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Rainfall Effects on Bacterial Contamination, a Clam Purging Study and a Monitoring Project

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A Final Report to
The New Hampshire Estuaries Project

Submitted by

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This report was funded in part by a grant from the Office of State Planning, New Hampshire Estuaries Project, as authorized by the U.S. Environmental Protection Agency pursuant to Section 320 of the Clean Water Act.

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EXECUTIVE SUMMARY

A Monitoring Plan has been drafted that includes six chapters focusing on issues determined to be of most significance for the NHEP. The structure of the chapters includes a review of existing monitoring programs, identification of monitoring gaps, and a list of monitoring objectives for each issue. Each objective is then delineated in terms of performance criteria, hypothesis testing, sampling locations, statistical methods and analytical methods. Text, summary tables, and responses to review comments have been completed.

The Jackson Estuarine Laboratory analyzed samples collected by NHEP/NHDHHS staff and volunteers from the shoreline of the Atlantic Coast, Isles of Shoals, Hampton Harbor and Little Harbor of New Hampshire. The samples were collected for determining shoreline sources of fecal contamination as well as more directed sampling of culverts in Hampton Harbor. Samples were analyzed for fecal coliforms, *E.coli* and pH. The results were routinely sent to NHEP/NHDHHS staff to enable follow up investigations of sources and to direct further sampling efforts. In all, 232 analyses on 116 samples collected from culverts in Hampton Harbor, 54 analyses on 27 samples collected from the Atlantic Coast and the Isles of Shoals, and 54 analyses on 27 samples from Little Harbor were conducted, for a total of 340 analyses. In addition to fecal coliforms and pH, *Escherichia coli* counts were determined on all samples, and the salinity was recorded for some samples. *E.coli* counts were included as a check on the relationship between fecal coliform levels and the levels of the target organism of the fecal coliform test: *E. coli*. Many of the bacterial concentrations were >500/100 ml, reflecting the success of the sampling strategy to identify pollution sources. Rainfall events caused elevated concentrations of bacteria in culverts and in Little Harbor, where contaminant concentrations then decreased to low levels soon after the event.

The response of clams following storm-related contamination events in the field were mixed. There was no clear demonstration of purging of bacterial contaminants in clams up to four days after storm events at both Middle Ground and Common Island. Other contamination events that occurred during the studies could have complicated interpretation of the results. More studies could provide better conditions for determining how long clams need to be exposed to clean water after a storm event in order to purge bacteria to lower levels.

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INTRODUCTION

The NHEP has focused attention on maintaining and improving the monitoring component of the state Shellfish Program with the goal of improving overall water and environmental quality as sources of fecal contamination are identified and eliminated. There are other aspects of monitoring that would greatly benefit the state for determining the status and trends of other types of environmental contaminants, important habitats and human activities and land use. A Monitoring Plan has been drafted to provide a comprehensive plan for monitoring throughout the Seacoast of New Hampshire.

Shellfish growing areas are important resources in New Hampshire for the recreational harvesting of oysters, clams and mussels. To protect public health, the overlying waters are monitored for fecal contamination, and areas are classified as either being open (approved) for shellfishing or as being closed (prohibited). To open areas that are closed because of inadequate water quality and pollution source information, detailed shoreline and water sampling surveys are required to document that the shellfish waters are not contaminated and that shellfish are safe to harvest and eat. The shoreline survey involves documentation of whether any residence, business, industry, stream or stormwater drain is a source of fecal contamination. Positive identifications should be used as the basis for elimination of the identified sources so the area, if classified as approved, will not be subject to direct inputs of pollution.

Fecal coliforms are bacterial indicators of fecal contamination. They are the most commonly used indicator in the U.S. and serve as the indicator used by New Hampshire to classify shellfish growing waters (Jones, 1999). The target of the fecal coliform test is *Escherichia coli* because of its abundance in fresh fecal material. The concern about fecal contamination is the potential for viral, protozoan and bacterial pathogens to be present in the shellfish-growing water, and the logic for using fecal coliforms as an indicator is that detection of the abundant indicator will be a warning of the possible presence of pathogens. Other nonfecal-borne bacteria, including naturally-occurring bacteria, can also produce positive fecal coliform tests, so tests for *E. coli* are a useful check for deciding if high fecal coliform counts are good indicators of actual fecal contamination. In addition, other water quality parameters such as pH and salinity help to interpret fecal coliform counts. Odd pH values may indicate a significant influence of source water on receiving waters that may affect bacterial counts. Salinity values can also help to interpret whether contaminants are associated with freshwater or tidal sources.

