

**CONNECTICUT RIVER  
"SWIMMING HOLE" PROJECT  
FINAL REPORT**

by

**Marie-Françoise Walk  
Jerry Schoen  
Paul Jos. Godfrey**

**November 13, 1998**

**Massachusetts Water Watch Partnership  
Blaisdell House  
University of Massachusetts  
Amherst, MA 01003-0820**

## Table of Contents

Executive Summary .....	3
Introduction .....	4
Methods .....	5
Site Selection .....	5
Organization .....	5
Sampling .....	5
Sample Analysis .....	7
Data Management .....	7
Quality Control .....	7
1. Training and Trainer Qualifications .....	7
2. Documentation and Records .....	7
3. Quality Control for Fecal Coliform Analyses .....	8
A. Field QC Checks .....	8
Field Audits .....	8
Field Blanks .....	8
B. Laboratory QC Checks .....	8
Lab Duplicates .....	8
Blind QCs .....	8
Lab Blanks .....	8
C. Data Analysis of QC Checks .....	8
D. Sample Holding Period .....	9
Results .....	9
Quality Control .....	9
A- Field Quality Control .....	9
Audits .....	9
Field Blanks .....	10
B- Lab Quality Control .....	10
Lab Duplicates .....	10
Blind QCs .....	11
Lab Blanks .....	11
C- Sample Holding Period .....	11
Weather and Water Level .....	13
Temperature .....	13
Recreation .....	14
Fecal Coliform Levels .....	14
Bacteria Levels for Wet Weather vs. Dry Weather .....	16
Discussion .....	17
Caveats .....	17
Findings .....	17

Recommendations .....	19
Recommendations for future monitoring .....	19
Recommendations for resource management .....	19
References .....	20
Appendix A .....	21
.....	21
Field Data Sheet .....	22
Appendix B .....	23
Laboratory Analysts Instructions .....	23
Appendix C .....	24
Lab Data Sheet Example .....	24
Appendix D .....	25
Fecal Coliform Data .....	25

### **Acknowledgments**

This project was funded by the Massachusetts Executive Office of Environmental Affairs as part of a Massachusetts Watershed Initiative grant, and by the Eugene A. Dexter Charitable Fund and the Nan and Matilda Heydt Fund through the Community Foundation of Western Massachusetts. We thank the following volunteers who made this project a success:  
 Lisa Barnes, Francis Maynard, Bill Barratt, Scott and Noah Girard, Karen Pena, Sue and Tom Dempsey, Tay and Gail Silveira, sample collectors; Carl Mailler, Peg McDonough, and Alice Silveira, sample collectors and reach coordinators; Mary Boyd, Sandy Shields, Linda Dunbar, and Laurie Catarino, lab analysts; and the towns of Montague, Greenfield, Amherst, and Chicopee for the use of their Water Pollution Control facilities and equipment.

## Executive Summary

The Massachusetts Water Watch Partnership (MassWWP) organized volunteers to test the Massachusetts portion of the Connecticut River for fecal coliform bacteria, an indicator of possible pathogenic health risks from water contact. Volunteers collected samples from a dozen sites every two weeks from June 14 to September 14. The site list varied somewhat each sample event. Twelve sites were sampled at least 5 times during this period, the remainder were sampled one to three times. All sites sampled are considered to receive a high degree of use for swimming, boating, fishing and other river recreation. Samples were analyzed at four local wastewater treatment plants.

This study focussed only on potential health impacts related to possible disease bearing organisms. We did not attempt to examine other issues such as nutrient loadings, toxic substances, or other potential problems. All findings, conclusions and recommendations pertain solely to health-related use of the river for recreational purposes.

Our major findings are that relative to fecal coliform bacteria:

- Water quality appears to be worse on wet days than on dry days.
- During dry weather, the river generally appears to be clean enough to support swimming, fishing, boating, and similar recreational uses.
- We found no significant difference in water quality between the upstream, rural areas and downstream, urbanized sites.

We conclude that the river, at the sites tested, generally supports recreational use during dry weather, and that particular caution should be exercised during wet weather conditions.

Communication of results: We released results to local news media after every sample event, posted signs at several river access points, and posted results on the MassWWP Web site (<http://www.umass.edu/tei/mwwp>). A public presentation is scheduled for November 14 in Hadley. The response, evidenced by calls received from the press, the general public, interested organizations and agencies, and by the number of visits to the Web site, indicates widespread interest in the condition of the river.

Recommendations: This program was not intended to locate sources of contamination. We recommend further studies to identify and/or measure these sources during high water periods. We also recommend further study to measure the length and magnitude of rain events that affect water quality. Land and water use and treatment programs would do well to concentrate on preventing or controlling pollution that stems from weather-related high water conditions. We found the general water quality picture good and promising. We encourage area residents, visitors, environmental officials, organizations and planners to recognize the Connecticut as a river that, in its present state, can with reasonable caution, be considered a valuable recreational resource. Planning efforts that assume a healthy river and that take steps to safeguard and improve the river's health are likely to provide a boost to the area's economic well being, quality of life, and community pride.

## Introduction

In 1997, a consortium of organizations received a Massachusetts Watershed Initiative grant from the Executive Office of Environmental Affairs. Collaborating organizations include the Pioneer Valley Planning Commission, Franklin Regional Council of Governments, Connecticut River Watershed Council, UMass Extension, the Massachusetts Water Watch Partnership (MassWWP) and others. MassWWP's contribution to the project, (titled the "Connecticut River Watershed Strategic Plan") was to produce an assessment of existing water quality information on the Connecticut River and to provide assistance to volunteer water monitoring efforts on the river.

In May of 1998, MassWWP released the "Connecticut River Watershed Assessment Report for the Connecticut River Strategic Plan Partnership". This report lists existing water quality studies and provides some analysis of the information contained in the earlier studies. One salient conclusion of the MassWWP assessment was

"there are significant gaps in the knowledge of the water quality in the Connecticut River in Massachusetts: more regular monitoring needs to be conducted... Lacking from the data reports we consulted was an assessment of the current and desired uses of the river. Those uses (recreation for instance) should be documented, and future monitoring should be tailored to assess the suitability of the water quality for these uses."

This scarcity of data is juxtaposed against a trend towards greater recreational use in the Connecticut River. Use has increased dramatically over the last 30 years, as water quality has improved, especially since the implementation of the Clean Water Act in 1972. Many people now wade, swim, fish, water ski, and boat in the river, with much of the use concentrated on a number of popular spots, such as Elwell Island (upstream of Rt. 9 bridge in Northampton) and the Great Falls area in Montague. When we consulted the literature, and posed the question "Is there a health risk associated with these uses?" to local and state river managers and activists, no consensus opinion, nor hard data was forthcoming. This ignorance of water quality and of human activities that influence water quality reduces individual and societal commitment to positive change.

With this background, the "Swimming Hole Project" was initiated. It was our hope that collecting and publicizing sound scientific data on river conditions would stimulate dialogue that leads to wise decisions on how we use and care for the river system. The project was therefore intended both as a means of obtaining information about water quality on the Connecticut River and as a public education tool. After much discussion with environmental agency professionals and watershed activists, project organizers reasoned that public interest would best be served by focussing a water quality investigation on bacterial contamination related to swimming and other water sports. MassWWP staff thus organized a program to test water samples for fecal coliform bacteria at a number of popular recreation sites on the Massachusetts portion of the Connecticut River, and to disseminate results to the watershed community. This report describes that effort.

