NORTHEAST CREEK WATER QUALITY AND THE THOMAS BAY CLAM FLAT CLOSURE

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EXECUTIVE SUMMARY

Located on Mount Desert Island, Maine, the Northeast Creek watershed flows into Thomas Bay. In January 2011, the State of Maine Department of Marine Resources Public Health and Safety Division (DMR) closed Thomas Bay to clamming because of bacterial contamination. Understanding the water quality of an area is crucial to recognizing and preventing pathogens and bacterial infections that cause water-borne illness and contaminate shellfish. Because the source of contamination has not been pinpointed, the goal of this project was to isolate potential sources of pollution by collecting water quality samples and testing them for fecal coliform bacteria. Our results are intended to supplement and inform future DMR decisions for restoring the area.

We collected 18 water samples between May 11 and May 18 and tested them for *E. coli* contamination. Our results indicate that pollution is entering Thomas Bay via both Northeast Creek and an ephemeral stream that travels past Willowind Therapeutic Horse Riding Center. We were unable to pinpoint the source of *E. coli* in Northeast Creek, though possible sources could be from local wildlife or from a faulty septic system further up in the watershed. Northeast Creek could also be contaminated by polluted water from the bay. If tides are above 10.7 feet, the saltwater from Thomas Bay will flow up into Northeast Creek. Runoff from a manure pile located less than 100 feet from the ephemeral stream on the Willowind property is the likely source of contamination for the ephemeral stream.

This report recommends that sampling should be conducted further upstream in Northeast Creek in order to pinpoint the sources of pollution and to ensure that the study's fecal coliform results were not a result of tidal influx from Thomas Bay. Willowind Riding Center should take steps to mitigate runoff from their horse manure pile by taking the following measures: move the manure pile farther away from the stream flowing out to Thomas Bay, cover the manure pile to reduce runoff, improve the vegetation buffer (sod grass) between the farm and the stream, and cut back on the pasture available to their horses between October 15 and May 15 of each year when the ground is typically frozen. The soils surrounding this area are predominantly composed of Lamoine-Scantic complex (LbB): a soil type that is poorly drained and is therefore prone to high levels of runoff. Therefore, future land use upstream that could lead to further compaction and decreased permeability of the soil should be avoided; farming endeavors should develop appropriate infrastructure to keep manure as far away and insulated from water sources as possible.

Introduction

This project was a component of Marine Policy, a course taught in the Spring of 2011 at College of the Atlantic, in Bar Harbor, Maine by Dr. Chris Petersen and Ken Cline, J.D. This report will describe the full scope of our project, ending with our recommendations for possible next steps.

The presence of fecal coliforms in Thomas Bay and in Northeast Creek was determined by the Maine DMR Public Health and Safety Division, which led to the January 19, 2011 closure of Thomas Bay. Rob Goodwin, the supervisor at the Maine DMR Lamoine Water Quality Laboratory, is in charge of collecting water quality samples in Maine, but due to time constraints and limited resources, he is only able to collect a few samples per area. This means that although Thomas Bay has been designated as closed to shellfish harvesting, no comprehensive study has been conducted to isolate the sources(s) of contamination.

Much of our project therefore focused on continuing the work of the Maine DMR by collecting water samples in the area and analyzing them for fecal coliforms. The Lamoine DMR Water Quality Laboratory and MDI Biological Laboratory provided us with equipment and taught us how to gather water samples from the Northeast Creek watershed and process them in our own facilities, following the DMR Fecal Coliform Protocol (Appendix VII).

Although we focused on pinpointing the source(s) of contamination within Thomas Bay and Northeast Creek, we also wanted to become familiar with the area and the perspectives of individuals who were involved or affected by the shellfish closure and contamination. We were especially interested in the role of Willowind Therapeutic Horse Riding Center, owned and operated by Dave Folger, in the closure. Since his riding center was initially highlighted as a potential source of contamination, much of our research also focused on searching for ways to help Dave Folger mitigate his contributions to the contamination and for funds to assist him in doing so.

We have also included information provided by Roland Dupuis from the United States Department of Agriculture Natural Resources Conservation Service (USDA-NRCS) on mitigation possibilities: after meeting with Mr. Dupuis, we determined our own recommendations for feasible mitigation measures and next steps. Finally, while the work done on this project was extensive, our results are still somewhat inconclusive; we have included our recommendations for continued water quality study in Northeast Creek.

DESCRIPTION OF THE AREA

Located on the Northern side of Mount Desert Island, Maine, Northeast Creek flows into Thomas Bay, and is constricted by the remains of an old rock dam and the Route 3 Bridge. The creek is at an elevation just slightly below mean high tide. Because of this, Northeast Creek receives saltwater inputs from Thomas Bay if the tide is over 10.7 feet. During large runoff events, the freshwater completely flushes the saltwater out of the estuary. Jay McNally owns property that borders Northeast Creek East of Route 3. Adjacent to and just South-West of McNally's property is the Willowind Therapeutic Horse Riding Center. Flowing over both the southern half of McNally's property and within 100 feet of a manure pile on the Willowind Riding Center property is an ephemeral stream which passes under Route 3 through a culvert. Once it flows under the roadway, the confluence of the stream and Northeast Creek is only a few hundred feet above Thomas Bay. There is a light residential population along Route 3; many of the houses in this area were built before the 1980s and are utilizing older septic technology (Nielsen, 2002). Upstream of Jay McNally's property, parts of the Northern bank of Northeast Creek are bordered by Acadia National Park (Appendix I(A)).

The land surrounding the Northeast Creek watershed is Lamoine Scantic Complex, or LbB soil, which is characterized by poorly drained Lamoine and Scantic soils (Appendix VIII). Lamoine Soils also have a perched high water table, which is only between 6 inches and 1.5 feet deep (USDA, 1998). Soils with high water tables have less capacity to hold nutrients, so it is harder for microbes to attenuate concentrations of nutrients before they run off the landscape. The LbB complex is composed of 6-7 inches of heavy silty loam covering clay loam: these fine-particled soils have low infiltration rates and are prone to increased runoff. (USDA,1998). The USA National Cooperative Soil Survey lists use for this scantic soils as "mostly idle or woodland, some areas are used for growing hay and pasture," these all constitute impact activities that will not exacerbate the poor drainage of this soil through further compaction.

The Thomas Bay closure was delineated by the Maine DMR on January 19th 2011: "Effective immediately, because of pollution, the shores, flats, and waters of Thomas Bay (Bar Harbor), inside and south of a line beginning at the northwest tip of Blunts Point and then running southwest to a red painted post (44 25' 20.5"N – 68 20' 50.5"W) on the eastern tip of an unnamed point forming the east margin of the salt pond at the mouth of Jones Marsh are classified as "Conditionally Approved" and shall be closed to the harvest of clams, quahogs, mussels and oysters from May 1 through September 30" (Maine DMR, 2011a).

PROFILES OF INVOLVED STAKEHOLDERS

DAVE FOLGER

Willowind Therapeutic Horse Riding Center (http://www.willowind.org) which offers a "safe and meaningful horse experience to riders who may be physically, mentally, or emotionally challenged," is owned and operated by Dave Folger. Started in 1998, the center is a 501(C)(3) nonprofit that currently consists of 3 acres of pasture along with a barn and several small outbuildings and is home to 9 horses. 7.5 acres of Jay McNally's property is also available to Dave to pasture his horses. The property and many of the horses were donated to Dave, and the main barn on the property was built through a community barn-raising. Several volunteers including College of the Atlantic students also work at Willowind Riding Center. These donations of time and money are a testament to the community's appreciation of the services Dave provides though his center. From the beginning of the project, we felt it was important to speak with Dave regarding his concerns regarding the potential contribution of his farm to the closure of the Thomas Bay clam flats. Dave showed us around his property and was very open about his situation and his perspectives on the clam flat closure.