The NHDES has made a major effort in recent years to identify and eliminate sources of microbial contaminants to coastal waters (Landry, 1997; NHDES, 1997). Much effort has focused on urban areas, with particular emphasis on stormwater drainage systems. In addition to urban areas, it is essential to investigate possible sources of fecal contamination along the full shoreline of all classified shellfish growing areas, including suburban and rural areas. Part of the focus of this study was to provide water quality analytical data from shoreline survey samples that would serve as a database for determining sources of fecal contamination. In addition, more specific sampling of culverts in Hampton Harbor will provide an assessment of the importance of these as pollution sources and direct efforts to eliminate contamination from them to the surface waters of the harbor.

The final component of this study is the need to know how long it takes clams to purge stormwater runoff-borne microbial contaminants from their tissue following runoff events in Hampton Harbor. At present, the state requires a five day wait following rainfall events to allow for filter-feeding clams to be exposed to clean water following rainfall events and purge contaminants as they pump clean water through their bodies. There have been many studies on the kinetics of microbial purging following contaminant exposure that have been conducted in laboratories. Many of these studies report that bacterial contaminants taken up during a contamination event are almost completely purged within 48 hours of exposure thereafter to clean water. However, few if any studies have measured contaminant concentration dynamics in clams under natural conditions. The final study reported here has focused on the determination of the dynamics of fecal coliform and *E.*

coli concentrations in the tissue of clams harvested from natural beds in Hampton Harbor before, during and after a runoff-associated contamination event.

PROJECT GOALS AND OBJECTIVES

The overall goal of these projects is to help make progress on NHEP tasks and projects that have been considered to be important or required during 2000. The specific goals are as follows:

1) to develop a monitoring plan for the New Hampshire Estuaries Project;
2) to analyze water samples collected by NHDES to determine effects of rainfall on fecal coliforms;
3) to analyze clam samples collected by NHDES to determine effects of time after rainfall events on fecal coliforms.

MATERIALS AND METHODS

Objective 1

The Monitoring Plan has been formulated through a process based on USEPA guidance and input from stakeholders, the public and scientists. The details of the process are included in the NHEP Management Plan.

Objective 2

Water samples collected by NHDES were transported on ice to JEL and placed into 5°C rooms for storage until analyses were conducted. Samples were usually processed for analysis within 2-4 hours of collection. However, sometimes samples were stored overnight and analyzed the day after sampling, all within <20 h of collection. Appropriate volumes of water were filtered through membrane filters (47 mm; 0.45 µm pore size) and the filters placed onto the surfaces of agar media in petri dishes. The agar medium used for fecal coliform and *Escherichia coli* analysis was mTEC agar (U.S. E.P.A., 1986). The agar media plates with filters were incubated for 24 h at 44.5 ±0.2 °C. Yellow colonies were counted as fecal coliforms, distinct from the negative purple colonies. The filter was then placed onto a cellulose pad soaked with urea solution and urease negative (remaining yellow) colonies were recounted as *E. coli* colonies. The data are reported in the attached tables as fecal coliform and *E. coli* colony-forming units (cfu) per 100 ml, to facilitate comparison of concentrations to state standards for shellfish and recreational waters. The pH of the water samples was also determined in at JEL using a Fisher Acumet model 1000 field pH meter.

Objective 3

Clams harvested from Hampton Harbor before, during and after rainfall events targeted by NHDES for study were transported in coolers to JEL. Duplicate shellfish samples collected in late September and early October from each of two sites were analyzed for fecal coliforms and *Escherichia coli*. There were twenty clams sampled from Common Island (CI) and Middle Ground (MG). For analyses, ten clams were shucked and composited prior to homogenization and dilution. The clams were shucked, the tissue homogenized in a Waring blender, and diluted in buffered peptone water. Decimally diluted tissue samples were added to LT broth in Durham tubes and incubated for 24 h at 35°C. Turbid, gas positive cultures were used as inocula for EC tubes. EC tubes were incubated for 24 h at 44.5 ± 0.2°C. Turbid, gas positive tubes were counted as positive for fecal coliform enumeration and further analyzed by exposure to UV light to determine *Escherichia coli* positive tubes. All positive tube data were recorded and MPN estimates of bacterial concentrations were determined from MPN tables (APHA, 1992). The data are summarized in the attached tables for each of two storm events.

