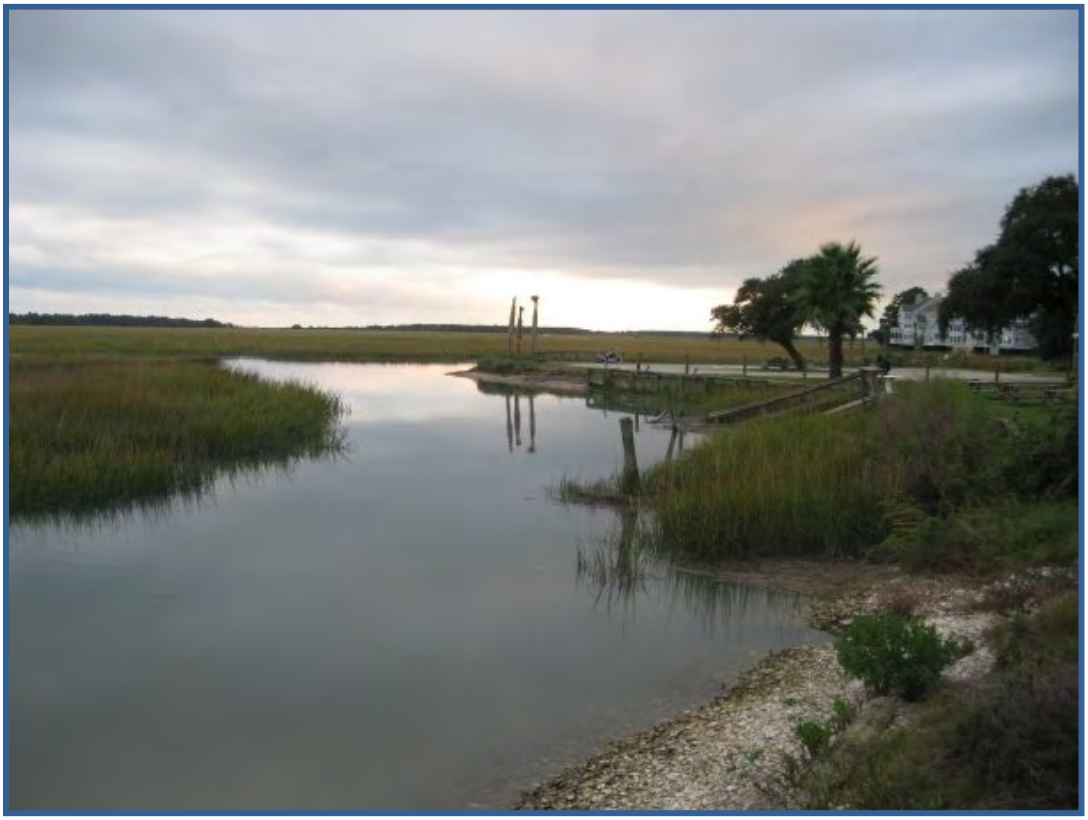
2014 Murrells Inlet Watershed Plan



A Community-Based Management Plan to Address Fecal Coliform Impairments in Local Shellfish Harvesting Areas

WACCAMAW REGIONAL COUNCIL OF GOVERNMENTS

Funded by USEPA Section 319 and 604(b) Grants through SC DHEC
Submitted to SC DHEC by the Waccamaw Regional Council of Governments.

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Table of Contents

Element G: Existing Infrastructure and Management Programs

Element H: Watershed Management Measures

Element I: Potential Funding Source Evaluation

Element J: Public Outreach and Education Resources

Acronyms and Abbreviations

The following is a list of abbreviations and acronyms utilized in the text of this plan document that refer to state and federal agencies, terms related to laws and regulations, and other common phrases related to water quality management.

