

Town of Chatham, Massachusetts
***Bacterial Source Assessment for a
Wetland-Dominated Watershed:***
Guidance Document and Case Study Report

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Hyannis, Massachusetts

BACTERIAL SOURCE ASSESSMENT FOR A WETLAND-DOMINATED WATERSHED: GUIDANCE DOCUMENT AND CASE STUDY REPORT

CHATHAM, MA

TABLE OF CONTENTS

SECTION 1 – INTRODUCTION AND PROJECT PURPOSE	1
SECTION 2 – BACTERIAL SOURCE ASSESSMENT GUIDANCE	1
SECTION 3 – CASE STUDY INTRODUCTION	5
3.1 – Watershed Overview	5
3.2 – Pollutants of Concern and Sources	6
SECTION 4 – SUMMARY OF TASKS	7
4.1 – Data Review	8
4.2 – Field Work	10
4.3 – Stakeholders’ Meetings	15
SECTION 5 – CONCLUSIONS	16
5.1 – Stormwater Runoff from Impervious Surfaces	16
5.2 – Septic Systems	17
5.3 – WWTF Effluent	18
5.4 – Flow from Buck’s Creek	18
5.5 – Natural Sources	18
5.6 – Summary	19
SECTION 6 – RECOMMENDATIONS	19
6.1 – Stormwater Mitigation	19
6.2 – Board of Health Inspections	19
6.3 – Further Analyses	20

LIST OF TABLES

Table 1	Summary of Board of Health and Building Department Information
Table 2	Summary of Septic Systems
Table 3	Possible Enterococci-Contributing Properties
Table 4	Summary of 2001-2004 Sampling Results
Table 5	July, August, and September 2005 Sampling Results
Table 6	July 2005 12-hour Tidal Cycle Sampling Results
Table 7	August 2005 12-hour Tidal Cycle Sampling Results
Table 8	WWTF Effluent Sampling
Table 9	Groundwater Monitoring Well Sampling

LIST OF FIGURES

Figure 1	Locus Map
Figure 2	Assessment Area Septic System Information
Figure 3	2001 Enterococci Values
Figure 4	2002 Enterococci Values
Figure 5	2003 Enterococci Values
Figure 6	2004 Enterococci Values
Figure 7	Sampling Locations
Figure 8	2005 Enterococci Sampling Events and Rain Events
Figure 9	2005 Upper Creek
Figure 10	2005 Mid Creek
Figure 11	2005 Lower Creek
Figure 12	2005 Tidal Pool
Figure 13	July Tidal Cycle Sampling
Figure 14	August Tidal Cycle Sampling
Figure 15	Groundwater Monitoring Well Locations

LIST OF APPENDICES

Appendix A	11-1-05 Stakeholders' Meeting Agenda
Appendix B	Stormwater Calculations
Appendix C	Bacterial Assessment Newsletter

BACTERIAL SOURCE ASSESSMENT FOR A WETLAND-DOMINATED WATERSHED: GUIDANCE DOCUMENT AND CASE STUDY REPORT

SECTION 1 – INTRODUCTION AND PROJECT PURPOSE

Coastal communities live, work, and play around their beautiful water resources. Many communities depend on the attraction of local waters to fuel the local economy. For these reasons, it is desirable to preserve the health of bathing beaches for use by locals and visitors.

Beach closures are primarily a concern in the summer season. Bacterial contamination is the most common factor in beach closures. Closures occur when water samples exceed contaminant limits established by either local, state, or federal agencies. Samples are tested in the laboratory for bacterial “indicator organisms.” These organisms, while not causing illness, indicate the possible presence of disease-causing microbes and indicate that fecal contamination may be present.

Both human and non-human sources can contribute to bacterial concentrations. In areas where elevated bacteria levels are regularly seen, it is desirable to determine the source of the bacteria. Non-human sources (such as wildlife activity) are only controllable to a limited degree. Human sources, on the other hand, can usually be eliminated or closely controlled. An assessment can be done to determine as much as possible about the sources of bacterial contamination in a particular watershed. The purpose of this document is to provide guidance in carrying out such an assessment. It also presents a case study of an enterococci source assessment performed in the Cockle Cove Creek watershed in Chatham, Massachusetts.

SECTION 2 – BACTERIAL SOURCE ASSESSMENT GUIDANCE

The following is a summary of the primary tasks to be performed in completing a bacterial source assessment. These steps could apply for enterococci or fecal coliform source assessments.

Step 1: Identify all possible sources of bacterial pollution. Each watershed is unique and, therefore, may have various contributors to bacteria levels. All of the

possible sources should be considered for a watershed. Among the possibilities are:

- Stormwater runoff
- Groundwater
- Septic system leachate or overflow discharge pipes
- Combined sewer overflows
- Wastewater treatment plant discharges
- Sewage pumpouts from boats anchored in the water
- Natural sources
- Watershed-specific sources

Step 2: Perform a detailed site inspection (site-walk) of the watershed when foliage is at a minimum. As much as possible of the watershed should be walked and inspected. The purpose of a site-walk is to locate possible stormwater runoff pipes discharging to the water; to identify septic system issues in nearby properties; to determine the extent of wildlife activity in the watershed; and to observe any other possible bacterial contributors unique to the watershed. Performing the site-walk when foliage is at a minimum provides a better opportunity to see pipes or washout from liquid streams (such as septic system breakout).