RESULTS

Objective 1

The Monitoring Plan was submitted to US EPA for review. Responses to reviewer comments are currently being summarized and a revised Plan will be drafted that includes all new work required to address comments. The products, which would include the full Monitoring Plan and summary tables, are too extensive to be included in this document. Copies should be obtained through the NHEP office in Portsmouth, NH.

Objective 2

The analytical results for the water samples collected at the various sites in the Seacoast are summarized in Table 1. In all, 232 analyses on 116 samples collected from culverts in Hampton Harbor (Table 1a), 54 analyses on 27 samples collected from the Atlantic Coast and the Isles of Shoals (Table 1b), and 54 analyses on 27 samples from Little Harbor (Table 1c) were conducted, for a total of 340 analyses. In addition to fecal coliforms (FC) and pH, *Escherichia coli* counts were determined on all samples, and the salinity was recorded for some samples. *E.coli* counts were included as a check on the relationship between fecal coliform levels and the levels of the target organism of the fecal coliform test: *E. coli*.

Many of the bacterial concentrations in water samples from Hampton Harbor, the Atlantic Coast and the Isles of Shoals were >500/100 ml, reflecting the success of the sampling strategy to identify pollution sources. The only unusual pH values were measured in two of the samples from the Isles of Shoals, both being >9 (Table 1b).The ratios of *E. coli* to fecal coliform concentrations are included in Tables 1a-c to help interpret the results. Low ratios suggest a portion of the water sample contaminants may not be of fecal origin.There were a few sites with low Ec/FC ratios,

The sampling of culverts on 9/11/00 and 9/13/00, during dry and wet weather, respectively, included 15 sites sampled on both days. The results for those common sites showed FC concentrations remained low at 3 sites and FC concentrations were much higher during wet compared to dry weather at the other 12 culverts. The samples collected in Little Harbor showed higher concentrations of bacteria at all sites on 11/6/00, the day after a large rainstorm, than on 11/7 and 11/8, the following dry weather days (Table 1c). This suggests that rainfall events negatively impact water quality but that the concentrations decrease rapidly by two days following an event.

Objective 3

Clams were harvested from Hampton Harbor at Common Island (CI) and Middle Ground (MG) to determine the kinetics of bacterial purging from clams in the field following a storm event. The results of bacterial analyses of clam tissue collected before, during and after storm events in Fall, 2000 in Hampton Harbor did not show clear trends. The results of the first storm showed a decrease in FC concentrations in clams during the storm, then increases 2 days and/or 4 days after the storm event at both study sites (Table 2a). The bacterial concentrations decreased in clam tissue following the second storm at both sites, but the highest bacterial concentrations were measured in the samples collected just prior to the storm (Table 2b). Thus, it appeared that the decrease reflected purging from a contamination event that occurred prior to the storm. There will be two studies on two more storm event this spring that may help elucidate the kinetics of bacterial purging from contaminated clams.

CONCLUSIONS and RECOMMENDATIONS

The bacterial studies further illustrates the usefulness of detailed and comprehensive shoreline assessments for identifying fecal contamination. The use of fecal coliforms appears to be a useful indicator, based on comparisons to *E. coli* counts made on the same samples. Storm events remain significant factors in triggering events with elevated concentrations of bacterial contaminants at Little Harbor and Hampton Harbor, similar to results found in other areas of the Seacoast. The determination of the time required for clams to purge bacteria in the field has shown intriguing, yet inconclusive results and will benefit from further study in 2001.

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U.S. Environmental Protection Agency (U.S. E.P.A.). 1986. Test methods for *Escherichia coli* and enterococci in water by the membrane filtration procedure, EPA 600/4-85/076. U.S. Environmental Protection Agency , Environmental Monitoring and Support Laboratory, Cincinnati, OH.

Table 1a. NHDES-CULVERT STUDY-Hampton Harbor: 2000.