Dave's primary concern in any mitigation measure is the potential cost: his operations are run on a tight budget. Because of this, Dave also wants to avoid spending money on a problem that may actually be a false positive result; he didn't think horse fecal coliforms really posed a bacterial threat to humans. However, although horse wastes (manure, urine and soiled bedding) are organic, biodegradable materials, they can still be detrimental to water quality (via nutrient loading and bacterial inputs) and adversely affect human health or aquatic life (Mazboudi, 2004). There are several steps Dave has already taken in order to reduce his contribution to the degradation of the water quality of Northeast Creek. He has cut back from 13 to 9 horses on his property and has maintained an alder swamp buffer between his manure pile and the stream that runs through his property. Dave has also been careful to keep his horses away from swampy areas, and his property is also partially fenced to prevent his horses from accessing the drainage ditch leading off the property.

Our analysis of water samples taken from Dave's property and from the culvert that channels water from his property to Thomas Bay indicate that there are substantial numbers of *E. coli* in these waters, especially after rain events (Appendix III, IV). Significantly higher *E. coli* counts after rain events are most likely a product of increased runoff, which is enhanced by the low permeability and infiltration of the soil composition. Dave's property used to be an old cattle farm which had removed most of the topsoil leaving a predominately clay base. Because the majority of precipitation in this area does not infiltrate into the soil, there is a dramatic increase in the amount of nutrients and *E. coli* running from the drainage ditch to Thomas Bay.

Looking at Dave's property, our primary concern is with the current location of his center's manure pile. The manure pile is currently located behind the horse barn right above the alder swamp that drains into Northeast Creek. This location is likely due to convenience as it is close to the barn. Dave wants to keep the horse manure for various purposes (i.e.: He uses the heat produced from the manure pile as a way to heat his water, thus offsetting power costs, and has sold the manure after it has had time to compost).

There are several low cost steps Dave could take in order to limit the runoff from the manure pile into the drainage ditch. First and foremost, moving the manure pile away from the drainage ditch could help decrease the amount of coliform-laden runoff from the manure pile and flowing directly out to Thomas Bay. Whenever there is a large buffer zone, there are more opportunities for nutrients and harmful bacteria to be absorbed or diluted by plant material. Covering the manure pile with a large tarp would also reduce the added effects of rainfall on manure runoff.

THEO & FIONA DE KONING

Fiona and Theo de Koning own Acadia Aqua Farms, which has operated independently since 2008. Acadia Aqua Farms has over 40 acres of sub-tidal mussel beds leased for their use at Hadley Point (which is West of Northeast Creek). Theo and Fiona hold exclusive dragging rights for the area but have a collaborative relationship with the lobstermen who also utilize the area. David Quinby also regularly uses the area to collect starfish for his biological supply company. This is mutually beneficial as starfish are major predators of mussels.

Acadia Aqua Farms employs 9-10 people full-time. Their operations include one vessel which drags, processes, and seeds the leased area. Sections of the plots are regularly harvested on a rotating system as it takes about 18 months for a mussel to reach an optimal harvesting size after they have been seeded. Another part of the operations is to collect seed and re-seed the leased area. Seed collection happens several times a year, usually in Spring and Fall.

If there is a rain event of more than two inches in under 24 hours, the Maine DMR Public Health Division will close the 40 acres at Hadley Point for 7 days (Maine DMR, 2010). In 2009-2010 Acadia Aquafarms operations were closed for 6 weeks and in 2008-2009 they were closed for a total of 5 weeks. We do not fully understand the reasoning for a 2-inch determination: Fiona did note that if it was a 3-inch limit her operations would have only been closed for one week last year.

The company harvests between 20,000 and 25,000 pounds of mussels monthly from 160 acres of water-bed leases in Frenchman Bay. At full capacity, the 40 acres at Hadley Point can produce 1.5 million pounds of mussels. In the summer, a single landing can bring in 7,000lbs of mussels at a time. Mussel prices can range from $0.85 USD to $1.60 USD per pound wholesale (Blank, 2010).

Acadia Aqua Farms makes three mussel shipments every week and 98% of their product is shipped out of state along the East Coast. Closures can cause the Aqua Farm to miss shipments which affects their perceived reliability and strains their relationship with shippers and buyers.

Closures also mean that employees on payroll at the Aqua Farms are unable to work during these periods. (F. DeKoning, personal communication, May 13th, 2011).

CLAMMERS: COMMERCIAL & RECREATIONAL

There are four commercially licensed clammers that can utilize the Thomas Bay Clam flat: Richard A. "Rat" Taylor, David Dunton, Josh Hodgekins and Josh Kane (P. A. Gray, personal communication, May 25, 2011). The number of commercial shellfish harvesting licenses is fixed at 4, which is set by the Bar Harbor Marine Resources Committee. Commercial licenses cost $106 each, are issued annually on July 1st, and are valid through June 30th of the following year (Town of Bar Harbor, 2010). According the Maine law, "the holder of a commercial shellfish license may fish for, take, possess or transport shellfish within the state limits or sell shellstock the holder has taken to a wholesale seafood license holder..."(Maine DMR, 2011c). We were unable to contact the commercial clammers and are therefore unsure of the level of use and income generated from Thomas Bay.

According to the Bar Harbor Town Clerk's Office, there are currently 96 recreational licenses issued (Jane Iverson, personal communication, May 25, 2011), however the number of licenses varies from year to year. Recreational shellfish licenses cost $21 (Maine DMR, 2011c). There is also a "personal use exception" which states that, "any person may take or possess no more than 1 peck (2 gallons) of shellstock or 3 bushels of "hen" or "surf" clams for personal use in one day without a license, unless municipal ordinances further limit the taking of shellfish (Maine DMR, 2011c).

WATER QUALITY

Coliforms are aerobic and facultative anaerobic, Gram-negative, non-spore-forming bacilli which ferment lactose with gas formation within 48 hours at 35ºC (Maine DMR, 2011c). Fecal coliforms are a subset of bacteria which are present in large numbers in the intestines of warm blooded animals and humans: Although coliforms are not harmful, they can indicate the possible presence of pathogenic bacteria, viruses and protozoans that also live in human and animal digestive systems (Hubbs, 1997). One of the main concerns with animal manure in particular is that bacterial pathogens may reach groundwater and/or surface water via runoff from storm events (Stoddard et al., 1998). Fecal contamination increases the levels of pathogens (agent causing disease or illness), such as Salmonella spp, Giardia spp, and Crypto spp in water bodies (The Regents of the University of California, 2010). Measurement of the quantity of fecal coliform bacteria is one of the most commonly used methods to establish the quality of natural waters (Valiela et al., 1991). Our samples measured *E. coli* colonies--a specific type of fecal coliform. Surface runoff from agricultural soils treated with manure could potentially exceed water quality standards for fecal bacteria (Coyne et al., 1995). Infectious diseases are easily transmitted in water, so human and livestock exposure to surface or groundwater contaminated with fecal bacteria is an important water quality concern (Stoddard et al., 1998).

A marine area is supposed to be closed to the harvest of shellfish immediately "if a sanitary survey reveals that during the most unfavorable hydrographic and pollution conditions, water samples taken from the area exhibit geometric means exceeding… 14 MPN fecal coliform bacteria per 100 milliliters of water and/or water samples indicate variability in quality beyond standards specific to the tests accepted by the National Shellfish Sanitation Program" (Maine DMR, 1997).

It is important to monitor levels of fecal coliforms in shellfish flats because shellfish--clams, mussels, and oysters--feed by filtering hundreds of gallons of water every day, which means that they will filter any bacteria present in the water column and build up in their tissues (Maine DMR, 2011b). As a result, bacteria can be 100 times more concentrated in shellfish tissue than in the surrounding water (Maine DMR, 2011b). Policy managers are careful to close clam flats if there is an indication of fecal coliforms: failure to do so could be a serious human safety concern (Maine DMR, 2011b).

MATERIALS & METHODS

It is essential that water samples are collected aseptically in sterile whirl-pak bags in the field: contamination will negatively affect results. We received training from Dr. Jane Disney at the Mount Desert Island Biological Laboratory to ensure that we understood the sampling protocol and could properly collect samples. The purpose behind collecting water quality samples was to see if we could actually pinpoint the source of contamination. With limited time to collect samples, we decided to prioritize collecting samples at a variety of sites rather than simply re-sampling the same sites. Since we suspected that the Willowind Therapeutic Horse Riding Center was one likely source we tried to collect at sites stretching from above Dave Folger's property dow into the closed clam flat (see map in Appendix I(A),(B)). Samples were also taken from upstream of Willowind Riding Center and from the main branch of Northeast Creek in order to see if there were other sources of contamination. We collected a total of 18 samples on 4 different days between May 11th and May 18th, 2011. We consistently collected water samples at the culvert next to Dave Folger's property in order to see how the water quality changed as a result of rainfall events (Appendix III, IV).