Step 3: Perform a data review. Reviewing any records of bacteria levels in the area provides information on how long the problem has been occurring. Other sampling programs may have been performed, or pollution sources may have been identified. This information can be utilized to narrow the possibilities or to verify suspected sources.

Additional data that should be reviewed is septic system information. Review of this information can aid in determining the predominant type of septic system (cesspool, Title 5, Innovative/Alternative), the age of the systems, and the location of the leaching area with respect to the waterbody. If the developed lots surrounding the water body are served by municipal sewer, leakage tests of the sewer pipes and manholes should be considered.

Step 4: Develop a sampling program and a sampling protocol. A sampling program should be developed that will provide a long-term view of the bacteria levels in the water. Sampling should be performed over a long enough time for patterns to be noticeable. Correlations may be noted between rain events, tide

stage, or temperature. Along with sampling results, information should be gathered regarding rainfall, tide stage (if applicable), and temperature. If the area being studied is a tidally influenced area, sampling should be done on both ebb tides and flood tides. Performing multiple samplings on all tide stages provides an indication of whether or not one tide stage is worse than another.

The sampling program should also identify sampling locations. Multiple sampling locations should be chosen throughout the water body being studied. The sampling locations should be selected so that different segments of the water body can be isolated. If stormwater point discharges (pipes) exist in the watershed, these should be sampled during rain events.

A sampling protocol should be developed that explains the basic required sampling procedures (sterile containers, sample size, etc.). The sampling protocol also outlines the desired sampling times (high tide, low tide, after rain, etc.). If the assessment area is an area that experiences tidal changes, a tidal cycle sampling round should be performed. Tidal cycle sampling involves sampling every sampling location once per hour over the course of twelve hours (one tidal cycle). A convenient way to identify the tide activity is to monitor salinity. As the tide comes in, salinity will increase, and vice versa.

Results obtained during the sampling program may indicate what areas of the water body experience higher levels of bacterial contamination and when the bacteria levels are the highest. Graphing the sampling results along with precipitation provides a visual way of determining if stormwater runoff is a contributor.

A sampling program should also be developed if groundwater is suspected of being a source of bacteria. The groundwater sampling should include sites located close to the water as well as further upstream in the watershed. If groundwater is further considered a possible contributor, the watershed should be analyzed closely to identify any sources contributing bacteria to the groundwater.

Step 5: Perform stormwater calculations. For areas where stormwater discharges are identified, or where sampling indicates that rain events have a direct connection with bacteria levels, stormwater runoff calculations should be performed. Where stormwater runoff is a potential or definite source of bacterial contamination, best management practices (BMPs) should be evaluated. The goal of most BMPs is to infiltrate the “first flush” of stormwater runoff. The first flush

is the initial runoff, which comes primarily from paved surfaces and other impervious areas (such as rooftops). The first flush, usually the first inch or half-inch of runoff from the impervious area, contains the highest concentration of pollutants. Containing and infiltrating this runoff can result in greatly improved water quality. The calculations aid in determining the peak runoff (information necessary for sizing pipes) and the water quality volume (information necessary for sizing catchbasins and other structures).

Step 6: Consider the use of microbial source tracking (MST) to identify the source species of the bacteria. MST is a developing analytical procedure to utilize genetic information (DNA, etc.) of the bacteria to identify the source species. There are several MST methods; and there is much discussion in the scientific community and by watershed managers on the effectiveness of MST, the best method to use, and the usefulness of MST findings and how they can be used in watershed management.

Due to the developing nature of this technology, this document will guide the interested reader to a reputable source for more detailed information. A search of the World Wide Web will identify many information sources and project case studies. An excellent place to start a web-based search is the United States Geologic Survey (USGS) site entitled “Water Quality Information – Microbial Source Tracking and Detection Techniques” at <http://water.usgs.gov/owq/microbial.html>.

Step 7: Evaluate mitigation measures and prioritize implementation. After all of the steps listed above have been performed, the likely contributors can be identified and mitigation measures can be evaluated for each potential source. Mitigation measures will vary, including public education, infrastructure improvements, stormwater best management practices, and legislation (regarding boat pumpouts or failing septic systems). After mitigation measures have been identified and evaluated for each source, all of the feasible measures should be prioritized for implementation. Priority should be based on the measures that are expected to have the largest positive effect for the watershed.

The following case study discusses the bacterial source assessment study performed in Cockle Cove Creek in Chatham, Massachusetts. The bacterial indicator of concern in the assessment was enterococci. The case study discusses the method of determining the enterococci sources following the general steps outlined above.

SECTION 3 – CASE STUDY INTRODUCTION

For the past several years, bacterial testing in Cockle Cove Creek has indicated elevated levels of enterococci bacteria. Enterococci counts are typically at acceptable levels during incoming tides, but consistently high levels on outgoing tides have prompted the Town to issue a swimming ban for the southern end of Cockle Cove Creek, which is adjacent to two popular Nantucket Sound beaches (see Figure 1). Cockle Cove Creek is not a designated bathing beach, but it does attract bathers from the adjacent bathing beaches because the water is warm and shallow.