Date	Site	Fecal Coliforms CFU/100ml	*E. coli* CFU/100ml	Ec/FC	pH
7/27/00	HH/HMP/215/1/A	40	20	0.50	6.38
7/27/00	HH/HMP/215/2/A	≈22800	≈11600		7.15
7/27/00	HH/HMP/215/2/B	13960	≈9000		7.1
7/27/00	HH/HMP/217/1/C	560	560	1.00	7.04
7/27/00	HH/HMP/226/4/A	<20	<20		5.96
7/27/00	HH/HMP/229/1/A	580	560	0.97	7.01
7/27/00	HH/HMP/229/1A/A	≈40480	≈20320		6.94
7/27/00	HH/HMP/230/9/A	40	<20		6.83
7/27/00	HH/HMP/230/9/B	3640	2200	0.60	6.78
7/27/00	HH/HMP/236/1/A	<20	<20		6.72
7/27/00	HH/HMP/236/1/B	NO SAMPLE COLLECTED			
7/27/00	HH/HMP/236/1/C	≈8000	??		7.5
7/27/00	HH/HMP/236/1/D	740	??		6.92
7/27/00	HH/HMP/236/2/A	NO SAMPLE COLLECTED			
7/27/00	HH/HMP/236/7/A	5320	??		6.47
7/27/00	HH/HMP/236/7/B	1200	1040	0.87	6.32
7/27/00	HH/HMP/236/7/C	≈80000	??		7.00
7/27/00	HH/HMP/239/1/A	5420	≈3580		6.92
7/27/00	HH/HMP/274/114/A	10220	≈5400		7.13
7/27/00	HH/HMP/274/151/A	3740	≈2400		7.39
7/27/00	HH/HMP/274/48/A	1760	1540	0.88	7.4
7/27/00	HH/HMP/281/74/A	4360	≈2900		7.46
7/27/00	HH/HMP/281/74/B	2080	??		7.36
7/27/00	HH/HMP/282/6/A	3420	1680	0.49	6.92
7/27/00	HH/HMP/287/22/A	40	<20		6.87
7/27/00	HH/HMP/287/34/A	≈34840	33400		6.85
7/27/00	HH/HMP/287/34/B	3280	2900	0.88	6.83
7/27/00	HH/HMP/287/50/A	≈7200	≈4800		7.25
7/27/00	HH/HMP/287/50/B	≈16640	??		6.68
7/27/00	HH/HMP/289/50/A	12840	1180	0.09	7.65
7/27/00	HH/HMP/292/46/A	2260	700	0.31	6.7
7/27/00	HH/HMP/292/46/B	DID NOT RECEIVE THIS SAMPLE			
7/27/00	HH/HMP/292/46/TVT	3200	??		6.47
7/27/00	HH/HMP/292/50/A	≈8000	??		7.17
7/27/00	HHT5	<20	<20		7.52
7/27/00	HHT6	7740	??		6.82
7/27/00	HHT7	3280	??		6.93
7/27/00	HHT8	200	200	1.00	7.92
7/27/00	LANDING RD	4000	3700	0.93	7.33

COUNTS WITH ≈ SYMBOL INDICATE mTEC PLATES THAT WERE COVERED WITH COLONIES AND WERE TOO NUMBEROUS TO COUNT. COUNTS WERE OBTAINED BY COUNTING THE NUMBER OF COLONIES ON 1/4 OF PLATE AND THEN MULTIPLYING BY 4.

?? SYMBOLS INDICATE mTEC PLATES THAT WERE IMPOSSIBLE TO READ WHEN CONDUCTING UREA TEST.

Table 1a. NHDES-CULVERT STUDY-Hampton Harbor: 2000.

Date	Site	Fecal coliforms CFU/100ml	*E. coli* CFU/100ml	Ec/FC	pH
8/23/00	HMP/236/7/A	<20	<20		6.72
8/23/00	HMP/236/7/B	<20	<20		7.39
8/23/00	HMP/217/1/C	120	100	0.83	6.94
8/23/00	HMP/217/1/B	880	800	0.91	7.44
8/23/00	HMP/217/1/A	120	100	0.83	7.42
8/23/00	HMP/230/9/B	<20	<20		7.11
8/23/00	HMP/217/2/A	<20	<20		6.69
8/23/00	HMP/229/1/A	16	16	1.00	7.02
8/23/00	HMP/241/13/A	8	0	0.00	6.94
8/23/00	HMP/241/8/A	24	22	0.92	7.4
8/23/00	HMP/274/48/A	1	1	1.00	7.48
8/23/00	HMP/274/151/A	3	2	0.67	7.13
8/23/00	HMP/282/6/A	10	4	0.40	7.23
8/23/00	HMP/281/74/A	30	26	0.87	7.35
8/23/00	HMP/281/74/B	21	9	0.43	7.17
8/23/00	HMP/287/22/A	2	0	0.00	6.81
8/23/00	HMP/287/50/A	31	12	0.39	7.25
8/23/00	HMP/287/50/B	17	4	0.24	7.17
8/23/00	HMP/287/34/A	40	26	0.65	6.81
8/23/00	HMP/287/34/B	14	12	0.86	7.58
8/23/00	HMP/289/50/A	660	640	0.97	7.33
8/23/00	HMP/292/46/A	20	12	0.60	7.53

Table 1a. NHDES-CULVERT STUDY (Dry Weather)-Hampton Harbor: 2000.