Tide plays an important role in determining when we collected our samples. Our samples were collected predominantly during a low tide series (Appendix VI) which enabled us to take samples closer to the clam flats as well as ensure that the samples we were collecting could be attributed to that area, and not be merely a result of water pushed uptream from high tide.

At each site we collected UTM coordinates using a handheld Garmin eTrex GPS. This allowed us to plot our sites on a map using ArcGIS. Before samples were taken from any site, we also took the following measurements: salinity, dissolved oxygen (DO), conductivity, water and air temperature, and wind speed, and days since last rain. These measurements have not yet been analyzed, but are listed in Appendix V. After samples are collected, they can remain in a refrigerator at 0-4 degrees C for 30 hours. All of our samples were processed in under 8.5 hours.

We used the Maine DMR Fecal Coliform Membrane Filtration Method with mTEC agar medium Protocol to process our samples (Appendix VII). This method works by filtering a set amount (50ml and 5ml dilutions) of our water sample though a 0.45 μm pore sized millipore filter. This filter is then placed on an agar medium and allowed to incubate for 26 hours: 2 in a dry oven and 24 submerged in a water bath. After this point, the *E. coli* colonies can be distinguished on the agar plate because they form distinct yellow colonies.

Results

After counting the yellow colonies present on the agar plates, we had to calculate the Colony Forming Unit (CFU), which indicates of the number of viable bacterial present in the water sample. A table of our fecal coliform counts and the calculated CFUs can be found in Appendix III. One of the most important results from our sampling was finding that *E. coli* was present in Northeast Creek, which means that the scale of contamination is larger then we had initially anticipated. We plotted rainfall against our coliform counts from our culvert site and from Northeast Creek directly upstream of Route 3 (Appendix IV), and found CFU levels and rainfall to be closely correlated, which indicates that major source of *E. coli* is from runoff. This supports our idea that runoff from the manure pile on Willowind Riding Center's property is a source of contamination.

Policy Implications

There are a variety of different classifications for marine and freshwater systems. Thomas Bay is classified as an SB water body under 36 M.R.S.A. §465-B Standards for classification of estuarine and marine waters. SB waters are the second highest marine classification and must be of such quality that they are suitable for the following designated uses: recreation in and on the water, fishing, aquaculture, propagation and harvesting of shellfish, industrial process and cooling water supply, hydroelectric power generation, navigation, and as habitat for fish and other estuarine and marine life (36 M.R.S.A.§465-B). The DO content of Class SB waters must be no less than 85% saturation. The numbers of total coliform bacteria or other specified indicator organisms in samples representative of the waters in shellfish harvesting areas may not exceed the criteria recommended under the National Shellfish Sanitation Program, United States Food and Drug Administration (36 M.R.S.A.§465-B). From what we could find, the National Shellfish Sanitation Program standards are as follows: "For *E. coli.*, sample results are unsatisfactory when any one sample exceeds an MPN of 330 or when two or more out of five exceed an MPN of 230 but are less than or equal to an MPN of 330" (NSSP, 2009).

Discharges to Class SB waters may not cause adverse impact to estuarine and marine life in that the receiving waters must be of sufficient quality to support all estuarine and marine species indigenous to the receiving water without detrimental changes in the resident biological community. There may be no new discharge to Class SB waters that would cause closure of open shellfish areas by the DMR.

Under 38 M.R.S.A. §468, Northeast Creek falls under both Class B and Class AA categorizations. While the creek, as a water body draining into the tidal waters of Hancock County, is generally designated as Class B, those segments of it that lie within Acadia National Park are designated as Class AA waters.

Class B waters must have a dissolved oxygen content of no less than 7 parts per million or a 75% saturation, whichever is higher, and “Between May 15th and September 30th, the number of Escherichia coli bacteria of human and domestic animal origin in these waters may not exceed a geometric mean of 64 per 100 milliliters or an instantaneous level of 236 per 100 milliliters” (38 M.R.S.A. §465-3B). The majority of our sampling focused on a portion of Northeast Creek that is designated as Class B. We sampled the water at the culvert under Route 3 by the Willowind Therapeutic Horse Riding Center 4 times: the geometric mean was 27.82 colony forming units (CFU)/100mL. On May 16th, we had an instantaneous CFU of 260 per 100 milliliters, which exceeds the Class B limitations.

Class AA waters are the highest ranked freshwater classification, and include “waters which are outstanding natural resources.” Water quality of class AA should have a dissolved oxygen and bacteria content “as naturally occurs” (38 M.R.S.A §465-1). On May 18th, we collected a sample far enough upstream in Northeast Creek that it fell within Acadia National Park land, and Class AA waters. Our sample from that area was 92 CFU per milliliters which is well above “naturally occurring” levels: we recommend that the National Park Service monitors this area of Northeast Creek.

The CWA focuses on regulating point-source pollution: we were unable to determine if there were specific regulations for manure piles, however, runoff is generally categorized as non-point source pollution (D. Witherill, personal communication, June 1, 2011).

ROLAND DUPUIS

We met with Roland Dupuis, district conservationist for the USDA-NRCS, to discuss best management and mitigation options in addition to exploring the potential sources of funding available for Dave Folger. Some of the initial mitigation options for reducing the impact of horse manure runoff which we discussed with Mr. Dupuis included removing manure from the property on a regular basis and building a roofed manure storage structure with a vegetative buffer strip. A roofed manure storage structure would require expensive infrastructure, and has to be in compliance with several guidelines. These structures are constructed on a contoured concrete pad which is poured over a minimum of 12 inches of compacted gravel, are usually three sided, and ideally roofed. The most important requirement of this structure is that the cement floor pad must be a minimum of two feet above the water table: this regulation is problematic for Dave's property as the Lamoine Soils in this area (Appendix VIII) have a perched high water table, which is only between 6 inches and 1.5 feet deep (USDA, 1998). The contours in the concrete channel runoff from the pile to one corner of the structure and then out onto an adjacent vegetative treatment strip that accompanies the structure: this strip is planted with sod grass, and designed to maximize the uptake of nutrients by slowing the flow and maximizing infiltration of the runoff as it moves across the strip. Generally, this mitigation option is very costly (Mr. Dupuis estimated the roof alone costs $13 per square foot), and given the qualities of the soils in this area, it is difficult to keep livestock and not have manure runoff problems, so the cost of this extensive mitigation may not outweigh the potential benefit.

Unfortunately, horse riding centers such as Willowind are also not considered "agricultural operations" and therefore are not eligible for any federal funding (R. Dupuis, personal communication, May 25, 2011). This means that both of these mitigation options are probably impractical because they are incredibly costly: without funding assistance, Dave Folger cannot afford to implement them. Willowind would only be considered an "agricultural operation" if they ran a stud program. It is thought that equestrian operations are the largest livestock contributors to water contamination because of the high demands of keeping horses (R. Dupuis, personal communication, May 25, 2011).

Ultimately, we do not recommend that such a manure storage structure be pursued as a mitigation option: our recommendations have instead been made in an attempt to recognize what is cost-effective and feasible for Dave Folger.

Mr. Dupuis also generally emphasized the use of buffer zones or setbacks in order to protect water quality. These are determined based on the site, and should also account for the field slope, soil type, but generally a pollution source should be 25 to 100 feet from intermittent and perennial streams (Maine Department of Agriculture, 2001).

OTHER FUNDING OPTIONS

Since there is no federal funding for mitigating equestrian activities, we also attempted to look for other funding opportunities. The state of Maine has an established "Shellfish Fund" under 12 M.R.S.A.§6651, into which 65 percent of all fees from shellfish licenses, mussel hand-raking and boat licenses, shellfish transportation licenses and wholesale seafood licenses must be paid. These funds, along with other sources of revenue (grants, etc), can be used for habitat restoration and shellfish conservation in the intertidal zone. We thought that using these funds in an effort to re-open a contaminated clam flat could potentially fall under the category of "restoration," and qualify as an acceptable use of the monetary resources from the Shellfish Fund. "Restoration" as it is referenced in the statute typically applies to shell-fish related activities such as the seeding of flats and not to indirect removal of the source of contamination. It is unclear if utilizing these funds to restore the water quality of the area would ever be a priority for this fund. This type of restoration would also go against the "polluter pays" principle, which states that the party responsible for producing pollution is responsible for paying for the damage done to the natural environment. It is important to note that this is a state fund, so opportunities for using it in this indirect, discrete case are unlikely.

