

Element C: Fecal Coliform Source Identification

Fecal Coliform and other pathogenic organisms come from a variety of sources and can enter the aquatic environment through a multitude of different pathways. A major challenge for water resource managers is to identify all of the potential sources of bacteria in the watershed and then prioritize efforts to address sources that are most likely to elevate fecal coliform levels at the SC DHEC monitoring stations. Another equally important approach is to mitigate the mechanisms by which bacteria is entering the estuary in circumstances where completely eliminating the actual source of bacteria is not practical. Managing bacteria in a watershed environment requires creativity and a multifaceted long-term approach.

Element G: Recommended Watershed Management Measures details numerous management strategies that if executed will help to lower fecal coliform levels in the Hog Inlet- Dunn Sound Creek watershed.

One of the initial steps during this planning process was to assess the various sources of bacteria that likely exist in the Hog Inlet- Dunn Sound Creek watershed. An immediate observation which was highlighted in **Element A: Description of the Hog Inlet- Dunn Sound Creek Watershed**, is the diverse land uses present throughout the watershed. These contrasting development patterns can help narrow in on the types of bacteria sources that would likely occur within each section of the watershed. As an example, the main bacteria sources on Waties Island, a mostly undeveloped barrier island, will likely be from wildlife or waterfowl, whereas in the Cherry Grove Beach portion of the watershed pet waste may be more of a prominent bacteria source concern.

The planning team relied heavily on the general public during this phase of the planning process. Residents and local workers who have a strong familiarity of the watershed may observe issues that the planning team might not have been aware of. Long-time residents can be particularly helpful as they can share perspectives on how the watershed has changed over time. A public meeting was held on March 10, 2016 to provide information about the Hog Inlet- Dunn Sound Creek Watershed Plan. Another objective of the meeting was to solicit input from attendees regarding their local knowledge of the watershed and their specific concerns as direct stakeholders of the estuary. The planning team supplemented the insight gained from that meeting by administering a survey that was made available both in paper copy and online during the Spring and Summer of 2016. A copy of the survey with a breakdown of the responses is included in **Appendix E**.



Figure C-1 Stakeholders asking questions about the watershed planning process at a public meeting held March 10, 2016.

I. Potential Sources of Bacteria

In this next section, each source of bacteria identified as potentially contributing to the SC DHEC monitoring site impairments is discussed. If a particular source of bacteria is of concern to a specific area within the watershed the Catchment Area detailed in **Element A** is highlighted.

A. Residential Septic Systems

While the majority of the residential neighborhoods and commercial corridors within the watershed are connected to the sanitary sewer system, there are areas that rely on septic systems to meet their wastewater treatment needs. In the right conditions, septic systems can be a reliable solution to treating wastewater effluent. Regular inspection and proper maintenance is critically important to avoid malfunctions. Properly siting septic systems in areas with suitable soils and water table levels is also necessary. A concern across coastal South Carolina is the lack of ideal site conditions for the placement of septic systems.

While there are some areas suitable for septic system installations, the preferred means of treating domestic wastewater is via the sanitary sewer system. Once a septic system begins to malfunction, it not only can become a major source of bacteria impacting the estuarine environment, but also a serious public health hazard. Little River Neck Road was the most recent extension of the force main sewer line within the North Myrtle Beach sewer service area. While some residents and neighborhoods such as Tidewater Plantation and Charleston Landing have connected to the sewer system, there are several side streets and adjacent neighborhoods within the Waties Island Catchment Area, Little River Neck-Marsh Catchment Area, Little River Neck- Waterway Catchment Area, and the Hill Street Catchment Area that currently rely on septic systems.

B. Sanitary Sewer System

Throughout the Grand Strand, investments in wastewater treatment facilities and associated infrastructure have helped protect water resources throughout the region and improved the quality of life for residents and visitors of the area. North Myrtle Beach owns and operates a sanitary sewer utility which provides service to the Hog Inlet- Dunn Sound Creek watershed area. Wastewater collected from the sewered portions of the watershed is transported through a network of pump stations and sewer lines to the Ocean Drive Wastewater Treatment Plant, located off of 2nd Ave South on the western side of US Hwy 17. The sewer system in North Myrtle Beach was initially installed in 1975, including the Cherry Grove Beach area. There have been several sewer extensions since that time particularly along Little River Neck Road. Myrtle Beach RV Park (1987), Tidewater(1997), the Future Farmers of America Camp (2001), Creekside Mobile Home Park (1976), Charleston Landing (2002), and Church View Lane (2001) are now all connected to North Myrtle Beach's centralized sanitary sewer system. Any infrastructure system of this scale requires ongoing inspections, routine maintenance, and periodic upgrades in order for the system to operate as efficiently as possible. The system must also be designed to accommodate peak flows during the summer tourism season, when sanitary sewer demands are at their greatest.

Even with a comprehensive maintenance plan in place, extreme weather events can stress the sewer system leading to mechanical malfunctions that can cause untreated wastewater effluent to enter the drainage network and impact water quality in the estuary. As an example, during the October 2015 flood event, sanitary sewer overflows were reported throughout the state. Over the span of one week, October 1-7, 2015, 125 sanitary sewer overflows were reported to SC DHEC. Only one occurred within the North Myrtle Beach service area, resulting in an estimated 1,500 gallon wastewater effluent spill at a pump station near the corner of 26th Ave. N and Duffy St in Cherry Grove Beach. There were similar problems across the state following Hurricane Matthew in October 2016, however no sanitary sewer overflows were reported by the City of North Myrtle Beach following the storm. While sanitary sewer overflows are usually infrequent, given the substantial physical infrastructure associated with a sanitary sewer system, smaller malfunctions can also occur. North Myrtle Beach should continue to implement techniques such as televising or smoke testing sewer lines, prioritizing older neighborhoods to spot sections that need to be repaired or replaced.



Figure C-2 Typical pump station within the North Myrtle Beach sanitary sewer system

C. Pet Waste

A source of bacteria that, individually, we have the greatest ability to prevent from entering our waterways is from pet waste. While the majority of pet owners dispose of their pet's waste responsibly, it remains an environmental, social, and even a public health issue. Pet owners who neglect to pick up after their pets collectively become a significant source of bacteria entering our waterways. A potential cause for pet owner negligence is that they are unaware that pet waste left on the ground gets transported into the estuary following the next rain event. This connection is not necessarily widely understood by everyone. Public education and providing convenient disposal options in public areas is the best strategy to reducing pet waste as a source of bacteria in our aquatic environment. North Myrtle Beach has been proactive in addressing this issue by investing in pet waste stations throughout the community. As of August 2016, 48 pet waste stations are installed and routinely restocked by North Myrtle Beach staff throughout the community. The City has also adopted an ordinance requiring dog owners to pick up after their pets. Public parks and other open spaces along with residential neighborhoods are areas within the watershed where pet waste is most likely going to be a source of bacteria in the estuary.



Figure C-3 Examples of pet waste stations at Heritage Shores Nature Preserve (on right) and Russell Burgess Coastal Preserve (on left)

D. Wildlife and Bird Populations

Perhaps the most difficult source of bacteria to manage is from wildlife and birds that inhabit the watershed. Eliminating these sources is impractical, therefore it must be understood that there will always be a baseline level of bacteria from these natural sources. There are however ways to mitigate these sources particularly in urbanized areas. They include avoiding feeding birds and wildlife and by enclosing dumpsters, which can attract nuisance animals such as raccoons and similar wildlife species. An additional strategy is to encourage the establishment of vegetated buffers near the estuary shoreline and along the edge of stormwater ponds. The vegetated buffer helps to filter the stormwater runoff prior to draining into the estuary, while also discouraging waterfowl from congregating in and near the ponds.



Figure C-4 There is a wide diversity of wildlife species that inhabit the Hog Inlet- Dunn Sound Creek watershed.

E. Feral Cat Populations

A common problem in many areas throughout Horry County is the overpopulation of free-roaming cats. These cats congregate in sizable colonies and reproduce at significant rates. Given their tendency to live in urban/suburban areas, feral cats can be a source of bacteria within the Hog Inlet- Dunn Sound Creek Watershed. To date there have only been a few reports of observed feral cat colonies within the Cherry Grove Beach and Little River Neck communities.

