2015-2017 Triennial
Shellfish Management Area Update
for the Oyster River, New Hampshire

December 2018

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2015-2017 Triennial Shellfish Management Area Update for the Oyster River, New Hampshire

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Introduction

The New Hampshire Department of Environmental Services (DES), under the authority granted by RSA 143:21 and 143:21-a, is responsible for classifying shellfish growing waters in the State of New Hampshire. The purpose of conducting shellfish water classifications is to determine if growing waters meet standards for human consumption of molluscan shellfish. The primary concern with the safety of shellfish growing waters is contamination from human sewage, which can contain a variety of disease-causing microorganisms. Shellfish pump large quantities of water through their bodies during normal feeding and respiration processes. During this time, shellfish also concentrate microorganisms that may include pathogens and a positive relationship between sewage pollution of shellfish growing areas and disease has been demonstrated many times (ISSC, 2017).

Though testing shellfish growing waters and/or shellfish meats for the pathogenic microorganisms themselves would seem to be the most direct method of determining whether or not growing waters are safe, several factors preclude this approach. Perhaps the most important is that the number of pathogens that may be in sewage is large, and laboratory methods that are practical, reliable, and cost effective are not available for all of the pathogens that may be present. Therefore, shellfish water classifications are based on evidence of human sewage contamination, which may include direct evidence (identification of actual pollution sources) or indirect evidence (elevated or highly variable indicator bacteria levels in the growing waters). If such evidence is found, then pathogens may be present, and the area is closed to harvesting. Areas may also be closed if contamination from animal waste or poisonous/toxic substances is found.

Under the authority granted by RSA 143:21 and 143:21-a, NHDES uses a set of guidelines and standards known as the National Shellfish Sanitation Program (NSSP) for classifying shellfish growing waters. These guidelines were collaboratively developed by state agencies, the commercial shellfish industry, and the federal government in order to provide uniform regulatory standards for the commercial shellfish industry. The NSSP is used by NHDES to classify all growing waters, whether used for commercial or recreational harvesting, because these standards provide a reliable methodology to protect public health. Furthermore, RSA 485-A:8 (V) states that "Those tidal waters used for growing or taking of shellfish for human consumption shall, in addition to the foregoing requirements, be in accordance with the criteria recommended under the National Shellfish Program Manual of Operation, United States Food and Drug Administration."

The sanitary survey is the process by which the shellfish management areas are accurately classified. The sanitary survey includes an evaluation of the pollution sources that may affect the areas, an evaluation of the meteorological and hydrographic factors that may affect distribution of pollutants throughout the area, and an assessment of water quality. A sanitary survey for the Oyster River was initially published in April 2003 (Nash 2003). A subsequent 12-year sanitary survey was published in December 2015 (Nash, 2015).

The NSSP requires that in addition to an annual review of the classification of the area, the management area classification and the supporting data from the sanitary survey be reviewed at least every three years. This triennial re-evaluation shall include the following:

- A review of the water quality samples.
- Documentation of any new pollution sources and an evaluation of their effect on the management area.
- Reevaluation of all pollution sources, including the sources previously identified in the sanitary survey, as necessary to fully evaluate any changes in the sanitary conditions of the management area. The reevaluation may or may not include a site visit.
- A comprehensive report which analyzes the sanitary survey data and makes a determination that the existing management area classification is correct or needs to be revised.

If the triennial re-evaluation determines that conditions have changed based on the information and data collected during the triennial review and that the management area classification is incorrect, immediate action shall be initiated to reclassify the area. If an emergency condition or situation is identified, then the management area will be immediately (within 24 hours) placed in the closed status.

The NSSP notes that work to complete a triennial reevaluation may include a number of activities, including:

- Inspection of wastewater treatment plants or collection of additional effluent samples to determine their impact on the management area.
- Hydrodynamic studies.
- Additional field work to determine the actual impact of pollution sources.
- Collection of additional water samples.

When a written triennial reevaluation report is not completed, the shellfish management area must be placed in the closed status.

This document presents the data and analyses for the 2015-2017 Oyster River triennial report.

Management Area

The tidal portion of the Oyster River begins at the Mill Pond head-of-tide dam in the town of Durham, New Hampshire, just upstream of the Route 108 crossing, and continues downstream to the river mouth at Wagon Hill Farm and Durham Point (Figure 1). Water depths are relatively shallow, with many mudflats exposed at low tide. Areas in the upper portion of the tidal section of the river exhibit low tide depths that average approximately two feet, while low tide channel depths in the lower portion of the river vary from six to fifteen feet. Water depths quickly increase to 30-60 feet just beyond the river mouth in Little Bay. The Oyster River includes approximately 330 acres of tidal waters, with 12 miles of tidal shoreline. The shoreline is predominately residential with a few agricultural fields and parks. The Town of Durham owns the Wagon Hill Farm recreational area, located near the river mouth on the northern shore. Wagon Hill Farm is a popular area for residents to walk their dogs.

In November of 2002, the NHDES Shellfish Program and the US Environmental Protection Agency conducted a dye study of the Durham, New Hampshire Wastewater Treatment Facility (WWTF) in order to determine the extent of a Prohibited area around the outfall, as required by the NSSP. That dye study determined that the Prohibited area around the outfall should encompass most of the tidal portion of the river from the head-of-tide at the Mill Pond Dam to Wagon Hill Farm and Durham Point (Nash and Bridges, 2003; Figure 1). An updated dye study on the Durham WWTF, designed to examine steady state dilution around the outfall, was performed in May 2017.

All but two commercial oyster aquaculture farms in coastal New Hampshire are located in Little Bay, and three of those are located adjacent to the mouth of the Oyster River (Figure 1). In 2017 there were 21 licensed farms ranging in size from 1.5 to 4.5 acres, plus four additional sites licensed for the operation of upwellers to raise young oyster spat. Two of those upwellers are located in the Oyster River. Larvae are acquired through a hatchery with an accompanying pathology certification (MSX and Dermo free) and are typically set on the aquaculture sites in the spring. All aquaculturists are required to contact the Shellfish Program prior to harvest to verify the open/closed status of the growing waters.

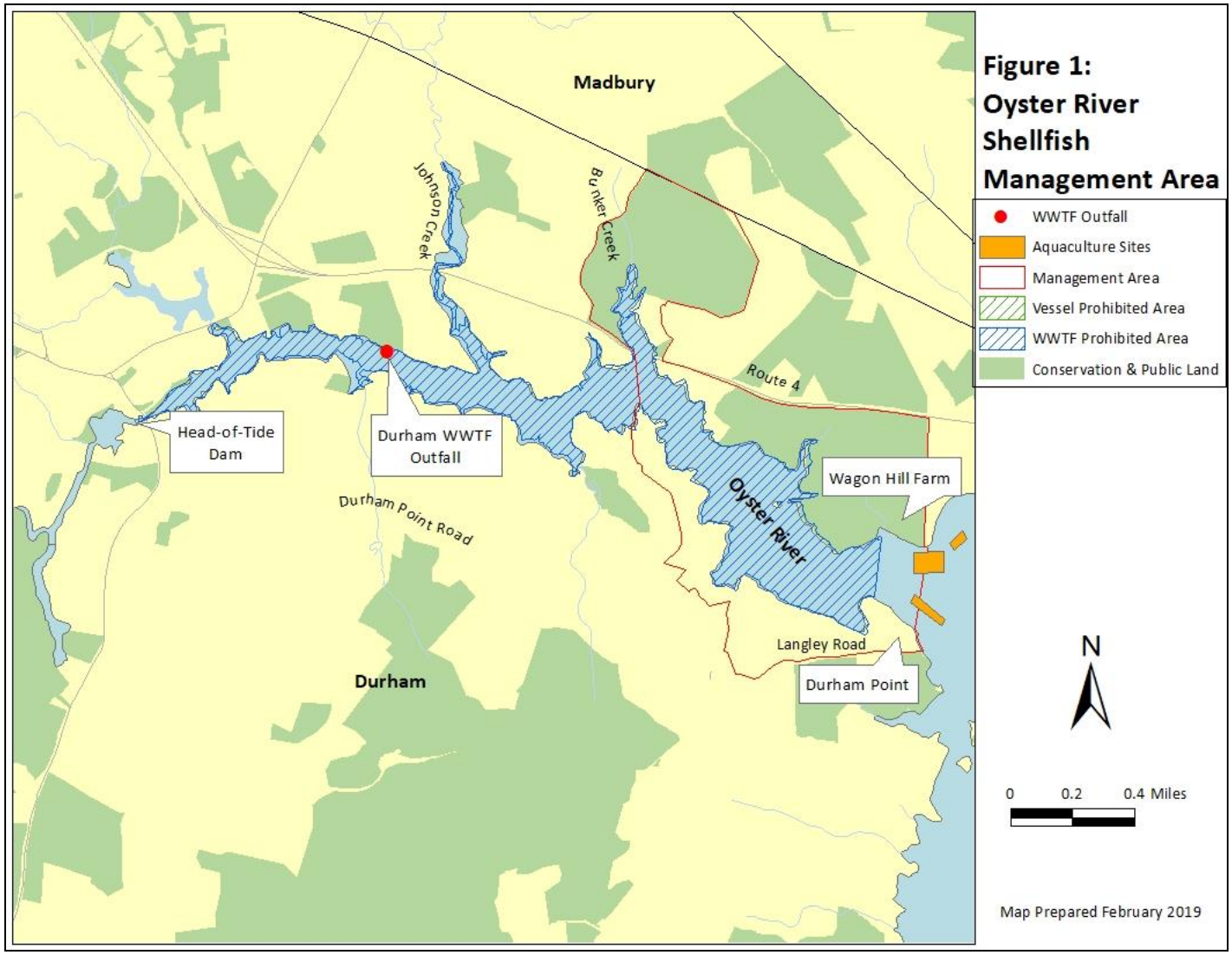


Figure 1: Oyster River Shellfish Management Area

Follow-up From Recent Reports

The most recent annual update for the Oyster River Management Area (Nash 2017) presented a number of recommendations to improve the classification of the area. These recommendations were developed from the results of previous recommendations presented in the original sanitary survey and subsequent annual/triennial updates. The italicized text describes how each recommendation has been addressed.

1. Augmented sampling of the ambient site for large rainfall events, especially storms in the 1.00-2.00 inch range, should continue to expand the database for ongoing evaluation of the appropriateness of the 1.5 inch rainfall closure threshold.

Over the triennial review period, there have been 12 samples collected at GB50 to help determine water quality impacts of rainfall in the 1.0 – 2.5 inch range. The 1.5 inch rainfall closure threshold continues to be a useful threshold to protect public health.

2. Update the 2002 dye study of the Durham wastewater treatment facility using FDA-recommended guidelines and procedures for delineation of safety zones around WWTF outfalls, including identification of the *steady state* 1,000:1 dilution area around the outfall. Adjust the current Prohibited/Safety Zone boundary as appropriate.

Field work for the dye study was done in May 2017. Examination of male specific coliphage samples in Durham WWTF effluent under a variety of operational conditions has been ongoing since 2015. Analysis of the data will continue in 2018, but preliminary analysis shows that Durham routinely achieves a high degree of MSC removal, especially when flows are low. It appears as though a 400:1 dilution area may be appropriate for part of the year. Under certain flow conditions, this 400:1 boundary would be located upstream of the current Prohibited/Conditionally Approved boundary at Wagon Hill.

3. Boat counts of the mooring field in the Oyster River should be conducted at least once a year during the summer to verify that the assumptions on which the sanitary survey is based continue to be valid. Of particular importance is verification of the size and number of vessels capable of discharging sewage. Because of the constant fluctuation in the number of moorings located in a given field, yearly updates should be made of the number of moorings in the mooring field.

Boat counts done in the summer and fall of 2015,2016, and 2017 showed boat numbers indicating very little usage of the mooring field. As part of the 2017 sanitary survey for Little Bay, an examination of how NHDES Shellfish defines and evaluates mooring fields was done. Under the new protocol, the "mooring field" in the Oyster River would no longer be considered a mooring field because of the low number of mooring balls present, and because they are so widely spaced apart.

Review of Water Quality Samples

Most of the Oyster River Shellfish Management Area is located within a Prohibited area; therefore, sampling efforts are focused primarily on the collection of samples in the vicinity of the boundary between the Prohibited area of the Oyster River and the Conditionally Approved area at the river mouth (Figure 2). These samples are taken as part of a larger sampling effort conducted for Little Bay. This area is sampled by boat for fecal coliform bacteria under the Systematic Random Sampling strategy, utilizing site GB50 (Table 1 and Figure 2). For the original sanitary survey, a second sampling location (GB51) was established in March 2002 to provide additional information on water quality flowing through the lower river, and to verify the representativeness of the data generated from site GB50. At its inception this site was also located on a possible open/closed line, pending the results of the wastewater plant dye study. When that original dye study suggested that the Prohibited line would be at GB50, sampling at GB51 was discontinued. However, the updated information from the 2017 dye study and sampling of Durham effluent suggested that moving the Prohibited line upstream might be appropriate. In anticipation of that possibility, sampling at GB51 was resumed in October 2017.

Table 1: Oyster River Ambient Sampling Station

Site	Latitude	Longitude	General Description	Rationale for Selection
GB50	43°07'23"N	70°52'14"W	Mid channel, mouth of Oyster River at Durham Point	Document general water quality, possible impact of Durham WWTF; near classification boundary
GB51	43°07'32"N	70°52'48"W	Mid channel in lower Oyster River, in vicinity of Smith Creek	Document general water quality, possible impact of Durham WWTF; near possible open/closed line

Per the NSSP guidelines for systematic random sampling, a monitoring schedule was established at the start of the year to ensure sample collection under a variety of environmental (seasonal, tidal, meteorological, etc.) conditions. Runs are scheduled to begin between 7am and 10am to randomize the tidal stage at which samples are collected. Sampling runs were rescheduled as a result of extenuating circumstances or when conditions were deemed unsafe. During this review period, several sampling runs needed to be rescheduled (Table 2). All samples were analyzed for fecal coliform MPN/100ml (5-tube method) by either the New Hampshire Department of Environmental Services state laboratory or the New Hampshire Department of Health and Human Services/Public Health Laboratory.

Table 2: Systematic Random Sampling Schedule Modifications

Date Originally Scheduled	Actual Date Sampled	Justification
3/4/15	3/30/15	The run was rescheduled due to snow and ice blocking access to boat ramp and the growing area
2/23/15	4/6/15	The run was rescheduled due to boat ramp blocked with snow.
8/10/15	8/13/15	The run was rescheduled to accommodate vibrio and male specific coliphage sampling.
10/7/15	10/15/15	The run was rescheduled to accommodate emergency

Date Originally Scheduled	Actual Date Sampled	Justification
		closure sampling on the Atlantic Coast.
12/2/15	12/4/15	The run was rescheduled to accommodate staff availability
2/23/16	2/22/16	The run was rescheduled due to time of low tide (dangerous conditions) and staff availability
5/16/16	5/17/16	The run was rescheduled due to hazardous wind and sea conditions.
8/9/16	8/17/16	The run was rescheduled due to staff availability.
10/11/16	10/10/16	The run was rescheduled to accommodate WWTF male specific coliphage sampling.
12/12/16	12/8/16	The run was rescheduled due to forecasted hazardous conditions (wind and cold).
1/23/17	1/22/17	The run was rescheduled due to forecasted snow.
2/13/17	2/21/17	The run was rescheduled due to snow.
3/13/17	3/6/17	The run was rescheduled due to staff availability (ISSC biotoxin meeting in Washington DC).
5/8/17	5/23/17	The run was rescheduled to accommodate post rainfall sampling in Hampton/Seabrook and in Great Bay Estuary.
8/16/17	8/1/17	The run was rescheduled to accommodate prescheduled Vibrio resubmergence study sampling

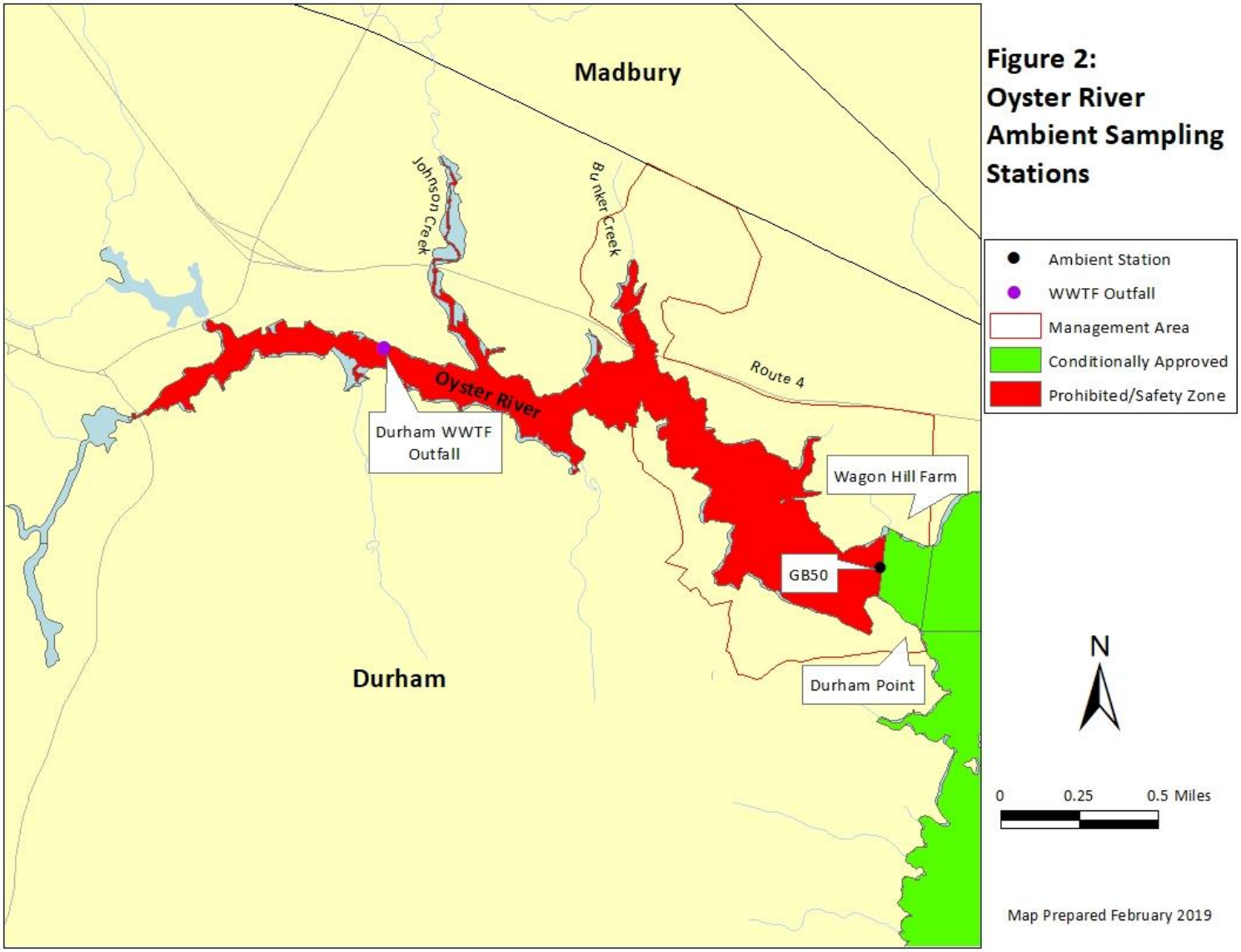


Figure 2: Oyster River Ambient Sampling Stations

Because the Oyster River Conditional Area Management Plan is based on the operation and performance of a wastewater treatment facility, monthly water samples are required when the growing area is in the open status (ISSC, 2017). Table 3 summarizes the status of the growing area for each month (if it was open part or all of the month) when samples were collected. This NSSP sampling régime was adopted by the Shellfish Program on January 1, 2007. Prior to 2007, the sampling régime outlined for areas affected by rainfall and open for less than six months was followed.

During the 2015-2017 review period, open status samples were collected in every month that harvesting was allowed. Note that for the month of May 2017, the open status samples were actually collected under the closed status, although the sampling runs were used to reopen the area. This was done because there were no other opportunities in May 2017 for a dedicated open status sampling run.

Table 3: Conditional Area Sampling Verification

2015	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Open for a portion of the month	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Date samples were collected in the open status	1/20	4/6	3/30	4/15	5/5	6/9	7/13	8/13	9/14	10/15	11/9	12/4
2016	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Open for a portion of the month	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Date samples were collected in the open status	1/6	2/22	3/9	4/6	5/17	6/13	7/13	8/17	9/12	10/10	11/14	12/8
2017	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Open for a portion of the month	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Date samples were collected in the open status	1/22	2/21	3/6	4/3	5/23 *	6/7	7/5	8/1	9/19	10/17	11/15	12/4

*samples collected when area was in the closed status, but ultimately the samples were used to reopen the area. There were no other opportunities during the month for a dedicated open status run.

Systematic random and open status samples collected from 2014 through 2017 and the relevant NSSP statistics are presented in Table 4. Station GB50 does meet NSSP fecal coliform criteria for Approved waters (geometric mean $\leq$ 14/100ml and the estimated 90th percentile statistic $\leq$ 43/100ml). However, rainfall and other data suggest an Approved classification would be inappropriate. The site is classified as Conditionally Approved. When the conditions specified in the Conditional Area Management Plan are applied to the data (i.e., exclusion of samples collected during times when the area was in the closed status), the routine monitoring stations meet NSSP criteria for Approved waters. This is discussed in greater detail in the "*Conditional Area Data Review*" section of this report.

Table 4: **2008 – 2011 Fecal Coliform (per 100ml) Samples for Oyster River Sampling Stations GB50 and GB51**

Fecal coliform (MPN/100ml) data for samples collected under the Systematic Random Sampling program. Samples over 43 MPN/100ml are in bold font. Samples collected during the closed status are shaded.

4-Day Rain Total (in)	Collection Date	GB50	GB51**
0.30	1/13/2014	**79**	---
0.71	2/24/2014	4.5	---
0.00	3/11/2014	<2	---
0.95	4/8/2014	2	---
0.05	5/6/2014	<2	---
0.09	6/11/2014	4.5	---
2.44	7/7/2014	17	---
0.25	8/6/2014	2	---
0.09	9/2/2014	6.8	---
0.61	10/6/2014	4.5	---
0.41	11/5/2014	7.8	---
0.00	12/1/2014	32	---
0.14	1/20/2015	17	---
0.72	3/30/2015	6.1	---
0.13	4/6/2015	23	---
0.02	4/15/2015	7.8	---
0.00	5/5/2015	<2	---
0.00	6/9/2015	4.5	---
0.13	7/13/2015	<2	---
0.74	8/13/2015	7.8	---
1.60	9/14/2015	**49**	---
0.00	10/15/2015	<2	---
0.00	11/9/2015	<2	---
0.30	12/4/2015	7.8	---
0.00	1/6/16	13	---
0.00	2/2/16	17	---
0.00	2/22/16	1.8	---
0.00	3/9/16	6.8	---
0.31	4/6/16	7.8	---
0.17	5/17/16	2	---
0.09	6/13/16	<2	---
0.73	7/13/16	<2	---
0.62	8/17/16	<2	---
0.23	9/12/16	2	---
1.28	10/10/16	23	---
0.00	11/14/16	2	---
	12/8/16	11	---
0.00	1/22/17	2	---
0.00	2/21/17	<2	---

4-Day Rain Total (in)	Collection Date	GB50	GB51**
0.00	3/6/17	<2	---
0.00	4/3/17	<2	---
0.34	5/23/17*	11	---
1.25	6/7/17	23	---
0.00	7/5/17	<2	---
0.00	8/1/17	2	---
0.19	9/19/17	4	---
0.00	10/17/17	4.5	4.5
2.42	11/1/17	**110**	**79**
0.15	11/15/17	<2	11
0.07	12/4/17	17	14
	Count	50	3
	Geomean	5.4	---
	Est 90th	22.5	---
	Water Quality	A	---
	Classification	P	---

*per NSSP, two runs used to reopen a closed area may be used for stats.