12 M.R.S.A §6671, §170-5, states that the fees for shellfish licensing "shall be used by the Town for shellfish management, conservation and enforcement." These would not amount to much,

given that there are only 4 commercial clammers, but some of these funds could be potentially allocated for mitigation of contaminated influent.

The Bar Harbor Marine Resources Committee is responsible for "supporting water quality monitoring efforts by local citizen and school groups that are working the Maine Department of Marine Resources in areas where shellfish beds are located" including "Submitting to the Town Council proposals for the expenditures of funds for the purpose of addressing water quality related issues." (12 M.R.S.A §6671, §170-3 (B)(10)(e)). The Marine Resources Committee also gets money that comes from the town: the committee budget was around $600 last year, (C. Petersen, personal communication, June 1, 2011) so this could also be a potential source of funds for mitigation efforts.

RECOMMENDATIONS

MAINE DEPARTMENT OF MARINE RESOURCES

One of the most surprising results from our water quality testing was that *E. coli* is present in Northeast Creek. Because we weren't able to pinpoint the source of this contamination, we recommend that the Maine DMR continue to monitor the water quality in Northeast Creek and take more water samples further upstream in an attempt to elucidate the potential source of the contamination (i.e., failing septic tanks, wildlife, and agricultural runoff). There may be information on new wildlife activity through Acadia National Park: potentially a recent beaver dam or other new mammal activities (otter, deer) could be contributing to contamination.

The larger watershed of Northeast Creek needs to be assessed to see if there are any tributaries to Northeast Creek that are by residential areas that could have faulty septic systems, whether there is property with livestock, or whether there are any campgrounds that could be contaminating the area.

The Northeast Creek Neighborhood South of Jay's property includes 31 homes, all of which have septic systems (Bar Harbor Housing Authority, 2011). Construction on these homes began in 2008, so we feel that it is fairly unlikely that the septic systems from these houses would be contributing to the *E. coli* contamination. Generally, because there was a close correlation between rain events and *E. coli* levels, it is most likely that the source of *E. coli* is from runoff and not from a septic system, which is already designed to be insulated from the water table and surface.

WILLOWIND THERAPEUTIC HORSE RIDING CENTER

Because we found *E. coli* in the stream on the Willowind property and levels of E. coli were so closely correlated to rainfall events, and therefore attributed to runoff, we recommend first and foremost that Dave Folger relocate his manure pile to a different location on his property, at least 100 feet away from any body of water. Second, we recommend that Dave cover the manure pile. This can be accomplished by purchasing a tarp large enough to cover the pile, or if possible, constructing a roofed enclosure to shelter the manure from rain. Third, we recommend that sod grass be planted in the area: if more grass was planted in the alder swamp near where the manure pile is currently located this would improve the uptake the nutrient-laden runoff from the property. Sod grass should also be planted around the new manure pile location to help absorb runoff. Fourth, we recommend that Dave continue to ensure that his horses stay within the fenced enclosures that he already has on his property, so that they are not in contact with standing water on the property. Fifth, we recommend that Dave allocate a portion of his property as far away from any water sources as possible as a "sacrifice area," and that he restricts his horses to that area between October 15 and May 15 every year when the ground is frozen and more prone to runoff.

Other potential mitigation measures may also include reducing the number of horses on the property and frequently removing the manure that builds up. We realize that these measures may be financially unfeasible for Dave, but they would reduce the amount of manure that is produced and therefore decrease the amount of runoff.

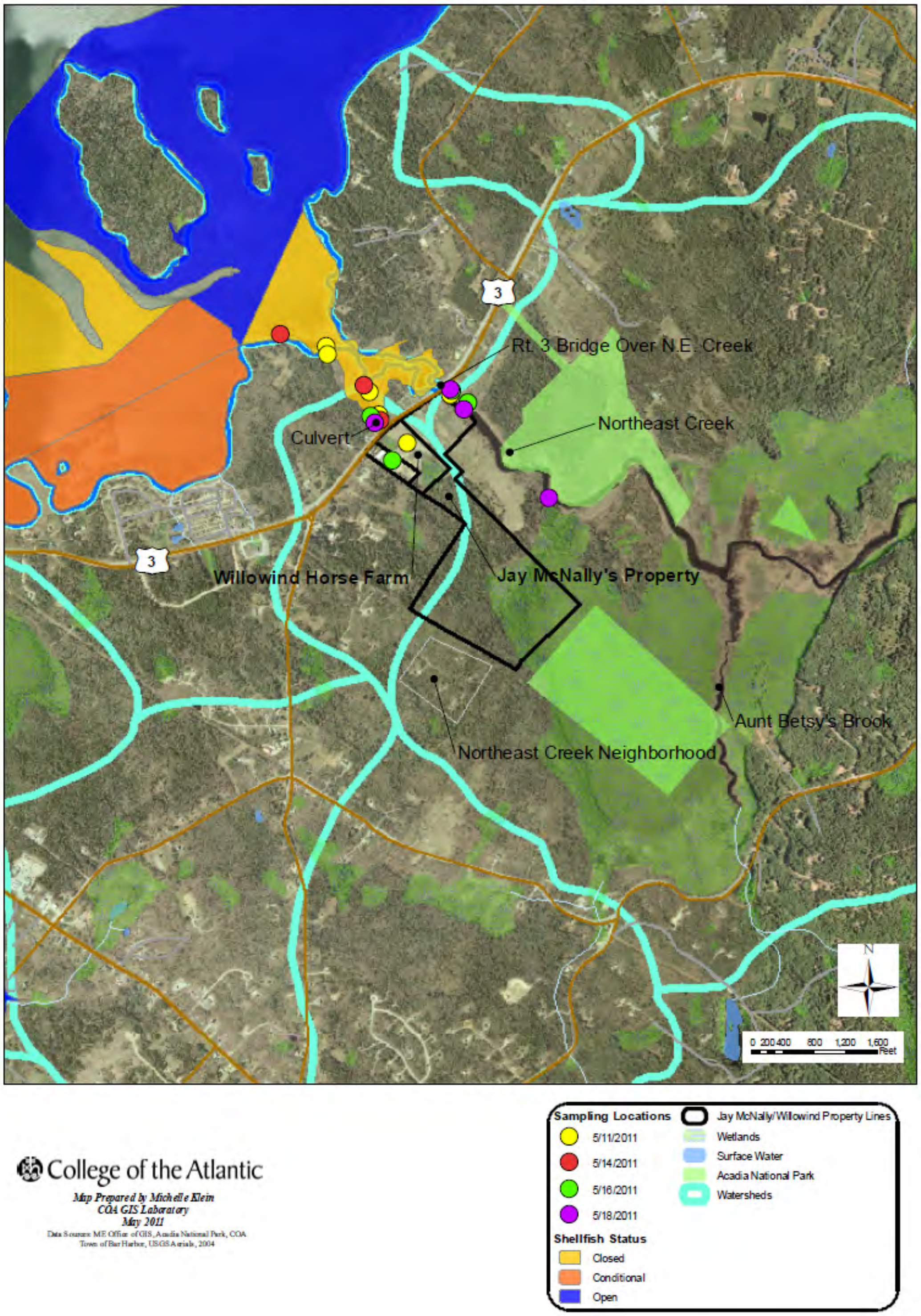
JAY MCNALLY

If Jay McNally intends to have livestock on his property in the future, he should take extra precautions to ensure that the manure produced on his land has adequate infrastructure and setbacks from Northeast Creek. The soils on Jay's property—LbB (Lamoine Scantic complex) and LuC (Lyman-Tunbridge) soils (appendix VIII)—have poor drainage and a high water table which reduces their capacity to hold nutrients. The permeability of these soils is compromised further with high levels of compaction from agricultural land use. Runoff is a serious factor to consider when looking at mitigating the impacts of land use decisions.