Natural sources, including fecal matter from wildlife in the area, are thought to be the primary contributor to the elevated bacterial levels. Stormwater runoff (originating from impervious surfaces and from natural overland flow) is also a suspected contributor. Other possible contributors include treated effluent from the Town of Chatham's Wastewater Treatment Facility (WWTF) (which discharges in the northern portion of Cockle Cove Creek's watershed) and septic system effluent from the numerous private residences located along the edges of the marsh.

The goal of this assessment project was to investigate the source of the bacteria, to provide greater understanding of the problem, and to aid in identifying possible management strategies to mitigate the bacteria problem.

3.1 Watershed Overview:

Cockle Cove Creek is a tidal creek with a bordering salt marsh consisting of more than 50 acres, illustrated in Figure 1. Cockle Cove Creek flows south from Route 28, turning east as it approaches and eventually discharges into Nantucket Sound. The upper portion of Cockle Cove Creek consists of an abandoned cranberry bog, with water flow primarily restricted to the old ditch system. The lower portion runs adjacent to Cockle Cove Beach and Ridgevale Beach in Chatham (both located on Nantucket Sound) until it merges with Buck's Creek to the east. Both of these beaches are popular family beaches in the summertime, and Cockle Cove Creek is a favorite area for young children because of its shallow, warm water and abundant marine animals, such as fiddler crabs. Although Cockle Cove Creek is not designated as a bathing beach, its proximity to the busy beaches attracts children. As a result, the Chatham Department of Health and Environment (DHE) includes sampling of Cockle Cove Creek in the weekly beach monitoring and has applied the bathing beach water quality standards as justification for Cockle Cove Creek's closure to the public. Marshes naturally have higher levels of bacteria than open waters, but no acceptable standard has been developed for these

systems. However, Town personnel would rather err on the side of caution by applying bathing beach standards to Cockle Cove Creek waters.

3.2 Pollutants of Concern and Sources:

The DHE has performed sampling through the summer and into the fall for several years. The summer months typically produce higher levels of enterococci than the cooler months of September or October. The high bacteria counts have resulted in the Town's voluntary closure of the area.

It has been assumed that the primary source of the enterococci is wildlife in Cockle Cove Creek's watershed because of the suitable habitat provided for many types of waterfowl and wildlife. However, this has never been verified through a detailed wildlife, stormwater, or sanitary survey, nor has a detailed sampling program been done.

Cockle Cove Creek's watershed contains the Town's WWTF, which serves the downtown portion of Chatham. The WWTF treats an average annual flow of 100,000 gallons per day (gpd) and average summer flow of 130,000 gpd (June through September). The treated effluent is discharged into sand infiltration beds, which are upstream in Cockle Cove Creek's watershed. There is no surface water connection between the infiltration beds and Cockle Cove Creek. Currently, there is no disinfection of the treated effluent.

The watershed also contains many residential properties along Cockle Cove Creek. Septic systems from these properties were considered as possible sources of enterococci. Some of the properties were developed before the 1978 Title 5 sanitary code and may be served by cesspools or could have overflow pipes to Cockle Cove Creek. These areas are illustrated on Figure 2.

The following possible sources were evaluated in this source assessment study:

- Stormwater runoff from impervious surfaces
- Septic systems
- WWTF effluent
- Flow from Buck's Creek
- Natural sources (wildlife, tidal flow, etc.)

Initially it was thought that this assessment would utilize Microbial Source Tracking (MST) sampling and analysis to try to "fingerprint" the enterococci through DNA

analysis. However, recent findings of the Massachusetts Office of Coastal Zone Management (CZM) (the funding agency for this project) indicate that these methods are currently believed to be unable to accurately identify animal and human sources. Correspondence between the Department of Environmental Protection (DEP) Wall Experiment Station and Laboratory in Lawrence, MA and CZM discusses the inability of MST to accurately identify animal sources. MST results are still considered inconclusive, and there is not complete agreement within the scientific community regarding the reliability of MST. Therefore, MST was not used as part of this Study.

SECTION 4 – SUMMARY OF TASKS

The following is a summary of the tasks that were outlined in the scope for this bacterial source assessment study:

1. Review and summarize pertinent project area watershed information and previous studies.
2. Review the Board of Health records to identify the location and type of septic system for each of the properties bordering the creek.
3. Walk and inspect the watershed to look for possible discharge pipes and human enterococci sources.
4. Identify and evaluate the impervious areas and road areas that contribute to any stormwater discharge points in the watershed. Determine approximate drainage areas for identified discharges reaching the receiving waters. Calculate discharge flows at the discharge points.
5. Develop a sampling program to gain better insight on the high enterococci values. The sampling program will be designed to investigate enterococci concentrations throughout the tidal cycle, throughout the lunar cycle (particularly for extremely high tides that flood the marsh), and in locations that isolate particular branches of the creek.
6. Review existing monitoring well network and identify 2-3 existing monitoring wells to investigate possible enterococci transport in the groundwater.
7. Conduct groundwater and surface water sampling program in accordance with the Town of Chatham Water Quality Laboratory QA/QC Program.
8. Evaluate the potential enterococci sources and potential management approaches.
9. Prioritize and schedule the implementation of recommended management strategies.
10. Convene stakeholders' meetings.
11. Summarize the findings in a Final Assessment Report.

