Executive Summary
The Maine Healthy Beaches (MHB) Program's routine monitoring of Laite Beach and Camden Yacht Club (CYC) Recreation Area has shown Enterococci bacteria levels above recreational water contact safety standards. Supplemental funding was obtained from the US EPA to conduct a Boater's Education Campaign and intensified monitoring to help identify pollution sources impacting these valued resources. Campaign activities included developing and distributing education and outreach materials, public presentations, and surveying Camden's mooring and slip permit holders. As a part of this effort, 106 samples were analyzed for Enterococci at 25 different monitoring locations. An additional 47 samples were analyzed for optical brightener concentrations at 22 of the 25 monitoring locations. The town's pump out boat records show an increase of over 4,000 gallons pumped from 2009 to 2010. The increase is likely amplified due to poor weather conditions and low boat traffic in 2009. Comparing 2008 and 2010 (both seasons had similar weather and boat traffic), there was an increase in 2,000 gallons pumped out. Harbor-wide monitoring documented bacterial contributions from the Megunticook River, Rock Brook, storm drain outfalls, the Camden Wastewater Treatment Facility outfall and the large waterfowl population residing in the inner harbor. MHB Program staff planned and facilitated problem-solving meetings with municipal staff and state agency partners to share data and remediation strategies. As a result, the town of Camden conducted an Illicit Discharge and Detection Evaluation Study that identified two illicit sewage cross connections to the storm drainage network. A separate investigation, led by DEP staff, in the Rock Brook watershed identified a broken sewer line.

Camden Harbor Water Quality Project

The Maine Healthy Beaches Program
April 2011

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Cover photo: Amy Gertner

The Unites States Environmental Protection Agency (US EPA) initiated the Beaches Environmental Assessment and Coastal Health Act of 2000 in response to the growing concern about public health risks posed by polluted coastal bathing beaches. The Maine Healthy Beaches Program is taking a leading role in this initiative. Program implementation is a partnership between the Maine Department of Environmental Protection, University of Maine Cooperative Extension, and Maine Sea Grant.

Funding for this project was provided by US EPA.

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I. Introduction

A. Background

In 2003, the town of Camden joined the Maine Healthy Beaches (MHB) Program, a statewide effort to monitor water quality and protect public health on Maine's coastal beaches. Routine monitoring during the summer months has documented that both the Camden Yacht Club Recreational Area and Laite Beach have frequently exceeded Enterococci bacterial standards.[1]

Enterococcus is an indicator of fecal contamination from the guts of warm-blooded animals and elevated levels suggest the presence of harmful pathogens in recreational waters. Fecal contaminated water can degrade marine habitats and lead to health problems for both swimmers and waders. When bacteria levels are above the United States Environmental Protection Agency (US EPA) approved safety limit, [2] the public is advised to avoid recreational water contact. Numerous exceedances in bacterial safety standards at both the Camden Yacht Club (CYC) and Laite Beach have prompted the need to track down and remediate the sources of fecal contamination impacting these valued resources.

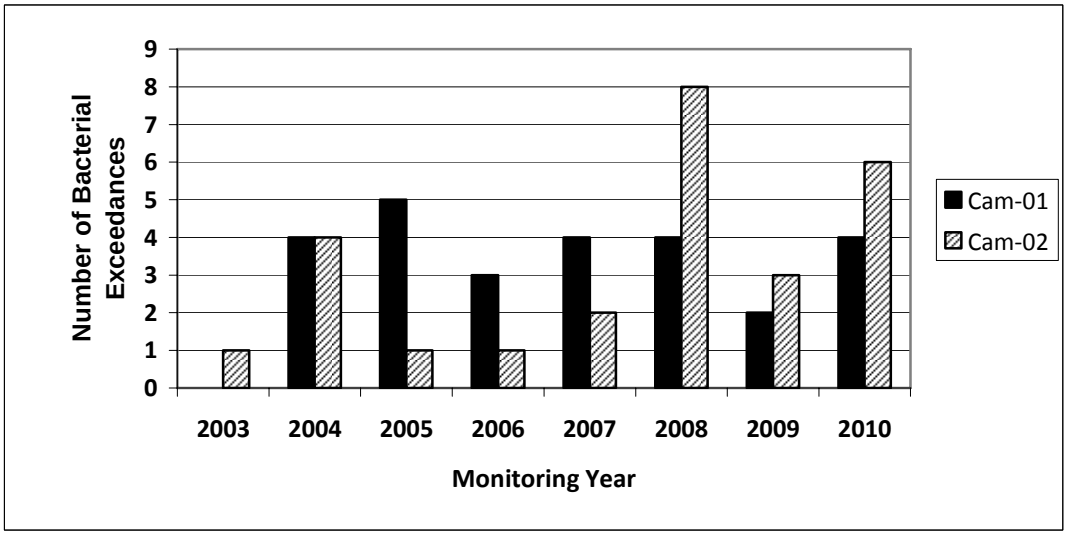


Figure 1. The number of times per year the Camden Yacht Club (Cam-01) and Laite Beach (Cam-02) have exceeded Enterococci bacteria safety standards for recreational water contact.

B. Area Characteristics

The town of Camden is a small coastal town largely sustained by tourism. The population almost doubles seasonally, increasing from about 4,500 in the winter to about 8,000 - 9,000 during the summer months. Camden Harbor is also a popular boating destination with the town

[1] Figure 1

[2] The US Environmental Protection Agency safety limit for recreational water quality is 104 most probable number (MPN) Enterococci colonies per 100mls marine water and 61MPN/100mls fresh water. Levels above this limit increase the likelihood of contracting a recreational waterborne illness.

managing approximately 50 slips and 415 moorings, which are available for recreational and commercial vessels. Wayfarer Marine, a popular destination in Camden Harbor, provides 60 moorings, 600' of linear dockage, and 1.5 harbor floats for transients and 39 seasonal slips.

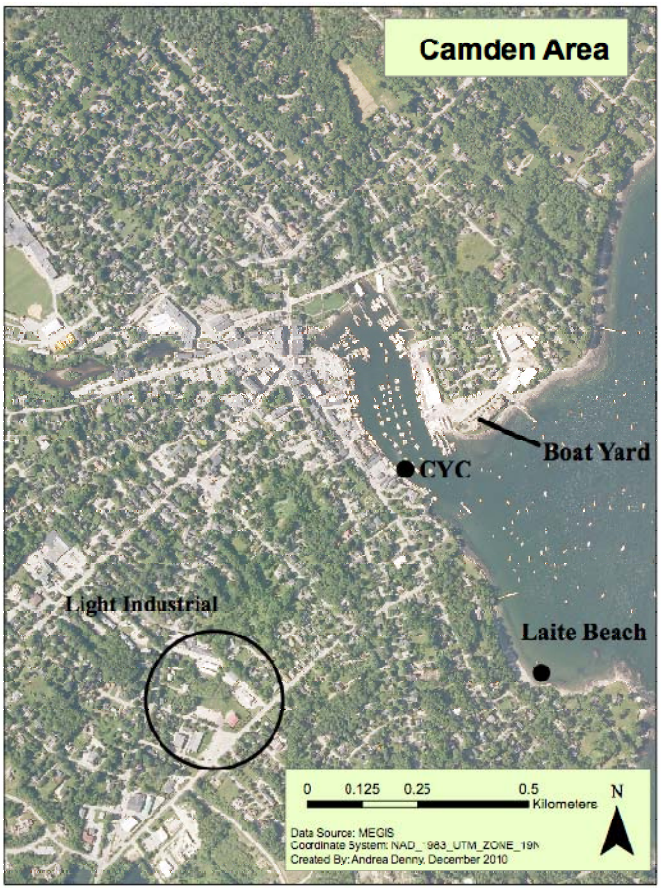


Figure 2. Aerial photograph of Camden Harbor.