There are efforts in Horry County that are focused on controlling the feral cat population using a non-lethal ethical approach. The Horry County Animal Care Center was recently awarded a Trap-Neuter-Return program grant from Petsmart Charities to focus efforts on identified feral cat colonies in the City of Conway. Sav-R-Cats International, Inc. is a no-kill feral cat shelter located in Surfside Beach focused on both trap-neuter-return initiatives as well as cat adoption.

F. Legacy Sources

In addition to the specific sources outlined above, there may be additional sources of bacteria from remnant infrastructure or contaminated sites that could still be impacting water quality in the estuary. A possible legacy source could be old septic systems in areas that are now connected to the public sanitary sewer system. Due to public safety and environmental concerns, there are recommended steps to disconnect septic systems that are no longer in use. They include disconnecting all of the piping, pumping out any remaining sewage, and filling the septic tank and field. Improper abandonment could leave behind a legacy source of bacteria that leaches into the aquatic environment over time. Areas to investigate would be Cherry Grove Beach and other older neighborhoods within the watershed that when originally constructed relied on septic systems, but are now connected to the North Myrtle Beach sanitary sewer system. It is also suspected that there are a few residences within Cherry Grove Beach that still rely on a septic system even though their street is served by sewer. These property owners may not even realize this because they receive a sewer utility bill from the City of North Myrtle Beach per city ordinance. Fortunately, initial findings from the microbial source tracking study conducted in 2016 do not indicate a signal for human-sourced bacteria in this area. The microbial source tracking study is outlined in much further detail in Element D.

II. Bacteria Transport Pathways into Estuary

Accounting for each of the sources of bacteria within the watershed is only one aspect of mitigating fecal coliform levels that are observed at SC DHEC's monitoring sites within the estuary. Another critical step is understanding how the bacteria migrates from its point of origin on the landscape all the way to its final drainage point into the estuary. The hydrology of the watershed influences both the quantity of stormwater and the rate at which it runs off various land surfaces and enters the estuary. The hydrologic dynamic can change considerably as development continues in the area.

This section further explains the influence of land use patterns and site design can have on drainage patterns within a watershed.



Figure C-5 There is a variety of land uses across the watershed ranging from large undeveloped forested parcels in Little River Neck (on left) to densely developed neighborhoods and corridors in Cherry Grove Beach (on right). Hydrologic conditions are strongly influenced by land use and development patterns requiring different management approaches depending on the site drainage characteristics.

A. Land Use Change

As coastal South Carolina continues to face growth pressures, land use changes are expected in the foreseeable future. The resulting urbanization entails an expansion of impervious surfaces including roadways, parking lots, driveways, houses, and commercial buildings. Each new development incrementally alters the hydrology of the watershed. There are numerous variables that ultimately influence the hydrology of a site. Even open space areas can differ significantly based on the site topography, underlying soils, and extent of vegetative cover.

B. Stormwater Runoff

Managing stormwater runoff is intrinsically linked to the land use or impervious surface coverage within a drainage basin. The typical storm sewer system found in most urbanized areas is designed specifically to minimize ponding and flooding along roadways, parking lots, and other portions of the built environment during and after storm events. As precipitation accumulates and runs off impervious surfaces or saturated ground surfaces, a system of curbs, gutters, pipes, and ditches carries stormwater downstream into receiving waters such as Hog Inlet and Dunn Sound Creek. This stormwater conveyance network can serve as a perfect transport mechanism for debris, sediment, and other pollutants such as bacteria and other pathogens. Most conventional stormwater systems are not equipped with treatment devices to remove or disinfect the contaminants entering the estuary.

Fortunately new approaches to stormwater management have advanced with a greater consideration towards protecting water quality in downstream portions of the watershed. One of the emerging strategies has been to reduce the stormwater runoff volumes generated at the parcel level. These concepts along with



Figure C-6 Typical storm drain adjacent to the Cherry Grove Canal

specific stormwater management recommendations are outlined in further detail in **Element G: Recommended Watershed Management Measures**.

C. Sedimentation

Sedimentation is a long-term process where soil that gets eroded off the upstream portions of the watershed settles out in the tidal creeks and channels of the estuary. Sedimentation is a natural process in any watershed system, however when it occurs at an excessive rate, a multitude of water resource management issues can arise. One of the most obvious issues within the Hog Inlet watershed is the sedimentation within the Cherry Grove Canal system. Presently, navigability in the canals is severely restricted raising the need for a major dredging operation which was completed in the Spring of 2017.



Figure C-7 The Cherry Grove Canal system is one of the more noticeable areas that have been affected by siltation. The sediment has built up in many sections of the canal network to a point where navigability is nearly impossible. A large scale dredging project was completed in the Spring of 2017 to improve navigability in this area.

From a water quality perspective, the following issues can arise due to excessive sedimentation:

- Bacteria along with other pollutants have a propensity to bind to sediment particles. As such, sediment can become a significant transport mechanism of bacteria entering the waterway.
- Oyster reefs provide tremendous ecosystem services and benefits in an estuarine environment. Perhaps most noteworthy is their role as prolific filter feeders leading to substantial water quality improvements, including a decrease in turbidity and an increase in dissolved oxygen. Silt can become a major stressor on oyster reefs if it buries oyster reefs faster than they can grow. Examining areas prone to siltation is important when selecting oyster restoration sites.

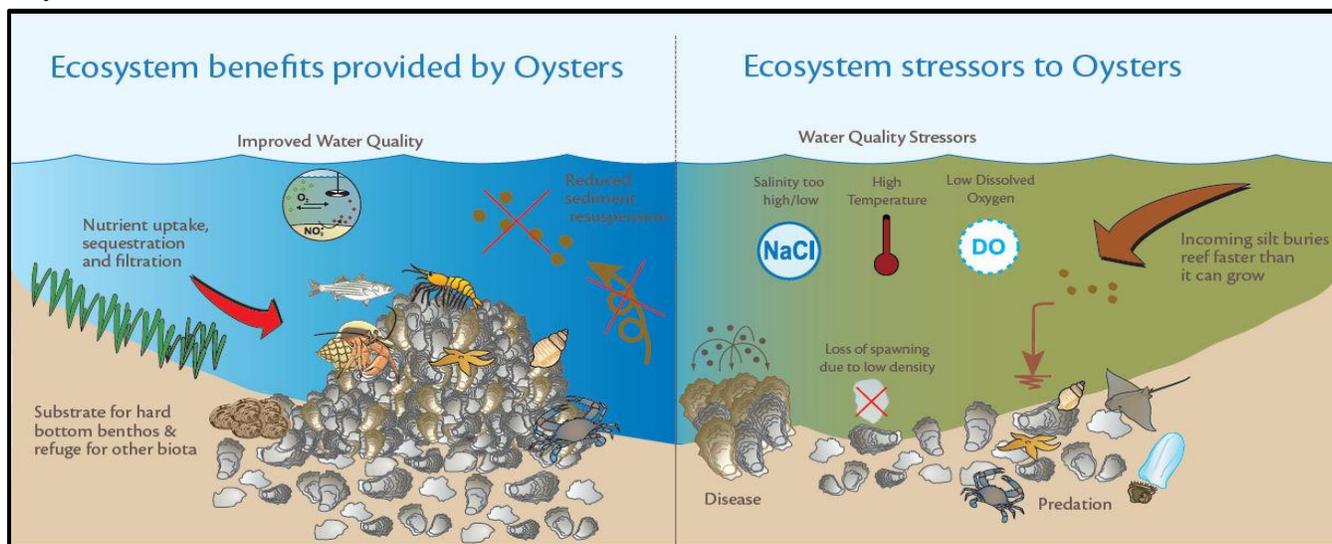


Figure C-8: Illustration showing that maintaining healthy oyster reef habitats can provide ecosystem wide benefits including improved water quality and reduced sediment resuspension.

- Sedimentation gradually alters the prevailing hydrology within the estuary. A regular and consistent daily tidal exchange is important for a healthy estuary ecosystem. The tides influence salinity levels across the estuary, which has an effect on marsh and oyster reef habitats. Maintaining a proper salinity balance is also essential to killing off bacteria that enter the estuary. Sedimentation can reduce the tidal exchange in the far reaches of the estuary near Sea Mountain Hwy and other tidal creeks that drain into the estuary. This diminished tidal exchange gives the bacteria entering the estuary a better chance to persist in the aquatic environment.

