Town of Camden
2012 – Water quality monitoring, testing, and remediation
For Megunticook River, Camden Harbor, and Laite Beach

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Engineering a Better Environment

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I. INTRODUCTION

A. Background

The town of Camden is a popular summer tourist destination and its picturesque harbor is one of its most valuable resources. Since 2003, two sites in the harbor, Laite Beach and the Camden Yacht Club (CYC), shown in Figure 1, have been monitored for fecal indicator bacteria as part of the Maine Healthy Beaches (MHB) program. Bacterial pollution can degrade ecosystems and threaten human health, and the MHB program monitors water quality along the coast in order to either ensure that bacteria levels meet the US Environmental Protection Agency's standards for recreational use, or else recommend beach advisories. The two sites in Camden Harbor have routinely exhibited elevated bacteria levels, so the Town has increased monitoring efforts and frequently posts advisories at Laite Beach and the neighboring Camden Yacht Club (CYC) Recreation Area.

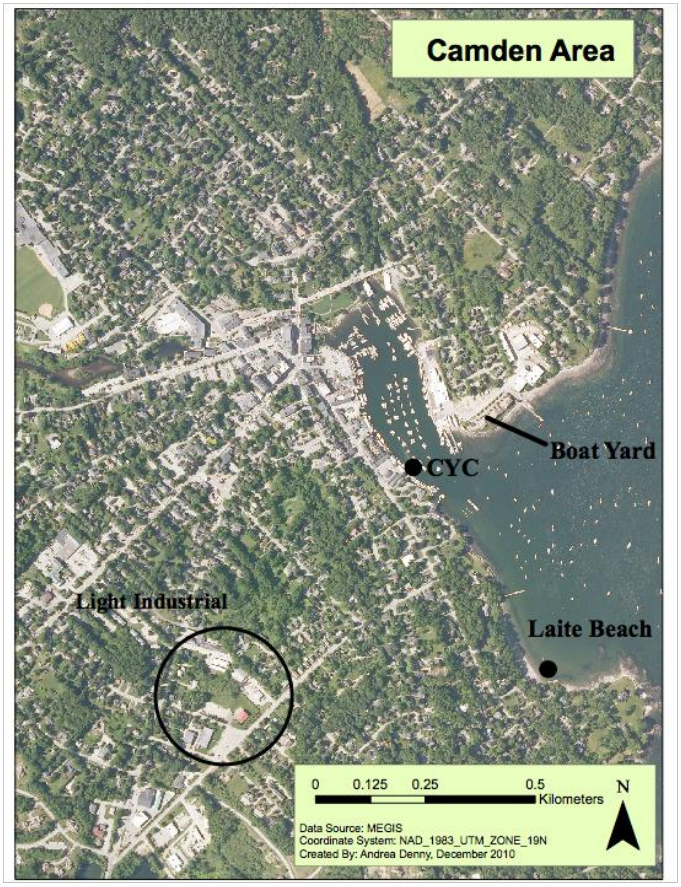

Figure 1.[1] Camden Harbor is a valued resource to visitors and the community.

[1] Picture taken from the MHB Program's April 2011Camden Harbor Water Quality Project Report

In 2010, the Town began to collaborate with local and state agency partners to identify and remove pollution sources. That year, the MHB Program acquired supplemental federal funding with which to establish a Boater Education Campaign and undertake a harbor-wide enhanced monitoring study. This work identified 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. Additionally, a 2010 and 2011 water quality study led by the Maine Department of Environmental Protection (DEP) documented bacterial contamination issues upland in the Megunticook River, its tributaries and adjacent storm drainage network. The river empties into the head of the harbor, and is currently on the state's list of "impaired waters" due to bacterial pollution.

In response to the findings of these studies, the Town conducted an Illicit Discharge Detection and Evaluation Study (IDDE)[2] that identified an illicit sewer cross connection to the harbor storm drain network from the sewer as well as an illicit sewer connection to the storm drain network discharging into the Megunticook River. A separate investigation, led by the DEP, identified a broken sewer line adjacent to Rock Brook. The Town remediated these sources of contamination and Rock Brook was removed from the state's list of impaired waters.

With Laite Beach still exceeding safety standards 41% of the time in the summer of 2011, the Town deemed it necessary to expand IDDE studies to other areas within the harbor watershed in order to explore the numerous potential pathways of pollution to the harbor. In 2012, the Town obtained supplemental funding from the Maine Coastal Program to support this work and to follow through on key recommendations from prior studies. The following report is a compilation of those efforts, their results, analysis, and the recommended next steps.

B. Area Characteristics

Located in mid-coast Maine, Camden Harbor is a popular tourist and cruising destination, supporting sailing, power boating, kayaking, swimming and other recreational activities. The Camden Harbor watershed is a mix of commercial and residential properties. The Camden Wastewater Treatment Facility (WWTF) serves the entire inner harbor from Wayfarer Drive to the Camden Yacht Club and serves approximately 90 percent of the properties surrounding the outer harbor from Curtis Island to Sherman's Cove. Beyond that, areas surrounding the harbor are served by overboard discharge (OBD) units and septic systems. Currently there are four DEP-licensed Overboard Discharge (OBDs) units that serve properties located off of Bay View Street and Belfast Road in the outer harbor. For disposal of boat sewage, the Town offers a free boat pump-out station, and pump-out services are also offered at Wayfarer Marine.