BMP- *Best Management Practice*

CDC- *Center for Disease Control and Prevention*

CMOM- *Capacity, Management, Operations, and Maintenance*

CWSEC- *Coastal Waccamaw Stormwater Education Consortium*

FDA- *United States Food and Drug Administration*

HUC- *Hydrologic Unit Code*

LID- *Low Impact Development*

ml- *Milliliter*

MGD- *Million Gallons per Day*

MPN- *Most Probable Number*

MS4- *Municipal Separate Storm Sewer System*

NOAA- *National Oceanic and Atmospheric Administration*

NOS- *National Ocean Service*

NLCD- *National Land Cover Data*

NPDES- *National Pollutant Discharge Elimination System*

SC DHEC- *South Carolina Department of Health and Environmental Control*

SC DNR- *South Carolina Department of Natural Resources*

SCORE- *South Carolina Oyster Restoration and Enhancement*

SFH- *Shellfish Harvesting Waters*

SWPPP- *Stormwater Pollution Prevention Plan*

TMDL- *Total Maximum Daily Load*

US ACE- *United States Army Corps of Engineers*

US EPA- *United States Environmental Protection Agency*

WSA- *Water and Sewer Authority*

WSD- *Water and Sewer District*

WWTF- *Wastewater Treatment Facility*

Acknowledgements

The opportunity to develop this watershed-based plan for Murrells Inlet was made possible by a Section 319 Grant awarded by SC DHEC. This planning effort was spearheaded by Murrells Inlet 2020. Several Murrells Inlet community members made significant contributions as steering committee members. Thanks to Jim Wilkie, Sandra Bundy, Gary Weinreich, and Lee Hewitt for providing invaluable insight regarding the history of Murrells Inlet and the economic and cultural importance of the estuary to the committee. Additional thanks to the Murrells Inlet Volunteer Monitoring Program, which has collected valuable water quality data in the Murrells Inlet estuary since 2008. Particular thanks to Gary Weinreich for his coordination of monitoring conducted in Georgetown County. Their dedicated efforts are greatly appreciated. Finally, thanks to Murrells Inlet 2020 for hosting the majority of our meetings at their office.

A significant portion of this plan required extensive technical assistance and data analysis. Stephen Williams of Earthworks Group, Inc. produced all of the major map inserts found in the document. These maps were vital in assessing existing conditions within the watershed and in evaluating priority areas for best management practice consideration. Thanks also to Heather Young and Dr. Susan Libes of Coastal Carolina University for performing a baseline assessment of fecal coliform data collected by SC DHEC's Shellfish Program. Their data analysis and reporting were the primary resources utilized by the steering committee to prioritize SC DHEC monitoring stations for water quality improvements. Stephen, Heather, and Susan were very responsive to all steering committee requests for further technical assistance as the planning process proceeded. Thanks for their tremendous contributions. Finally, thanks to Dr. Dan Hitchcock, Clemson University Baruch Institute of Coastal Ecology and Forest Science, who led several site visits to evaluate potential opportunities for implementing stormwater best management practices. His technical expertise was also very beneficial.

Throughout the planning process several information requests were sent out to various agencies and institutions throughout the state. Thanks to Wade Cantrell, Banu Varlik, Amy Bennett, and Mike Pearson from SC DHEC, Nancy Hadley from SC DNR, Dr. Dwayne Porter from University of South Carolina, Dr. Keith Walters from Coastal Carolina University, Kim Jones from the Town of Bluffton, Tommy Kennedy from Georgetown County Water and Sewer District, and Neeraj Patel from Grand Strand Water and Sewer Authority for supporting this planning effort by providing useful information from their respective agencies. Thanks to Coastal Carolina University for allowing the steering committee to setup a Cloud Site as an access portal for all of the references and draft reports.

Additional thanks to Dave Fuss from Horry County Stormwater and Tracy Jones from Georgetown County Stormwater for their role on the project steering committee. They have steadfastly supported the need for the watershed plan and were integral in all aspects of the process including the review of the final document. It has been a pleasure to work with all of the steering committee members. Their commitment to protecting the water quality and natural resources of Murrells Inlet is commendable.

Dan Newquist
Planner, Waccamaw Regional Council of Governments

Executive Summary

Introduction

Murrells Inlet is a coastal community with strong economic and cultural ties to the salt marsh estuary that bears its name. The natural resources in Murrells Inlet attract residents and visitors to numerous outdoor recreation activities including bird watching, boating, fishing, shellfish harvesting, hiking, etc. The local commercial fishing industry helps support a vibrant restaurant scene, which has led Murrells Inlet to become regarded as the "Seafood Capital of South Carolina". Protecting and sustaining these natural resources is of paramount importance to the Murrells Inlet community. This watershed plan serves as a means to guide the implementation of best management practices based on water quality trends and current landscape conditions. The primary focus of this watershed plan is to assess and mitigate sources of bacteria pollution in Murrells Inlet.