D. Boating:

Boating is a popular recreational activity in the Little River/ Cherry Grove area. While there are no marinas within Hog Inlet and Dunn Sound Creek, SC DNR maintains Cherry Grove Park and Boat Ramp, on 53th Ave North. This is a very popular boat ramp, providing direct access for boaters to Hog Inlet. The Cherry Grove canal system is designed to allow homeowners access to Hog Inlet via their private docks. SC DNR enforces the state's boating regulations which covers the illegal discharge of sewage from boating vessels. Given the shallow depths and narrow channels within Hog Inlet, boats that typically are big enough to have onboard sanitary sewer systems are generally uncommon. While this is an unlikely bacteria source in Hog Inlet, the suspicion of illegal discharge should be reported and all means of enforcing the regulations should be pursued when known incidents have occurred.

Another concern associated with boating is the generation of wakes near sensitive marsh areas. Wakes can exacerbate erosion rates along exposed shorelines and can also resuspend sediment particles in the water column. As noted in the subsection above, sediments are known to be a good medium for bacteria survival and propagation. Properly enforcing no-wake zones for boats and jet skis can help minimize these impacts.



Figure C-9: Boating is a popular activity in the Cherry Grove area. Following the state boating laws is important not only for public safety purposes but also to ensure the protection of the watershed environment.

III Conclusion:

The primary purpose of this element is to take a holistic view of the watershed and identify each of the potential bacteria sources that must be accounted for in pursuing water quality improvements within Hog Inlet and Dunn Sound Creek. For each management strategy discussed in **Element G: Recommended Watershed Management Measures**, part of the selection and design of each BMP should evaluate the source of bacteria that will be minimized or the transport mechanism that will be mitigated by the implementation of each specific BMP. The next element examines water quality trends within Hog Inlet and Dunn Sound Creek, primarily by reviewing water monitoring samples collected by SC DHEC's Shellfish Program.

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Element D: Fecal Coliform Data Trends

Water quality monitoring is an essential tool for water resource managers to help them understand the current health of a local waterbody and to detect trends that would require a management response. Water quality monitoring is also critical in evaluating the success of a water quality project or initiative. This element will review data collected by the SC DHEC Shellfish Program as well as provide a summary of a microbial source tracking study recently completed by the Environmental Quality Lab at Coastal Carolina University. The DHEC data provides the regulatory basis for shellfish harvesting classifications across the state. The purpose of the microbial source tracking study was to determine whether human sourced bacteria is present in the estuary and to also assess the influence of wet weather events on bacteria levels in Hog Inlet.

I. SC DHEC Shellfish Management Area 01 Data Review

Currently, SC DHEC collects water quality samples monthly at nine monitoring stations in Hog Inlet and Dunn Sound Creek as part of a regulatory program to ensure that shellfish resources are safe for the public to harvest and consume. In total, there have been 20 different monitoring site locations that have been sampled in this area since 1992. **Figure D-1** displays the number of sites that DHEC has monitored each year since 1992.

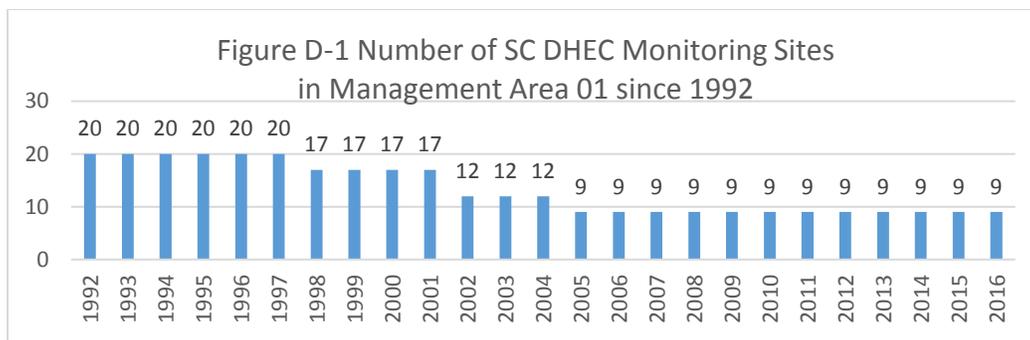


Table D-1 provides a list of all the monitoring stations that have been sampled as part of the SC DHEC Shellfish Management Program in Hog Inlet/Dunn Sound Creek along with the number of samples collected at each site since 1992. The majority of this element and the watershed plan as a whole will reference the nine active monitoring sites, as those sites determine the current shellfish harvesting restrictions within Management Area 01.

Table D-1 History of Sampling at Monitoring Sites Located within DHEC Shellfish Management Area 01		
Monitoring Site #	Years Sampled	# of Samples Total
01-01	January 1992-present	278
01-02	January 1992-present	278
01-03	January 1992- January 2002	109
01-04	January 1992- October 2005	155
01-05	January 1992-present	278
01-06	January 1992-present	278
01-07	January 1992-present	278
01-08	January 1992- October 2005	155
01-09	January 1992- October 2005	155
01-10	January 1992- January 2002	109
01-11	January 1992 – June 1998	67
01-12	January 1992 – June 1998	67
01-13	January 1992 – June 1998	67
01-14	January 1992-January 2002	110
01-15	January 1992-January 2002	110
01-16	January 1992-January 2002	110
01-17	January 1992-present	280
01-17A	January 1992-present	281
01-18	January 1992-present	281
01-19	January 1992-present	280

Note: Information provided by SC DHEC Shellfish Program Staff

This element reviews the water monitoring data collected by SC DHEC and provides a summary of water quality trends since 1992. At the outset of the data analysis process the following pertinent questions were identified to help focus the scope of the data set review:

- Which monitoring sites have had persistently high fecal coliform levels in the period of record?
- Which monitoring sites have the greatest chance of meeting the fecal coliform standard within the next 5-10 years?
- Is there a correlation between fecal coliform levels and other variables such as turbidity, salinity, and precipitation preceding the sampling date?
- Are there any unusual data trends at a particular monitoring site or during a period of sampling dates that stand out from the rest of the data set?

This element will provide an interpretation of the available data to help answer these questions which will ultimately help to prioritize management efforts in the watershed. Appendix D provides a summary profile of the data collected at each monitoring site. The following section provides a series of tables comparing the monitoring sites across Management Area 01.

Table D-2 compares the median fecal coliform levels for each of the monitoring sites from 1992-2016 as well as 2013-2016, which is the period by which SC DHEC made its most recent management decision regarding shellfish harvesting classifications. Through the entire period of record, fecal coliform levels are relatively low. In fact Sites 01-01, 01-07, 01-17A, 01-18, and 01-19 are all within both the geometric mean (14 MPN/100ml) and the 90th percentile (43 MPN/100ml) standards. The 2013-2016 three year period indicates that higher levels of fecal coliform are being observed across the estuary. In that time period none of the monitoring sites are within the geometric mean threshold and each site had a higher median in the 3-year subset in comparison to the entire period of record. Site 01-01 saw the greatest increase in fecal coliform median levels over the past 3 years with a median of 32 MPN in comparison to a median of 13 MPN for the entire period of record. It is important to note that Site 01-01 is located at the mouth of Little River Inlet, which receives significant freshwater inputs upstream from Little River Inlet and the Atlantic Intracoastal Waterway. Site 01-01 only has a small hydrological connection with the Dunn Sound Creek.

Table D-2 Comparison of Median Fecal Coliform Levels at each Monitoring Site within Management Area 01		
Monitoring Site	Median Fecal Coliform Level- 1992-2016	Median Fecal Coliform Level- Previous 3 Years, February 2013-February 2016
01-01	13 MPN	32 MPN
01-02	23 MPN	39.5 MPN
01-05	23 MPN	33 MPN
01-06	21 MPN	34.5 MPN
01-07	7.8 MPN	15.5 MPN
01-17	17 MPN	23 MPN
01-17A	13 MPN	19 MPN
01-18	8 MPN	19.5 MPN
01-19	13 MPN	17 MPN

Note: Based on samples taken by SC DHEC from January 1992 through February 2016
 Fecal Coliform Standard for Approved Classification: Geometric mean: 14MPN/100ml 90th Percentile: 43MPN/100ml

Table D-3 summarizes the frequency of exceedingly high fecal coliform levels observed at the SC DHEC monitoring stations. A threshold of 260 MPN/100mL was selected for evaluation, because any sample above that level exceeds all regulatory standards established under SC DHEC's Shellfish Management program. Under a permit issued by DHEC, shellfish are allowed to be relayed and depurated from locations that have fecal coliform levels between 44 MPN/100mL and 260 MPN/100mL. Anything above that threshold is completely off-limits to any kind of harvesting. On the whole, the frequency of excessively high fecal coliform levels in Management Area 01 is relatively low. Even site 01-02 which had 19 samples above 260 MPN/100ml still only exceeded that threshold on average of less than one time per year. However, the data does suggest that high level readings are more regularly observed during the three year sampling

period of February 2013- February 2016. Although, site 01-07 did not have any samples above that threshold during that timeframe.