Laite Beach and nearby CYC Recreation Area are valued resources for visitors and the community. Residents, visitors and often bus-loads of youth groups swim and beach comb the shoreline. The Yacht Club sailing school students swim in the harbor daily. Several types of recreational water contact activities occur throughout the harbor including sailing, kayaking, paddle boarding, etc.

The land surrounding Camden Harbor is a mix of business and residential properties. All properties, with the exception of one residence with a subsurface wastewater disposal (i.e. septic) system, are serviced by the Camden Wastewater Treatment Facility (WWTF). Two sewage pump out facilities are available in Camden Harbor: a dock-side pump out facility located at Wayfarer Marine (east side of harbor) and a free pump out boat service provided by the town of Camden.

II. Project Elements:

Observations of numerous boats and dry weather exceedances at all tidal stages led to the suspicion that boats illegally discharging raw sewage, or poorly functioning treatment systems were likely degrading water quality in Camden harbor and adjacent beach and recreation areas. Other potential sources of bacterial contamination include freshwater inputs to the harbor such as river and stream outlets, storm drains, runoff, etc. In an effort to identify sources and improve water quality, supplemental funding was obtained from the US EPA to conduct a Boater's Education Campaign and intensified monitoring throughout Camden Harbor.[3]

A. Boater's Education Campaign

Field observations suggested boat sewage may be contributing to degraded water quality. The goal of the Boaters Education Campaign was to promote usage of pump-out services, help boater's link poor practices to degraded water quality and educate boaters about the recent No Discharge Area (NDA) designation for West Penobscot Bay. NDA's are designated bodies of water that prohibit the discharge of treated or untreated boat sewage.

Figure 3. Education and outreach materials were developed and distributed as part of the 2010 Boater's Education Campaign in Camden Harbor.

The Boater's Education Campaign included the following activities

- Launched Campaign in May by distributing a letter,[4] *Healthy Boating Equals Healthy Beaches* brochures[5] and the ME DEP's *No Discharge Area Fact Sheet*[6] to Camden's 415 mooring and 50 slip permit holders in Camden Harbor.
- Held five planning meetings with the town of Camden, Wayfarer Marine, The Harbor Committee, and the ME Department of Environmental Protection (ME DEP).
- Developed and distributed a Boater's Education Campaign press release.[7] The release was published in two local newspapers and posted on the *Maine Boats, Homes & Harbors* Facebook Page.
- Developed a *Use your Head Pump It, Don't Dump It!* flyer[8] and distributed this and other Boater's Education and MHB Program materials to the Chamber of Commerce, Camden

[3] For a complete project timeline, see **Appendix A**.
[4] See **Appendix B**
[5] See **Appendix C**
[6] See **Appendix D**
[7] See **Appendix E**
[8] See **Appendix F**

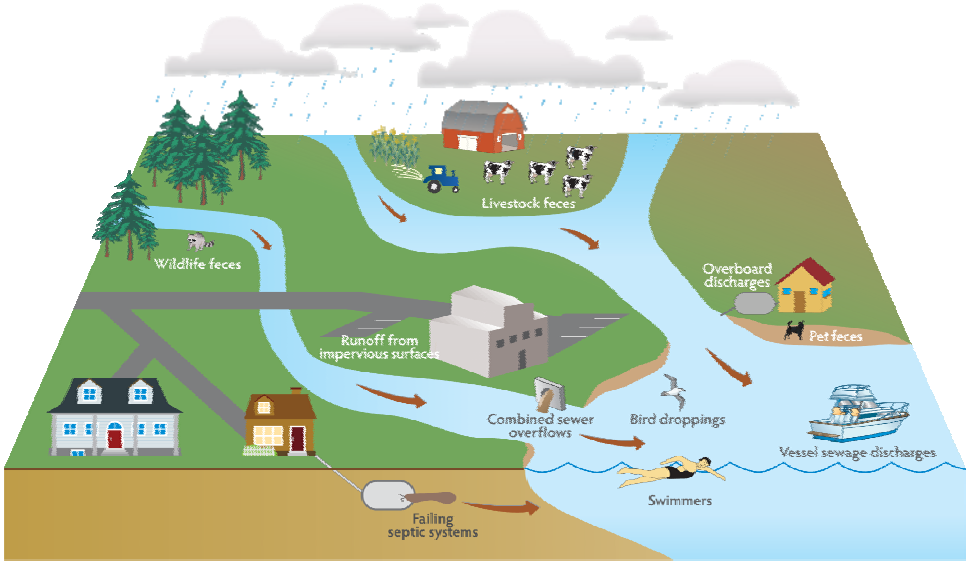
Harbormaster Office, Wayfarer Marine and the Camden Yacht Club.[9]

- Organized and delivered public presentations at the Camden Yacht Club (in partnership with DEP) and the Camden Public Library.[10]
- Interviewed with a local reporter and had an article published on the front page of *Village Soup*.[11]
- Surveyed Camden's 415 mooring and 50 slip permit holders to determine the success of the Campaign regarding usage of the free sewage pump out boat, knowledge of the NDA Designation, and awareness regarding boat sewage's impact on local water quality.

B. Intensified Monitoring

i. *Enterococci*

This project also included intensified harbor-wide monitoring[12] to help pinpoint additional sources of bacterial pollution. Monitoring sites targeted freshwater inputs to the harbor including: storm drain outfalls, the mouth of the Megunticook River, the mouth of Rock Brook, and the Camden WWTF outfall located in the middle of the harbor.



Disease-causing pathogens can enter Casco Bay coastal waters from multiple sources, leading to potential public health risks.
Illustration by Waterview Consulting including symbols adapted from the Image Gallery and Application Network, University of Maryland Center for Environmental Science.

Figure 4. Sources of fecal contamination from upland areas typically enter the shoreline via direct runoff, stream, river and storm drain outlets.

An adaptive monitoring regime was implemented where site locations and monitoring frequency changed in response to recorded bacteria levels. Site locations were monitored on a weekly basis during the month of June, bi-monthly for July and August, and once in September.

