TOWN OF ROCKPORT
GOODIES BEACH
STORMWATER TREATMENT FEASIBILITY STUDY



Prepared For:

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EXECUTIVE SUMMARY

Goodies Beach is a small (approximately 100' wide) protected pocket beach frequented by residents and visitors to the Town of Rockport's Marine Park. It has been the subject of past Public Health Advisories due to bacterial contamination. Through the extensive efforts of town staff and the Rockport Conservation Commission, the adjacent stormwater outfall pipe was identified as a contributor of contamination.

Gartley & Dorsky Engineering & Surveying, Inc. was retained to "*provide an estimate of the volume of surface runoff for the area draining to a culvert adjacent to Goodies Beach, to include peak flows and seasonal total runoff,*" as well as to "*identify and assess the feasibility of stormwater management options for eliminating or greatly reducing negative impacts on water quality observed at Goodies Beach.*" Two watersheds associated with the outfall adjacent to Goodies Beach were delineated, characterized, and modeled for seasonal base flows, 1, 2, 5, 10, and 25-year return interval storm events, provided in Table 4 through 6.

Maine Healthy Beaches performs water quality testing weekly at Goodies Beach during the summer season. Currently, Public Health Advisories are posted by Maine Healthy Beaches (MHB) when a single sample exceeds 104 MPN/100mL (MPN = Most Probably Number) of Enterococci or when five results within a 30 day period exceed 35 MPN/100mL. The objective of implementing water quality treatment is to beneficially reduce or decrease the number of Public Health Advisory Days by reducing Enterococci exceedances.

Prior to this study, over half of the exceedances (53%) observed by Maine Healthy Beaches (for Goodies Beach) occurred in dry weather conditions. Dry weather exceedances (less than $1/10^{th}$ of an inch of rain in the prior 48-hours) indicate factors including boats, surface water base flows, dogs, and organics on the beach are also probable sources of microbiological contamination. Town staff and supporters have increased housekeeping measures and awareness efforts since the issue has risen. The last two summers have been relatively dry. Nonetheless, the number of exceedances has been decreasing, with the summer of 2016 being the best water quality year observed by Maine Healthy Beaches for Goodies Beach since testing commenced in 2009. This apparent decrease in dry weather exceedances indicates the Town's increased housekeeping efforts are helping the water quality of Rockport Harbor.

Based on previous sampling, the adjacent outfall pipe does contribute Enterococci to Goodies Beach. For assessing feasibility of treating this outfall water, storm event and design flows were estimated and are provided in Table 4. Based on a relationship between Enterococci concentrations at Goodies Beach and the outfall (Figure 6), removing 99% of the Enterococci from the base flow of this surface water could reduce microbial contamination at the beach from that source. Because the quantity of precipitation does not have a demonstrated effect on the concentration of Enterococci coupled with the incidence of exceedances in dry weather, the design flow rates suggested for treatment of the outfall are the first inch of rain (about 0.5 acre-feet of water with a peak flow of approximately 3.5 cubic feet per second or 1,571 gallons per minute) and the monthly base flows from June through August (approximately 0.01 to 0.07 cubic feet per second or 4.5 to 31.4 gallons per minute).

COST ASSESSMENT

Appropriate stormwater management options were evaluated based on their capability to obtain 2-log removal (99%) of Enterococci for the given environmental conditions. Of the available stormwater management options evaluated, Ultraviolet Disinfection was determined to be the best option if treatment is deemed appropriate. To further assess the feasibility of implementing Ultraviolet Disinfection, the outfall was sampled with respect to pH, Turbidity and Ultraviolet (UV) Transmittance during base flow conditions. The outfall was also sampled during a storm event for pH, Turbidity, UV Transmittance, Iron (Fe), Manganese (Mn), and Enterococci. This water quality data was provided to a leading UV manufacturer for cost estimation. The estimated capital cost to construct a Ultraviolet Disinfection system, in 2018, for this application is approximately $175,000.00. This capital cost is subject to final costing. Additionally, the facility would have ongoing operation and maintenance costs.

EFFICACY

The cost to treat this one source is quantifiable, however many factors affect bacterial levels. Other affected surface waters have previously been identified by the Conservation Commission, such as the Goose River and an urban stream at the head of the harbor. The reduction in Public Health Advisories is difficult to estimate by only treating the Goodies Beach outfall. Prior to recommending treatment, we suggest actions be taken to both enhance water quality and minimize dependence on treatment. Specific next steps prior to considering treatment are provided in the body of the document, including:

- Clean Goodies Beach regularly by actively removing decaying vegetative matter from the beach throughout summer.

- Consider pet policy restrictions on Goodies Beach for the swimming season, June through August.

- Expand public outreach and eliminate pet waste inputs particularly at the beach, the open wetland, and stormwater collection system within the adjacent outfall's drainage area.

- Extend sanitary survey efforts to other watersheds draining to Rockport Harbor.

If these best management practices have been reasonably accomplished and monitoring data suggests further actions are required, we recommend field validation prior to implementing treatment. To field verify treatment as a next step priority, we suggest implementing a limited duration testing protocol to remove the suspect source during a summer bathing season. Two options were outlined for diverting the outfall. The first option was to bypass a portion of the flow and pump the flow away to the sanitary system for July and August during a summer season. The second option was to extend the outfall approximately 500' to the middle of the harbor to induce mixing and dilution. Owing to the ability only to bypass pump the base flow (but no storm event), the pumping option would not be conclusive and extending the outfall to the middle of the harbor is recommended as the test methodology.

To summarize this study we:

- Determined the base and storm event related flows incident to the beach from the single input.
- Concluded that treatment of bacterial contamination of stormwater, while atypical, is technically viable. Treatment costs, upon estimation, are high.
- Identified, in confirmation with prior data, that additional surface waters and contamination sources remain as a potential risk. This risk brings into question the effectiveness of treating the outfall.
- Short duration testing of rerouting the discharge pipe should be implemented upon acquiring the necessary permitting.
- Further housekeeping, public education, and rulemaking is recommended.
- After completing education measures, determine if bypass piping contributed substantially to reducing exceedances, decide if bypass should be permanent or to implement treatment.

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GOODIES BEACH – STORMWATER TREATMENT FEASIBILITY STUDY
INTRODUCTION & BACKGROUND

Goodies Beach is a small beach at the head of Rockport harbor. It is owned by the Town of Rockport and is part of Rockport Marine Park. As a protected inner harbor beach that is frequented by families with small children throughout the summer, there is appropriate concern over the health risks associated with exposure to pathogenic microorganisms while utilizing the beach. In order to provide guidance for the level of risk associated with microbiological contamination of water, surrogates or indicator species such as *E. coli* and Enterococci are measured. Operating with local, state and federal partners, Maine Healthy Beaches is a program of the University of Maine Cooperative Extension/Sea Grant to monitor pollution at coastal bathing beaches under the USEPA BEACH act.[1] For beach water quality, the Maine Healthy Beaches Program suggest Public Health Advisories be posted when a single sample exceeds 104 MPN[2]/100mL of Enterococci or when the geometric mean of five or more samples collected over a 30-day period exceeds 35 MPN/100mL.

Together with the harbormaster and Conservation Commission, the Maine Healthy Beaches program has been measuring Enterococci levels at Goodies Beach since June of 2009, and has concluded the concentration of Enterococci at Goodies Beach are among the highest in the state of Maine. A full data set of reported values is available at http://www.mainecoastdata.org.

The water body is not administratively characterized as impaired by the State per EPA. Consistent with its charge under the Town's comprehensive plan, the Rockport Conservation Commission has spearheaded efforts to identify and minimize deleterious effects from non-point source pollution. In conjunction with town staff, the conservation commission has planned and implemented measures to improve water quality through initiatives over many years. In order to address this particular water quality issue, the Rockport Conservation Commission tracked down existing and potential impairments to the quality of water at Goodies Beach and the harbor watershed and watersheds in Town, generally. Through their extensive efforts, an adjacent stormwater outfall has been identified as a contributor of contamination (identified by the Conservation Commission as PA 1&2).

The Town's infrastructure is not regulated per 40 CFR Part 122 – National Pollutant Discharge Elimination System (NPDES) regulations. The commission sought services to determine the volume of surface runoff for the area draining to the adjacent stormwater outfall at Goodies Beach, as well as to *"Identify and assess the feasibility of storm water management options for eliminating or greatly reducing negative impacts on water quality observed at Goodies Beach."* Management by pumping stormwater for offsite treatment is impractical given the location, surrounding land uses and available property. The objective of this study, then, is to assess the feasibility of treatment onsite and define target flow data.

[1]Information retrieved from: mainehealthybeaches.org/about
[2]MPN = Most Probable Number

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METHODOLOGY

Initial treatment feasibility assessment began by analyzing Enterococci levels using a data set provided by Robert Kennedy, PhD of the Rockport Conservation Commission's ad hoc Water Quality committee and the Maine Healthy Beaches program Goodies Beach data. This compiled data set was analyzed with respect to precipitation data obtained from the National Oceanic and Atmospheric Administration (NOAA)'s nearest weather station (Camden 0.4 SSW, ME US) and the Maine Water Company's weather station at the Mirror Lake facility in West Rockport.[3] Of all the samples found to exceed 104 MPN/100mL, 53% occurred in dry weather conditions. The extents of dry weather exceedances indicate other sources and base flows have an effect on water quality. When plotted, a correlation is not present between precipitation and Enterococci levels at Goodies Beach (Figure 1), even though water is the contaminant's dominant transport mechanism. To focus on contributions, mass balances were conducted on all observations of Enterococci taken on surface waters around the inner harbor to initially determine the proportionality of contamination. Concurrently, Gartley & Dorsky compiled hydrologic data for the several surface water sources proximate to the beach and developed a hydrological base map in AutoCAD Civil 3D for the adjacent stormwater outfall pipe that supports a working hydrologic model of the subject stormwater source.

In the early part of the 2016 summer season, with the assistance of the Maine Healthy Beaches Program, further water quality analyses were performed during select environmental conditions at the target site. For this data analysis, independent sampling for dry, low flow and rainfall events were performed at the two identified sub-watersheds (Conservation Commission sample locations PA 1&2) to coincide with beach sampling.

Maine Healthy Beaches samples are analyzed for Enterococci at a 1/10 serial dilution, resulting in a minimum detection limit of 10 MPN/100mL. To correct for this analytical limit, observations within this report recorded as less than 10 MPN/100mL were assigned a value of 5 MPN/100mL for numerical analysis. Maine Healthy Beaches' data was obtained from: http://www.mainecoastdata.org with the last observation recorded on 09/30/2016.

[3] Monthly cumulative data reported in Figure 4 was obtained from Knox County Regional Airport

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<u>WATER QUALITY ANALYSIS</u>

Prior to this study, Maine Healthy Beaches collected 114 observations of Enterococci concentrations at Goodies Beach. Of these observations, 43 exceed 104 MPN/100mL of Enterococci. Within these exceedances, 23 occurred when there was less than 1/10 of an inch of precipitation over the last 48 hours. As has been noted, over 50% of the exceedances at Goodies Beach occurred in dry weather conditions prior to this study. Because the majority of exceedances occur during dry weather conditions, addressing boats, dogs and organics on the beach, together with surface water base flow constituents will be more effective than treating stormwater runoff only.