## **Methods**

### Site Selection

A list of sites was chosen at the initial volunteer meeting from a larger list previously developed with help from various river users and agencies. To be included on the final list, a site had to be a popular recreation spot and easy to reach by foot or boat. The list included 21 sites altogether, located from Northfield near the Vermont/New Hampshire border to Agawam near the Connecticut border (See Figure 1.)

Because the laboratories who volunteered to analyze the samples pro bono could only handle 5 samples each, including one quality control sample each collection, a total of 12 sites were to be sampled each collection. Some sites were to be sampled at every collection, and a number of other sites were sampled on a roving basis, so that we could visit each site at least once during the sampling season.

### Organization

The river was divided into 3 reaches: northern Massachusetts border to Montague, Sunderland to Hadley, and South Hadley to the southern Massachusetts border. Each reach had a Coordinator, a lab, and was sampled at 4 sites each collection. The project was managed by the Mass. Water Watch Partnership at UMass in Amherst. Reach coordinators reported to MassWWP staff.

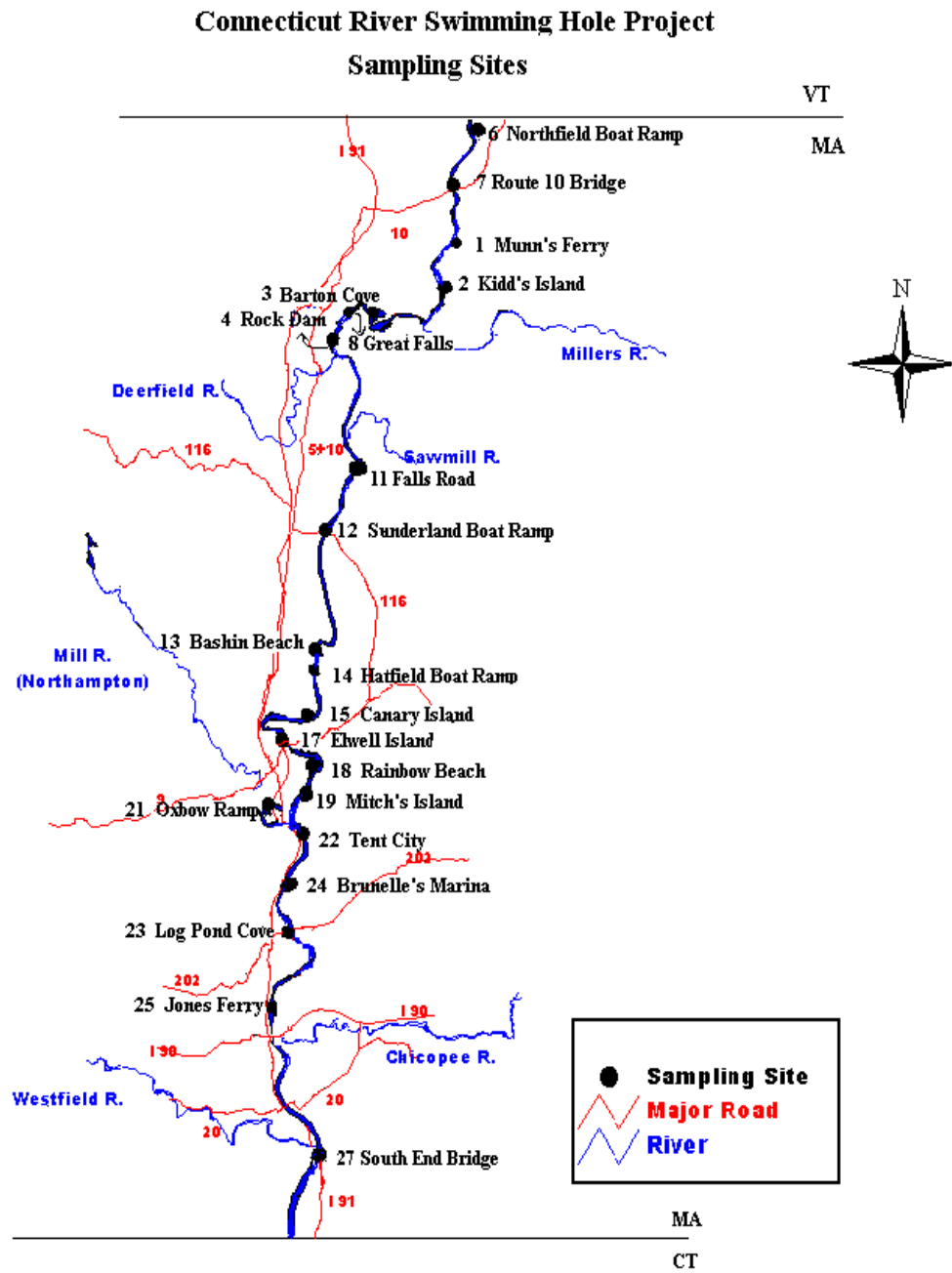
### Sampling

River sampling was done by volunteers who had been recruited through a press release in the Connecticut River valley. The volunteers were gathered at the University of Massachusetts on June 10, 1998 to be assigned sites and to be trained in sampling techniques as well as to receive their equipment and paperwork.

Surveyed parameters included air temperature, water temperature, and fecal coliforms. Volunteers were instructed to visit their sites between 2 P.M. and 5 P.M. every other Sunday for a total of seven collections, starting June 14, 1998. An eighth collection was completed by MassWWP staff and one volunteer September 14, 1998 for quality control purposes discussed below.

Volunteers were given a cooler, freezer pack, metal-case alcohol thermometer, sterilized sample bottles, instructions sheets and field data sheets (see Appendix A). Instructions directed samplers to put their freezer pack in their home freezer the night before collection day, then put it in their cooler just before leaving for sampling. Once at their site, samplers were asked to make observations on the current weather, past 48-hours weather, water color and odor, presence or absence of debris and wildlife, and types of recreation observed at time of sampling (See field sheet example in Appendix A). They would then record air temperature, water temperature, and take a river sample in the sterilized bottle for later fecal coliform analysis following Standard Methods 9060A.

Figure 1: Sampling Sites



Samplers were to deliver their samples (kept in the cooler during transit) to their Reach Coordinator before 6 P.M. that same day. Samples were kept in the reach coordinator's refrigerator until the next morning, when the coordinator brought the samples to the reach lab (Montague Water Pollution Control Facility in reach 1, with a back-up of Greenfield Water Pollution Control Facility(GWPCF); Amherst Water Pollution Control Facility in reach 2, Chicopee Water Pollution Control Facility in reach 3).

### Sample Analysis

Labs started analyzing the samples for fecal coliform bacteria between 8 A.M. and 1 P.M. on Monday, the day after collection. They followed Standard Methods 9222(D) (APHA, 1995). Results were faxed to MassWWP at the end of analysis, usually on Tuesday afternoon.

### Data Management

At the start of the project, labs reported results in various ways which were not all consistent, so after a few collections, MassWWP requested that only the raw colony counts be reported. MassWWP then calculated coliform density according to Standard Methods. MassWWP also went back to the previous collections and recalculated the coliform densities using Standard Methods protocols.

Calculated fecal coliform colony densities, air and water temperatures were then entered in a Microsoft Excel file by a MassWWP volunteer and entries were checked and corrected by MassWWP staff.

After checking quality control figures and validation, the data were posted on MassWWP's web page. They were also printed and sent to local media along with a brief explanation and interpretation by MassWWP staff.

