/l)	(um/l as N)	(um/l as N)	(um/l as N)	(um/l as N)	(um/l as N)
1-Oct-90	81.34	18	16			.			
15-Oct-90	87.32	19	21		0.12	0.18	-0.06	0.63	69.55
29-Oct-90	86.51	9	5	7	0.2	0.23	-0.03	0.58	40.11
13-Nov-90	88.41	3	0	2.2	21.79	1.02	20.77	0.5	57.67
26-Nov-90	90.62	7	6	0.5	23.02	1.87	21.15	6.8	74.44
12-Dec-90		4	4		15.07	0.15	14.92	0.25	65.91
6-Jan-91	89.27	4	6	0.6	33.86	0.16	33.7	13.35	99.63
21-Jan-91			-2	2.9	28.2	0.64	27.56	12.64	97.34
3-Feb-91	96.41	6	15	0.90	40.6	2.3	38.3	5.89	81.47
18-Feb-91	112.18	3	2	1.4	21.3	0.19	21.11	19.33	88.50
3-Mar-91	111.35	12	16	1.3	37.71	0.48	37.23	5.42	5.91
17-Mar-91	95.42	8	12	1	15.12	1.31	13.81	7	66.48
1-Apr-91	80.22	8	4.5	1.3	21.34	0.21	21.13	4.64	68.02
14-Apr-91	104.39	13	12.8	1.2	24.57	0.2	24.37	9.93	78.78
28-Apr-91	103.65	11.5	12	2.2	33.9	0.35	33.55	0.53	67.93
12-May-91	86.24	19	24		36.69	1.6	35.09	1.94	54.78
27-May-91	98.60	24	26	0.2	41.85	2.24	39.61	0.43	88.48
10-Jun-91	91.47	24	28	1	24.69	0.3	24.39	5.58	129.43
23-Jun-91	88.35	21.5	19	0.8	27.84	0.45	27.39	2.49	133.04
8-Jul-91	95.03	24	31	1.4	10.83	0.33	10.5	13.98	88.33
21-Jul-91	95.38	27	34.5	0.9	0.54	0.6	0	2.4	48.21
4-Aug-91	101.57	24	20	1.8	89.68	2.07	87.61	26.19	186.36
18-Aug-91	102.86	25	29	0.2	133.2	0.66	132.54	7.83	236.12
# samples	21	22	23	19	22	22	22	22	22
mean	94.60	14	15	1.5	31.01	0.80	30.21	6.74	87.57
st dev	8.97	8	11	1.5	29.58	0.74	29.33	6.84	49.10

WOONASQUATUCKET/VAL ST.

DATE	DON (um/l as N)	DIP (um/l as P)	tot dis P (um/l as P)	DOP (um/l as P)	PART PHOS (um/l as P)	TOTAL P (um/l as P)	Cr (ug/l)	Ni (ug/l)	Cu (ug/l)
1-Oct-90					2.20		1.1	2.3	2.5
15-Oct-90	68.80	0.71	2.811	2.101	2.18	4.991	0.9	2.9	7.5
29-Oct-90	39.33	0.64	1.011	0.371	2.75	3.761	0.9	2.3	2.4
13-Nov-90	35.38	0.41	1.710	1.300	3.99	5.7	0.6	1.4	2.1
26-Nov-90	44.62	1.9	3.270	1.370	2.47	5.74	0.6	1.8	2.4
12-Dec-90	50.59	0.12	2.250	2.130	2.71	4.96	0.6	1.9	4.6
6-Jan-91	52.42	1.67	2.868	1.198	1.46	4.328	0.6	2.3	2.3
21-Jan-91	56.50	0.87	2.328	1.458	1.17	3.498	0.6	2.2	1.9
3-Feb-91	34.98	0.68	1.987	1.307	2.00	3.987	0.5	2.6	1.5
18-Feb-91	47.87	1.03	2.437	1.407	2.09	4.527	0.5	3.3	6.5
3-Mar-91	-37.22	0.33	0.56	0.230	3.11	3.67	0.6	3.4	3.6
17-Mar-91	44.36	0.17	1.69	1.520	2.85	4.54	0.3	2.3	5
1-Apr-91	42.04	0.17	1.46	1.290	2.58	4.04	4.2	1.6	2.2
14-Apr-91	44.28	0.29	2.63	2.340	2.84	5.47	2.4	1.9	2.5
28-Apr-91	33.50	0.16	1.51	1.350	2.08	3.59	1.8	3.4	10.8
12-May-91	16.15	1.01	1.55	0.540	1.59	3.14	1.3	1.7	3.2
27-May-91	46.20	1.49	0.99	-0.500	2.45	3.44	1.1	1.8	3.1
10-Jun-91	99.16	1.17	3.293	2.123	0.92	4.213	0.4	1.7	2.4
23-Jun-91	102.71	0.93	3.523	2.593	1.02	4.543	0.5	2.4	4.6
8-Jul-91	63.52	0.96	4.015	3.055	1.21	5.225	0.6	2.7	5.7
21-Jul-91	45.27	0.39	1.935	1.545	3.63	5.565	0.7	1.6	2.9
4-Aug-91	70.49	2.07	4.82	2.750	4.51	9.33	1.3	4.1	9.8
18-Aug-91	95.09	2.37	5.76	3.390	2.64	8.4			
# samples	22	22	22	22	23	22	22	22	22
mean	49.82	0.89	2.47	1.58	2.37	4.85	1.0	2.3	4.1
st dev	29.29	0.66	1.27	0.94	0.92	1.52	0.9	0.7	2.6

WOONASQUATUCKET/VAL ST.

DATE	Pb (ug/l)	Cd (ug/l)	Ca (mg/l)	Mg (mg/l)	hardness calculated (mg/l CaCO3)
1-Oct-90	1.5	0.01	10.0	2.40	34.9
15-Oct-90	3.7	0.08	8.2	1.80	27.9
29-Oct-90	2.4	0.07	6.0	1.50	21.2
13-Nov-90	2.1	0.17	5.6	1.70	21.0
26-Nov-90	2.9	0.07	6.0	1.70	22.0
12-Dec-90	1.9	0.06	6.0	1.70	22.0
6-Jan-91	2.8	0.03	6.0	1.50	21.2
21-Jan-91	2	0.06	7.2	2.00	26.2
3-Feb-91	1.9	0.03	6.6	2.50	26.8
18-Feb-91	3.1	0.05	6.8	1.90	24.8
3-Mar-91	2.5	0.04	7.2	1.70	25.0
17-Mar-91	1.6	0.05	7.2	1.60	24.6
1-Apr-91	2	0.08	7.8	2.00	27.7
14-Apr-91	1.8	0.19	9.7	1.95	32.3
28-Apr-91	8.9	0.34	8.0	1.71	27.0
12-May-91	2.3	0.04	8.8	2.00	30.2
27-May-91	2.4	0.08	8.9	2.30	31.7
10-Jun-91	1.5	3.04	11.5	1.64	35.5
23-Jun-91	2.2	0.09	13.3	2.68	44.2
8-Jul-91	3.9	0.09	13.1	2.40	42.6
21-Jul-91	10.1	0.08	17.3	2.61	53.9
4-Aug-91	9.9	0.32	9.9	1.79	32.1
18-Aug-91					
# samples	22	22	22	22	22
mean	3.3	0.23	8.69	1.96	29.75
st dev	2.6	0.63	2.94	0.36	8.43

WOONASQUATUCKET/RT.44

	RAINFALL AT GREENE AIRPORT (INCHES)	cumulative rainfall 5 days inches	WOONASQ. FLOW AT GAUGE (CFS)	WOONASQ. FLOW AT MOUTH * (CFS)	TIME	DO 1 (mg/l)	DO 2 (mg/l)	DO AVG (mg/l)	DO SAT (mg/l)
1-Oct-90	0.01	0.05	29	39	13:00	8.8	8.5	8.65	9.9
15-Oct-90	0.00	2.60	140	190	6:00	7.5	7.6	7.55	9.0
29-Oct-90	0.00	0.35	111	151	6:30	9.4	9.4	9.4	11.0
13-Nov-90	0.00	1.12	92	125					
26-Nov-90	0.00	0.19	63	86	6:30	12.4	12.6	12.5	12.8
10-Dec-90	0.00	0.31	86	117	6:30	10.2	10.4	10.3	13.1
7-Jan-91	0.00	0.10	67	91	11:00	11.2	11.4	11.3	13.1
21-Jan-91	0.11	0.15	96	130					
3-Feb-91	0.00	0.30	75	102	18:00	11.6	11.2	11.4	13.1
19-Feb-91	0.42	0.51	86	117	15:00	12.2	12.2	12.20	13.5
3-Mar-91	0.61	1.23	94	128	15:00	10.6	11	10.8	12.1
17-Mar-91	0.00	0.58	117	159	9:00	11.8	11.8	11.8	13.1
31-Mar-91	0.00	0.43	118	160	8:00	11.2	12	11.6	12.4
14-Apr-91	0.00	0.10	70	95	8:00	9.7	9.4	9.5	11.6
28-Apr-91	0.00	0.00	106	144	7:00	9.4	9.2	9.3	10.8
13-May-91	0.00	0.66	79	107	8:00	8.4	8.6	8.5	9.9
29-May-91	0.00	0.05	45	61	9:00	7.2	7.2	7.2	8.7
10-Jun-91	0.00	0.00	32	43	7:00	6.95	6.85	6.9	9.5
23-Jun-91	0.01	0.49	19	26	9:00	7.6	7.6	7.6	9.1
7-Jul-91	0.08	0.31	19	26	9:00	6.6	6.4	6.5	9.3
28-Jul-91	0.00	1.60	23	31	8:00	6	6.1	6.05	8.9
4-Aug-91	0.79	0.86	22	30	9:00	5.6	5.8	5.7	9.0
20-Aug-91	0.14	2.67	68	92	8:30	7.4	7.6	7.5	8.7
# samples	23	23	23	23		42		21	21
mean	0.37	36.34	85	98		9.2		9.2	10.9
st dev	0.21	0.76	36	49		2.1		2.2	1.8