Date	Site	Fecal Coliforms CFU/100ml	*E. coli* CFU/100ml	Ec/FC	pH
9/11/00	HH/SEA/F	<20	<20		7.62
9/11/00	HH/SEA/G	<20	<20		6.94
9/11/00	HMP/217/1/A	225	220	0.98	7.54
9/11/00	HMP/217/1/B	640	620	0.97	7.65
9/11/00	HMP/217/1/C	13	13	1.00	7.23
9/11/00	HMP/217/2/A	<2	<2		7.42
9/11/00	HMP/226/4/B	<20	<20		5.12
9/11/00	HMP/229/1/A	<5	<5		6.99
9/11/00	HMP/230/9/B	113	113	1.00	7.13
9/11/00	HMP/274/114/B	<20	<20		6.86
9/11/00	HMP/274/151/A	<1	<1		7.41
9/11/00	HMP/274/48/A	2	<1		7.36
9/11/00	HMP/281/74/A	<20	<20		7.38
9/11/00	HMP/281/74/B	<20	<20		7.01
9/11/00	HMP/282/6/A	20	20	1.00	7.32
9/11/00	HMP/287/22/A	<5	<5		6.91
9/11/00	HMP/287/34/A	980	980	1.00	7.14
9/11/00	HMP/287/34/B	<20	<20		7.63
9/11/00	HMP/287/50/A	20	20	1.00	7.10
9/11/00	HMP/287/50/B	<20	<20		7.21
9/11/00	HMP/289/50/A	<20	<20		7.43
9/11/00	HMP/292/46/A	<20	<20		7.77
9/11/00	SEA/14/32-0/A	140	140	1.00	7.31
9/11/00	SEA/14/6-183/A	<20	<20		8.08
9/11/00	SEA/17/46-0/A	TNTC	TNTC		7.33
9/11/00	SEA/17/46-0/B	<20	<20		7.36

*** Samples were collected on 9/11/00 and processed on 9/12/00 ***

TNTC = Too Numerous to Count. After filtering 2.5mls of sample and incubating over night, the filter paper was covered with colonies and uncountable.

Table 1a. NHDES-CULVERT STUDY (Wet Weather)-Hampton Harbor: 2000.

Date	Site	Fecal Coliforms CFU/100ml	*E. coli* CFU/100ml	Ec/FC	pH
9/13/00	HMP/215/2/A	1160	920	0.79	6.30
9/13/00	HMP/215/2/B	<200	<200		7.15
9/13/00	HMP/217/1/C	860	760	0.88	6.98
9/13/00	HMP/217/1/D	120	120	1.00	6.98
9/13/00	HMP/217/2/A	<10	<10		6.97
9/13/00	HMP/226/4/A	1380	1380	1.00	5.96
9/13/00	HMP/229/1/A	<40	<40		6.69
9/13/00	HMP/229/1/A/A	≈ 175200	≈ 124800		6.35
9/13/00	HMP/230/9/B	3400	3400	1.00	6.63
9/13/00	HMP/236/1/A	<20	<20		7.55
9/13/00	HMP/236/1/C	200	200	1.00	6.27
9/13/00	HMP/236/1/D	4560	4460	0.98	6.08
9/13/00	HMP/236/3/A	280	280	1.00	6.66
9/13/00	HMP/236/7/A	1200	1200	1.00	6.12
9/13/00	HMP/236/7/B	700	660	0.94	5.61
9/13/00	HMP/239/1/A	<200	<200		not enough sample
9/13/00	HMP/241/13/A	<10	<10		8.16
9/13/00	HMP/241/8/C	780	760	0.97	7.04
9/13/00	HMP/274/114/B	5960	4560	0.77	6.96
9/13/00	HMP/274/15/A	≈ 10320	≈ 8960		6.95
9/13/00	HMP/274/48/A	1640	1580	0.96	7.06
9/13/00	HMP/281/74/A	7200	7000	0.97	6.97
9/13/00	HMP/281/74/B	2900	2380	0.82	7.08
9/13/00	HMP/282/6/A	560	520	0.93	7.10
9/13/00	HMP/287/22/A	<20	<20		6.69
9/13/00	HMP/287/34/A	13400	12000	0.90	6.75
9/13/00	HMP/287/34/B	TNTC	TNTC		6.81
9/13/00	HMP/287/50/A	15600	13200	0.85	6.95
9/13/00	HMP/287/50/B	20800	11200	0.54	6.71
9/13/00	HMP/289/50/A	9600	6800	0.71	6.91
9/13/00	HMP/292/46/A	≈ 10560	??		6.73
9/13/00	HMP/292/46/B	5480	2300	0.42	6.34

TNTC= Too Numerous to Count. After filtering 2.5mls of sample and incubating over night, the filter paper was covered with colonies and uncountable.