** Site GB51 was created in March 2002, during the original sanitary survey, but was discontinued in 2003 when the area was classified as Prohibited. Following the Durham dye study in May 2017, it was reactivated when the dye study data suggested the area could possibly qualify for a Conditionally Approved classification. All of the historical data for Site GB51 are presented in Table 10.

Statistics for ambient sampling site GB50 are calculated on an annual basis and are published in Annual Shellfish Management Area Updates. Table 5 presents these annual statistics for the last three years. Data for GB51 are not included in Table 5 because that site only has four samples in the last three years. GB50 shows relatively stable statistics over the study period.

Table 5: Summary of the Ambient Sampling Station GB50 Yearly Statistics

Year	GB50 All Data	GB50 Open Status Only
Geometric Mean		
2015	5.2	5.1
2016	5.4	5.2
2017	5.4	5.1
Est. 90th Percentile		
2015	18.9	18.0
2016	20.9	19.6
2017	22.5	19.0

Documentation and Evaluation of New Pollution Sources

Land Use Changes

During the 2015-2017 field seasons, NHDES Shellfish Program staff noted land use changes in the Oyster River Shellfish Management Area during both routine field work and annual drive-through surveys. In addition to the field investigations, NHDES staff examined the NHDES Wetlands and Subsurface Permit databases to find if any permits were given in the last three years to properties within the Oyster River Shellfish Management Area.

The drive-through surveys and permit database queries identified three property modifications (Table 6; none in 2017)), none of which are anticipated to adversely affect water quality in the Oyster River shellfish growing waters.

Table 6: Oyster River Management Area Property Modifications

TOWN	TAX MAP	TAX LOT	DESCRIPTION
Durham	11	24-3	(2015): Piscataqua Road. Subsurface construction approval for a septic system (500 gpd) issued on 08/27/2015. Operational on 09/22/2015. No pollution sources previously identified by NHDES Shellfish on the property.
Durham	12	8-2	(2016): 156 PISCATAQUA ROAD ROUTE 4 Expedited Application (approved): Install a 30' long temporary wave/ice-barrier-like test structure constructed of wooden posts and coir logs in the inter-tidal zone to collect data as a first phase of potential future living shoreline restoration at an eroded shoreline area of Town of Durham Wagon Hill Farm at the mouth of the Oyster River. Two pollution sources previously identified by NHDES Shellfish on the property. OYSPS009 is a 1-2ft wide intermittent stream, and OYSPS010 is a 2-3ft wide intermittent stream. This permitted work is not anticipated to affect fecal coliform loading from these two sources.
Durham	23	18	(2016): 16 DEER MEADOW RD Permit by Notification (PBN complete): Repair in-kind an existing tidal docking structure including repairs to existing crib support, permanent pier, and replace rotted or damaged pilings. No pollution sources previously identified by NHDES Shellfish on the property.

In addition to the property alterations in Table 6, the Durham WWTF implemented some treatment and infrastructure upgrades during the study period. In 2015, upgrades at the WWTF included new screw presses, a new chemical building, to replace interior hypochlorite tanks and exterior bisulfite tanks, and new waste activated sludge pumps. Additionally, 550 feet of Baghdad sewer line replacement was completed. In 2017, a new generator was installed and put online at the WWTF. The WWTF started adding a new carbon source to the activated sludge system to improve nitrogen removal, installed two new R.A.S. (return activated sludge) pumps, and rebuilt a secondary clarifier. As for infrastructure improvement, the Town of Durham replaced the main pump at Dover Road pump station, completed a new roof and new driveway for Oyster River pump station, and slip-lined 1,000 feet of sewer line on Baghdad Road.

Re-evaluation of Existing Pollution Sources

Perhaps the most significant pollution source with the potential to affect the growing area is the municipal wastewater treatment facility in Durham, which discharges directly to the tidal portion of the Oyster River. Evaluation of the facility's impact is described below.

Durham Wastewater Treatment Facility

The Durham WWTF is a secondary treatment plant with chlorine disinfection. The facility is located on the immediate shore of the tidal portion of the Oyster River near Johnson Creek, approximately 4,500 feet downstream of the tidal dam and approximately 11,000 feet upstream of the mouth of the Oyster River near Durham Point in Little Bay.

The most recent NPDES permit (NH0100455) for Durham became effective on January 29, 2000 and expired on January 29, 2005. An application for permit renewal was received by EPA on June 11, 2004 and is still under review. The annual compliance inspection reports for 2015, 2016, and 2017 by the NHDES Wastewater Engineering Bureau show no significant deficiencies in regards to effluent bacteria concentrations, plant flow levels, or operation of the disinfection system.

Review of the facility's Monthly Operations Reports (MORs) shows the facility routinely meets its bacteria permit limits. The four elevated fecal coliform readings in October 2016 were caused by a foaming problem in the main aeration tank interfering with disinfection effectiveness. Plant flows show seasonal characteristics, with highest values in the spring (Table 7).

Table 7: Durham WWTF Flow and Bacterial Monitoring Data (from Monthly Operations Reports)

Month	2015 Flow (MGD)		2015 Fecal Coliform (per 100ml)		2016 Flow (MGD)		2016 Fecal Coliform (per 100ml)		2017 Flow (MGD)		2017 Fecal Coliform (per 100ml)	
	Mon. Avg. (low)	Mon. Avg. (high)	Mon. Avg.	Num. of Samples >43 per 100ml	Mon. Avg. (low)	Mon. Avg. (high)	Mon. Avg.	Num. of Samples >43 per 100ml	Mon. Avg. (low)	Mon. Avg. (high)	Mon. Avg.	Num. of Samples >43 per 100ml
Jan	0.55	1.07	1.1	0	0.58	1.48	1.2	0	0.67	1.42	1	0
Feb	0.74	1.08	1.2	0	0.85	1.99	0	0	0.85	2.18	1.1	0
Mar	0.67	1.93	1.0	0	0.68	1.60	1.0	0	0.63	1.79	1.1	0
Apr	1.11	2.43	1.1	0	0.90	1.58	1.0	0	0.93	2.63	1.1	0
May	0.41	1.10	1.1	0	0.43	1.09	1.0	0	0.77	1.76	1.4	0
Jun	0.41	0.98	1.2	0	0.38	0.66	0	0	0.59	1.04	1.1	0
Jul	0.48	0.89	1.5	1 (491)	0.38	0.73	1.1	0	0.46	0.71	1.1	0
Aug	0.42	0.84	1.0	0	0.39	0.87	1.2	0	0.43	1.01	1.1	0
Sep	0.75	1.36	0	0	0.64	1.07	1.4	0	0.83	1.18	1.1	0
Oct	0.70	1.40	1	0	0.62	1.60	3.2	4 (51,125, 74,46)	0.79	1.71	1.0	0
Nov	0.43	1.19	1.1	0	0.55	1.45	1	0	0.49	1.19	1.1	0
Dec	0.59	1.02	0	0	0.45	1.75	1	0	0.45	1.01	1.0	0

A hydrographic dye study was initially conducted on the Durham WWTF in 2002 (Nash and Bridges, 2003). That study involved a three-hour injection of dye into the effluent stream, and surface tracking of dye on the ebbing tide using fluorometers towed behind boats. That study established that insufficiently diluted effluent from the WWTF arrived at Bunker Creek after three hours and at the mouth of the Oyster River after four hours.

A new hydrographic dye study for the Durham WWTF was conducted in May 2017. This study was designed to incorporate different injection and data analysis protocols more recently adopted in the NSSP, namely, a 12.4-hour injection of dye, in-situ measurements of dye concentration at fixed stations to allow for estimation of steady-state dilution, mobile fluorometer tracking, and vertical profiling of dye concentration at selected locations. The injection began at 1:53am on 5/3/17 (slack low tide), continued through the flooding tide (slack high at the WWTF was around 7:20am on 5/3/17), and then continued through the ebbing tide. The injection was terminated at 2:17pm on 5/3/18.

The data from the 2017 study is currently under review and will be formulated into a report to help better understand the possible effects of the WWTF on the nearby growing waters. However, a preliminary review of the data allows some decisions regarding the proper classification and management of the Oyster River.

Fluorometers at fixed locations were placed in various locations in the Oyster River, Little Bay, Bellamy River, and Great Bay. Station locations, as well as the estimated steady state dilution for each station, are illustrated in Figure 3. Note that Station 9 was located at Fox Point and the instrument never turned on, so no data are available at that site. Data for Station 8 in the Bellamy River and Station 6 in Great Bay at Nannie Island are still being developed.

The station data, as well as mobile fluorometer tracking, are helpful for estimating time of travel of effluent discharged to the Oyster River. Figure 4 presents information on time of travel on the first ebbing tide between the WWTF and the mouth of the Oyster River. The in-situ fluorometer at Station 2, moored in approximately 10 feet of water just downstream of Bunker Creek, registered dye at 9:50am (approximately 2.5 hours after slack high tide at the WWTF). Surface tracking data indicated the dye was present at this location before 9:50am. The in-situ fluorometer at Station 3, moored in approximately 15 feet of water at the mouth of the Oyster River, just downstream of Wagon Hill Farm, registered dye at 1:54pm (a little more than six hours after slack high tide at the WWTF). Surface tracking data indicated the dye was present at this location well-before that time, with surface dye measurements observed around 10:15, about three hours after the time of high tide at the WWTF.

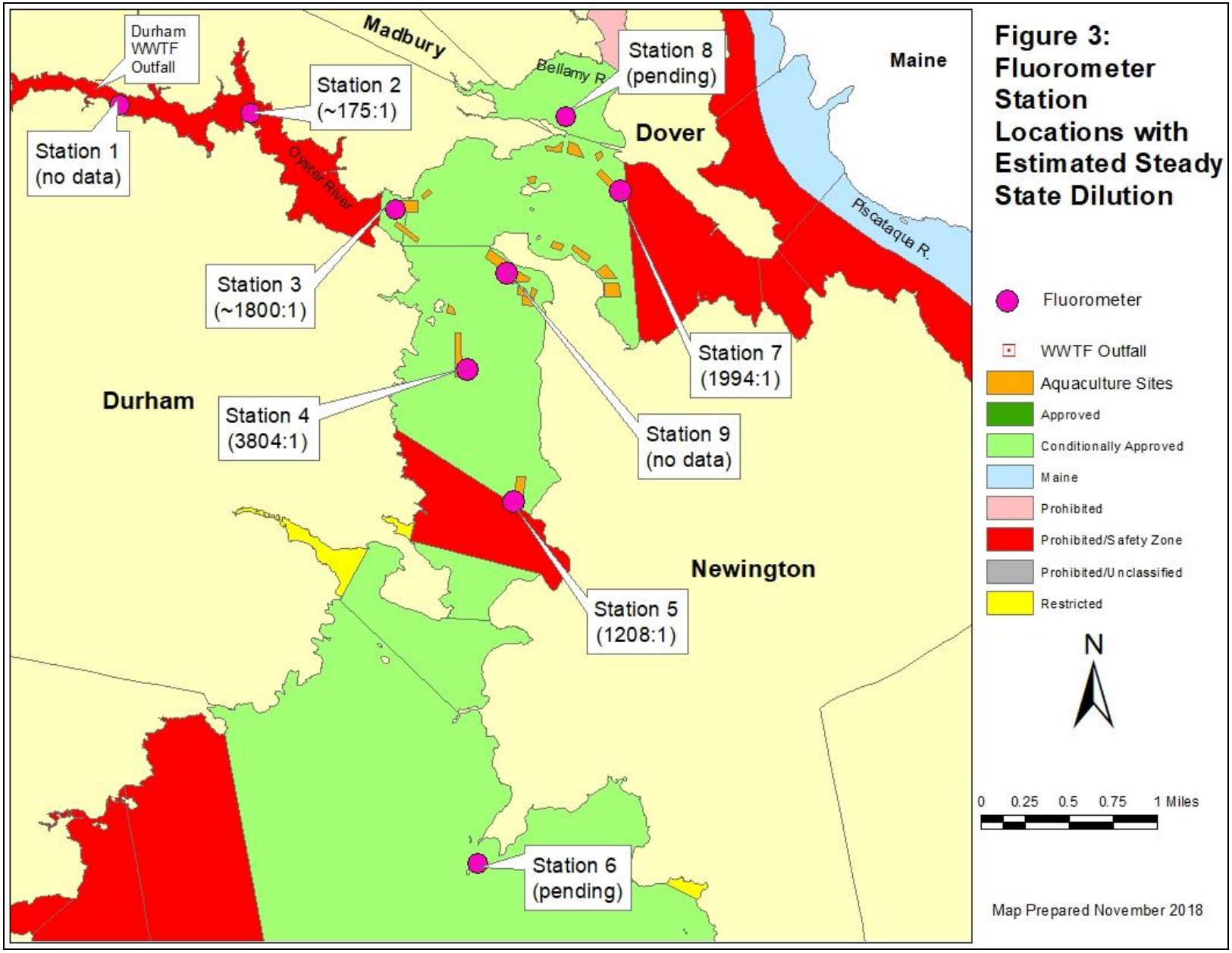
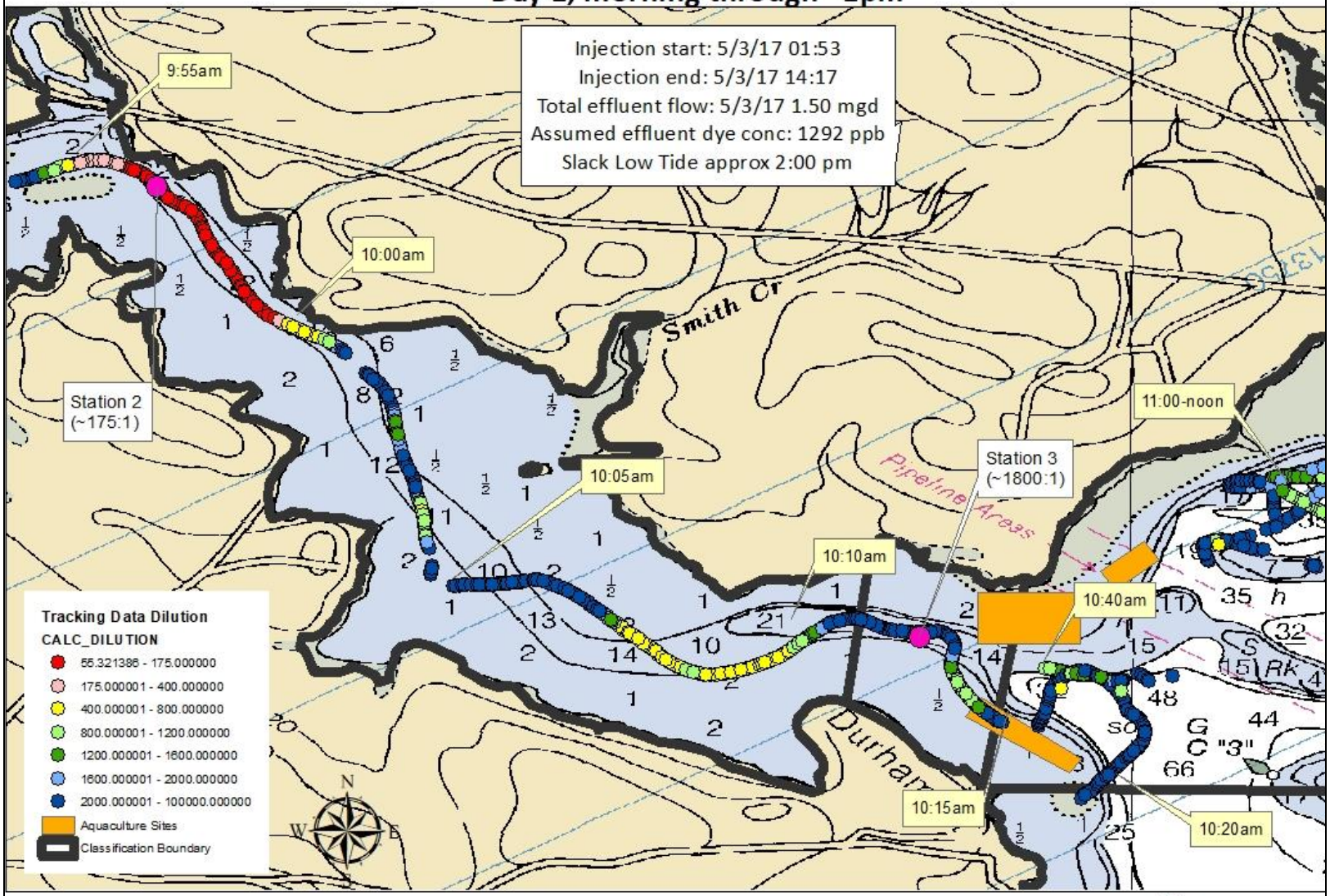


Figure 3: Fluorometer Station Locations with Estimated Steady State Dilution

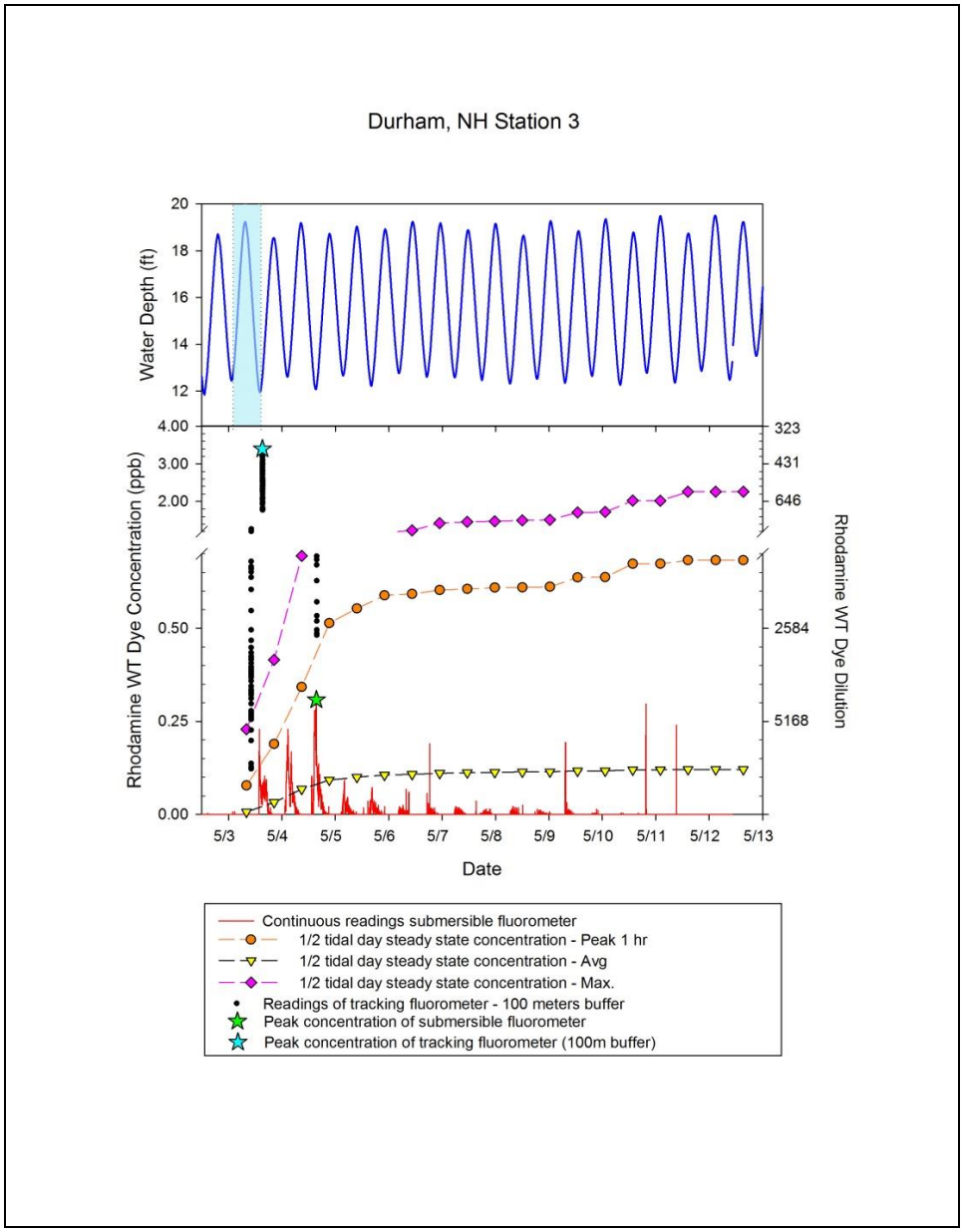
Figure 4: Surface Dye Tracking, Ebbing Tide
Day 1, morning through ~1pm



Pink Dots are stations with in situ fluorometers (estimated peak 1-hr steady state dilution in parentheses)

Additionally, concurrent measurements of dye concentrations at the surface versus depth in the Oyster River itself indicate higher dye readings on the surface. Figure 5 shows the dye concentrations measured by the stationary fluorometer on the bottom of the Oyster River at Station 3 (red lines), as well as concurrent surface measurements near the surface at the same time and location, taken from the towed tracking fluorometer (black dots). The surface estimates are up to 10 times higher than the corresponding depth measurements.