WOONASQUATUCKET/RT.44

	% SAT	WATER T	AIR T	diss NOX	D NO2	D NO3	D NH4	tot dis N	DON	DIP
	%	(C)	(C)	(um/l as N)	(um/l as N)	(um/l as N)	(um/l as N)	(um/l as N)	(um/l asN)	(um/l as P)
1-Oct-90	87.6	16	15							
15-Oct-90	83.9	20.5	24	17.72	0.67	17.05	0.42	113.39	95.25	2.53
29-Oct-90	85.2	11	5	1.45	0.18	1.27	0.67	57.43	55.31	0.51
13-Nov-90										
26-Nov-90	97.9	5	2	17.56	1.36	16.2	21.97	91.65	52.12	1.11
10-Dec-90	78.6	4	5	16.12	0.15	15.97	0.48	79.45	62.85	0.12
7-Jan-91	86.2	4	7	34.88	0.88	34	15.55	83.10	32.67	1.53
21-Jan-91										
3-Feb-91	87.0	4	6	32.11	0.91	31.2	3.42	116.10	80.57	0.55
19-Feb-91	90.6	3	4	26.29	0.34	25.95	32.66	130.36	71.41	1.42
3-Mar-91	89.0	7	15	22.85	0.44	22.41	11.33	45.06	10.88	0.67
17-Mar-91	90.0	4	9	13.91	0.23	13.68	4.94	50.01	31.16	0.22
31-Mar-91	93.2	6	4	24.45	0.21	24.24	0.63	57.20	32.12	0.12
14-Apr-91	82.2	9	6	24.95	0.24	24.71	1.21	72.07	45.91	0
28-Apr-91	86.3	12	9	13.63	0.75	12.88	5.25	43.19	24.31	0.4
13-May-91	86.1	16	21	16.46	0.36	16.1	13.26	42.18	12.46	0.09
29-May-91	82.3	22	24	23.84	1.73	22.11	25.71	158.82	109.27	0.58
10-Jun-91	72.9	18	14	76.14	0.51	75.63	3.54	157.57	77.89	2.34
23-Jun-91	83.6	20	22	193.23	0.54	192.69	4.86	215.09	17.00	3.63
7-Jul-91	70.1	19	21	70.65	2.4	68.25	5.46	169.53	93.42	9.48
28-Jul-91	67.9	21	18	318.09	2.64	315.45	40.86	679.85	320.90	8.07
4-Aug-91	63.3	20.5	19	63.21	0.57	62.64	11.04	215.52	141.27	6.45
20-Aug-91	85.8	22	19	25.32	1.32	24	18.33	156.27	112.62	0.93
# samples	21	21	21	20	20	20	20	20	20	20
mean	83.3	13	13	51.64	0.82	50.82	11.08	136.69	73.97	2.04
st dev	8.5	7	8	75.18	0.72	74.79	11.61	139.42	68.69	2.78

WOONASQUATUCKET/RT.44

	tot dis P	DOP	PART PHOS	TOT P	Cr	Ni	Cu	Pb	Cd
					(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
	(um/l as P)	(um/l as P)	(um/l as P)	(um/l as P)					
1-Oct-90			2.80	2.80					
15-Oct-90	5.20	2.67	2.82	8.02	0.7	2.4	2.8	1.1	0.05
29-Oct-90	2.32	1.81	2.15	4.47	0.9	2.2	11.4	6	0.38
13-Nov-90									
26-Nov-90	3.08	1.97	2.44	5.52	0.8	1.7	1.9	1.2	0.03
10-Dec-90	2.43	2.31			0.7	1.6	2.9	2	0.06
7-Jan-91	2.05	0.52	2.63	4.68	1	2.3	4.2	3.6	0.08
21-Jan-91									
3-Feb-91	1.48	0.93	3.01	4.49					
19-Feb-91	3.84	2.42	2.53	6.37	0.3	2.8	3.9	1.6	0.08
3-Mar-91	1.66	0.99	2.97	4.63	0.3	3.3	9.6	2.6	0.29
17-Mar-91	1.48	1.26	2.94	4.42	0.3	0.8	4.8	1.2	0.05
31-Mar-91	2.79	2.67	2.25	5.04	0.8	1.7	2.3	1	0.08
14-Apr-91	2.95	2.95	2.45	5.40	2.5	1.8	9.6	2.6	0.15
28-Apr-91	1.19	0.79	1.39	2.58	1.1	2	4.1	2.2	0.11
13-May-91	0.94	0.85	2.45	3.39	1.1	0.9	2.7	0.8	0.05
29-May-91	3.89	3.31	1.52	5.41	0.9	1.9	4.8	0.9	0.14
10-Jun-91	5.14	2.80	0.78	5.92	0.6	1.7	5.1	1.2	0.11
23-Jun-91	5.90	2.27	0.80	6.70	0.9	5.1		1.8	0.13
7-Jul-91	13.69	4.21	0.95	14.64	0.9	3.5	7.4	1.1	0.15
28-Jul-91	11.22	3.15	2.44	13.66	0.9	3.6	5.5	1.2	0.14
4-Aug-91	10.70	4.25	1.99	12.69	0.7	3.3	5.2	0.7	0.05
20-Aug-91	4.33	3.40	0.92	5.25					
# samples	20	20	20	20	18	18	17	18	18
mean	4.31	2.28	2.11	6.30	0.9	2.4	5.2	1.8	0.1
st dev	3.58	1.12	0.77	3.42	0.5	1.1	2.8	1.3	0.1

WOONASQUATUCKET/RT.44

	Ca	Mg	hardness
			calculated
	(mg/l)	(mg/l)	(mg/l CaCo3)
1-Oct-90			
15-Oct-90	6.2	1.80	22.9
29-Oct-90	4.6	1.60	18.1
13-Nov-90			0.0
26-Nov-90	4.1	2.00	18.5
10-Dec-90	4.3	2.00	19.0
7-Jan-91	3.9	2.00	18.0
21-Jan-91			0.0
3-Feb-91	6.0	1.50	21.2
19-Feb-91	5.4	1.60	20.1
3-Mar-91	5.3	1.20	18.2
17-Mar-91	5.2	1.10	17.5
31-Mar-91	6.4	1.19	20.9
14-Apr-91	6.8	1.51	23.2
28-Apr-91	6.8	1.56	23.4
13-May-91	5.5	1.77	21.0
29-May-91	7.9	1.36	25.3
10-Jun-91	7.9	2.08	28.3
23-Jun-91	8.9	1.99	30.4
7-Jul-91	8.8	2.01	30.3
28-Jul-91	9.1	1.57	29.2
4-Aug-91	8.7	1.28	27.0
20-Aug-91			
# samples	19	19	21
mean	6.4	1.64	20.6
st dev	1.7	0.32	8.0

APPENDIX B

River Rescue Laboratory Methods

ANALYTICAL METHODS

Petroleum Hydrocarbons[1]

Samples were collected at each site in a 2 liter teflon bucket. The sample was poured into two 4 liter amber glass bottles (3.6 liters of sample in each bottle) each bottle containing approximately 7 mL of methylene chloride which acted as a preservative to retard bacterial activity.

The samples were returned to the laboratory within 15 hours of collection and 50 uL of an internal standard solution in solvent was added to each bottle. Next a 10% volume of 360 mL of methylene chloride was added to each bottle which was then shaken for one minute and allowed to settle over night. After settling, the aqueous portion of each bottle was decanted off and the sample extracts were combined in a separatory funnel. The methylene chloride extract was then collected in a round bottom flask and was evaporated down to about 1 to 2 mL. This solvent was then exchanged into hexane and again evaporated down to about 1 to 2 mL.

The compounds isolated in the extracts were separated into two fractions by silica gel micro- column chromatography. In this operation, the sample extract was charged onto a 0.5 x 10 cm column of fully activated silica gel (Grace grade 922, mesh size; 200 - 325). The first fraction (F1) was eluted with 15 mL of 98:2, hexane:methylene chloride and the second fraction (F2) was eluted with 15 mL of 80:20, hexane:methylene chloride, and archived for future analysis.

The F1 fraction was concentrated on a rotary evaporator (<30 °C) then analyzed on a Hewlett Packard 5890 gas chromatograph (GC) utilizing the spitless injection option and equipped with a 250 um i.d. x 30 m fused silica column (0.25 um film thickness DB-5, J&W Scientific); with helium as the carrier gas, (flow rate - 1 mL/min), the column was heated from 100 to 310 °C at 8 °C/min. The temperature was then maintained at 310 °C for 29 minutes. The injection port and the detector were kept at 300 and 310 °C respectively.

Fraction one (F1) contains non - aromatic hydrocarbons including aliphatic constituents: normal, branched, isoprenoid, cyclic, and cyclic - branched, of both petroleum and non - petroleum origin.

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[1] text taken from Latimer, James S., S. A. Cormier and J. G. Quinn. 1992. *Non-Aromatic Petroleum and Natural Hydrocarbons Entering Narragansett Bay from Four Tributaries Under Dry Weather Conditions.* Final Report to the River Rescue Program.