Monitoring Site	#/% of Samples Greater than 260 MPN/100 mL Fecal Coliform- 1992-2016	#/% of Samples Greater than 260 MPN/100 mL Fecal Coliform- 2013-2016
01-01	14 samples/ 5.0% of total samples collected	3 samples/ 8.3% of total samples collected
01-02	19 samples/6.8% of total samples collected	4 samples/ 11.1% of total samples collected
01-05	16 samples/5.8% of total samples collected	3 samples/8.3% of total samples collected
01-06	15 samples/5.4% of total samples collected	5 samples/ 13.9% of total samples collected
01-07	4 samples/ 1.4% of total samples collected	No samples have exceeded 260 MPN/100mL
01-17	11 samples/3.9% of total samples collected	2 samples/ 5.6% of total samples collected
01-17A	11 samples/3.9% of total samples collected	2 samples/5.6% of total samples collected
01-18	5 samples/1.8% of total samples collected	2 samples/ 5.6% of total samples collected
01-19	8 samples/ 2.9% of total samples collected	2 samples/5.6% of total samples collected

Note: Based on samples taken by SC DHEC from January 1992 through February 2016
 Shellfish harvesting is allowed for the purpose of relaying and depuration at monitoring stations with measurements between 44 MPN/100ml and 260 MPN/100ml.
 Shellfish harvesting is completely off limits at monitoring stations with measurements above 260 MPN/ 100ml

The 23 samples that exceeded 260 MPN/ 100mL between February 2013 and February 2016 were obtained over nine sampling dates. Table D-4 analyzes the relationship between those sampling dates and the amount of precipitation that preceded the sampling date. It appears by the data reviewed, that rain is not always the sole determining factor in the fecal coliform levels observed. As an example on December 15, 2014, six of the nine sampling sites exceeded 260 MPN/100mL. However the last rainfall event preceding the sampling date was on December 9, 2014 and the rainfall totals were modest- 0.17 inches between December 6-9, 2014. All of the samples had salinity levels between 24-34 psu which is not indicative of a significant freshwater input that may have influenced bacteria levels.

Sampling Date	Monitoring Sites Exceeding 260/100mL	Precipitation prior to sampling
April 15, 2013	01-02, 01-06	0.53in on 4/14-15 and 1.69in on 4/12
December 16, 2013	01-17, 01-18	0.25in on 12/13-14
August 18, 2014	01-01, 01-06	0.05in on 8/18 and 0.2in on 8/16
December 15, 2014	01-01, 01-02, 01-05, 01-17, 01-17A, 01-19	Last rain on 12/9- 0.01in. and 0.07in on 12/8
March 2, 2015	01-19	Last rain on 02/10- 0.04 in
May 13, 2015	01-17A	5.55in between 5/7-12
June 8, 2015	01-06	1.67 in between 6/3-5
July 6, 2015	01-01, 01-02, 01-05, 01-06, 01-18	0.97in on 7/3-4
February 8, 2016	01-02, 01-05, 01-06	1.11in on 2/7 and 3.17 in between 2/3-6.

Shellfish harvesting is allowed for the purpose of relaying and depuration at monitoring stations with measurements between 44 MPN/100ml and 260 MPN/100ml.
 Shellfish harvesting is completely off limits at monitoring stations with measurements above 260 MPN/100ml

One of the immediate observations in analyzing a fecal coliform data set is the variability in measurements from one sampling date to the next. This can make it difficult to determine whether fecal coliform levels are increasing or decreasing over time. That is clearly evident when you look at the scatter plot graphs of each of the monitoring site profiles included in **Appendix D**. To help visualize the long-term fecal coliform trends a linear trendline was calculated in excel and displayed on each of the scatter plot graphs. Table D-5 summarizes the trendline patterns for each of the monitoring sites for the entire data set, February 1992-February 2016. The trendlines indicate that 7 of the 9 monitoring sites have shown trends of increasing levels of fecal coliform bacteria over the period of record. However, the increase appears to be modest at most of the sites.

Table D-5 Summary of Linear Trendlines of Scatter Plot Graphs for Management Area 01 Monitoring Sites.

Monitoring Site	Trendline Direction
01-01	Increasing
01-02	Increasing
01-05	Increasing
01-06	Increasing
01-07	Decreasing
01-17	Increasing
01-17A	Decreasing
01-18	Increasing
01-19	Increasing

Note: Based on samples taken by SC DHEC from February 1992 through February 2016. See Appendix D for scatter plot graphs of each of the monitoring site data sets.

II. Summary Findings from the Hog Inlet Microbial Source Tracking Study

Prior to the Cherry Grove canal dredging project in the fall of 2016, North Myrtle Beach and Horry County stormwater management personnel wanted to get a baseline assessment of water quality conditions in Hog Inlet before dredging operations commenced. The Environmental Quality Lab at Coastal Carolina University was contracted to collect and analyze water samples in both antecedent dry and wet weather conditions. Samples were collected at eight sites throughout the estuary. Four of the sampling locations were at current SC DHEC sampling stations. Four additional sampling sites were utilized to obtain data from the northern extent of Hog Inlet at the Waties Island Causeway to the southern extent of the estuary at Sea Mountain Highway. These sites were also located close to the upland shoreline and selected to represent the variety of land use types within the watershed. **Table D-6** provides a location description for each of the sampling locations.

Table D-6. Sampling locations for the Hog Inlet - Cherry Grove Microbial Source Tracking Study.

SC DHEC Shellfish Management Area Water Quality Sampling Stations	
01-17	42nd Avenue - Cherry Grove (collected at Fishermans Wharf dock)
01-17A	53rd Avenue Bridge on Canal- Cherry Grove (collected at East side of bridge)
01-18	Dunn Sound at Hog Inlet (collected at Doulaveris Retreat dock)
01-19	53rd Avenue at Main Creek- Cherry Grove (collected at Cherry Grove Boat Ramp dock)
Additional sampling stations	
JCR	Jack's Circle Road at House Creek (collected beside Creekside Clubhouse)
SGB	Sea Gull Boulevard at Williams Creek (collected on path at picnic tables)
SMH	Sea Mountain Highway at Nixon Creek (collected at Nixon Creek culvert)
WIC	Waties Island Causeway at Dunn Sound Creek (collected at east side of bridge)

A corresponding sampling location map is included in the Exhibit below:



Water samples were collected during three dry and three wet events, categorized using established US EPA stormwater protocols. For this study, dry weather events were defined as a 72 hour dry period with less than 0.1 inches of rainfall prior to sampling. Wet weather events were preceded by at least 72 hours of dry weather, with a minimum precipitation of at least 0.25 inches of rainfall within a 4 hour period before sampling. The wet weather samples were collected on 8/18/2016, 9/23/2016 and 9/27/2016. Dry weather samples were collected on 8/3/2017, 8/24/2016, and 9/7/2016.

Microbial source tracking analytical techniques were used to determine whether human-sourced bacteria are present in water samples collected from Hog Inlet. Seven chemical and biological tracers were used in a weight of evidence approach to evaluate and compare the water quality conditions at each of the eight monitoring sites. The tracers used are described in **Table D-7** below.