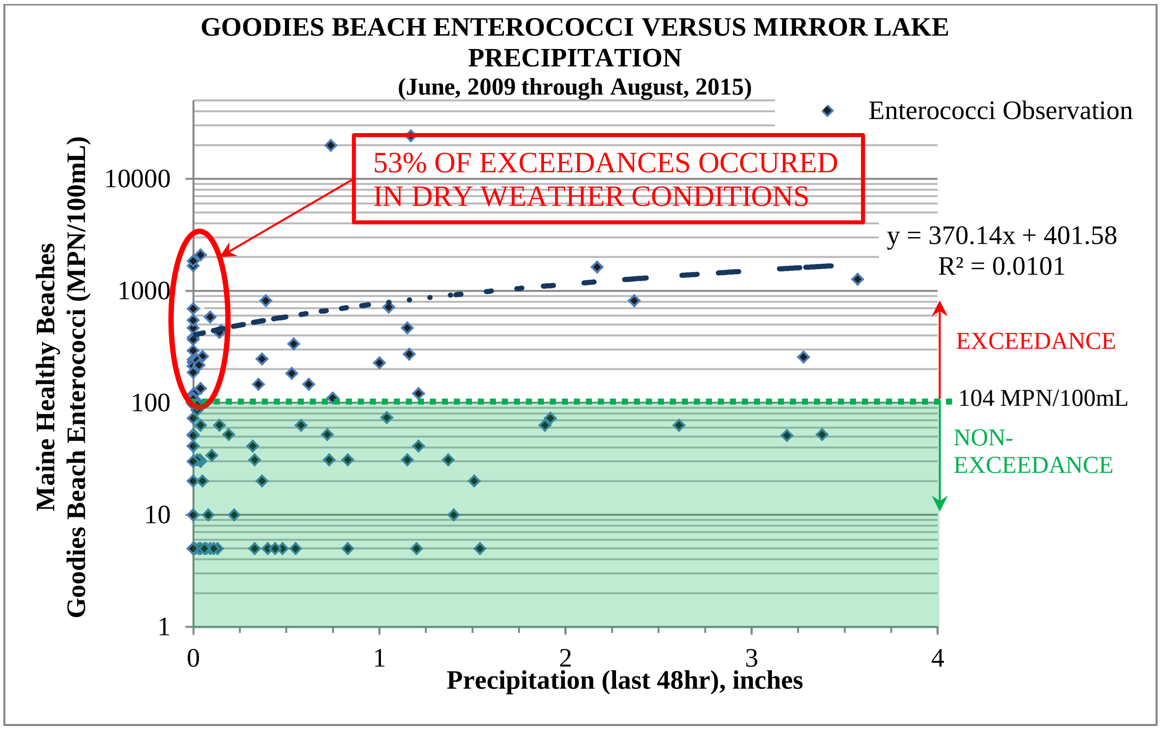


Figure 1: Concentration of Enterococci at Goodies Beach as a Function of Precipitation
(Enterococci data courtesy of Maine Healthy Beaches/Precipitation data courtesy of The Maine Water Company's Mirror Lake Treatment Facility)

In order to account for all surface water sources of Enterococci to the inner harbor, watersheds draining to it were delineated and integrated into a mass balance solution. A mass balance of the inner harbor assumes water quality at Goodies Beach is impacted by the quantity and quality of the surface waters draining to the inner harbor which is modeled as completely mixed without decay. The full modeling of transport and fate of contaminants from the numerous surface waters that may affect water quality at Goodies Beach has not been performed, and is beyond the scope of this study. Currently, the mass balance solution predicts there is continued potential for Enterococci exceedances in the inner harbor, even if the subject outfall is completely free of Enterococci.

Although the last two summers have been dry, Maine Healthy Beaches' data, presented in Figures 2 and 3, suggests the level of Enterococci is trending lower. As depicted in Figure 2: the level of Enterococci is typically at its highest in August, during the dryer part of summer when more people and boaters are active in the harbor area. This relatively higher level of Enterococci in August suggests sources of pollution other than stormwater runoff are a constituent of exceedances at Goodies Beach.

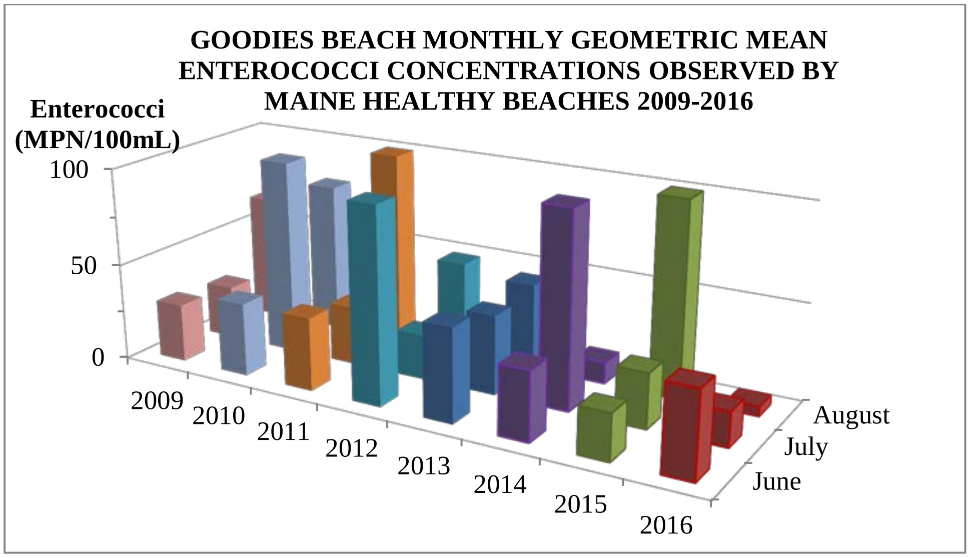


Figure 2: Monthly Geometric Mean Enterococci Levels at Goodies Beach (2009 - 2016)
(Enterococci data courtesy of Maine Healthy Beaches)

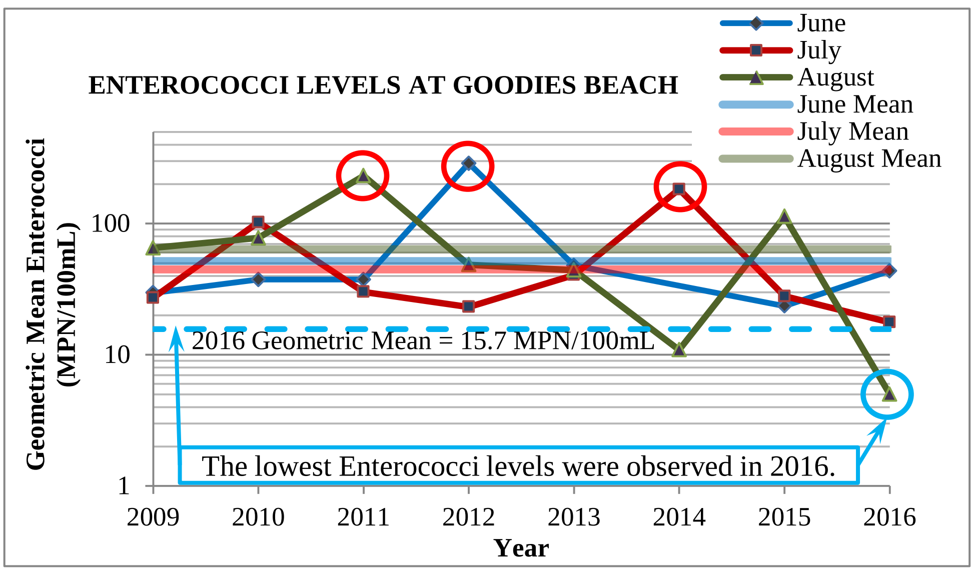
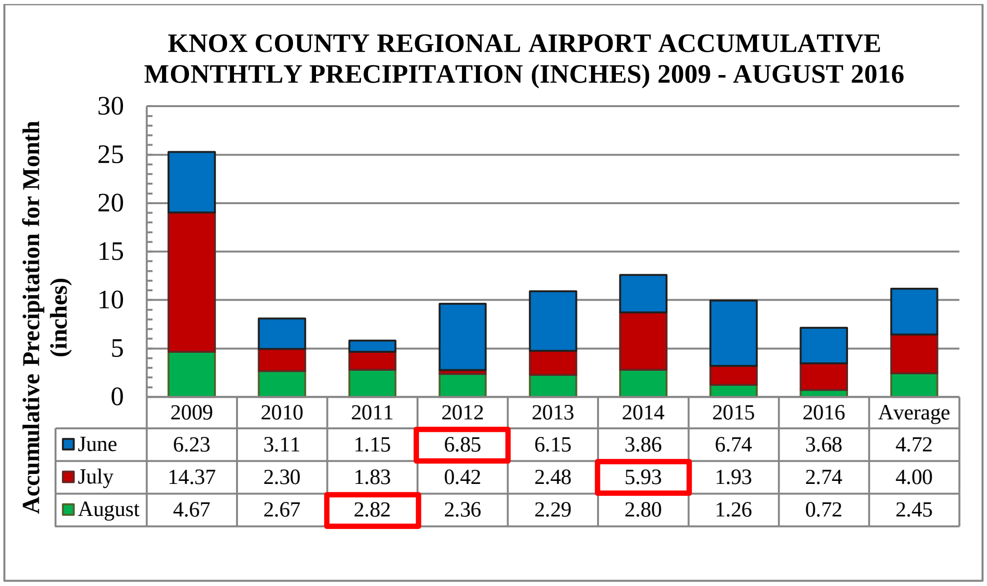


Figure 3: Mean Enterococci levels at Goodies Beach per Month by Year
(Enterococci data courtesy of Maine Healthy Beaches)

According to the Maine Healthy Beaches data, Goodies Beach had six recordings less than 10 MPN/100mL in a row from July 27th through August, 2016 and a total of eight observations below the minimum detection limit in the 2016 season. Observations in August of 2016 were below the minimum detection limit, and the geometric mean for the 2016 season is 15.7 MPN/100mL (identified as a blue dashed line in Figure 3). For reference, Goodies Beach averages four observations per season that are less than 10 MPN/100 mL, with a total of 34 to date. This data indicates the level of Enterococci at Goodies Beach has improved as enhanced housekeeping efforts have coincided with relatively low amounts of rainfall (Figure 4).



	2009	2010	2011	2012	2013	2014	2015	2016	Average
June	6.23	3.11	1.15	6.85	6.15	3.86	6.74	3.68	4.72
July	14.37	2.30	1.83	0.42	2.48	5.93	1.93	2.74	4.00
August	4.67	2.67	2.82	2.36	2.29	2.80	1.26	0.72	2.45

Figure 4: Accumulative Monthly Precipitation (2009 - August 31, 2016)
(Red boxes above in Figure 4 identify the three months circled in Figure 3 where Enterococci levels were found to be the highest on record. Precipitation data presented above in Figure 4 was obtained from: https://www.wunderground.com/history/airport/KRKD on August 31, 2016)

As depicted in Figures 1 through 3, the concentration of Enterococci at Goodies Beach is dynamic with the environment. As previously noted, 53% of exceedances occurred in relatively dry conditions, not resultant of the quantity of precipitation received. This point is indicated by a lack of correlation (R^2 = 0.01) between precipitation and Enterococci levels at Goodies Beach presented in Figure 1. To estimate the treatment level required for the adjacent surface water outfall, all available data representing same day sampling of Enterococci at Goodies Beach and the subject outlet were evaluated (Figure 5).