4.1 – Data Review: A GIS map of the project area was overlaid with a parcel map in order to identify all of the properties that border Cockle Cove Creek. Once the properties were identified, the DHE records were reviewed for all of the bordering properties. The DHE issues Disposal Works Construction Permits (DWCP) for all types of septic systems constructed in Town, and this was the primary source of information used in this study. The information was reviewed to determine the type of wastewater disposal system, date of construction/renovation, and location of the leaching system on all of the identified properties. A separate review of known variances issued for these properties was also performed. A few properties have not built or upgraded their septic systems since the Town began maintaining records of disposal facilities. For those properties, Building Department and Conservation Department records were reviewed to obtain any pertinent information. Table 1 provides a detailed summary of the results of the review of the Town's records.

Using information obtained during the record review, Figure 2 was developed to display the approximate location of known leaching facilities and identify the types of septic system (cesspool, Title 5, or Innovative/Alternative [I/A]). As can be seen in the figure, the majority of properties had information available in Health, Building, or Conservation Department records. Those properties are identified by blue or green shading. The two properties shaded in green had information regarding the type of system, but no plans on record showing the location of the leaching system. The properties shaded in yellow had no records in any of the Town's departments. These properties were likely developed/constructed before the Town began maintaining records; apparently no renovations of the house or the septic systems have taken place since then. It is assumed that these properties have cesspools, since the Town began keeping records prior to the institution of Title 5 regulations. The other properties identified as having cesspools were classified as such based on information in Town records.

A small number of properties had leaching systems that were less than 100 feet from the marsh. Leaching facilities within 100 feet of waterways have a much higher likelihood of contributing bacteria to the receiving waters. These properties were researched further to determine if a variance was granted allowing construction of leaching facilities in close proximity to the marsh. The majority of these properties did have variances granted. Table 2 summarizes the main findings of the review of records.

Table 2 – Summary of Septic Systems

<u>Septic System Information</u>	<u>Count</u>
Number of Title 5 Systems	68
Number of I/A Systems	2
Number of Cesspools	7
Number of Unknown Systems	5
Number of Leaching Facilities with 100' of Wetland – With Variance	8
Number of Leaching Facilities with 100' of Wetland – Without Variance	1
Vacant Properties	7

As can be seen from the summarized data, Cockle Cove Creek is surrounded by a large number of developed residential lots. This portion of Town is not served by the Town's sanitary sewer system. All of the houses in the area are served by on-site treatment systems (cesspools, Title 5 systems, or I/A systems). If any of the lots bordering Cockle Cove Creek have failing systems or overflow pipes from their systems, Cockle Cove Creek could experience bacterial contamination. As will be discussed in following sections, site walks were performed and review of Town records was done to determine if there are any disposal systems that are likely contributing to bacterial contamination. No evidence of overflow pipes or septic system effluent was observed during any of the site walks. However, a small number of properties were identified as properties of concern, based on the location of the leaching facilities or the presence (assumed or confirmed) of a cesspool. These properties are listed in Table 3. The conclusions and recommendations sections of this report discuss these properties further.

The DHE monitors many bathing beaches during the summer months to ensure the water quality is safe for human recreational uses. Two of the regularly sampled locations are in Cockle Cove Creek. Town personnel have monitored enterococci levels at these two sampling stations (B4b and B4c, see Figure 7) for several years. 2001 to 2004 sampling data was provided by the DHE for use in this Study. Table 4 summarizes the data from the historic sampling results. Additionally, Figures 3, 4, 5, and 6 graphically display the sampling results and precipitation data.

**Table 4 – Summary of 2001-2004
Sampling Results**

Year	Month	Precipitation ⁽¹⁾	Sampling Events ⁽²⁾	Range ⁽³⁾ (B4b)	Range ⁽³⁾ (B4c)
2001	June	3.00	3	25-830	5-90
	July	3.35	5	2-620	1-210
	August	5.36	5	3-13590	5-7650
2002	June	2.88	3	20-980	9-370
	July	0.48	8	5-370	1-270
	August	2.45	8	7-550	1-380
2003	June	5.07	5	3-31	2-80
	July	1.80	5	12-428	2-180
	August	3.51	4	30-592	2-180
2004	June	1.60	3	47-193	8-72
	July	2.38	7	23-532	1-218
	August	5.51	7	2-578	1-290
1. Total precipitation for the month. 2. Total sampling events for the month. 3. Range of values (enterococci/100 ml) for all sampling events during the month.					

4.2 – Field Work

Site Walks: The marsh area was walked by Town and Stearns & Wheler (S&W) personnel on two occasions (April 27, 2005 and July 21, 2005). The goal of the site walks was to look for possible enterococci sources (stormwater discharge pipes, septic overflow pipes, etc.) before the marsh area was overgrown for the summer and again during the summer when the enterococci levels are typically the highest.