Figure 5: Dye Concentrations and Projected Steady State Dilution at Station 3

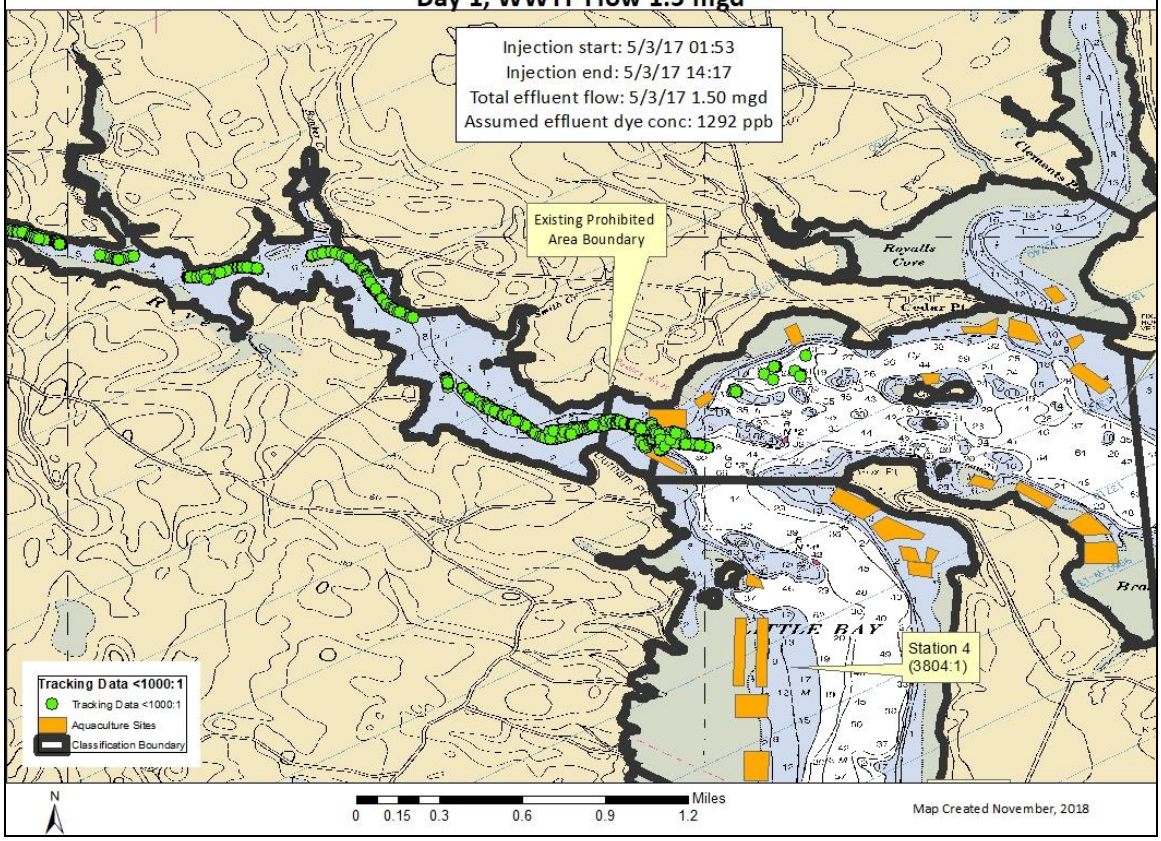


Estimation of steady state dilution shows that bottom water dilution was over 1,000:1 at the mouth of the river during the study (note the WWTF flow was rather high, at approximately 1.5 mgd). Steady state dilution numbers for more shallow waters, where aquaculture activity would

be occurring, is not available (stationary fluorometers are typically not deployed in these shallow environments as there is a risk of them being exposed at low tide during the study). A conservative approach to considering the surface data would be to regard those data as steady state. This is done in Figures 6 and 7.

Standard NSSP guidance for a secondary treatment facility under normal operating conditions is to delineate a Prohibited area around the outfall that provides for at least 1,000:1 dilution. In Figure 6, tracking data points on Day 1 with dilution <1,000:1 are shown. Several points occurred in the area that is Conditionally Approved.

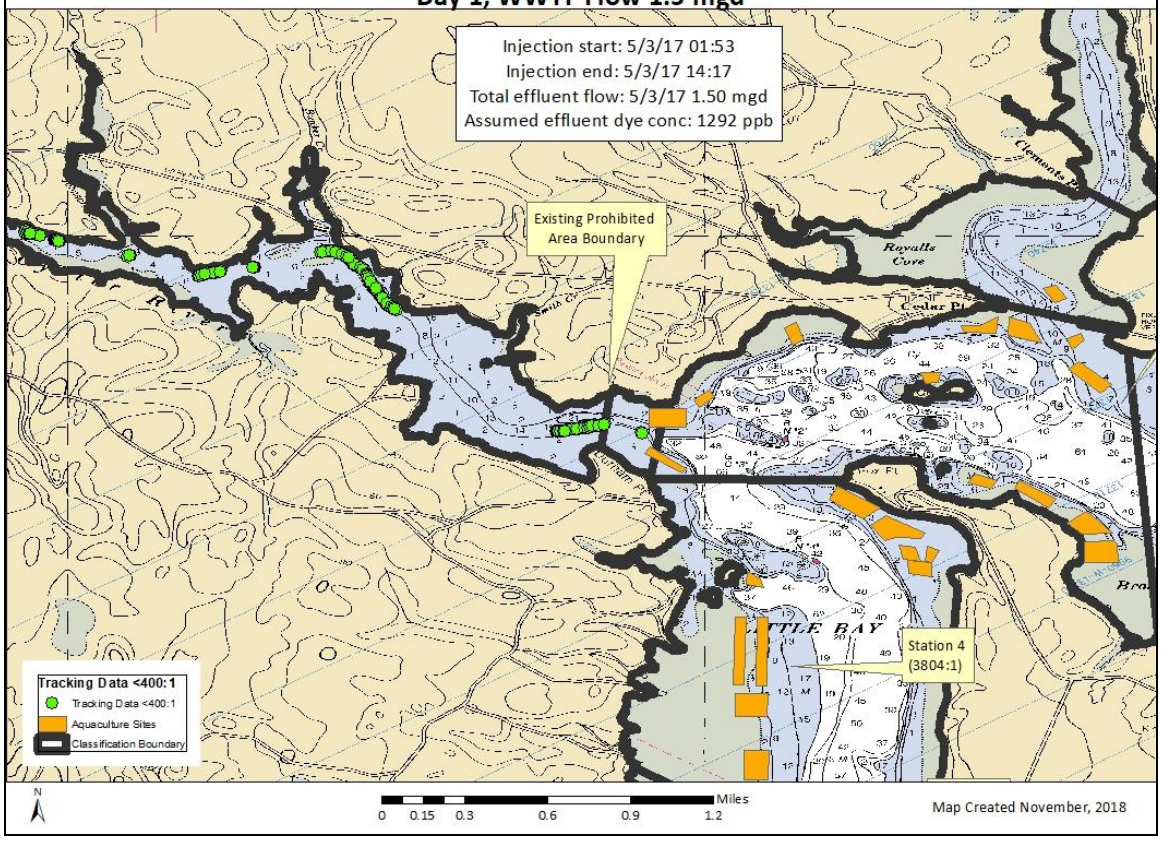
Figure 6: Surface Dye Tracking Data with Dilution <1000:1
Day 1, WWTF Flow 1.5 mgd



For WWTFs that are very efficient at removing viruses from the final effluent, the 1,000:1 dilution standard can be relaxed. A standard of 400:1 has been used for some highly efficient plants in other parts of the country, and may be appropriate when a reliable and predictable level of removal efficiency is documented (FAO and WHO, 2018). A great deal of sampling effort has been directed at documenting the MSC removal efficiency of the Durham WWTF under different operational conditions, and understanding how flow changes in response to weather (Appendix I). Examination of the data suggests that as long as the facility is not under operational stress from high flows (or perhaps even with rapidly changing flows such as when UNH students return to campus after the summer session or some other extended break), a

400:1 standard is appropriate for the Durham WWTF outfall. Data in Figure 6 were queried again to show only points with dilution of less than 400:1 (Figure 7).

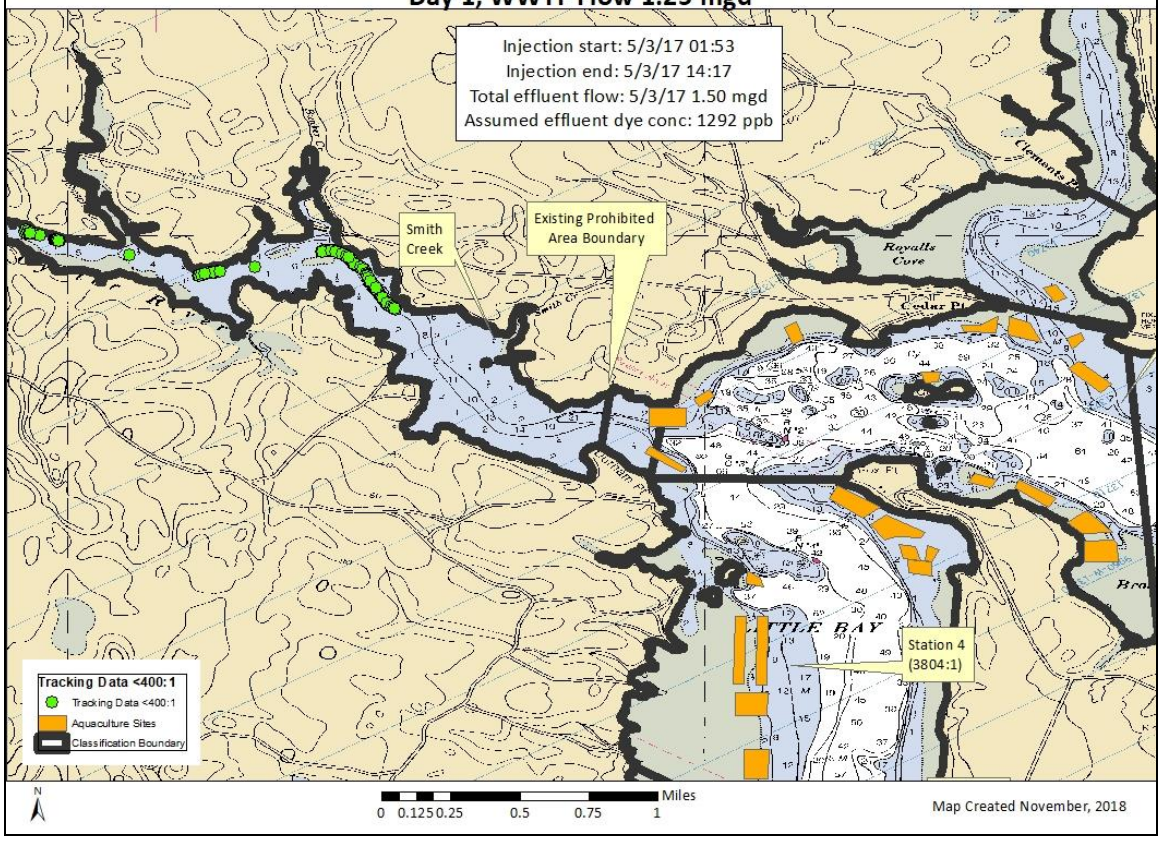
Figure 7: Surface Dye Tracking Data with Dilution <400:1
Day 1, WWTF Flow 1.5 mgd



The 400:1 map in Figure 7 illustrates surface measurements with less than 400:1 when the WWTF is flowing at 1.5 mgd. That is a relatively high flow, not typical of WWTF operations during most of the year. During the main harvest season of summer and early fall, the plant is typically operating in the range of 0.5 – 1.0 mgd.

When the dilution values are adjusted for a lower flow value of 1.0 mgd, and even 1.25 mgd, the green points near the existing Prohibited area boundary shown in Figure 7 disappear (Figure 8). This suggests an area of the Oyster River upstream of that boundary, in the vicinity of Smith Creek, is appropriate for conditional harvest, so long as the WWTF flow is low enough to not compromise MSC removal efficiency. Such an adjustment is ultimately adopted in the present sanitary survey report, and is shown in the final classification map in Figure 10.

Figure 8: Surface Dye Tracking Data with Dilution <400:1
Day 1, WWTF Flow 1.25 mgd



During episodes of high flow, MSC removal efficiency appears to degrade. At some flow level above 1.5 mgd, the use of 400:1 dilution is no longer appropriate in the Oyster River, and the use of 1,000:1 may no longer be appropriate in the Oyster River and/or portions of Little Bay. This issue will be more closely examined in the dye study report currently being drafted for the May 2017 dye study. Should a flow higher than 1.5 mgd present a public health issue for the Conditionally Approved waters of Little Bay, the Little Bay Conditional Area Management Plan will be adjusted accordingly.

Portsmouth Wastewater Treatment Facility

The Portsmouth Municipal Wastewater Treatment Facility is a 4.8 mgd primary treatment facility that discharges to the Lower Piscataqua River. Although the outfall is located several miles away from Great Bay, a 2012 hydrographic study (Ao et. al, 2017) illustrated that a disinfection failure occurring at low tide could result in insufficiently diluted effluent reaching Little Bay in approximately 4.5 hours.

The most recent NPDES permit (NH0100234) for the Portsmouth WWTF became effective on August 1, 2007 and expired on July 31, 2012. A new permit has not yet been issued. The most recent compliance inspection report by the NHDES Wastewater Engineering Bureau (August

2017) shows no significant deficiencies in regards to effluent bacteria concentrations or operation of the disinfection system. Review of the facility's Monthly Operations Reports shows the facility routinely meets its bacteria permit limit (Table 8), but frequently exceeds its design flow. The City of Portsmouth is currently operating under a consent decree to upgrade the existing primary treatment facility to secondary treatment. Construction began in 2017. Because the process of upgrading the Portsmouth WWTF to secondary treatment will involve a substantial amount of time and money, the City has been given interim permit limits by the EPA. The new permit will not become active until the construction of a new secondary treatment plant is completed (construction estimated to be done December 2019, with the plant fully operational by April 2020). Although the WWTF routinely exceeds its design flow of 4.8 mgd, their interim permit limits only require that they report effluent flow volumes. Therefore, as long as they report flow levels, they are in full compliance with their permit (S. Larson, NHDES Wastewater Engineering Bureau, personal communication).

In December 2012, the U.S. Food and Drug Administration and NHDES conducted a hydrographic dye study of the Portsmouth municipal WWTF on Peirce Island (Ao et.al, 2017). The 2012 study includes a simulation of a hypothetical disinfection failure at the WWTF, using an effluent fecal coliform concentration assumption of 1,000,000 FC/100ml. This rather high assumption is based on repeated sampling of pre-disinfection effluent at the facility, and is much higher than an assumption that would be appropriate for a secondary treatment facility. The 2012 study indicates that for a disinfection failure occurring at slack low tide, insufficiently diluted effluent would reach Little Bay during the first flooding tide, in approximately 4.5 hours, and would travel throughout Little Bay and into the Oyster River during that first flood tide. Dye concentrations in Lower Little Bay were higher than those observed in Upper Little Bay, where dye patches were more diffuse and diluted. Observed dilution was not enough to dilute effluent with 1,000,000 FC/100ml (a very high assumed fecal coliform concentration, deemed reasonable because Portsmouth is not currently a secondary treatment facility) down to 14 FC/100ml. For this reason, recreational harvest in Little Bay and at the mouth of the Oyster River is now only allowed on Saturdays, 9:00am-sunset. This management strategy affords the City of Portsmouth and NHDES sufficient time to detect WWTF operational problems that might occur on Friday evening/early Saturday morning. If such problems result in the discharge of high bacteria effluent, NHDES can implement and communicate a harvest closure to recreational harvesters in a timely manner.

When the new secondary facility is operational, the classification of this area can be revisited because the assumed FC concentration of effluent under a disinfection failure scenario will probably be much lower than 1,000,000 FC/100ml.

Table 8: Portsmouth WWTF Flow and Bacterial Monitoring Data (from Monthly Operations Reports)

Month	2015 Flow (MGD)		2015 Fecal Coliform (per 100ml)		2016 Flow (MGD)		2016 Fecal Coliform (per 100ml)		2017 Flow (MGD)		2017 Fecal Coliform (per 100ml)	
	Mon. Avg. (low)	Mon. Avg. (high)	Mon. Avg.	Num. of Samples >43 per 100ml	Mon. Avg. (low)	Mon. Avg. (high)	Mon. Avg.	Num. of Samples >43 per 100ml	Mon. Avg. (low)	Mon. Avg. (high)	Mon. Avg.	Num. of Samples >43 per 100ml
Jan	3.028	7.107	1.1	0	3.60	12.17	1.1	0	3.772	7.908	1.1	0
Feb	2.82	5.194	1.1	0	3.318	9.265	1.1	0	3.143	10.990	1.1	0
Mar	2.722	9.83	1.0	0	4.275	9.022	1.4	0	3.468	8.127	1.0	0
Apr	4.355	14.74	1.3	1 (43)	3.172	6.367	1.1	0	4.297	14.487	1.2	1 (60)
May	2.715	4.221	1.1	0	2.632	4.298	1.1	0	4.069	11.187	1.3	1 (115)
Jun	2.596	9.323	1.3	0	2.421	5.398	1.3	0	3.086	5.807	1.0	0
Jul	2.635	5.234	1.2	0	2.387	4.427	2	2 (194, 249)	2.465	4.104	1.1	0
Aug	2.535	4.353	1.4	0	2.308	3.767	1.3	1 (59)	2.331	5.305	1.2	1 (44)
Sep	2.319	9.032	1.2	0	2.113	4.223	1.5	2 (86, 78)	2.268	5.216	1.2	0
Oct	2.466	6.309	1.2	0	2.213	8.122	1.3	1 (135)	2.190	7.534	2.0	1 (75)
Nov	2.524	6.277	1.1	0	2.634	5.588	1.0	0	2.562	3.992	1.1	0
Dec	2.787	7.248	1.0	0	2.819	8.861	1.3	1 (80)	2.580	3.959	1.1	0

Another issue with respect to Portsmouth's influence on Little Bay and Oyster River water quality is the chronic loading of viruses to the estuary. The December 2012 dye study of the Portsmouth WWTF included multiple measurements of male-specific coliphage in the effluent. Male-specific coliphage (MSC) is a viral indicator, used as a means to assess the possible presence of viral pathogens in municipal wastewater streams. The December 2012 study found very high levels of MSC in Portsmouth effluent. This prompted a more robust, multi-year characterization of MSC concentration and variability in Portsmouth effluent to examine MSC levels under various operational conditions. The multi-year study also included periodic measurements of MSC levels in Little Bay seawater and shellfish tissue, in order to gauge possible public health risks to consuming shellfish that may be affected by Portsmouth effluent.

The multi-year study showed that Portsmouth effluent typically has MSC concentrations well over 10,000 plaque-forming units per 100ml, and sometimes approached 1,000,000 pfu/100ml (Figure 4). This is a very high value compared to MSC levels in other coastal WWTFs, all of which employ more advanced treatment technologies. MSC values at these secondary treatment facilities typically range from <10 – 250 pfu/100ml, and rarely exceed a value of 1,000 pfu/100ml. Current NSSP guidance for well-run secondary treatment facilities calls for a Prohibited zone around the outfall large enough to provide a minimum of 1,000:1 dilution. Applying that dilution value to typical secondary treatment effluent MSC concentrations, the NSSP guidance would call for MSC concentration in the seawater at the Prohibited area boundary to be in the range of 250/1000 = 0.25 MSC/100ml. In the case of Portsmouth, the December 2012 dye study established a steady-state dilution value of approximately 4,600:1 at entrance to Little Bay at Dover Point. Achieving a 0.25 MSC/100ml in Dover Point seawater would mean Portsmouth effluent should not exceed 1,150 MSC/100ml. The multi-year study

documented that Portsmouth effluent routinely exceeds this amount, often by a factor of 100. Indeed, seawater MSC concentrations in Little Bay, particularly in the cold weather months when MSC persists in the environment, are typically in the range of 10-40 pfu/100ml (Table 6). This is particularly concerning because the persistence of MSC in the seawater first occurs in the fall, when cooling water temperatures prompt more vigorous feeding activity in shellfish, leading to a more pronounced bio-accumulation of virus particles in their gut. This tissue accumulation was consistently documented in Little Bay shellfish during the fall/winters of 2013-2017.

The combination of high MSC concentration in Portsmouth effluent, insufficient dilution at Dover Point, and unacceptably high MSC concentration in seawater entering Little Bay during the fall and winter months, prompted NHDES to implement a seasonal closure of Lower Little Bay (including the mouth of the Oyster River) and the Bellamy River in October 2018. The seasonal closure will be lifted on April 1, 2019. A similar closure will be implemented October 2019-March 2020. The Portsmouth WWTF upgrade to secondary treatment, which is expected to dramatically reduce effluent MSC levels, is scheduled for completion in April 2020. The continuation of seasonal cold-weather closures in Lower Little Bay will be revisited once MSC levels in effluent from the upgraded facility are confirmed.

Wastewater Treatment Facility Infrastructure

In case of a discharge of improperly treated or raw sewage from a WWTF or from sewage collection infrastruction such as pump stations or sewer lines, WWTF staff is required to immediately contact the NHDES Shellfish Program.

The Town of Durham reported two 500-gallon infrastructure overflows in 2015, both occurring in November. The first involved 500 gallons released due to a Baghdad Road sewer line blockage. No discharge reached surface waters. The second involved 500 gallons of sludge from a blown end cap at the WWTF, some of which migrated offsite but did not reach surface waters. In 2016, the Town of Durham reported no infrastructure overflows. In 2017, the Town of Durham reported no sewage overflow events, although they did have one instance of 56,000 gallons of undisinfected effluent discharged to the Oyster River. A May 2017 thunderstorm disrupted chlorine pumps. Adjacent Conditionally Approved waters were closed for harvest at the time, and evaluation by the NHDES Program indicated this event would likely not have adversely affected the Conditionally Approved growing waters.

The City of Portsmouth reported no infrastructure overflows in 2015. The City of Portsmouth reported several minor discharges and two larger discharges in 2016. The largest involved 52,000 gallons of sewage discharge to the Piscataqua River (classified as Prohibited) from a failed pump station on Deer Street. Another 5,000-gallon discharge of combined sewage overflow to South Mill Pond (classified as Prohibited) occurred during a heavy rainfall event. None of the Portsmouth discharges were large enough to affect the water quality in the Oyster River. In 2017, the City of Portsmouth reported six instances of sewage discharge. Most were minor in nature, although a February incident involving discharge of 58,000 gallons of raw sewage was significant. A contractor hit a 24-inch sewer line on Peirce Island, near the WWTF, with an excavator. Discharge went into the nearby Piscataqua River (Prohibited).

Non-Permitted Pollution Sources

For this review period, the evaluation of the potential sources of pollution previously identified in the Oyster River Shellfish Management Area focused on conducting site visits and updating fecal coliform concentration data under dry and/or wet weather conditions. From previous shoreline surveys, 14 individual stations were identified for sampling and/or evaluation. OYSPS013 is a station to sample raw influent at the Durham WWTF, and there was no reason to sample this station for the triennial report. OYSPS012 is the outfall of the Durham WWTF, and it was not sampled by NHDES Shellfish Program staff because treated effluent is repeatedly tested by the WWTF staff and reported in the Discharge Monitoring Reports. OYSPS015 was not sampled because it was a shore site originally established to assess water quality at the mouth of the river. There is an ambient boat station (GB50) already located at the mouth of the river that is sampled on a regular basis, so it was sampled instead of OYSPS015.

At the start of 2011, all previous data for the Oyster River sources were reviewed, and sampling plans were devised for each. Each station was sampled once in dry weather and once in wet weather except for OYSPS011, which was only sampled in wet weather. These stations were sampled by land using a sampling pole, by land using a bridge sampler, or by boat using a sampling pole. They all showed low to no flow and no significant change in FC loading rates since the previous triennial (Table 8).

Sampling results for all sites are summarized in Appendix II. Figure 9 illustrates locations for all of the Oyster River "active" sampling stations that were sampled and/or evaluated during the 2009-2011 triennial review period. Pollution source sampling data collected during the 2015-2017 review period are presented in Table 9.