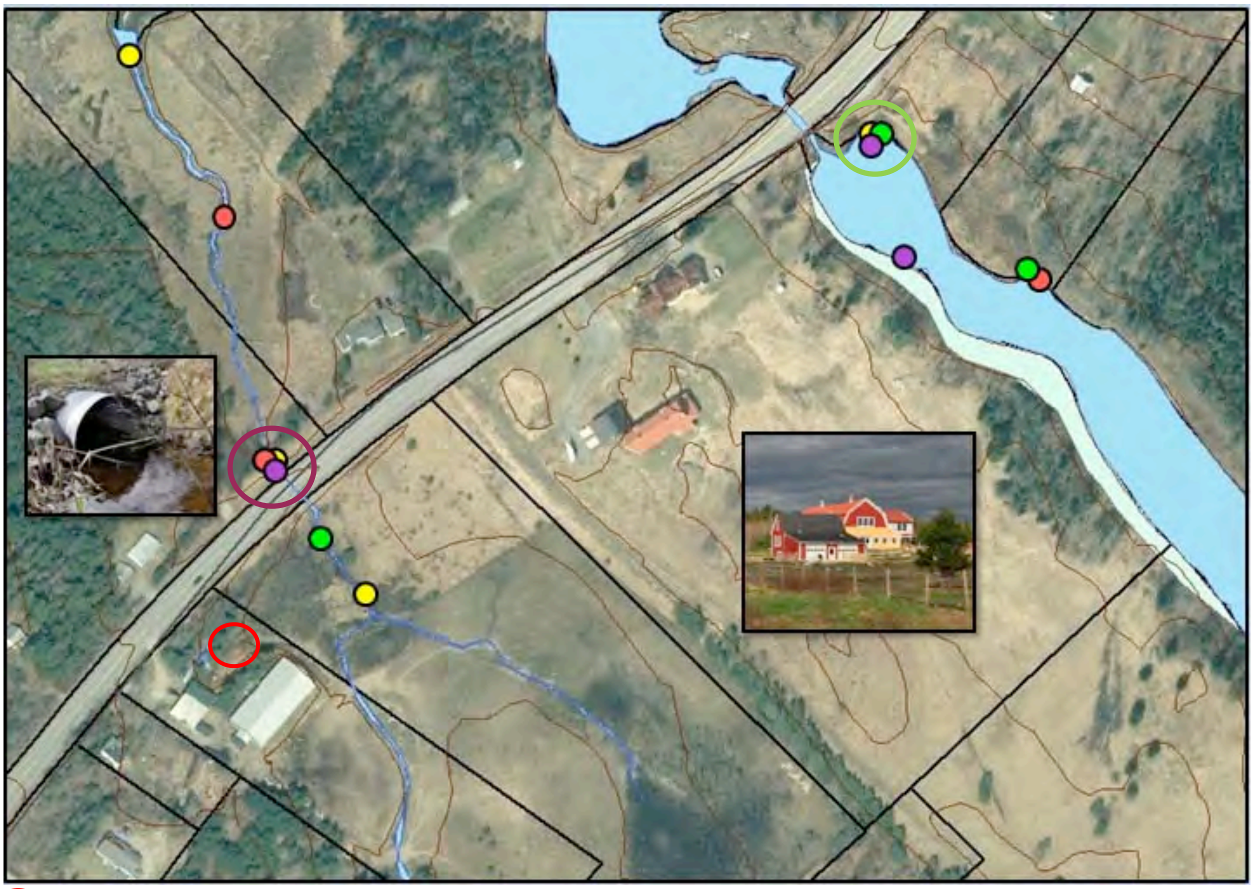
APPENDICES

I. (A)GIS MAP OF WATER QUALITY SAMPLING SITES

Northeast Creek Water Quality Monitoring Project
Marine Policy Spring 2011



I. (B) Closer View GIS of Area of Concern



=Manure Pile Location

= Samples used in the Appendix IV Graph for Northeast Creek

= Samples used in the Appendix IV Graph (taken at the culvert)

Sampling Dates

- (green) = 5/16/2011
- (yellow) = 5/11/2011
- (purple) = 5/18/2011
- (red) = 5/14/2011

II. SAMPLE WATER QUALITY DATA SHEET

Collected By________________________

Processed By________________________

Gps Coordinates: Lat_________________ Long_____________________

Tide height_______________ Going Out ☐ Coming In ☐

What is written on the Bag: Site Name___________ Date__________

Time sample collected ___________ Time sample filtered______________

into Incubator______________

into Water Bath_____________

Time Counted_____________

Narrative Location Description

____

____

____

02 (mg/L)	Conductivity µS or mS	Salinity ppm	Water temp C	Air Temp C	Windspeed	Days since last rain	# Fecal Coliform Colonies	
							Green	Yellow

Photo#s

Visible Pollution indicators (birds, sewage, litter, etc.)

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Other notes:

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III. TABLE OF FECAL COLIFORM COLONY COUNTS AND COLONY FORMING UNITS (CFU)

Fecal Coliform Colony Counts				
Date	**Site #**	**50mL**	**5mL**	**CFU/100mL**
5/11/2011	Blank (control)	0	0	0
5/11/2011	1	2	0	4
5/11/2011	2	2	0	4
5/11/2011	3	2	3	9.09
5/11/2011**	4	6	0	12
5/11/2011	5	2	1	5.45
5/11/2011	6	0	0	0
5/11/2011	Blank (control)	0	0	0
5/14/2011	Blank (control)	0	0	0
5/14/2011	1	0	0	0
5/14/2011	2	9	1	18.18
5/14/2011**	3	2	0	4
5/14/2011	4	9	0	18
5/16/2011	Blank (control)	0	0	0
5/16/2011**	1	TNTC	13	260
5/16/2011	2	TNTC	10	200
5/16/2011	3	TNTC	18	360
5/16/2011	4	TNTC	6	120
5/18/2011	Blank (control)	0	0	0
5/18/2011**	1	24	4	48
5/18/2011	2	46	5	92
5/18/2011	3	49	N/A	98
5/18/2011	4	38	[illegible]	76

*TNTC = Too Numerous To Count (over 80 Fecal Coliform Colonies)
** Sites from the Culvert
Red highlight= samples taken along NE creek upstream from rt. 3