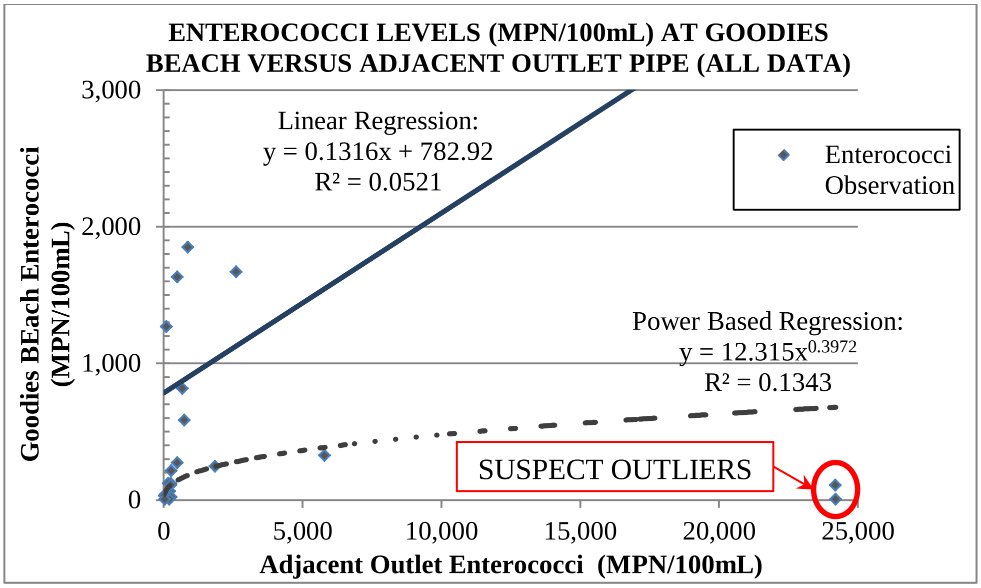


Figure 5: Enterococci Levels at Goodies Beach versus Adjacent Outlet (All Data)

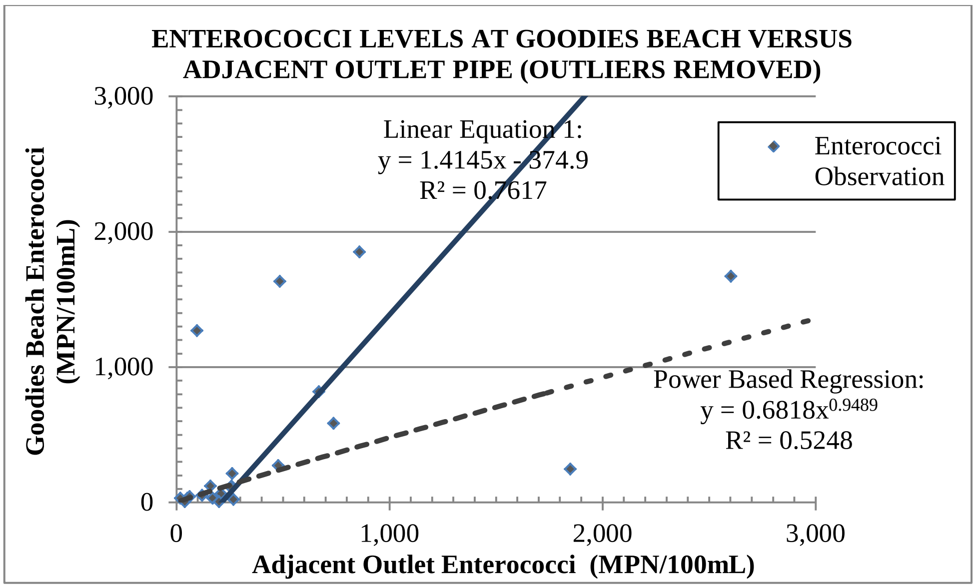


Figure 6: Enterococci Levels at Goodies Beach versus Adjacent Outlet (Observations Removed)

A review of the potential correlation (Linear Equation 1) presented in Figure 6 and poor correlation to precipitation levels (Figure 1) indicates a focus on components to bacterial contamination other than stormwater runoff is warranted. If the correlation depicted in Figure 6 (Linear Equation 1) is valid (R^2 = 0.76), then the minimum outlet concentration that is associated with beach closure events can be related as:

$$[ENT.]_{OUTLET} \text{ at } 338 \text{ MPN/100mL} \rightarrow [ENT.]_{GOODIES\ BEACH} = 104 \text{ MPN/100mL}$$

Assuming the Enterococci levels at Goodies Beach are correlated to the adjacent stormwater outlet pipe, then the level of removal required to achieve 104 MPN/100mL or lower from that source can be estimated. A summary is provided below in Table 1.

Table 1: Removal Requirements as a Function of Linear Equation 1

OBSERVED PIPE OUTLET CONCENTRATIONS		ANTICIPATED ENTEROCOCCI LEVEL AT GOODIE'S	% REMOVAL TO ACHIEVE 104MPN/100mL	LOG REMOVAL REQUIRED TO ACHIEVE 104 MPN/100mL
MIN.	20	-347	N/A	N/A
GEOMETRIC MEAN	323	82	N/A	N/A
AVERAGE	1,168	1,277	91.85%	1.1
MAX.	24,190	33,842	99.69%	2.5

As portrayed in Table 1, the treatment objective for the adjacent outlet pipe only is 99 to 99.9% (two to three log) removal of Enterococci. The extent of dry weather exceedances and lack of relationship between quantity of precipitation and Enterococci at Goodies Beach indicate base flows are the target. If treatment is implemented, the base flow, first flush, and (possibly given further refinement) up to a 1-year storm event are appropriate treatment rates (Table 4). With these design considerations, removing 99% of the Enterococci is likely an effective treatment objective.

SAMPLING EVENT:

The Maine Healthy Beaches Program samples Goodies Beach on Tuesday mornings from June to September. On Tuesday, June 28, 2016 the level of Enterococci observed at Goodies Beach was less than 10 MPN/100mL. At that time, there was no contribution from the adjacent outlet pipe, as there was no flow through the system. This June 28, 2016 observation of less than 10 MPN/100mL provided a known control, where no contribution from the suspect source is evident as there was no flow through the targeted drainage system. That night, over an inch of rain fell in the area and Gartley & Dorsky sampled both the beach water and the adjacent outfall pipe on June 29, 2016 at low tide. Both the beach and adjacent outlet pipe had levels of Enterococci greater than 2,420 MPN/100mL indicating there is a possible correlation between Goodies Beach and the adjacent outlet pipe's Enterococci levels. Other environmental factors and sources may have also contributed to the system and observation.

To assess operational feasibility, water quality data was obtained by Gartley & Dorsky. The subject culvert outfalls 3 & 4 were sampled with respect to pH, Turbidity and Ultraviolet (UV) Transmittance. Additionally, the June 29th storm event was sampled from the beach's adjacent outfall for pH, Turbidity, UV Transmittance, Iron (Fe), Manganese (Mn), and Enterococci. This data is tabulated in Table 2 and this storm event data was provided to the UV manufacturer for treatment suitability and cost implications.

Table 2: Pertinent Water Quality Data Obtained for Feasibility Study

	pH	Turbidity (NTUs)	TSS (mg/L)	UV Transmittance	Enterococci (MPN/100mL)	Fe (mg/L)	Mn (mg/L)
Area 1(Culvert 4) 06/14/16 [Sample A]	7.66	4.18	--	0.340	--	--	--
Area 1(Culvert 4) 06/14/16 [Sample B]	7.67	3.52	--	0.336	--	--	--
Area 2 (Culvert 3) 06/14/16 [Sample A]	7.72	0.25	--	0.827	--	--	--
Area 2 (Culvert 3) 06/14/16 [Sample B]	7.76	0.25	--	0.818	--	--	--
Adjacent Outlet 06/29/16 [Storm Event Sample]	6.55	16.40	20	0.428	>2420	0.260	0.043
pH, Turbidity, TSS, UV transmittance recordings provided by the Water Treatment Technology Assistance Center at UNH. Enterococci, Fe, Mn laboratory analyses were conducted by Maine Water Company.							

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HYDROLOGIC CHARACTERISTICS

The total drainage area upstream of the suspect outlet pipe is approximately 30 acres in size. Within this watershed are residences on public sewer and some undeveloped parcels. Notable hydrogeological features are approximately 1/3 acre residential lots (average parcel size), a cemetery, a forested wetland identified as palustrine scrub shrub on the national wetland inventory (±7 acres) an associated surface water (1/2 acre), and roads with curbs, culverts and catch basins. Table 3 portrays the approximate areas of each surface feature modeled in the watershed. Worth noting, within the watershed are bedrock outcrops (depicted in the Aerial of the Drainage Area). These bedrock outcrops are important hydrological characteristics of this drainage area, as they are impervious areas. With extensive bedrock outcrops, a ponded wetland and shallow soils, the quality of the stormwater leaving this drainage area appears to mimic that of an urban watershed and the weighted curve number (CN) was estimated at 86 for A1 and 87 for A2.

Table 3: Hydrologic Features of Drainage Areas

Area	Residential	Freshwater Wetland	Grass	Impervious Surfaces	Woods	Total Area
A1	10.83	7.04	0.25	1.29	4.35	23.75
A2	5.01	N/A	N/A	0.67	0.55	6.23

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STORM EVENT & DESIGN FLOWS

Storm event and design flows were computed by applying two methodologies. The first method implemented a relative size factor based on neighboring reference watersheds of the Goose River and Ells Stream (USGS - StreamStats Version 3.0 Flow Statistics Ungaged Site Report). The second method applied TR20/TR55 models in Hydro CAD 9.10 from the hydrogeological characteristics previously presented herein. Tables 4, 5, and 6 depict the expected flows with respect to the Goodies Beach outlet and select environmental conditions.

Table 4: Seasonal and Storm Event Flows and Volumes

GOODIES ADJACENT OUTFALL FLOWS AND VOLUMES			
	Flow (CFS)	Flow (GPM)	Total Volume (gallons)
Mean Seasonal (June to September)	0.04 (B)	17 (B)	2,200,043
Median Seasonal (June to September)	0.02 (B)	9 (B)	1,148,031
1" of Precipitation over 24 hours	3.5 (P)	1,566 (P)	146,307
1-Year (2.6")	28 (P)	12,635 (P)	1,010,138
2-Year (3.2")	39 (P)	17,500 (P)	1,402,789
5-Year (3.9")	52 (P)	23,330 (P)	1,882,115
10-Year (4.6")	65 (P)	29,241 (P)	2,376,757
25-Year (5.7")	86 (P)	38,577 (P)	3,173,789

(B) = Base Flow Rate, (P) = Event Peak Flow Rate

Table 5: Monthly Mean Flows and Volumes from June through August

GOODIES ADJACENT STORMWATER OUTLET MONTHLY AND SEASONAL FLOWS AND VOLUMES					
Month	Mean CFS	Mean GPM	Total Cubic Feet Per Month	Total Gallons Per Month	Accumulative Gallons
June	0.065	29.2	168,412	1,259,805	1,259,805
July	0.023	10.4	62,217	465,418	1,725,223
August	0.017	7.6	45,443	339,939	2,065,162

Table 6: Stormwater Runoff Cumulative Volume

DRAINAGE AREA	A1 - Wetlands	A2 - Amsbury Hill	Total	Units
1" PRECIPITATION RUNOFF VOLUME	0.344	0.105	0.449	acre-feet
	14,985	4,574	19,558	cubic feet
	112,093	34,214	146,307	gallons

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APPLICABLE TREATMENT OPTIONS & RECOMMENDATIONS

The Conservation Commission reported that, at a November 24, 2014 workshop with the select board, the issue of exceedances at Goodies Beach was discussed and a range of options were identified as:

Take no action and continue posting advisories

Relocate the outfall to deeper water

Collect and treat runoff as sewage

Treat runoff onsite

Treat runoff offsite

Simply posting advisories was not pursued, as the Town has engaged in more sanitary surveys, public education and outreach to reduce pollutants. This proactive stance includes the further studies undertaken by Maine Healthy Beaches, the Conservation Commission and commissioning this report. Of interest, the option to extend the point of discharge into the harbor can serve as a ground-truthing measure to determine the potential efficacy of applying measures to this outfall. Considering the sewer connection option, treating any substantial fraction of runoff from the outfall is problematic from a regulatory issue and cost perspective. Available pumping capacities at the Marine Park (95 GPM, intermittent service) and at the Harbor View (150 GPM) pump stations are inadequate for any diverted storm event, or even any consequential fraction thereof. Treatment of stormwater offsite is problematic in that additional land is needed, as is infrastructure to pump. Those associated capital costs are added to the treatment cost. As a gravity flow plan and Town owned land are available, the onsite treatment option is preferable. Treatment can be implemented by utilizing available Town land, while maintaining gravity flow. With sedimentation and filtration requiring additional measures, disinfection was selected for further analysis.