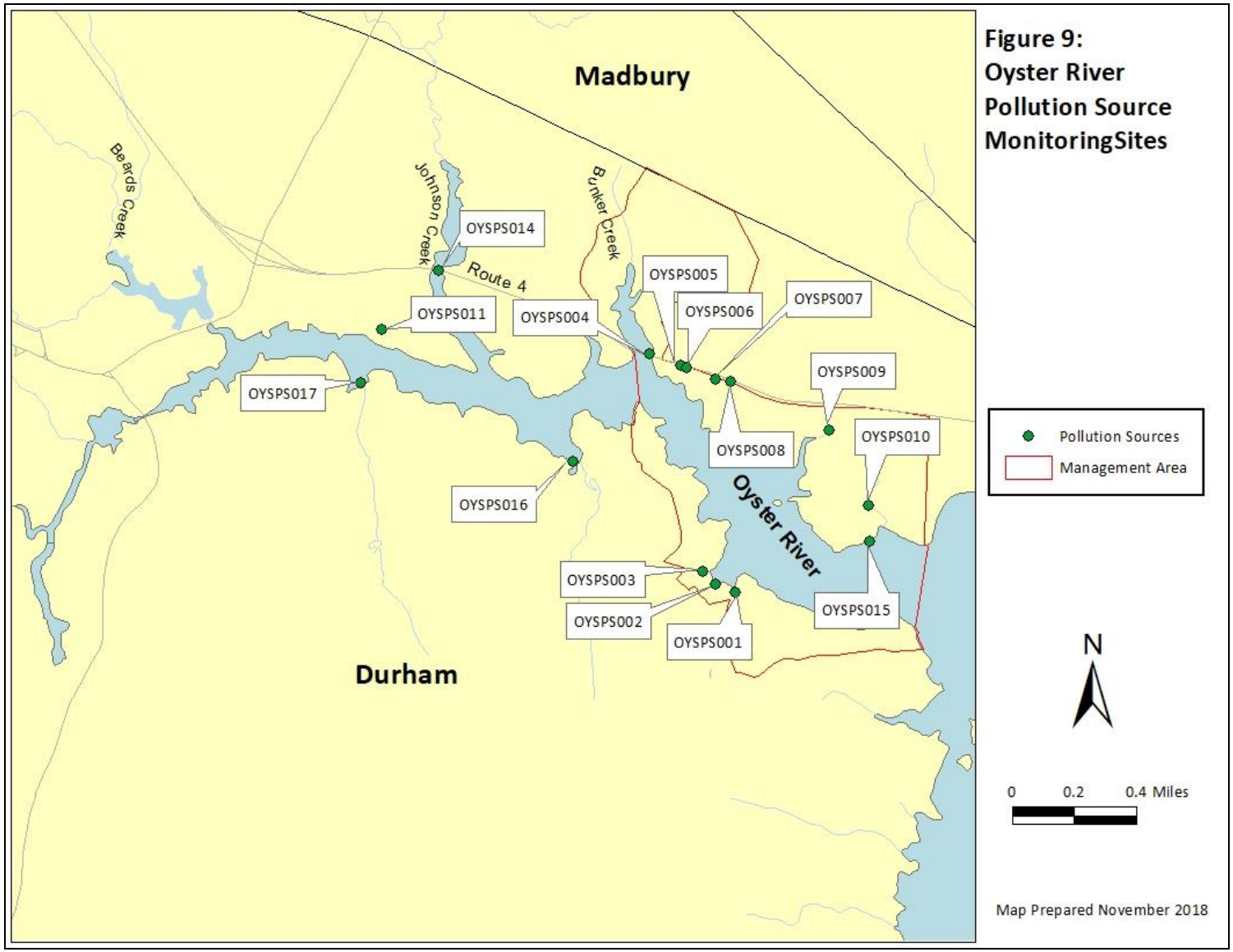


Figure 9: Oyster River Pollution Source MonitoringSites

Table 9: Pollution Source Fecal Coliform Sampling Results, 2015-2017

Station ID	Source	Date	FC/100ml	Units
OYSPS001	TIDAL CREEK	3/14/2016	330	MPN/100ML
OYSPS001	TIDAL CREEK	6/8/2016	4900	MPN/100ML
OYSPS001	TIDAL CREEK	6/8/2016	<2	MPN/100ML
OYSPS001	TIDAL CREEK	11/1/2018	30	CFU/100ML
OYSPS002	TIDAL CREEK	11/1/2018	10	CFU/100ML
OYSPS003	TIDAL CREEK	11/1/2018	<10	CFU/100ML
OYSPS004	TIDAL CREEK	11/1/2018	10	CFU/100ML
OYSPS009	INTERMITTENT STREAM	10/22/2018	210	CFU/100ML
OYSPS010	INTERMITTENT STREAM	5/30/2018	90	CFU/100ML
OYSPS010	INTERMITTENT STREAM	6/12/2018	110	CFU/100ML
OYSPS010	INTERMITTENT STREAM	6/25/2018	1110	CFU/100ML
OYSPS010	INTERMITTENT STREAM	10/22/2018	14400	CFU/100ML
OYSPS010	INTERMITTENT STREAM	11/6/2018	1300	CFU/100ML
OYSPS011	WWWT PRE-DISINFECTION EFFLUENT	2/22/2017	13000	MPN/100ML
OYSPS011	WWWT PRE-DISINFECTION EFFLUENT	2/27/2017	24000	MPN/100ML
OYSPS011	WWWT PRE-DISINFECTION EFFLUENT	3/20/2017	3300	MPN/100ML
OYSPS011	WWWT PRE-DISINFECTION EFFLUENT	4/6/2017	14000	MPN/100ML
OYSPS014	TIDAL CREEK	11/1/2018	20	CFU/100ML
OYSPS015	TIDAL RIVER	5/30/2018	<10	CFU/100ML
OYSPS015	TIDAL RIVER	6/12/2018	20	CFU/100ML
OYSPS015	TIDAL RIVER	6/25/2018	10	CFU/100ML
OYSPS015	TIDAL RIVER	8/28/2018	60	CFU/100ML
OYSPS015	TIDAL RIVER	10/22/2018	10	CFU/100ML
OYSPS015	TIDAL RIVER	11/6/2018	30	CFU/100ML
OYSPS016	INTERMITTENT STREAM	11/1/2018	50	CFU/100ML
OYSPS017	INTERMITTENT STREAM	11/1/2018	70	CFU/100ML

Wagon Hill Farm Recreational Area

The Wagon Hill Farm Recreational area is a popular location for area residents to walk their dogs. The Town of Durham encourages users to clean up pet waste by providing numerous trash bins, disposable "doggi" bags for pet waste, and signage. Because of the number of dogs that can be present, and the fact that they have free access to the Oyster River, the NHDES Shellfish Program conducted multiple surveys in 2018 to document usage, to record observations of dog feces left by owners on the ground, and make other observations to help evaluate the risk of dog feces contamination from the area. These observations would include the number of dogs present, the number of piles of dog feces evident on the ground, the usage of pet waste bags and trash receptacles, and other observations. Water samples were collected from the Oyster River itself (station ID OYSPS015; Figure 10) and from a nearby intermittent stream near the area that people walk their dogs (station ID OYSPS010; Figure 9). These observations are particularly important because commercial oyster farms are located approximately 700 feet away from Wagon Hill.

Table 10 presents information on the six surveys that were conducted by NHDES staff in 2018.

Table 10: 2018 Wagon Hill Farm Dog Usage Survey Data

Date	Number of dogs present	Piles of feces evident?	OYSPS010 FC/100ml	OYSPS015 FC/100ml	Other observations
5/30/2018	1	1	90	<10	Only pile of feces off in woods. Observed 3 doggi bag stations with trash barrels. Evidence that stations are being used
6/12/2018	20	0	110	20	One possible piece of dog feces, but uncertain and far from management area. Evidence of use at doggi bag stations
6/25/2018	4	1	1110	10	One pile of feces far from water. Two doggi bag stations farthest from water out of bags, but two closest still had bags
8/28/2018	---	---	---	60	Sample collected by boat; this sampling event was not a typical Wagon Hill dog park survey
9/19/2018	3	0	---	---	No piles of feces were visible; evidence of doggi bag stations being used and doggi bag stations appear to be fully stocked. Water samples not collected.
10/22/2018	12	1	14400	10	One old pile of feces far from water. Dog bags fully stocked
11/6/2018	0	2	1300	30	Both piles of dog feces are near OYSP010

Survey data indicate consistent use of pet waste bags and trash receptacles. There were not many instances where numerous piles of dog feces were found left on the ground. Water

sampling data shows consistently low fecal coliform in the Oyster River itself, but some rather high bacteria levels were observed at OYSPS010. The NHDES Environmental Monitoring Database was queried for flow data on this small stream, to be used for a simulated analysis of bacterial loading and dilution. Using the highest value of fecal coliform for this source (14,400 FC/100ml) and the largest flow value in the database for this source (0.81 cubic feet per second), a three- hour fecal coliform load estimate was developed. A dilution analysis on this load was performed, in which the entire load was assumed to be completely mixed in the receiving water (Oyster River, with 5-foot depth estimate). The calculations suggest that a semicircular area around OYSPS010 with a radius of 1,058 feet would be needed to safely dilute the fecal coliform load (Figure 10). The commercial oyster farms near Wagon Hill lie just outside this radius. With a more typical concentration of 2,000 fecal coliform per 100ml at Station OYSPS010, the dilution radius would be approximately 400 feet.

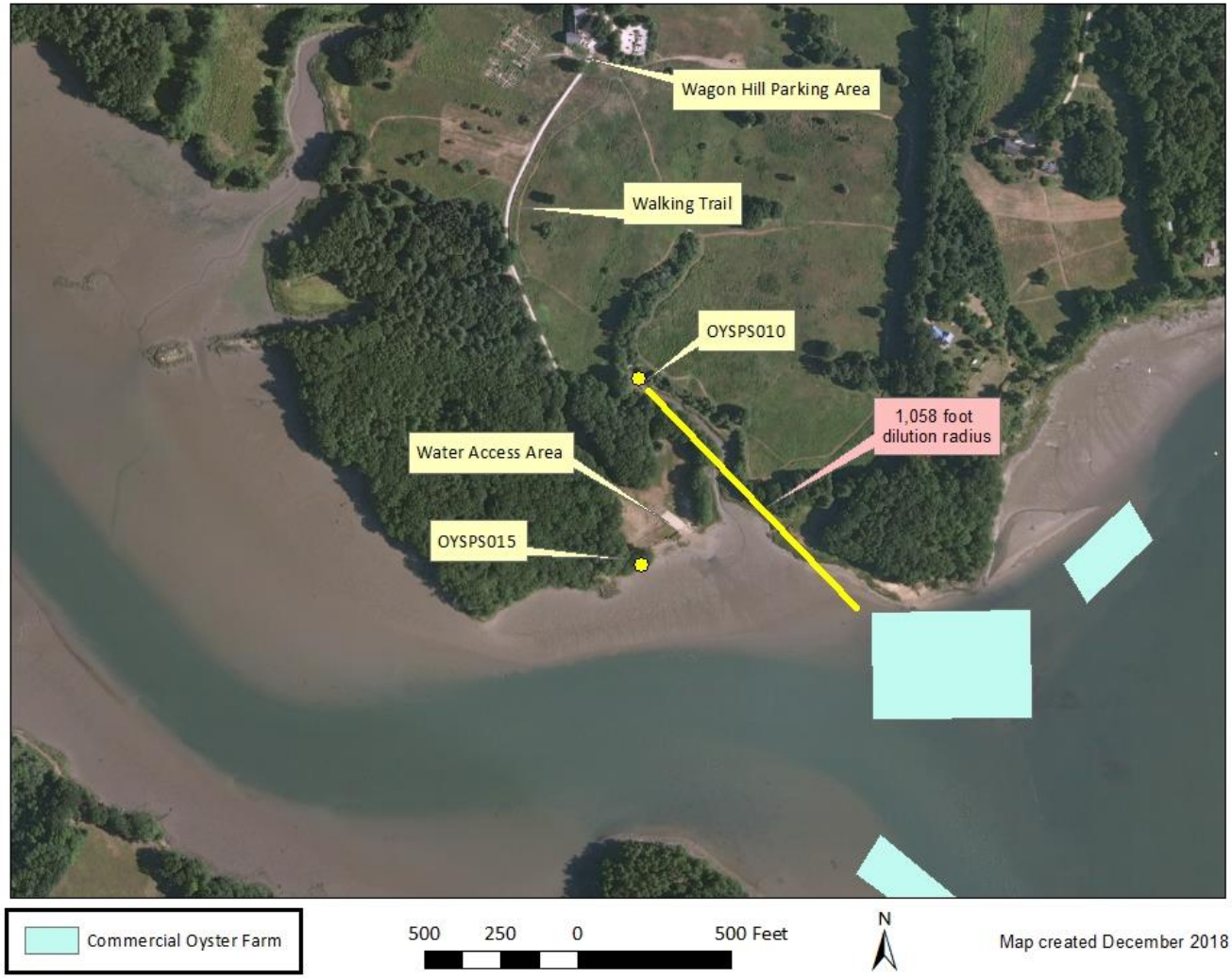
Given the usage observations, water quality data, and dilution analysis, the potential public health risk from dog feces contamination appears to be low. The current distance between commercial farms and the water access area (approximately 700 feet) appears to be adequate.

A Living Shoreline Stabilization project has been initiated at Wagon Hill Farm. The project is designed to minimize the severe erosion of the shoreline, restore the degraded salt marsh habitat, and create a buffer around the recreational area. Construction of this shoreline project is anticipated to begin in summer 2019, and it will consist of using primarily natural infrastructure to rebuild, stabilize and protect the shoreline and salt marsh. The shoreline and beach area will be surrounded by a fence extending into the forested trails of the farm; therefore, public will be restricted to beach entrance at the beach/boat access ramp only. This will protect the sensitive marsh areas from foot traffic, but it may concentrate pet walking (and potential fecal coliform contamination) to a smaller area at the beach access point. Once construction is complete, the NHDES Shellfish Program will perform a series of site inspections similar to those done in 2018, checking for evidence of pet waste, use of pet waste bags, etc. A new sampling location in the Oyster River may need to be created, as land access to station OYSPS015 will likely be restricted by the new fencing.

Boating Activity

During the summer months, the eastern portion of the Oyster River experiences increased recreational boating activity, although most of this activity is scattered among private docks and not concentrated in a marina or mooring field. There are a few boat moorings located in between ambient monitoring sites GB50 and GB51 (Figure 2), but with only four moorings present (and rarely is there a boat on those moorings), this is not considered to be a mooring field that would require evaluation for sewage risk to the growing waters. NHDES will continue to monitor the area annually to detect any changes to the number of boats/moorings present.

Figure 10: Wagon Hill Recreation Area Sampling Stations



Marine Biotoxins

The waters of the Gulf of Maine are prone to "blooms" of microscopic algae that can produce potent neurotoxins, and filter-feeding shellfish can accumulate concentrations of these toxins such that the shellfish themselves become a public health threat to consumers. For this reason, the NHDES maintains a biotoxin monitoring program, focused on Paralytic Shellfish Poisoning (PSP) in blue mussels. Weekly samples are collected from Star Island, Isles of Shoals and from Hampton/Seabrook Harbor. PSP samples are typically not collected in the Oyster River because toxicity is typically not observed in the estuarine areas of Great Bay. Toxicity is sometimes observed in nearby Little Bay, and monitoring at nearby sites, such as Fox Point, indicates little toxicity in this area of the estuary.

Discussion

WWTF Prohibited Areas

The size of the Durham WWTF Prohibited area is based, in part, on the notification time demonstrated in the past by the WWTF staff. Durham typically notifies NHDES staff of problems involving direct discharge of improperly treated sewage to tidal waters within six hours; however, NHDES Shellfish Program staff are only on-call to receive notification of issues from 6am to 9pm. An issue occurring overnight could go on for several hours before a harvest closure could be initiated. For this reason, recreational harvest near the mouth of the Oyster River is limited to Saturdays only, 9am-sunset. This restriction provides adequate time for implementation of harvest closures, and notification to the public, when necessary.

Evaluation of the Conditional Area Management Plan

The majority of the Oyster River is classified as Prohibited, but a small portion near Little Bay in the vicinity of Wagon Hill Farm is Conditionally Approved. This area must be evaluated annually in order to keep the management plan up-to-date. The current evaluation period is January 1, 2015 through December 31, 2017. During the review period, the NHDES Shellfish Program was in full compliance with the conditions of the management plan. The conditions under which the Conditionally Approved Area will be placed in the closed status are listed below along with the evaluation of the closure criterion in italics:

1. Total daily effluent flow shall not exceed 2 mgd for the Durham WWTF, and 4.8 mgd for the Portsmouth WWTF.

   During this review period, NHDES was contacted eight times by the Durham WWTF concerning exceedences of the flow reporting thresholds. Two occurred in 2015, and the other six occurred in 2017. None of the flow exceedences resulted in the closure of the management area. Records of the incidents are on file with NHDES. .

During this review period, NHDES was contacted multiple times by the Portsmouth WWTF concerning exceedences of the flow reporting thresholds. The facility is under consent decree to build a new facility, and it will have a design threshold higher than the current facility. The new facility will, under high flow conditions, be able to divert and treat excess flow to the old facility, and will blend treated effluent with treated effluent from the new facility. None of the flow exceedences resulted in the closure of the management area. Records of the incidents are on file with NHDES.

2. Bacteriological quality of the effluent shall not exceed 43 Fecal Coliform/100ml after disinfection at the Durham WWTF

   During this review period, NHDES was contacted five times by the Durham WWTF concerning effluent FC levels. One event occurred in 2015, and the other four occurred in October 2016. The October 2016 issue was caused by a foaming problem in the main aeration tank interfering with disinfection effectiveness. All of the incidents were either diluted to levels below NSSP standards well within the WWTF Prohibited area.

   During the review period, NHDES was contacted six times by the Portsmouth WWTF concerning effluent FC levels. One event occurred in 2015, one occurred in 2016, and four events occurred in 2017. None were large enough to cause a closure of the Conditionally Approved waters near the Oyster River.

   Records of the incidents are on file with NHDES.

3. Any discharge of raw sewage or partially treated sewage from the Durham WWTF or the Portsmouth WWTF, or from any part of the sewage collection system. For the purposes of this performance standard, "partially treated sewage" means sewage/effluent that has been released to the environment before undergoing all aspects of treatment required by the most recent NPDES permit.

   During this review period, the Town of Durham reported two 500-gallon infrastructure overflows, both occurring in November 2015. The first involved 500 gallons released due to a Baghdad Road sewer line blockage. No discharge reached surface waters. The second involved 500 gallons of sludge from a blown end cap at the WWTF, some of which migrated offsite but did not reach surface waters. In 2016, the Town of Durham reported no infrastructure overflows. In 2017, the Town of Durham reported no sewage overflow events, although they did have one instance of 56,000 gallons of undisinfected effluent discharged to the Oyster River. A May 2017 thunderstorm disrupted chlorine pumps. Adjacent Conditionally Approved waters were closed for harvest at the time, and evaluation by the NHDES Program indicated this event would likely not have adversely affected the Conditionally Approved growing waters.

   In 2015, the City of Portsmouth reported no incidents of sewage discharge. The city did report several minor discharges and two larger discharges in 2016. The largest

involved 52,000 gallons of sewage discharge to the Piscataqua River (classified as Prohibited) from a failed pump station on Deer Street. Another 5,000-gallon discharge of combined sewage overflow to South Mill Pond (classified as Prohibited) occurred during a heavy rainfall event. In 2017 the City of Portsmouth reported six instances of sewage discharge. Most were minor in nature, although a February incident involving discharge of 58,000 gallons of raw sewage was significant. A contractor hit a 24-inch sewer line on Peirce Island, near the WWTF, with an excavator. Discharge went into the nearby Piscataqua River (Prohibited).

4. Failure of the Durham WWTF or the Portsmouth WWTF to complete its required effluent monitoring, such that the biological, physical, and/or chemical quality of the effluent is unknown.

   Review of the WWTF records and discussions with the plant operators indicate that the Durham WWTF and the Portsmouth WWTF completed all of their required effluent monitoring during this evaluation period.

5. Rainfall events of more than 1.5 inches total precipitation. The 1.5 inch criterion is intended to generally apply to a 24-hour period; however, rainfall events that occur over a longer period of time may also warrant closure.

   During this review period, NHDES had to implement a closure of the management area due to exceedences of the rainfall threshold 15 times (four in 2015, three in 2016, and eight in 2017). Though the rainfall threshold was exceeded several additional times during the 2015-2017 review period, the rain events occurred while the management area was already in the closed status. In these instances, the management area was kept in the closed status until fecal coliform samples confirmed that a reopening was appropriate.

All appropriate WWTF staff have been given documents summarizing the provisions they are responsible for in the conditional area management plan and are expected to be familiar with the types of incidents that require contact of the Shellfish Program. Comparison of facility monthly operating reports with Shellfish Program pager memos indicates that the Durham WWTF staff and the Portsmouth WWTF staff contacted the Shellfish Program during all appropriate instances. This concurrence of documents demonstrates good cooperation between WWTF staff and the Shellfish Program and reaffirms that existing agreements enable the Shellfish Program to implement appropriate and timely management actions to protect public health.

Conditional Area Data Review

Review of all data collected under the systematic random sampling program (Table 4) shows that water quality in the growing area does meet the statistical requirements for Approved classification for the period of 2014-2017. However, the area would not meet Approved criteria for a number of reasons, including proximity to a WWTF and high variability of fecal coliform data following significant rainfall/runoff events. Thus, the area is classified as Conditionally Approved. When the conditions specified in the Conditional Area Management Plan are applied to the data in Table 4 (i.e., exclusion of samples collected during times when the area was in the closed status), the routine monitoring station meets NSSP criteria for Approved waters (geometric mean $\leq$ 14/100ml, and the estimated 90th percentile statistic $\leq$ 43/100ml; Table 11).

Table 11: 2014 – 2017 Fecal Coliform (per 100ml) Samples for Oyster River Sampling Station GB50 (Open Status Only). Fecal coliform (MPN/100ml) data for samples collected under the Systematic Random Sampling Program during open status only. Samples >43 MPN/100ml are in bold font.

4-Day Rain Total (in)	Collection Date	GB50
0.3.0	1/13/2014	**79**
0.71	2/24/2014	4.5
0.00	3/11/2014	<2
0.95	4/8/2014	2
0.05	5/6/2014	<2
0.09	6/11/2014	4.5
0.09	9/2/2014	6.8
0.61	10/6/2014	4.5
0.41	11/5/2014	7.8
0.00	12/1/2014	32
0.14	1/20/2015	17
0.72	3/30/2015	6.1
0.13	4/6/2015	23
0.02	4/15/2015	7.8
0.00	5/5/2015	<2
0.00	6/9/2015	4.5
0.13	7/13/2015	<2
0.74	8/13/2015	7.8
1.60	9/14/2015	**49**
0.00	10/15/2015	<2
0.00	11/9/2015	<2
0.30	12/4/2015	7.8
0.00	1/6/16	13
0.00	2/2/16	17
0.00	2/22/16	1.8

4-Day Rain Total (in)	Collection Date	GB50
0.00	3/9/16	6.8
0.31	4/6/16	7.8
0.17	5/17/16	2
0.09	6/13/16	<2
0.73	7/13/16	<2
0.62	8/17/16	<2
0.23	9/12/16	2
1.28	10/10/16	23
0.00	11/14/16	2
	12/8/16	11
0.00	1/22/17	2
0.00	2/21/17	<2
0.00	3/6/17	<2
0.00	4/3/17	<2
0.34	5/23/17*	11
1.25	6/7/17	23
0.00	7/5/17	<2
0.00	8/1/17	2
0.19	9/19/17	4
0.00	10/17/17	4.5
0.15	11/15/17	<2
0.07	12/4/17	17
	Count	47
	Geomean	5.1
	Est 90th	19.0
	Water Quality	A
	Classification	P

As previously mentioned, ambient station GB51, located upstream of GB50, was reactivated in 2017 after preliminary analyses of the May 2017 Durham WWTF dye study suggested more of the Oyster River could possibly be classified as Conditionally Approved. The station was initially created in March 2002 for the original Oyster River Sanitary Survey. Table 12 illustrates the historical data at GB51. Although NSSP statistics are presented in Table 12, they are for illustrative purposes only. Most of the data in Table 12 are so old that they cannot be used for a present-day evaluation of water quality at this site. However, the data do illustrate that this site will likely pass NSSP statistical evaluation once Conditional Area Management Plan criteria are applied to the dataset. When the closed status samples are removed, the geometric mean and estimated 90th percentile of the remaining 20 samples is 7.0 and 23.7, respectively.