[2] An IDDE Study is an in-depth investigation to assess the integrity of storm and sewer infrastructure. IDDE tools include but are not limited to intensified monitoring of multiple water quality parameters as well as smoke, camera and dye-testing to identity damaged pipes, and illicit cross-connections between storm and sewer.

The focus of the study was on the storm drainage network in the vicinity of Mechanic Street, Rawson Avenue, Bay View and Maple streets, and the Old Marina Lock System as well as on a tributary of the Megunticook River known as Rawson Brook. Land use is primarily residential. The study area is shown in Figure 2 (in Appendix A).

II. PROJECT ELEMENTS

A. Enhanced Monitoring

An adaptive monitoring regime was implemented during which MHB staff monitored a total of 26 sample sites over a period of 14 weeks between June and September, 2012. The sample sites are shown on Figure 2 (in Appendix A) and consisted of 16 storm drain outfalls and eight sites in Rawson Brook. Two additional sample sites were selected above and below the confluence of Rawson Brook and the river, to observe the effect that the Rawson Brook was having on the Megunticook River. Seventeen sites were originally selected but the design allowed for sites to be added and dropped over the course of the project based on recorded bacteria levels and field conditions.

The primary focus of this study was in a tributary of the Megunticook River called Rawson Brook as well as storm drains in the vicinity of Mechanic and Rawson Avenue. In addition, to ensure the integrity of the former sewer system outfall, which was converted to a storm drain outfall and discharges just offshore of Laite Beach, the upland storm drain sites on Bay View and Maple Street were routinely investigated (based on flow). Also assessed as part of this project were the upland tributaries contributing to the Old Marina Lock System, which discharges to the mid-harbor area.[3]

A total of 220 water samples were collected alongside temperature (both air and water), precipitation, and other observations according to established protocols outlined in the US EPA-approved Maine Healthy Beaches Program Quality Assurance Project Plan. Two hundred and twenty samples were tested for Escherichia coli (*E. coli*) and 219 samples were tested for Optical Brightener levels. As can be seen in the raw data included in Appendix C, 8 sampling days were conducted during wet conditions and 6 sampling days were conducted during dry conditions.

A separate effort lead by DEP monitored several sites along the Megunticook River and in the vicinity of Rawson Brook as part of the State's ongoing efforts to improve water quality in "impaired" water bodies. Refer to Appendix E for a summary of results from the DEP monitoring effort.

i. Escherichia coli (E. coli)

E. coli is a fecal coliform associated with human and animal waste and is used to measure the possible presence of disease-causing pathogens in ambient waters. Elevated levels of bacteria during dry conditions can indicate the presence of direct wastewater discharges,

[3] For a site description and a map showing the sampling sites see Appendix A.

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 waterfowl). Elevated levels of bacteria during wet conditions (rainfall) can indicate contamination from human-waste and non-point pollution sources such as wildlife and domesticated animals (including pets), stormwater runoff (including municipal separate storm sewer systems or MS4s), or discharges from combined sewer overflows (CSOs). While Camden does not have any CSOs, they do have Emergency Bypass Structures at the Public Landing and the Sea Street Pump Stations. When the Public Landing Pump Station was upgraded approximately 8 years ago, an alarm system was installed that would alert Camden to a bypass at that station. However, they have not received any such alarms. They do not (yet) have such an alarm at the Sea Street Pump Station and cannot be as certain that there have been no bypasses at this station. It is important to note that since they have not experienced any equipment failures at this station, any bypass would have to have been in conjunction with an extraordinary storm event. During this past year, they did install a basic method for determining if this station had bypassed and have not yet received an indication that there had been any.

Conventional bacterial testing for *E. coli* was conducted to determine contamination levels relative to State water quality standards. To meet Maine State standards for a Class B stream[4], a water body must attain a geometric mean of 64 MPN of *E. coli* /100mL and an instantaneous water quality standard of 236 MPN/100mL (ME DEP). *E. Coli* analysis was conducted by Maine Water laboratories in Rockport, ME, using the IDEXX Colilert multiple tube fermentation, most probable number methodology.

ii. Optical Brighteners

Since bacterial testing alone cannot be used to differentiate between human and non-human sources of pollution, an extra sample was collected at each site to be analyzed for optical brighteners. Optical brighteners are chemicals that are commonly added to commercial or retail products such as most laundry detergents, soaps, paper products, personal care products, and textiles brighten the whiteness of materials and make them appear whiter. After use, these products are typically flushed down the drain. The presence of optical brighteners in stormwater is often an indication that domestic wastewater is present. Therefore, when the presence of optical brighteners is found in conjunction with elevated bacteria levels, it is an indication that fecal contamination is likely of a human source. According to the MHB program, when concentrations of optical brighteners are greater than 200 µg/L in water with elevated fecal indicator bacterial levels, human sources of fecal contamination should be suspected.

Optical brightener samples were collected and analyzed by the MHB Program/UMaine Cooperative Extension using a Turner Designs 10 AU Fluorometer.

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[4] "The State has four classes for freshwater rivers, all of which attain the minimum fishable-swimmable standards established in the federal Clean Water Act. Class A waters allow impoundments and very restricted discharges, so the risk of degradation, while quite small, does increase since there is some small human intervention in the maintenance of the ecosystem. Classes B and SB have fewer restrictions on activities but still maintain high water quality criteria." ("Classification of Maine Waters.", *Maine Department of Environmental Protection*.)

iii. Pharmaceutical and Personal Care Products (PPCP)

On August 28, 2012, the pollution source-tracking toolbox was expanded to include analysis of pharmaceutical and personal care products (PPCPs). This suite of parameters can help further differentiate between human and non-human sources. In partnership with DEP and US EPA, PPCP samples were collected at two sites in Rawson Brook and one site upland of the Rawson Brook outlet in the Megunticook River. Analysis was conducted by the US EPA New England Regional Laboratory in North Chelmsford, MA.