Owing to environmental considerations, chemical dependent disinfection systems such as chlorination/dechlorinating are not suitable for this application. Constituents in surface waters, such as organic compounds, can react with a chemical disinfectant. The daughter products of such reactions could be more harmful to humans and the ecosystem than the bacteria eliminated. As depicted in Table 7, Ozonation and Ultraviolet light (UV) disinfection systems do not introduce by-product issues and are capable of maintaining two to four log removals in a single unit process. Treatment options are tabulated in Table 7. Stormwater treatment BMPs are generally focused on solids, nutrients, and gross pollutants such as oils. Nationwide studies indicate relatively low efficacy for removing bacteria by use of conventional BMPs like wetponds and swales. Sedimentation, filtration and disinfection are methods applicable to eliminating Enterococci and other microorganisms from surface waters. In order to achieve and maintain 99% to 99.9% removal of Enterococci, additional unit processes would be required for the currently available sedimentation or filtration stormwater treatment BMPs.

Ozone is often used in water treatment to control taste and odor issues while obtaining a treatment objective. Ozonation has also been applied to industrial runoff for quality issues. Ozonators create Ozone (O_3) by applying an electrical current to Oxygen in the atmosphere and bubbling the resultant O_3 gas through the water column. The inherent instability of O_3 in these environmental conditions makes it react rapidly and oxidize chemical compounds and microorganisms alike. The oxidation processes within Ozonation require sufficient mixing and sufficient contact times to obtain targeted treatment levels for a given source water characteristics.

UV reactors disinfect water by imparting electromagnetic radiation at a wavelength between 100 and 400 nanometers to sufficiently high enough energy levels to break chemical bonds of the target microorganism's DNA. With ruptured DNA molecules, the organisms are no longer capable of procreation. As such, the process is often termed inactivation. UV reactors are capable of delivering 99-99.9% inactivation of Enterococci in surface waters and do not present the same level of residual water quality problems as chemical disinfection systems. UV has a proven track record for disinfecting stormwater, among many applications.

Table 7: Stormwater Treatment Options

Treatment Option	Field Validated to Maintain Required Removal	Advantages	Disadvantages
Sedimentation	No	Simple process with low energy and O&M requirements. Reduces TSS.	Not capable of achieving treatment objective.
BMP Filters	No	Simple process with low energy and O&M requirements. Reduces turbidity, TSS, pathogens.	Not proven to effectively remove pathogens.
Chemical Disinfection	Yes	Simple proven process with low energy requirements.	Chemical dependent. Chemical residuals and disinfection byproducts could be more harmful to children than the Enterococci killed. Housing structure and skilled operator required.
UV Disinfection	Yes	Proven process capable of inactivating pathogenic microorganisms in stormwater systems.	Energy intensive, UV bulbs contain Mercury and require maintenance. No removal of contaminants achieved. Housing structure and skilled operator required.
Ozonation	Yes	Proven process with moderate energy and O&M costs. Breaks down complex molecules and oxidizes pathogens.	Energy intensive, housing structure and skilled operator required. Ozone presents a possible public perception problem. Oxidation of tertiary constituents may inhibit efficacy. Required contact time raises capital cost for storm event flows

To further assess treatment viability, an economic analysis was performed for two TrojanUV units capable of two and four log (99 & 99.99%) removal of Enterococci during base flow conditions (Trojan 3600K and 3001M) and one unit capable of 99% removal during base flows and up to a 1" rainfall event (Trojan 3000B). Depicted in Table 9, the anticipated construction costs for a UV disinfection system in 2018 for this project range from approximately $175,000 to $250,000, respectively. This cost range between treating just the base flows versus base flows and up to 1” of rain indicates water quality prior to treatment should be improved. treatment requirements should be minimized. Measures to reduce/remove Enterococci sources in this watershed will produce benefits if treatment is implemented. Operation and maintenance costs including operator time will be additional.

Table 8: Economic Estimates for UV Treatment Units

ECONOMIC ESTIMATES FOR UV TREATMENT SYSTEMS			
UV unit	Trojan 3600K	Trojan 3001M	Trojan 3000B
log removal	2	4	2
Design Flow Range	Base Flow	Base Flow	Up to 1" of Precipitation
Assumed design life (years)	25	25	25
Average inflation rate per design life	2.5%	2.5%	2.5%
Days in Season	92	92	92
Percent in operation	95%	95%	95%
Number of lamps	48	80	128
watts/lamp	87.5	87.5	87.5
kW/Unit	4.2	7	11.2
Capital cost of UV Reactor (2018)	$73,400	$103,100	$140,000
Capital cost of lamps (when replaced)	$2,500	$4,100	$6,500
2016 $/kWh Electricity Rate*	$0.145	$0.145	$0.145
Electricity cost (2018 season)*	$1,350	$2,240	$3,590
Estimated Life Cycle Electricity Costs*	$46,200	$77,000	$123,100
Capital cost of Treatment Building (2016)	$54,000	$54,000	$97,200
Capital cost of treatment building (2018)	$60,000	$60,000	$110,000
Life cycle maintenance cost of treatment building**	$97,600	$97,600	$175,600
Estimated cost of site work (2018)	$26,000	$26,000	$26,000
Estimated Total Construction Cost (2018)	**$160,000**	**$190,000**	**$276,000**
10% Contingency	**$16,000**	**$19,000**	**$28,000**
Total Estimated Construction Cost (2018)	**$176,000**	**$209,000**	**$304,000**
*Electricity estimates do not account for service fees and other miscellaneous charges. **Annual maintenance cost of treatment building is 5% of capital subject to average inflation rate per year.			

PERMITTING:
Municipal review and permitting would be necessary for activities related to treatment facility construction. (Town of Rockport Land Use Ordinance review and MUBEC Code review). The Maine Department of Environmental Protection was consulted and determined that UV treatment of stormwater does not require permits or licenses.

TOWN OF ROCKPORT
GOODIES BEACH – STORMWATER TREATMENT FEASIBILITY STUDY
CONCLUSIONS & NEXT STEP RECOMMENDATIONS

Rockport has taken an aggressive approach to improving water quality and should continue to do so. The extent of dry weather exceedances and lack of relationship between the quantity of precipitation and Enterococci levels at Goodies Beach indicate surface water base flows, wildlife, dogs, organics on the beach, and human activities (such as boating) are components that add microbiological contamination. Large storm events are not specifically indicated. Treatment of base flow and first flush by UV is technically feasible. Correlation between the adjacent outfall pipe and Goodies Beach Enterococci levels suggest a modest efficacy of treatment as other sources of contamination have been identified. Coupled with the cost of treatment, these findings suggest additional steps are warranted before implementing treatment.

To actively improve the inner harbor water quality in general, we recommend considering the following prior to implementing treatment:

- Perform water quality assessments for the Goose River, Ells Brook, and remaining inner harbor drainage areas. Assess the Enterococci source of previously identified hot spots as observed by the Conservation Commission (such as the Winter Street ditch), and implement housekeeping and public education.

- Increase street sweeping schedule, vacuum catch basins at least every spring and keep storm drains clean and clear of debris within the inner harbor drainage area.

- Increase beach maintenance efforts by raking and removing seaweed from the beach, keeping the beach clean and clear of organics.

- Provide and maintain additional pet waste receptacles with 'mutt mitts' in the harbor watersheds, inclusive of streets. Expand receptacles (particularly at the open wetland and collection system) within the adjacent outfall's drainage area.

- Consider a policy prohibiting dogs on the beach during the beachgoing season (June to September).

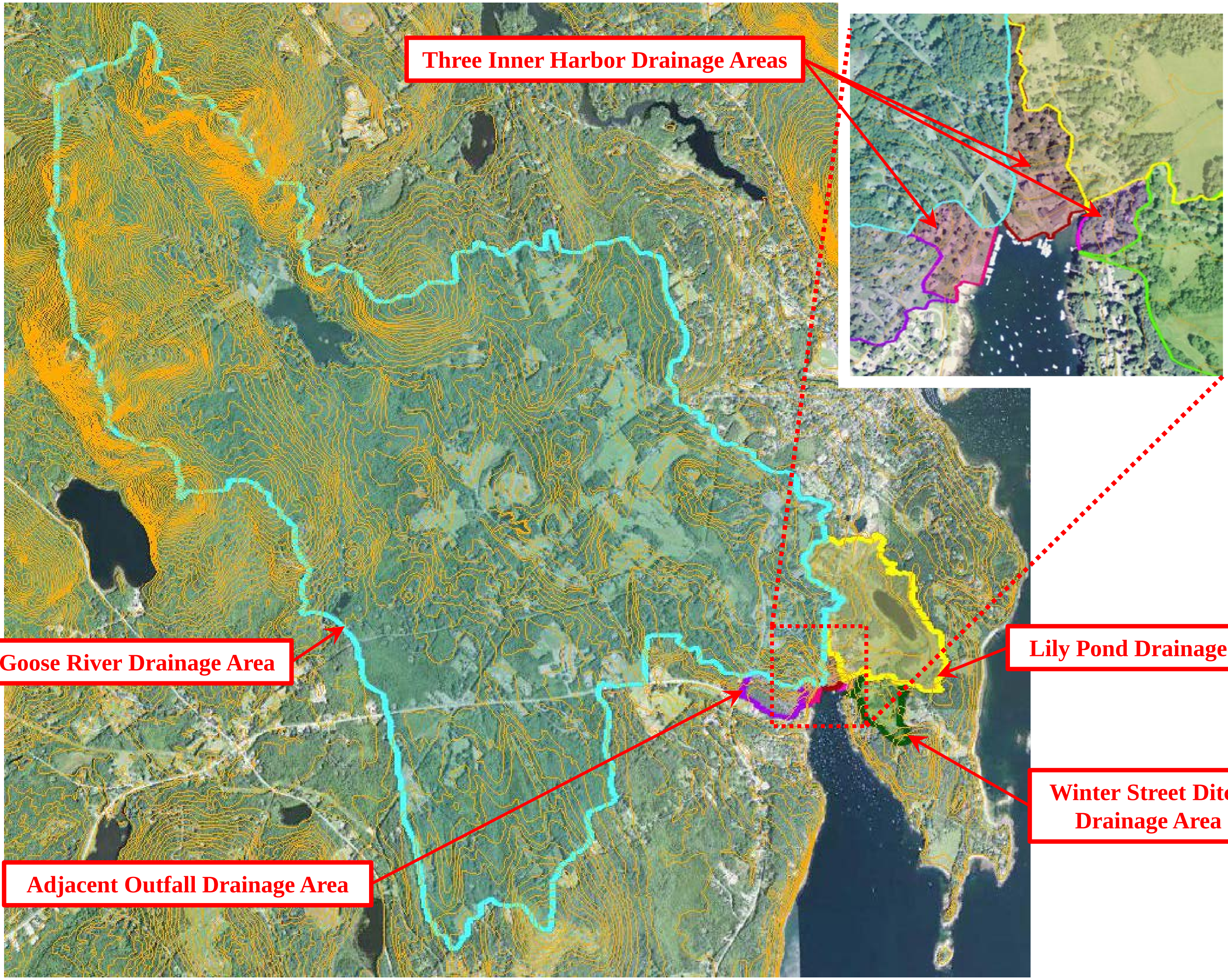
- Continue public education on water quality issues and good housekeeping techniques.

- Implement an educational component to harbor interactions such as boat registration, taxes and mooring transactions.

- Sample all water quality monitoring locations in the same tide stage of the same day and environmental conditions, and refine the inner harbor mass balance.

- As a single season experiment, or as determined practical, extend the outfall ±500’ to the middle of the harbor and monitor at an increased schedule. Should an extension be implemented, permitting with Maine DEP, U.S. Army Corps of Engineers and Maine DOC will be required.