IV. Comparing Rainfall and CFU Samples

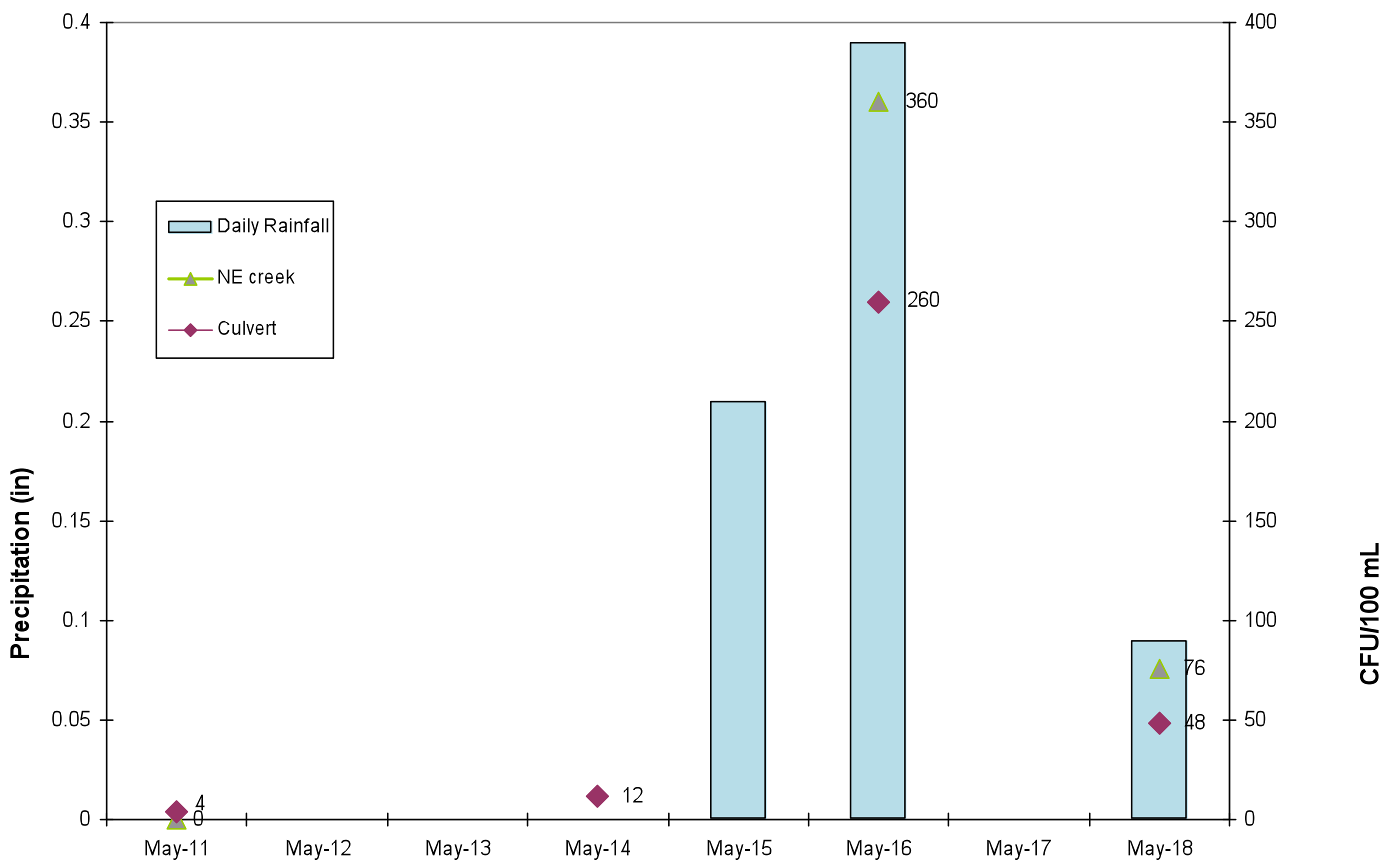


Figure 1: CFU samples from the Thomas Bay basin and total rainfall collected in May 2011. Rainfall is reported as daily total inches, which does not account for the time the samples were collected.

This graph shows the increase in CFU levels concurrent to the rainfall event of May 16, which was the highest rainfall event of the month. Samples before this point showed consistent low levels, and after the rain event, CFU numbers dropped. For both samples with elevated counts, the Northeast CFU numbers were higher than the samples collected at the culvert. Given the low permeability of the soil in this area, this result is also evidence that the area is prone to high amounts of runoff with rainfall events. Precipitation data was collected from the wunderground.com/history of Bar Harbor, ME precipitation. Both of the site locations are highlighted in Appendix I(B).

V. Table of Other Measurements

Date	Sample	Rain in 48 hours	Dissolved 02 (mg/L)	Conductivity (µs or ms)	Salinity (ppm)	Water temp (°C)	Air temp (°F)	Avg Wind (MPH)	UTM Easting	UTM Northing
11-May	1	0.35	10.5	28.1(ms)	97.70%	9.8	54.5	6	553138	4919423
11-May	2	0.35	10.4	12.5(ms)	95%	10.1	53.6	6	553136	4919424
11-May	3	0.35	9.8	5.5(ms)	85%	9.3	52.9	5.2	553281	4919299
11-May	4	0.35	11.5	140.1 (µs)	92%	10	57.4	4.1	553343	4919125
11-May	5	0.35	6.4	51.1 (µs)	57%	11.2	57	4	553407	4919050
11-May	6	0.35	11.6	670 (µs)	99%	11.4	60.8	1.7	553614	4919274
14-May	1	0.01	10.24	16.39 (ms)	11.9	15.8	54	4	552947	4919487
14-May	2	0.01	10.1	10.6 (ms)	7.4	16.1	54.3	3.1	553275	4919359
14-May	3	0.01	10.5	201.6 (µs)	0.1	14.3	63	1.1	553342	4919120
14-May	4	0.01	9.27	3003 (µs)	1.6	16.8	64	1.3	553691	4919196
16-May	1	1.81	11.26	69.3 (µs)	0	11	55.2	1.6	553691	4919195
16-May	2	1.81	11	56.5 (µs)	0	9.5	48.5	3.3	553691	4919195
16-May	3	1.81	10.7	5.7 (ms)	2.4	10.6	52.7	1.2	553615	4919273
16-May	4	1.81	10.4	4000 (µs)	2.3	10.4	47.5	3	553685	4919206
18-May	1	2.07	10.66	124.7(µs)	0.1	11.1	53.5	2.6	553341	4919123
18-May	2	2.07	8.7	232.8 (µs)	0.2	11.3	52.4	1	553808	4918949
18-May	3	2.07	8.9	635 (µs)	0.4	11.6	55.2	2.4	553671	4919174
18-May	4	2.07	9.4	838 (µs)	0.6	11.5	56.3	1.5	553612	4919274

VI. Tide Chart, Bar Harbor, ME

Date	High				Low			
	AM	ft	PM	ft	AM	ft	PM	ft
11th May 2011	5:15	10.9	5:55	10.7	11:38	0.2	/	/
12th May 2011	6:18	11	6:54	11.2	12:08	0.8	12:38	0.1
13th May 2011	7:22	11.1	7:53	11.8	1:12	0.3	1:37	0
14th May 2011	8:25	11.3	8:50	12.3	2:15	-0.3	2:35	-0.3
15th May 2011	9:24	11.6	9:44	12.8	3:14	-0.9	3:31	-0.5
16th May 2011	10:21	11.8	10:37	13.2	4:10	-1.5	4:25	-0.6
17th May 2011	11:15	11.8	11:29	13.2	5:03	-1.8	5:17	-0.6
18th May 2011	/	/	12:07	11.8	5:55	-1.8	6:09	-0.4

VII. REDACTED MAINE DEPARTMENT OF MARINE RESOURCES FECAL COLIFORM PROTOCOL

Fecal Coliform Membrane Filtration Method with mTEC for Seawater Samples

Purpose

The MF method provides a direct count of bacteria in water based on the development of colonies on the surface of the membrane filter. A quantity of water is filtered using a vacuum pump through the membrane which retains the bacteria. After filtration, the membrane containing the bacterial cells is placed on the mTEC agar, a selective and differential medium, incubated at 35degC for 2 hours to resuscitate injured or stressed bacteria, and the incubated at 44.5degC for 24 hours. Following incubation, yellow, yellow-green or yellow-brown colonies are counted with the aid of a fluorescent lamp and a magnifying lens. This is an alternate method to the A-1 media method for measuring fecal coliform density. Two dilutions are used, 50 ml and 5ml, to provide a range of < 2 to >1600 CFU/100ml. This method is from Rippey, Adams, and Watkins. "Enumeration of fecal coliforms and *E. coli* in marine and estuarine waters." JWPCF, Washington D.C., August 1987 and United States Environmental Protection Agency, Improved Enumeration Methods for the Recreational Water Quality Indicators: *Enterococci* and *Escherichia coli*, EPA/821/R-97-004, EPA, Washington, DC.

Equipment

- mTEC MF agar
- Pipets, sterile, 10 mL volume
- Membrane filtration units (filter base and funnel), marked at 50mL, sterilized.
- Ultraviolet unit for sanitation of the filter funnel between filtrations
- Timer for timing UV sterilization
- Line Vacuum, electric vacuum pump
- 6 space filter manifold
- Collection receptacle for filtered waste water
- Nalgene Autoclaveable Low Boy Carboy, 8 liter.
- Duck bill Forceps, to handle filters without damage.
- 95% Ethanol, methanol or isopropanol in a small beaker, for flame-sterilizing forceps.
- Phosphate Buffer Saline (PBS)
- Distilled Water
- Alcohol Burner
- Petri dishes, sterile, plastic, 9 x 50 mm, with tight-fitting lids
- Millipore E-Z Pak Membrane filters, sterile, white, grid marked, 47 mm diameter, with $0.45 \pm \mu L$, sterile, disposable
- Whirl-Paks for sealed water bath incubation
- Incubator maintained at 35 ± 0.5 °C
- Waterbath maintained at 44.5 ± 0.2 °C
- Dissecting Scope

Sample Requirements

Water samples are collected aseptically in sterile whirl-pak bags. Samples are clearly identified with site number, date collected, and time collected. Samples are held at 1-10 °C during transit and in the laboratory prior to analysis. Upon receipt at the laboratory, the samples are held in a refrigerator at 0 to 4°C. The maximum holding time from time of collection is 30 hours.