Metals

All polyethylene bottles and accessories used in the analysis of trace metals are pre-soaked for three 48 hour periods in a 3 % nitric acid solution and then rinsed with deionized water. The polycarbonate filters are soaked in 3 % nitric acid for 10 days and tested for contamination by filtering in deionized water.

HNO3 (Baker-Ultrex II) is added to the bottles containing the total trace metals samples. The acid volume is sufficient to leach the trace metals from the particulate phase (one week) and keep the trace metals from adsorbing to surfaces or complexing. Cadmium, chromium, copper, lead, and nickel are analyzed in duplicate samples directly using the Perkin-Elmer 5100 PC atomic absorption spectrophotometer (AAS) equipped with a HGA Graphite Furnace. Analyses for magnesium and calcium are performed on a Perkin-Elmer model 3030 B flame atomic absorption spectrophotometer. Quantification is based upon calibration curves of standard solutions of metals made up in the approximate acid proportions to the samples. The calibration curves will be plotted and all concentrations will be calculated by Perkin-Elmer analytical software.

The Perkin-Elmer AAS, 5100 PC is equipped with a Zeeman/500 system designed to provide the graphite furnace with background correction. Such systems will enhance measurement sensitivity by reducing any interferences in the sample background.

LIMITS OF DETECTION

METALS

Cadmium	0.05 ug/L
Chromium	0.2 ug/L
Copper	0.2 ug/L
Lead	0.2 ug/L
Nickel	0.2 ug/L
Magnesium	0.05 mg/L
Calcium	0.05 mg/L

RIVER RESCUE
SUMMARY OF ANALYTICAL METHODS
NUTRIENTS AND CONVENTIONAL PARAMETERS

PARAMETER	METHOD	INSTRUMENT DETECTION LIMITS
DISSOLVED OXYGEN	Azide modification, Winkler method LaMotte Chemical Direct Reading Titrator Performed in field by volunteers	0.2 mg/l
HARDNESS (kit)	EDTA Titration LaMotte Chemical Direct Reading Titrator	4 mg/l
pH	Bromthymol Blue color reading by eye HACH Wide Range pH test kit	pH 5.5-8.5 0.1 pH units
TSS	Filtration thru pre-weighed glass fiber filter. Standard Method* number 2540 D.	
NH3	Phenate Method EPA Method** 350.1	0.05 umoles/L
NO2+NO3	Colorimetric Method EPA Method** 353.2	0.07 umoles/L
PO4	EPA Method** 365.3	0.02 umoles/L
DON	Persulfate digestion***	0.07 umoles/L
DOP	Persulfate digestion***	0.06 umoles/L
Partic. P	Solorzano and Sharp****, 1980	

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* APHA, AWWA, WPCF, 1989. Standard Methods for the Examination of Water and Wastewater, Seventeenth Edition. American Public Health Association Washington, DC.

** EPA Methods for the Chemical Analysis of Water and Wastes, 1983. EPA-600/4-79-020

*** Valderrama, J.C., 1981. The simultaneous analysis of total nitrogen and total phosphorus in natural waters. Mar. Chem. 10:109-122.

**** Solorzano, L., and J. Sharp, 1980. Determination of total dissolved phosphorus and particulate phosphorus in natural waters. Limnol. Oceanogr. 25(4):754-758.

Dissolved Inorganic Phosphorous and Nitrogen

Filtered river water samples of 50ml are collected and preserved with chloroform. These are kept refrigerated until they can be analyzed for nitrate, nitrite, phosphate, and ammonium on a Lachat Model 80 Flow Injection Ion Analyzer. Ammonium is determined by the phenate method (EPA 350.1). Nitrate and nitrite are determined using the colorimetric method of EPA 353.2. This follows the reduction of nitrate to nitrite with cadmium. Phosphorous is determined using the ascorbic acid reduction method of EPA 365.3. Automated regression of standard curves and integration of sample peaks yield concentration output directly.

Dissolved Organic Nitrogen and Phosphorous

River Rescue uses a method adapted from Valderrama (1981) to determine total dissolved nitrogen and phosphorous. Dissolved organic N and P are calculated by subtracting the dissolved inorganic fraction from the total. N and P are determined simultaneously in this method. River water samples are filtered in the field by volunteers using a syringe and filter apparatus. Samples are frozen until they can be prepared and analyzed. Preparation includes dilution and persulfate oxidation in a boric acid--sodium hydroxide system. Dilution of the river water is necessary due to high concentrations of N . Samples are then analyzed for nitrate plus nitrite and phosphate according to the EPA methods 353.2 and 365.3 on a Lachat Model 80 FIA. Calculations are based on inorganic standard curves and an assumed 100 percent recovery.

Particulate Phosphorous

Volunteers filter two 50ml aliquots of river water. The filtrate is collected for DIN/DON and DON/DOP determinations. The filters are placed in acid-washed, precombusted vials and frozen until they are analyzed for particulate phosphorous. The method used follows that given by Solorzano and Sharp (1980). The filters are dried with magnesium sulfate and baked at 450C to decompose the organic P. The residue is then hydrolyzed with hot HCl. The resulting orthophosphate is determined using the molybdate--ascorbic acid method as in Standard Method 4500-P E. Absorbances are read at 885 nm on a spectrophotometer and are then converted to concentrations using a calibration curve. Final values are corrected for P contributed by blanks and for the volume of water filtered.

References

APHA, AWWA, WPCF, 1989. Standard Methods for the Examination of Water and Wastewater, seventeenth edition. American Public Health Association, Washington D.C.

EPA Methods for the Chemical Analysis of Water and Wastes, 1983. EPA-600/4-79-020.

Solorzano, L. and J. Sharp, 1980. Determination of total dissolved phosphorous and particulate phosphorous in natural waters. Limnology and Oceanography, 25(4):754-758.

Valderrama, J.C. 1981. The simultaneous analysis of total nitrogen and total phosphorous in natural waters. Marine Chemistry, 10:109-122.

Total Suspended Solids

April 1992

Volunteers collect two 500 ml grab samples of whole river water for determination of total suspended solids. These should be kept refrigerated and analyzed within a seek or so of collection. This is a simple test thast does not take very long.

1. Preweigh one 47mm Gelman A/E glass fiber filter for each station on the analytical balance in room 108. Record this weight to the nearest .0001g. You can identify the filters by placing them in numbered aluminum pans.

2. Using a pump, filter flask, and funnel, filter approximately 1L of river water through each preweighed filter. The volume must be known exactly so use a one liter graduated cylinder and record the vlume to the nearest 1 ml. Rinse cylinder and filter apparatus between samples.

3. Place filters in numbered aluminum pans. Know which number corresponds to which sample. Put pans in a 60°C oven to dry over night. There is an oven upstairs and one downstairs that can be used for this purpose.

4. Weigh the filters the next day. Calculate the TSS in mg/L.
   TSS = (mass final - mass initial) / volume in liters * 1000

5. Rinse and recycle sample bottles. Discard filters. Save aluminum pans to use again.

APPENDIX C

River Rescue Field Methods Manual

SAFETY FIRST!

GENERAL PRECAUTIONS

1. River Rescue volunteers must attend a training session before they can begin sampling.

2. Try to sample with a partner. This allows one person to do the titrations while the other person is collecting samples.

3. Be familiar with your instructions and procedures before going out in the field. Prepare bottle labels and filter apparatus at home before you go into the field.

4. Keep all equipment and reagent chemicals out of the way of small children. These chemicals are poison!

5. Call Poison Control if you have an accident or a suspected poisoning:

   In Rhode Island, call 277-5727

   In Massachusetts call 1-800-682-9211

USE PROPER ANALYTICAL TECHNIQUE

1. Avoid contact between reagent chemicals and shin, eyes, nose and mouth.

2. Use caps or stoppers, not your fingers while handling reagent chemicals.

3. Hold squeeze bottles upside down, not at an angle, when dispensing reagents.

4. Wipe up spills when they occur. In the field, wash spills with a bucket of water if they are on the ground.

5. Tightly close all reagent containers immediately after use.

6. Protect equipment and reagents from prolonged exposure to direct sunlight, and extreme temperatures.

7. Be careful when handling river water. These rivers are polluted. Wear gloves if you wish, or wash your hands carefully (with full lather) after you are done.

PREPARING FOR SAMPLING

WHILE YOU ARE STILL AT HOME

1. Collect the sample bottles you will need for the day's sampling:

    1 *DIN/DIP bottle*. These bottles are labeled DIN/DIP and are seemingly empty. Actually 4 drops of chloroform have been added to the bottle. Do not open the bottles until you are ready to add sample.

    1 *DON/DOP bottle*. These bottles are labeled DON/DOP and are full of distilled water. You should empty the bottle at the sampling site.

    2 *Particulate Phosphorus vials*. These are small glass vials labeled PP. Again, these bottles have been carefully prepared. Do not open the bottles until you are ready to put the filter in them.

    1 *Metals bottle*. These bottles come in various shapes and sizes. They are always labeled "metals".

    2 *TSS bottles*. These are large bottles (500 ml). They will be labeled TSS.

2. Label all the sample bottles. USE AN INDELIBLE MARKER, NOT PEN!!!! Some of the label will be filled out, but be sure that the following information is included:

    Sampling date and time
    Your name
    Station name (River and number)
    Type of sample

3. Fill out the data sheet with your name and the date.

4. Load filters into two filterheads. Do not touch the filters with your fingers. Do not touch the filtering surface of the filterhead with your fingers.