APPENDICES



Aerial Images Courtesy of Google Earth Pro

G&D

AERIAL OF INNER HARBOR DRAINAGE AREAS

ROCKPORT, MAINE

OCTOBER, 2016 | PROJ. NO 2016-083 | GOODIES BEACH

PICTURE 1
(Taken: April 16, 2016)

PICTURE 2
(Taken: April 15, 2016)

Gartley & Dorsky
ENGINEERING SURVEYING
59B Union Street P.O. Box 1031 Camden, ME 04843-1031
Ph. (207) 236-4365 Fax (207) 236-3055 Toll Free 1-888-282-4365
165 Main Street Suite 2F P.O. Box 1072 Damariscotta, ME 04543
Ph. (207) 790-5005

EXISTING CONDITIONS PHOTOGRAPHS
ROCKPORT, MAINE

OCTOBER, 2016 PROJ. NO 2016-083 GOODIES BEACH

PICTURE 3
(Taken: April 15, 2016)

PICTURE 4
(Taken: April 15, 2016)

Gartley & Dorsky
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EXISTING CONDITIONS PHOTOGRAPHS

ROCKPORT, MAINE

OCTOBER, 2016 | PROJ. NO 2016-083 | GOODIES BEACH

PICTURE 5
(Taken: June 14, 2016)

PICTURE 6
(Taken: June 14, 2016)

Gartley & Dorsky
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EXISTING CONDITIONS PHOTOGRAPHS
ROCKPORT, MAINE

OCTOBER, 2016 PROJ. NO 2016-083 GOODIES BEACH

PICTURE 7
(Taken: June 14, 2016)

PICTURE 8
(Taken: June 14, 2016)

Gartley & Dorsky
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EXISTING CONDITIONS PHOTOGRAPHS
ROCKPORT, MAINE

OCTOBER, 2016 PROJ. NO 2016-083 GOODIES BEACH

PICTURE 9
(Taken: June 14, 2016)

PICTURE 10
(Taken: June 14, 2016)

Gartley & Dorsky
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EXISTING CONDITIONS PHOTOGRAPHS
ROCKPORT, MAINE

OCTOBER, 2016	PROJ. NO 2016-083	GOODIES BEACH

PICTURE 11
(Taken: June 28, 2016)

PICTURE 12
(Taken: June 28, 2016)

Gartley & Dorsky
ENGINEERING SURVEYING
59B Union Street P.O. Box 1031 Camden, ME 04843-1031
Ph. (207) 236-4365 Fax (207) 236-3055 Toll Free 1-888-282-4365
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EXISTING CONDITIONS PHOTOGRAPHS
ROCKPORT, MAINE

OCTOBER, 2016 PROJ. NO 2016-083 GOODIES BEACH

TOWN OF ROCKPORT
GOODIES BEACH – STORMWATER TREATMENT FEASIBILITY
MAINE HEALTHY BEACHES RISK ASSESSMENT MATRICES

MAINE HEALTHY BEACHES IMPACT GUIDELINES FOR POTENTIAL AND ACTUAL SOURCES OF CONTAMINATION ADJACENT TO THE BEACH, A STREAM THAT EMPTIES WITHIN A MILE OF THE BEACH, OR DRAINS DIRECTLY TO THE BEACH*				
Inventory Items	Points Awarded per Item Inventoried	Initial Estimation	Points	% Contribution
Land Drain	1	Unknown		
Farm/Kennel		Unknown		
Roof Gutter Drain		Unknown		
Grey Water Drain		Unknown		
Uninspected Subsurface Waste Water Disposal System	3	Unknown		
Intermittent Stream Flow	5	5	25	22%
Waterbody on the 303d list with bacteria	10	0	0	
Waterbody with a TMDL study for bacteria		0	0	
Marina	15	1	15	13%
Mooring Field		1	15	13%
Stormwater Pipe or Drain		1	15	13%
Stream flows (not related to rain event)		3	45	39%
Malfunctioning Subsurface Wastewater Disposal System		0	0	
Overboard Discharge Unit		0	0	
Illegal Straight Pipe	25	0	0	
Combined Sewer Overflow (CSO)		Unknown		
Waste Water Treatment Plant Outfall (within 1 mile of beach)		0	0	

*Protocol prior to 2016.

MAINE HEALTHY BEACHES IMPACT GUIDELINES FOR INFRASTRUCTURE ASSESSMENT & INVENTORY ADJACENT TO THE BEACH, A STREAM THAT EMPTIES WITHIN A MILE OF THE BEACH, OR DRAINS DIRECTLY TO THE BEACH*				
Inventory Items	Points Awarded per Item Inventoried	Initial Estimation	Points	% Contribution
Wastewater Treatment Plant Outfall	25	0	0	0%
Sewer System		Yes	0	0%
20+ year old Subsurface Wastewater Systems		Unknown	--	--
Combined Sewer Overflows		Unknown	--	--
Marina or Mooring Field		2	50	17%
Rivers or Streams		3	75	25%
Public Bathrooms		Yes	0	0%
Rivers or Streams on 303d list for Bacteria	15	0	0	0%
Stormwater Drains or Pipes		5	75	25%
More than a Small Amount of Seaweed Accumulate on Beach		Yes	15	5%
Intermittent Streams or Flows Related to Rain Only	10	2	20	7%
Domestic Animal Farms, Hobby Farms/Kennels		1	10	3%
Marsh and Wildlife Areas/Preserves		N/A	0	0%
Marsh Draining to Beach		N/A	0	0%
Compost Operations or Farms that Spread Manure		1	10	3%
Dogs Allowed on Beach (May-September)		1	10	3%
Large Number of Waterfowl Regularly Present		No	0	0%
Crescent Shaped Beach		No	0	0%
Onshore Prevailing Winds		Yes	10	3%
Tidal Flushing Partially Restricted		Yes	10	3%
Average >50,000 visitors/500ft of beach (July-August)		No	0	0%
Average 20,000 to 50,000 visitors/500ft of beach (July-August)	5	No	0	0%
Paved Parking Lots Located within 100 ft of Beach		1	5	2%
Tide Pools on Beach		No	0	0%
Average 10,000 to 20,000 visitors/500ft of beach (July-August)	3	No	0	0%
Trash Cans on Beach		Yes	0	0%
How Many Paved Roads within 500' of Beach	2	4	8	3%

*Current Protocol

TOWN OF ROCKPORT
GOODIES BEACH – STORMWATER TREATMENT FEASIBILITY STUDY
DATES AND ENTEROCOCCI LEVELS (MPN/100mL) REPORTED IN FIGURES 4 & 5

DATE	Outlet @ Beach or Inlet @ Beach Enterococci (MPN/100mL)	Goodies Beach Enterococci (MPN/100mL)
6/17/2010	259	119
6/29/2010	669	816
7/13/2010	479	272
6/15/2011	210	63
6/21/2011	121	52
7/5/2011	52	31
8/22/2011	2603	1670
8/24/2011	171	31
5/17/2012	160	121
5/29/2012	860	1850
5/30/2012	738	583
6/5/2012	97	1267
6/12/2012	63	41
6/19/2012	20	30
6/26/2012	11199	19863
6/27/2012	487	1631
7/3/2012	269	20
*7/17/2012	24200	5
7/24/2012	262	213
8/21/2012	256	110
*8/28/2012	24190	108
9/4/2012	201	5
6/4/2013	40	5
6/11/2013	1850	246
7/2/2013	5790	327

*Observations were removed as outliers per R. Kennedy.

Map Scale: 1:5,170 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0, 50, 100, 200, 300

Feet: 0, 250, 500, 1000, 1500

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 19N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Knox and Lincoln Counties, Maine
Survey Area Data: Version 15, Sep 15, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 17, 2010—Aug 31, 2010

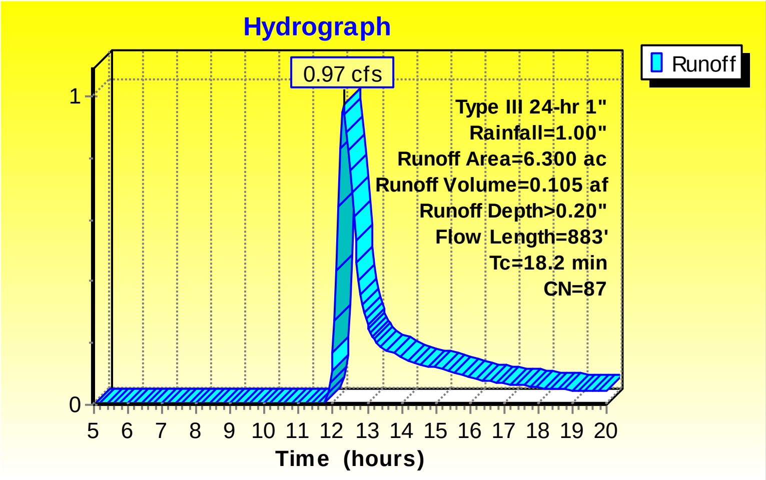
The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Knox and Lincoln Counties, Maine (ME601)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
Bg	Biddeford mucky peat, 0 to 3 percent slopes	6.8	5.3%
BoC	Boothbay silt loam, 8 to 15 percent slopes	0.0	0.0%
Dp	Dumps-Pits complex	1.1	0.9%
EgB	Eldridge fine sandy loam, 3 to 8 percent slopes	7.9	6.1%
LmB	Lyman-Brayton variant-Rock outcrop complex, 0 to 8 percent slopes	0.3	0.2%
LrC	Lyman-Rock outcrop-Tunbridge complex, 8 to 15 percent slopes	39.1	30.4%
RmC	Rock outcrop-Lyman complex, 3 to 15 percent slopes	3.5	2.8%
Sw	Swanville silt loam, 0 to 3 percent slopes	28.7	22.3%
TrC	Tunbridge-Lyman complex, 8 to 15 percent slopes, rocky	9.2	7.1%
Ud	Udorthents-Urban land complex	16.1	12.5%
W	Water bodies	15.9	12.4%
Totals for Area of Interest		**128.5**	**100.0%**

TOWN OF ROCKPORT
GOODIES BEACH – STORMWATER TREATMENT FEASIBILITY
HYDROCAD OUTPUTS

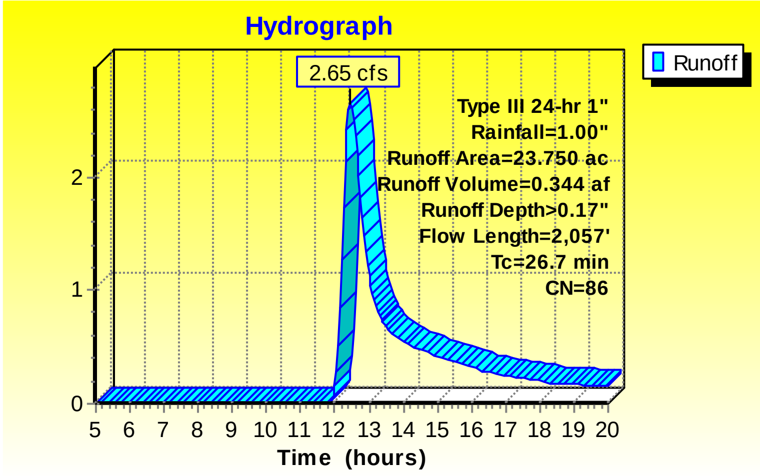
AMSBURY HILL 1" EVENT:



Hydrograph for Subcatchment 3: AMSBURY HILL

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
5.00	0.06	0.00	0.00
5.50	0.06	0.00	0.00
6.00	0.07	0.00	0.00
6.50	0.08	0.00	0.00
7.00	0.09	0.00	0.00
7.50	0.10	0.00	0.00
8.00	0.11	0.00	0.00
8.50	0.13	0.00	0.00
9.00	0.15	0.00	0.00
9.50	0.17	0.00	0.00
10.00	0.19	0.00	0.00
10.50	0.22	0.00	0.00
11.00	0.25	0.00	0.00
11.50	0.30	0.00	0.00
12.00	0.50	0.02	0.17
12.50	0.70	0.09	0.76
13.00	0.75	0.10	0.26
13.50	0.78	0.12	0.18
14.00	0.81	0.13	0.15
14.50	0.83	0.14	0.13
15.00	0.85	0.15	0.12
15.50	0.87	0.16	0.10
16.00	0.89	0.17	0.09
16.50	0.90	0.17	0.08
17.00	0.91	0.18	0.07
17.50	0.92	0.18	0.06
18.00	0.93	0.19	0.06
18.50	0.94	0.19	0.05
19.00	0.94	0.19	0.05
19.50	0.95	0.20	0.05
20.00	0.96	0.20	0.04

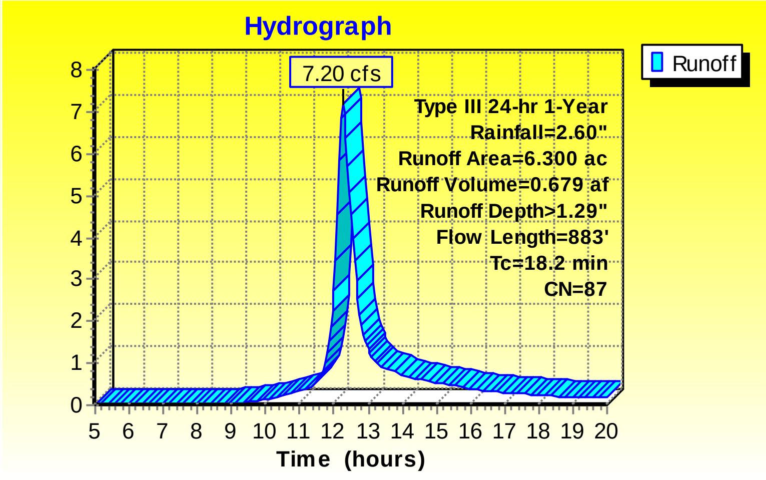
WETLANDS 1" EVENT:



Hydrograph for Subcatchment 4: A1 - Wetlands

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
5.00	0.06	0.00	0.00
5.50	0.06	0.00	0.00
6.00	0.07	0.00	0.00
6.50	0.08	0.00	0.00
7.00	0.09	0.00	0.00
7.50	0.10	0.00	0.00
8.00	0.11	0.00	0.00
8.50	0.13	0.00	0.00
9.00	0.15	0.00	0.00
9.50	0.17	0.00	0.00
10.00	0.19	0.00	0.00
10.50	0.22	0.00	0.00
11.00	0.25	0.00	0.00
11.50	0.30	0.00	0.00
12.00	0.50	0.02	0.15
12.50	0.70	0.07	2.62
13.00	0.75	0.09	1.13
13.50	0.78	0.10	0.67
14.00	0.81	0.11	0.56
14.50	0.83	0.12	0.47
15.00	0.85	0.13	0.43
15.50	0.87	0.14	0.38
16.00	0.89	0.14	0.32
16.50	0.90	0.15	0.28
17.00	0.91	0.15	0.25
17.50	0.92	0.16	0.23
18.00	0.93	0.16	0.20
18.50	0.94	0.17	0.18
19.00	0.94	0.17	0.17
19.50	0.95	0.17	0.16
20.00	0.96	0.18	0.16

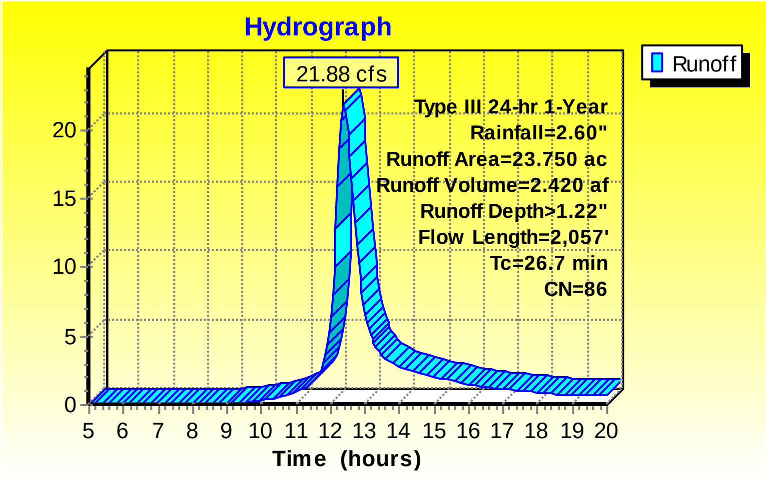
AMSBURY HILL 1-YEAR EVENT:



Hydrograph for Subcatchment 3: AMSBURY HILL

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
5.00	0.15	0.00	0.00
5.50	0.17	0.00	0.00
6.00	0.19	0.00	0.00
6.50	0.21	0.00	0.00
7.00	0.24	0.00	0.00
7.50	0.26	0.00	0.00
8.00	0.30	0.00	0.00
8.50	0.33	0.00	0.01
9.00	0.38	0.00	0.04
9.50	0.43	0.01	0.08
10.00	0.49	0.02	0.14
10.50	0.56	0.04	0.22
11.00	0.65	0.07	0.34
11.50	0.77	0.11	0.59
12.00	1.30	0.40	2.75
12.50	1.83	0.77	4.54
13.00	1.95	0.87	1.33
13.50	2.04	0.93	0.88
14.00	2.11	0.99	0.73
14.50	2.17	1.04	0.61
15.00	2.22	1.08	0.54
15.50	2.27	1.12	0.47
16.00	2.30	1.15	0.39
16.50	2.34	1.17	0.34
17.00	2.36	1.20	0.30
17.50	2.39	1.22	0.27
18.00	2.41	1.24	0.24
18.50	2.43	1.26	0.22
19.00	2.45	1.27	0.20
19.50	2.47	1.29	0.19
20.00	2.49	1.30	0.18

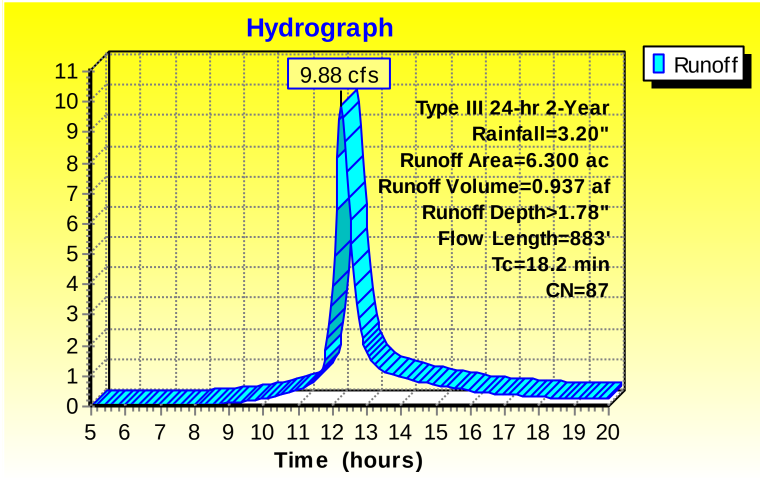
WETLANDS 1-YEAR EVENT:



Hydrograph for Subcatchment 4: A1 - Wetlands

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
5.00	0.15	0.00	0.00
5.50	0.17	0.00	0.00
6.00	0.19	0.00	0.00
6.50	0.21	0.00	0.00
7.00	0.24	0.00	0.00
7.50	0.26	0.00	0.00
8.00	0.30	0.00	0.00
8.50	0.33	0.00	0.00
9.00	0.38	0.00	0.05
9.50	0.43	0.01	0.18
10.00	0.49	0.02	0.36
10.50	0.56	0.03	0.61
11.00	0.65	0.05	0.99
11.50	0.77	0.10	1.69
12.00	1.30	0.36	6.45
12.50	1.83	0.72	19.73
13.00	1.95	0.81	6.59
13.50	2.04	0.88	3.54
14.00	2.11	0.93	2.81
14.50	2.17	0.98	2.34
15.00	2.22	1.02	2.06
15.50	2.27	1.06	1.79
16.00	2.30	1.09	1.52
16.50	2.34	1.11	1.28
17.00	2.36	1.13	1.15
17.50	2.39	1.15	1.03
18.00	2.41	1.17	0.91
18.50	2.43	1.19	0.81
19.00	2.45	1.20	0.76
19.50	2.47	1.22	0.73
20.00	2.49	1.23	0.69

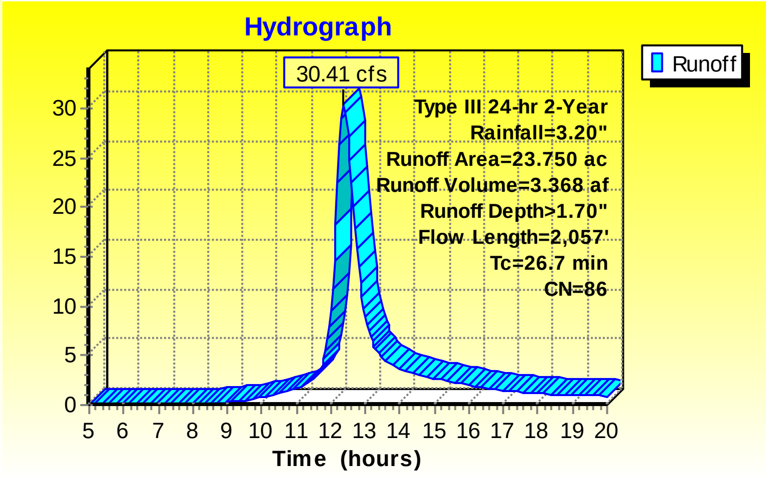
AMSBURY 2-YEAR EVENT:



Hydrograph for Subcatchment 3: AMSBURY HILL

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
5.00	0.18	0.00	0.00
5.50	0.21	0.00	0.00
6.00	0.23	0.00	0.00
6.50	0.26	0.00	0.00
7.00	0.29	0.00	0.00
7.50	0.33	0.00	0.00
8.00	0.36	0.00	0.03
8.50	0.41	0.01	0.06
9.00	0.47	0.02	0.11
9.50	0.53	0.03	0.18
10.00	0.60	0.05	0.26
10.50	0.69	0.08	0.37
11.00	0.80	0.13	0.54
11.50	0.95	0.20	0.90
12.00	1.60	0.61	3.94
12.50	2.25	1.10	6.10
13.00	2.40	1.23	1.75
13.50	2.51	1.32	1.15
14.00	2.60	1.39	0.95
14.50	2.67	1.45	0.80
15.00	2.73	1.51	0.71
15.50	2.79	1.56	0.61
16.00	2.84	1.60	0.51
16.50	2.87	1.63	0.44
17.00	2.91	1.66	0.39
17.50	2.94	1.69	0.35
18.00	2.97	1.71	0.31
18.50	2.99	1.73	0.28
19.00	3.02	1.76	0.26
19.50	3.04	1.77	0.25
20.00	3.06	1.79	0.24

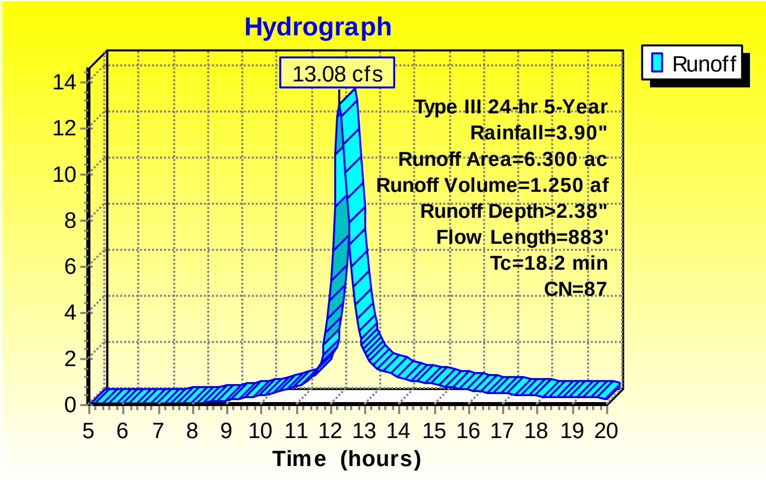
WETLANDS 2-YEAR EVENT:



Hydrograph for Subcatchment 4: A1 - Wetlands

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
5.00	0.18	0.00	0.00
5.50	0.21	0.00	0.00
6.00	0.23	0.00	0.00
6.50	0.26	0.00	0.00
7.00	0.29	0.00	0.00
7.50	0.33	0.00	0.00
8.00	0.36	0.00	0.02
8.50	0.41	0.00	0.12
9.00	0.47	0.01	0.27
9.50	0.53	0.02	0.49
10.00	0.60	0.04	0.76
10.50	0.69	0.07	1.12
11.00	0.80	0.11	1.68
11.50	0.95	0.17	2.69
12.00	1.60	0.56	9.56
12.50	2.25	1.04	27.09
13.00	2.40	1.16	8.83
13.50	2.51	1.25	4.69
14.00	2.60	1.32	3.70
14.50	2.67	1.38	3.08
15.00	2.73	1.44	2.70
15.50	2.79	1.48	2.34
16.00	2.84	1.52	1.98
16.50	2.87	1.56	1.68
17.00	2.91	1.59	1.50
17.50	2.94	1.61	1.34
18.00	2.97	1.64	1.18
18.50	2.99	1.66	1.05
19.00	3.02	1.68	0.99
19.50	3.04	1.70	0.95
20.00	3.06	1.72	0.90

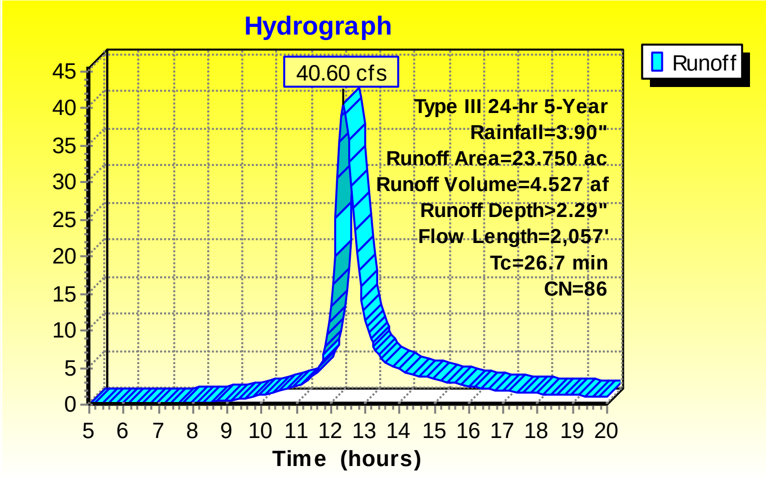
AMSBURY 5-YEAR EVENT:



Hydrograph for Subcatchment 3: AMSBURY HILL

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
5.00	0.22	0.00	0.00
5.50	0.25	0.00	0.00
6.00	0.28	0.00	0.00
6.50	0.31	0.00	0.00
7.00	0.35	0.00	0.02
7.50	0.40	0.01	0.05
8.00	0.44	0.01	0.09
8.50	0.50	0.02	0.14
9.00	0.57	0.04	0.21
9.50	0.65	0.07	0.31
10.00	0.74	0.10	0.42
10.50	0.84	0.15	0.58
11.00	0.98	0.21	0.81
11.50	1.16	0.32	1.30
12.00	1.95	0.87	5.40
12.50	2.74	1.51	7.93
13.00	2.92	1.67	2.25
13.50	3.06	1.79	1.48
14.00	3.16	1.88	1.21
14.50	3.25	1.96	1.02
15.00	3.33	2.03	0.90
15.50	3.40	2.09	0.77
16.00	3.46	2.14	0.65
16.50	3.50	2.19	0.56
17.00	3.55	2.22	0.50
17.50	3.59	2.26	0.44
18.00	3.62	2.29	0.39
18.50	3.65	2.32	0.35
19.00	3.68	2.34	0.33
19.50	3.71	2.37	0.32
20.00	3.73	2.39	0.30

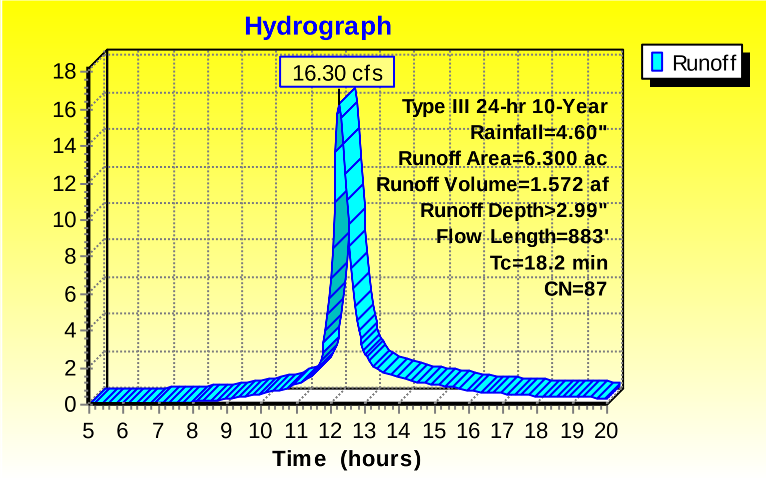
WETLANDS 5-YEAR EVENT:



Hydrograph for Subcatchment 4: A1 - Wetlands

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
5.00	0.22	0.00	0.00
5.50	0.25	0.00	0.00
6.00	0.28	0.00	0.00
6.50	0.31	0.00	0.00
7.00	0.35	0.00	0.01
7.50	0.40	0.00	0.09
8.00	0.44	0.01	0.20
8.50	0.50	0.02	0.36
9.00	0.57	0.03	0.60
9.50	0.65	0.05	0.92
10.00	0.74	0.08	1.30
10.50	0.84	0.13	1.81
11.00	0.98	0.19	2.58
11.50	1.16	0.28	3.97
12.00	1.95	0.81	13.40
12.50	2.74	1.44	35.84
13.00	2.92	1.60	11.46
13.50	3.06	1.71	6.03
14.00	3.16	1.80	4.75
14.50	3.25	1.88	3.94
15.00	3.33	1.95	3.45
15.50	3.40	2.01	2.99
16.00	3.46	2.06	2.53
16.50	3.50	2.10	2.13
17.00	3.55	2.14	1.91
17.50	3.59	2.17	1.70
18.00	3.62	2.20	1.50
18.50	3.65	2.23	1.33
19.00	3.68	2.26	1.26
19.50	3.71	2.28	1.20
20.00	3.73	2.31	1.14

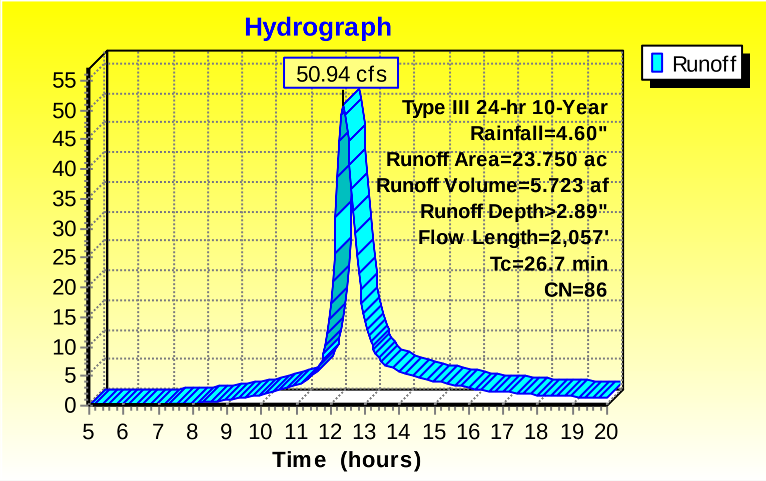
AMSBURY 10-YEAR EVENT:



Hydrograph for Subcatchment 3: AMSBURY HILL

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
5.00	0.26	0.00	0.00
5.50	0.30	0.00	0.00
6.00	0.33	0.00	0.01
6.50	0.37	0.00	0.03
7.00	0.42	0.01	0.06
7.50	0.47	0.02	0.11
8.00	0.52	0.03	0.16
8.50	0.59	0.05	0.22
9.00	0.67	0.07	0.33
9.50	0.76	0.11	0.45
10.00	0.87	0.16	0.59
10.50	1.00	0.22	0.80
11.00	1.15	0.31	1.09
11.50	1.37	0.45	1.71
12.00	2.30	1.15	6.90
12.50	3.23	1.94	9.77
13.00	3.45	2.14	2.75
13.50	3.60	2.28	1.80
14.00	3.73	2.39	1.47
14.50	3.84	2.49	1.24
15.00	3.93	2.57	1.09
15.50	4.01	2.65	0.94
16.00	4.08	2.71	0.78
16.50	4.13	2.76	0.67
17.00	4.18	2.81	0.60
17.50	4.23	2.85	0.54
18.00	4.27	2.88	0.47
18.50	4.30	2.92	0.42
19.00	4.34	2.95	0.40
19.50	4.37	2.98	0.38
20.00	4.40	3.01	0.36

WETLANDS 10-YEAR EVENT:



Hydrograph for Subcatchment 4: A1 - Wetlands

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
5.00	0.26	0.00	0.00
5.50	0.30	0.00	0.00
6.00	0.33	0.00	0.00
6.50	0.37	0.00	0.03
7.00	0.42	0.00	0.13
7.50	0.47	0.01	0.27
8.00	0.52	0.02	0.43
8.50	0.59	0.04	0.65
9.00	0.67	0.06	0.98
9.50	0.76	0.09	1.40
10.00	0.87	0.14	1.90
10.50	1.00	0.20	2.56
11.00	1.15	0.28	3.55
11.50	1.37	0.41	5.33
12.00	2.30	1.08	17.37
12.50	3.23	1.86	44.67
13.00	3.45	2.05	14.10
13.50	3.60	2.19	7.38
14.00	3.73	2.30	5.79
14.50	3.84	2.40	4.79
15.00	3.93	2.48	4.19
15.50	4.01	2.55	3.63
16.00	4.08	2.61	3.07
16.50	4.13	2.67	2.59
17.00	4.18	2.71	2.32
17.50	4.23	2.75	2.07
18.00	4.27	2.79	1.82
18.50	4.30	2.82	1.62
19.00	4.34	2.86	1.53
19.50	4.37	2.89	1.45
20.00	4.40	2.91	1.38

TOWN OF ROCKPORT
GOODIES BEACH – STORMWATER TREATMENT FEASIBILITY
WATER QUALITY RESULTS

University of New Hampshire - Water Treatment Technology Assistance Center (WTTAC)											
Total Suspended Solids (TSS)											
Town of Rockport - Goodies Beach											
Subsample I.D.	**Initial Weight**		**Final Weight**		**Difference (g)**	**Difference (mg)**	**x 1000**	/25 mL	mg/L		mg/L
A	17.3665	17.3666	17.3670	17.3672	**0.00055**	**0.55**	550	**22**	**22**		
	Average:	**17.36655**	Average:	**17.3671**						Average:	**20**
B	16.9767	16.9769	16.9772	16.9773							
	Average:	**16.9768**	Average:	**16.97725**	**0.00045**	**0.45**	450	**18**	**18**		
Note: Filters rinsed initially with 100 mL distilled water before being dried overnight.											
All samples filtered were followed by a 50 mL distilled water rinse											
25 mL were filtered for the sample analysis											