Table D-7 Tracers used during Hog Inlet Microbial Source Tracking Study		
Tracer	Description/Purpose	Water Quality Standard
Human-sourced <i>Bacteriodes</i> (BacHum)	Samples for qPCR analysis were selected in consultation with Horry County and North Myrtle Beach officials. They were chosen based on the strongest evidence of fecal contamination. Out of the 53 total water samples, 26 were selected for qPCR analysis using the BacHum and GenBac assays. The BacHum assay detects human-sourced bacteria markers.	Measured as # genome copies/ 100 mL > 100 is considered very high < 10 is considered low
<i>Bacteriodes</i> (GenBac)	Similar purpose as BacHum tracer described above. The GenBac assay detects a broader class of bacteria from warm-blooded animals.	Measured as # genome copies/ 100mL > 6250 is considered very high < 2275 is considered low

Table D-7 Tracers used during Hog Inlet Microbial Source Tracking Study, Continued

Tracer	Description/Purpose	Water Quality Standard
Enterococci	This is the saltwater recreational water quality standard as established by SC DHEC.	Measured as Most Probable Number (MPN)/ 100mL The single sample standard is >104 MPN/100mL. Permanent advisories are posted at sites that have exceeded this level in more than 10% of samples collected over a 5 year period. Advisories are also issued if a single day maximum value of >500 MPN ml is measured.
Fecal Coliform	This is the regulatory standard for designated Shellfish Harvesting Areas as established by SC DHEC	Measured as Most Probable Number (MPN)/ 100mL To obtain Approved harvesting classification monitoring sites must have geometric means less than 14 MPN per 100mL and an estimated 90 th percentile below 43 MPN mL.
Caffeine	This tracer is an indication of human wastewater as it is detectable in human urine.	Measured as # nanograms (ng)/mL Minimum detection limit is 0.175ng/ml > 0.4ng/mL suggests presence of significant human inputs
Turbidity	Turbidity provides an indication of the level of land derived sediment loads or resuspended sediments within the water column. Previous studies have indicated a correlation between fecal bacterial contamination and increased turbidity as fecal bacteria often bind to sediment particles. Turbidity levels are commonly higher during the wet-weather sampling dates.	Measured as NTU Nephelometric Turbidity Unit/100mL Considered elevated > 25 NTU. (SC DHEC regulatory standard for estuarine and saline waters)
Salinity	Analyzed to evaluate comparative levels of freshwater inputs throughout the system. Larger open water areas that are strongly tidally influenced generally have higher salinity levels than upstream smaller creeks and tributaries. Salinity levels are generally lower during the wet-weather sampling dates.	Measured as psu (practical salinity unit) >30 psu indicative of insignificant freshwater inputs <15 psu indicative of substantial freshwater inputs

Source: Hog Inlet, Horry County, Microbial Source Tracking Study- Final Report, Coastal Carolina University

Below is a summary of the data observed for each of the parameters analyzed in this study.

A. Salinity: SC DHEC sites 01-17, 01-17A, 01-18, and 01-19 are all located in larger creeks within the estuary and are strongly tidally influenced. Therefore, salinity levels were comparable to ocean salinity values. Monitoring sites JCR and CVL are located at upstream creek sites, which are more likely to be influenced by freshwater inputs from stormwater runoff and groundwater flow. Site WIC has a hydrological connection with Little River Inlet which tends to have salinity levels more consistent with freshwater systems. The SMH site is influenced by an impoundment with lower salinity flows during periods of an ebb tide. All of the SC DHEC sites maintained salinity levels above 30.0 psu in both the dry and wet weather samples. This indicates that the influence of freshwater inputs is insignificant at these sites. Sites CVL and JRC maintained salinity levels above 30 psu except for the wet weather sample taken on 8/18/2016 (CVL measured 21.8 psu and JRC measured 19.9 psu on that sampling date). Site SMH consistently had the lowest salinity levels with a mean of

16.2 psu during the dry weather samples and 6.18 psu during the wet weather samples. As anticipated, the WIC site showed some influence of freshwater input especially during wet weather events. The mean was 26.5 psu for the dry weather samples and 21.0 psu for the wet weather samples.

B. Turbidity: A consistent finding across all sampling sites was that turbidity levels were considerably lower during the dry weather sampling dates. The JCR site showed the greatest levels of turbidity with a mean of 95.3 NTU during wet weather samples. The next highest levels were observed at the WIC site with a mean of 35.7 during the wet weather sampling dates. As indicated in **Table D-7** a turbidity measurement above 25 NTU is considered elevated and above the established water quality standard. The CVL site (33.3 NTU) was the only other sampling site with a mean above 25 NTU during the wet weather sampling dates.

C. Caffeine: Values above the reporting limit were inconsistent between dry and wet weather samples. Caffeine was detected in 9 of the 23 samples taken during the dry weather events. Caffeine was detected in all three dry weather samples collected at site 01-18. Only 3 of the samples were above the 0.4 ng/ml threshold of concern. Two of these samples were from the JCR site while the third was one of the samples from site 01-18. Only 4 of the 23 wet weather samples had detectable levels of caffeine and only one sample at site 01-18 was above the 0.4 ng/ml threshold.

D. Fecal Indicator Bacteria: Samples were analyzed for four indicators of bacteria. A summary of findings for each indicator is provided below.

Enterococcus: There was a stark difference between Enterococcus levels measured during the dry sampling events and the wet sampling events. During the dry weather events, all of the samples were consistently within the water quality standards except for monitoring sites SMH and JCR. At SMH, each of the samples was above the 104 MPN/100mL advisory standard and the sample collected on August 8, 2016 was 1,178 MPN/100mL, more than double the single day advisory standard of 500 MPN/100mL. At JCR, two of the three dry weather samples exceeded the 500 MPN/100mL standard. During the wet weather events 17 of the 24 total samples collected exceeded the 104 MPN/100mL standard and all 8 of the monitoring sites exceeded the standard at least once. On the August 18, 2016 sampling date, site 01-17A recorded a measurement of 4,352 MPN/100mL.

Fecal Coliforms: Measurements during wet weather events were also noticeably higher than dry weather events for Fecal Coliform bacteria as well. Sites JCR and SMH were once again noticeably higher than the remainder of the sampling sites. The dry sampling mean measurements for sites 01-17, 01-17A, 01-18, 01-19, and CVL were all within the geometric mean (14 MPN/100mL) and 90th Percentile (43 MPN/100mL) water quality standards for shellfish harvesting areas. During the wet weather samples only sites 01-18 (27 MPN/100mL) and 01-19 (29 MPN/100mL) had mean measurements within the 90th percentile regulatory standard.

GenBac MST Assay: Sources of fecal bacteria from warm-blooded animals were detected in all 26 of the samples selected for qPCR analysis. Similar to the fecal coliform and enterococcus levels observed in this study, the GenBac assay had stronger positive signals in the wet-weather sample subset. As before, the JCR, SMH, and WIC sites had the highest positive indication for the GenBac assay.

BacHum MST Assay: Out of the 26 water samples selected for qPCR analysis, only one sample yielded a positive detection for human-sourced bacteria. The sample that the BacHum assay detected positive was collected during the wet weather event on September 27, 2016 at the WIC site. It was a low level detection of 2 genome copies/ 100mL. Above 100 genome copies per 100mL is considered high.

The following are findings from the report that have implications on the prioritization of management efforts in Hog Inlet, which will guide many of the recommendations outlined in this watershed plan.

- The only monitoring site that had any detection of human-sourced bacteria from the BacHum assay was at the Waties Island Causeway location, and the level of detection was low. This site is located just outside of the main Cherry Grove/Hog Inlet watershed. Based on the lack of evidence of human bacteria and the strong evidence of

the GenBac marker data, it appears that the bacteria contamination observed in the estuary is of non-human origin.

- There appears to be a strong correlation between precipitation and bacteria levels. Smaller creeks and tributaries which are more likely to receive greater volumes of freshwater inputs from stormwater runoff are more likely to exceed the water quality standards for enterococcus and fecal coliform.
- The Jack Circle Road and Sea Mountain Hwy sites were consistently high for turbidity, fecal coliforms, Enterococcus, and warm-blooded animal feces (excluding human-sourced bacteria). Levels for each of these parameters was high, even during the dry weather sampling dates. It is worth evaluating the need to prioritize these areas of the watershed for future management activities.

III. Summary Review and Conclusions of Monitoring Results

The following section is a review of the questions posed at the beginning of the element. This analysis provides guidance on management implementation priorities. While this data analysis is thorough and very insightful there are still unknowns regarding water quality conditions in the Hog Inlet estuary. **Element I** outlines recommendations for future monitoring needs to continue to increase our knowledge of the estuary and to evaluate the impact of management strategies that are implemented.