B. Geographical Information Systems (GIS) Mapping & Analysis and Other IDDE Efforts

i. GIS Mapping & Analysis

As part of this effort, the town of Camden, Maine Healthy Beaches, and Wright-Pierce developed a geographic information system (GIS) project to delineate the Rawson Brook watershed, to map the water quality monitoring locations, and to further delineate the watershed into sub-catchment areas for each of the monitoring locations. The purpose of the GIS work is to provide a tool to assist with the detection of possible sources of bacterial contamination by helping to determine which properties could be affecting water quality at each particular site.

MHB program staff collected water quality samples at numerous locations through the Rawson Brook watershed. During the sample collections, GPS locations for the sampling locations were also collected. Wright-Pierce then used a digital elevation model, hydrography data (i.e. streams), and the Town's storm sewer system GIS data (i.e. pipes) to delineate the catchment area or drainage basin feeding the sample locations.

Not all storm drain pipes were in the Town's GIS database, so in some cases, there were questions about the boundary between one catchment area and another. The Town and Wright-Pierce are currently working to improve the GIS data using local knowledge of the system. In addition, the Town is using its GIS to help determine the likely locations of septic systems. By overlaying the GIS data for buildings, parcels, and the sanitary sewer system, it can give an indication of which buildings are not served by Town sewer and are likely to have septic systems. This information is meant to inform further investigations such as property surveys to identify malfunctioning septic systems and/or other contributions to bacterial pollution.

ii. Other IDDE Efforts

Part of this project was also the immediate investigation by the Camden Wastewater and Public Works Department of a property that was pinpointed as a source of a pollution problem. This was immediately remediated. Its resolution is directly attributable to the efforts of this project and associated support.

Overboard Discharge (OBD) units located off of Bay View Street and Belfast Road in the outer harbor have the potential to affect nearby water quality. The local codes

enforcement officer/plumbing inspectors contacted DEP's Bureau of Land and Water Quality about the status and compliance records (over the last ten years) for the five known OBDs located in Camden Harbor. Correspondence between the Town and DEP is included in Appendix F.

C. Boater Education and Public Outreach

Although there are many freshwater outfalls into the harbor to be investigated, it is also important to acknowledge the potential detriment to harbor water quality that illicit dumping of sewage from boats can have. Illegal dumping is difficult to detect and "No Discharge Areas" are therefore hard to enforce. The Town has free pump-out facilities in the harbor, but the Town must still heavily rely on boaters' initiative to utilize these facilities. The Town continued its "Pump it, don't dump it" boater education campaign with the mailing of 541 letters and informational flyers[5] to all boaters with mooring and/or slip rentals, reminding them that West Penobscot Bay, including Camden Harbor, is designated as a "No Discharge Area" and urging them to take advantage of the free facilities and encourage others to do the same. The flyer also contained general tips for protecting the watershed, such as not feeding waterfowl, maintaining home septic systems, disposing of pet waste appropriately, and retaining vegetative buffers along the shoreline. In addition to this mailing, flyers were posted on the harbor side of the pier pilings and in other common areas to reach a broader audience.

D. Planning and Problem Solving Meetings

Over the course of the summer and early fall of 2012, four planning meetings were held to discuss results, improvements to the project, next steps, and to encourage collaborative efforts between the many partners in the study. MHB staff, town administrators, the harbormaster, and representatives from the Camden Wastewater department, Maine Water laboratories in Rockport, Wright-Pierce GIS services, and the DEP all attended one or more of the meetings focused on sharing resources and solving problems.

[5] Appendix B

III. RESULTS AND DISCUSSION

A. Enhanced Monitoring[6]

At all but three sites (RASD 3, Jacobs, and Maple 1), the samples exceeded the bacterial water quality standard for Class B Maine Waters instantaneous level of 236 MPN/100ml. At all but four sites (MSD 3, RB 3N, CEDAR, and RB 3S), the samples exceeded the bacterial water quality standard for Class B Maine waters geometric mean water quality standard of 64 MPN/100ml. The sample sites showing the greatest impairment (i.e. highest *E. coli* geometric mean) are associated with the storm drainage network in the vicinity of Rawson Avenue and Willow Street. In general, the storm drain samples had a higher geometric mean (201MPN/100ml) when compared to the brook and river samples (103MPN/100ml and 101MPN/100ml, respectively). Although bacterial monitoring does not often lead directly to precise sources of pollution, valuable information about the harbor watershed was gained through this intensified monitoring and optical brightener analysis.

Additionally, Camden experienced an intense rainfall event on the morning of July 5, 2012, resulting in approximately 0.5 inches of rain over a period of thirty minutes, which directly preceded a monitoring event. The first 0.5 inches of rain is typically referred to as the "first flush." The first flush of a rainfall event typically results in the highest concentration of runoff pollutants and is a worst-case scenario for water quality. Bacteria levels are generally more elevated during and within 24 hours after rainfall and decline over time.[7] Bacteria have a tendency to cling to sediments and debris so when preceded by dry weather, water from a first flush is picking up material from an untold number of sources. In addition to runoff and other non-point sources, the so-called biofilm that lines the storm drainage pipes may also slough off and affect results, since very small amounts of biofilm can have extremely elevated bacteria levels. All sites were in exceedance on that date and most exceeded the reporting limits of the testing method.