Sample I.D.	**pH**		**Turbidity (NTUs)**		**TSS (mg/L)**	**UV 254 mm (unfiltered)**		**UV Transmittance (unfiltered)**		**UV 254 mm (filtered)**		**Transmittance (filtered)**	
Area 1(Culvert 4) 06/14/16 [A]	7.66	7.66	4.1	4.26	--	0.468	0.468	0.340	0.340	0.459	0.460	0.348	0.347
Area 1(Culvert 4) 06/14/16 [A]	7.69	7.65	3.6	3.48	--	0.473	0.475	0.337	0.335	0.463	0.463	0.344	0.344
Area 2 (Culvert 3) 06/14/16 [A]	7.70	7.74	0.2	0.26	--	0.083	0.082	0.826	0.828	0.081	0.081	0.830	0.830
Area 2 (Culvert 3) 06/14/16 [B]	7.74	7.78	0.3	0.23	--	0.088	0.086	0.817	0.820	0.081	0.082	0.830	0.828
Adjacent Outlet 06/29/16 Storm Sample	6.55	6.54	17	16	20	0.368	0.369	0.429	0.428	0.334	0.334	0.463	0.463
Note: Samples filtered with Whatman/GE GF/C membrane, rinsed in RO water. Transmittance = 1/10^UV@254nm													

Id. Cedit
Bill

MAINE DRINKING WATER PROGRAM
TOTAL COLIFORM BACTERIA RESULTS

Water Test Results for the Month: June 29th **Year:** 2016

Public Water System Information	
System Name	Po 16-083
Sampler's Phone #	207-236-4365
PWSID #	N/A
Address	59 Union St. Camden
Sample Category (1)	~~Routine Compliance~~ O & M
Sampler's Name	Jeff Senders

Laboratory Information	
Laboratory's Name	**The Maine Water Company MIRROR LAKE LABORATORY**
Certification #	**ME 022**
Manager's Name	**Bill Gower**
Phone #	**207-236-8428**
Sample Received	Date/Time By

#	Sample Collection Point	Date & Time Sample was taken	Laboratory Sample ID#	Date & Time Sample was Run	ENTEROCOCCI Total Coliform Count (MPN/100ml)	E.Coli (MPN/100ml)	EPA Standard Method	Notes NEEDSTHIO
1	CULVERT	6/29/16 1:00		6/29/16 ML 0200	> ~~201~~ 2420		9223 B	
2	BEACH	6/29/16 1:00		↓	> ~~201~~ 2420			
3					ML 6/30/16 0215 ML 6/30/16			
4								
5								

I (we) understand that this report will be submitted to the Maine Drinking Water Program.

Sampler's Signature: [signature]

Laboratory Signature: [signature]

Customer:

WIMS: NA

MaineWater

LAB B

SAMPLE RECEIVED:

Date ________ #______

Time ________

By ________

NEED BILLING: Y N

Total *coliform* (MPN/100 ml) ______ } 18

e. coli (MPN/100 ml) ______ } 24

Nitrate –N (mg/L)	______
Nitrite –N (mg/L)	______
pH	______
Turbidity (NTU)	10.5
Cu (mg/L)	______
Fe (mg/L)	0.26
Mn (mg/L)	0.043
Hardness (mg/L)	______
Chloride (mg/L)	______
Fluoride (mg/L)	______

Iron related bacteria ______ Lot # _____ Analyzed _____ Read ______

Sulfur reducing bacteria ______ Lot # _____ Analyzed _____ Read ______

As ____ **Na** ____ **Rn** ____

Pb ____ **U** ____ **1st draw lead** ____

TSS = <0.1 ml/L

SAMPLES CAN ONLY BE ACCEPTED AT THE MAINE WATER COMPANY LAB
MONDAY THRU WEDNESDAY, 7:30AM - 4:30PM AND THURSDAY 7:30AM - 2:30PM **5681**
SAMPLES OVER 30 HOURS OLD CAN NOT BE ACCEPTED FOR ANALYSIS

For any questions, please call the Lab at 236-8428 or 800-287-1643

Date & Time Collected: ________

Collected from: ____ Faucet CULVERT Other

By: JEFF SENDERS

Source of sample: ___ Dug well ___ Drilled Well ___ Spring X Other

Has source been Chlorinated? ? ___ Yes ___ No

Test to be completed: ☐ Bacteria Other (Specify): TSS & NTUs

Results to: Jeff Senders, 59 UNION ST. #1, CAMDEN, ME 04843 Property Owner: —

Property address: —

Phone: 207-236-4365

e-mail: jsenders@gartleydorsky.com

SAMPLES CAN ONLY BE ACCEPTED AT THE MAINE WATER COMPANY LAB
MONDAY THRU WEDNESDAY, 7:30AM - 4:30PM AND THURSDAY 7:30AM - 2:30PM **5678**
SAMPLES OVER 30 HOURS OLD CAN NOT BE ACCEPTED FOR ANALYSIS

For any questions, please call the Lab at 236-8428 or 800-287-1643

Date & Time Collected: ________

Collected from: ____ Faucet CULVERT Other

By: JEFF SENDERS

Source of sample: ___ Dug well ___ Drilled Well ___ Spring X Other

Has source been Chlorinated? ? ___ Yes ___ No

Test to be completed: ☐ Bacteria X Other (Specify): IRON

Results to: Jeff Senders, 59 UNION ST. #1, CAMDEN, ME 04843 Property Owner: —

Property address: #16-083

Phone: 207-236-4365

e-mail: jsenders@gartleydorsky.com

Would you like results sent by e-mail? Y / N

Date & Time Collected: ________

Collected from: ____ Faucet CULVERT Other

By: JEFF SENDERS

Source of sample: ___ Dug well ___ Drilled Well ___ Spring X Other

Has source been Chlorinated? ? ___ Yes ___ No

Test to be completed: ☐ Bacteria X Other (Specify): MANGANESE

Results to: JEFF SENDERS, 59 UNION ST. #1, CAMDEN, ME 04843 Property Owner: —

Property address: —

Phone: 207-236-4365

e-mail: jsenders@gartleydorsky.com

Would you like results sent by e-mail? Y / N

TOWN OF ROCKPORT
GOODIES BEACH – STORMWATER TREATMENT FEASIBILITY
MASS BALANCE

Due to the lack of correlation between the target outlet levels and Goodies Beach Enterococci levels, mass balances were conducted on the inner harbor of Rockport to further assess treatment efficacy. As depicted in the attached Aerial of Inner Harbor Drainage Areas, watersheds were delineated for each of the Conservation Commission's sampling locations. The remaining inner harbor drainage areas were delineated from aerial images and iterated to a solution within the mass balance. The Goose River, Ells Brook, and Lily Pond watersheds were modeled using the United States Geological Survey (USGS) StreamStats Program.

The small drainage areas contributing surface water to the inner harbor are unsuitable to model flows from the USGS StreamStats Program. As a result, a relative size coefficient was applied using the adjacent Goose River, Ells Brook, and Lily Pond watersheds. Because there are no single dates where all locations of interest were sampled, the mass balances performed were limited to three observational events consisting of Enterococci levels recorded within a 48-hour period. In this screening, only one sample location is missing.

Back to back observations taken at Goodies Beach on five separate occasions from 2009 to 2016 enabled assessment of the day to day changes in Enterococci levels with no inputs from precipitation. These five sample sets, all coincidently taken in August, depict Goodies Beach has an average percent change in Enterococci from day to day of 68% (See Table A1). A more conservative day to day change (30%) in Enterococci levels at Goodies Beach was derived iteratively from the mass balance as discussed in the following paragraphs.

Table A1: Goodies Beach Back to Back Sampling Events

DATE	MPN/100mL	PERCENT CHANGE
8/20/2013	691	73%
8/21/2013	187	
8/1/2012	369	38%
8/2/2012	228	
8/2/2011	546	86%
8/3/2011	74	
8/10/2010	465	44%
8/11/2010	259	
8/4/2009	134	96%
8/5/2009	<10	
	Average:	68%

Of the three mass balances assessed, one provided a reasonable solution. Goose River (GR-2), Lily Pond (LPS-1), and Winter Street Ditch (WS-1) were sampled on June 18, 2012, while the ditch above Goodies Beach and Goodies Beach were sampled on June 19, 2012. Without significant prior precipitation events, flows used are the median June base flows according to USGS Streamstats delineations and outputs.

The Enterococci levels expected of the three Minor Drainage Areas were then treated as unknowns. Setting all three areas to the same concentration of Enterococci as one input closed the iteration within the mass balance to allow for a solution. The day to day change of Enterococci levels at Goodies Beach was iterated to 30%, which resulted in the remaining three drainage areas mimicking that of other sample locations (See Figure A1). Within the closed mass balance, Goodies Beach Enterococci levels were then scaled above 104 MPN/100mL standard, by applying a multiplier of 10 to the concentration of all sources, this factor is denoted as ‘coefficient’ in Figure A1. At these uniformly elevated levels of Enterococci, the raw concentration of the Goodies Beach outfall was assessed for significance as a factor in the beach water quality.

Treatment of the Goodies Beach outfall was simulated at two (99%) and four (99.99%) log removals. As depicted in Figure A1, the majority of surface water entering the inner harbor is from the Goose River, with Ells Brook a distant second. The outfall pipe adjacent to Goodies Beach contributes less than one percent (1%) of the surface water to the inner harbor of Rockport. The surface water mass balances indicate there may be no apparent difference in Enterococci levels at Goodies Beach with either two or four log removals obtained at the adjacent outfall location.

6/18/2012
Goose River (GR-2)

coefficient	10
C	170
Q (cfs)	7.43
Q as %	89.4%

Three Minor Drainage Areas

coefficient	10
C*	283
Q (cfs)	0.02664
Q as %	0.3%

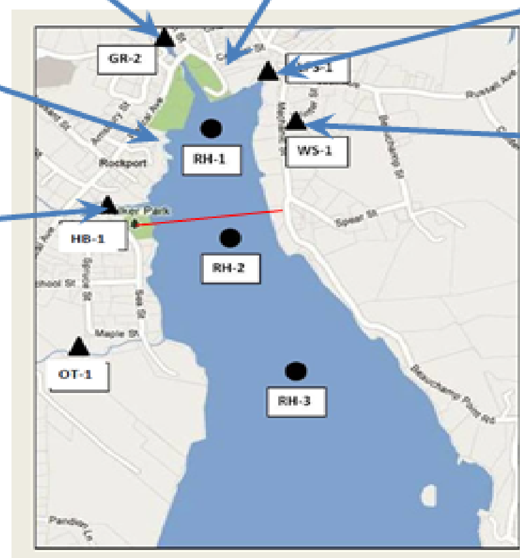
C* = Calculated from mass balance

6/19/2012
GB-Ditch

coefficient	10
C(post 4-log)	0.02
Q (cfs)	0.0353007
Q as %	0.4%

6/18/2012
Lily Pond (LPS-1)

coefficient	10
C	240
Q (cfs)	0.27
Q as %	3.2%



6/18/2012
Winter St Ditch (WS-1)

coefficient	10
C	340
Q (cfs)	0.05
Q as %	0.6%

6/18/2012
Ells Brook (HB-1)

coefficient	10
C	780
Q (cfs)	0.5
Q as %	6.0%

6/19/2012

Goodies Beach	
coefficient	**10**
C	**210**
C(post 4-log)	**209.6**
% Change	**0.4%**
Q (cfs)	**8.3**

1. Tide Stage During Sampling Event was MF (assumed Mid-Falling)
2. Previous Precipitation event was 0.4-0.5 inches on 6/14/2012

Figure A1: Mass Balance Solution with 4-log Removal Applied to Adjacent Stormwater Outfall