≈ symbol indicate counts that were obtained by counting the number of colonies on 1/4 of the filter paper and then multiplying by four to find the total count.

Table 1b. NHDES-SHORLINE SURVEY-Atlantic Coast and Isles of Shoals: 2000.

Date	Site	Fecal Coliforms CFU/100ml	*E. coli* CFU/100ml	Ec/FC	pH
8/3/00	AC/Rye/EelPond/B	60	20	0.33	7.06
8/3/00	AC/NHM/1/Little River	440	440	1.00	6.82
8/3/00	AC/Rye/5.0/EelPond/A	<20	<20		7.03
8/3/00	AC/Rye/17.3/28/A	200	180	0.90	7.29
8/3/00	AC/Rye/17.3/29/A	320	320	1.00	7.27
8/3/00	AC/Rye/17.3/5/A	>8000	>8000		7.22
8/3/00	AC/Rye/19.4/56/A	15980	11880	0.74	6.77
8/3/00	AC/NHM/5/9/A	180	180	1.00	7.08

NHDES-SHORLINE SURVEY-ATLANTIC COAST

DATE	SITE	Fecal Coliforms CFU/100ml	*E. coli* CFU/100ml	Ec/FC	pH
8/14/00	AC/NHM/1/LITTLE RIVER	1060	840	0.79	7.21
8/14/00	AC/NHM/5/9/A	350	270	0.77	7.37
8/14/00	AC/RYE/5.0/EEL POND/A	<20	<20		6.8
8/14/00	AC/RYE/5.0/EEL POND/B	900	850	0.94	7.92
8/14/00	AC/RYE/5.0/EEL POND/C	14	12	0.86	7.94
8/14/00	AC/RYE/5.0/EEL POND/D	66	58	0.88	7.88
8/14/00	AC6C	240	160	0.67	7.72
8/14/00	AC6	300	160	0.53	7.25
8/14/00	AC6E	320	260	0.81	7.24
8/14/00	AC6F	20	20	1.00	8.01
8/14/00	AC/RYE/2/73/A	440	400	0.91	6.91
8/14/00	AC/RYE/2/84/A	420	360	0.86	7.06
8/14/00	AC/HMP/267/51/A	140	40	0.29	7.59
8/14/00	AC/HMP/134/HMP/A	40	20	0.50	7.31
8/14/00	AC/RYE/2/69/A	~27360	~14560		6.56
8/14/00	AC/RYE/2/67/A	640	460	0.72	6.19

NHDES-SHORLINE SURVEY-ISLES OF SHOALS

Date	Site	Fecal coliforms CFU/100ml	*E. coli* CFU/100ml	Ec/FC	pH
8/17/00	IS/Rye/28/3/C	TNTC	TNTC		9.72
8/17/00	IS/Rye/28/3/F	10	10	1.00	10.96
8/17/00	IS/Rye/28/3/E	<.5	<.5		7.95

Table 1c. NHDES-Little Harbor Rainfall Study: 2000.

Date	Site	Fecal Coliforms CFU/100ml	*E. coli* CFU/100ml	Ec/FC	pH
11/6/00	T1	2	2	1.00	7.89
11/6/00	LH2	≈ 382	≈ 382		8.22
11/6/00	T6	≈ 680	≈ 680		7.86
11/6/00	T7	25	21	0.84	7.16
11/6/00	T8	≈ 321	≈ 321		7.94
11/6/00	T13	348	344	0.99	7.94
11/6/00	T14	42	42	1.00	7.78
11/6/00	T6A	5300	5300	1.00	7.96
11/6/00	T16	20	20	1.00	8.1
11/7/00	T1	1	1	1.00	7.86
11/7/00	LH2	<20	<20		8.11
11/7/00	T6	<20	<20		8.05
11/7/00	T7	8	8	1.00	6.94
11/7/00	T8	<2	<2		7.98
11/7/00	T13	2	2	1.00	7.98
11/7/00	T14	3	3	1.00	7.71
11/7/00	T6A	<1	<1		8.06
11/7/00	T16	19	19	1.00	8
11/8/00	T1	1	1	1.00	7.87
11/8/00	LH2	2	2	1.00	8.11
11/8/00	T6	1	1	1.00	8.08
11/8/00	T7	9	9	1.00	7.16
11/8/00	T8	2	2	1.00	7.84
11/8/00	T13	1	1	1.00	7.83
11/8/00	T14	10	10	1.00	7.47
11/8/00	T6A	2	1	0.50	7.89
11/8/00	T16	2	1	0.50	7.73

≈ symbol indicate counts that were obtained by counting the number of colonies on 1/4 of the filter paper and then multiplying by four to find the total count.