During the initial site walk, no discharge pipes were observed. Any stormwater runoff that flows to Cockle Cove Creek apparently results from overland sheet flow. A catchbasin was seen on Cockle Cove Road (the west side of Cockle Cove Creek), but no discharge pipes were observed running out of the catchbasin into Cockle Cove Creek. Although Cockle Cove Road does not have curbs to prevent stormwater from flowing into the marsh, there are segments of Cape Cod berm (such as on the east side of a hill on Cockle Cove Road) and portions of the road are sloped in such a way that stormwater runoff flows away from the marsh. Additionally, the lower end of Cockle Cove Road is relatively flat, and grassy areas on the shoulders of the road likely allow infiltration of a portion of stormwater runoff.

A possible stormwater runoff area was identified on Cockle Drive, a narrow, U-shaped road off of Cockle Cove Road. The road makes a sharp turn and drastically slopes in the direction of Cockle Cove Creek. Stormwater runoff was evident by the piles of sand at the bend in the road and minor washout along the edge of the road. However, the runoff flows through a wooded, vegetated area before reaching the marsh. A portion of the runoff is believed to flow onto a grassy area of an adjacent property.



Paved swale on Route 28

The second site walk again showed no evidence of stormwater discharge pipes. However, it was noted that a paved swale on Route 28 directs stormwater runoff into the northern end of the abandoned cranberry bog (see picture at left). Upon inspection, it was noted that the swale discharges into a dry area at the head of the abandoned cranberry bog. Stormwater runoff has a fairly long distance to travel over densely wooded land

before reaching Cockle Cove Creek's waters. The paved swale along Route 28 was the only stormwater source for which runoff calculations were performed.

In the majority of areas where stormwater runoff flows from the roadways to Cockle Cove Creek, there are long distances of vegetated land over which the stormwater travels before entering Cockle Cove Creek water (as shown at right). Decreased velocity of the runoff allows additional infiltration as the water travels over the vegetated land.



View of Cockle Cove Road and Cockle Cove Creek (far right)

Although no significant stormwater point sources were evident, there were several natural enterococci sources evident on the initial site walk. Several piles of wildlife feces were observed on the marsh (see photo at left). There was also abundant evidence of wildlife living and eating in and around Cockle Cove Creek.



The July site walk again showed abundant evidence of wildlife activity. The marsh grass was quite tall, yet trails were worn down from the upland to the edge of Cockle Cove Creek; crab shells left by a predator were seen; and waterfowl were observed swimming in Cockle Cove Creek.



There were also other possible natural bacteria sources observed during this site walk. Many large clumps of algae and wrack were observed along Cockle Cove Creek's edge. Wrack and algae can serve as a reservoir for bacteria. As the tide comes in, bacteria harbored in the wrack can be washed out along with the outgoing tide.

Sampling: A sampling plan and a sampling protocol designed to provide a better understanding of the correlation between high enterococci levels and the tidal cycle, the lunar cycle, and particular sections of Cockle Cove Creek were developed by the DHE and S&W.

In order to isolate various sections of Cockle Cove Creek, eight sampling locations were identified. The sampling locations are listed below and displayed on Figure 7.

- CM-G: located in the upper portion of the abandoned cranberry bog
- CM-J: located at the site of an abandoned dike
- CM-F: located approximately in the middle of Cockle Cove Creek
- CM-K: located prior to the mouth of the east fork of Cockle Cove Creek
- B4b: located by the Cockle Cove Beach parking lot
- CM-12: located at the mouth of Cockle Cove Creek (identified as B4c for historic sampling events)
- CM-L: located in Buck's Creek, just prior to meeting Cockle Cove Creek (identified as B3c for historic sampling events),
- CM-T, a pool on the marsh plain (only flooded during lunar high tides)

For the months of July, August, and September, sampling was performed weekly. Because the highest levels of enterococci were observed on ebb tides, the weekly sampling was performed within 1 ½ hours prior to low tide. The sampling locations are somewhat spread out; however, all of the sampling locations were sampled within a 45 minute period. The results of the sampling program are provided in Table 5 and illustrated in Figures 8, 9, 10, 11, and 12. Figure 8 provides an overview of 3 months of sampling for all locations. Figures 9 through 12 present results grouped by location (Upper Cockle Cove Creek, Mid Cockle Cove Creek, Lower Cockle Cove Creek, and Tidal Pool). All of the graphs are plotted on the same vertical scale for easy comparison of results.

Precipitation was suspected to contribute to elevated bacteria levels. However, the sampling results indicate that, although precipitation does tend to slightly increase bacteria levels, the correlation is not strong enough to conclude that precipitation is a significant factor in bacterial contamination. For example, the sampling performed on August 9 was preceded by several dry days. The August 16 sampling was preceded by two days of rain. The differences in the bacteria levels are relatively small; in fact, some sampling locations had lower bacteria levels after the rain.

In addition to the weekly sampling, two tidal cycle samplings were performed, one on July 22 and one on August 22. These sampling events involved hourly sampling over the course of twelve hours. The dates of these sampling events were chosen to be the days with the highest tides of the month, which were expected to yield the highest bacteria counts. In addition to sampling for enterococci, samples were analyzed for salinity to give an indicator of the tide stage.