### Quality Control

A Quality Assurance Project Plan was written before the onset of the project and sent to various reviewers. The QAPP was revised in July after receiving a review from EPA via DEP. The major points of the quality control program were:

#### 1. Training and Trainer Qualifications

Volunteer monitors were trained by MassWWP staff in sample collection. Monitor performance was evaluated through a field check: MassWWP sampled alongside the volunteers at least once during the sampling season and observed volunteers and corrected them if necessary. Lab analysts were professional lab technicians and needed no further training. They were sent instructions (see Appendix B) on methods to follow for this project at the beginning of the monitoring season.

#### 2. Documentation and Records

Field data sheets were given by collectors to reach coordinators who sent them to MassWWP. Chain of custody forms were used to follow the samples from collection to analysis. Lab sheets were filled out at the lab and faxed to MassWWP.

Labs used lab data sheets (see Appendix C), on which they recorded the date and time of sample analysis, volume filtered, number of colonies counted, and result in colonies per 100 ml. Also on the lab data sheet was the name of the analyst and the internal QC procedures followed. These lab data sheets were faxed to the MassWWP office, along with the chain of custody forms.

### 3. Quality Control for Fecal Coliform Analyses

One quality control procedure was to be performed each collection for each reach, consisting of field audits, field blanks, lab duplicates, or lab blinds. Additionally, laboratory blanks were run every collection. Of the 21 planned lab QC tests (3 reaches or labs x 7 sample events), 2 were not run, due to miscommunication, and one was changed from a field audit to a field duplicate.

#### A. Field QC Checks

Field Audits were done twice during the sampling season to duplicate each volunteer. This check served two purposes: a quality control of the sample collectors as MassWWP staff watched them sample; and a field duplicate, as MassWWP staff then took a sample at the same location and at the same time. The lab analyzed both samples.

Field Blanks were done at one randomly chosen site per Reach during the first sampling. Sampling bottles filled with sterilized deionized water were distributed to each reach coordinator, who brought them to the lab as if they were a regular field sample. This procedure was chosen first to ensure that no contamination was happening in transit and in the lab.

#### B. Laboratory QC Checks

Lab Duplicates were done twice per season at each lab: the lab split a randomly chosen sample and analyzed both subsamples.

Blind QCs: A river sample from the Green River was collected from a site known to be contaminated by fecal coliforms and split into 4 sample bottles; one sample was analyzed by Sandy Shields of the GWPCF and the other three brought to the participating labs. The GWPCF is certified by the State for the analysis of fecal coliform bacteria and its results were used as the expected value for the blind QC sample. This sample was also used as a “positive” plate sample, to test that a sample known to contain bacteria indeed showed colony counts. This was done twice during the season.

Lab Blanks: Each lab ran lab blanks for each collection.

#### C. Data Analysis of QC Checks

River data and QC data were reviewed as soon as they came in from the labs after each collection. QC data was compared to the quality objectives (e.g. blanks should have zero colonies, duplicates should be reasonably close<sup>1</sup> to each other, positives should show bacterial growth, etc). River data were reviewed as well to ensure that no field or lab contamination had occurred (data were compared to those of other sites and of previous collections).

#### D. Sample Holding Period

---

<sup>1</sup> As a check, because the labs did not provide us with their mean duplicate value (a lab’s average difference between lab duplicates the lab has run over time), duplicates had to be close enough so that interpretation of the results would not differ whether one duplicate or the other were used to determine safe recreation levels. See recreation standards discussion in Results section.

One of the objectives of this study was to determine whether the sites tested were appropriate for the recreational uses observed there. Therefore, it was desirable to collect samples during weekend afternoons, when most recreation took place. The labs volunteering their services were however not able to start analyses until Monday morning when their staff was at work. It was therefore decided to sample on Sunday afternoons and keep the samples iced until the next morning. This increased the holding time from the 6 hours recommended in Standard Methods (APHA, 1995) to 24 hours. Discussions with Water Pollution Control Facility operators and the State Lab microbiologist indicated that increasing the holding time would probably not change the bacteria counts enough to cause a data interpretation error, given the study's objectives.

However, communication received from EPA during our study raised concerns about our decision, and mentioned that Standard Methods specifically stipulates that an extension to 24 hours for POTABLE water only may be allowable. To address this concern, we added an extra sampling, to run a comparison of 6 vs. 24 hour holding times. MassWWP staff and the reach 3 coordinator conducted an additional "quality control" sampling: on the morning of Mondays September 14 and October 13, samples were collected from the regular Connecticut River sites plus the QC Green River site and brought immediately to three labs (The Greenfield and Amherst labs were used September 14th and the Chicopee lab on October 13th). The labs split the samples, analyzed one aliquot per site within 6 hours, and kept the other aliquot iced until the next day when they performed the analysis to match the 24 hour holding time.

## **Results**

### Quality Control

A discussion of Massachusetts Water Quality Standards for fecal coliform bacteria is necessary to interpret the following results.

Massachusetts Water Quality Standards for fecal coliform bacteria are as follows:

Primary Contact Recreation:

- fewer than 5 samples: <400 colonies/100ml
- more than 5 samples: geometric mean<200 colonies/100ml and less than 10% of samples>400 colonies/100ml

Secondary Contact Recreation:

- fewer than 5 samples: <2000 colonies/100ml
- more than 5 samples: geometric mean<1000 colonies/100ml and less than 10% of samples>2000 colonies/100ml

The five samples should be taken over not more than a 30-day period and should not average together dissimilar events such as low and high flows.

Because we did not have 5 samples taken within a 30-day period, we used the 400 and 2000 colonies/100ml criteria.

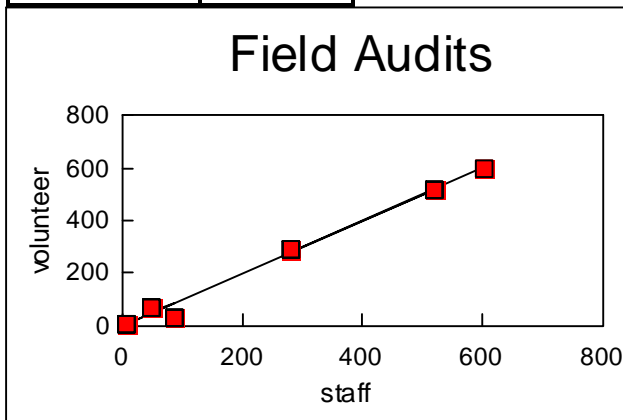
### A- Field Quality Control

Audits: Percent differences for field audits ranged from 0% to 111%. Although the latter figure may seem large, looking at the data in Table 1 shows that volunteer and staff results were always in the same range and using one or the other figure would not alter the water quality standards category. As can also be seen in Figure 2, results for volunteer samples are very close to those

of samples taken by staff. The squares represent data points and the line is the one-to-one relationship.

**Table 1:** Fecal Coliforms Results of volunteer-collected vs. staff-collected samples.

Volunteer	Staff
596	604
290	280
520	520
2	7
31	88
65	49



**Figure 2.** Fecal Coliforms Results of volunteer-collected samples vs. staff-collected samples.

Field Blanks: Two of the three labs ran field blanks. They both had results of zero colonies/100ml and therefore passed the contamination test.

**B- Lab Quality Control**

Lab Duplicates: Percent differences for lab duplicates ranged from 5% to 60%, with an absolute value average of 26%. Again, looking at the table below one can see that duplicates were reasonably close: Using one or the other of the aliquots would yield consistent interpretation of the water quality of the river for recreation standards.

