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Optical Brightener Study of Spruce Creek

Town of Kittery, ME

FB Environmental Associates, Inc.

Optical Brightener Study of Spruce Creek – Kittery, ME

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A Final Report Submitted to:

Piscataqua Region Estuaries Partnership

Submitted by:

Town of Kittery, ME and
FB Environmental Associates, Inc.

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1. Abstract

Elevated bacteria levels in the Spruce Creek Watershed have led to shellfish bed closures in the Spruce Creek Estuary and impaired waters listings by the State of Maine. Since 2005, the Town of Kittery, Spruce Creek Association and numerous partners have assessed the local waters to attempt to determine the sources of bacteria impairment. Stormwater outfalls and residential septic systems have been identified as potential sources of impairment. To help address these concerns, the Town of Kittery received a grant in 2009 through the Piscataqua Region Estuaries Partnership to further investigate potential bacteria hotspots. Project staff worked with Federal, State and local partners to identify potential hotspots through targeted fecal coliform testing and testing and analysis for optical brighteners. Spring and autumn testing revealed elevated levels of bacteria which has led to immediate repair of a school septic system, and further assessment of a residential neighborhood.

1.2. Executive Summary

Spruce Creek, particularly the tidal portion, is being intensely manipulated and impacted by people's desire to live near the water and to have water views, and by polluted stormwater. The developed areas surrounding the Creek and its tributaries are currently contributing to its water quality degradation at an increasing rate. Phased treatment of existing sources of polluted stormwater is crucial for watershed health. The effective way to achieve water protection is to address cumulative impacts resulting from increasing development and polluted runoff.

Stormwater outfall to Spruce Creek

To address and quantify these concerns, project partners have recently conducted assessments of the watershed to determine the extent of these environmental threats. The results of these environmental condition studies include the observation of stormwater outfalls discharging high concentrations of pollutants, observations of potentially failing septic systems, and several non-licensed overboard discharges. A Section 319-funded, community-led watershed survey conducted in 2005 identified 197 sites contributing high levels of polluted runoff to Spruce Creek. Additionally, a comprehensive riparian habitat assessment conducted in 2006 identified 90 degraded riparian areas. Despite all of this recent scientific research and assessment of the watershed, project partners have recommended that additional measures be taken to locate specific "hotspots" for bacterial contamination.

The Spruce Creek Optical Brightener project employed various analysis techniques to further assess bacterial contamination in Spruce Creek. An end-of-pipe sampling program was develop and funded by the Town of Kittery as a precursor to the optical brightener study. This sampling program focused on eight potential hotspots and identified two hotspots (Admiralty Village stormwater outfall, and Mitchell School outfall) that showed persistent high levels of E coli in both dry and wet weather sampling. Levels at the Admiralty Village outfall far exceeded the allowable instantaneous standard (236 cfs/100 ml) at each sample. Levels at Mitchell School were also elevated and there was a resulting effort by the Town to successfully upgrade the septic system which has resulted in bacteria levels below the allowable standard.

The second portion of the project involved autumn sampling for E coli and fecal coliform within the estuary in conjunction with continuous flow optical brighter sampling. Optical brighteners are chemicals that are added to most laundry detergents and their presence in the Estuary could be an indication that domestic wastewater is present. Methods utilized were consistent with similar projects undertaken by the US EPA Region 1 and the Maine Healthy Beaches Program. A Quality Assurance Project Plan, which did not previously exist for this method, was developed for this sampling and analysis. While not fully conclusive, the results of the optical brightener sampling indicated elevated levels near Admiralty Village in the southwestern portion of the Estuary and slightly elevated levels of optical brighteners near the east-central portions of the Estuary where overboard discharges (OBDs) may exist. Fecal coliform and E coli results were lower than spring levels but were also elevated at the two sites with slightly elevated optical brightener levels.