5. Gather your equipment. You will need:

- Cooler with ice
- sampling instructions
- data sheet and pencil
- sampling bucket and rope
- DO kit
- pH kit
- Hardness kit
- thermometer
- syringe
- two loaded filterheads
- forceps
- labeled sample bottles

AT YOUR SAMPLING STATION

1. **Collect the water sample**. Drop the bucket off the bridge, close to the midpoint of the flow of the river. Retrieve the bucket, slosh it around and dump the water back. Repeat the rinse. Lower the bucket a third time and fill it about 2/3 full. Raise the bucket as carefully as possible to avoid mixing the sample and adding oxygen to the water.

2. **Measure the dissolved oxygen**. See attached instructions.

3. **Measure the hardness**. See attached instructions.

4. **Measure the pH**. See attached instructions.

5. **Measure the water temperature**. Place thermometer in the bucket and leave it there for 3 - 5 minutes. Record the temperature to the nearest 0.5 degree on the data sheet.

6. **Measure the air temperature**. Place the thermometer in a safe spot away from the direct sunlight. Wait 3 - 5 minutes and read the temperature. Record to the nearest 0.5 degree on the data sheet.

7. **Collect samples for nutrient analyses.** Be sure to **MIX** the water in the bucket before you collect each sample.

DON/DOP - Fill 60 ml syringe with 50 ml of well mixed water. Turn the syringe upside down and flick out the bubbles. Make sure you still have 50 ml. Put on a filterhead loaded with a filter. Slowly filter the water into the DON/DOP bottle. Filter the entire 50 ml. If some spills or if some water leaks out of the filterhead, mark this on your data sheet. Cap the bottle and place it in the cooler.

DIN/DIP - Repeat the above procedure using the second loaded filterhead. Be sure you are filtering into the bottle labeled for DIN/DIP!!

Particulate P (PP) - Carefully unscrew one of the filter heads. Remove the filter, using your forceps, and fold it into one of the vials. Try to get all the pieces of the filter even if it breaks and some stays stuck to the filterhead. You will have TWO particulate P samples, one from each filterhead.

8. **Collect metals sample.** Pour out the water and collect a new sample. Pour the mixed water into the metals bottle.

9. **Collect the TSS samples.** Pour the water into the two TSS bottles.

BEFORE LEAVING YOUR STATION

1. Complete the data sheet.

2. Rinse the bucket.

3. Put away the reagents and kits.

AT HOME

1. Rinse your equipment. The test vials for the DO, Hardness and pH tests should be rinsed with distilled water. Rinse your syringe with distilled water.

2. Store samples correctly:

    in the freezer: DON/DOP and 2 PP vials

    in the refrigerator: DIN/DIP, metals, TSS

DISSOLVED OXYGEN (DO) TITRATION

NOTE: Duplicate tests are run on each sample to guard against operator error. If the amount of DO in the second test is more than 0.6 ppm different than the first test, you should do a third test. Record the average of the two closest results.

STEP 1. To avoid contamination, thoroughly rinse the water sampling bottle (0688-DO) with the water to be sampled.

STEP 2. Tightly cap the mouth of each bottle, submerge the bottle in the bucket, and remove the cap to allow the bottle to fill.

STEP 3. Tap the sides of the submerged bottle to dislodge any air bubbles clinging to the inside of the bottle. Replace the cap while the bottle is still submerged.

STEP 4. Retrieve the bottle and examine it carefully to make sure that no air bubbles are trapped inside. Once a satisfactory sample has been collected, proceed immediately with Steps 5 and 6.

Note: Be careful not to introduce air into the sample while adding the reagents in steps 5 and 6. Simply drop the reagents onto the test sample, cap carefully, and mix gently.

STEP 5. Add 8 drops of Manganous Sulfate Solution (4167) and 8 drops of Alkaline Potassium Iodide Solution (7166) to the sample. Cap the bottle and mix by inverting it several times. A precipitate will form. Allow the precipitate to settle below the shoulder of the bottle before proceeding.

NOTE: You can proceed with the other tests while waiting for the precipitate to settle.

STEP 6. Using the 1.0 G measuring spoon (0697), add one level measure of Sulfamic Acid Powder (6286) to the two sampling bottles. Cap the bottles and gently shake to mix, until both the reagent and the precipitate have dissolved. A clear-yellow to brown-orange color will develop, depending on the oxygen content of the water (the more oxygen that is in the water, the darker the color will be).

NOTE: Once STEP 6 is completed, contact between the water sample and the atmosphere will not affect the test result. Once the sample has been "fixed" in this manner, it is not necessary to perform the actual test procedure immediately. Thus, several samples can be collected and "fixed" in the field, and then carried back to your home for the final titration. The titration should be completed no longer than 8 hours after the sample has been fixed.

STEP 7. Pour 20 ml of the solution from one of the Sample Bottles into the Glass Test Tube (0299) -- fill to the white line.

STEP 8. Fill the small syringe (0377) to the 0 mark with Standard Sodium Thiosupfate solution (4169).

NOTE: If small air bubbles form in the syringe, expel the bubble by partially filling the syringe and pumping the Sodium Thiosulfate solution into the reagent container. Repeat until the air bubble is expelled.

STEP 9. Titration goes like this: Add 1 drop of Sodium Thiosulfate to the test tube; swirl the test tube to mix. Add another drop of the Sodium Thiosulfate and swirl the tube. Continue this titration process one drop at a time until the yellow-brown solution in the test tube just begins to fade or to get lighter. Then put the remaining Sodium Thiosulfate aside for a moment.

STEP 10. Add 8 drops of Starch Solution (4170-G) to the test tube. Swirl the tube to mix. The solution should turn from light yellow to dark blue.

STEP 11. Continue the titration process (described in STEP 9) with the remaining Sodium Thiosulfate, until the test tube solution turns from blue to clear. Do not add any more Sodium Thiosulfate than is necessary to produce the color change. Be sure to swirl the test tube after each drop.

STEP 12. Using the scale on the side of the syringe, count the total number of units of Sodium Thiosulfate used in the experiment. That number equals the number of parts per million (ppm) or milligrams per liter (mg/l) of oxygen in the water.

STEP 13. Carry out Steps 8-13 on the second sample bottle.

STEP 14. Record the results of the two tests on the data sheet. Calculate the average DO concentration. If the two samples are more that 0.6 mg/l (ppm) apart, do a third measurement.

EVERYTHING YOU EVER WANTED TO KNOW ABOUT THE DISSOLVED OXYGEN TITRATION

1. Be sure the sample bottle is clean and rinsed TWICE with the same water you will test. Check carefully for bubbles.

2. Hold dropper bottles vertically when adding drops of Manganous Sulfate and Alkaline Potassium Iodide solutions. These reagents are added in excess so the precise number of drops is not critical. If you add 9 or 10 drops you do not have to start all over. However, you MUST add the Manganese Sulfate first.

3. The Sulfamic Acid crystals are added in excess so the amount is not critical. You can spill a few grains and not have to start over. The addition of the acid will dissolve the flocculant. If a few grains of acid do not go into solution and all the floc is dissolved, you may continue the titration. You may at times find that organic material or sediment in the water do not dissolve either. This will not affect the test results.

4. The amount of sample to be titrated is CRITICAL. Measure carefully. The bottom of the miniscus should be at on top of the white line on the titration tube.

5. The titration is also extremely CRITICAL. When the DO is above 10 mg/l (as it often is in the winter at these stations), you will have to refill the syringe. For accurate results, fill to the 0 mark and add the amount titrated from the second syringe to the 10 from the first syringe.

6. When and how much Starch Solution is added is not critical. The important thing is that the sample turns blue. Once you have added the starch, titrate very carefully toward the endpoint. Mix the sample well after each drop. It is easy to go past the endpoint.

7. If your second titration is more than 0.6 different than the first, do the titration a third time. Record the average of the closest two measurements.

HARDNESS TITRATION

We will be measuring the TOTAL hardness of the water samples. The hardness of water determines how toxic the metals present in the water are to aquatic species. Softer waters (water with little hardness) are generally more toxic than hard waters. Our water in Rhode Island is generally soft.

1. Thoroughly rinse the titration tube with the water to be tested.
2. Fill the tube to the 12.9 mL line with the water sample.
3. Add 5 drops of Hardness Reagent #5 , cap and mix.
4. Add one Hardness Reagent #6 Tablet and shake tube to dissolve tablet. A red color will develop.
5. Fill the titrator with Hardness Reagent #7. Insert the titrator in the center hole of the titration tube cap.
6. Add the Reagent one drop at a time. Mix well after each drop. You have reached the endpoint when the red color changes to blue. Read your result off the titrator. The units are mg/L CaCO3. Enter the result on your data sheet.
7. Repeat the measurement. Rinse the tube well before filling a second time.

pH MEASUREMENT

The pH indicates how acidic (pH less than 7) or basic (alkaline, pH more than 7) the water sample is. Water dissolves mineral substances, picks up aerosols and dust from the air, receives man-made wastes, and supports photosynthetic organisms, all of which affect pH. The natural pH of water will vary, although the pH of most waters is between 5.0 and 9.0.

River pH will be estimated using the Bromthymol Blue indicator solution. The water will turn yellow, green or blue depending on the pH. The color of the test solution is compared to a color disk, and the pH is read. This test is approximate.

1. Rinse out the two sample tubes with the water to be tested. Then fill the tubes to the 5 mL line with the water to be tested.

2. Add eight drops of the Bromthymol blue indicator solution to one of the tubes. Swirl to mix.

3. Insert the tube of prepared sample into the top right opening of the color comparator (if you have the color wheel in the comparator, this is the opening that does not show any color).

4. Insert the untreated sample into the top left opening of the color comparator (the opening that shows the colors on the color wheel).