[9] See Materials Distribution, **Appendix G.**
[10] See Presentation Flyer, **Appendix H**.
[11] See **Appendix I**.
[12] See Figure 5.

With one exception, each monitoring event occurred during ebbing tidal conditions to determine the bacterial contribution of fresh water sources draining from upland areas. Wet-weather events were not specifically targeted as a part of the study; however, rainfall within 48 hrs preceded 7 out of the 10 monitoring dates. Samples were collected and analyzed using standard protocols outlined in the US EPA-approved, MHB Program Quality Assurance Project Plan.

As a part of this effort, 106 samples were analyzed for Enterococci at 25 different monitoring locations. Samples were processed using the Enterolert methodology at the MHB Program/UMaine Extension Laboratory in Waldoboro, Maine.

Additionally, the Camden WWTF collected samples at several of the MHB Program monitoring locations intermittently in July and August. These samples were analyzed using the Enterolert methodology by Aqua Maine in Rockport, Maine.

Figure 5. Camden Harbor 2010 water quality project monitoring sites targeted fresh water inputs to the harbor such as the local waste water treatment facility outfall, river mouths storm drains which transfer pollutants from upland sources to the shoreline.

ii. Optical Brighteners

Additionally, 47 samples were analyzed for optical brightener concentrations at 22 of the 25 monitoring locations. Optical brighteners are commonly used in commercial or retail products such as clothing detergents, dishwashing, personal care products, etc., to brighten the whiteness of materials. After use, these products are typically flushed down the drain; therefore, the presence of optical brighteners in ambient water samples can indicate human sources are contributing to fecal bacteria levels.

	High Bacteria	**Low Bacteria**
High Optical Brightener	Black water (e.g. human sources- malfunctioning septic system, sanitary sewer cross connection)	Grey or Gray water (e.g. laundry, wash water)
Low Optical Brightener	Human or non-human sources	Potentially low or no fecal contamination

Table 1. Elevated optical brightener levels coupled with elevated Enterococci levels suggests the likelihood of human-sourced fecal contamination.

iii. E. coli

The ME DEP Division of Environmental Assessment monitored *E. coli* in the Megunticook River and Rock Brook as part of the state's Integrated Water Quality Monitoring and Assessment Reports. Similar to Enterococci, *E. coli* is an indicator of fecal contamination and is often used to determine bacterial water quality in freshwater systems. ME DEP utilizes *E. coli* concentrations to classify water bodies for their designated use. Historically, both water bodies have been listed on the state 303d list as "impaired" due to bacterial contamination.[13]

In an effort to update the status and classification of these water bodies and to pinpoint potential sources, ME DEP staff conducted an intensified monitoring effort in 2010. Samples were collected on six separate occasions throughout the summer. Maine Healthy Beaches limited their investigation of both the Megunticook River and Rock Brook to avoid duplicating efforts. The MHB Program and ME DEP shared information and data on their respective monitoring efforts periodically throughout the summer.

[13] To meet Maine state standards for a class B stream, the water body must attain a geometric mean of 64 MPN of *E. coli* /100mls and an instantaneous mean water quality standard of 236MPN/100mls (ME DEP)

C. Waterfowl Feeding Education/Outreach

A large population of waterfowl resides in the inner harbor and lower reaches of the Megunticook River. Waterfowl waste may significantly contribute to fecal bacteria levels in recreational waters. Feeding waterfowl can cause unnatural behavior, disease outbreaks, delayed migration, overcrowding, poor nutrition and can increase fecal matter in the water column. The MHB Program developed and posted signs[14] advising citizens not to feed waterfowl in Camden Harbor Park and along the public access points to the harbor docks.

D. Logistical/Problem Solving Meetings

Throughout the course of the project, the MHB Program planned and facilitated five meetings to share data and ensure inclusivity in planning next steps. Site locations and monitoring frequency were adapted based on results. Participants included representatives from several town departments, including the Harbormaster, town Administrator, town Codes Enforcement/Assessment/Planning, Public Works, the Wastewater Treatment Facility as well as a local business representative from Wayfarer Marine.

Additionally, two larger meetings were initiated and facilitated by MHB Program staff to forge relationships between the town and the ME DEP. The technical expertise of ME DEP staff can augment the town's efforts to find and eliminate pollution sources. Several representatives from the ME DEP's Division of Environmental Assessment including specialists in streams, beaches, wastewater compliance and wastewater engineering joined the effort to find solutions to the bacterial contamination issues in Camden Harbor.[15]

III. Findings/Results

A. Boating Activity

Camden Harbor is a popular cruising destination, especially during the summer months.
In addition to the 415 permitted mooring and 50 permitted slip holders, transient boating activity tends to increase toward the middle of July and continues to remain high through the month of August.[16]

[14] See Flyer: Do not feed waterfowl, **Appendix J**.
[15] For meeting details and notes, see **Appendix K**.
[16] See Figure 6.

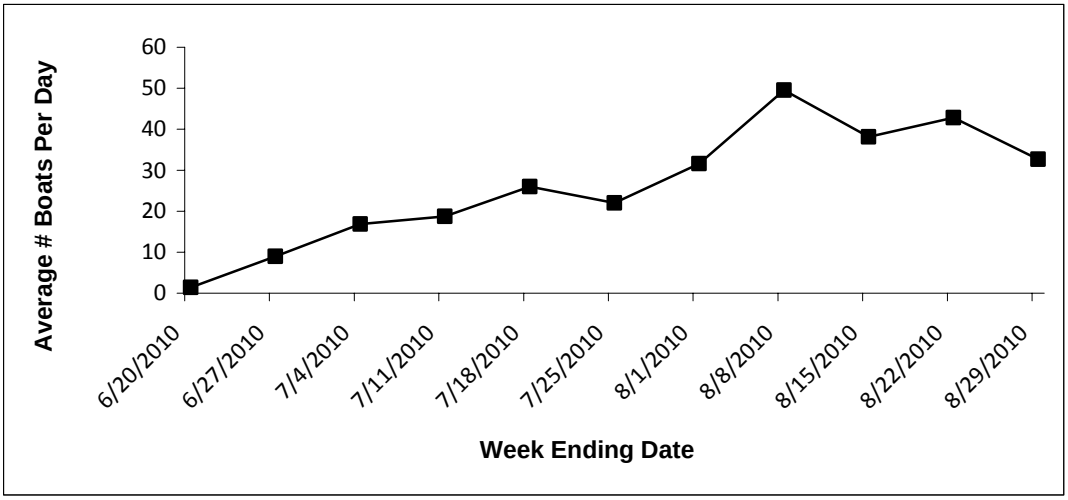


Figure 6. The average number of transient boats observed by the Harbor Master's office, Camden Yacht Club and Wayfarer Marine per day each week in Camden Harbor spanning the end of June through August 2010. Peak activity occurred during the second week in August and remained high through the end of August.

Figure 7. The town owned pump out boat is free to the public. Photos: Katy Morrison.