Recommendations for future analysis were formally presented to the Kittery Town Council and Town Manager and include 1) undertaking an Illicit Discharge Detection and Elimination Study in the Admiralty Village area; 2) Expanding the end-of-pipe sampling program to 25-30 additional outfalls in the watershed; 3) mapping historic OBD locations; and 4) repeating the optical brightener study during the summer months. There are currently ongoing efforts (volunteer and grant funded) in the Spruce Creek Watershed to address potential sources of pollution and to educate residents, commercial entities, and visitors on water quality issues.

2. Introduction

The Spruce Creek tidal estuary in Kittery and Eliot, Maine (see photo below), has experienced chronic and persistent bacterial contamination from unidentified sources that have restricted shellfish harvesting. Assessments conducted in cooperation with the Maine Department of Marine Resources (Maine DMR) to date have helped to identify some sources and projects are being implemented to remedy these known sources. The Optical Brightener Study of Spruce Creek was designed to more accurately identify other suspected illicit discharges and sources of fecal contamination.

Aerial view of Spruce Creek – Spruce Creek is located on the left portion of this photo which is oriented facing the east.

3. Project Goals and Objectives

The primary goal of this project was to expand assessment efforts in order to help understand the source of bacteria in order to find ways to improve water quality and re-open shellfish harvesting areas. While a portion of Spruce Creek has been open to shellfish harvesting in the past, the flats have been closed since 2005 due to poor water quality. In July of 2005 clam samples were found to have very high fecal coliform concentrations. The Creek is currently classified "restricted for depuration harvesting only". Spruce Creek is one of the sample sites used by the Maine Department of Environmental Protection for their study "A Decade of Monitoring Toxic Contaminants along Maine's Coast". Results of this study indicate potential toxic contamination in addition to bacteria.

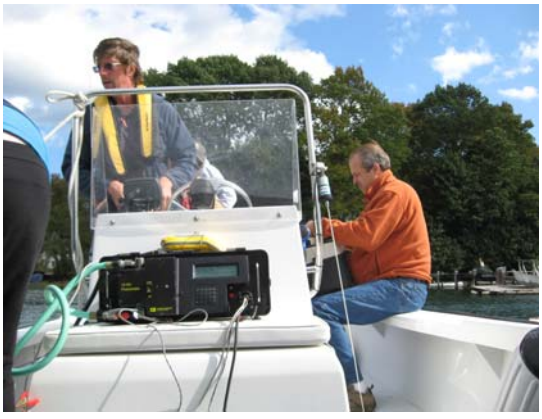
The scope of the proposed study included a spatially-and temporally-intensive assessment of bacterial concentrations throughout the surface waters that may affect water quality in Spruce Creek. The sampling was designed to capture possible problematic conditions (storm events) as well as to bracket areas where suspected sources of fecal contamination are present. The latter part of the design helped to identify actual pollution sources, including animal farms, non-sewered areas and overboard discharges. To enhance the interpretation of these results, fluorescence readings were also taken in the Estuary to detect optical brighteners, because these substances are present in most human sewage sources and would be coincident with elevated bacterial concentrations. Thus, detection of optical brighteners can help to differentiate sources of fecal pollution as human or non-human. Follow up studies may be pursued to identify and eliminate the specific pollution source(s).

4. Methods

Preliminary Sample Methods

The sampling and real-time fluorometric assessment for this project was conducted on October 5, 2009. Samples were collected during an outgoing tide to reflect more closely the conditions in the immediate proximity of these sample locations and to minimize confounding factors associated with the estuarine mixing regime. Project team members including Tim Bridges from the US EPA, Sarah Mosley from the Maine Healthy Beaches Program, Forrest Bell and Cayce Dalton from FB Environmental Associates, and Bion Pike the Kittery Harbor Master participated in the project. Project staff observed trends in fluorometry readings at multiple locations along the estuary. Project staff also collected fecal coliform water samples, and measured temperature, salinity and dissolved oxygen at each sample location.

Project staff recorded the chain of custody, as well as record all laboratory work done, including membrane filtration and counting dates, person(s) conducting filtration, time in and out of incubator, dilution volumes, fecal coliform and E. coli colony counts, person(s) conducting bacterial colony counts and any other pertinent comments. Data from all forms were entered into an Excel spreadsheet for tabulation.