**Table 2.** Lab Duplicates of Fecal Coliform Samples

<b>Aliquot 1</b>	<b>Aliquot 2</b>
28	15
41	39
17	18
32	23
860	980

Blind QCs: In the first blind QC test (7/13/98), the percent differences for double blinds ranged from 40% to 100% with an absolute value average of 60%. For the second occurrence (9/7/98), the results of the two labs with valid counts can be compared: they agreed within 6% of each other. One lab did not receive the blind QC sample, and the control lab -GWPCF- got results of TNTC (too numerous to count).

**Table 3.** Fecal Coliform Results for Blind QC Samples

<b>Date</b>	<b>Lab</b>	<b>Lab Result</b>	<b>Expected Result</b>
7/13/98	Montague	77	232
7/13/98	Amherst	140	232
7/13/98	Chicopee	112	232
9/7/98	Montague	4600	TNTC
9/7/98	Chicopee	5100	TNTC

TNTC= Too numerous to count

This type of QC sample resulted in more variation than the other tests. This was to be expected because the samples sent to each lab were probably not perfectly similar: the Green River sample was taken in one large bottle, from which 4 aliquots were poured into smaller bottles. Even though the big bottle was shaken between filling of the small bottles, it is difficult to assume that the same amount of bacteria is present in each aliquot. Even when the same sample is analyzed twice by the same lab, there is variation in the results, as was discussed above. Nevertheless, the variation in results still was not large enough to cause a problem in data interpretation. As shown in Table 3, within the same date, all samples fall within the same category of water quality standards.

Lab Blanks: All blank samples ran by the labs had results of zero colonies per 100 milliliters. There was therefore no laboratory contamination.

#### C- Sample Holding Period

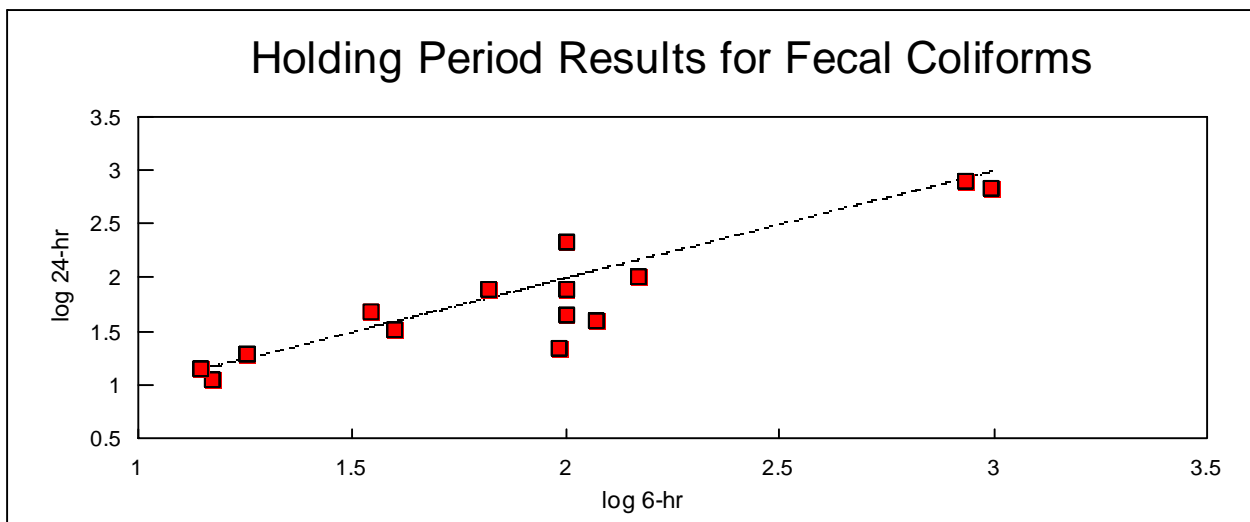
Analysis of the 14 samples done shows that the percentage difference between analysis done at 6-hour and at 24-hour ranged from 0 to 125%, with a mean of the absolute values at 43 percent. Most counts at 24-hours were lower than they were at 6-hours: Four samples (29%) had higher

counts after 24 hours (average of 36 colonies higher or 14% higher), 9 samples (64%) had lower counts (average of 72 colonies lower or 50% lower), 1 sample (7%) had no change.

To determine whether the difference between the two holding periods was statistically different, a regression analysis was performed on the data. Fecal coliform values were first transformed to logarithmic values to allow for a t-test. The t-test was then performed on the slope of the line to obtain a 95% confidence interval around the slope. The analysis showed that at the 95% confidence level, the slope was not significantly different from one, meaning that the 24-hour data set was not significantly different from the 6-hour data set.

**Table 4: Regression Analysis Results**

<b>Log of Fecal Coliforms for 24 hours vs 6 hours</b>	
<b>Regression Output:</b>	
<b>Intercept</b>	<b>0.04</b>
<b>Std Err of Y Est</b>	<b>0.25</b>
<b>R Squared</b>	<b>0.82</b>
<b>No. Of Observations</b>	<b>14</b>
<b>Degree of Freedom</b>	<b>12 (t=1.771 (95%))</b>
<b>Slope</b>	<b>0.92</b>
<b>Std Err of Slope</b>	<b>0.13</b>



**Figure 3:** Fecal coliforms of samples held 24 hours vs samples held 6 hours. Squares represent data and the line represent the 1:1 relationship.

We therefore conclude that holding samples 24 hours rather than the recommended 6 did not yield dramatically different results. The variation becomes even more negligible when the actual

counts are considered: in no case was the 24-hour result different enough from the 6-hour result to change the evaluation of a site for recreation purposes. In all cases, coliform values for samples held either 6 or the 24 hours remained in the same category of suitable for primary contact, for secondary contact, or unsuitable for either.

Weather and Water Level

Except for the month of June, the summer of 1998 was very dry. The June 14th and 28th collections took place during wet weather events. It had rained significantly (up to 4 inches) the days before June 14th and it was still raining on the sampling. In the afternoon of June 28th it was not raining, but it had rained the day before, including some heavy precipitation in Vermont upstream of our sites (see Table 4). In July and August it never rained during the 2 days before the sampling day. The September 7th collection was preceded by a rainy day and some localized downpours. September 14th was dry and sunny again. Because of the amount of precipitation in June, water level was very high on June 14th and even higher on June 28th. Banks were flooded and samples could not be taken at the normal spots; rather, they had to be taken higher up on the bank, sometimes even in wooded areas. A lot of debris, such as logs, was observed at all sites in June. Water levels did not return to normal until July 26th.