The use of the Camden pump out boat has increased considerably over time, from just over 1,000 gallons of sewage pumped out over the course of the boating season in 2003 to over 8,000 gallons (263 pump out actions) in 2010.[17] The town sewage pump out boat records show an increase of over 4,000 gallons pumped from 2009 to 2010. Comparing 2008 and 2010, there was an increase in 2,000 gallons pumped out.

Similarly, there was an increase documented at the Wayfarer Marine pumping station with 49 hours of use in 2010 and 18 hours in 2009. Additionally, the Chapter T Boats (larger passenger schooners) in Camden Harbor have been retrofitted to be pumped out more easily and on a more regular basis.

[17] See Figure 8.

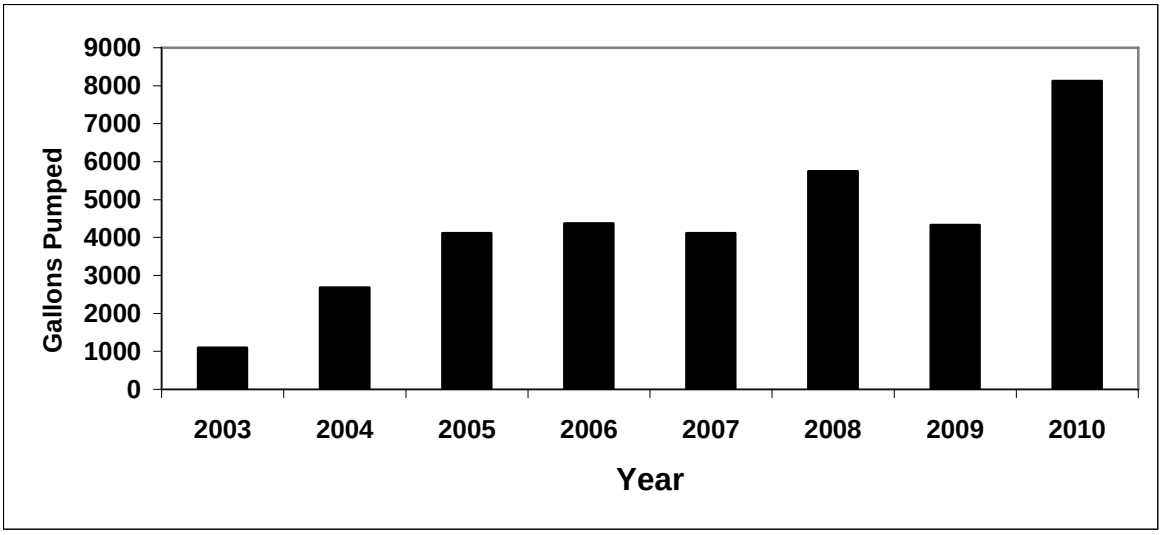


Figure 8. Number of gallons of boat sewage pumped out per year by the Camden Harbor pump-out boat. The pump-out boat began servicing boats in the Camden harbor in 2003.

As a follow-up to the Boater's Education Campaign, the 465 town-permitted mooring and slip holders were mailed letters including a link to an online survey. The survey was used to determine usage of the pump-out boat service, knowledge of the NDA designation, and awareness regarding boat sewage's impact on local water quality. The response count was low with only 36 people (7.7 %) completing the survey. Results indicated that 72.2 % of the 36 respondents did not use the pump out boat service during the 2010 season. Comments indicated that some vessels were day sailors without toilets, while others claimed to consistently use shore facilities. Usage of the pump out boat was limited; however, 88.9 % of the 27 respondents who did not use the pump out boat were aware the service was free and 100 % of the 11 respondents who did use it reported the service to be user-friendly.

Regarding the recent NDA Designation for West Penobscot Bay, 91.7 % of 36 respondents were aware of the designation; however, 78.1% of the 32 respondents who were aware claimed this knowledge did not increase usage of the pump out boat. A total of 91.7 % of 36 respondents were aware that bacterial pollution from boat sewage can significantly impact local beach water quality.

B. Monitoring Results

i. Enterococci[18]

Aside from the special study, routine monitoring indicated Camden Yacht Club (Cam-01) exceeded bacterial safety limit 4 times and Laite Beach (Cam-02) 6 times throughout the

[18] For monitoring site descriptions, Enterococci and optical brightener results, **see Appendix L**.

monitoring season. Comparing the 2009 season to 2010, the number of exceedances doubled for both sites.[19]

Intensified harbor-wide monitoring showed that of the seven regularly monitored (more than 5x) study sites, six had bacterial exceedances greater than 70 % of the time.[20] Additional sites were added upriver or upland in the storm drainage networks to help pinpoint possible bacteria sources contributing to elevated levels at these locations.[21]

Site	# of Samples	# of Exceedances	% Exceedances
LO-1	7	5	71.4
MR-1	7	7	100
OML-1	10	9	90
PS-1	7	5	71.4
STP-1	10	6	60
STP-2	8	7	87.5
WGS-2	8	7	87.5
TOTAL	*57*	*46*	*80.7*

Table 2. Percent of samples (for routine sites monitored more than five times) exceeding US EPA Enterococci bacteria safety standards for recreational water contact in both marine and freshwater habitats.

Storm Drainage Pipe at Steamboat Landing-
The monitoring site (WGS-2) was located at the end of a storm drain pipe discharging to the shoreline, east side of the harbor, at Steamboat Landing.[22] Effluent leaving the storm drain had zero salinity. The drainage network is a mixture of surface and subsurface flows draining from upland areas. This was the most consistently problematic site monitored during the 2010 study.[23] Seven out of eight samples exceeded recreational safety standards, and two samples exceeded the reporting limit of >24,196MPN/100mls. [24] The results for the remaining 5 samples exceeding safety standards ranged from 130MPN/100mls to 2,279MPN/100mls. Similarly, two samples collected by the Camden WWTF at this site were above the EPA safety limit for recreational (fresh) water quality with readings of 1,370 MPN/100 mls and 70 MPN/100mls.[25]

At this site, water was observed leaving the end of the pipe during dry and wet weather conditions, with a significant increase in flow during and following rain events. Rainfall within 48hrs of the monitoring date preceded six out of the seven recorded bacterial exceedances. Due to high bacteria results at the outlet, an additional 5 sites were added to the network to

[19] See Figure 1.
[20] See Table 2.
[21] See Figure 5.
[22] See Figure 9.
[23] See Camden Harbor Monitoring Data, **Appendix L**.
[24] The standard dilution for marine recreational water quality samples is 10:1. Another dilution of the collected sample water could have resulted in a more specific bacteria result.
[25] See WWTF Monitoring Data, **Appendix M.**

help pinpoint upland sources. A monitoring site was added just offshore (WGS-1) to determine the impact of the pipe effluent on ambient water quality.