All of the sites reported an arithmetic mean less than what is considered a high concentration for optical brighteners (200 µg/L). Although none of the mean optical brightener levels were strikingly high, there were some spikes throughout the summer and levels were elevated enough to strongly suggest that human sources could be contributing to the bacterial problem in several of the storm drainage areas. In particular, a few of the sites reported maximum readings greater than the high mark (MSD 1, Wil 1, and Wil 2). Together, with the elevated fecal indicator bacterial levels, human sources of fecal contamination should be suspected at these locations. It should also be noted that these three locations are geographically near each other. Generally speaking, a significant correlation between optical brighteners and bacteria levels was observed at storm drainage sites as demonstrated in Figure 3.

[6] For raw data, see Appendix C

[7] Schueler, T. 1999. Microbes in urban watersheds: concentrations, sources and pathways. *Watershed Protection Techniques* 3:551-584.

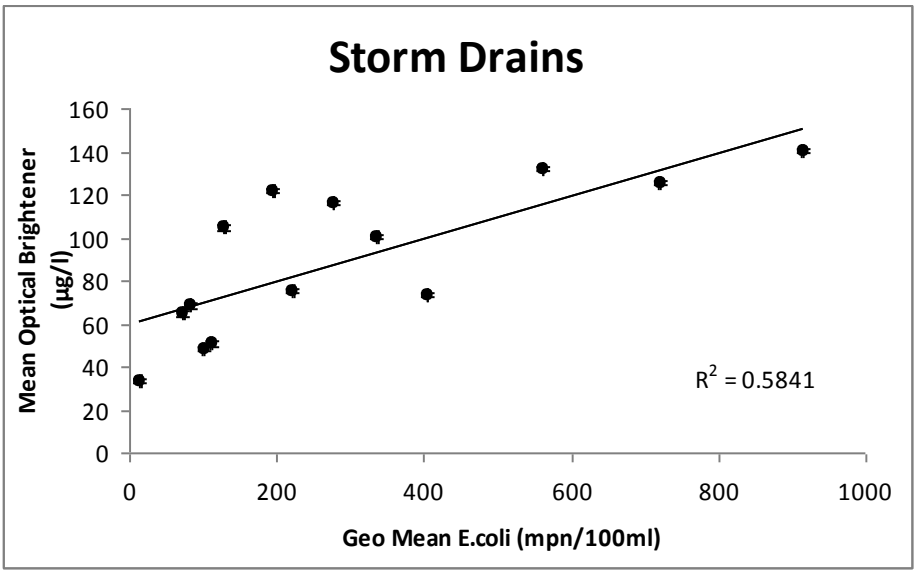

Figure 3. Correlation between bacteria and optical brighteners at all storm drain sites

The sample results for specific storm drainage areas as well as the Rawson Brook and Megunticook River are described in more detail in the following subsections.

i. Mechanic Street storm drainage

Table 1. Summary of results for Mechanic Street storm drainage system

Station	*Escherichia Coli*			Optical Brightener			*All*	
Name	GeoMean[8]	Max [9]	Std Dev	Mean	Max	Std Dev	*n*	*% instantaneous exceedances*
MSD 1	**720**	2,421	1046	**125**	236	62	13	77%
Wil 1	**561**	2,421	1620	**132**	244	98	3	67%
Wil 2	**276**	770	351	**117**	239	106	3	67%
Maple 1	**100**	186	81	**49**	66	16	3	0%
MSD 2	**82**	2,421	699	**68**	130	27	14	29%

Class B geometric Mean standard = 64 MPN/ 100mL. Green = complies, Yellow =slightly exceeds (65-100MPN/100mL), Orange= significantly exceeds (101-500 MPN/100mL), Red = extremely exceeds (>500 MPN/100mL)

MSD 1 showed *E. coli* levels in extreme exceedance (geometric mean of 720MPN/100mL) of the State standard, with ten instantaneous exceedances. The elevated bacteria levels ranged from 435 MPN/100 mL to 2,420 MPN/100mL and six samples were greater than 2,421 MPN/100mL (a magnitude too numerous to count using employed methodology).

[8] Geographic Mean calculated from samples of n< 6 should be interpreted with caution due to inadequate sample size.
[9] Values for *E. coli* reading 2,421MPN/100ml indicate the upper limit of the methodology employed to enumerate bacteria. This value may be >2,421 MPN/100ml.

After the repeated exceedances at MSD 1, the addition of the three sites on Willow Street immediately revealed a very specific problem. The town was able to identify and remediate a faulty sewer connection from a single house. Because the storm drain and sewer system were not separated until 1970, there are still pipes connected to some houses and businesses that lead to the storm drain system. The problem at the Willow Street house was a result of confusion over this phenomenon when a contractor tied into the wrong pipe.

The bacteria levels during the next monitoring event were back down to acceptable levels. However, after another week, MSD 1 again displayed extremely elevated bacteria levels as shown in Figure 4. Unfortunately, the other sites on Willow Street had already been dropped under the impression that the problem was fixed, so there is no data at those sites until the last two weeks of the summer. On the last monitoring event, the same two sites (Wil 1 and Wil 2) showed even higher levels than on the first week they were tested, and optical brighteners for that date are also some of the highest observed during the entire study (ranging from 66 µg/l to 244 µg/l). This suggests that either the malfunction was not entirely repaired or that there is another house on Willow Street exhibiting a similar problem. A municipal employee also observed the dumping of pet waste into a storm drain, another reminder of the many potential contamination sources.