**Table 4:** Rain amounts for three dates at the lab sites and upstream of the sampling area.

Location	6/13/98	6/14/98	6/15/98	6/27/98	6/28/98	6/29/98	9/6/98	9/7/98	9/8/98
White River, VT	0.08	0.76	0.67	0.01	0.01	0.01	no data	no data	no data
Mascoma, NH	0.15	0.55	0.77	1.08	0.51	0	no data	no data	no data
Millers R., NH	0.84	1.13	0.69	0.08	0.05	0	no data	no data	no data
Keene, NH	0.37	0.38	0.14	0.18	0.01	0	no data	no data	no data
Otter Bk, NH	0.64	0.85	0.72	0.02	0.12	0.1	no data	no data	no data
West River, VT	0.17	1.28	1.13	0.16	0.02	0	no data	no data	no data
Montague, MA	0.95	0.95	1.41	0.2	0	0.1	0.3	0.02	0.3
Amherst, MA	0.43	1.37	0.33	0.06	0.07	0	0	0.02	0.3
Chicopee, MA	0.1	0.2	0.4	0.1	no data	0.1	no data	0.3	no data
The last 3 rows of data were provided by the Waste Water Treatment Plants of those towns									
All other data were obtained from NOAA's Hourly Rain Data Web Site									

Temperature

Air and water temperature were measured to document whether ambient conditions were favorable to recreation at collection time. Air temperature ranged from 18°C to 38°C. Water

temperature ranged from 14°C to a maximum of 36°C. Those temperatures are all compatible with recreation on the river, except the 14°C water temperature, which occurred on June 14th at the Oxbow Ramp in Northampton. The weather that day was rainy and water current conditions were very strong so that hardly any recreation was observed anywhere on the river: some fishing at Jones Ferry and boating at the Oxbow ramp, but nobody was observed in the water.

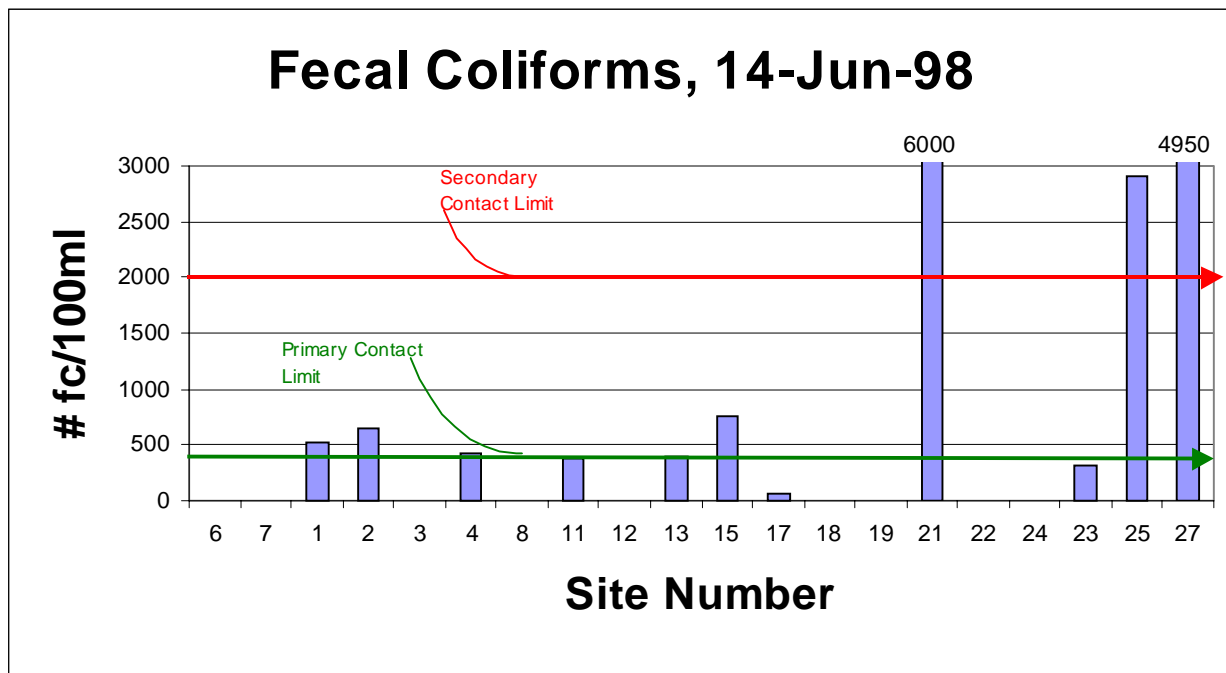
Recreation

Except for the first collection in June, considerable recreational use was observed on the river at the sampling sites: swimming, fishing, wading, boating, jet skiing, tubing, water skiing, camping, even sitting in garden chairs waist-deep in the river.

Fecal Coliform Levels

Full results are listed in Appendix D.

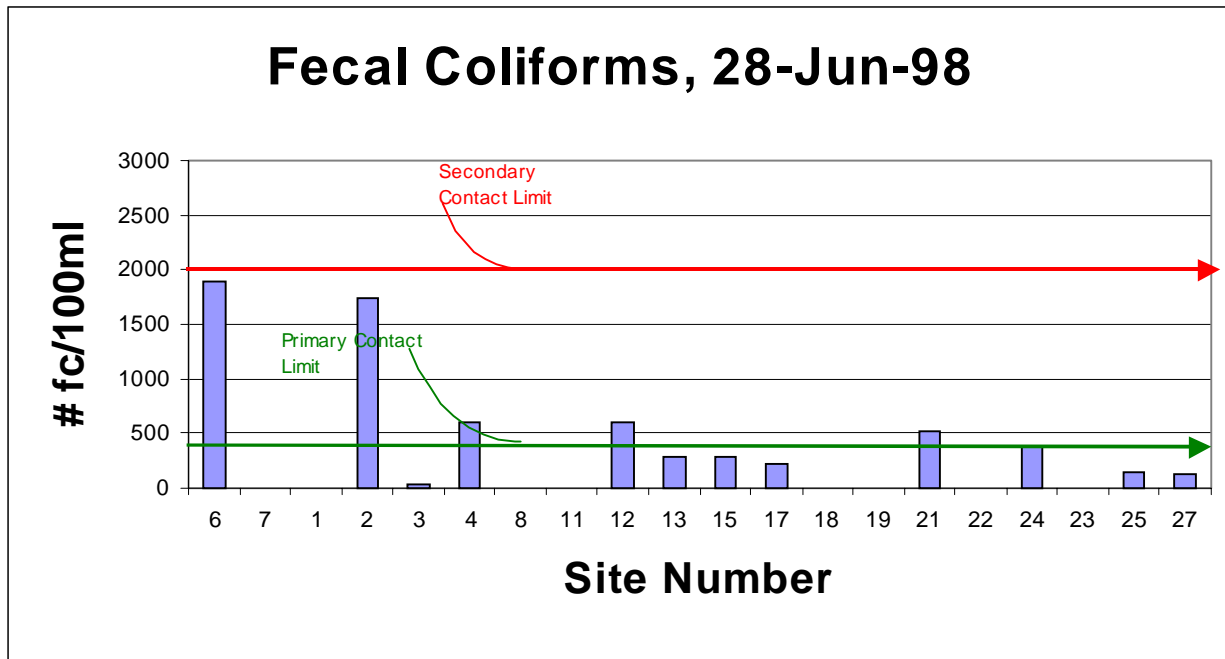
Fecal coliform counts were in general low and below the standard of 400 colonies/100ml for primary contact recreation. Exceptions were observed the first two collections, which were done in or following wet weather. On June 14th, 8 of 12 sites had counts above 400 col/100ml and 3 sites even exceeded the secondary contact recreation standard of 2000 col/100ml (see Figure 4).