Field sampling on Spruce Creek, October, 2009

Fluorometric Field Measurements

Project Team members assessed the sites by boat using the Turner 10-AU field fluorometer to investigate the possible presence of optical brighteners. The instrument was outfitted with a flow-cell

and sample probe to continuously monitor for fluorescence. Before the field survey, the fluorometer was calibrated with a 500 µg/L fluorescent dye solution and blanked with seawater obtained from a sample site. Meter readings were be expressed in µg/L. Project team members attempted to travel near all inflowing tributaries in the watershed with the fluorometer to begin measuring before proceeding slowly back downstream. Project staff geographically analyzed the bacterial concentrations using GIS maps prepared for the survey and combined the results of the October sampling with the spring end-of-pipe sampling Results are displayed in Figure 2.

Bacterial analysis for water samples was conducted in accordance with EPA Method 1103.1 (Escherichia coli in Water by the Membrane Filter Procedure, 1985). This procedure for fecal coliform testing was employed by Jackson Estuarine Lab in Durham, NH.

Data Analysis

Senior staff was assisted by US EPA's Tim Bridges to analyze the resulting data, adjusting for organic interference. The averages and geometric means for each site were calculated, along with graphs of each sample date showing fecal coliform and E. coli concentrations. A full Quality Assurance Project Plan was developed and accounted for much of the staff time devoted to this project.

The Turner 10-AU field fluorometer and data screen while in use

5. Results and Discussion

Bacteria Sampling Results

Conventional bacterial testing for fecal coliform was conducted on water samples to determine contamination levels relative to State and Federal water quality standards. Testing in both publicly and privately held lands, our team attempted to identify specific sources and magnitudes of fecal contamination affecting the shellfish of Spruce Creek. Testing protocols included water sampling, and optical brightener tests using state-of-the-science methods.

Birds gather on a residential dock

Storm drain system reconnaissance and sampling was conducted prior to the fluorometry testing. Reconnaissance and mapping served to develop an understanding of storm drain connectivity and to identify potential sources to address during the fluorometry survey. A set of reconnaissance and bacteria sampling surveys were conducted in parts of the Kittery storm drain network in the spring of 2009. Ambient bacteria data were collected during both wet and dry conditions to estimate the bacteria levels from all contributing sources because many sources of bacteria are diffuse and intermittent (rather than flowing from an identifiable pipe on a regular basis). High levels of bacteria during dry conditions indicate the presence of direct wastewater

discharges, or contamination from groundwater leachate (from agriculture, leaking sewer pipes, illicit connections to storm drains), from recreational activities (swimmers and boaters), or from wildlife (including birds). High levels of bacteria during wet conditions (rainfall) indicate contamination from wildlife and domesticated animals (including pets), stormwater runoff (including municipal separate storm systems or MS4s), or discharges from combined sewer overflows (CSOs). A map of the results of the end-of-pipe survey is provided below:

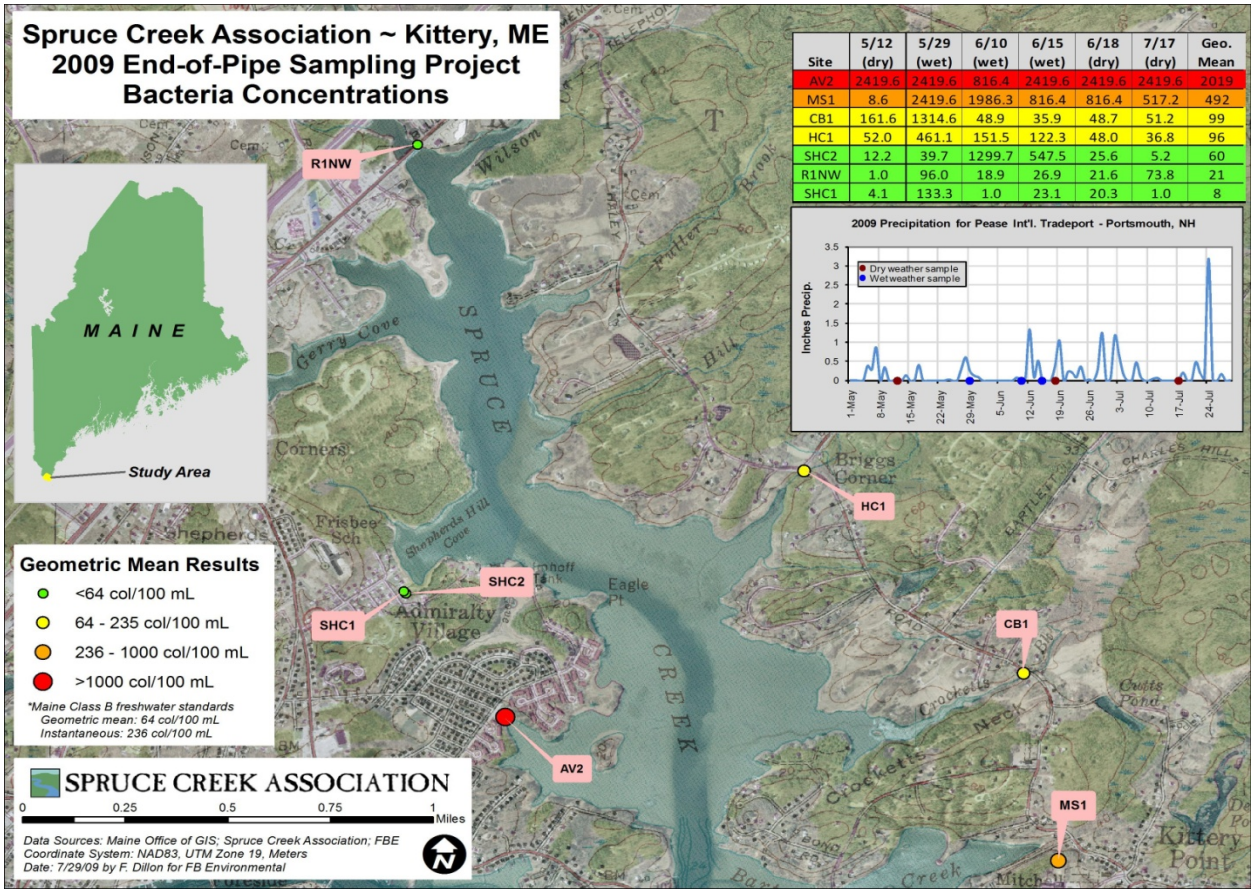


Figure 1. Geometric Mean results of the 2009 End-of-Pipe Sampling Project displaying potential bacterial contamination inputs to Spruce Creek

Success of the project depended heavily on partner and stakeholder involvement, including volunteers from the Kittery Shellfish Commission and the Spruce Creek Association and professional scientists from the US EPA, Maine Healthy Beaches Program, Jackson Estuarine Lab, and the Town of Kittery. Results of this study and the accompanying end-of-pipe sampling project were presented to the Kittery Town Council on December 14, 2009 (see meeting minutes at www.kittery.org) and identified hot spots will be addressed for remediation in conjunction with the Town of Kittery's "Spruce Creek Watershed Improvement Project (Phase II)", a project funded through the Maine Department of Environmental Protection Nonpoint Program or through other funding avenues.

The preliminary end-of-pipe study revealed the following results:

- Exceedances of the bacteria water quality standard (*E.* coli >236 cfs/100 ml or a Geomean of 64/100 ml) were found throughout the study area during preliminary end-of-pipe testing.

- Several hotspots were found – the most significant being the stormwater outfall at Admiralty Village in Kittery (picture to the right). This site had very high readings during both wet and dry weather.

- Bacteria counts tended to increase during wet weather conditions.

Significant hotspot stormwater outfall in Admiralty Village in Kittery

Bacteria counts are displayed in Table 1 below. Site locations are identified in Figure 1 (preceding page).