As mentioned, an entire set of sampling took approximately 45 minutes. Because the tidal cycle sampling involved hourly sampling, two samplers were required to expedite the process. One sampler was stationed on the east side of Cockle Cove Creek and one on the west side. This resulted in an entire sample set being collected within a much shorter time frame.

The results of the tidal cycle sampling are displayed in Figures 13 and 14 and Tables 6 and 7. Location CM-T was not sampled hourly during the tidal cycle because very little change was expected in the isolated pool. In addition, CM-L was not sampled every hour. This sampling location was inaccessible from noon to 4:00 pm due to the water level. The tidal cycle sampling confirmed previous observations that enterococci levels are higher on the outgoing tides. As can be seen on Figures 13 and 14, the bacteria levels typically decreased as the salinity increased (indicating the tide was coming in) and vice versa. Samples from stations CM-G and CM-J had 0 salinity throughout the sampling period, indicating that these stations are groundwater dominated, not tidally dominated.

Groundwater monitoring: The Town's monitoring well network was reviewed along with reports indicating the groundwater flow direction from the WWTF. Several wells were identified as possible sampling locations. Town personnel located the potential sampling sites to determine if sampling would be feasible. Four of the wells were selected as sampling points (Figure 15). These wells are:

- SW-12 –located at the WWTF, adjacent to the sand infiltration beds
- SW-7 – located south of Route 28, close to the paved drainage swale
- MW-2 – located along Cockle Cove Creek's edge, east of Island View Drive
- MW-4 – located between two residential properties on Island View Drive

The wells were selected based on their location relative to the suspected WWTF effluent plume. Wells MW-2 and SW-7 are located within the plume; well SW-12 is located at the WWTF adjacent to the effluent sand bed; well MW-4 is located along the western edge of the groundwater plume.

Wells SW-7, MW-2 and MW-4 were located and found to be suitable for sampling. SW-7 and MW-4 are sampled monthly by the WWTF for nitrates, nitrites, and TKN; however, no bacterial sampling had been performed by WWTF personnel. Although the casing at SW-12 had been damaged, the well still appeared to be in good enough condition to be sampled. Samples were collected, but damage to the casing and cover may cause the sample results to be influenced by stormwater or other sources. The age

of all the wells and the fact that they were not designed specifically for bacterial sampling may also influence the results.

In addition to the groundwater monitoring wells, it was decided that the WWTF effluent would be sampled for enterococci. The effluent samples would be used to determine what the bacteria levels are prior to infiltration in the sand beds. The results for the WWTF effluent sampling are shown in Table 8.

**Table 8 - WWTF
Effluent Sampling**

Date	Enterococci CFU/100 ml
10/12/2005	25,000
10/13/2005	10,760
10/17/2005	14,450
10/18/2005	24,790
10/20/2005	12,340
10/25/2005	15,610
10/26/2005	22,780
10/27/2005	14,560
11/2/2005	11,290
11/3/2005	12,980

The results from the monitoring well sampling are included in Table 9. The sampling results are discussed further in the Conclusions section.

Table 9 - Monitoring Well Sampling

Date	SW-12	SW-7	MW-2S	MW-4S
	Enterococci CFU/100 ml	Enterococci CFU/100 ml	Enterococci CFU/100 ml	Enterococci CFU/100 ml
10/27/2005	3	<1	<3	215
11/2/2005	7	<1	<3	28
11/3/2005	<3	<1	<3	58

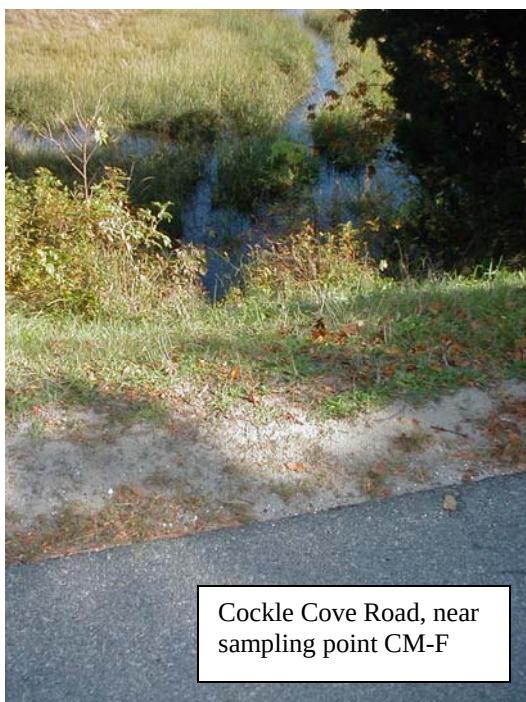
4.3 – Stakeholders’ meetings: A stakeholders’ meeting was held on November 1, 2005 to update Town personnel on the findings and to solicit input on the preliminary conclusions and recommendations. Representatives from the DHE, the Department of Public Works, the Board of Health, Massachusetts CZM, and Stearns & Wheler attended the meeting. An overview of the assessment process was presented and the preliminary findings and recommendations were outlined. See Appendix A for the meeting minutes

of the stakeholders' meeting. At the stakeholders' meeting, sample location CM-F became the center of the discussion because the highest bacteria levels were nearly always seen at that location. This section of the assessment area was revisited after the stakeholders' meeting and is discussed in the conclusions section.