5. Hold the comparator up to a light source such as the sky, a window or lamp and view through the openings in front. Rotate the disc to obtain your best color match.

6. Read the pH to the nearest 0.1 unit. Record the number on your data sheet.

APPENDIX D

River Rescue Mapping Results
Year One (October 1990 - August 1991)

River Captain Map Results

During the first year, River Rescue volunteers mapped sections of the Moshassuck, Woonasquatucket and Blackstone Rivers. Volunteers were asked to make note of shoreline characteristics, the type of development along the shoreline, the location of pipes and debris, and the characteristics of the bottom material. The following section summarizes the major results of the mapping efforts. Detailed maps prepared by the volunteers can be obtained from the River Rescue coordinator.

Blackstone River

Volunteers prepared maps of the main stem of the Blackstone River in Millville, Massachusetts and in Rhode Island from Manville to Slater Mill. The results are summarized below.

Millville area - Width 10 - 25 yards, Depth 2-5 feet

Immediate watershed characteristics: Rural, residential

Potential sources of pollution: Brook Rd. drainage culvert near Central Street Bridge, 8 inch drains on west river bank about 1/10 mile downstream of Central Street bridge.

Manville to Albion Dam - Depth 6 feet

Immediate watershed characteristics: wooded, old factories, dump site

Pipes: Four drainage pipes discharge to the river immediately downstream of Manville dam. Three were not discharging, one 40 inch concrete pipe was discharging gray, odorless water. A 1 ft. metal pipe was noted on the west bank of the river about 0.2 miles upstream of Albion Dam. It was not discharging.

Debris: Two dump sites were noted. Just downstream of Manville Dam was an abandoned industrial site. Rubber, plastic refuse from wires was mixed into the soil and stratified along the wall. About 0.2 miles upstream of the Albion Dam a large dump was seen on the eastern shore of the river. This appeared to be an abandoned landfill that was still used for illegal dumping of tires and refuse.

Access sites: West shore of river just upstream of Albion Dam. No access along east side of river, no litter either!

Albion Dam to Ashton Dam -

Immediate watershed: Wooded, residential development on west side near Albion Mill complex.

Debris: Tires at mouth of several tributaries.

Ashton Dam to Lonsdale Ave near Lonsdale -

Immediate shoreline - Wooded, meadows, farming. Sections of the watershed are dense residential and industrial development. Sand and gravel operations along shore or near to shore areas.

Pipes: Six pipes in the vicinity of Rt. 116 bridge. Ten pipes from industrial sites in the Berkeley area (0.2 miles above and below Martin St.).

Dumps: J.M.Mills landfill upstream of Ashland Dam.

Lonsdale Ave to Slater Mill:-

Immediate watershed characteristics: wetland/forest above Broad St., residential/industrial below Broad St.

Pipes: bridge drain on bridge downstream of Lonsdale Ave.
pipe outlet into diversion canal on east bank below Broad St. bridge, no discharge
6 pipes seen on west bank below Broad St., no discharge
11 pipes on east side of river just below RR bridge below Broad St.
pipes on east and west banks at Central Falls Public Works site below Broad St.

Debris: metal debris and machinery in water below Lonsdale Ave.
car dump on west bank downstream of second RR bridge below Broad St.
metal debris along shore near Central Falls Public Works

Woonasquatucket River

Volunteers mapped the lower section of the Woonasquatucket River, from Acorn St. to the mouth at Citizens Plaza.

Acorn St. to Citizens Plaza - width about 40 feet, depth varied

immediate watershed: dense urban, construction from Park St. downstream

Pipes: 3 ft. pipe downstream of I95 overpass, stagnant water in it
large pipes under overpass, runoff from highway
CSO near Bath St., no discharge during dry weather
three pipes on Kinsley Ave side of river between overpass and Bath St.
7 pipes between Pleasant Valley and Bath St., all dry
5 pipes above Pleasant Valley
numerous drainage pipes along wall downstream of Acorn St.

Debris: mattress, shopping carts, lots of tires, road signs

Moshassuck River

Volunteers canoed and walked the Moshassuck River from Butterfly Pond to the mouth. Excessive weed growth was noted as a severe problem in the upper ponds. Barney Pond has been monitored with Watershed Watch and was noted as eutrophic in 1991.

Butterfly Pond to Moffit Mill: width 8 - 15 ft., depth 3-4 ft.

watershed: wooded, residential, road, light industry

water quality problems: Choking weeds on Butterfly Pond in mid-summer

debris: paper, cans and bottles and 1-10 tires

Moffit Mill to Barney's Pond: - width 30 ft (excluding pond), depth 2.5 - 15 ft.

watershed: wooded, residential

water quality problems: vegetation heavy in eastern Barney's Pond in mid-summer

debris: paper, cans/bottles, tires and carts

Lower Barney's Pond to Walker St. - width 10 ft., depth 1 - 10 ft.

watershed: wooded, residential, light industry

water quality problems: choking vegetation in lower Barney's Pond during mid-summer

debris: small trash

Walker St. to Higginson Ave. -

watershed: industrial, railroad

water quality concerns: numerous pipes from industries below Walker St., 5 pipes from Tamatex Chemical Co. building plus green hose dripping into the river, railroad adjacent to river

debris: metal debris below Walker St., Cement blocks, wire spool near Tamatex, tree in river near Collayer, Inc.

Higginson Ave. to Weeden St. -

watershed: industrial, residential, sand pit

water quality concerns: 7 large (12 inch) pipes below Higginson Ave.

debris: below Higginson Ave.

Weeden St. to Grotto Ave. -

watershed: residential, industrial

water quality concerns: pipes from Lorraines and Monet Co.

debris: tires and metal , stove

Mouth of West River to Citizens Bank

watershed: urban, river channelized along most of section

Water quality concerns: storm runoff, numerous drain into river

debris: brush and trash caught on bridges on lower river

APPENDIX E

River Rescue Combined Sewer Overflow Monitoring Results
Year One (October 1990 - August 1991)

Combined Sewer Overflow (CSO) Monitors

River Rescue volunteers were assigned to 11 combined sewer overflow sites in the Providence area. Volunteers were asked to observe the overflow sites on a regular basis and look for discharges of wastewater during dry weather when the CSOs should not be discharging.

The CSO monitoring program was designed in cooperation with the Narragansett Bay Commission (NBC), the agency responsible for the operation of the Providence sewage treatment plant. NBC staff selected the CSOs assigned to volunteers. Sites were selected that were easy and safe to access. It was also important that the discharge site be above the water so the volunteers could see what was discharging from the pipes.

Volunteers had mixed reactions to the CSO monitoring. Several volunteer were regular CSO observers, while others only submitted one report. The CSO data is shown on the following pages.

The following key describes the CSO summary report fields.

CSO	the number assigned to the CSO
DATE	date observations were made
START/FIN	times observations were made
FLOW	Was there a discharge from the CSO? (Y)es or (N)o. Sometimes it was impossible to see if the CSO was flowing because the CSO was covered by tidal waters.
VOL	volume of flow from the CSO. (I)ntermittent, (ST) = slow trickle, (M)oderate, (H)eavy
PPT	precipitation recorded at Greene Airport on the day of observation (day 0) and the three previous days (Days -1, -2, -3)
APPEARANCE	appearance of flow. Sometimes the CSO was not flowing, but water was standing in the pipe or river water washed in the pipe. Observations were made on this water.

RIVER RESCUE CSO DATA

						PPT (INCHES)				
CSO	DATE	START	FIN	FLOW	VOL	DAY 0	- 1	- 2	- 3	APPEARANCE
23	9/22/90	16:20	16:25	Y	ST	1.2	0	0.5	0.9	CLEAR
23	10/8/90	17:25	17:30	Y	M	0	0	0	0	CLEAAR
23	10/9/90	18:30	18:34	N		0.31	0	0	0	
23	10/14/90	11:40	11:45	N	I	1.52	0.71	0.3	0.07	CLEAR
23	10/21/90	15:05	15:08	N		0	0	0.31	0.45	
23	11/11/90	9:35	9:38	Y	M	T	1.12	0	0.13	CLEAR WITH LEAVES
23	11/18/90	13:15	13:17	N		T	T	0	0	CLEAR
23	11/25/90	12:00	12:03	Y	M	0	0.08	0.11	0	CLEAR
23	12/2/90	13:50	13:53	Y	M	0	0	0	0.02	COLORED (GRAY WITH WHITE FLECKS)
23	12/9/90	19:35	19:38	Y	ST	0	0.26	0.05	0	CLEAR
23	12/16/90	10:40	10:44	Y	M	0.17	0.75	0	0	CLEAR
23	12/30/90	13:07	13:09	N	M	T	T	0.37	0	SLIGHTLY COLORED WITH SOLIDS PRESENT
23	1/13/91	13:22	13:27	Y	M					TURBID/CLOUDY
23	1/21/91	16:12	16:17	Y	ST					CLEAR
23	1/27/91	11:50	11:55	Y	ST					CLEAR
23	2/3/91	16:25	16:30	Y	M					CLEAR
23	2/10/91	11:15	11:20	N						CLEAR
23	2/17/91	14:46	14:50	Y	M					TURBID - MURKY
23	3/2/91	14:45	14:50	Y	M					FOAMING, A LITTLE MURKY
25	9/22/90	16:50	15:55	Y	ST	1.2	0	0.5	0.9	COLORED/MURKY
25	10/8/90	17:30	17:35	N		0	0	0	0	NO FLOW
25	10/9/90	18:36	18:38	N		0.31	0	0	0	FOAM
25	10/14/90	11:50	11:55	N	I	1.52	0.71	0.3	0.07	COLORED
25	10/21/90	15:12	15:15	N		0	0	0.31	0.45	CLEAR
25	11/11/90	9:40	9:45	?		T	1.12	0	0.13	CLEAR
25	11/18/90	13:07	13:10	N		T	T	0	0	CLEAR
25	11/25/90	11:53	11:57	N		0	0.08	0.11	0	CLEAR
25	12/2/90	13:57	14:00	?		0	0	0	0.02	CLEAR WITH WEEDS AND LEAVES
25	12/9/90	7:28	7:30	N		0	0.26	0.05	0	CLEAR
25	1/1/04	10:29	10:32	N		0.17	0.75	0	0	CLEAR