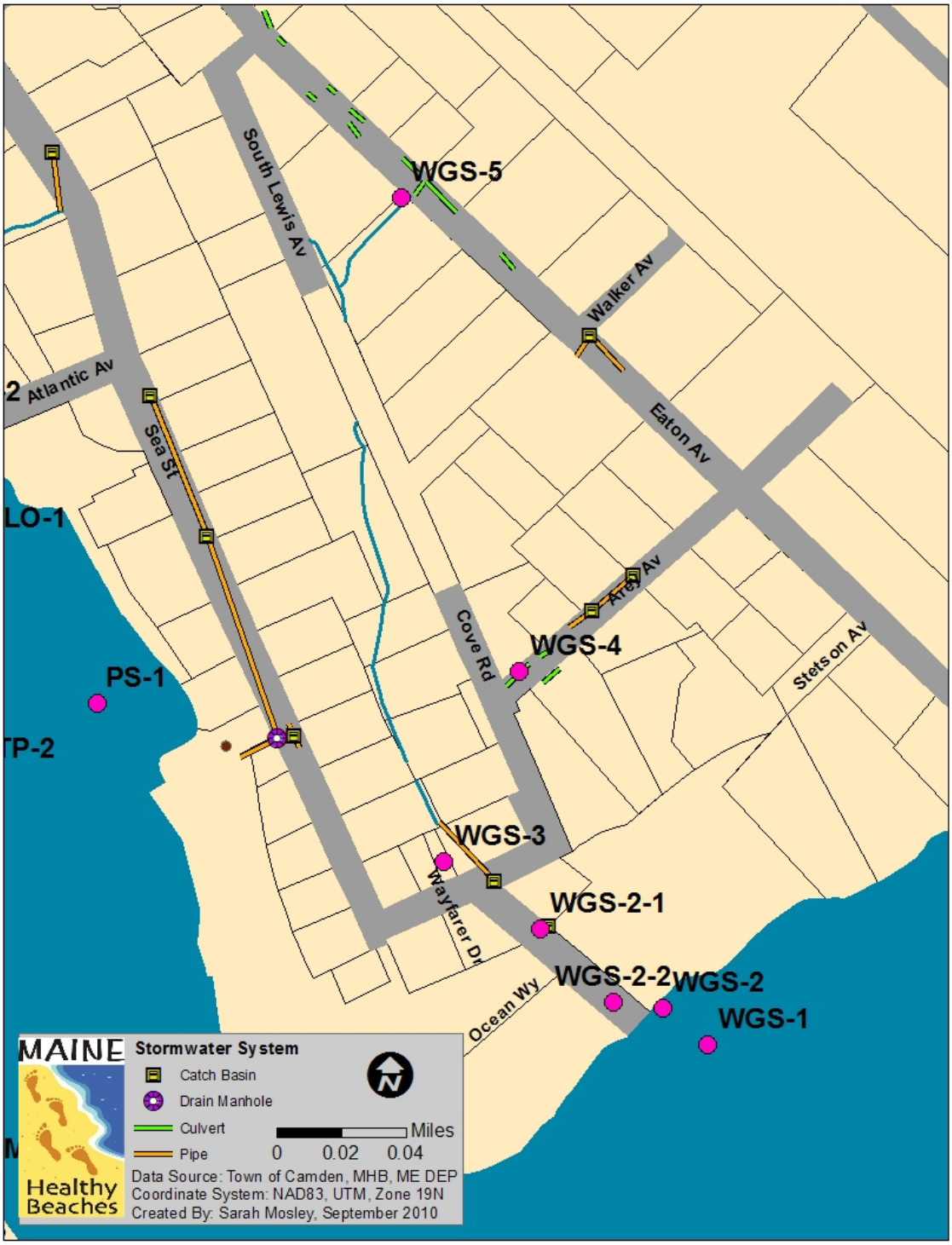


Figure 9. Elevated bacteria levels leaving a storm drain pipe (WGS-2) prompted adding additional monitoring sites upland in the storm water network to help pinpoint problem areas.

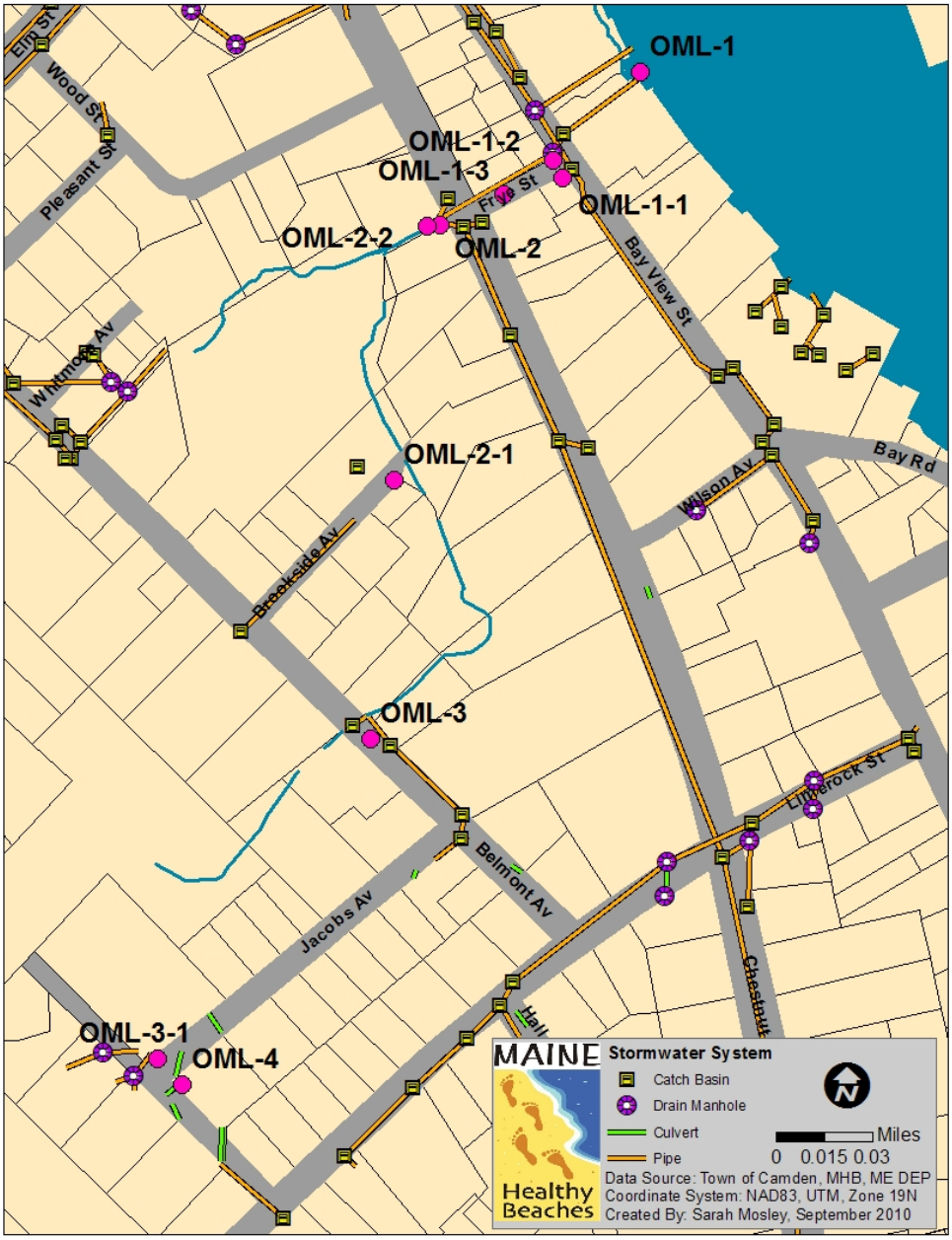


Figure 10. The Old Marina Lock System is currently a storm water outfall draining from upland business and residential areas, west side of the harbor.