Table 12: Historical Fecal Coliform (per 100ml) Samples for Oyster River Sampling Station GB51

Fecal coliform (MPN/100ml) data for samples collected under the Systematic Random Sampling program. Samples over 43 MPN/100ml are in bold font. Samples collected during the closed status are shaded.

4-Day Rain Total (in)	Collection Date	GB51
0.91	3/5/02	4.5
0.54	3/20/02	7.8
0.88	4/2/02	<2
0.04	4/11/02	<2
0.56	4/17/02	7.8
0.53	5/6/02	<2
2.36	5/15/02	**540**
2.36	5/16/02	**49**
0.9	5/19/02	**49**
1.58	6/10/02	4.5
1.07	6/19/02	4.5
0.33	7/16/02	2
0.33	7/17/02	2
0.79	9/18/02	4.5
0.92	9/29/02	4.5
0.94	10/14/02	11
0.26	10/23/02	4.5
1.19	11/14/02	17
1.19	11/14/02	**49**
1.53	11/20/02	16
0	12/2/02	**49**
0.62	4/16/03	2
0.99	6/23/11	7.8
0.13	6/30/11	2
0	10/17/17	4.5
2.42	11/1/17	**79**
0.15	11/15/17	11
0.07	12/4/17	14
Count		28
Geomean		8.8
Est 90th		52.9

Conclusions

After review of the relevant information collected over the past three years for the Oyster River Shellfish Management Area, NHDES determined that some changes should be made to its current classification, namely a reduction in the size of the Prohibited area around the Durham WWTF outfall (Figure 11). This determination was based in part on results of the Durham WWTF dye study of May 2017 (report in progress), as well as ongoing evaluation of effluent quality and pollutant levels under varying operational conditions. For 2018, the classification illustrated in Figure 2 will remain in force. The new classification incorporating a reduced size for the Prohibited area around the Durham WWTF outfall, shown in Figure 11, will take effect on 1/1/2019.

Legal Description

The classification of the Oyster River is as follows:

The waters of the Upper Oyster River are classified as Prohibited/Safety Zone. For the purposes of this classification, the Upper Oyster River is defined as the water body bounded by the head-of-tide dam at Mill Pond ($43^0$07'51.68"N, $70^0$55'07.97"W and $43^0$07'50.66"N, $70^0$55'07.96"W), downstream to a line near Smith Creek, from a point on the Oyster River shore located at $43^0$07'36.56"N, $70^0$52'38.92"W, running southwesterly to a point on the Oyster River shore at $43^0$07'32.09"N, $70^0$52'51.88"W.

The waters of the Lower Oyster River are classified as Conditionally Approved (this classification will become effective 1/1/19). For the purposes of this classification, the Lower Oyster River is defined by a line near Smith Creek, from a point on the Oyster River shore located at $43^0$07'36.56"N, $70^0$52'38.92"W, running southwesterly to a point on the Oyster River shore at $43^0$07'32.09"N, $70^0$52'51.88"W. The downstream boundary of the Lower Oyster River is defined by a line near Wagon Hill Farm, from a point on the Oyster River shore located at $43^0$07'30.21"N, $70^0$52'51.88"W, running southerly to a point on the Oyster River shore near Durham Point at $43^0$07'20.13"N, $70^0$52'9.41"W.

The waters of the Oyster River Mouth are classified as Conditionally Approved. For the purposes of this classification, the Oyster River Mouth is defined by a line near Wagon Hill Farm, from a point on the Oyster River shore located at $43^0$07'30.21"N, $70^0$52'51.88"W, running southerly to a point on the Oyster River shore near Durham Point at $43^0$07'20.13"N, $70^0$52'9.41"W. The downstream boundary of the Oyster River mouth is defined by a line from a point on the Oyster River shore located at $43^0$07'28.66"N, $70^0$52'07.14"W, running southerly to a point on the Oyster River shore near Durham Point at $43^0$07'14.50"N, $70^0$52'10.19"W.

Regarding the major tributaries of the Oyster River, including but not limited to Bunker Creek, Smith Creek, Johnson Creek, and Beards Creek, this classification extends to the head-of-tide and/or the intersection with Route 4, whichever is farthest downstream. All tidal waters upstream of these points should be considered as unclassified, and therefore prohibited for shellfish harvesting.

For the purposes of this classification, all Conditionally Approved waters are closed for harvesting following rainfall events of over 1.50 inches. These waters may be closed following discharges of improperly treated sewage from the Durham WWTF or the Portsmouth WWTF. Furthermore, the Conditionally Approved waters of the Oyster River Mouth shall be placed in the closed status for the period of early October to the end of March each year. When the Lower Oyster River classification becomes effective on January 1, 2019, it also will be in the closed status until the end of March.

Figure 11 depicts revised classifications. Appendix 1 describes the conditions under which the Conditionally Approved area will be placed in the closed status.

At the discretion of NHDES, some or all of the Conditionally Approved waters may be placed in the closed status, per emergency closure protocols, when unusual or rare conditions that may endanger public health exist. Such conditions include but are not limited to episodes of high shellfish toxicity from harmful algal blooms, spills of petroleum products or other poisonous/deleterious substances, or other conditions. NHDES will determine when the areas will be re-opened for harvest on a case-by-case basis, utilizing procedures outlined in the National Shellfish Sanitation Program and/or State of New Hampshire Interagency Memoranda of Agreement regarding NSSP implementation in New Hampshire.

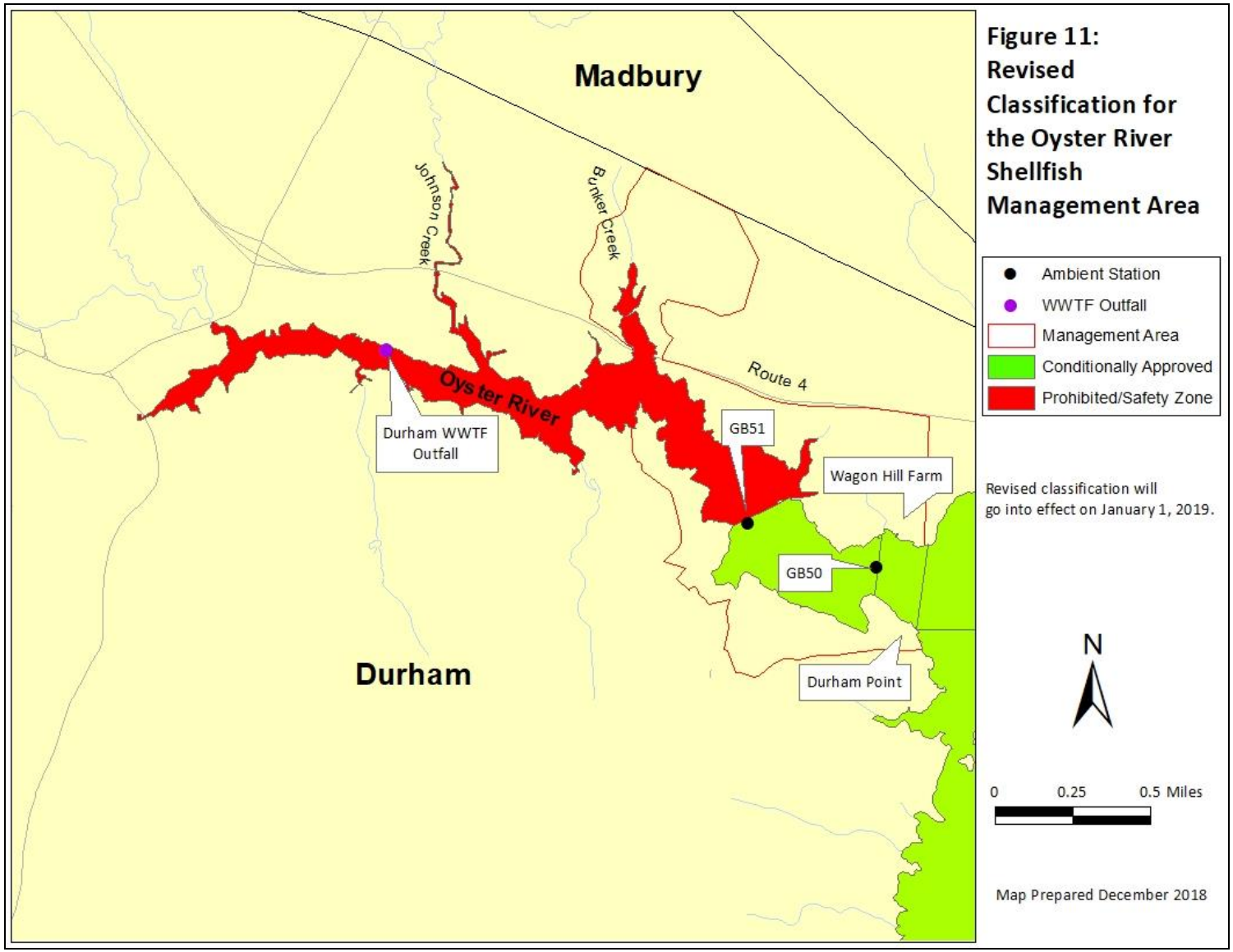


Figure 11: Revised Classification for the Oyster River Shellfish Management Area

Recommendations

1. Augmented sampling of the ambient site for storms in the 1.00-2.50 inch range should continue to expand the database for ongoing evaluation of the appropriateness of the 1.5 inch rainfall closure threshold.

2. Plan to implement the classification change regarding the re-sizing of the Durham WWTF outfall Prohibited area shown in Figure 11 on January 1, 2019.

3. Continue with sampling of the Durham WWTF effluent under various operational conditions, especially around the times the University is transitioning in and out of session, to examine male-specific coliphage levels.

4. Continue to evaluate the usage of the Wagon Hill Recreational area by dog owners, through usage observation and through sampling at OYSPS010 and OYSPS015 (or alternative site). Conduct site inspections during and after construction of the Wagon Hill Farm shoreline stabilization project, to assess any changes to the risk of pet waste contamination. Furthermore, assess the need for a new water sampling station to replace OYSPS015.

5. Conduct extra sampling at GB51, particularly during the months when harvesting will be allowed in the lower Oyster River (May through September) to build the dataset for better statistical evaluation.

6. When the Portsmouth WWTF upgrade is complete, evaluate the need to continue to include Portsmouth in the Oyster River Conditional Area Management Plan. Furthermore, evaluate fall/winter/spring concentrations of male specific coliphage in the seawater to determine if the current seasonal closure can be lifted.

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Appendix I

Durham NH Wastewater Treatment Facility: Examination of Flows and Variability in Finished Effluent Male-Specific Coliphage Concentration

Facility Description

The Durham Municipal Wastewater Treatment Facility (NPDES No. NH0100455) provides secondary treatment to wastewater from residents and businesses in the Town of Durham, as well as wastewater from the University of New Hampshire. The treatment plant is designed for a flow of 2.5 million gallons per day (mgd) and utilizes an activated sludge process, including secondary clarifiers, chlorine disinfection, scum collection, and sludge disposal. The outfall is a multiport diffuser in the Oyster River and is located below the low tide line. In anticipation of limits on nitrogen in the next NPDES permit, the facility has been retrofitted with systems to remove nitrogen.

The most recent NPDES permit for Durham became effective on January 29, 2000 and expired on January 29, 2005. An application for permit renewal was received by EPA on June 11, 2004 and is still under review. The most recent compliance inspection report by the NHDES Wastewater Engineering Bureau (April 2017 shows no significant deficiencies in regards to effluent bacteria concentrations, plant flow levels, or operation of the disinfection system. Review of the facility's MORs shows the facility routinely meets its bacteria permit limits. Plant flows show seasonal characteristics, with highest values in the spring.

The permit sets limits on a number of parameters, including BOD, TSS, pH, fecal coliform, total residual chlorine, and others. Whole Effluent Toxicity Testing is required four times per year, and the permit requires the facility to immediately notify NHDES/Watershed Management Bureau/Shellfish Program in the event of a lapse in treatment at the WWTF or from the sewage collection system.

The plant has little capacity to hold/store treated sewage. The plant operator indicates that under the best circumstances (low flow, one aeration and one clarifier tank offline and therefore available for use as storage vessels) the plant might be able to hold a half day of treated effluent. Sludge is dewatered on site and transported for composting in Holderness, NH. Industrial users include the University of New Hampshire (although no industrial discharges, only sewage, are permitted to the system) and a minor discharge from Heidleberg-Harris Printing (approximately 13 gallons of pre-treated process water per day).

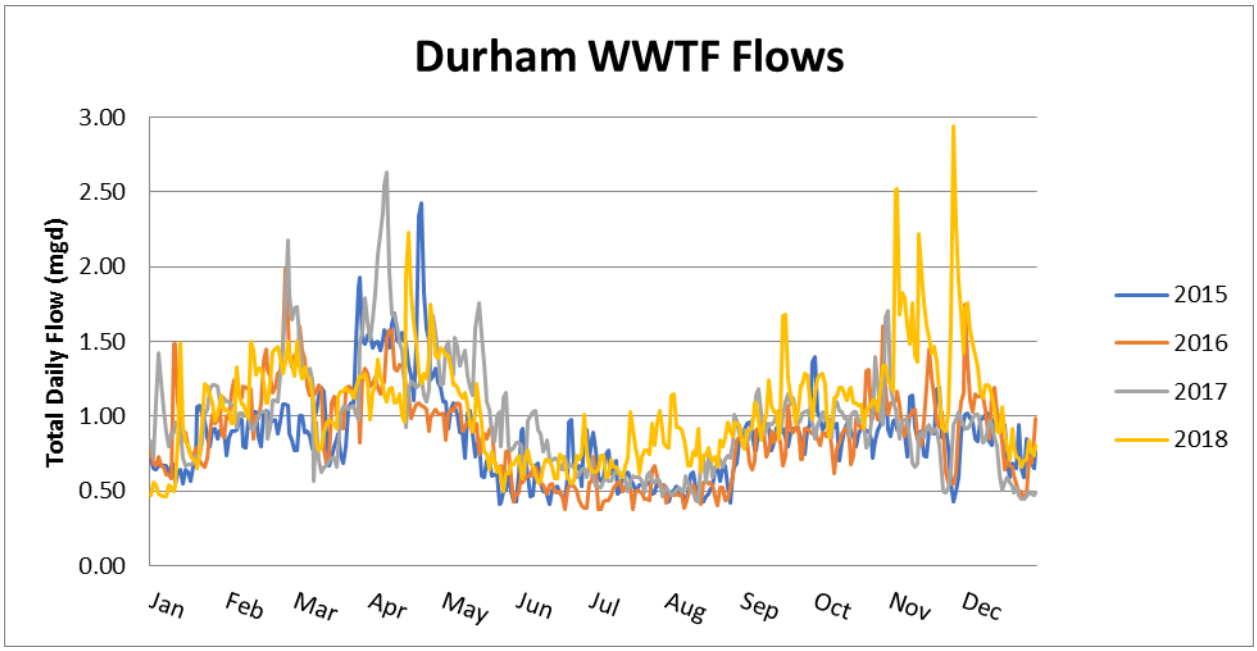
Disinfection is achieved with sodium hypochlorite and sodium bisulfite for dechlorination. Contact time is typically 1.5 hours when both tanks are online. A maximum of 3,000 gallons of sodium hypochlorite is stored on site, which typically provides for 2.5 months of disinfection. Chlorine injection pumps are backed up, and both primary and backup pumps are operational even in the event of a loss of power at the facility. The chlorine contact tanks are cleaned every 1-2 weeks.

The plant is staffed Monday-Friday, 8am-4:30pm, and checked every morning on the weekends (1-2 hours). Staff is on-call 24 hrs/day and typically responds in less than one hour of notification

in the event of a problem at the plant. Loss of power, abnormally high flows, etc. trigger alarms that are tied to the police station, which in turn results in staff notification. Chlorination pump failures/abnormal chlorine residuals are also alarmed.

Examination of WWTF Flow Characteristics

The Durham WWTF exhibits a predictable and repeatable seasonality of flow, with peaks in the spring and the fall. The facility receives over half of its flow from the University of New Hampshire, so when the university is out of session (summer, extended breaks for holidays or spring break, etc.), flows drop dramatically. Summer flows are particularly low, generally under 1 mgd. It is rare for the WWTF to approach or exceed its 2.5 mgd design flow, but such high flows do occur during particularly wet periods, such as the fall of 2018.



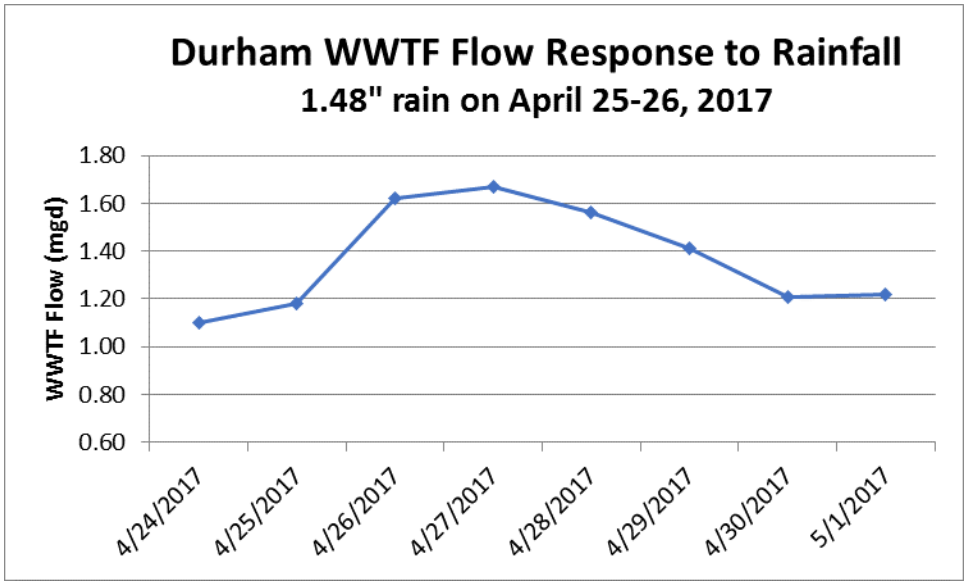
Distribution of flows for four years of data (total daily flow values, 2015-2018) shows that over 85% of all days in the year have a flow of under 1.25 mgd

Table 1: Documentation of Flow Frequency

	# observations	% of total	cumulative %
≤0.50 mgd	89	6.1	6.1
0.51 - 0.75 mgd	408	27.9	34.0
0.76 - 1 mgd	441	30.2	64.2
1.01 - 1.25 mgd	317	21.7	85.9
1.26 - 1.50 mgd	121	8.3	94.2
1.51 - 1.75 mgd	53	3.6	97.8
1.76 - 2 mgd	18	1.2	99.0
>2 mgd	14	1.0	100.0

Flow Response to Rainfall Over 1 Inch

Operators of the WWTF observe that flows increase in response to rainfall events. For example, during a 1.5-inch rainfall event that occurred on April 25-26, 2017, flows increased immediately after the rainfall.



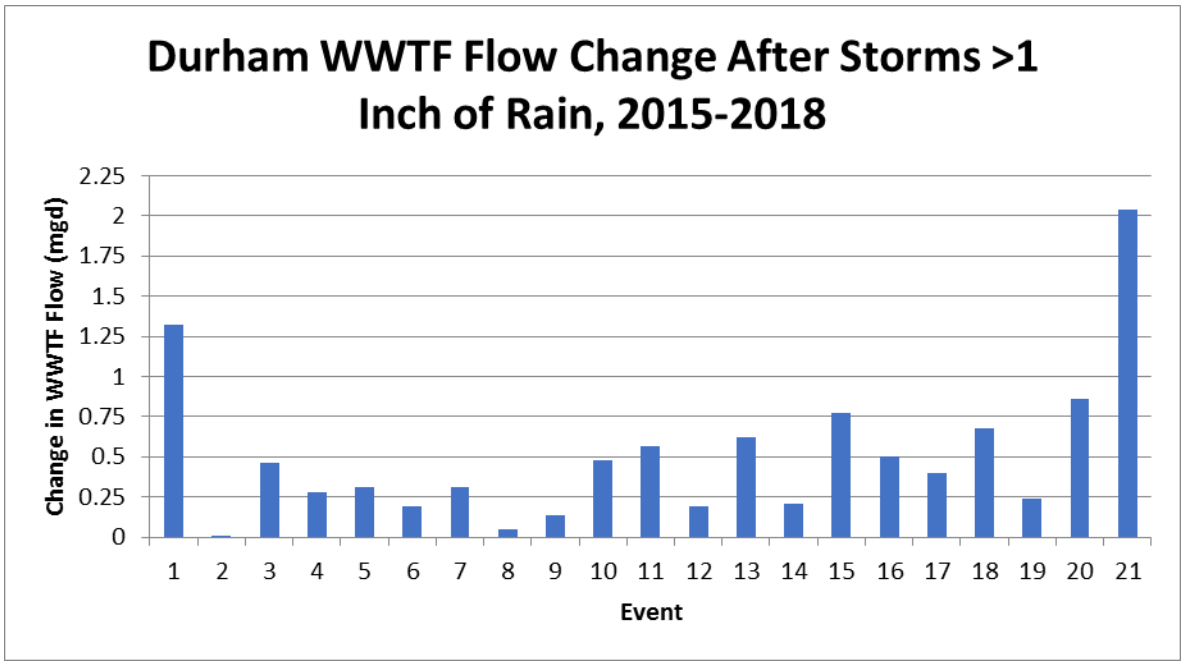
In this case, approximately six days were required before the WWTF nearly returned to pre-storm flow.

To determine if this six-day period is a typical response to rainfall, precipitation data from the Portsmouth/Pease International Tradeport weather station was acquired to identify when heavy rainfall (one inch or more) occurred. For this analysis, data from time periods when UNH was not in session were not included. Furthermore, if heavy rainfall events occurred within seven days of each other, the first event was ignored. For the 2015-2018 period, 21 events were identified, and several flow characteristics for each event were documented.