RIVER RESCUE CSO DATA

						PPT (INCHES)				
CSO	DATE	START	FIN	FLOW	VOL	DAY 0	- 1	- 2	- 3	APPEARANCE
25	12/30/90	13:02	13:05	N		T	T	0.37	0	CLEAR
25	1/13/91	13:34	13:42	Y	ST					?
25	1/21/91	16:20	16:25	N						CLEAR
25	1/27/91	12:03	12:05	N						CLEAR WITH FOAM
25	2/3/91	16:20	16:23	N						?
25	2/10/91	11:20	11:25	N						CLEAR
25	2/17/91	14:55	15:00	Y	ST					CLEAR
25	3/2/91	14:55	15:00	Y	M					COLORED
19	9/15/90	10:30	10:45	Y	H	0.61	0	0	0	CLOUDY,CLOLRED,SOLIIDS (TP, FECES...)
19	10/13/90	11:15	11:25	Y	ST	0.71	0.3	0.07	T	CLEAR
19	11/10/90	12:30	12:45	Y	H	1.12	0	0.13	0	TURBID,GRAY,LEAVES,OIL,SEWAGE SMELL,FOAM
19	12/8/90	11:15	11:30	Y	M/H	0.26	0.05	0	0	CLEAR,OIL,LEAVES,CIGARETTES
45	12/4/90	11:00	11:20	Y	?	2.09	0.02	0	0	COLORED WITH SOLIDS
49	12/4/90	10:30	11:00	Y	H	2.09	0.02	0	0	COLORED WITH SOLIDS
37	12/4/90	10:40	10:50	Y	H	2.09	0.02	0	0	COLORED
35	12/4/90	10:20	10:30	Y	M	2.09	0.02	0	0	COLORED (LOTS OF DIRT)
34	12/4/90	13:15	13:30	Y	M	2.09	0.02	0	0	TURBID
34	12/14/90	10:00	10:05	N		0	0	0	0	

APPENDIX F

Water Quality Data used in Historical Comparisons

Historical Nutrient Data

data entered by Meg Kerr					
	blackstone	blackstone	blackstone	blackstone	blackstone
	nh3	no2	nox	DIN	don
date	uM/L	uM/L	uM/L	uM/L	uM/L
7/26/82	25				
8/10/82	30				
8/23/82	22	1.98	144.67	166.67	
9/7/82	122	3.7	136.05	258.05	
9/23/82	48	2.58	193.43	241.43	
10/5/82	125	4.95	189.08	314.08	
10/19/82	76	4.7	135.77	211.77	
11/2/82	86	4.05	129.17	215.17	
11/16/82	36	1.06	50.53	86.53	
12/1/82	120	1.14	64.52	184.52	
12/15/82	154	0.9	75.15	229.15	
1/5/83	129	0.93	76.21	205.21	28.09
1/18/83	64	0.56	41.36	105.36	15.54
2/1/83	66	0.52	41.36	107.36	17.64
2/8/83	31	0.47	38.57	69.57	17.83
2/23/83	37	0.45	38.08	75.08	34.12
3/8/83	24	0.53	36.19	60.19	30.91
3/23/83	10	0.39	26.8	36.8	29.3
4/6/83	31	0.73	56.98	87.98	10.42
4/19/83	17	0.72	30.1	47.1	15.58
5/3/83	16	1.46	39.58	55.58	43.62
5/17/83	33	3.18	68.04	101.04	17.16
6/7/83	18	2.6	47.59	65.59	
6/22/83	17	3.75	102.47	119.47	24.63
7/6/83	19.3	2.38	122.11	141.41	
7/19/83	4.8	1.58	148.52	153.32	
8/2/83	13.7	3.81	186.29	199.99	74.41
8/16/83	91.1	7.42	209.07	300.17	
8/30/83	28.9	3.59	206.03	234.93	
9/13/83	32	3.7	175.95	207.95	73.25
9/27/83	69.96	7.4	243.6	313.56	76.44
10/11/83	23.24	4.73	170.46	193.7	
10/25/83	52.99				
11/8/83	113	7.2	129.67	242.67	
11/22/83	55.14	1.61	48.62	103.76	17.54
12/6/83	64.9	0.3	41	105.9	10.1
12/21/83	46.71	0.3	41	87.71	14.39
				0	
				0	
average	52.78	2.51	102.47	155.25	30.61
st dev	39.74	2.12	65.16	104.90	22.08

1982-1983 DATA FROM SCOTT NIXON, (In Prep.)

Historical Nutrient Data

blackstone	blackstone	blackstone			
dip	tdn	dop			
uM/L	uM/L	uM/L			
3.67		1.02			
5.64		0.88			
3.41		0.56			
4.65		0.31			
8.42		1.1			
8.81		1.12			
7.14		2.24			
3.64		2.16			
3.84		0.63			
6.51		0.9			
7.27	233.3	3.48			
3.46	120.9	1.47			
2.83	125	0.7			
1.29	87.4	0.52			
1.59	109.2	1:05			
1.43	91.1	0.68			
0.84	66.1	0.4			
1.99	98.4	0.63			
1.54	62.68	0.63			
1.86	99.2	0.66			
2.98	118.2	1.04			
2.86		1.06			
4.31	144.1	1.16			
1.99		0.86			
3.26		0.99			
9.07	274.4	1.15			
5.9		0.81			
7.82		1.09			
6.98	281.2	1.2			
9.05	390	1.19			
8.98		0.54			
11.69		1.02			
1.97	121.3	1.27			
2.9	116	1.54			
2.09	102.1	1.71			
4.62	146.70	1.08			
2.89	88.38	0.60			

1982-1983 DATA FROM SCOTT NIXON, (In Prep.)

Historical Nutrient Data

date	pawtux nh3 uM/L	pawtux no2 uM/L	pawtux nox uM/L	pawtux DIN uM/L	pawtux don uM/L
7/26/82	72	5.66	56.25	128.25	
8/10/82	33	2.21	33.68	66.68	
8/23/82	108	3.94	55.42	163.42	218.08
9/7/82	122	2.4	31.2	153.2	
9/23/82	101	1.46	40.43	141.43	
10/5/82	179	3.24	52.51	231.51	
10/19/82	27	2.63	45.67	72.67	
11/2/82	260	2.31	43.66	303.66	
11/16/82	97	1.3	43.41	140.41	
12/1/82	139	3.53	42.4	181.4	13.2
12/15/82	160	1.65	45.7	205.7	
1/5/83	135	0.92	51.04	186.04	26.37
1/18/83	64	0.71	49.8	113.8	33.6
2/1/83	54	0.48	52.5	106.5	8.5
2/8/83	34	0.43	40.4	74.4	19.9
2/23/83	39	0,53	44.5	83.5	26.4
3/8/83	29	0.48	34.9	63.9	17.7
3/23/83	20	0.45	23.23	43.23	
4/6/83	26	0.46	28.42	54.42	
4/19/83	24	0.4	31.12	55.12	15.35
5/3/83	20	0.39	24.84	44.84	34.66
5/17/83	51	0.89	35.96	86.96	19.74
6/7/83	56	3.83	35.15	91.15	
6/22/83	76.5	5.19	10.25	86.75	99.95
7/6/83	79.2	10.25	72.94	152.14	
7/19/83	119.7	8.71	62.59	182.29	
8/2/83	99.8	8	68.05	167.85	31.95
8/16/83	131.5	6.25	52.86	184.36	
8/30/83	127.8	7.28	59.95	187.75	37.15
9/13/83	160	9.24	88.91	248.91	97.59
9/27/83	156	12.09	41.91	197.91	160.09
10/11/83	117.64	4.96	42.59	160.23	
10/25/83	104.7	4.04	46.05	150.75	4
11/8/83	148	5.75	46.1	194.1	
11/22/83	17.45	1.33	33.69	51.14	73.56
12/6/83	43.69		34	77.69	38.31
12/21/83	49.39	1	38	87.39	37.11
				0	
				0	
average	88.69	3.46	44.33	133.01	50.66
st dev	56.42	3.21	14.67	71.09	54.94

1982-1983 DATA FROM SCOTT NIXON, (In Prep.)

pawtux	pawtux	pawtux
dip	dop	tdn
uM/L	uM/L	uM/L
3.67	2.65	
4.65	0.71	
24.87	0.05	381.5
5.03	0.44	
13.84	1.58	
10.23	1.68	
24.66	6.75	
11.9	3.75	
11.86	1.31	194.6
15.76	2.05	
11.85	3.51	212.4
9.23	2.72	147.4
5.26	0.93	115
2.48	0.53	94.3
3.89	0.61	109.9
2.73	0.35	81.6
1.12	0.42	
1.91	0.8	
2.23	1.09	70.47
1.74	0.45	79.5
3.72	1.03	106.7
6.9	1.38	
9	1.32	186.7
11.64	1.49	
15.77	1.35	
13.04	0.94	199.8
17.65	0.94	
17.72	1.88	224.9
24.83	1.82	346.5
19.94	0.8	358
12.96	1.27	
115.21	25.13	154.75
16.91	1.79	
72.61	15.29	124.7
3.03	1.58	116
4.79	1.61	124.5
14.85	2.56	171.46
21.27	4.66	93.99

1982-1983 DATA FROM SCOTT NIXON, (In Prep.)