- **Which monitoring sites have had persistently high fecal coliform levels in the period of record?**

Currently all of the monitoring stations within Management Area 01 exceed both the geometric mean and the 90th percentile standards for Approved harvesting classification. However, sites 01-06, 01-07, and 01-18 all have met each of the standards within the past five years. Also, none of the sites appear to be elevated to a point where a concerted management effort cannot help improve water quality. With that said, sites 01-02, 01-05, 01-06, and 01-17 all have a median fecal coliform level above the geometric standard of 14 MPN/100mL through the whole data set. As noted in **Table D-2**, sites 01-01, 01-02, 01-05, and 01-06 all have median fecal coliform levels above 30 MPN/100mL over the most recent three years of available data and therefore should be monitored closely moving forward. On a positive note, the microbial source tracking study indicated that human sourced bacteria does not appear to be an immediate concern in the Hog Inlet estuary.

- **Which monitoring sites have the greatest chance of meeting the fecal coliform standard within the next 5-10 years?**

Since monitoring sites 01-06, 01-07, and 01-18 all met both the geometric mean and 90th percentile standards as recently as 2011, it gives reason to believe that it is possible to return to those levels once again. The scatter plot graph trendline analysis also indicated that fecal coliform levels at sites 01-07 and 01-17A are decreasing over time, making each of those sites possible candidates to meet the Approved harvesting classification standard within a ten-year period.

- **Is there a correlation between fecal coliform levels and other variables such as turbidity, salinity, and precipitation preceding the sampling date?**

The Hog Inlet Microbial Source Tracking Study was very beneficial in validating some of the suspected drivers of fecal coliform levels in the estuary. The study was designed to collect samples during dry conditions as well as during wet weather events. Bacteria levels were noticeably higher for both fecal coliforms and enterococcus at each of the sites during wet weather events, with the exception of Jack Circle Road where dry and wet weather samples were comparable. The study also indicated that turbidity levels were consistently higher in the wet weather samples and there was a positive statistical relationship between turbidity and the fecal coliform and enterococcus values measured. The study also revealed that monitoring sites that are located in upstream areas and tend to have lower salinity values can be prone to high fecal coliform levels. The Sea Mountain Highway site showed the strongest correlation between low salinity values and elevated bacteria levels. This site is adjacent to a freshwater impoundment that discharges into the southern end of Hog Inlet.

- **Are there any unusual data trends at a particular monitoring site or during a period of sampling dates that stand out from the rest of the data set?**

With such a large data set dating back to 1992 it is easy to find anomalies in a single sampling date, especially since fecal coliform bacteria can be so variable. As discussed earlier in the element, on some sampling dates the fecal coliform levels are noticeably high without any evidence of a correlating factor such as precipitation or salinity that would contribute to the high readings. The December 9, 2014 DHEC sampling date stands out as six of the nine sampling sites were well above 260 MPN/100mL. In fact, five of the sites measured over 1,600 MPN/100mL. There was little to no rain prior to the sampling date that would attribute to these numbers. This is why anecdotal evidence from active watershed users can be helpful in providing insight into unusual or suspicious water quality conditions that are observed.

IV. Prioritization of Monitoring Sites for Management Purposes

The SC DHEC monitoring data set, along with the microbial source tracking study results, provided the planning team with a wealth of information about current water quality conditions and past trends within Hog Inlet. An immediate challenge is determining where to begin management efforts in the watershed. Based on the analysis of the monitoring data, the planning team evaluated each DHEC site and prioritized them into 3 Tiers. A general description of each Tier is provided below:

Tier One Priority Sites: 01-07, 01-18, 01-19, 01-17A, 01-17

These are the highest priority sites for future management purposes. Sites 01-07, and 01-18 were two of the most recent sites to meet the Approved shellfish harvesting classification standards. As **Table D-2** indicates, Sites 01-07 and 01-18 have fairly low median fecal coliform levels, both historically and in the past three years. Reductions needed to achieve Approved status once again might be much more realistic than other sites within Management Area 01 that have a longer history of elevated bacteria levels. Site 01-17 is the closest sampling location to the Sea Mountain Highway site that was sampled during the microbial source tracking study. This site also had consistently high turbidity and bacteria indicators in both wet and dry weather sampling events. DHEC Monitoring Site 01-19 was also sampled in the microbial source tracking study. This site is located in the main channel of Hog Inlet near the SC DNR boat landing at 53rd Ave N, one of the busiest areas for water-based recreation in the estuary. Since this site is both highly visible and centrally located within the watershed, it is an important site to regularly sample and closely monitor water quality trends at this site. In both the DHEC data review and the microbial source tracking study, bacteria levels at this site seem to be fairly stable. The microbial source tracking study also indicated that among the four DHEC sites sampled, 01-19 had the highest mean salinity levels in both wet and dry sampling events and turbidity levels well within the regulatory water quality standards. Both of these parameters provide indication that issues with sedimentation and large volumes of stormwater runoff are less of a concern at this site. Finally, monitoring site 01-17A is located on the 53rd Ave bridge over the Cherry Grove canal. It is anticipated that the recent dredging in the fall of 2016 will likely have a significant impact on the hydrology within this portion of the estuary as well as the fecal coliform levels at this monitoring site. Regularly reviewing the data trends at site 01-17A will help watershed managers assess the impacts of dredging on water quality in Hog Inlet.

Tier Two Priority Sites: 01-05, 01-06

After a review of the available SC DHEC data set, the planning team decided to designate monitoring sites 01-05 and 01-06 as Tier Two Priority Sites. Site 01-05 is located in the far downstream portion of Dunn Sound Creek before it enters Little River. The site is adjacent to Tilghman Point, which is primarily undeveloped open space. New BMP options are limited in this area. Site 01-05 is particularly important because if it ever does meet the fecal coliform standards, it would open up a significant acreage of oyster reef habitat to harvesting. Site 01-06 is the closest SC DHEC site to the Jack Circle Road site in the microbial source tracking study which indicated some concerns related to bacteria, salinity and turbidity, likely requiring additional stormwater management measures along this portion of Little River Neck Road. However, it is suspected that site 01-06 is influenced primarily by wildlife sources of bacteria, limiting some of the stormwater management options that may be available in close proximity to the site.

It will be important for the planning team to closely review data trends at these sites in the future. If either site shows indications of significantly increasing fecal coliform levels, then the watershed plan implementation committee should consider redesignating them as Tier One sites. Also if significant progress is made on the Tier One sites listed above, then watershed managers can begin to shift their focus on these two sites. Also, it should be noted that BMPs will still be pursued in upstream drainage basins adjacent to these sites as opportunities present themselves.

Tier Three Priority Sites: 01-01, and 01-02

These are the lowest priority sites for future management purposes. The primary reason is due to their location within SC DHEC Shellfish Management Area 01. Site 01-01 is located near the mouth of Little River Inlet, therefore has very little hydrological connectivity with Hog Inlet and Dunn Sound Creek. Site 01-01 is more predominantly influenced by upstream flows from the Little River Inlet, Calabash River, and the Atlantic Intracoastal Waterway. The closest portion of the focus area of this watershed plan is Waties Island, which has a limited number of potential BMPs that can be implemented. Also with such a large upstream drainage area, it is difficult to determine whether an increase or decrease in fecal coliform levels can be attributed to a management practice implemented within the Hog Inlet and Dunn Sound Creek watersheds. Site 01-02 is similarly on the northern edge of the watershed and is significantly influenced by freshwater inputs from Little River Inlet and Atlantic Intracoastal Waterway.

This element provides a wealth of information to guide the recommendations for future watershed management strategies in Hog Inlet and Dunn Sound Creek. The next element describes existing management resources and partnership activities that are occurring within the watershed. The remainder of the document outlines long-term implementation activities designed to improve water quality within the estuary.

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Element E: Existing Water Resource Management Programs

While improving water quality in Hog Inlet and Dunn Sound Creek will entail numerous projects and initiatives, it will not be necessary to start completely from scratch. Both North Myrtle Beach and Horry County have made water quality protection a top priority in the provision of services, enforcement of regulations, and in the design of public infrastructure projects. There are also resources available throughout the region and state that can be utilized for public education purposes, research opportunities, and other beneficial partnerships. This element describes some of the programs and initiatives that are already in place or readily available to water resource managers working in the watershed.

I. Municipal Separate Storm Sewer System- MS4 Permit:

In an effort to reduce the negative impacts associated with stormwater runoff on nearby waterbodies, the EPA developed the MS4 permit program to address these challenges. Phase I of the MS4 permit program began in 1990 and initially focused on larger urban cities and regions with a population greater than 100,000. Currently, SC DOT, the City of Columbia, Greenville County, and Richland County are designated as Phase I MS4 jurisdictions, and must comply with an individual National Pollutant Discharge Elimination System (NPDES) permit. Phase II of the MS4 program took effect in 1999 and incorporated smaller urbanized areas into the program. Horry County and North Myrtle Beach are two of more than seventy regulated small MS4s in South Carolina. Each jurisdiction complies with the state General NPDES permit (SCR03000), which DHEC updates and renews every five years.