**Figure 4:** Fecal coliform concentrations at 12 sites on the Connecticut River on June 14, 1998

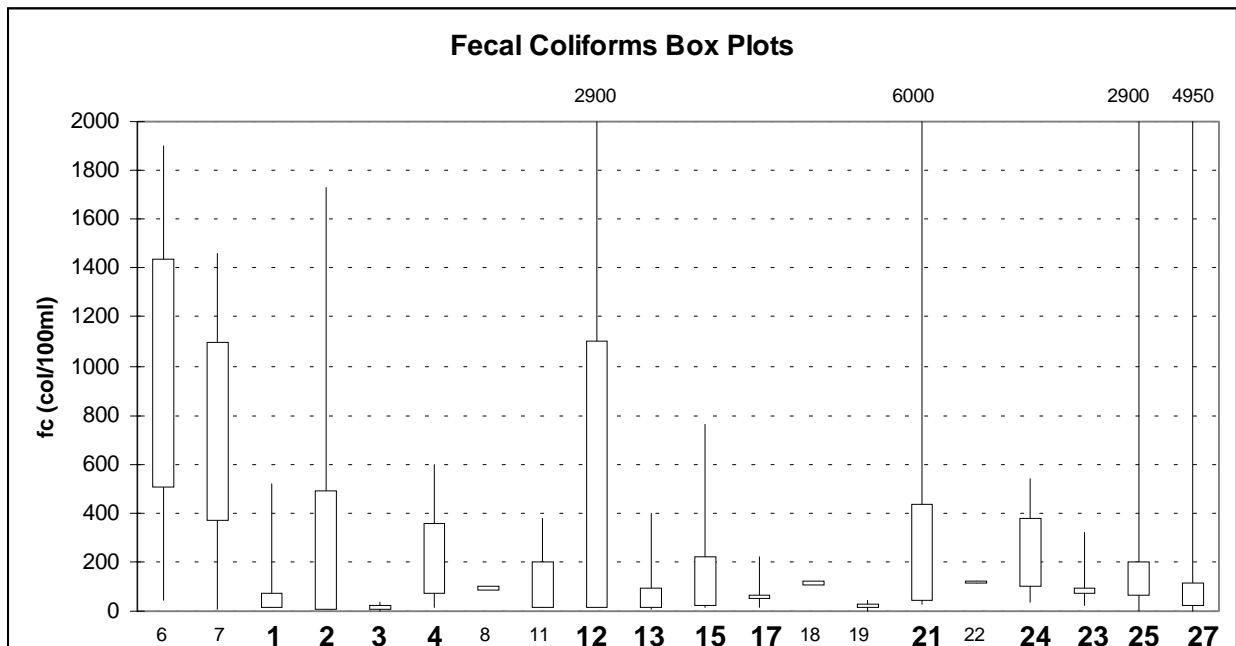
On June 28th, 5 sites exceeded 400 col/100ml, but all were below 2000 col/100ml (see Figure 5). Throughout July and August, as well as September 14th, all sites remained under 400 col/100ml except for site 24 (Brunelle’s Marina in South Hadley) which had a count of 540 col/100ml on August 23rd. On September 7th, two sites far exceeded the primary contact standard: Site 7 (Rte 10 Bridge in Northfield) with a count of 1460 and site 12 (Rte 116 Bridge in Sunderland) with 2600 col/100ml, while all other sites were well below that standard.

Of all the sites sampled four or more times, site 3 (Barton Cove in Gill) had the lowest bacteria counts with a geometric mean of 9 fc col/100ml. The site with the highest bacteria geometric



**Figure 5:** Fecal coliform concentrations at 12 sites on the Connecticut River on June 28, 1998

mean of 187 was site 21 (Oxbow Ramp in Northampton) followed by site 24 (Brunelle's Marina in South Hadley) with a geometric mean of 172 fc col/100ml. See Figure 6 to compare sites.



**Figure 6:** Summary of fecal coliform data at all sites, all dates: the top of each line represents the maximum value for that site; the bottom of the line below the box represents the minimum value; the top of the box depicts the 3rd quartile (below that point lay 75% of the data) and the bottom

of the box shows the 1st quartile (25% of the data lay below that point). Sites that were sampled 4 or more times are written in large bold character.

Figure 6 also shows that site 3 was lowest in fecal coliforms, closely followed by sites 13 and 23. Sites with consistent high bacteria were numbers 12 and 21. These statistics do not show site 24 to have exceedingly high fecal coliforms.

**Bacteria Levels for Wet Weather vs. Dry Weather**

For purposes of this project, wet weather events were to be defined as rainfall that exceeds 1.0 inches within the 24 hour period prior to sampling in any area within the immediate sampling vicinity (i.e. in communities along the Massachusetts portion of the Connecticut main stem); or within 48 hours prior to sampling in areas encompassing major tributaries or upstream areas (i.e. Vermont or New Hampshire portions of the watershed). All other days were to be considered dry weather, regardless of whether it was raining at the time of sampling or not.

Because sampling on September 7th just followed some heavy, localized thunderstorms, we included that sampling day in the wet weather category for our data analysis, even though the rain data at our normal points do not show greater than 1" precipitation (See table 4). We are therefore considering 3 wet days and 5 dry days.

Twenty sites were sampled on dry days, with from 1 to 5 samples taken at each site. Sixteen sites were sampled on wet days, with from 1 to 3 samples taken at each of these sites. We computed the average and maximum coliform values for each site on the three wet days and the five dry days.

<b>Comparison of bacteria levels , wet vs. dry days</b>		
	<u>Dry days</u>	<u>Wet Days</u>
Range of Fecal Coliform among sites (# col/100ml)		
Average	6 - 224	15 - 2541
Maximum value	6 - 540	28 - 6000
Composite values for all sites		
Average	55	893
Maximum value	540	6000

Comparing values for the different sites against the criteria for primary and secondary contact, we find:

<b>Comparison of water use, wet vs. dry days</b>		
	Dry days	Wet days
Number of sites where average bacteria counts exceeds primary criteria (400 colonies / 100ml)	0 of 20	7 of 16
Number of sites where average bacteria counts exceeds secondary criteria (2000 colonies /100 ml)	0 of 20	2 of 16
Number of sites with at least one violation of primary criteria	2 of 20	11 of 20