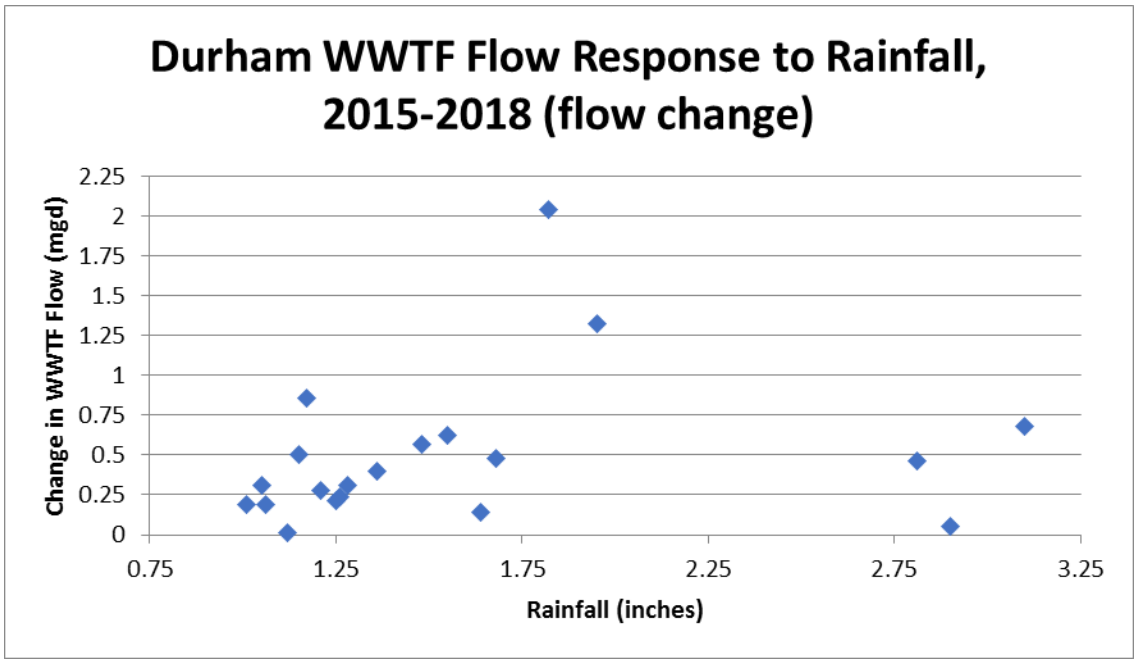
Table 2: Durham WWTF Flow Response to Rainfall Over One Inch

Date	rain (in)	Prestorm flow (mgd)	Peak Post Storm Flow (mgd)	Abs. Value of Flow Change (mgd)	Flow Change (%)	# Days for Flow to Return to Prestorm Level
4/20/15	1.95	1.11	2.43	1.32	118.9	12*
9/13/15	1.12	0.92	0.93	0.01	1.1	3
9/29/15	2.81	0.94	1.4	0.46	48.9	6
10/28/15	1.21	0.91	1.19	0.28	30.8	4
11/20/15	1.05	0.88	1.19	0.31	35.2	3
9/19/16	1.06	0.74	0.93	0.19	25.7	7
10/9/16	1.28	0.62	0.93	0.31	50.0	7
10/21/16	2.9	0.92	0.97	0.05	5.4	3
10/28/16	1.64	0.98	1.12	0.14	14.3	4
11/15/16	1.68	0.97	1.45	0.48	49.5	5
4/25/17	0.76	1.1	1.67	0.57	51.8	6
5/5/17	1.01	1.34	1.53	0.19	14.2	4
5/14/17	1.55	1.14	1.76	0.62	54.4	6
9/6/17	1.25	0.97	1.18	0.21	21.6	7
10/30/17	2.42	0.94	1.71	0.77	81.9	7
4/25/18	1.15	1.25	1.75	0.5	40.0	11*
9/10/18	1.36	0.84	1.24	0.4	47.6	6
9/18/18	3.1	1	1.68	0.68	68.0	5
9/25/18	1.26	1.05	1.29	0.24	22.9	5
11/13/18	1.17	1.36	2.22	0.86	63.2	7
11/26/18	1.82	0.9	2.94	2.04	226.7	17*

For each event, the total change in flow was determined. For almost every event, the change in flow is at least 0.25 mgd. The average change was 0.51 mgd, and the median change was 0.40 mgd.

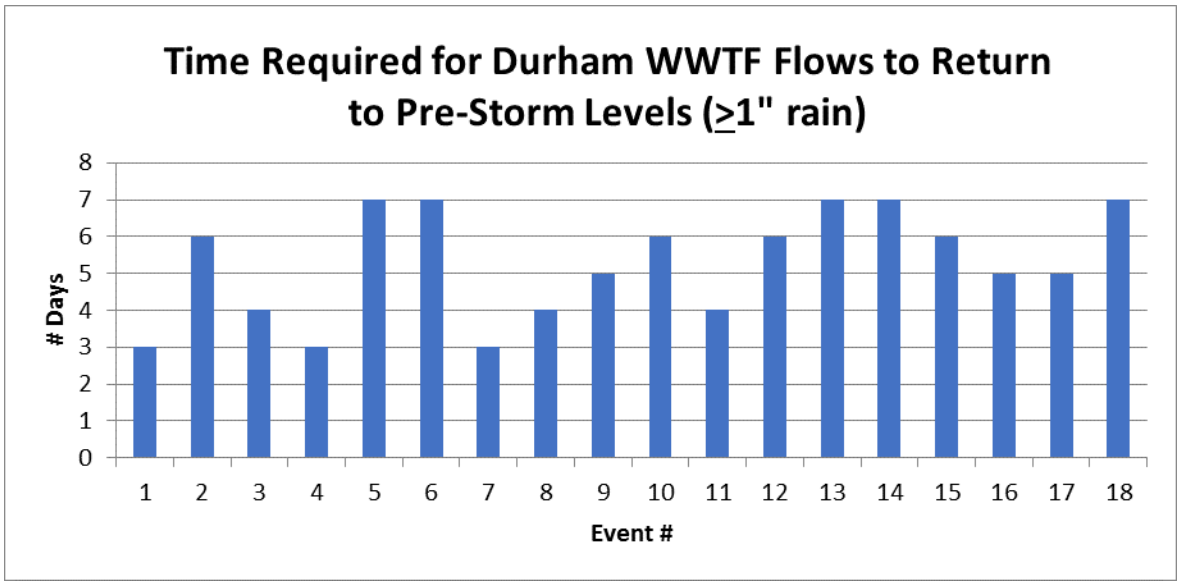


To see if there is a correlation between the amount of rain that fell and the magnitude of the flow change, these variables were plotted against each other:



There does not appear to be a linear relationship between rainfall and change in flow. Interestingly, the change in flow for four events with the highest rainfall (over 2.25”) is in the same range as flow changes that occurred for 1-1.75 inches of rain.

The time required for WWTF flows to return to pre-storm levels was also documented for the events listed in Table 2 (note that the events labelled as likely having extended response times due to additional rainfall are not included in this graph.



The average time required for flows to return to pre-storm levels is 5.3 days. All events were back to pre-storm levels in seven days.

Flow Response to Rainfall Over 0.50 - 1 Inch

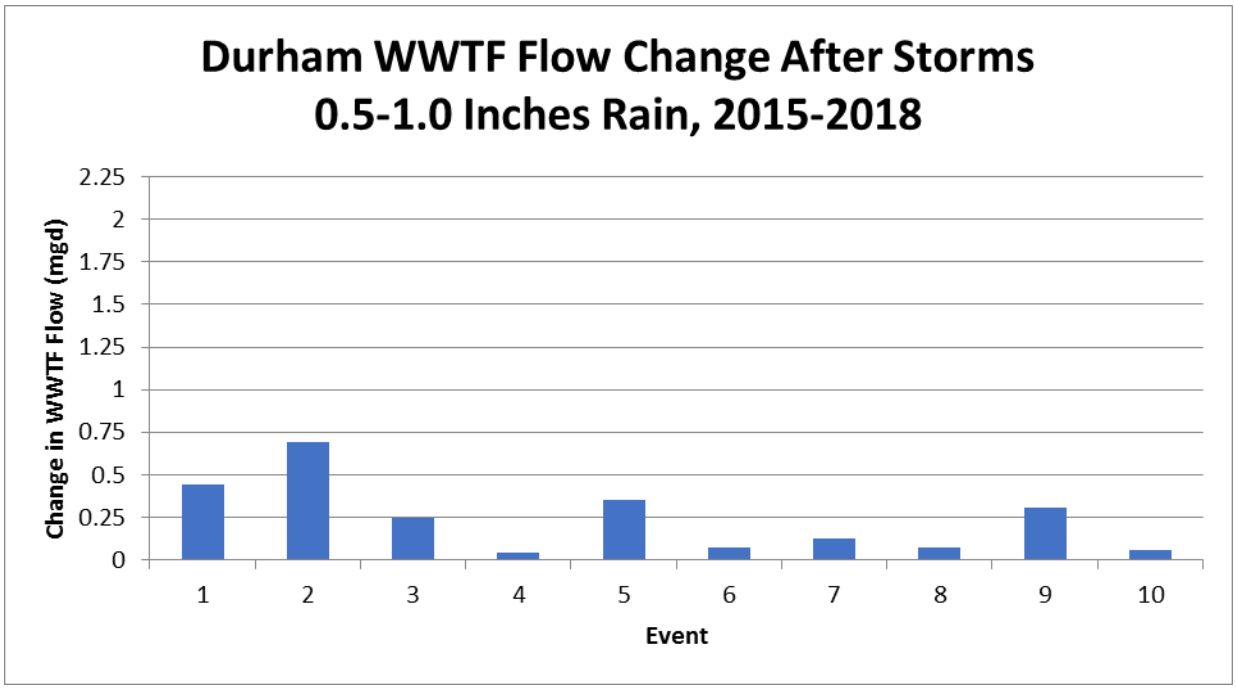
Ultimately it is important to understand how much rain is capable of affecting WWTF flows. In this approach a flow response was quantified for rainfall events over 1 inch, while UNH is in session, in the previous section. In this section a similar exercise is performed for storms in the range of 0.50 to 1.0 inch. The flow response of these events can be quantified and compared to the response for larger storms.

Table 3: Durham WWTF Flow Response to Rainfall 0.5 – 1.0 Inch

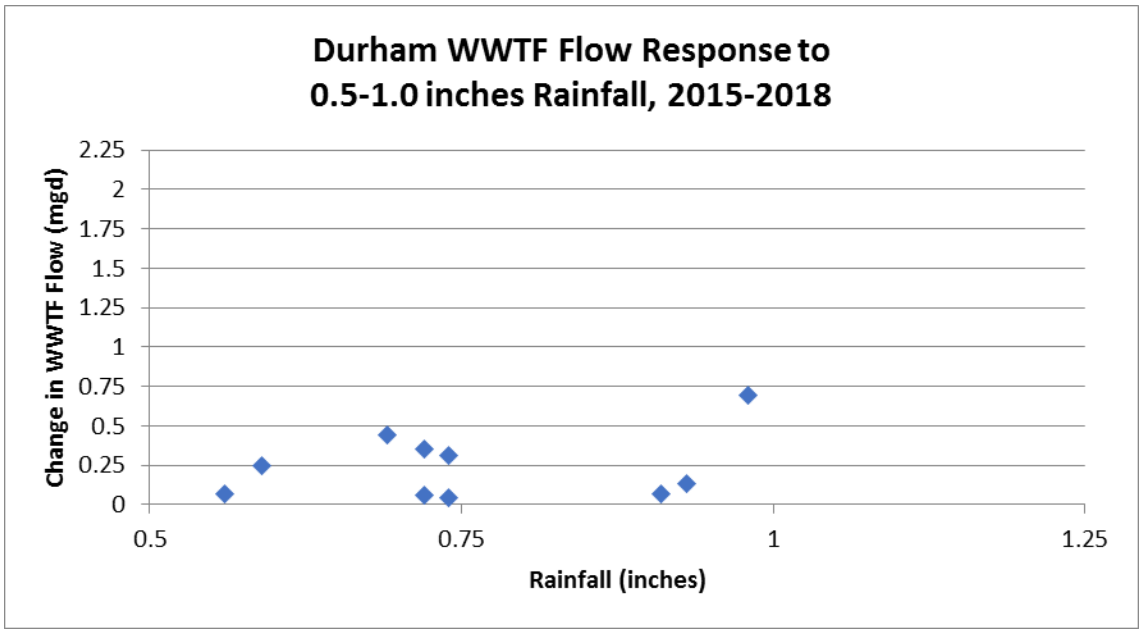
Date	rain (in)	Prestorm flow (mgd)	Peak Post Storm Flow (mgd)	Abs. Value of Flow Change (mgd)	Flow Change (%)	# Days for Flow to Return to Prestorm Level
3/26/15	0.69	1.49	1.93	0.44	29.5	5
2/24/16	0.98	1.3	1.99	0.69	53.7	5
3/2/16	0.59	1.35	1.6	0.25	18.5	4
3/10/16	0.74	1.17	1.21	0.04	3.4	3
4/7/16	0.72	1.23	1.58	0.35	28.5	8
4/21/17	0.91	1.19	1.26	0.07	5.9	3
10/8/17	0.93	0.97	1.1	0.13	13.4	8
12/5/17	0.56	0.94	1.01	0.07	7.4	5
10/1/18	0.74	0.98	1.29	0.31	31.6	7
10/11/18	0.72	1.13	1.19	0.06	5.3	4

*note: a 0.54-inch storm on 10/1/16 had no post-storm flow increase; flows dropped from 0.9 mgd (pre-storm) to 0.81 mgd over the next two days

For each event, the total change in flow was determined. For half of the events, the change in flow was 0.25 mgd or greater. The average change was 0.24 mgd (0.51 mgd for storms >1 inch), and the median change was 0.19 mgd (0.40 mgd for storms >1 inch).

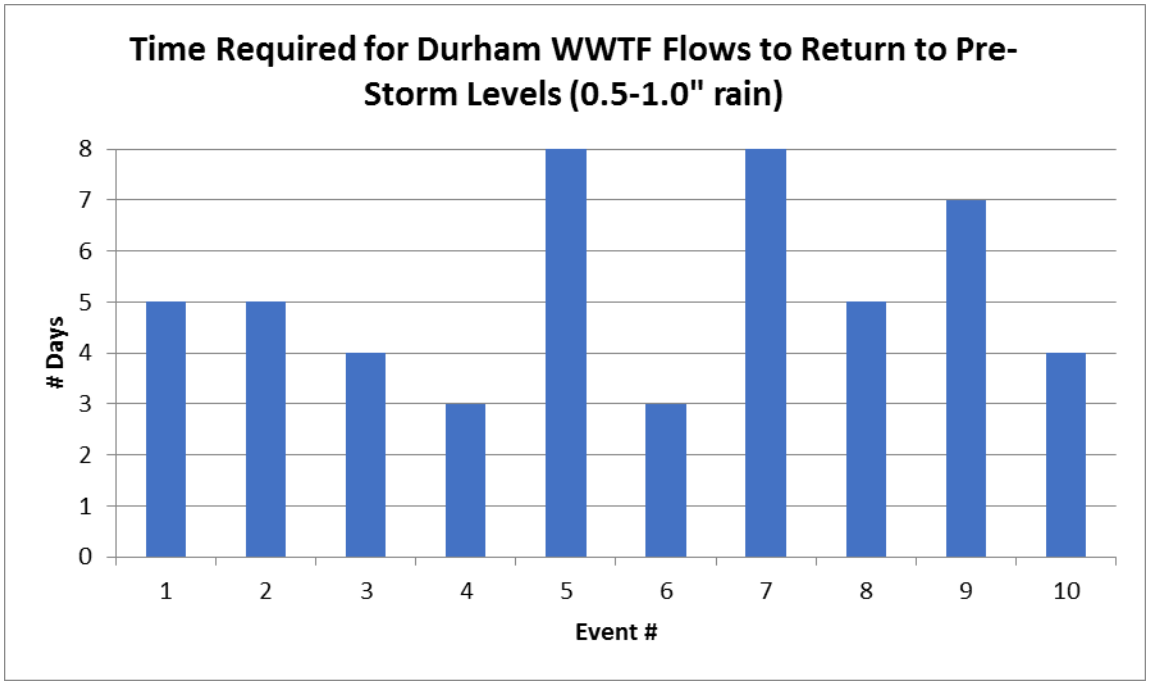


To see if there is a correlation between the amount of rain that fell and the magnitude of the flow change, these variables were plotted against each other:



There does not appear to be a linear relationship between rainfall and change in flow.

The time required for WWTF flows to return to pre-storm levels was also documented for the events listed in Table 3.



The average time required for flows to return to pre-storm levels is 5.2 (5.3 days for storms over 1 inch). Eight of 10 events were back to pre-storm levels in seven days, while the other two were back to pre-storm levels in 8 days.

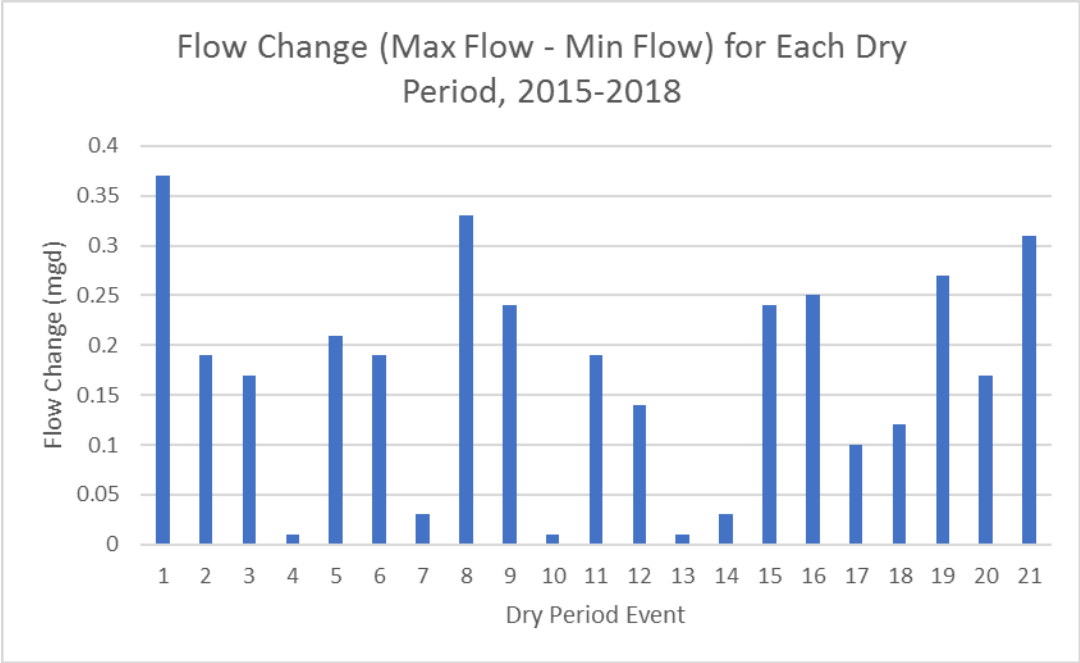
Variability in Dry periods

The previous analyses indicate that Durham WWTF flows are affected by rainfall events, and that the change in flow is usually 0.25 mgd or higher. The next step in this analysis is to quantify how much flow varies when it is not being influenced by rainfall.

To identify dry periods, the 2015-2018 Durham WWTF flow record was again examined. Dates when UNH was out of session were removed from the dataset for separate consideration. Precipitation data from the Portsmouth/Pease International Tradeport weather station was acquired and, using the accompanying snowfall record, precipitation events were characterized as rainfall, snowfall, or a mix. Dry periods were identified by identifying a date when rainfall, regardless of amount, occurred. After the rainfall ended, the dry period was defined to begin on the eighth day after the end of the rainfall event, in order to ensure that sufficient time had elapsed to ensure that rainfall effects were no longer influencing WWTF flows. The dry period was deemed to last until the next rainfall event (any amount of rain). For the 2015-2018 period, 21 events were identified, and several flow characteristics for each event were documented.

Event #	Start Date	End Date	Min flow mgd	Max flow mgd	Max-Min	Avg flow for Event	Std Dev. for event	Avg. change (mgd)	Std Dev. Flow Change (mgd)
1	5/5/15	5/11/15	0.72	1.09	0.37	0.95	0.13	0.11	0.11
2	9/1/15	9/9/15	0.77	0.96	0.19	0.89	0.07	0.06	0.05
3	9/21/15	9/28/15	0.75	0.92	0.17	0.87	0.06	0.05	0.06
4	11/9/15	11/10/15	1.13	1.14	0.01	1.14	0.01	0.01	---
5	12/10/15	12/13/15	0.81	1.02	0.21	0.92	0.11	0.07	0.10
6	1/27/16	2/2/16	0.86	1.05	0.19	0.96	0.07	0.07	0.06
7	4/20/16	4/22/16	1.06	1.09	0.03	1.07	0.02	0.02	0.01
8	1/27/15	3/3/15	0.74	1.07	0.33	0.93	0.09	0.07	0.07
9	2/12/16	2/15/16	0.85	1.09	0.24	0.98	0.10	0.09	0.07
10	8/30/16	8/31/16	0.86	0.87	0.01	0.87	0.01	0.01	--
11	12/9/16	12/11/16	0.85	1.04	0.19	0.92	0.10	0.10	0.09
12	2/3/17	2/7/17	0.93	1.07	0.14	1.01	0.06	0.06	0.07
13	3/21/17	3/23/17	1.05	1.06	0.01	1.06	0.01	0.01	0.01
14	8/31/17	9/2/17	0.88	0.91	0.03	0.90	0.02	0.02	0.02
15	10/17/17	10/23/17	0.79	1.03	0.24	0.94	0.09	0.05	0.06
16	12/14/17	12/16/17	0.61	0.86	0.25	0.76	0.13	0.13	0.09
17	1/31/18	2/3/18	0.95	1.05	0.1	1.02	0.05	0.04	0.04
18	3/19/18	3/28/18	1.12	1.24	0.12	1.18	0.05	0.03	0.02
19	4/20/18	4/24/18	1.22	1.49	0.27	1.31	0.11	0.10	0.07
20	8/30/18	9/5/18	0.78	0.95	0.17	0.99	0.06	0.05	0.05
21	12/10/18	12/15/18	0.9	1.21	0.31	1.12	0.12	0.06	0.06

The average length of the 21 dry periods identified was eight days, with an average flow of 0.99 mgd. During these periods, the flow varied anywhere from 0.01 to 0.37 mgd. When the maximum flow change for each event was averaged, the average change in flow was 0.17 mgd.



In the previous section, a flow change value of 0.25 mgd was established as indicating flow was affected by rainfall. Flow changes during dry periods should generally not exceed that value. Of the 21 dry periods identified, 16 fall below that standard.

Flow Characteristics When UNH is out of session.

The preceding analyses were repeated using flow data during late spring and summer, when UNH was not in session.

For storms over one inch, ten events were identified. On average flows increased 0.21 mgd, and flows returned to pre-storm levels in 4-5 days.

Event	**Date**	**rain (in)**	**Prestorm flow (mgd)**	**Peak Post Storm Flow (mgd)**	**Abs. Value of Flow Change (mgd)**	**Flow Change (%)**	**# Days for Flow to Return to Prestorm Level**
1	5/31/2015	3.33	0.43	0.92	0.49	114.0	7
2	8/21/2015	1.24	0.53	0.67	0.14	26.4	6
3	6/5/2016	1.23	0.6	0.66	0.06	10.0	5
4	7/23/2016	1.03	0.45	0.45	0.00	0.0	0
5	5/26/2017	1.73	0.8	1.16	0.36	45.0	3
6	6/16/2017	1.13	0.7	0.72	0.02	2.9	3
7	6/30/2017	1.13	0.59	0.71	0.12	20.3	4
8	8/18/2017	1.57	0.56	0.75	0.19	33.9	3

9	7/17/2018	1.73	0.72	1.03	0.31	43.1	4
10	8/3/2018	1.91	0.79	1.15	0.36	45.6	7
AVERAGE					0.21		4.20

For storms 0.5 - 1 inch, six events were identified. On average, flows increased by 0.17 mgd, and returned to pre-storm levels in 6-7 days.