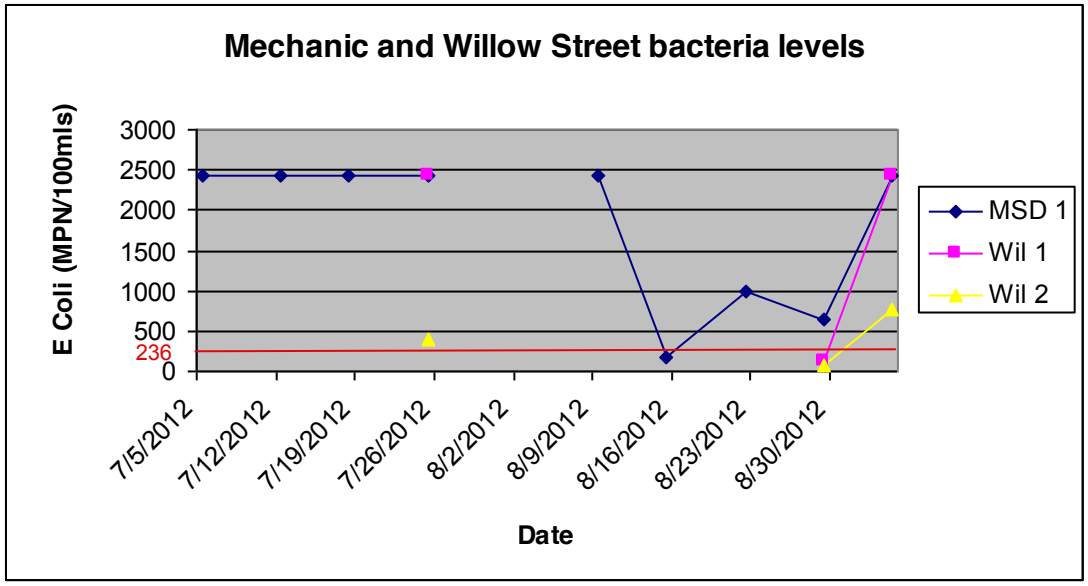

Figure 4. Bacteria levels for July and August at impaired Mechanic and Willow Street sites. Red line marks State instantaneous water quality standard of 236 MPN/100mL

ii. Bay View and Cedar Street storm drains

Table 2. Summary of results for Bay View and Cedar storm drains

Station	*Escherichia Coli*			Optical Brightener			*All*	
Name	GeoMean*	Max	Std Dev	Mean	Max	Std Dev	*n*	*% instantaneous exceedances*
BVS	**111**	2,420	1030	**51**	79	22	5	40%
BVN	**73**	2,420	1390	**65**	78	13	3	33%
CEDAR	**14**	2,421	852	**33**	99	26	8	13%

Class B geometric Mean standard = 64 MPN/ 100mL. Green = complies, Yellow =slightly exceeds (65-100MPN/100mL), Orange= significantly exceeds (101-500 MPN/100mL), Red = extremely exceeds (>500 MPN/100mL)

Three storm drains flow together under the street at the intersection of Cedar and Bay View Streets and then enter the harbor slightly offshore of Laite Beach. Samples were obtained here during the beginning of the summer but flow at these sites lessened and/or disappeared as the summer became dryer even for samples collected during wet weather (especially for sites BVS and BVN).

The geometric mean results from BVS and BVN should be interpreted with caution because so few samples were obtained, but Cedar was one of only four sites whose geometric mean met State standards for Class B streams. Although bacteria levels were extremely elevated during the rainfall on July 5, 2012, Cedar and BVN had no other instantaneous exceedances of the State standards, and BVS had only one other. Additionally, optical brightener levels were low throughout the summer, including on July 5, 2012 (always below 100 µg/l), suggesting mainly non-human sources of contamination.

iii. Rawson Avenue storm drainage

Table 3. Summary of results for Rawson Avenue Storm drainage

Station	*Escherichia Coli*			Optical Brightener			*All*	
Name	GeoMean*	Max	Std Dev	Mean	Max	Std Dev	*n*	*% instantaneous exceedances*
RASD 2	**914**	2,421	1468	**141**	194	75	2	100%
RASD 4	**411**	411	-	**175**	175	-	1	100%
RASD	**405**	2,421	861	**73**	132	28	14	57%
RASD 3	**236**	236	-	**85**	85	-	1	100%

Class B geometric Mean standard = 64 MPN/ 100mL. Green = complies, Yellow =slightly exceeds (65-100MPN/100mL), Orange= significantly exceeds (101-500 MPN/100mL), Red = extremely exceeds (>500 MPN/100mL)

The storm drainage system that flows down Rawson Avenue from Mechanic Street flows into Rawson Brook at the pump station on Rawson Avenue (site RASD). This site began to show more elevated bacteria levels as the summer progressed, so three sites (RASD 2,

RASD 3 and RASD 4) were added further upland in the drainage system in an attempt to pinpoint where the contamination might begin.

All of these sites exceeded standards, but, with the exception of RASD, they were not monitored for long enough to obtain a robust geometric mean (five or more samples). RASD had eight instantaneous exceedances, ranging from 272 MPN/100mL to 2,421 MPN/100mL, out of fourteen monitoring events. The other sites ranged from 236 MPN/ 100 mL to 2,421 MPN/100mL and exceeded instantaneous standards for all monitoring events.