Old Marina Lock System Storm Drain Outlet–

The site (OML-1) is located on the west side of the harbor adjacent to the Waterfront Restaurant. The old marina lock system is currently an outlet of a storm drainage network capturing runoff from nearby business and residential areas. The network is a mixture of surface and subsurface flows. Salinity levels at this location ranged from 13-25. Freshwater draining from upland areas lowered salinity levels, especially during and following wet weather condition and during an ebbing tide. Rainfall within 48hrs of the monitoring date preceded six out of the nine recorded bacterial exceedances.

Elevated bacteria levels recorded at the outlet prompted further investigation, and a total of twenty-eight samples were collected in the larger OML storm drain network. Fifteen of these samples were above 500MPN/100mls with the highest readings documented at two upland, strictly fresh water sites. A bacterial count of 10,462MPN/100mls was recorded at site OML-2-1 and 11,199MPN/100mls at site OML-1-2. Similarly, the WWTF conducted monitoring in this vicinity and recorded 190 MPN/100mls on July 30th at the Frye Street storm drain and 14,140 MPN/100mls at the same location and 410 MPN/100mls at the Bayview Street pump station on August 19th.

Outfall - Camden Wastewater Treatment Facility –
Monitoring site (STP-1) was located in close proximity to the town's WWTF outfall in the middle of the harbor. Salinity at this location ranged from 25-30. Bacteria counts above 1,000MPN/100mls were observed for two monitoring events during consecutive weeks in June. Bacteria levels decreased to 134MPN/100mls on July 22nd; however, there was another spike to 410 MPN /100mls in August. Seven of ten samples collected at this location were above the EPA-accepted safety limit for recreational water quality. Rainfall within 48hrs preceded five of the seven exceedances.

Monitoring site (STP-3) was added in the Wastewater Treatment Facility outfall pipe at the public landing, capturing effluent after it passed through the system, but before it mixed with water in Camden Harbor. This site was strictly fresh water and two of the four samples collected indicated Enterococci levels above the EPA safety limit for recreational water contact.[26] Similarly, samples collected by the WWTF at this location indicated Enterococci levels above the EPA safety limit. Compliance records consistently demonstrated that the WWTF effluent contained acceptable levels of fecal coliform bacteria for discharge into the harbor.[27]

Site STP-2 was placed just outside of the WWTF outfall towards the head of the harbor. This site was problematic with 7 out of the 8 samples exceeding the safety limit. Site PS-1 was also added in close proximity to the WWTF pump station located on the east side of harbor and adjacent to Wayfarer Marine. The station pumps sewage from properties on Steamboat Landing. A total of 5 out of the 7 samples collected exceeded bacterial safety standards.

Megunticook River Mouth –
The site (MR-1) was located just below the falls where the mouth of the river meets the inner harbor. Salinity levels at this location ranged from 4-8 with one outlier of 24 when the sample was collected at mid to high tide. The mouth of the Megunticook River had 100 percent bacterial exceedances, with levels ranging from 145 MPN/100mls to 1,918MPN/100mls. Rainfall within 48hrs preceded five of the seven exceedances. The MHB Program did not conduct monitoring upriver to pinpoint potential sources due to ME DEP's intensified *E. coli* monitoring.[28]

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[26] See Camden Harbor Monitoring Data, **Appendix L**.
[27] See WWTF Monitoring Data, **Appendix M**.
[28] See Section III. B. iii

ii. Optical Brighteners

Samples collected from monitoring sites within the Old Marina Lock system (OML) storm drainage network, effluent from the WWTF pipe (STP-03) before discharge to the harbor, and the storm drainage network at Steamboat Landing (WGS) contained high bacteria levels and moderate to high optical brightener levels.

Site	**OML-01-2**		**OML-01-3**		**OML-02**		**OML-02-1**		**OML-03**	
Date	Entero	OB	Entero	OB	Entero	OB	Entero	OB	Entero	OB
7/22/2010	**703**	---	**538**	**211**	**744**	**257**	---	---	**1112**	**284**
7/29/2010	**120**	**279**	**146**	**270**	---	---	---	---	---	---
8/5/2010	---	---	---	---	---	---	**11199**	**217**	**677**	**264**
8/16/2010	**10462**	189	---	---	**4611**	---	---	---	**143**	---
9/7/2010	---	---	---	---	---	---	---	---	---	---
Site	**OML-04**		**STP-03**		**WGS-02**		**WGS-04**		**WGS-05**	
Date	Entero	OB	Entero	OB	Entero	OB	Entero	OB	Entero	OB
7/22/2010	---	---	**504**	**500**	**>24192**	**254**	**201**	186	---	---
7/29/2010	**199**	**235**	52	**500**	**1956**	184	30	163	---	---
8/5/2010	---	---	31	**500**	**959**	**203**	**546**	152	**216**	**320**
8/16/2010	---	---	**96**	**500**	**130**	**203**	**389**	**366**	---	---
9/7/2010	---	---	---	---	**1467**	**201**	---	---	---	---

Table 3. Enterococci and optical brightener levels were monitored for 6 sites within the Old Marina Lock System storm drainage network, the WWTF effluent before mixing in the harbor and 3 sites within the storm drainage network at Steamboat Landing.

iii. E. coli[29]

Following rainfall on June 28th, two sites were in exceedance of DEP's geometric mean water quality standard. On July 22nd, one site was in exceedance of the geometric mean standard and for the remaining monitoring days, all sites were at acceptable levels.

For all six monitoring dates two of the five monitoring sites in the Megunticook River, site NMG03 (located off of Mechanic Street at the intersection of Mechanic and Knowlton Streets) and site NMGUA01 (located at Rawson Avenue in an unnamed tributary that enters the Megunticook River), either "extremely" or "significantly" exceeded geometric mean *E. coli* water quality standards. On June 28th, these sites exceeded the reporting limit of >2,420MPN/100mls. Overall, the 2010 monitoring season was dry providing the opportunity to assess illicit discharges' contributions to bacteria levels compared to storm water runoff.