Event	Date	rain (in)	Prestorm flow (mgd)	Peak Post Storm Flow (mgd)	Abs. Value of Flow Change (mgd)	Flow Change (%)	# Days for Flow to Return to Prestorm Level
1	8/11/2015	0.74	0.5	0.63	0.13	26.0	4
2	6/28/2016	0.59	0.39	0.73	0.34	87.2	6
3	7/9/2016	0.73	0.47	0.57	0.10	21.3	9
4	7/6/2017	0.7	0.52	0.63	0.11	21.2	11*
5	7/24/2017	0.77	0.49	0.63	0.14	28.6	7*
6	6/4/2018	0.65	0.58	0.77	0.19	32.8	6
AVERAGE					0.17		6.25

*flow recovery extended by additional rain

As for dry periods, only three were identified using the criteria previously outlined.

Event #	Start Date	End Date	Min flow mgd	Max flow mgd	Max-Min	Avg flow for Event	Std Dev. for event	Avg. change (mgd)	Std Dev. Flow Change (mgd)
1	6/10/2015	6/14/2015	0.41	0.56	0.15	0.49	0.05	0.04	0.03
2	6/19/2016	6/20/2016	0.38	0.51	0.13	0.45	0.09	0.13	
3	7/31/2017	8/4/2017	0.47	0.52	0.05	0.496	0.02	0.02	0.01

The main conclusions from these analyses are:

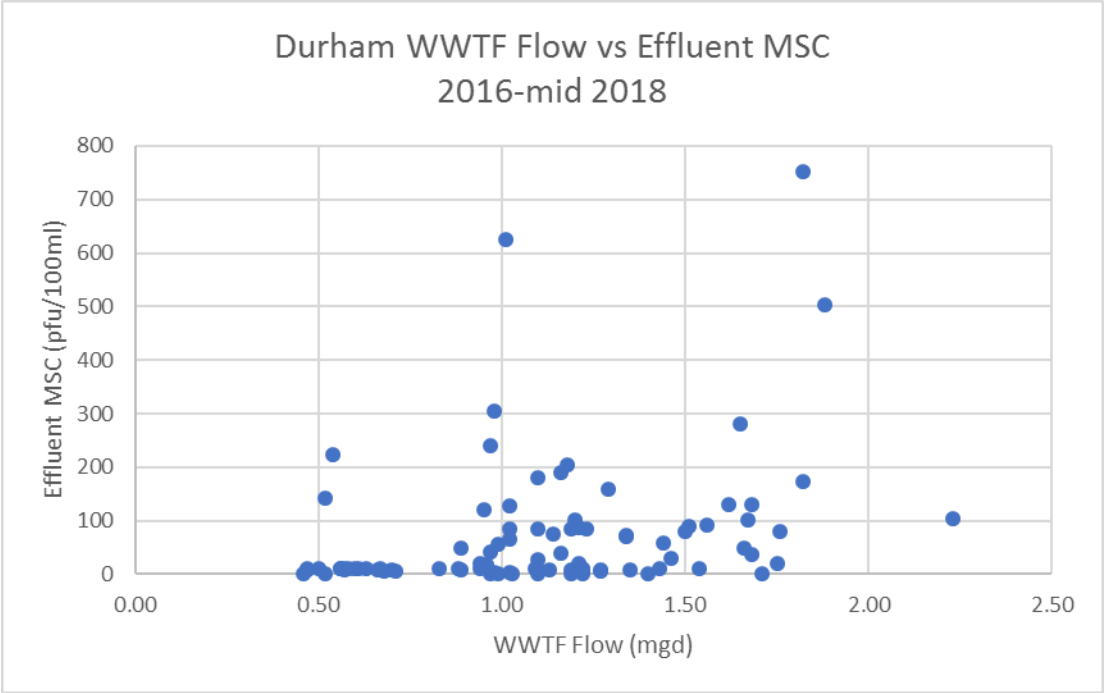
When UNH is in session, heavy rainfall events (over one inch) typically cause a flow increase of 0.25 mgd or more, and it takes 5-7 days after the rain ends for flows to return to pre-storm levels. During the summer, the flow response is a bit less (0.21 mgd increase in flow, and 4-5 day period for flows to return to pre-storm levels.

For lesser rainfall events (0.50 – 1.0 inch) when UNH is in session, WWTF flows increase of 0.25 mgd half the time, and it takes 5-8 days after the rain ends for flows to return to pre-storm levels. During the summer, the flow response is a bit less (0.17 mgd increase in flow, and 6-7 day period for flows to return to pre-storm levels.

Male-Specific Coliphage Testing In Finished Effluent:

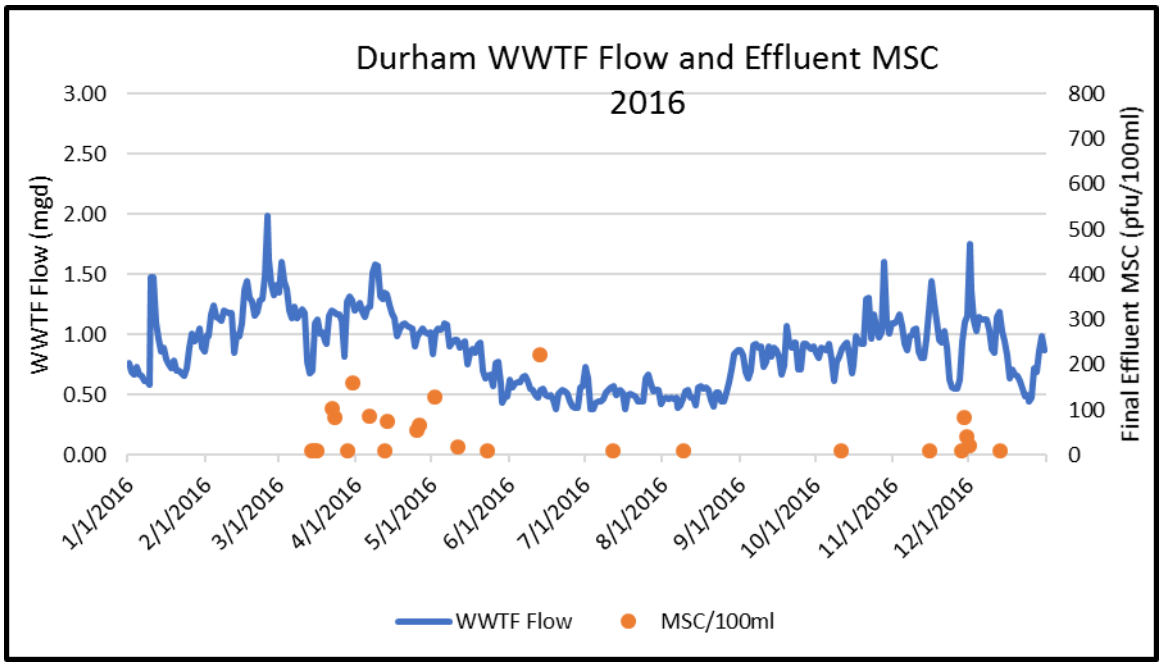
91 grab samples of finished effluent were collected 2016-2018, primarily by NHDES Shellfish Program staff and Spinney Creek Shellfish staff. A variety of seasons and weather conditions were targeted. Lab analyses by USFDA/Dauphin Island, MA Division of Marine Fisheries/Newburyport, NHDHHS Water Analysis Laboratory, and Spinney Creek Shellfish. Most samples are single grabs. Samples collected/analyzed by Spinney Creek were run in triplicate, and three hourly samples were taken each sampling date (9am, 10am, 11am). For the present analysis, the highest of the three Spinney Creek samples on each date is used to represent effluent MSC/100ml for that date. For the 91 samples:

count	91
geomean	23.9
median	19
min	0.9
max	753

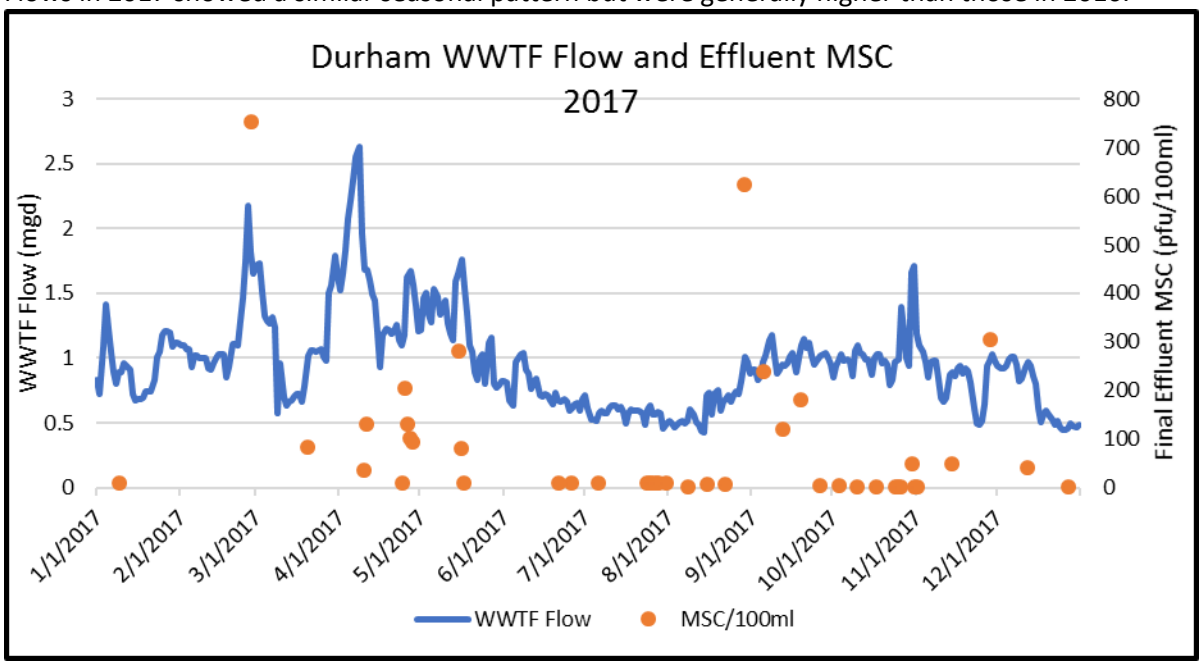


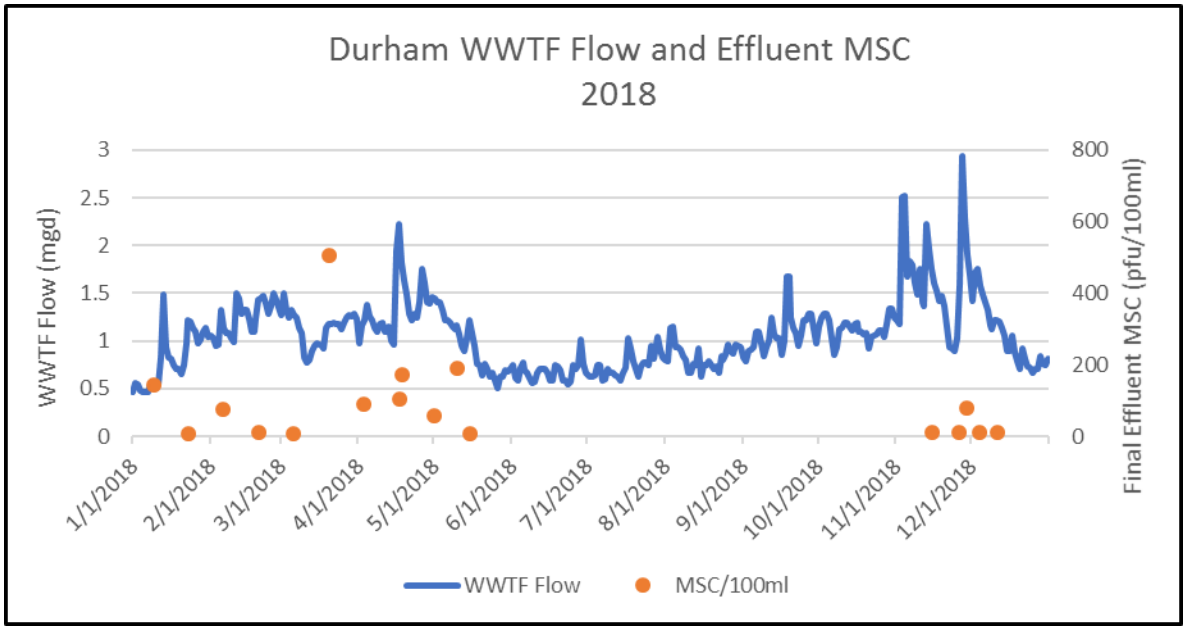
Effluent Flows, 2016-2018

Flows taken from Monthly Operations Reports for 2016 show seasonal lows in summer, with increased flow when UNH comes back into session in late August. Seasonal high flows from snowmelt, rainfall, and higher groundwater levels in the spring.
For calendar year 2016 (with effluent MSC data):



Flows in 2017 showed a similar seasonal pattern but were generally higher than those in 2016.





Distribution of flows for four years of data (total daily flow values, 2015-2018)

	# observations	% of total	cumulative %
≤0.50 mgd	89	6.1	6.1
0.51 - 0.75 mgd	408	27.9	34.0
0.76 - 1 mgd	441	30.2	64.2
1.01 - 1.25 mgd	317	21.7	85.9
1.26 - 1.50 mgd	121	8.3	94.2
1.51 - 1.75 mgd	53	3.6	97.8
1.76 - 2 mgd	18	1.2	99.0
>2 mgd	14	1.0	100.0

Distribution of flows for the proposed May-September harvest period over four years of data (total daily flow values, 2015-2018)

	# observations	% of total	cumulative %
≤0.50 mgd	89	14.6	14.6
0.51 - 0.75 mgd	263	43.0	57.6
0.76 - 1 mgd	167	27.3	84.9
1.01 - 1.25 mgd	68	11.1	96.1
1.26 - 1.50 mgd	17	2.8	98.9
1.51 - 1.75 mgd	6	1.0	99.8
1.76 - 2 mgd	1	0.2	100.0
>2 mgd	0	0.0	100.0

MSC under various flow regimes:

WWTF Flow	# samples	MSC average	MSC median	MSC min	MSC max
0.46-1.00 mgd	35	40.4	9.9	1.9	304
1.01-1.25 mgd	29	74.6	27	0.9	625
1.26-1.5 mgd	11	46.3	30	1.9	160
1.51-2.23 mgd	16	159.7	97.5	1.9	753

<u>Is 1000:1 or 400:1 appropriate for Durham?</u>

To examine this question, I used the following table as a guide:

Recommended dilution for sizing buffer zones based on analysis of sixty-two (62) mechanical[1] sewage treatment works with a total of 595 samples of influent and effluent assessed in a meta-analysis of the reduction of norovirus and male-specific coliphage concentrations from Pouillot et. al, 2015 is presented in Table 1 (below). The median and ninety percentile MSC in influent and log reduction in mechanical STW considering no disinfection, chlorine, and UV were used to estimate the concentration of MSC in bivalve molluscs based on the recommended dilution in growing area (provided by a buffer zone) and assuming 100-fold bioaccumulation based on Burkhardt & Calci, 2000.

Table 1: Recommended minimum buffer zone dilution based on data from Pouillot et al., 2015:

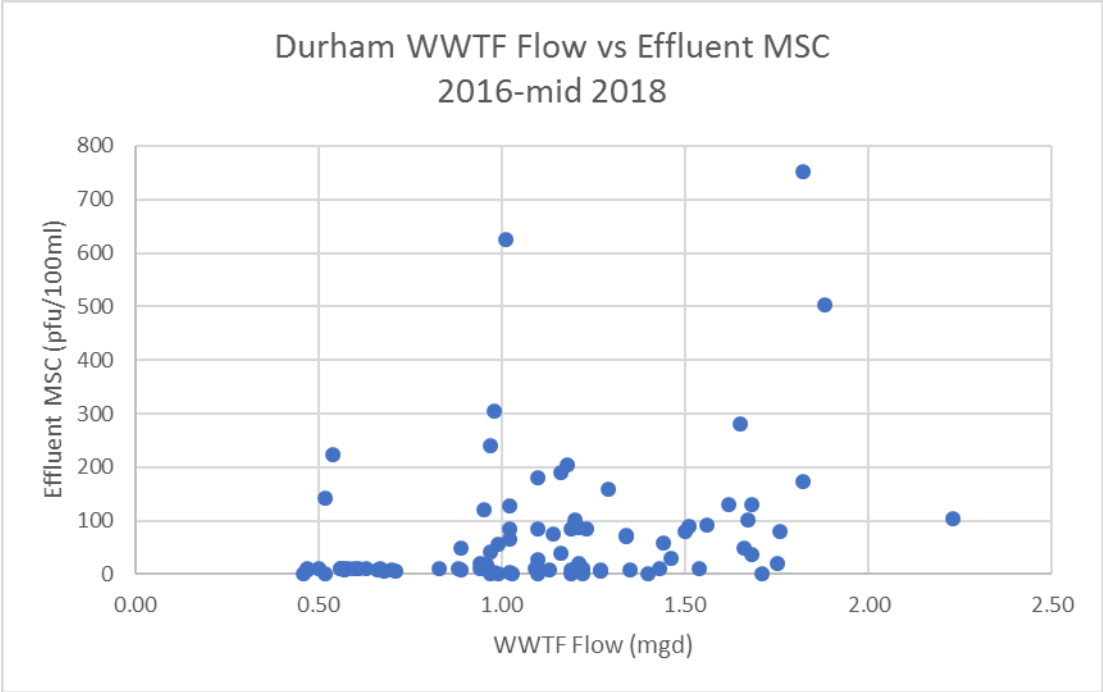
Mechical WWTP	Influent	MSC in Influent PFU/100 ml[1]	Log Reduction WWTP[1]	Estimated MSC in Effluent PFU/100 ml	Minimum Dilution in Growing Area	Estimated MSC in Growing Area PFU/100 ml	Estimated MSC in Bilvalves PFU/100 g[2]
Influent raw	Median	158,000	0.0	158,000	350,000	0.45	45
Influent raw	90%tile	214,000	0.0	214,000	350,000	0.61	61
Partially treated[3]	Median	158,000	1.0	16,000	100,000	0.16	16
Partially treated[3]	90%tile	214,000	0.5	68,000	100,000	0.68	68
No disinfection	Median	158,000	2.4	631	10,000	0.06	6
No disinfection	90%tile	214,000	2.1	1,811	10,000	0.18	18
Chlorine	Median	158,000	2.8	251	1,000	0.25	25
Chlorine	90%tile	214,000	2.5	620	1,000	0.62	62
UV	Median	158,000	4.3	8	300	0.03	3
UV	90%tile	214,000	3.9	27	300	0.09	9

[1] MSC in influent and log reduction for no disinfection, chlorine, and UV based on Pouillot et al., 2015
[2] Estimated MSC in bivalve molluscs assuming 100-fold bioaccumulation based on Burkhardt & Calci, 2000
[3] Log reductions for partially treated sewage were assumed for illustration whereas others based on Pouillot et al., 2015

Table citation:

This table suggests that a secondary chlorine facility such as Durham, under normal operating conditions, should produce finished effluent with MSC averaging 250 pfu/100ml. When divided by a factor of 1000, the growing area at the edge of the 1000:1 zone would see MSC in seawater of 0.25 pfu/100ml.

In Durham's case, in 91 samples collected over 2.5 years (2016 to mid 2018) and under a variety of conditions, almost all of the samples are below 250. Many are below 100.



The five samples that were over 250 pfu/100ml were:

Date	WWTF mgd	MSC (pfu/100ml)	Comments
2/27/17	1.82	753	after ~0.5 inches rain, plant flows nearly doubled over the course of 3 days (1.29 to 2.18 mgd from 2/23-2/26)
5/15/17	1.65	280	over 1.5 inches of rain the day before, plant flows go from 1.14 to 1.65 from 5/13 to 5/15
8/29/17	1.01	625	UNH returning to session, plant flows 0.72 to 1.01 mgd from 8/27 to 8/29
11/28/17	0.98	304	UNH returning to session after Thanksgiving; flows Saturday 11/25 were 0.52, rise to 0.94 on 11/27
3/20/18	1.17	504	no rainfall. UNH spring break 3/11-3/15, flows around 0.90. classes resume 3/18, flows rise to 0.92 on 3/18, 1.17 by 3/20

Three of these five dates would have been outside of the harvesting season in Little Bay. Because virtually all of the data points (86 of 91, or 94.5 percent) showed MSC values of 250 or less, it made sense to see how often a 400:1 scenario might be appropriate. Again, using the 0.25 MSC /100ml in seawater as a guide, the effluent MSC effluent number to key in on would be (0.25 * 400 = 100 pfu/100ml).

71 of 91 observations (78 percent) had MSC less than 100. Of the remaining 20, most occurred within the April to September harvest season (sorted in ascending order of flow)

Date	WWTF mgd	MSC (pfu/100ml)	Comments
1/9/18	0.52	142	closed season
6/13/16	0.54	223	
9/12/17	0.95	121	
9/5/17	0.97	240	
11/28/17	0.98	304	closed season
8/29/17	1.01	625	UNH returning to session
5/2/16	1.02	129	
9/19/17	1.10	180	
5/10/18	1.16	190	
4/25/17	1.18	205	
3/22/16	1.20	102	closed season
3/30/16	1.29	160	closed season
4/26/17	1.62	130	
5/15/17	1.65	280	
4/27/17	1.67	102	
4/11/17	1.68	130	
4/18/18	1.82	173	
2/27/17	1.82	753	closed season
3/20/18	1.88	504	closed season
4/17/18	2.23	103	

The above table does not illustrate that 400:1 is appropriate at all times. Over 20 percent of the time the WWTF MSC level is probably too high to be safely diluted within a 400:1 zone.

To help identify when, and where, the 400:1 zone might be sufficiently protective to allow for harvest, it is helpful to review the dye tracking data (see Figures 6, 7, and 8 in the sanitary survey). The discussion in the sanitary survey around those Figures helps establish the following criteria for when harvest in areas with 400:1 dilution or greater is appropriate:

Time of year: April or May until early October, AND
WWTF Flow: no greater than 1.25 mgd
Location: no farther upstream than Smith Creek

It may be more practical to select May as the start month, as flows in April frequently exceed 1.25 mgd. Other typical C.A conditions, such as rainfall thresholds and normal operation of the WWTF would also apply.

The 1.25 mgd threshold is a reasonable management standard, as 96 percent of the plant flows are at or below that number for the proposed May-September harvest period.