It does appear that elevated bacteria levels at RASD occur during both wet and dry weather. In addition, the maximum optical brightener level for RASD was relatively high, which could indicate the potential of a human source of contamination. There seems to be a significant problem at the bottom of the Rawson Avenue Storm drain but there is little information on where that might be originating. Increasing sample size at RASD and the sites above it should be a priority for future monitoring.

iv. Old Marina Lock System storm drainage

Table 4. Summary of results for Old Marina Lock system

Station	*Escherichia Coli*			Optical Brightener			*All*	
Name	GeoMean*	Max	Std Dev	Mean	Max	Std Dev	*n*	*% instantaneous exceedances*
BELL S	**336**	2,421	837	**101**	136	18	9	67%
Jacobs	**195**	222	35	**122**	140	26	2	0%
BELL N	**128**	345	95	**105**	132	18	9	11%

Class B geometric Mean standard = 64 MPN/ 100mL. Green = complies, Yellow =slightly exceeds (65-100MPN/100mL), Orange= significantly exceeds (101-500 MPN/100mL), Red = extremely exceeds (>500 MPN/100mL)

In addition to being well above the DEP's geometric mean standard, Bell S also had instantaneous exceedances on six of the nine testing days, ranging from 260 MPN/100 mL to 2,421 MPN/100mL. In light of these repeatedly elevated bacteria levels, another site was added upstream of Bell S on Jacobs Avenue (Jacobs). All three of the sites in the system exceeded State standards for geometric mean, and optical brightener levels were also significant. It should be noted that Bell S and Bell N were only monitored for the latter half of the summer and only two weeks of data were collected at the Jacobs site.

All the sites in this system did not meet the DEP's water quality standards, although Jacobs had an insufficient number of samples for a robust geometric mean to be obtained. The relatively high optical brightener levels at these sites point to some human contamination. For the two weeks that Jacobs was monitored, bacteria levels were significantly higher at the downstream site (Bell S) than at Jacobs. This suggests that, in addition to there being a problem above Jacobs Avenue, there might be another source of pollution between Jacobs and Bell S.

v. Rawson Brook and Megunticook River

Table 5. Summary of results for Rawson Brook and Megunticook River

Station		*Escherichia Coli*			Optical Brightener			*All*	
Name	Type	GeoMean*	Max	Std Dev	Mean	Max	Std Dev	*n*	*% instantaneous exceedances*
RB 6	Rawson Brook	**377**	2,421	602	**68**	114	21	14	79%
RB 1	Rawson Brook	**321**	2,421	641	**92**	157	37	14	50%
RB 2	Rawson Brook	**285**	2,421	801	**120**	162	17	14	57%
RB 4	Rawson Brook	**215**	2,421	827	**50**	97	21	14	36%
RB 5	Rawson Brook	**170**	2,421	832	**52**	93	19	14	21%
MSD 3	Rawson Brook	**42**	2,421	699	**79**	119	23	14	29%
RB 3N	Rawson Brook	**37**	2,421	903	**89**	140	41	7	14%
RB 3S	Rawson Brook	**6**	488	198	**41**	68	17	6	17%
RB 8	River	**125**	2,421	620	**40**	87	15	14	21%
RB 7	River	**82**	2,421	628	**35**	44	4	14	14%

Class B geometric Mean standard = 64 MPN/ 100mL. Green = complies, Yellow =slightly exceeds (65-100MPN/100mL), Orange= significantly exceeds (101-500 MPN/100mL), Red = extremely exceeds (>500 MPN/100mL)

Geometric means of five of the eight sites (RB 1, 2, 4, 5, and 6) on Rawson Brook exceeded the DEP's acceptable limit. RB 6 also exceeded its standard for instantaneous water quality eleven out of the fourteen weeks sampled. RB 1 exceeded that standard seven times, and RB 2 exceeds the standard eight times, their exceedances ranging from 272 MPN to 2,421 MPN/100mL.

Optical brightener levels were relatively low for all of the Rawson Brook sites, with RB 2 exhibiting the highest levels (mean 120 µg/l).

Although several of the Rawson brook stations, particularly RB 6, RB 1 and RB 2 showed potentially harmful bacterial levels, there was a relatively low correlation between these numbers and optical brightener levels as illustrated in Figure 5. Elevated bacterial levels and lower optical brightener levels at these sample sites suggest dilution of optical brightener levels (volume of water and proximity to point sources) and/or non-human sources of contamination. The pharmaceutical analysis also indicated a "weak to moderate" human signal at RB 6 and a weak signal at site RB 2.[10] It is likely that the samples taken for the pharmaceutical testing were diluted by the heavy rain that occurred directly preceding the testing, resulting in levels that were lower than they might be on a typical dry day, so human sources should not be entirely ruled out based on the data obtained on that one date. However, upstream from the RB 6 site is a large marshy area, which is likely home to many varieties of wildlife that could be contributing to the problem. (This marsh also makes the stream difficult to access for monitoring purposes.) The geometric mean of 377 MPN/100mL, as well as the numerous instantaneous exceedances, suggests a chronic problem, but it seems unlikely that human sources of

[10] See Pharmaceutical Report in Appendix D.

pollution will be identified upriver of the site. However, further examination into possible sources located upriver would be appropriate.