Table 1. End-of-Pipe E. coli sampling results during wet and dry conditions

Site	5/12 (dry)	5/29 (wet)	6/10 (wet)	6/15 (wet)	6/18 (dry)	7/17 (dry)	Geo. Mean
AV2	2419.6	2419.6	816.4	2419.6	2419.6	2419.6	2019
MS1	8.6	2419.6	1986.3	816.4	816.4	517.2	492
CB1	161.6	1314.6	48.9	35.9	48.7	51.2	99
HC1	52.0	461.1	151.5	122.3	48.0	36.8	96
SHC2	12.2	39.7	1299.7	547.5	25.6	5.2	60
R1NW	1.0	96.0	18.9	26.9	21.6	73.8	21
SHC1	4.1	133.3	1.0	23.1	20.3	1.0	8

Geomean <64 col/100mL **Geomean 236-1,000 col/mL**
Geomean 64-235 col/mL **Geomean >1,000 col/mL**

Optical Brightener Survey

Optical brighteners are chemicals that are added to most laundry detergents. Their presence in stormwater is often an indication that domestic wastewater is present. The survey revealed generally lower than average levels of optical brighteners for most of the estuary. According to Tim Bridges (US EPA) project advisor, readings over 100 ug/l are considered high optical brightener levels. The highest optical brightener levels observed for this study were 46.3 mg/l. Some elevated readings occurred in specific locations and are graphically displayed on the map on the following page. Note that a portion of the western shoreline was not studied due to the absence of development and the need to survey more developed areas downstream before low tide occurred.