Appendix II

Shoreline Pollution Source Sampling Results
(samples collected during the triennial review period are shaded)

Station ID	Weather Conditions	Pollution Source	Date	Fecal Coliform per 100ml	Units
OYSPS001	DRY	TIDAL CREEK	6/30/2011	10	#/100ML
			5/8/2014	<10	#/100ML
			7/25/2006	60	#/100ML
			5/12/2008	230	#/100ML
			11/1/2018	30	CFU/100ML
			7/1/2002	412	#/100ML
	SURVEY	TIDAL CREEK	7/1/2002	412	#/100ML
	WET	TIDAL CREEK	6/23/2011	130	#/100ML
			7/23/2008	220	#/100ML
			9/4/2002	>20000	#/100ML
			9/16/2002	50	#/100ML
OYSPS002	DRY	TIDAL CREEK	6/30/2011	20	#/100ML
			5/8/2014	<10	#/100ML
			7/25/2006	110	#/100ML
			5/12/2008	80	#/100ML
			11/1/2018	10	CFU/100ML
			7/1/2002	220	#/100ML
	SURVEY	TIDAL CREEK	7/1/2002	220	#/100ML
	WET	TIDAL CREEK	6/23/2011	110	#/100ML
			7/23/2008	190	#/100ML
			9/4/2002	290	#/100ML
			9/16/2002	460	#/100ML
OYSPS003	DRY	TIDAL CREEK	6/30/2011	<10	#/100ML
			5/8/2014	<10	#/100ML
			7/25/2006	20	#/100ML
			5/12/2008	30	#/100ML
			11/1/2018	<10	CFU/100ML
			7/1/2002	38	#/100ML
	SURVEY	TIDAL CREEK	7/1/2002	38	#/100ML
	WET	TIDAL CREEK	6/23/2011	90	#/100ML
			7/23/2008	70	#/100ML
			9/4/2002	40	#/100ML
			9/16/2002	30	#/100ML
OYSPS004	DRY	TIDAL CREEK	6/29/2011	<9	#/100ML

Station ID	Weather Conditions	Pollution Source	Date	Fecal Coliform per 100ml	Units
			4/15/2014	9	#/100ML
			5/8/2014	9	#/100ML
			7/25/2006	40	#/100ML
			5/12/2008	<10	#/100ML
			11/1/2018	10	CFU/100ML
			7/1/2002	66	#/100ML
	SURVEY	TIDAL CREEK	7/1/2002	66	#/100ML
	WET	TIDAL CREEK	6/23/2011	10	#/100ML
			4/16/2014	90	#/100ML
			7/23/2008	30	#/100ML
			9/16/2008	80	#/100ML
			9/4/2002		#/100ML
			9/16/2002	<10	#/100ML
OYSPS005	DRY	ROAD CULVERT	4/15/2014	<10	#/100ML
			7/1/2002		
			7/25/2006		#/100ML
			6/29/2011		#/100ML
			10/22/2018		#/100ML
	SURVEY	ROAD CULVERT	7/1/2002		
	WET	ROAD CULVERT	4/8/2014	210	#/100ML
			4/16/2014	60	#/100ML
			9/4/2002		
			9/16/2002		
			7/23/2008		#/100ML
			6/23/2011		#/100ML
OYSPS006	DRY	ROAD CULVERT	4/15/2014	<10	#/100ML
			7/1/2002		
			7/25/2006		#/100ML
			6/29/2011		#/100ML
			10/22/2018		#/100ML
	SURVEY	ROAD CULVERT	7/1/2002		
	WET	ROAD CULVERT	4/8/2014	<10	#/100ML
			4/16/2014	20	#/100ML
			9/4/2002	>2000	#/100ML
			9/16/2002		
			7/23/2008		#/100ML
			6/23/2011		#/100ML

Station ID	Weather Conditions	Pollution Source	Date	Fecal Coliform per 100ml	Units
OYSPS007	DRY	ROAD CULVERT	7/1/2002		
			7/25/2006		#/100ML
			6/29/2011		#/100ML
			10/22/2018		#/100ML
	SURVEY	ROAD CULVERT	7/1/2002		
	WET	ROAD CULVERT	9/4/2002		
			9/16/2002		
			7/23/2008		#/100ML
			6/23/2011		#/100ML
OYSPS008	DRY	STORMWATER OUTFALL	4/15/2014	<10	#/100ML
			7/25/2006	10	#/100ML
			7/1/2002	0	#/100ML
			5/12/2008		#/100ML
			6/29/2011		#/100ML
			10/22/2018		#/100ML
	SURVEY	STORMWATER OUTFALL	7/1/2002	0	#/100ML
	WET	STORMWATER OUTFALL	4/8/2014	<10	#/100ML
			4/16/2014	<10	#/100ML
			9/4/2002		
			9/16/2002		
			7/23/2008		#/100ML
			6/23/2011		#/100ML
OYSPS009	DRY	INTERMITTENT STREAM	6/29/2011	<10	#/100ML
			4/15/2014	<10	#/100ML
			7/25/2006	10	#/100ML
			5/12/2008	50	#/100ML
			10/22/2018	210	CFU/100ML
			7/1/2002	126	#/100ML
	SURVEY	INTERMITTENT STREAM	7/1/2002	126	#/100ML
	WET	INTERMITTENT STREAM	6/23/2011	140	#/100ML
			4/16/2014	150	#/100ML
			7/23/2008	50	#/100ML
			9/16/2008	250	#/100ML
			9/4/2002		
			9/16/2002		
OYSPS010	DRY	INTERMITTENT	6/29/2011	40	#/100ML

Station ID	Weather Conditions	Pollution Source	Date	Fecal Coliform per 100ml	Units
		STREAM	4/15/2014	<10	#/100ML
			7/25/2006	10	#/100ML
			5/12/2008	9	#/100ML
			5/30/2018	90	CFU/100ML
			6/12/2018	110	CFU/100ML
			10/22/2018	14400	CFU/100ML
			7/1/2002	158	#/100ML
	SURVEY	INTERMITTENT STREAM	7/1/2002	158	#/100ML
	WET	INTERMITTENT STREAM	6/23/2011	50	#/100ML
			4/8/2014	<10	#/100ML
			4/16/2014	50	#/100ML
			7/23/2008	140	#/100ML
			6/25/2018	1110	CFU/100ML
			11/6/2018	1300	CFU/100ML
			9/4/2002	290	#/100ML
			9/16/2002	<10	#/100ML
			9/16/2008		#/100ML
OYSPS011	DRY	NPDES FACILITY	8/1/2012	40000	MPN/100ML
			5/28/2008	<20	MPN/100ML
			7/30/2008	<20	MPN/100ML
			8/27/2008	<20	MPN/100ML
			10/14/2008	24000	MPN/100ML
			3/14/2016	330	MPN/100ML
			6/8/2016	4900	MPN/100ML
			2/22/2017	13000	MPN/100ML
			2/27/2017	24000	MPN/100ML
			3/20/2017	3300	MPN/100ML
			9/26/2000	30000	MPN/100ML
			11/20/2000	50000	MPN/100ML
			12/6/2000	300000	MPN/100ML
			2/22/2001	14000	MPN/100ML
			12/3/2001	7900	MPN/100ML
	SURVEY	NPDES FACILITY	6/18/2001	490000	MPN/100ML
	WET	NPDES FACILITY	6/23/2011	1700	MPN/100ML
			4/16/2014	790	MPN/100ML
			4/6/2017	14000	MPN/100ML
			7/31/2000	50000	MPN/100ML

Station ID	Weather Conditions	Pollution Source	Date	Fecal Coliform per 100ml	Units
			8/17/2000	80000	MPN/100ML
			4/10/2001	140000	MPN/100ML
			6/18/2001	490000	MPN/100ML
			8/13/2001	130000	MPN/100ML
			10/16/2001	220000	MPN/100ML
OYSPS012	DRY	NPDES OUTFALL	5/8/2014	9	#/100ML
			11/1/2018	<10	CFU/100ML
OYSPS014	DRY	TIDAL CREEK	6/29/2011	50	#/100ML
			4/15/2014	40	#/100ML
			7/25/2006	50	#/100ML
			5/12/2008	70	#/100ML
			11/1/2018	20	CFU/100ML
	WET	TIDAL CREEK	6/23/2011	160	#/100ML
			4/16/2014	240	#/100ML
			7/23/2008	150	#/100ML
			9/16/2008	120	#/100ML
OYSPS015	DRY	TIDAL RIVER	5/30/2018	<10	CFU/100ML
			6/12/2018	20	CFU/100ML
			8/28/2018	60	CFU/100ML
			10/22/2018	10	CFU/100ML
			9/24/2001	20	#/100ML
			10/5/2001	<10	#/100ML
	WET	TIDAL RIVER	6/25/2018	10	CFU/100ML
			11/6/2018	30	CFU/100ML
			10/17/2001	0	#/100ML
OYSPS016	DRY	INTERMITTENT STREAM	6/30/2011	10	#/100ML
			5/8/2014	9	#/100ML
			5/12/2008	100	#/100ML
			11/1/2018	50	CFU/100ML
			10/20/2008		#/100ML
	WET	INTERMITTENT STREAM	6/23/2011	230	#/100ML
			7/23/2008	60	#/100ML
			9/16/2008		#/100ML
OYSPS017	DRY	INTERMITTENT STREAM	6/30/2011	100	#/100ML
			5/8/2014	<10	#/100ML
			5/12/2008	<10	#/100ML
			11/1/2018	70	CFU/100ML
			10/20/2008		#/100ML
	WET	INTERMITTENT	6/23/2011	200	#/100ML

Station ID	Weather Conditions	Pollution Source	Date	Fecal Coliform per 100ml	Units
		STREAM	7/23/2008	1350	#/100ML
			9/16/2008		#/100ML
OYSPS018	DRY	ROAD CULVERT	4/15/2014	<10	#/100ML
			10/22/2018		#/100ML
	WET	ROAD CULVERT	4/8/2014	<10	#/100ML
			4/16/2014	40	#/100ML
OYSPS019	DRY	NPDES FACILITY	6/8/2016	<2	MPN/100ML

Appendix III

Conditional Area Management Plan for the Oyster River
Revision 13: October 31, 2018

DESCRIPTION OF CONDITIONALLY APPROVED AREA

The waters of the Oyster River Mouth are classified as Conditionally Approved. For the purposes of this classification, the Oyster River Mouth is defined by a line near Wagon Hill Farm, from a point on the Oyster River shore located at $43^0$07'30.21"N, $70^0$52'51.88"W, running southerly to a point on the Oyster River shore near Durham Point at $43^0$07'20.13"N, $70^0$52'9.41"W. The downstream boundary of the Oyster River mouth is defined by a line from a point on the Oyster River shore located at $43^0$07'28.66"N, $70^0$52'07.14"W, running southerly to a point on the Oyster River shore near Durham Point at $43^0$07'14.50"N, $70^0$52'10.19"W.

FACTORS INDICATING SUITABILITY OF PORTIONS OF THE OYSTER RIVER AS CONDITIONALLY APPROVED

1. The major pollution source(s) with the potential to adversely affect water quality in the Oyster River are point source in origin, namely, the wastewater treatment facilities in Durham and Portsmouth. The Conditionally Approved area is separated spatially from each wastewater treatment facility outfall by a Prohibited/Safety Zone. National Pollutant Discharge Elimination System (NPDES) permit requirements for the facilities require the plant operators to immediately notify NHDES when discharges of improperly treated sewage occur, and experience to date has shown the plant operators do provide timely notification to NHDES. There are no other significant point sources in the Conditionally Approved area.
2. The waters of the Oyster River can be affected by nonpoint sources of pollution following rainfall events of 1.5 inches or more per 24 hours. Weather information is available in real-time from the Pease airport weather tower in Portsmouth, which is staffed 24 hours a day.
3. The Oyster River can be adversely affected very quickly by a discharge of improperly disinfected effluent from the Portsmouth WWTF. Therefore, there must be very tight control over when recreational and commercial harvesting can occur.
4. The Oyster River exhibits a tidal range that indicates substantial exchange with coastal ocean waters.

POLLUTION EVENTS THAT MAY TRIGGER CONDITIONAL AREA CLOSURE

Durham Wastewater Treatment Facility

The following performance standards may be used to trigger a closure of the Conditionally Approved areas at the Oyster River mouth. Violation of any of the following shall trigger notification of the NHDES Shellfish Program by the Town of Durham:

- Effluent flow: total daily flow shall not exceed the WWTF design flow of 2 MGD.
- Bacteriological quality of the effluent: shall not exceed 43 fecal coliform/100ml after disinfection. Notification of results over 43/100ml shall occur as soon as the laboratory test results are completed.
- Bypasses: any discharge of raw sewage or partially treated sewage from the WWTF or from any part of the sewage collection system. For the purposes of this performance standard, "partially treated sewage" means sewage/effluent that has been released to the environment before undergoing all aspects of treatment required by the most recent NPDES permit.
- Failure of the WWTF to complete its required effluent monitoring, such that the biological, physical, and/or chemical quality of the effluent is unknown.

Portsmouth Wastewater Treatment Facility (Peirce Island, Portsmouth, New Hampshire 03801. Timothy Babkirk, Operator, 603-957-8780)

The following performance standards may be used to trigger a closure of the Conditionally Approved areas in the Oyster River. Exceedence of any of the following shall trigger immediate notification of the NHDES Shellfish Program by the City of Portsmouth:

- Effluent flow: total daily flow shall not exceed 4.8 mgd.
- Bacteriological quality of the effluent: shall not exceed 43 fecal coliform/100ml after disinfection. Notification of results over 43/100ml shall occur as soon as the laboratory test results are completed.
- Bypasses: any discharge of raw sewage or partially treated sewage from the WWTF or from any part of the sewage collection system. For the purposes of this performance standard, "partially treated sewage" means sewage/effluent that has been released to the environment before undergoing all aspects of treatment required by the most recent NPDES permit.
- Failure of the WWTF to complete its required effluent monitoring, such that the biological, physical, and/or chemical quality of the effluent is unknown.

Meteorological or Hydrological Events

Rainfall events of more than 1.50 inches total precipitation shall trigger a closure of the Conditionally Approved area of the Oyster River. The 1.50 inch criterion is intended to generally apply to a 24-hour period; however, rainfall events that occur over a longer period of time may also warrant closure. Analysis of precipitation records from Portsmouth, NH, suggests that on average, such events will occur approximately 5-10 times per year. An analysis of the relationship between rainfall and bacteria levels is presented in the sanitary survey report.

For the purpose of this performance standard, rainfall data will be obtained from the meteorological observation station at the Pease International Tradeport Airport in Portsmouth, New Hampshire. Real-time checks of rainfall data are made via phone calls to the weather observation station at the airport tower. Data from other coastal New Hampshire weather stations (e.g., Seabrook) may also be used to institute a closure.

Closures will be instituted for precipitation events that fall primarily as rainfall. Precipitation that falls primarily as snow and/or ice will generally not trigger a closure, as these events do not produce the runoff that transports bacterial contamination to the growing waters. However, precipitation events that fall as a mix of rain and snow/ice, or snow/ice events that are immediately followed by a significant melting period, may trigger a closure. The potential for growing area contamination by such events will be evaluated by NHDES Shellfish Program staff on a case-by-case basis, and closure decisions will be made accordingly.

Other Events

Recreational shellfish harvest will only be allowed on Saturdays, 9am-sunset. The delayed start time gives NHDES and the WWTF time to communicate any overnight treatment issues to recreational harvesters via the Clam Hotline and the NH Coastal Atlas, and initiate temporary harvest closures as needed. Commercial harvesting (where allowed by NH Fish and Game) is controlled by NHDES through direct communication with each harvester on a harvest-by-harvest basis, so commercial harvesting can be allowed any day of the week, provided that conditions in the Conditional Area Management Plan are being met.

IMPLEMENTATION OF A CONDITIONALLY APPROVED AREA CLOSURE

Notification of Management Plan Violation

The Durham and Portsmouth WWTFs are responsible for immediately notifying NHDES in the event of a violation of the aforementioned performance standards. The response time between management plan violation and notification of NHDES can vary, depending on the sewage discharge. However, historical experience with these WWTFs indicates notification can be expected within four-to-six hours of the management plan violation. Notification time is shortened by the availability of a pager maintained by NHDES staff (Chris Nash, Shellfish Program Manager, 222 International Drive, Suite 175, Pease Tradeport, Portsmouth, New Hampshire 03801). The Shellfish Program pager is to be used for notification (603/771-9826). The Shellfish Program also maintains a cell phone (603/568-6741) to be used by WWTF as needed (if direct contact with Shellfish staff is not made via cellphone, a page must be sent).

The Prohibited/no-harvest zone around each outfall is based in part on the time of travel notification time (response time) by each WWTF. WWTF response times will be reviewed annually to determine if a change in the size of the zone is warranted.

NHDES Shellfish Program staff are responsible for monitoring weather forecasts and conditions, and acquiring real-time rainfall data from the Pease Airport or other sources for the purposes of determining when a rainfall closure is necessary.

Implementation of Closure

Response time between management plan violation notification and

legal closure by NHDES is relatively short for all facilities, typically within four to six hours. The short response times are aided by the automated alarm systems at the facilities and the fact that the NHDES Shellfish Program staff are on call (cellphone and pager) every day, 6am-9pm. Rainfall closures are also implemented quickly, as NHDES maintains direct contact with the Pease airport weather observation station. Notification of NHF&G (patrol agency) by NHDES typically occurs immediately following NHDES notification. Implementation of closure by NHF&G is often immediate as well, and typically occurs immediately after notification by NHDES. The following notification protocol is followed for each closure:

> Initiation of Closure: Each week, the NHDES Shellfish Program calls the NHF&G Law Enforcement Division and sends a "Clam Hotline update" email to NHF&G Marine Fisheries Division/Durham,NHF&G Law Enforcement Division/Durham, and NHF&G Public Affairs Division in Concord. The email makes note of any management plan violations that have occurred, as well as any necessary closures. These emails typically outline the more common types of temporary closures, such as those occurring after rainfall events. For the more rare management plan violations that could involve prolonged closures (e.g., significant discharges of improperly treated waste from a WWTF), an informational email is sent not only to NHF&G Marine Fisheries Division/Durham, NHF&G Law Enforcement Division/Durham, and NHF&G Public Affairs Division in Concord, but also to the NHDHHS/Bureau of Food Protection, the NHDHHS Public Health Laboratory in Concord, and the NHDES Public Information Office in Concord.
>
> F&G will enforce provisions of Fis 606.02(b) once NHDES has placed the area in the closed status.
>
> Public Dissemination of Closure Information: NHF&G will serve as the lead agency to inform recreational harvesters and the general public of any closures and subsequent reopenings. Procedures to inform the public may include such vehicles as the Clam Hotline and press releases. NHNHDES will assist with informing the general public via updates to the NH Coastal Atlas. NHDHHS will serve as the lead agency to inform the commercial shellfish industry of any closures and subsequent reopenings.

Enforcement of Closure

The New Hampshire Fish and Game Department is the agency responsible for patrolling waters closed for public health reasons. The frequency of patrols will be at the discretion of NH Fish and Game /Law Enforcement Division staff (Lt. Michael Eastman, Sgt. Jeremy Hawkes, Conservation Officer James Benvenuti, Conservation Officer Graham Courtney), NHF&G Region 3 Office, 225 Main Street, Durham, New Hampshire 03824, 603/868-1095).

REOPENING A CONDITIONALLY APPROVED AREA AFTER CLOSURE

Wastewater Treatment Plant/Collection System-Related Closures: Following closures triggered by discharges of raw or partially treated sewage from a wastewater treatment facility and/or any part of its sewage collection system, NHDES will be the lead agency for identifying necessary

sampling locations and frequency needed to reopen the shellfish beds. At a minimum, water sampling will be conducted at monitoring site GB50. If site access is limited by ice cover or other conditions, alternative shoreline sites will be used. Because access to shellfish tissue sampling sites can vary with tide stage, ice, and daylight considerations, shellfish tissue sampling sites will be determined on a case-by-case basis. NHDES will be the lead agency in collecting water and shellfish tissue samples and will notify the NHDHHS lab of its intention to sample. All samples will be held on ice and will be delivered to the NHDHHS Laboratory in Concord by the collecting agency as soon as practical, but always within 24 hours of collection. Upon completion of the laboratory tests, NHDHHS laboratory personnel will promptly inform the NHDES Shellfish Program of the results. NHDES will then decide whether or not the sample results support a reopening of the area and will notify F&G/Law Enforcement Division of the decision. Sampling will continue until meat samples show a FC MPN of 230/100g or less (or a different baseline value established for a particular site) and confirmatory water samples show FC of 43/100ml or less. When sampling demonstrates that the area was in fact impacted by a significant sewage discharge, the area will remain closed for a period of at least three weeks, per U.S. FDA recommendations relating to the time required for viral pathogens to be purged from shellfish. Reopening may alternatively be driven by sampling of shellfish meats for male-specific coliphage, per NSSP guidelines (<50 pfu/100g tissue, or higher if documented background levels dictate). Reopening after the three week closure will be done in concert with water and meat samples that show sufficiently low fecal coliform results.

Rainfall-Related Closure Periods: Because water quality impacts can vary among storms of the same size, NHDES may elect to conduct an initial round of sampling, involving water samples only, of the Conditionally Approved area in the day(s) following closures from rainfall events. The purpose of such sampling is to determine if the rainfall event did in fact cause bacterial contamination of the growing area, and therefore to determine if a closure was warranted. At a minimum, water sampling will be conducted at Site GB50. If site access is limited by ice cover or other conditions, alternative shoreline sites near GB50 will be used. If these water samples show low fecal coliform levels (i.e., the samples indicate that there was no water quality impact from the storm to begin with), then the closure may be lifted with no additional sampling of waters or shellfish meats. If high FC levels are observed, then the area will remain in the closed status until post-rainfall meat samples show a FC MPN of 230/100g or less (or a different baseline value established for a particular site), and confirmatory water samples show FC of 43/100ml or less, or until fourteen consecutives days with no storms >1.50 inches have elapsed and confirmatory water samples show FC of 43/100ml or less, whichever is less.

NHDES will be the lead agency in collecting samples from sites in the Conditionally Approved area and will notify the NHDHHS laboratory, as well as the F&G Law Enforcement Division of its intention to sample. All samples will be collected as soon as practical after the rainfall event has ended, will be held on ice, and will be delivered to the NHDHHS Laboratory in Concord, or an appropriate contracting laboratory, by the collecting agency within 24 hours of collection. Upon completion of the laboratory tests, NHDHHS will promptly inform the NHDES Shellfish Program of the results. NHDES will then decide whether or not to close the area for harvesting, and will notify F&G/Law Enforcement Division of the decision.

Notification of Reopening: NHDES will promptly rescind the closure after it is determined that the shellfish growing waters meet NSSP standards. Upon this determination, NHDES will email a reopening notice to the NHF&G Marine Fisheries Division/Durham, NHF&G Law Enforcement

Division/Durham, and the NHF&G Public Affairs Division, as well as to the other individuals/organizations that received a closure notice. NHF&G will serve as the lead agency to inform recreational harvesters and the general public of any closures and subsequent reopenings. Procedures to inform the public may include such vehicles as the Clam Hotline and press releases. NHDES will assist with informing the general public via updates to the NH Coastal Atlas. NHDHHS will serve as the lead agency to inform the commercial shellfish industry of any closures and subsequent reopenings.

MANAGEMENT PLAN EVALUATION

This plan shall be evaluated once per year as part of the NHDES Shellfish Program's annual report.