[29] For ME DEP E. coli Reports, See **Appendix N**.

C. Rainfall [30]

All sites had exceedances in both dry and wet weather conditions with bacterial levels increasing for most sites during and following rainfall. The two largest wet weather events captured during this project occurred on June 29th and July 22nd. In the 48 hours prior to the June 29th monitoring event, 1.3 inches of rainfall was recorded. All of the sites monitored that day exceeded safety standards. Bacteria levels ranged from 246 MPN/100mls to >24,196MPN/100mls with ten of the eleven samples exceeding 500MPN/100mls

On July 22nd, 2.3 inches of rainfall was recorded within 48 hours of monitoring and 14 out of 17 samples exceeded recreational safety standards. Exceedances ranged from 134MPN/100mls to >24,192 MPN/100mls with eight of those 14 samples exceeding 500MPN/100mls.

D. Waterfowl

Observations of numerous waterfowl residing in the inner harbor region were recorded for all monitoring dates. Sites with the largest concentration of waterfowl were located at: the mouth of the Megunticook River (MR-1), the mouth of Rock Brook (LO-1), the Wastewater Treatment Facility's outfall (STP-1) and just offshore of the pump station for the sewer systems on Steamboat Landing (PS-1).

The Riverhouse Hotel is a business that promotes waterfowl feeding as a tourist attraction. The business provides food dispensers with signs promoting waterfowl feeding on a bridge crossing the lower reaches of the Megunticook River.

IV. Discussion

The assumption behind this special project was that boat sewage was the primary factor leading to elevated bacteria levels at Camden's beaches. Although boat sewage is likely a contributor, this study illustrated that freshwater inputs, the Megunticook River, storm drain outlets and the local WWTF outfall, also impact Camden Harbor and adjacent beach water quality.

Throughout the study the MHB Program worked closely with the town to find and remediate sources of bacterial contamination impacting Camden Harbor water quality. The data collected and awareness generated through this study initiated additional monitoring and inspection by the Camden WWTF and Public Works. Inclusive problem-solving meetings augmented the town's efforts by transforming the data to usable information, identifying next steps, and providing the technical assistance of the ME DEP.

A. Boat Sewage

Tracking pollution from boat sewage, catching a particular vessel "in the act" of illegally discharging sewage, and measuring the success of the Boater's Education Campaign are difficult tasks. Comparing the number of exceedances from 2009 to 2010 at both Laite Beach and the CYC Recreation Area is not a good measure of the Campaign's success due to the contribution

[30] For a table of rainfall amounts within 48 hours of each monitoring date, see **Appendix L**.

of other sources including the freshwater inputs to the harbor. An in-depth circulation study would have to be conducted to determine the fate and transport of contaminants from known or suspected pollution sources.

Overall there has been a consistent increase in total gallons pumped each year by the Camden pump out boat except for 2009 when usage along with boating traffic and the number of summer visitors was significantly reduced. The drop off was likely attributed to poor weather conditions and the record amount of rainfall that fell during the summer months. The total number of gallons pumped out during 2010 was almost double the amount of 2009. This increase may demonstrate the Campaigns' goals were achieved; however, it is difficult to rule out other factors outside of the Campaign (i.e. lower boat traffic due to poor weather) that may have contributed to this increase. A better indicator of the Campaign's success may be the increase in the number of gallons pumped out in 2008 to 2010 due to the similarity in weather conditions and boat traffic. Similarly, the increase in the number of hours the pumping station was used at Wayfarer Marine demonstrates the likelihood of the Campaign's success.

The survey of all the town-permitted mooring and slip holders had a very low respondent count; therefore, results may not be indicative of the larger target audience. Moreover, a more concerted effort to increase the number of respondents, to target boats with toilets on board, as well as implementing a pre and post survey to measure the success of the Campaign would likely strengthen measurement of success. The Campaign may have contributed to the large percentage of respondents that indicated that the pump-out services in Camden Harbor are user-friendly, their knowledge of the recent NDA Designation and awareness that boat sewage impacts local water quality.

B. Camden WWTF

The town of Camden separated the sanitary sewer lines from the storm water lines in 1970. Some residential and business connections may have been overlooked during this separation, and connections that were sealed over forty years ago may also have deteriorated over time. The town of Camden has accidentally located misconnected sewer lines several times since the separation.

In order for optical brighteners to be useful in detecting human sources, levels must be examined in conjunction with Enterococci results. It is important to build a profile of each location to determine the baseline for each site and how results fluctuate over space and time. Typically, examining multiple sites over multiple seasons is necessary to draw conclusions. The optical brightener data set was not large enough in this study to illustrate a strong relationship between Enterococci and optical brightener levels. However, preliminary results indicated the possible presence of human sewage in the Steamboat Landing and Old Marina Lock System storm drainage networks. Additionally, the high optical brightener levels recorded at the WWTF outfall before treated water mixed with the harbor (STP-3) can be attributed to the fact that optical brighteners are not removed from human sewage during the treatment process.

High optical brightener levels were recorded in conjunction with elevated bacteria levels at the storm drain outlets and at several sites within the upland drainage network, indicating the likelihood of human-sources. Moreover, the storm drain outlet at Steamboat landing had flow during dry weather which is also indicative of possible sewer line cross connections to the storm drainage system.