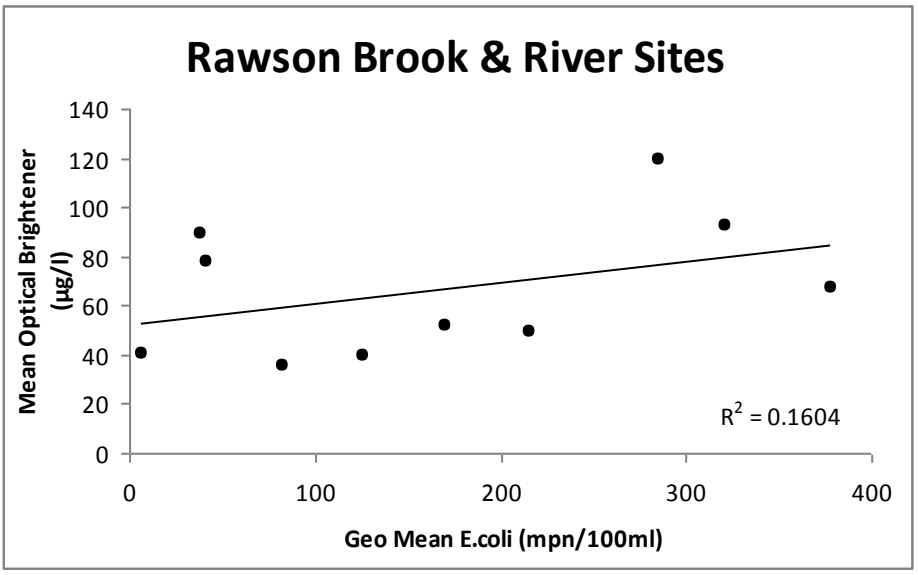

Figure 5. Correlation between bacteria and optical brighteners at Rawson Brook and Megunticook River sites.

Their low bacteria levels (geometric means, 37 MPN/100mL and 6 MPN/100mL) and the fact that they dried up in the absence of regular rainfall, both suggest that RB 3N and RB 3S are properly functioning storm drainage systems for Cobb Rd, and are contributing a minimal amount of pollution to Rawson Brook. Similarly, the storm drainage from the east end of Mechanic Street (MSD 3) was one of the few sites that did meet the DEP's geometric mean standard. Although it had several instantaneous exceedances, those all occurred in wet weather, suggesting that they were the result of non-point, storm water runoff, rather than a specific human source.

The two sites along the river also did not meet State standards although their bacteria levels were lower than those at the sites located in Rawson Brook. The downstream site (RB 8) showed bacteria levels that were consistently higher than the site upstream from the Rawson Brook confluence (RB 7), suggesting that the brook's inflow is having an effect on water quality in the river. This monitoring season gave some insight into where this pollution is coming from, but more work is needed to pinpoint sources.

The DEP also conducted limited monitoring of the Megunticook River. According to their mini-report, their most downriver site (located at the bottom of Knowlton Avenue) failed water quality standards for Class B water bodies. The geometric mean was 190MPN/100ml and it had two instantaneous exceedances out of the six times it was monitored this summer. Results are summarized in a report entitled "2012 Restoration of Streams Impaired by NPS Bacteria." [11]

[11] See Appendix E

vi. Merry Garden Estates culvert

Table 6. Summary of results for Merry Garden Estates culvert

Station	*Escherichia Coli*			Optical Brightener			*All*	
Name	GeoMean*	Max	Std Dev	Mean	Max	Std Dev	*n*	*% instantaneous exceedances*
MGE	**221**	2,421	1,007	**75**	141	58	5	40%

Class B geometric Mean standard = 64 MPN/ 100mL. Green = complies, Yellow =slightly exceeds (65-100MPN/100mL), Orange= significantly exceeds (101-500 MPN/100mL), Red = extremely exceeds (>500 MPN/100mL)

The geometric mean for this site is driven by two high readings, one of which was during the very intense rainfall event on July 5, 2012. The other high reading (488MPN/100ml) was during dry weather; however, there is no strong correlation between elevated bacteria levels and optical brighteners. This site does capture water draining from a wetland area, therefore, onsite investigations of visual observations, such as the presence of waterfowl and wildlife at this site would be recommended as a next step prior to any additional monitoring.

B. Geographical Information Systems (GIS) Mapping & Analysis and Other IDDE Efforts

i. GIS Mapping & Analysis

The current GIS product is presented as Figure 2 (in Appendix A), which shows the stormwater sample catchment areas for each monitoring site within the study area as well as the sample results. Additionally, as part of the GIS mapping and analysis task, the area tributary to Rawson Brook was delineated, and figures were created that show the storm drain system and sewer system features that are currently in the Town's GIS database with respect to the Rawson Brook watershed boundary. These figures are included in Appendix A as Figures 6 and7.

ii. Other IDDE Efforts

The inquiry to the DEP into the five OBD units located off of Bay View Street and Belfast Road showed that one had been removed and the other four show good compliance records over the last ten years.[12]

The elevated bacteria levels on Mechanic and Willow Streets resulted in the investigation of properties on Willow Street and the discovery of a faulty connection made by a contractor tying into the storm drain system rather than the sewer. The cross-connection was repaired within a week of its discovery.