SECTION 5 – CONCLUSIONS

5.1 Stormwater runoff from impervious surfaces: As discussed previously, stormwater runoff was considered a possible source of enterococci pollution but comparison of the sampling results with precipitation data did not fully support a connection.

No stormwater discharge pipes were observed during the site walks. The paved swale on Route 28 was the only direct discharge of stormwater runoff into the marsh system. As mentioned, this discharge is in the upper end of the marsh (the abandoned cranberry bog), and any stormwater runoff must travel over densely vegetated land before reaching surface waters. Additionally, catchbasins along Route 28 direct a large portion of the stormwater from Route 28 to a discharge pipe on the northern side of the road. A culvert under Route 28 connects the wetlands on the northern side of Route 28 to the Cockle Cove Creek marsh system. However, this culvert was found to be completely buried by sediment, so no stormwater that is discharged to the north of Route 28 is able to flow to Cockle Cove Creek.



Stormwater calculations were performed for the drainage area that directs stormwater runoff to the swale. The drainage area that flows to the paved swale consists of over six acres of land, nearly 40% of which is impervious (rooftops, pavement, etc.). Preliminary calculations indicate that the peak flow at the swale ranges from 5.3 cubic feet per second (cfs) during the 2-year storm event to 13.5 cfs during the 25-year storm event. In the absence of any best management practices at the swale, it should be considered as a potential source of enterococci contamination to Cockle Cove Creek. Based on the Massachusetts Stormwater Policy, the water quality volume that should be the basis of any drainage structure design is 8,000 cubic feet. This volume would contain the first flush of stormwater runoff,

which typically contains the highest concentration of contaminants, including bacteria.

After discussion among the stakeholders and review of the sampling data, stormwater runoff in the vicinity of sampling location CM-F was reconsidered as a possible factor in enterococci pollution. The section of Cockle Cove Road that is closest to CM-F has no berms or curbs to prevent stormwater runoff from entering the marsh. Additionally, Cockle Cove Creek's water where CM-F is located is a relatively short distance from the edge of the road (see photo above).

As discussed previously, analysis of sampling results in comparison with precipitation data do not indicate a direct correlation between stormwater runoff and elevated bacterial levels. Although precipitation may be a factor in the consistently high readings at sampling point CM-F, other factors should also be considered. Upstream of CM-F is a large, open marsh area. During high tides, the marsh area can contribute large amounts of bacteria to the water. The winding length of Cockle Cove Creek upstream of CM-F may present opportunities for the sediment in the creek bed to be disturbed. Sediments can provide an ideal location for bacterial growth. Sediment analysis would provide further insight into the Cockle Cove Creek bacteria levels.

5.2 Septic Systems: The dense residential development in the vicinity of Cockle Cove Creek presented a large potential for bacterial contamination. However, after extensive review of the Town's records, it was determined that there are very few possible septic systems with the potential to contribute bacterial contamination to Cockle Cove Creek. Previous studies have shown that bacteria does not travel very long distances through soil. Most of the properties that have leaching systems within 100 feet of the marsh were granted variances for construction (Chatham setback requirements of 100 feet are more stringent than the Title 5 requirement of 50 feet). The earliest of these variances was issued in 1988; all of the variances were granted for either Title 5 systems or I/A systems, therefore it is expected that they are located above the groundwater, minimizing any potential hydraulic connection to Cockle Cove Creek.

Of the 88 properties bordering Cockle Cove Creek, 11 have known or assumed cesspools. Cesspools are considered substandard septic systems. These systems may also be located in the groundwater and therefore have a greater potential to impact Cockle Cove Creek. However, none of the cesspools are located within 100 feet of the wetland system. Identification of these properties is useful to the Town for inspection purposes, as will be discussed further in the Recommendations section.

5.3 WWTF Effluent: Effluent from the WWTF is discharged into open sand infiltration beds. These beds allow the effluent to leach into the soils and eventually reach the groundwater. To determine if the WWTF effluent contributes to bacterial contamination in Cockle Cove Creek, samples were taken from the WWTF effluent and in several monitoring wells downstream in the groundwater flow. The samples taken from the WWTF had enterococci counts ranging from 10,000 cfu/100 ml to 25,000 cfu/100 ml. Four monitoring wells downstream of the WWTF were sampled. The samples in the wells had bacterial counts ranging from <1 cfu/100 ml to 215 cfu/100 ml, as shown in Table 9. The one well that had high bacterial counts was the well furthest away from the WWTF, and was suspected to be impacted by nearby septic systems. These findings would indicate that the WWTF is not a factor in the enterococci contamination of Cockle Cove Creek. However, MW-4 (the well with the high counts) raised further questions regarding nearby septic systems. DHE records for properties in the vicinity of this well were reviewed to determine the location of the septic systems. All of the nearby properties have Title 5 systems, but the leaching facilities are not in the immediate vicinity of the monitoring well. The results from the second and third rounds of sampling were much lower than those of the initial sampling. This well will be investigated further to try to locate the source of the bacterial contamination of the well.