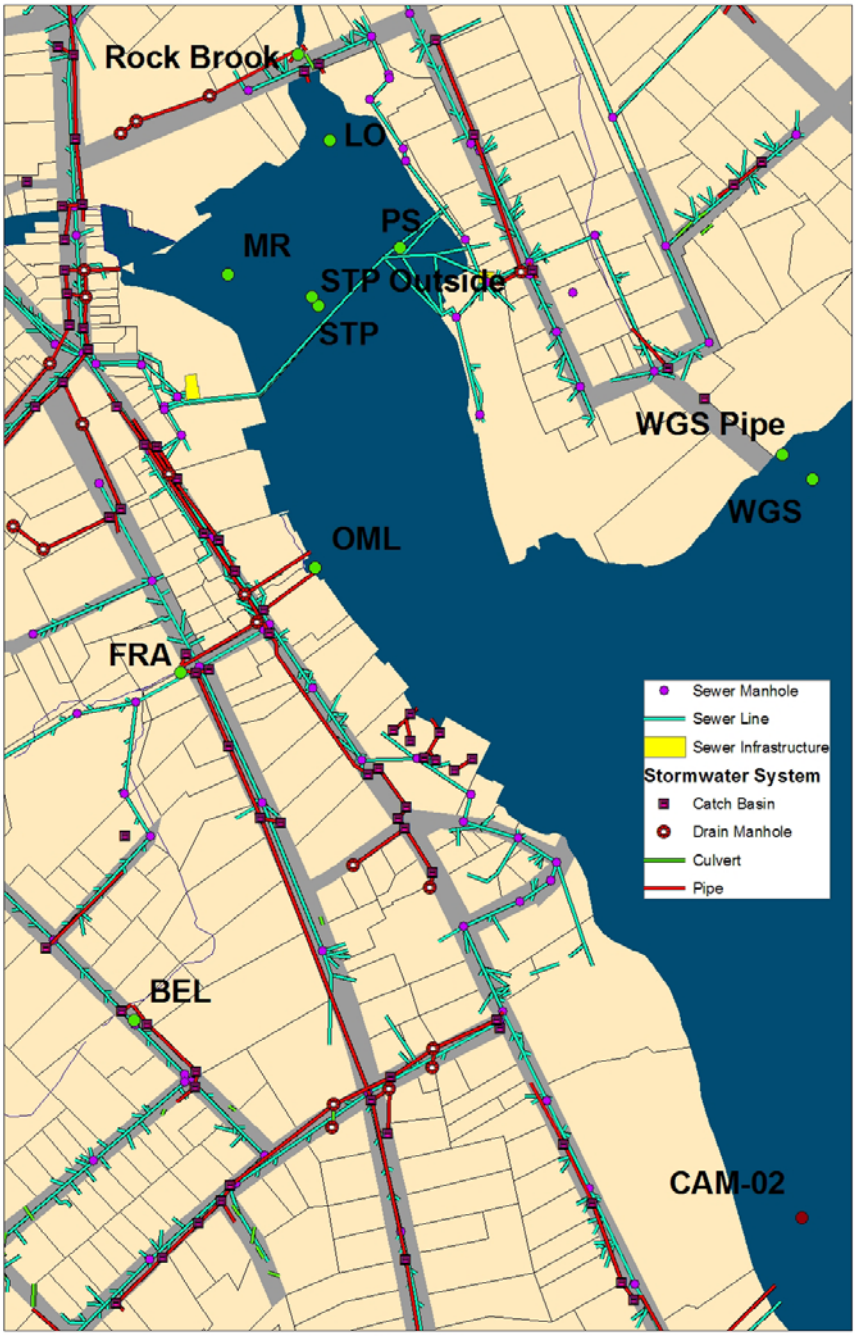

Figure 11. The municipal sewer lines and storm water drainage network surrounding Camden Harbor.

Results from this study reinforced the WWTF's existing proposal to conduct an Illicit Discharge Detection & Elimination (IDDE) Study using tools such as visual field screenings, cameras, smoke and dye tests to detect illicit cross connections in the vicinity of Steamboat Landing. The IDDE Study was instrumental to the town discovering two illicit sewage cross connections (one residential, one business) to the storm drain network emptying to site WGS-2. Both sources were remediated in the fall of 2010. In the coming year, the Public Works Department will also be digging up, repairing and replacing much of the storm drain network on Steamboat Landing which may help detect additional sources.

In addition to focusing on Steamboat Landing and the Megunticook River, the WWTF has conducted additional monitoring and inspection to determine the cause of elevated bacteria levels documented at the WWTF outfall (site STP-1). This site had elevated bacteria levels for four consecutive weeks in June; however, levels improved over the course of the monitoring study. The WWTF effluent (STP-3) collected in the sewer line before it mixed with the harbor also demonstrated improvement over the course of this study.

For 6 of the 8 monitoring dates, site STP-2 located just above STP-1 (towards the head of the harbor) had higher bacteria levels compared to STP-1. This suggests that the WWTF outfall is not the only contributor to high bacteria levels in the head of the harbor region. Other sources (i.e. waterfowl, storm water, Megunticook River) were likely compounding and leading to elevated bacteria levels at both monitoring locations.

C. Rock Brook and the Megunticook River

The IDDE Study was expanded beyond Steamboat Landing and will continue into 2011. A broken sewer line was discovered parallel to Rock Brook, and the line was repaired in the fall of 2010. Suspected sources of pollution along the banks of Rock Brook include domestic pet and wildlife waste that are likely washed into the brook during wet weather conditions. The ME DEP will recommend removing Rock Brook from the state list of impaired waters (303d list).

Due to the impaired status of Megunticook River and the elevated *E.coli* levels documented by the ME DEP, the town plans on expanding the IDDE study to include the lower reaches of the Megunticook River below Rawson Avenue.[31] It will remain on the Maine List of Impaired Waters, the 303d list until ME DEP *E. coli* results are consistently within acceptable limits.

D. Waterfowl

The large population of waterfowl may significantly contribute to bacteria levels in Camden Harbor. The Riverhouse Hotel, a business located at the lower reaches of the Megunticook River, highlights and advertises waterfowl feeding as a tourist attraction. MHB Program and municipal staff delivered educational materials and encouraged the Hotel to implement best practices. The hotel was not compliant and permission to post anti-waterfowl feeding signs near the bridge and Hotel was denied. Many people in the Harbor Park as well as boaters in the Camden Harbor feed the waterfowl year-round. With a consistent food source, these

[31] IDDE Program, Megunticook River, January 2011, **Appendix O**.

populations will likely remain and waterfowl waste will continue to add to the bacterial pollution in Camden Harbor.

E. Rainfall
Typically, the worst case scenario for bacterial water quality is during and following rainfall conditions, especially on an ebbing (outgoing) tide. Rainwater picks up various contaminants from the land and eventually drains to the shoreline. An intensified monitoring effort specifically targeting wet weather events is necessary to gain a better understanding of how rainfall impacts water quality in Camden Harbor and adjacent recreational areas.

V. Recommendations

A. Target Human Sources First
The town's efforts to monitor boating activity, provide accessible pump out facilities, and conduct the IDDE study are commendable. It is recommended to expand the IDDE Study to include the Old Marina Lock System storm water drainage network and the Megunticook River watershed. Additionally, specifically targeting properties with subsurface wastewater disposal (i.e. septic) systems to ensure they are functioning properly will help maintain/improve water quality. Routine monitoring, maintenance and upgrades to the wastewater infrastructure will also help prevent sources.

B. Education & Outreach
Continuing to post signage and educational information regarding the No Discharge Area designation of West Penobscot Bay, best boating practices, not feeding the waterfowl, picking up and disposing of pet waste properly, reporting illicit discharges, etc. is recommended. Additionally, an illicit discharge and pollution reporting hotline would be a useful and innovative tool to identify intermittent sources easily missed during inspections and source tracking efforts. Working with local watershed associations, conservation commissions, etc. will help augment the town's existing efforts.

C. Water Quality Ordinances, Low Impact Development & Vegetative Buffers
Water quality ordinances targeting illicit discharges, waterfowl feeding, routine pumping of septic systems, etc. will help maintain and improve water quality. Following Low Impact Development guidelines, reducing impervious surfaces and maintaining/planting vegetative buffers will allow rainwater to naturally percolate into the ground, helping to reduce the impact of contaminated storm water.

For more information and links to additional resources:
Municipal Guide to Clean Water: Conducting Sanitary Surveys to Improve Coastal Water Quality:
http://www.seagrant.umaine.edu/extension/municipal-guide-to-clean-water

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