Number of sites with at least one violation  
of secondary criteria

0 of 20

4 of 16

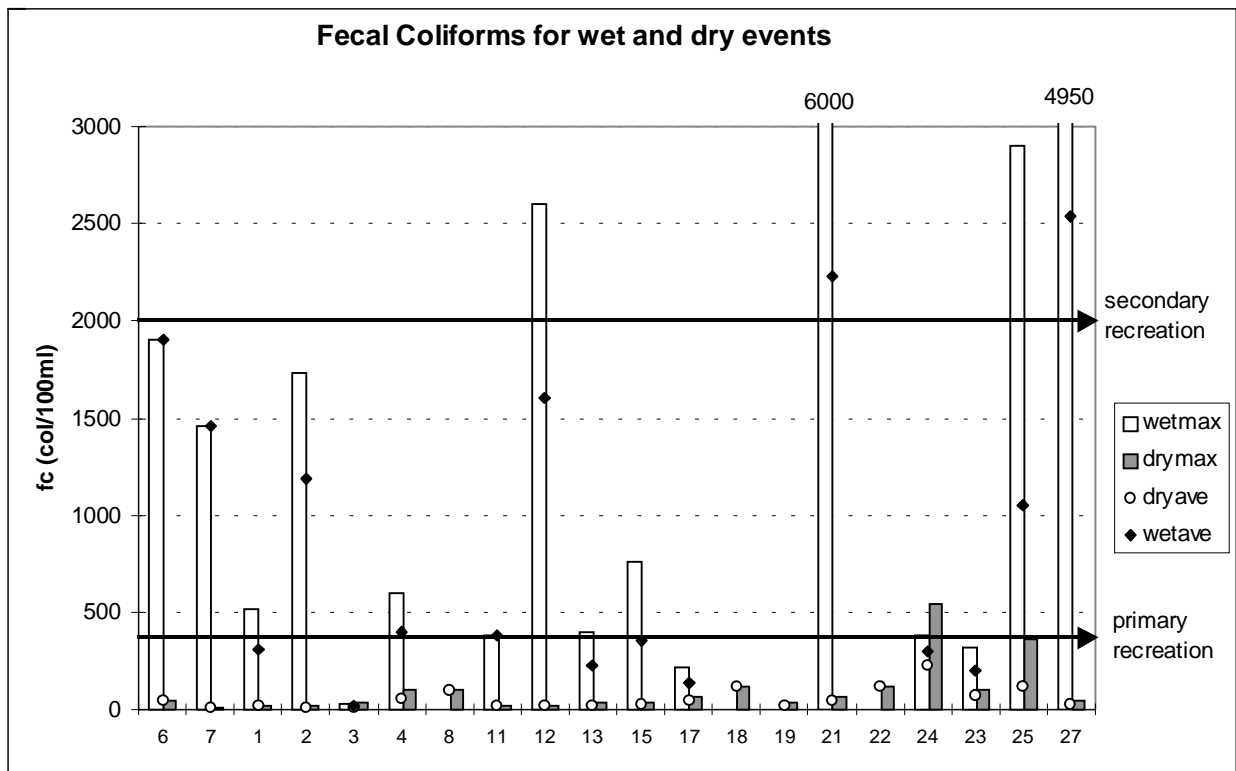


Figure 7: Maximum and Average Fecal Coliforms during Wet and Dry Events at all sites

## Discussion

### Caveats

This study focussed only on bacteria and associated health risks from recreational water contact. We did not attempt to examine issues such as nutrient loadings, toxic substances, or other potential problems. All findings, conclusions and recommendations reflect this focus.

Our discussion is intended to characterize the river at the sites and season that we sampled. Any extrapolation to other areas and times should be done with caution.

As previously noted, we compared coliform values against a primary contact criteria of 400 colonies per 100 ml of sample, and a secondary contact criteria of 2000 colonies /100 ml, rather than the commonly used primary and secondary criteria of 200 and 1000 colonies /100 ml, respectively. This is done because we did not take 5 samples per site within a 30-day period, as stipulated in the state standards.

### Findings

The data reveal three salient points:

- 1) Water quality (i.e. coliform levels) appears to be worse on wet days than on dry days.

- 2) During dry weather, the river generally appears to be clean enough to support swimming, fishing, boating, and similar recreational uses. It was cleaner than our research of existing water quality reports had led us to believe it would be.
- 3) We found no significant difference in water quality between the upstream and downstream sites tested. Again, this was unexpected, as previous water quality assessment reports had stated or suggested that combined sewer overflows and other problems originating in the urban areas of the lower reaches render the river unsuitable for recreation.

The tables and graphs shown in the results section above compare wet weather conditions with those found on dry days. In every case, average levels were higher on wet days than on dry days, sometimes significantly so. Compare average values for these sites, for instance (all of these were sampled at least 3 times each in wet and in dry weather).

Site	Site#	Average dry	Average wet
Barton Cove	3	12	15
Rock Dam	4	59	395
Bashin Beach	13	21	231
Canary Island	15	23	356
Oxbow Ramp	21	45	2233
Jones Ferry	25	115	1048

The Oxbow Ramp and Jones Ferry averages might be a bit misleading, because each was skewed by a single high reading, 6000 and 2900, respectively. However, using a geometric mean instead, the comparisons would be: Oxbow, 43 vs. 825; Jones Ferry, 50 vs. 345 for wet and dry.

Of 57 samples taken on dry days, only one (a reading of 540 colonies/100 ml at site number 24 on September 14) exceeded the swimming threshold, and it remained well within boating limits. In contrast, 15 "wet" samples (at 11 sites) of a total of 36 taken, exceeded the swimming threshold. Three of these (one each at sites 12, 21 and 25) also exceeded the boating standard.

The clear implication is that contact recreation poses a greater health risk after recent rains than during dry weather. This is not a surprise, given ample documentation of combined sewer overflow (CSO) problems in the watershed. However, these reports might lead one to believe that weather-related problems would be concentrated in the lower reaches of the river, where the greatest number of CSOs exist (Mass. Clean Water Council, 1997). We were somewhat surprised, therefore, to find wet weather problems were distributed throughout the river at different times. For instance, on June 14, the first wet weather date, the three sites that exceeded the boating standard (2000 fecal colonies/100ml) were all in reach 3, in the lower river. However, on June 28, none of these sites exceeded 520 colonies, while four sites in the upper reaches did, with two sites near the Vermont border approaching the boating standard at 1900 and 1733 colonies. Similarly, on September 7th, the highest readings were found in or above Sunderland.

We believe there may be two explanations for this situation. On June 14, preceding heavy rain had fallen throughout the watershed, and presumably CSOs occurred in the lower reaches especially. However, on June 28, the heaviest preceding rains fell north of the Massachusetts border, apparently bringing polluted water from Vermont and New Hampshire to the northern

sites. On or before September 7th, locally heavy downpours occurred in various parts of the watershed with a resulting spotty pattern of pollution problems. It is likely that other non-point sources of pollution (farm operations, urban runoff, etc.) also contribute to the upper reaches' pollution.

From these data and observations, it appears that weather can be used as a general predictor of water quality. If the weather is dry, there is an excellent chance that water meets primary contact recreation standards. Note that this is true at the sites that we tested. There may be other sites with specific local influences (e.g. downstream of an outfall pipe) that override this general statement. Conversely, if the weather is wet, then water users should proceed with caution. Chances that water does not meet recreational standards are much greater. The authors of this report have used this information to guide their own decisions on recreational use of the river. On several occasions this summer, we have taken our families swimming in the Connecticut. All these occasions were during dry weather. As this report goes to print, all are in good health.

We didn't see any notable difference in water quality between upstream and downstream reaches. There was as much variation between dates at individual sites as there was variation between sites on any given day. The variation among sites also followed no discernable trend. This was a surprise, considering the lower river's reputation as a polluted stretch of water. In essence, the places where people frequent the river - at least the sites we visited - are reasonably clean, from the Vermont border to the Connecticut line.

## **Recommendations**

### Recommendations for future monitoring

This study did not measure how large a precipitation event must be to cause high bacteria concentrations in the Connecticut River, nor do we know how long polluted conditions persist after a wet weather event. We recommend more wet weather sampling, including a program that measures bacteria levels immediately after a storm, and again at specific intervals after (i.e. one day, two days, etc.) the event.

Nor did we attempt to locate sources of bacterial pollution. We recommend that future surveys sample at additional sites, including tributary streams, to identify sources. This information might then be used to guide resource allocation decisions on projects undertaken to address remaining pollution problems.

### Recommendations for resource management

When we began organizing the Swimming Hole Project, we consulted with numerous private citizens and representatives of nonprofit organizations, agencies, academics, and businesses concerning the health and use of the river. Our sense from these communications is that many people continue to regard the river as a "problem", or at best, a resource which might some day, with considerable effort, become valuable. This perception may in itself be an impediment to further progress in cleaning up remaining pollution sources, as benefits may not appear to outweigh costs involved. Our experience with the project, including both the data we collected and our observations of heavy use the river receives, suggests that the river is now, in its present state, an extremely valuable resource for residents, businesses, and visitors alike. There is no longer a need to operate in a "holding pattern", waiting for the day when water quality improves

enough to benefit the public. That day is here now. The Connecticut River is surely a significant benefit to the local economy and quality of life. Management and planning decisions, for the river itself and for adjacent land use, should take this into account. Water quality projects would do well to concentrate on preventing or controlling pollution that stems from weather-related high water conditions. Other actions such as providing increased river access, development of park lands and other riverfront properties, and adding riparian trail systems will, we believe, prove a sound investment for the watershed community.