As a small MS4 permitted entity, Horry County and North Myrtle Beach must oversee a stormwater management program to address the following six minimum control measures. They are listed and briefly explained below:

- 1. Public Education and Outreach:** MS4s are required to develop programs to educate the public about the impact of stormwater discharges on local waterways and steps that they can take as citizens or business owners to reduce contamination of stormwater.
- 2. Public Participation and Involvement:** To further increase the positive impacts of public engagement, MS4 permit holders are required to develop initiatives that actively engage citizens in stormwater improvement programs. Both North Myrtle Beach and Horry County are members of the Coastal Waccamaw Stormwater Education Consortium which utilizes regional partners to plan and host events aimed at educating members of the public about stormwater related issues in our coastal region. Horry County has a Council-appointed Stormwater Advisory Board and both Horry County and North Myrtle Beach have Keep America Beautiful chapters which frequently host cleanup events meeting the criteria of this minimum control measure.
- 3. Illicit Discharge Detection and Elimination:** The primary objective of this requirement is to develop mechanisms to identify and respond to incidents of contaminated non-stormwater discharges entering the storm drainage system. The MS4 must maintain a map of the storm drain system and establish enforcement mechanisms to hold known polluters responsible. Staff must be properly trained to detect common pollutants, such as oils, chemicals and sewage, as well as their sources.
- 4. Construction Site Runoff Control:** This measure requires MS4s to enact ordinances or other regulatory mechanisms to control runoff from active construction sites that cause land disturbances of greater than one acre or less than one acre if the site is part of a larger common development plan. As a coastal county, this regulation applies to construction sites within a ½ mile of a receiving waterbody that cause a land disturbance of greater than ½ acre. One of the main concerns that needs to be addressed by developers is designing onsite controls to minimize erosion and stabilize disturbed soils.
- 5. Post-construction Site Runoff Control:** MS4s are required to institute provisions within their development regulations to ensure that stormwater control measures be installed to minimize runoff volumes and protect water quality as part of the site design of a new development project.
- 6. Pollution Prevention/ Good Housekeeping:** This measure establishes stormwater best management practices that the permitted MS4 entity pursues in the operation of services and/or management of municipal facilities and properties. It also outlines a plan for how each MS4 will maintain their respective drainage system.

II. Cherry Grove Canal Dredging Project

As a result of long-term siltation, the Cherry Grove canal system extending from 39th Ave N to 63rd Ave N has become unnavigable in many locations, especially during low tide conditions. An extensive dredging project was proposed and ultimately approved by North Myrtle Beach City Council and permitted by the Army Corps of Engineers. The dredging project commenced in October 2016 and was completed in the Spring of 2017.

In addition to the enhancements provided to boaters and property owners within the dredging project area, it is anticipated that there will be some ancillary long-term water quality improvements observed following the dredging project. As explained in **Element C: Fecal Coliform Source Identification**, sedimentation can create conditions favorable for the survival of bacteria in the aquatic environment. Bacteria tends to bind to sediment particles which can enter the estuary as erosion occurs. Sediment can shelter bacteria from UV light which can naturally disinfect bacteria. Finally, over time the hydrology within the estuary changes as sedimentation builds up and the channels within the Cherry Grove canal system become shallower. Salt water acts as another natural disinfectant but its effectiveness is reduced as the hydrology is altered, particularly in the upper reaches of the estuary where a full daily tidal exchange can become more limited as sedimentation increases.

The dredging project removed large volumes of sediment and opened up both the main channel of Hog Inlet as well as all of the finger canals within Cherry Grove, thereby significantly improving the tidal exchange throughout a substantial area of the estuary. SC DHEC monitoring sites that should be carefully analyzed for fecal coliform bacteria trends following the dredging project include 01-17, 01-19, 01-17A, 01-18, and 01-07. It is very likely that in the first 6-12 months, fecal coliform levels could be elevated since the dredging project will disturb and resuspend sediments into the water column. However, it is anticipated that long-term fecal coliform levels will decrease as long as bacteria sources continue to be mitigated.



Figure E-1: General Boundaries of the Cherry Grove Dredging Improvement District



Figure E-2 Pipeline directing dredged material from the project site extending ultimately to the spoils site west of Little River Neck Road.

As part of the dredging permit issued by the Army Corps of Engineers, an oyster reef mitigation plan has been developed and will be executed after the dredging has been completed. The mitigation plan is intended to ensure that any oyster reefs disturbed during the dredging process will be properly mitigated by the establishment of an oyster reef restoration site within Hog Inlet. A total of 2.5 acres of oyster reefs will be restored at candidate sites currently being explored along House Creek, Nixon Creek, and Williams Creek. Site selection will be assessed by Dr. Keith Walters from Coastal Carolina University and all necessary approvals for oyster shell sources used to restore the reefs will be obtained from SC Department of Natural Resources. Restoration work is scheduled to begin in the fall of 2017 and will be monitored for three years to ensure that they have been successfully established. In addition to the oyster reef restoration work, there will also be marsh mitigation work completed at a site in Heritage Shores Park.

III. Complementary Planning Initiatives

Both Horry County and the City of North Myrtle Beach engage in several planning initiatives within their respective jurisdictions. Both entities have Planning Departments along with appointed Planning Commissions and other relevant boards. Included in their scope of responsibilities is to oversee the development and implementation of the Comprehensive Plan as well as the administration and enforcement of the zoning ordinance and other land use regulations.

It is the intention of the Hog Inlet- Dunn Sound Creek Watershed Plan to complement and support those planning documents and efforts. This section highlights issues and strategies outlined within these planning documents that have relevancy to the objectives of this watershed plan.

A. North Myrtle Beach Comprehensive Plan

The 2010 North Myrtle Beach Comprehensive Plan Update highlights several long-term environmental issues within the Hog Inlet watershed and identifies numerous resources and long-term strategies to ensure that water quality and natural resources protection is an ongoing priority for the community. Below is a summary list of items outlined in the Comprehensive Plan that apply to the activities recommended in this watershed management plan. The majority of the items below are included in the Natural Resources element while a few are found in the Land Use, Community Facilities, and Priority Investment elements.

- The Natural Resources Element highlights the importance of public lands and preserved open space areas to the City of North Myrtle Beach, including Waties Island, Russell R Burgess Jr. Coastal Preserve, and Heritage Shores Nature Preserve. These areas provide critical habitat to sensitive plant and animal species, offer direct public access to the Atlantic Ocean and Cherry Grove Marsh, and feature extensive interpretive signage enhancing public education and awareness of local environmental issues.
- The Cherry Grove dredging project has been an identified need in North Myrtle Beach planning documents for several years. It is highlighted within the Natural Resources Element and describes the need to take protective measures for limiting and mitigating any negative impacts to sensitive marsh areas.
- Tree preservation was cited as a priority issue in the Natural Resources Element. Tree planting can provide excellent stormwater management benefits by intercepting rainfall and slowing down stormwater runoff rates. Trees help to reduce erosion and are particularly beneficial in stabilizing shoreline areas. North Myrtle Beach has been very proactive by creating a Tree Planting Master Plan in 1999 and adopting tree preservation standards into the Zoning Ordinance in 2002. Most recently in 2009, the City enacted a complete streets policy, which requires the planting of new trees along street corridors within newly developed areas. North Myrtle Beach has participated in the Tree City USA program since 2006 and has established a Tree City Board to oversee this program and other tree preservation and planting initiatives.
- The ocean outfall program was cited within the Natural Resources Element and includes the proposed outfall location at 18th Ave North, which is described in greater detail later in this element.
- One of the stated goals within the Natural Resources Element is: “Protect the City’s sensitive natural areas, wetland habitats, and ecological diversity”. A corresponding strategy to meet this goal is to hire a consultant to perform a natural resources and water quality study of Cherry Grove Marsh to determine methods to restore water quality and protect shellfish beds. This watershed plan for Hog Inlet and Dunn Sound Creek is a major step in meeting this stated goal for the City of North Myrtle Beach.
- A recommendation outlined in both the Natural Resources Element and the Priority Investment Element is to develop a Special Area Plan for Little River Neck. The goal of the study would be to ensure that future development in this area is carefully planned to accommodate new development while preserving the unique natural and cultural resources within this area. This watershed plan supports sustainable development practices along Little River Neck with a particular focus of ensuring the water quality in the adjacent marsh areas in Hog Inlet and Dunn Sound Creek are protected.
- An implementation strategy highlighted within the Community Facilities Element is to implement low impact development techniques to improve water quality.