Table 2a. Hampton Harbor clam purging study: 1st storm

Sample date	9/26/00 previous day						
Sample #	Target organisms	MPN reading	1st dilution	Closest table MPN	Table MPN per 100 g	MPN/100g	Standard deviation
CI #1	Fecal coliforms	530	1	530	80	800	
	E. coli	530	1	530	80	800	
CI #2	Fecal coliforms	510	1	510	30	300	
	E. coli	400	1	400	13	130	
CI ave.					Fecal coliforms	**550**	354
					E. coli	**465**	474
MG #1	Fecal coliforms	522	1	522	90	900	
	E. coli	522	1	522	90	900	
MG #2	Fecal coliforms	510	1	510	30	300	
	E. coli	510	1	510	30	300	
MG ave.					Fecal coliforms	**600**	424
					E. coli	**600**	424

Sample date	9/27/00 storm day						
Sample #	Target organisms	MPN reading	1st dilution	Closest table MPN	Table MPN per 100 g	MPN/100g	
CI #1	Fecal coliforms	420	1	420	22	220	
	E. coli	420	1	420	22	220	
CI #2	Fecal coliforms	410	0.5	410	17	340	
	E. coli	310	0.5	310	11	220	
CI ave.					Fecal coliforms	**280**	85
					E. coli	**220**	0
MG #1	Fecal coliforms	411	0.5	411	21	420	
	E. coli	410	0.5	410	17	340	
MG #2	Fecal coliforms	110	0.5	110	4	80	
	E. coli	100	0.5	100	2	40	
MG ave.					Fecal coliforms	**250**	240
					E. coli	**190**	212

Sample date	9/29/00 2 days after						
Sample #	Target organisms	MPN reading	1st dilution	Closest table MPN	Table MPN per 100 g	MPN/100g	
CI #1	Fecal coliforms	532	0.5	532	140	2800	
	E. coli	532	0.5	532	140	2800	
CI #2	Fecal coliforms	400	0.5	400	13	260	
	E. coli	400	0.5	400	13	260	
CI ave.					Fecal coliforms	**1530**	1796
					E. coli	**1530**	1796
MG #1	Fecal coliforms	420	0.5	420	22	440	
	E. coli	420	0.5	420	22	440	
MG #2	Fecal coliforms	200	0.5	200	4	80	
	E. coli	100	0.5	100	2	40	
MG ave.					Fecal coliforms	**260**	255
					E. coli	**240**	283

Table 2a. Hampton Harbor clam purging study: 1st storm
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Sample date	10/1/00 4 days after						
Sample #	Target organisms	MPN reading	1st dilution	Closest table MPN	Table MPN per 100 g	MPN/100 g	Standard deviation
CI #1	Fecal coliforms	540	0.5	540	130	2600	
	E. coli	530	0.5	530	80	1600	
CI #2	Fecal coliforms	541	0.5	541	170	3400	
	E. coli	541	0.5	541	170	3400	
CI ave.					Fecal coliforms	**3000**	566
					E. coli	**2500**	1273
MG #1	Fecal coliforms	531	0.5	531	110	2200	
	E. coli	500	0.5	500	23	460	
MG #2	Fecal coliforms	551	0.5	551	300	6000	
	E. coli	551	0.5	551	300	6000	
MG ave.					Fecal coliforms	**4100**	2687
					E. coli	**3230**	3917

SUMMARY

Fecal coliforms

Site	Timing	Average	Std. Dev.
CI	prior day	**550**	355
	storm day	**280**	85
	2 days after	**1530**	1800
	4 days after	**3000**	570
MG	prior day	**600**	420
	storm day	**250**	240
	2 days after	**260**	255
	4 days after	**4100**	2690

E. coli

Site	Timing	Average	Std. Dev.
CI	prior day	**465**	470
	storm day	**220**	0
	2 days after	**1530**	1800
	4 days after	**2500**	1270
CI	prior day	**600**	420
	storm day	**190**	210
	2 days after	**240**	280
	4 days after	**3230**	3920