Procedure

1. Two volumes are filtered for each sample, 50ml and 5ml. Tough Tags are used to label plates and designate volume on plates, **green** for 50 ml and **yellow** for 5 ml aliquot - sample site and date are written on the tags.
2. Check bulbs in UV sterilizer, using appropriate eye protection to view the UV bulbs
3. The first round of filtering is done with a blank using sterile PBS. A blank filter is run through the funnel for every date of samples, or, at least every 4 samples.
4. Place sterile filter base units on the manifold
5. Using the filter forceps aspectically place a sterile membrane filter on the filter base, grid side up. Filter forceps are sterilized by dipping in the 95% alcohol and flaming in the alcohol burner.
6. Attach the funnel to the base so that the membrane filter is held between the funnel. Secure funnel top and base securely.
7. Shake the sample vigorously at least 25 times to distribute the bacteria uniformly.
8. When processing the **5ml aliquot:**

   Put 30 ml of PBS into the designated funnel

   -Use a 5 or 10 ml pipet to deliver the 5 ml aliquot to the funnel

   - Filter the sample, and rinse the sides of the funnel with 20-30 ml of PBS.

   When processing the **50ml aliquot:**

   -Measure the 50 ml volume directly into the funnel at the 50 ml mark.

   -Filter the sample, and rinse the sides of the funnel with 20-30 ml of PBS.
9. Use sterile forceps to aseptically remove the membrane filter from the filter base, and roll it onto the mTEC agar to avoid the formation of bubbles between the membrane and the agar surface. Place the filter grid side up on the media. Reseat the membrane if bubbles occur. Run the foreceops around the edge of the filter to be sure that the filter is properly seated on the agar. Always re-sterilize forceps between membrane filter transfers.
10. Close the dish, **invert.** (Membrane should be facing down to avoid the formation of condensation on the lid of the dish.)
11. In between filtering different sample sites, place the funnels and bases and pipets in the UV sterilization unit for 2 minutes.
12. Place petri dishes in whirl-pak and close, taking care to properly twist and seal to prevent water form leaking in
13. Place sealed dishes on rack and place in the 35 °C air incubator for 2 hours.
14. After 2 hour incubation, transfer to the 44.5 ± 0.2 °C waterbath for 24 hours. The dishes must be submersed beneath water.
15. After 24 hours, remove the dishes from the waterbath.

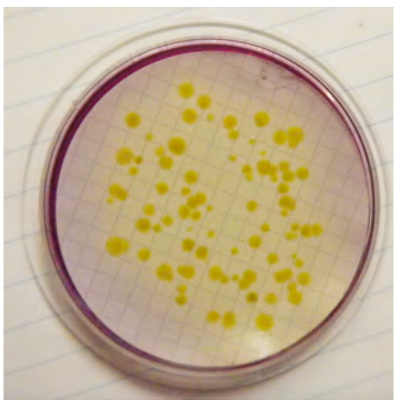
Reading Plates

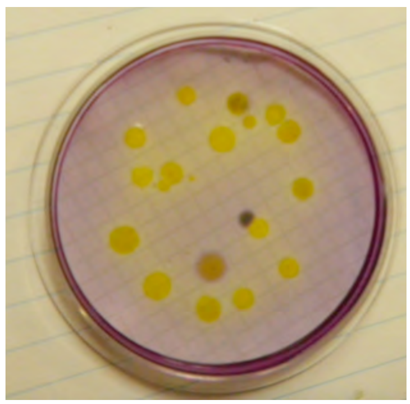
With the two dilutions, 50 ml and 5ml, results can range from < 2 to >1600 CFU/100ml. This range should be adequate to tripper the P90 criteria for the systematic random sampling strategy used by the Maine Shellfish Sanitation Program.

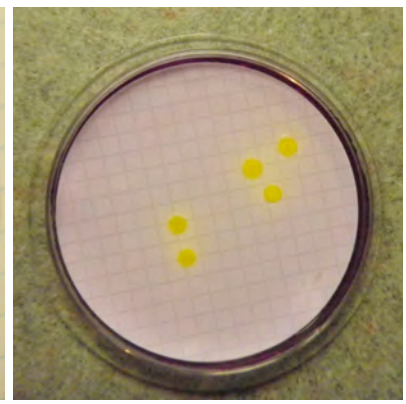
:

Read all yellow, yellow-green, and yellow-brown colonies. When colonies are just touching but show two distinct centers, read as two colonies. Ideally calculate results using plates with 20 to 80 colonies. Read any plates over 80 colonies as Too Numerous To Count (TNTC).

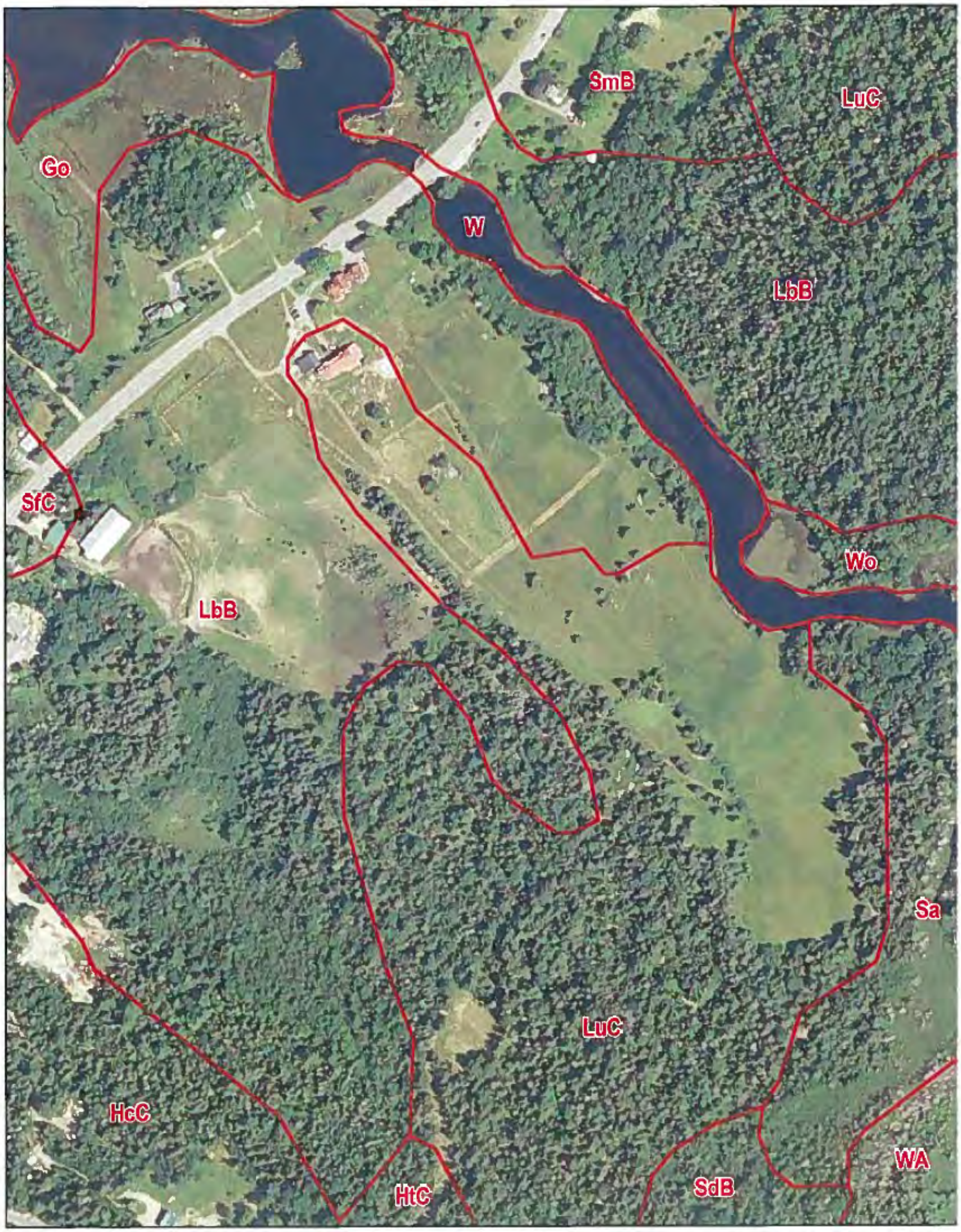
Example Agar Plate colonies


50mL sample (3), 5/16, site 3


5mL sample, 5/16, site 3


5mL sample, 5/18, site 2

VIII. GIS Soil Profile of the Area (provided by Roland Dupuis at the NRCS)



1 inch = 300 feet

LbB= Lamoine-Scantic complex

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LITERATURE CITED

Bar Harbor Housing Authority. (2011). Northeast Creek Neighborhood Information <http://www.northeastcreekneighborhood.org/Northeast_Creek_Home.html>.