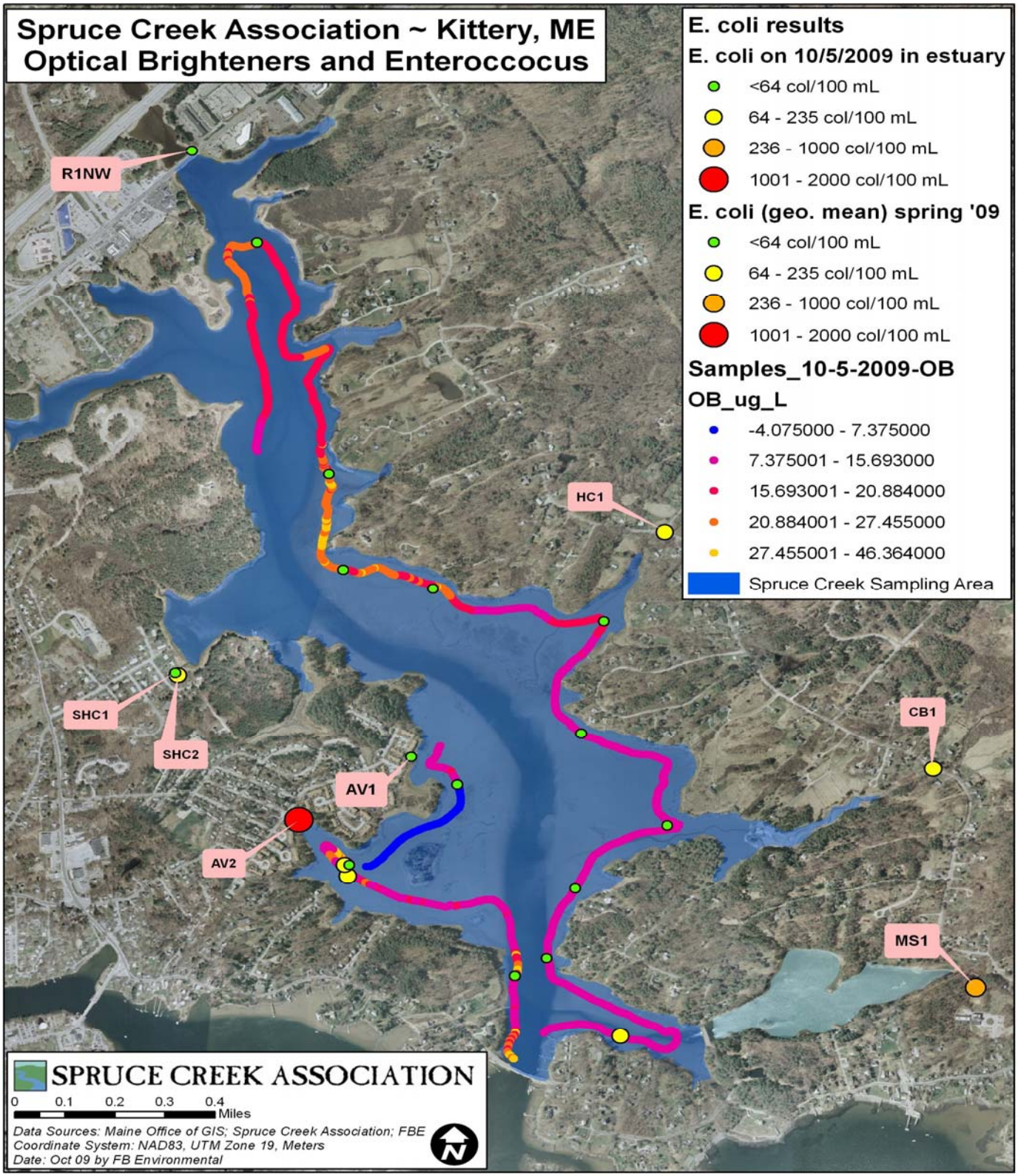


Figure 2. Optical Brightener results combined with E. coli samples taken in October 2009

The table below displays the results of bacteria samples taken during the fluorometery survey at 15 locations around the perimeter of the Spruce Creek estuary. These locations are shown on figure 2 as a graduated colored dot beginning at the mouth of the Creek and proceeding counter-clockwise.

Table 2. E. coli bacteria sample results in October 2009

Site #	Volume filtered	CFU per plate		CFU per 100 ml	
		Fecal coliforms	*E. coli*	Fecal coliforms	*E. coli*
SC 1	50 5	45 4	39 4	90	78
SC 2	50 5	6 0	6 0	12	12
SC 3	50 5	13 0	12 0	26	24
SC 4	50 5	9 0	7 0	18	14
SC 5	50 5	12 3	12 3	24	24
SC 6	50 5	5 1	5 1	10	10
SC 7	50 5	3 0	2 0	6	4
SC 8	50 5	1 0	1 0	2	2
SC 9	50 5	2 0	2 0	4	4
SC 10	50 5	6 1	6 1	12	12
SC 11	50 5	0 0	0 0	<2	<2
SC 12	50 5	13 0	13 0	26	26
SC 13	50 5	55 5	54 5	110	108
SC 14	50 5	76 8	76 8	152	152
SC 15	50 5	3 1	3 1	6	6

6. Conclusions

The bacteria testing revealed several sites in the watershed that are contributing high levels of bacteria to Spruce Creek. These results indicate that further testing and assessment are needed particularly in the area of Admiralty Village. Optical Brightener testing was partially inconclusive but did reveal some elevated levels near Admiralty Village and some potential overboard discharge (OBD) areas in the southern reaches of the Creek. Elevated levels of bacteria were also found near Mitchell School in Kittery and this resulted in immediate further investigation by the Town and subsequent upgrading of the school septic system. Follow up tests conducted by the Town have indicated that the bacteria levels in this area have substantially decreased.

7. Recommendations

Further analysis of bacteria and optical brighteners is needed to assess bacterial contamination in Spruce Creek. The following recommendations were developed and have been presented to the Town of Kittery.

1. Assess the primary hotspot located for this project at admiralty village using Illicit Discharge Detection and Elimination (IDDE) methods. Specific methods should include mapping the storm drain system, using optical brightener pads and bacteria testing to bracket problem areas, and ground reconnaissance. Additional methods could include camera surveys of the storm drain, smoke testing, and dye testing.

2. Conduct further wet and dry weather end-of-pipe testing in 2010 at the 25-30 untested stormwater outfalls in the Spruce Creek watershed. These locations should be mapped prior to or during testing.

3. Evaluate Kittery file archives and map historical OBD locations.

4. Repeat the fluorometric survey procedure in the summer of 2010 (with the assistance of the US EPA) when there are more residents present in the Spruce Creek Watershed and readings could potentially be higher.

Spruce Creek at sunset