Historical Nutrient Data

date	woon nh4 uM/L	woon nox uM/L	woon DIN uM/L	woon tdn uM/L	woon no2 uM/L
7/26/82	9	46.7	55.7	30.4	0.87
8/10/82	9	32.28	41.28	43.6	0.84
8/23/82	10	41.38	51.38		0.66
9/7/82	128	26.94	154.94		0.24
9/23/82	0.5	44.9	45.4		0.32
10/5/82	53	40.97	93.97		0.19
10/19/82	191	56.94	247.94		0.29
11/2/82	26	29.15	55.15		0.3
11/16/82	6	27.97	33.97		0.23
12/1/82	28	32.22	60.22	2.28	0.39
12/15/82	37	57.31	94.31		0.41
1/5/83	36	47.21	83.21		0.23
1/18/83		43.48	43.48	26.52	0.28
2/1/83	24	35.64	59.64	5.06	0.29
2/8/83	6	33.51	39.51	15.79	0.27
2/23/83	7.3	41.34	48.64	41.26	0.56
3/8/83	10	34.83	44.83	19.27	0.36
3/23/83	4.5	26.09	30.59	16.31	0.24
4/6/83	12	36.79	48.79	17.21	0.38
4/19/83	9	24.37	33.37	18.93	0.31
5/3/83	8	27.82	35.82	18.68	0.29
6/7/83	6	22.74	28.74		0.42
6/22/83	5.4	38.77	44.17	30.63	0.77
7/6/83	3.4	19.68	23.08		0.33
7/19/83	0.4	22.48	22.88		0.33
8/2/83	4.4	58.89	63.29	27.81	1.44
8/16/83	12	43.3	55.3		0.97
8/30/83	3.9	34.83	38.73	13.18	0.77
9/13/83	4	30	34	22	0.94
9/27/83	1.53	44.55	46.08	24.92	0.43
10/11/83	10.84	46.33	57.17		0.45
10/25/83	4.13	52.04	56.17	18.83	0.28
11/8/83	10.9	57.46	68.36		0.59
11/22/83	74.45	29.02	103.47		0.27
12/6/83	3.93	38.6	42.53	21.07	0.13
12/21/83	9.5	34.62	44.12	18.38	0.16
			0		
			0		
			0		
average	21.97	37.81	59.78	21.61	0.45
st dev	38.52	10.64	49.16	10.11	0.29

1982-1983 DATA FROM SCOTT NIXON, (In Prep.)

Historical Nutrient Data

woon	woon	woon			
tdn	dip	dop			
uM/L	uM/L	uM/L			
86.1	3.67	1.43			
84.88	3.93	1.33			
	1.29	0.4			
	1.93	0.36			
	2.95	0.55			
	4.6	0.53			
	6.08	1.51			
	2.59	0.86			
62.5	2.75	0.53			
90.58	5.66	0.56			
77.8	4.55	1.19			
70	2.03	0.85			
64.7	1.54	0.54			
55.3	1.14	0.52			
89.9	1.3	0.32			
64.1	0.81	0.12			
46.9	0.35	0.26			
66	0.93	0.53			
52.3	1.04	0.62			
54.5	1.04	0.59			
	1.26	0.66			
74.8	1.69	0.62			
	1.46	1.13			
	2.16	0.47			
91.1	2.13	0.84			
	1.87	0.6			
51.9	1.74	0.68			
56	3.3	0.81			
71	0.86	3.43			
	2.88	0.93			
75	1.34	0.7			
	1.19	0.35			
74.2	0.68	0.33			
63.9	1.16	0.62			
62.5	0.56	0.55			
68.95	2.13	0.75			
13.32	1.44	0.57			

1982-1983 DATA FROM SCOTT NIXON, (In Prep.)

Historical Nutrient Data

date	mosh nh3 uM/L	mosh no2 uM/L	mosh nox uM/L	mosh DIN uM/L	mosh don uM/L
12/15/82	37	0.82	59.5	96.5	9.38
1/5/83	41	1.09	86.43	127.43	
1/18/83	6	0.46	55.55	61.55	29.59
2/1/83	30	0.45	56.16	86.16	
2/8/83	7	0.82	50.78	57.78	12
2/23/83	8.4	0.68	52.49	60.89	26.03
3/8/83	10	0.57	54.24	64.24	23.29
3/23/83	7	0.57	38.85	45.85	22.78
4/6/83	10	4.36	50.8	60.8	18.34
4/19/83	16	5.32	34.79	50.79	17.17
5/3/83	19	2.44	38.69	57.69	26.57
5/17/83	12	1.08	35.23	47.23	15.39
6/7/83	17	1.6	44.03	61.03	
6/22/83	12	1.6	51.22	63.22	25.88
7/6/83	12.2	8.97	42.86	55.06	
7/19/83	8.1	1.79	57.37	65.47	
8/2/83	25	2.01	31.65	56.65	11.44
8/16/83	15.6	1.64	57.62	73.22	7.14
8/30/83	13	2.05	59.71	72.71	22.34
9/13/83	13.2	3.76	59.6	72.8	17.04
9/27/83	10.38	1.22	64.01	74.39	18.39
10/11/83	29	0.89	54.96	83.96	
10/25/83	28	0.92	45.52	73.52	
11/8/83	13.7	1.79	60.84	74.54	
11/22/83	3.54	2.56	50.88	54.42	36.62
12/6/83	10.77	0.83	49.18	59.95	15.62
12/21/83	25.89	0.6	63.5	89.39	22.21
average	16.33	1.88	52.09	68.42	19.85
st dev	9.80	1.86	11.37	21.17	7.41

1982-1983 DATA FROM SCOTT NIXON, (In Prep.)

Historical Nutrient Data

mosh	mosh	mosh
tdn	dip	dop
uM/L	uM/L	uM/L
105.88	0.62	0.67
	0.53	0.39
91.14	0.61	0.82
	0.32	0.32
69.78	0.32	0.13
86.92	0.32	0.27
87.53	0.81	0.05
68.63	0.35	0.43
79.14	0.22	0.54
67.96	2.33	1.46
84.26	0.89	0.123
62.62	0.55	0.66
	1.14	0.11
89.1	0.58	0.32
55.06	0.79	0.32
	0.94	0.16
68.09	0.74	0.44
80.36	0.98	0.29
95.05	1.13	0.29
89.84	1.26	0.69
92.78	0.91	0.42
	0.96	0.4
	1.13	0.98
	0.39	0.18
91.04	1.34	0.99
75.57	0.71	0.34
111.6	1.59	3.31
82.62	0.83	0.56
14.39	0.46	0.64

1982-1983 DATA FROM SCOTT NIXON, (In Prep.)

Water Quality Survey of

[illegible]

A Summary of Results from

the SINBADD Cruises

1985-1986

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and

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GSO Technical Report No. 89-3

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Table A-9. Measured concentrations of trace metals in river samples collected during the SINBADD cruises. Reported as dissolved (-d) and as total (-t) concentrations in units of ng/L (= 10^{-9} g/L); 'na' means not analysed, 'nd' means not detected.

River	Sal S	Ag-d ng/L	Ag-t ng/L	Cd-d ng/L	Cd-t ng/L	Cu-d ng/L	Cu-t ng/L	Cr-d ng/L	Cr-t ng/L	Ni-d ng/L	Ni-t ng/L	Pb-d ng/L	Pb-t ng/L
SINBADD-1													
Blackstone	0.04	nd	nd	1160	1450	6130	9670	1140	2280	12380	12620	980	2700
Woonasquatucket	3.30	na	na	470	420	17900	32000	na	na	86000	73000	na	na
Moshassuck	1.50	28	30	300	210	3740	5580	730	1410	9290	97600	1290	3550
Pawtuxet	0.31	nd	nd	2400	2260	11090	12500	600	840	30950	32620	840	2410
Taunton	15.90	na	na	640	660	2460	2700	na	na	4660	12970	na	na
SINBADD-2													
Blackstone	0.03	nd	nd	1280	1970	7920	10000	950	2490	8570	9760	930	3230
Woonasquatucket	0.03	nd	nd	120	120	2450	3220	2900	2420	5240	5380	890	2930
Moshassuck	0.05	nd	nd	220	1280	6390	7770	1250	1600	4390	4520	2180	3530
Pawtuxet	0.01	nd	nd	110	110	4970	7830	300	650	9090	9760	760	2580
Taunton	17.77	na	na	860	840	2510	4200	na	na	5410	6340	na	na
SINBADD-3													
Blackstone	0.02	nd	nd	890	1050	5030	6450	980	1760	7620	8570	930	2450
Woonasquatucket	0.74	nd	nd	250	310	8850	11700	5850	6400	12380	14050	1780	6040
Moshassuck	0.06	nd	nd	210	340	5550	9540	460	1030	2270	2320	1910	7450
Pawtuxet	0.04	nd	nd	1050	1290	7520	10230	300	650	14520	16430	980	2630
Taunton	0.03	nd	nd	120	180	3100	3510	520	890	1820	1810	980	2310
SINBADD-4													
Blackstone	0.05	nd	nd	580	920	6690	8490	950	1760	23300	29000	2010	10120
Woonasquatucket	0.99	23	20	150	250	5150	9440	4100	5960	10000	13100	1240	6050
Moshassuck	0.07	nd	nd	80	310	5550	11800	710	1600	3500	3600	1680	5750
Pawtuxet	0.09	48	50	590	940	8240	14700	430	1270	17600	24100	930	1920
Taunton	0.77	nd	nd	90	120	3840	4100	760	1660	2400	2800	890	683

Table A-9. Measured concentrations of trace metals in river samples collected during the SINBADD cruises. Reported as dissolved (-d) and as total (-t) concentrations in units of ng/L (= 10^{-9} g/L); 'na' means not analysed, 'nd' means not detected.