[12] See Appendix F

C. Boater Education and Public Outreach

Table 7 summarizes the data from the public boat pump-out program offered by the Town for years 2008 to 2012. The total gallons of sewage pumped per year is also displayed in Figure 8. It should be noted that the Harbormaster believe that marine enthusiasts began installing larger holding tanks in response to DEP moving towards a zero tolerance policy for overboard discharges. As a result, the Town is seeing a fewer number of pump-outs, but a greater average number of gallons pumped per pump-out.

Table 7. Town of Camden public boat pump-out program data from 2008-2012.

Year	Gallons	Number pumped	Begin	End	Avg Gallons
2012	8,024	150	6/2/2010	10/6/2012	53.49
2011	5,810	145	6/29/2011	10/10/2011	40.07
2010	8,122	263	5/27/2010	10/12/2010	30.88
2009	4,328	138	6/21/2009	9/26/2009	31.36
2008	5,906	143	6/12/2008	10/11/2008	41.30

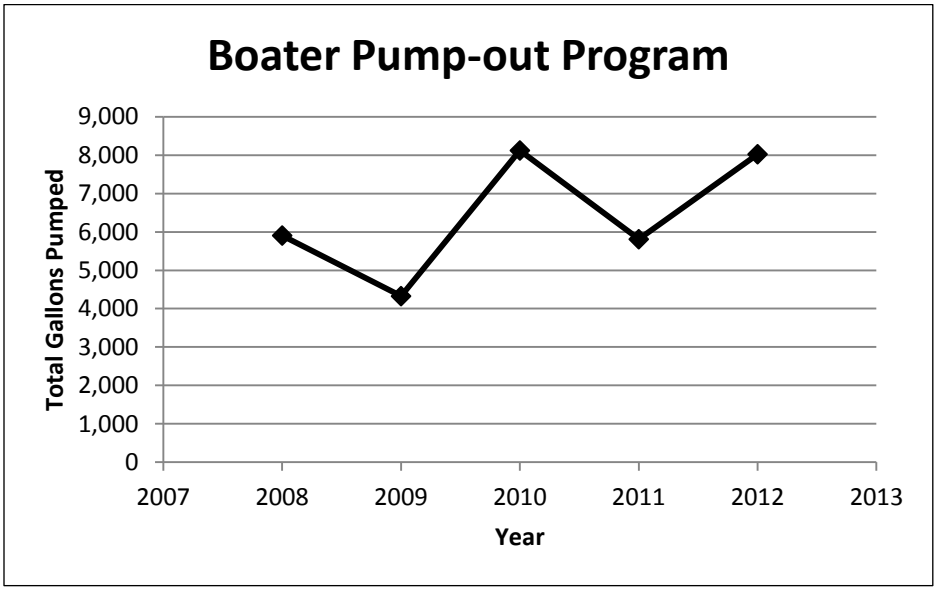

Figure 8. Total gallons of sewage pumped by the Town's boater pump-out program.

IV. NEXT STEPS

This project was an important step in the ongoing process of improving the water quality in Camden Harbor. While the potential effect of the many non-human sources (pets, waterfowl, and other wildlife) on harbor water quality cannot be ignored, the Town plans to focus its future efforts primarily on reducing the impact of human sources of contamination. Although the precise origins of those sources remain unknown, insight has been gained into which areas should be further investigated.

In the very least, this study illustrates that steps need to be taken to improve water quality. It is clear that a study like this one was needed, but it is only the beginning of the solution to a larger problem. The following is a summary of next steps for the Town to pursue in the areas of water quality monitoring (if the Town is able to continue an enhanced monitoring program), GIS mapping and analysis, other IDDE efforts, and boater education and public outreach.

Enhanced Monitoring Program

- Focus future efforts on storm drains, especially the sites in the vicinity of Rawson Avenue, Willow Street, and Jacobs Avenue.
- Increase the sample size at Rawson Avenue, Willow Street, and Jacobs Avenue to better understand what is contributing to the contamination.
- While this year's efforts focused on freshwater sites, consider returning to the inclusion of marine waters monitoring and using *enterococci* as a bacterial indicator for any monitoring of marine recreational waters. *Enterococci* indicate fecal contamination and the possible presence of pathogens. Studies conducted over the past two decades have shown that *enterococci* can survive longer in salt water compared to *E. coli*, and *enterococci* is the indicator showing the best correlation with adverse health effects for marine waters.
- Purchase equipment to undertake in-house bacterial monitoring to help facilitate data collection upstream of RB 6, which is difficult to access, and to make data collection in this area easier and more efficient.

GIS Mapping & Analysis

- Continue to conduct GIS mapping of all the subwatersheds of each of the monitoring sites.
- Use GIS to help determine the number of houses within the study area that are not served by the public sanitary sewer.
- Create a priority list of which individual properties should be investigated.

Other IDDE Efforts

- Conduct onsite visual observations of the Merry Garden Estates to evaluate the likelihood of non-human sources of bacteria at this site.
- Continue to investigate aging pipes.

- Use tools such as cameras, smoke, and dye tests to identify leaky pipes and/or sewer-storm drain cross-connections as well as malfunctioning septic systems for properties not on the Town's sanitary sewer system.
- Continue to keep the sanitary sewer infrastructure under careful and constant observation to ensure that the water being discharged into the head of the harbor is within acceptable levels.

Boater Education and Public Outreach

- Continue current education and outreach campaign with sign postings in the harbor and educational flyers relative to boat pump-outs, proper disposal of pet waste, and caring for home septic systems.
- Consider posting signage or stencils next to any open storm drains or catch basins letting residents know that they drain directly to the harbor.