## **References**

American Public Health Association, 1995

“Standard Methods for the Examination of Water and Wastewater” 19th ed., American Water Works Association, Water Pollution Control Federation, Washington, DC.

Massachusetts Clean Water Council, 1997

“ The Connecticut River: A Working Report”

National Oceanographic and Atmospheric Administration, 1998

Hourly Rain Data from NOAA's Forecast Systems Laboratory, web site address:  
[http://precip.fsl.noaa.gov/hourly\\_precip.html](http://precip.fsl.noaa.gov/hourly_precip.html)

Walk, M.F., 1998

“Connecticut River Watershed Assessment Report” Marie-Françoise Walk, Massachusetts Water Watch Partnership, Blaisdell House, UMass, Amherst, MA 01003-0820.

## Appendix A

# Instructions for Field Sampling

You should have with you: (Remember to stick the Koolit in a freezer the night before)

- |                             |   |
|-----------------------------|---|
| ① Cooler                    | ⑥ Sampling Instructions                       |
| ② Frozen Koolit             | ⑦ Data Sheet, Clipboard, and Pencil           |
| ③ Thermometer               | ⑧ Pair of Latex Gloves                        |
| ④ Sterile Sample Bottle     | ⑨ First Aid Kit - Life jacket if using a boat |
| ⑤ Directions to Sample Site | ⑩ Jug of Water and Towel to wash your hands   |

### Temperature:

1. Take air temperature first. Hang thermometer in the shade, or use your body to shade it. Wait 2 minutes or more, then read temperature to nearest degree and write on data sheet.
2. Water temperature: place thermometer in the river. Immerse thermometer to a depth of at least 4 inches (attach the string to a rock or hold on to it). Read temperature after 30 seconds or more and record on data sheet.

### Weather and Use:

Record your observations of the weather, use of the river at this time, and physical characteristics of the water, in the appropriate places on the data sheet

### Fecal Coliform Sample:

1. Use only sterile bottles obtained from the project. Label bottle with volunteer name, date, time, and sample number. Fill out sample number on data sheet.
2. Wash hands before starting sample run. If you sample in an area that may have high fecal levels, rinse hands before handling the next sample bottle. Be careful not to touch your hands to yourself before you have cleaned them in order to avoid coming into contact with pathogens. If you are sampling from waters known to be contaminated with sewage, wear latex gloves to protect yourself.
3. Take sample at designated site. Either wade in the water or sample from the side of a boat or dock. Always sample upstream of your body, and point the bottle opening upstream. Keep the bottle closed until just ready to sample. Do not rinse the bottle. Remove cap and hold it to the side. Hold the bottle near its base and plunge it, neck downward, at least 4 inches below the surface. Turn bottle until neck points slightly upward and mouth is directed toward the current. If there is no current, create a current artificially by pushing bottle forward horizontally in a direction away from the hand. Be careful not to collect any sediment you may have suspended by walking on the streambed. Also avoid collecting any water from the surface layer of the water as this is uncharacteristic of the water flowing through. Replace cap leaving 1" of air space in bottle. It is important to leave the air space so that the sample will constantly mix while transported.
4. Place sample bottle in cooler.

## FIELD DATA SHEET

SITE NAME: \_\_\_\_\_ TOWN: \_\_\_\_\_

SITE NUMBER: \_\_\_\_\_ DATE: \_\_\_\_\_ TIME: \_\_\_\_\_

VOLUNTEERS: \_\_\_\_\_

**WEATHER OBSERVATIONS** (check appropriate boxes):

Weather now: Clear Partly Cloudy Overcast Cloudy Drizzle Raining Other:

Air Temperature: \_\_\_\_\_°C

Weather past two days: \_\_\_\_\_

If it has rained in past two days, estimate amount of precipitation: \_\_\_\_\_ inches

Was the rain light, moderate, or heavy?

**WATER OBSERVATIONS** (check appropriate boxes):

Water color: clear cloudy muddy green brown tea colored iridescent

other: \_\_\_\_\_

Water odor: none rotten egg gasoline sewage detergent fishy

other: \_\_\_\_\_

Water Temperature: \_\_\_\_\_°C

Any floating debris? (describe): \_\_\_\_\_

**RIVER USE OBSERVATIONS** (check appropriate boxes):

swimming wading boating fishing picnic hanging out other: \_\_\_\_\_

\_\_\_\_\_

Any wildlife? Describe: \_\_\_\_\_

Comments: \_\_\_\_\_

\_\_\_\_\_

## **Appendix B**

### Laboratory Analysts Instructions

# **JOB DESCRIPTION LABORATORY ANALYST**

Laboratory Analysts are responsible for:

- Signing Chain-of Custody forms as they are brought in by Reach Coordinators on Monday mornings
- Analyzing five samples for fecal coliform bacteria using Standard Methods 9222 (D) within 24 hours of sample collection. Analysis dates will be June 15, June 29, July 13, July 27, August 10, August 24, September 8, and on two special occasions following a storm (MassWWP staff will call labs to OK 48 hours in advance)
- Completing lab data sheets for each analysis day
- Sending or faxing Chain-of-Custody forms and lab data sheets to MassWWP as soon as possible after completion of each analysis day
- Contacting MassWWP as soon as possible if they must discontinue their participation in the project before the end of sampling season

**Appendix C**

**LAB DATA SHEET**  
**Fecal Coliform Bacteria Analysis - Membrane Filter Method**

LAB NAME: \_\_\_\_\_

LAB ANALYST: \_\_\_\_\_

DATE: \_\_\_\_\_

Sample ID (Bottle #)	Begin Time	End Time	Dilution Factor	# Colonies	#Colonies/ 100ml

Comments:

## Appendix D

Fecal Coliform Data (number of colonies per 100 milliliters)

Site #	14-Jun	28-Jun	12-Jul	26-Jul	9-Aug	23-Aug	7-Sep	14-Sep
6	ns	1900	ns	42	ns	ns	ns	ns
7	ns	ns	ns	ns	6	ns	1460	ns
1	520	ns	18	22	11	11	92	ns
2	648	1733	4	11	5	16	ns	ns
3	7	28	7	ns	2	4	11	35
4	420	600	16	60	ns	nd	166	100
8	ns	ns	ns	ns	ns	ns	ns	96
11	380	ns	ns	17	18	ns	ns	ns
12	ns	600	ns	ns	ns	13	2600	17
13	400	285	32	14	19	27	7	14
15	760	280	36	12	20	ns	27	ns
17	60	220	67	50	15	60	ns	ns
18	ns	ns	ns	ns	ns	115	ns	ns
19	ns	ns	ns	1	ns	ns	ns	40
21	6000	520	66	ns	39	ns	180	30
22	ns	ns	112	ns	ns	120	ns	ns
24	ns	377	ns	ns	98	540	230	33
23	320	ns	91	96	ns	ns	73	20
25	2900	147	82	49	3	367	96	73
27	4950	131	1	23	28	49	ns	ns

ns= not sampled

nd= no data