River	Sal S	Ag-d ng/L	Ag-t ng/L	Cd-d ng/L	Cd-t ng/L	Cu-d ng/L	Cu-t ng/L	Cr-d ng/L	Cr-t ng/L	Ni-d ng/L	Ni-t ng/L	Pb-d ng/L	Pb-t ng/L
SINBADD-1													
Blackstone	0.04	nd	nd	1160	1450	6130	9670	1140	2280	12380	12620	980	2700
Woonasquatucket	3.30	na	na	470	420	17900	32000	na	na	86000	73000	na	na
Moshassuck	1.50	28	30	300	210	3740	5580	730	1410	9290	97600	1290	3550
Pawtuxet	0.31	nd	nd	2400	2260	11090	12500	600	840	30950	32620	840	2410
Taunton	25.90	na	na	640	660	2460	2700	na	na	4660	12970	na	na
SINBADD-2													
Blackstone	0.03	nd	nd	1280	1970	7920	10000	950	2490	8570	9760	930	3230
Woonasquatucket	0.03	nd	nd	120	120	2450	3220	2900	2420	5240	5380	890	2930
Moshassuck	0.05	nd	nd	220	1280	6390	7770	1250	1600	4390	4520	2180	3530
Pawtuxet	0.01	nd	nd	110	110	4970	7830	300	650	9090	9760	760	2580
Taunton	17.77	na	na	860	840	2510	4200	na	na	5410	6340	na	na
SINBADD-3													
Blackstone	0.02	nd	nd	890	1050	5030	6450	980	1760	7620	8570	930	2450
Woonasquatucket	0.74	nd	nd	250	310	8850	11700	5850	6400	12380	14050	1780	6040
Moshassuck	0.06	nd	nd	210	340	5550	9540	460	1030	2270	2320	1910	7450
Pawtuxet	0.04	nd	nd	1050	1290	7520	10230	300	650	14520	16430	980	2630
Taunton	0.03	nd	nd	120	180	3100	3519	520	890	1820	1810	980	2310
SINBADD-4													
Blackstone	0.05	nd	nd	580	920	6690	8490	950	1760	23300	29000	2010	10120
Woonasquatucket	0.99	23	20	150	250	5150	9440	4100	5960	10000	13100	1240	6050
Moshassuck	0.07	nd	nd	80	310	5550	11800	710	1600	3500	3600	1680	5750
Pawtuxet	0.09	48	50	590	940	8240	14700	430	1270	17600	24100	930	1920
Taunton	0.77	nd	nd	90	120	3840	4100	760	1660	2400	2800	890	683

	A	B	C	D	E	F	G
1	METALS DATA FROM TABLE A-9 PILSON ET AL WATER QUALITY OF NARRAGANSETT BAY.						
2	A SUMMARY OF RESULTS OF THE SINBADD CRUISES						
3	1985-1986	ENTERED BY MEG KERR					
4							
5			units ug/L				
6							
7			Cr tot	Ni tot	Cu tot	Pb tot	Cd tot
8							
9	blackstone	1	2.28	12.62	9.67	2.7	1.45
10		2	2.49	9.76	10	3.23	1.97
11		3	1.76	8.57	6.45	2.45	1.05
12		4	1.76	29	8.49	10.12	0.92
13							
14		avg	2.07	14.99	8.65	4.63	1.35
15							
16	woon	1	na	73	32	na	0.42
17		2	2.42	5.38	3.22	2.93	0.12
18		3	6.4	14.05	11.7	6.04	0.31
19		4	5.96	13.1	9.44	6.05	0.25
20							
21		avg	4.93	26.38	14.09	5.01	0.28
22							
23	mosh	1	1.41	97.6	5.58	3.55	0.21
24		2	1.6	4.52	7.77	3.53	1.28
25		3	1.03	2.32	9.54	7.45	0.34
26		4	1.6	3.6	11.8	5.75	0.31
27		avg	1.41	27.01	8.67	5.07	0.54
28							
29	pawt	1	0.84	32.62	12.5	2.41	2.26
30		2	0.65	9.76	7.83	2.58	0.11
31		3	0.65	16.43	10.23	2.63	1.29
32		4	1.27	24.1	14.7	1.92	0.94
33		avg	0.85	20.73	11.32	2.39	1.15

Table 4. Average concentration of total aliphatic hydrocarbons in samples collected from Rhode Island rivers over the last 8 years (µg/L).

RIVER	DATE	N	ACTUAL MEAN	CORRECTION FACTOR	CORRECTED MEAN	REFERENCE
BRSM*	Oct.90-Aug.91	21	21	2	**42**	This Study
BRSM[1]	Oct.88-May 89	5	64	1.25	**80**	Latimer *et al*, In Prep.
BRSM[1]	Oct.85-May 86	4	47	1.25	**59**	Quinn *et al*, 1988
BRSM[2]	Jul.85-Oct.85	3	92	1	**92**	Quinn *et al*, 1987
WOON*	Oct.90-Aug.91	18	9.7	2	**19**	This Study
WOON[1]	Oct.88-May 89	3	23	1.25	**29**	Latimer *et al*, In Prep.
WOON[1]	Oct.85-May 86	4	63	1.25	**79**	Quinn *et al*, 1988
MOSH*	Oct.90-Aug.91	21	30	2	**60**	This Study
MOSH[1]	Oct.88-May 89	2	17	1.25	**21**	Latimer *et al*, In Prep.
MOSH[1]	Oct.85-May 86	4	66	1.25	**82**	Quinn *et al*, 1988
PAWT*	Oct.90-Aug.91	21	15	2	**30**	This Study
PAWT[1]	Oct.88-May 89	4	59	1.25	**74**	Latimer *et al*, In Prep.
PAWT[1]	Oct.85-May 86	4	49	1.25	**61**	Quinn *et al*, 1988
PAWT[2]	Jun.83-Sep.84	3	110	1	**110**	Quinn *et al*, 1985

*Whole water extraction F1 fraction only (assumed 50% of total, correction factor = 2).

[1]Particulate F_1 fraction only (usually ~80% of the total, correction factor = 1.25). Samples represent 24 hour composites.

[2]Combined particulate and soluble fractions; F_1 and F_2 fractions.

REFERENCES IN TABLE 4

Latimer, J. S., J. T. Ellis, L. LeBlanc and J. G. Quinn. (In Prep.). Inputs of organic contaminants to Narragansett Bay under wet weather conditions. Final Report to the Narragansett Bay Project. Narragansett Bay Project, Providence, RI.

Quinn, J. G., E. J. Hoffman, J. S. Latimer and C. G. Carey. (1985). A study of the water quality of the Pawtuxet River: chemical monitoring and computer modeling of pollutants. Volume 1: Chemical monitoring of pollutants in the Pawtuxet River. Final Report. University of Rhode Island, Kingston RI 02881.

Quinn, J. G., J. S. Latimer, C. G. Carey, J. T. Ellis and J. Zheng. (1987). Development of a one dimensional water quality model for the Blackstone River, Part 1: chemical monitoring of pollutants in the Blackstone River. Final Report. **NBP-88-03**. Narragansett Bay Project, Providence, RI.

Quinn, J. G., J. S. Latimer, J. T. Ellis, L. A. LeBlanc and J. Zheng. (1988). Analysis of archived water samples for organic pollutants. Final Report. **NBP-88-04**. Narragansett Bay Project, Providence, RI.

Percent Improvement

	A	B	C	D	E	F
1			mosh	woon	black	pawt
2	DIN	82/83	68.41	59.78	155.25	133.01
3		90/91	44.78	37.75	85.18	138.29
4		% chg	34.54	36.85	45.13	-3.97
5	DIP	82/83	0.83	2.13	4.62	14.85
6		90/91	0.16	0.89	2.44	5.99
7		% chg	80.72	58.22	47.19	59.66
8	P HC	85/86	82	79	59	61
9		90/91	60	19	42	30
10		% chg	27	76	29	51
11	PB	85/86	5.07	5.00	4.62	2.38
12		90/91	4.98	3.45	4.69	3.51
13		% chg	1.79	31.10	-1.52	-47.48
14	CU	85/86	8.67	14.09	8.65	11.31
15		90/91	6.23	4.25	9.13	16.51
16		% chg	28.12	69.84	-5.55	-45.98
17	NI	85/86	27.01	26.38	14.98	20.72
18		90/91	2.54	2.40	4.59	8.38
19		% chg	90.61	90.92	69.36	59.56
20	CD	85/86	0.53	0.28	1.34	1.15
21		90/91	0.10	0.24	0.43	0.69
22		% chg	80.75	12.00	67.91	40.00
23	CR	85/86	1.41	4.92	2.07	0.85
24		90/91	0.83	1.03	1.72	0.89
25		% chg	40.99	79.07	16.91	-4.71
26						
27						
28						
29						
30		Percent Improvement calculated as:				
31		(old data - Current data)/(old data) * 100				

Comparison of historical and Year One River Rescue Data