Blank, C. (2010). Is there a market for premium mussels? Seafood News Aquaculture. <http://www.seafoodsource.com/newsarticledetail.aspx?id=4294989080>.

Coyne, M.S., R.A. Gilfillen, R.W. Rhodes, and R.L. Blevins. 1995. Soil and fecal coliform trapping by grass filter strips during simulated rain. J. Soil and Water Cons. 50(4):405-408.

Hubbs, A. K. 1997. Fecal Coliform Concentrations in Surface Runoff From Pastures With Applied Dairy Manure (A Thesis). <http://etd.lsu.edu/docs/available/etd-1026102-231639/unrestricted/Hubbs_thesis.pdf>.

Maine Center for Disease Control & Prevention. (2010). Infectious Disease Epidemiology Program: Escherichia coli summary. <http://www.maine.gov/dhhs/boh/ddc/epi/disease/summary/escherichia-coli.shtml>

Maine Department of Agriculture. (2001). Agriculture Manure Utilization Guidelines. <http://www.maine.gov/agriculture/narr/nutrientmanagement.html>.

Maine Department of Marine Resources. (2011a). Notice of Emergency Rule-Making. <http://www.maine.gov/dmr/rm/public_health/closures/47.pdf>.

Maine Department of Marine Resources. (2011b). The Scoop on Fecal Coliform. <http://www.maine.gov/dmr/rm/public_health/coliform.htm>.

Maine Department of Marine Resources. (2011c). Compilation of Shellfish Laws and Regulations. <http://www.maine.gov/dmr/rm/public_health/shellfishlaws&regs4-11.pdf>.

Maine Department of Marine Resources. (2010). DMR Response to Industry Proposed Flood Closure Transition Plan dated May 7, 2010. <http://www.maine.gov/dmr/council/shellfish/MicrosoftWord-ResponsetoSCSFloodPlanFinal.pdf>.

Maine Department of Marine Resources. (2006). Maine Bacterial Closures: Shellfish Pollution Area Inventory. <http://www.maine.gov/dmr/rm/public_health/closures/closedarea.htm>.

Maine Department of Natural and Rural Resources. (2005a). Nutrient Management Program. <http://www.maine.gov/agriculture/narr/nutrientmanagement.html>.

Maine Department of Natural and Rural Resources. (2005b). Rules and Regulations. <http://www.maine.gov/agriculture/narr/rulesregs.html>.

Maine Department of Marine Resources. (1997). Standards for Closure of Contaminated or Polluted Flats. <http://www.maine.gov/portal/search?q=cache:lj3-dFn5TkMJ:www.maine.gov/sos/cec/rules/13/188/188c023.doc+water+quality+fecal+coliform&access=p&output=xml_no_dtd&ie=UTF-8&client=test_collection&proxystylesheet=test_collection&oe=UTF-8>.

Mazboudi, Z. (2004). Equestrian-Related Water Quality Best Management Practices. <http://www.missionrcd.org/Pub%2520Ed%2520%2520Rainbow%2520Creek/Manure%2520Management/Equestrian%2520Best%2520Management%2520Practices.pdf+best+management+practices+%2B+riding+stables&hl=en&gl=us&pid=bl&srcid=ADGEESi7Es6oGfwL8_Mqr8_ZznJo2cSZlVxg4JY9_YyCq6LkYqCmcQETQOgNDCx45TDdkibIJ5GPx7xMDRywVgglXULUnJhQlVMUwLPVrJYJgUI9X9B7zfVAwQv2OARZrCjGgXEcrC_s&sig=AHIEtbQtKYg1gotC_2HKlURaJxB_YbS_Mg>.

NSSP. (2009). NSSP 2009 Section IV Chap II .12 Bacteriological Examination of Shellfish Shipments Decision Tree National Shellfish Sanitation Program Guide for the Control of Molluscan Shellfish 2009. < http://www.fda.gov/Food/FoodSafety/Product-SpecificInformation/Seafood/FederalStatePrograms/NationalShellfishSanitationProgram/UCM059282>.

Nielsen, M. G. (2002). Water Budget for and Nitrogen Loads to Northeast Creek, Bar Harbor, Maine. U.S. Geological Survey Water-Resources Investigations Report 02-4000. <http://pubs.usgs.gov/wri/wri024000/pdf/wri02-4000.pdf>.

Stoddard, C.S., M.S. Coyne, and J.H. Grove. 1998. Fecal bacteria survival and infiltration through a shallow agricultural soil: timing and tillage effects. J. Environ. Qual. 27:1516-1523.

Town of Bar Harbor. (2010). Clamming License / Shellfish Information. <http://www.barharbormaine.gov/xhtml/147/ViewDefault/>.

USDA. (1998). Soil Survey of Hancock County Area, Maine. Natural Resources Conservation Service. 289pp.<http://soildatamart.nrcs.usda.gov/manuscripts/ME611/0/hancock.pdf>

USFDA. (2009). BAM: Enumeration of Escherichia coli and the Coliform Bacteria. <http://www.fda.gov/food/scienceresearch/LaboratoryMethods/BacteriologicalAnalyticalManualBAM/ucm064948.htm>.

USGS. (2011). Acadia National Park Nutrient Load and Estuarine Response Decisions Support System. <http://www.umesc.usgs.gov/management/dss/anp_nutrient.html>.

USGS. (2011). National Water Information System: Web Interface. USGS 01022805 Old Mill Brook Below Crooked Road Near Bar Harbor, Maine. <http://water.epa.gov/type/rsl/monitoring/vms511.cfm>.

USGS. (2011). Water-Quality Sampling by the U.S. Geological Survey: Standard Protocols and Procedures.< http://pubs.usgs.gov/fs/2010/3121/fs2010-3121.pdf>.

USGS. (2011). National Water Information System: Web Interface. USGS 01022820 Northeast Creek at Route 3 Bridge Near Bar Harbor, ME. <http://nwis.waterdata.usgs.gov/nwis/qwdata/?site_no=01022820&agency_cd=USGS&inventory_output=0&rdb_inventory_output=file&TZoutput=0&pm_cd_compare=Greater%20than&radio_parm_cds=all_parm_cds&format=html_table&qw_attributes=0&qw_sample_wide=wide&rdb_qw_attributes=0&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=brief_list>.

Valiela, I., M. Alber, and M. LaMontagne. 1991. Fecal coliform loadings and stocks in Buttermilk Bay, Massachusetts, USA, and management implications. Environmental Management. 15(5):659-674.

12 M.R.S.A. §6651. Shellfish Fund. <http://www.mainelegislature.org/legis/statutes/12/title12sec6651.html>.

12 M.R.S.A. §6671. Chapter 170: Shellfish Conservation. <http://www.maine.gov/dmr/crd/smd/ordinances/documents/BarHarborShellfishOrdinance.pdf>.

38 M.R.S.A §465. (2011). Standards for classification of fresh surface waters. <http://www.mainelegislature.org/legis/statutes/38/title38sec465.html>.

38 M.R.S.A. §468. (2011). Classifications of minor drainages.<http://www.mainelegislature.org/legis/statutes/38/title38sec468.html>

38 M.R.S.A §469. (2011). Classification of estuarine and marine waters. <http://www.mainelegislature.org/legis/statutes/38/title38sec469.html>.