5.4 Flow from Buck's Creek: During the tidal cycle sampling, observations were made of the flows from both Cockle Cove Creek and Buck's Creek. It was noted that the outgoing tide from Buck's Creek stops flowing out before Cockle Cove Creek stops flowing out. Once the tide starts flowing into Buck's Creek, the outgoing water from Cockle Cove Creek begins flowing into Buck's Creek as well. This led to the conclusion that Buck's Creek is not a source of bacterial contamination of Cockle Cove Creek, as no water from Buck's Creek was observed to flow into Cockle Cove Creek.

5.5 Natural sources: A variety of natural bacterial contamination sources were identified during the study. Abundant evidence of wildlife activity was seen during the site walks. As the animals travel through the marsh, they leave feces and food remnants (crab shells, etc.) in marsh grass and other areas close to the water's edge. During rain events or tidal movements, the debris can wash into the water and increase the bacterial counts.



Wrack lines were observed in many spots throughout the marsh. Some of the wrack lines were algal wrack; others were vegetation wrack (seaweed, grass, etc.). Wrack lines are capable of harboring bacteria. As the rain or tide washes over the wrack, bacteria can be transferred to the marine waters.

5.6 – Summary: Evaluation of many of the possible factors in the enterococci levels in Cockle Cove Creek did not lead to a determination of any single cause. Many possible sources were eliminated as potential causes (such as the WWTF effluent and flow from Buck’s Creek into Cockle Cove Creek) and others were considered unlikely causes (residential septic systems). While stormwater runoff from impervious surfaces may play a small role in contributing to enterococci contamination, it is believed that the major causes of the bacteria levels are natural sources.

SECTION 6 – RECOMMENDATIONS

6.1 Stormwater mitigation. Although some of the Town-maintained roads may contribute a small amount of stormwater to the marsh, the major contributing road is Route 28, which is maintained by the Massachusetts Highway Department (MHD). It is recommended that the MHD consider construction of a catchbasin and leaching facilities to replace the existing paved swale, which directs stormwater runoff directly towards Cockle Cove Creek. The catchbasins should be designed to contain, at a minimum, the first flush of stormwater runoff.

An alternative recommendation for stormwater mitigation is to construct a fresh water pond in the upper portion of Cockle Cove Creek. Construction of the pond would involve installation of a flow control structure, possibly in the area of one of the abandoned dikes in the upper Cockle Cove Creek area. The pond would be designed to contain large volumes of stormwater runoff, allowing overflow into Cockle Cove Creek only during large rain events. Containment of stormwater runoff would allow bacteria-containing solids to settle out of the water. This would minimize the transportation of bacteria from stormwater runoff into Cockle Cove Creek’s waters and improve the water quality of Cockle Cove Creek in general. It should be noted that careful design of any stormwater retention pond is critical because stormwater retention ponds have been found to be bacterial sources.

6.2 Board of Health inspections. After review of the residential properties bordering Cockle Cove Creek, several were identified as possible contributors to enterococci contamination. The properties that have the greatest potential as bacteria contributors have been identified in Table 3. This list also includes properties that are assumed to

have cesspools, based on the lack of information regarding the property. It is recommended that the Board of Health order inspections of these systems.

The Town of Chatham has done extensive work on a Town-wide Comprehensive Wastewater Management Plan (CWMP). When implemented, the CWMP may include sewerage a large portion of the properties in Chatham. The Cockle Cove Creek area is currently being evaluated for sewers to aid in nitrogen management for the Town. Because the final recommendations have not been made on what solutions will be implemented as part of the CWMP, the Board of Health will have to evaluate the need to require upgrades to any septic systems prior to the CWMP completion. Therefore, if the Board of Health inspections find cesspools or septic systems functioning improperly, homeowners may be ordered to make repairs or improvements that will temporarily alleviate the problem while not imposing a large financial burden on the homeowner.

If recommended as part of the CWMP, the sewerage of the Cockle Cove Creek watershed would eliminate any possible future effects from failing septic systems, bacterial or otherwise.

6.3 Further analyses: Sediments in Cockle Cove Creek may naturally harbor enterococci bacteria. When disturbed (such as during a rain event or tidal movement), this bacteria may be suspended in the water, increasing bacterial counts. Therefore, analysis of Cockle Cove Creek's sediments can provide further insight into the nature of the Cockle Cove Creek ecosystem.

In addition, the highest bacterial counts are typically seen in the warmer summer months. This indicates that temperature may be a factor in the concentration of bacteria. It is recommended that the Town perform an analysis of water temperature versus bacterial counts to supplement the existing knowledge of the bacterial concentration trends. The Town plans to continue sampling these locations indefinitely (though not as intensively), including over the winter months. This will assist in determining the trend of enterococci levels as they relate to water temperatures.

As discussed previously, marshes tend to have higher levels of bacteria than other water resources, such as bathing beaches. The lack of bacterial standards for marsh systems makes it impossible to conclusively state that the enterococci levels in Cockle Cove Creek are unnaturally high and/or abnormal. Further investigation may continue to narrow the possibilities.