Table 2b. Hampton Harbor clam purging study: 2nd storm

Sample date	10/5/00 previous day						
Sample #	Target organisms	MPN reading	1st dilution	Closest table MPN	Table MPN per 100 g	MPN/g sample	Standard deviation
CI #1	Fecal coliforms	5555	0.05	555	1600	3.20E+05	
	E. coli	5555	0.05	555	1600	3.20E+05	
CI #2	Fecal coliforms	553	0.5	553	900	1.80E+04	
	E. coli	553	0.5	553	900	1.80E+04	
CI ave.					Fecal coliforms	**169000**	213546
					E. coli	**169000**	213546
MG #1	Fecal coliforms	5553	0.05	553	900	1.80E+05	
	E. coli	5553	0.05	553	900	1.80E+05	
MG #2	Fecal coliforms	5555	0.05	555	1600	3.20E+05	
	E. coli	5555	0.05	555	1600	3.20E+05	
MG ave.					Fecal coliforms	**250000**	98995
					E. coli	**250000**	98995

Sample date	10/6/00 storm day						
Sample #	Target organisms	MPN reading	1st dilution	Closest table MPN	Table MPN per 100 g	MPN/g sample	
CI #1	Fecal coliforms	551	0.5	551	300	6.00E+03	
	E. coli	550	0.5	550	240	4.80E+03	
CI #2	Fecal coliforms	551	0.5	551	300	6.00E+03	
	E. coli	521	0.5	521	70	1.40E+03	
CI ave.					Fecal coliforms	**6000**	0
					E. coli	**3100**	2404
MG #1	Fecal coliforms	5531	0.05	531	110	2.20E+04	
	E. coli	5531	0.05	531	110	2.20E+04	
MG #2	Fecal coliforms	551	0.5	551	300	6.00E+03	
	E. coli	551	0.5	551	300	6.00E+03	
MG ave.					Fecal coliforms	**14000**	11314
					E. coli	**14000**	11314

Sample date	110/9/00	3 days after					
Sample #	Target organisms	MPN reading	1st dilution	Closest table MPN	Table MPN per 100 g	MPN/g sample	
CI #1	Fecal coliforms	410	0.5	410	17	3.40E+02	
	E. coli	410	0.5	410	17	3.40E+02	
CI #2	Fecal coliforms	521	0.5	521	70	1.40E+03	
	E. coli	521	0.5	521	70	1.40E+03	
CI ave.					Fecal coliforms	**870**	750
					E. coli	**870**	750
MG #1	Fecal coliforms	520	0.5	520	50	1.00E+03	
	E. coli	520	0.5	520	50	1.00E+03	
MG #2	Fecal coliforms	541	0.5	541	170	3.40E+03	
	E. coli	531	0.5	531	110	2.20E+03	
MG ave.					Fecal coliforms	**2200**	1697
					E. coli	**1600**	849

Table 2b. Hampton Harbor clam purging study: 2nd storm
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Sample date	10/10/00 4 days after						
Sample #	Target organisms	MPN reading	1st dilution	Closest table MPN	Table MPN per 100 g	MPN/g sample	Standard deviation
CI #1	Fecal coliforms	510	0.5	510	30	6.00E+02	
	E. coli	510	0.5	510	30	6.00E+02	
CI #2	Fecal coliforms	510	0.5	510	30	6.00E+02	
	E. coli	510	0.5	510	30	6.00E+02	
CI ave.					Fecal coliforms	**600**	0
					E. coli	**600**	0
MG #1	Fecal coliforms	540	0.5	540	130	2.60E+03	
	E. coli	540	0.5	540	130	2.60E+03	
MG #2	Fecal coliforms	530	0.5	530	80	1.60E+03	
	E. coli	530	0.5	530	80	1.60E+03	
MG ave.					Fecal coliforms	**2100**	707
					E. coli	**2100**	707

SUMMARY

Fecal coliforms

Site	Timing	Average	Std. Dev.
CI	prior day	**160000**	214000
	storm day	**6000**	0
	3 days after	**870**	750
	4 days after	**600**	0
MG	prior day	**250000**	99000
	storm day	**14000**	11300
	3 days after	**2200**	1700
	4 days after	**2100**	710

E. coli

Site	Timing	Average	Std. Dev.
CI	prior day	**160000**	214000
	storm day	**3100**	2400
	2 days after	**870**	750
	4 days after	**600**	0
CI	prior day	**250000**	99000
	storm day	**14000**	11300
	2 days after	**1600**	850
	4 days after	**2100**	710