B. Horry County Comprehensive Plan

The Horry County Comprehensive Plan identifies several planning related issues within the watershed plan focus area or that pertain to concerns outlined in this plan. The following is a summary list of issues and corresponding recommendations documented in the Horry County Comprehensive Plan:

- In the Natural Resources Element, degraded water quality within the salt marsh areas of Cherry Grove was recognized as a concern. Shellfish harvesting restrictions near Waties Island and Cherry Grove were specifically mentioned.
- Septic tank suitability is identified as a countywide problem. Approximately 88 percent of Horry County has severe limitations for septic tank absorption fields due to soil drainage and other site conditions. Note that site scale evaluation should be conducted to determine septic tank suitability for individual properties.
- Urban forestry efforts are encouraged as one strategy to help control stormwater runoff along with several other benefits. On the county level, a Tree Preservation and Landscape Buffer Ordinance is in place to protect mature trees across the county.
- Several goals and implementation strategies that were developed to protect water resources in Horry County are outlined throughout the Comprehensive Plan.

IV. Pet Waste Campaigns



The City of North Myrtle Beach is very proactive in addressing improper pet waste disposal in the community. As of August 2016, the City of North Myrtle Beach has installed and maintains 48 pet waste stations throughout the city. In addition, the city has enacted an ordinance requiring pet owners to properly remove waste from public property.

Figure E-3 Pet waste station in a prominent and convenient location in Heritage Shores Nature Preserve Park

V. Stormwater Infrastructure Projects

The City of North Myrtle Beach Public Works Department and the Horry County Stormwater Department have displayed innovative leadership implementing their MS4 permit programming within their respective communities. In addition to meeting the basic requirements of their MS4 permit, they have invested in significant infrastructure projects to improve both drainage and water quality in several locations, including many within the Hog Inlet and Dunn Sound Creek watershed. Below is a profile of some of the work projects completed or in progress to date.

A. Pervious Surface Parking Lots

Parking facilities are a priority public infrastructure need within the watershed, particularly in the Cherry Grove Beach area, where visitors seek convenient access to the beach. As a means to reduce stormwater runoff rates and volumes while still meeting the parking demand along the oceanfront, the City of North Myrtle Beach has installed several pervious parking lots to enable stormwater to infiltrate onsite. North Myrtle Beach has utilized pervious concrete, brick paver, and coquina, all proven materials, at these parking locations. **Table F-1** lists the locations and materials used for each of the pervious parking lots within the Cherry Grove area. The City of North Myrtle Beach has also invested in street sweeping vehicles and maintains a regular schedule for sweeping roadways and public parking lots.

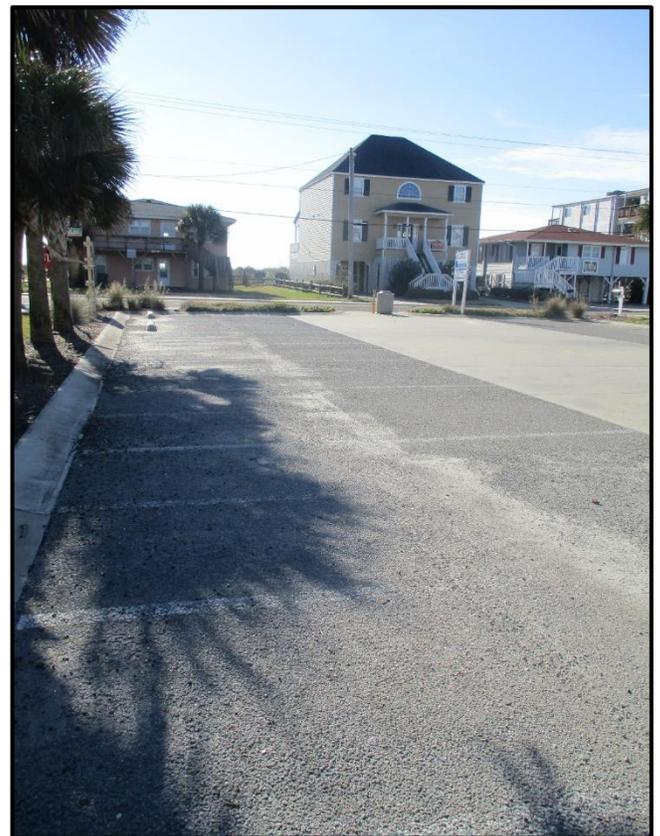


Figure E-4 Pervious concrete pavement at a beach access parking lot at 53rd Ave North and Ocean Blvd.

Table E-1: Pervious Parking Lot Locations in the Cherry Grove Beach Area

Location	Material
Heritage Shores Nature Preserve Parking lot- 53 rd North & Boat Ramp	Brick Paver
53 rd North & North Ocean Boulevard	Brick paver entrance and pervious concrete parking stalls
27 th North Oceanfront	Brick paver walkway and brick paver golf cart parking area
2108 Ocean Park	Brick pavers between sidewalks in the park
Spring Street & 21 st North	Brick paver entrance & brick paver parking stalls
12 th Avenue North Street end	Coquina parking lot
13 th Avenue North Street end	Coquina parking lot
14 th Avenue North Street end	Coquina parking lot
15 th Avenue North Street end	Coquina parking lot
16 th Avenue North Street end	Coquina parking lot
17 th Avenue North Street end	Coquina parking lot
18 th Avenue North Street end	Coquina parking lot

Note: This list only includes the parking lots located within the Cherry Grove Beach area. North Myrtle Beach has installed 23 pervious parking sites across the entire city.

B. Ocean Outfall Projects

A much larger scale project along the North Myrtle Beach coast involves diverting stormwater outfalls, which historically have discharged near the immediate shoreline of the beach areas, to a larger outfall device extending 1,300 ft offshore. Long-range capital improvement plans include diverting stormwater from a series of ponds within the Surf and Beach Club development to a new ocean outfall structure replacing the existing outfall at 18th Ave North. Currently these ponds drain into Hog Inlet near Sea Mountain Hwy and Duffy Street. This will reduce significant volumes of stormwater runoff from the southern reaches of the estuary. Each outfall structure is equipped with devices to contain sediment and debris as well as kill bacteria before discharging the stormwater. Further details of this project including estimated costs and timeframes is discussed in **Element F: Recommended Watershed Management Measures**.

VI. South Carolina Onsite Septic System Regulations

As assessed in **Element C: Fecal Coliform Source Identification**, septic systems are a potential source of bacteria within the Hog Inlet and Dunn Sound Creek watershed. The state of South Carolina enacted regulation 61-56- Onsite Wastewater Systems in 1976 to prevent public health hazards and protect local water quality in areas where public wastewater facilities are not available. The regulation includes a number of conditions on the placement and utilization of septic systems to ensure that domestic wastewater is properly treated and disposed of into the environment. Horry County and North Myrtle Beach need to work with SC DHEC to properly administer and enforce septic system regulations within the watershed.

VII. North Myrtle Beach Sanitary Sewer System

As highlighted in **Element C: Fecal Coliform Identification**, the installation and expansion of the sanitary sewer system throughout North Myrtle Beach has been a major infrastructure investment providing both public health and environmental benefits to the region. Sanitary sewer was initially installed in the Cherry Grove Beach area in 1975. Incremental extensions have occurred along the Little River Neck Road corridor ever since. Wastewater collected from businesses and residences within the Cherry Grove and Little River Neck Road area are transported via a system of gravity and force sewer main pipelines and pump stations to the Ocean Drive Wastewater Treatment Plant for final treatment and discharge. Extending the sanitary sewer to portions of Little River Neck Road and connecting residences with poorly performing septic systems will continue to be an important strategy in water quality protection efforts within the Hog Inlet and Dunn Sound Creek watershed.

The next element outlines recommendations to continue these best management practice efforts, examine ways to improve upon current activities, and explore new opportunities to further water quality protection accomplishments in the Hog Inlet and Dunn Sound Creek estuaries.

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