Below are the main overarching goals that guided the watershed planning process and serve as the ultimate measure of success for the Murrells Inlet community:

- ***Identify sources of fecal coliform bacteria impacting the water quality in and around the Murrells Inlet oyster beds.***
- ***Over a 20 year period, aim to improve water quality by reducing the level of fecal coliform entering Murrells Inlet and achieve a target of 80% of all SC DHEC designated shellfish acres, excluding those administratively designated as Prohibited, as an Approved or Conditionally Approved classification.***
- ***Continue to highlight the history of the fisheries industry in Murrells Inlet and promote the cultural, economic, and outdoor recreational benefits associated with sustaining viable shellfish harvesting opportunities in the community.***
- ***Increase public awareness regarding the environmental sensitivities of the local shellfish harvesting areas and promote ways by which individuals and the community as a whole can protect local water quality.***

The Murrells Inlet watershed extends from the Huntington Beach State Park and North Litchfield portions of Georgetown County to the Garden City Beach and the southern tip of Surfside Beach in Horry County along the Hwy 17 corridor. The watershed area is approximately 9,313 acres or 14.55 square miles in its entirety. SC DHEC estimates that 3,108 acres within the watershed are suitable habitat for the production of shellfish. Through an analysis of drainage characteristics, 51 distinct subwatersheds drain into Murrells Inlet ranging in size from 5 acres to 633 acres.

Regulatory Framework

South Carolina Department of Health and Environmental Control (SC DHEC) has classified the entire Murrells Inlet estuary as a Shellfish Harvesting Area water of the state. Shellfish Harvesting Areas are held to the highest water quality standard for fecal coliform bacteria (a geometric mean of 14MPN/100ml and an est. 90th percentile of 43MPN/100ml). This standard is established by the Food and Drug Administration to help protect the public from food-borne illnesses associated with the consumption of raw shellfish.

Through the state Shellfish Program, SC DHEC collects water quality samples on a monthly basis at 25 locations throughout Murrells Inlet. The results determine whether areas within Murrells Inlet are approved for shellfish harvesting. As required by state law, SC DHEC administratively classifies a total of 155 acres (5% of total area) as Prohibited, in the three areas in Murrells Inlet with marina establishments. Presently, the vast majority of Murrells Inlet (2217 acres of 71% of total area) meets the fecal coliform water quality standard and is approved for shellfish harvesting.

While the majority of Murrells Inlet meets the stringent fecal coliform standards for Shellfish Harvesting Areas, in 2005 SC DHEC drafted a Total Maximum Daily Load (TMDL) report for the Murrells Inlet watershed identifying eight monitoring sites that failed to meet the fecal coliform standard. The TMDL identifies non-point sources of pollution as the main contributor and established an ~80% reduction in bacteria loads in order to comply with the water quality standard.

Bacteria Source Assessment

Given the varied landscapes across the watershed, the contributing sources of bacteria can differ significantly from one area of Murrells Inlet to another. Several potential bacteria sources were identified based on available data, community stakeholder input, and information provided by various management agencies. Wildlife and waterfowl are the largest contributing sources of fecal coliform in the Inlet. Pet waste is considered to be the second largest source. Septic systems, sewer infrastructure, and illicit boat discharges are not believed to be contributing factors. However, the report does recommend some focused monitoring to confirm a few isolated areas with septic system concern and to inspect the sewer pump station inventory.

Rainfall events transport fecal coliform bacteria to the Inlet via stormwater runoff through the extensive network of drainage ditches and pipes. Bacteria readings are compounded by a few other issues such as small mammals (raccoons, possums, etc) which migrate to the ditches for water sources and utilize them as pathways. Bacteria are also known to attach to sediments, which also get transported downstream. Increased siltation is occurring on the north and south ends and along Parsonage Creek. In areas of heavy siltation, there is limited saltwater flow to dilute and flush away the bacteria and less salinity to kill the bacteria.

Another factor that may influence high bacteria levels is existing and increasing residential development. The south-end of the watershed is less developed meaning fewer impervious surfaces which allow for bacteria die-off or infiltration into the soil before being washed into the inlet. However, the wildlife and waterfowl concentration on the south-end is higher because these natural habitats become a migration point for other animals from the developed areas in the Inlet. Areas of the Inlet's east and west shorelines, and on the north-end, have greater development resulting in more impervious surfaces. These impervious surfaces cause the water carrying the bacteria to arrive in the Inlet more quickly without natural filtration. Additionally, more fresh water inputs into the inlet reduce salinity which allows bacteria to survive longer.

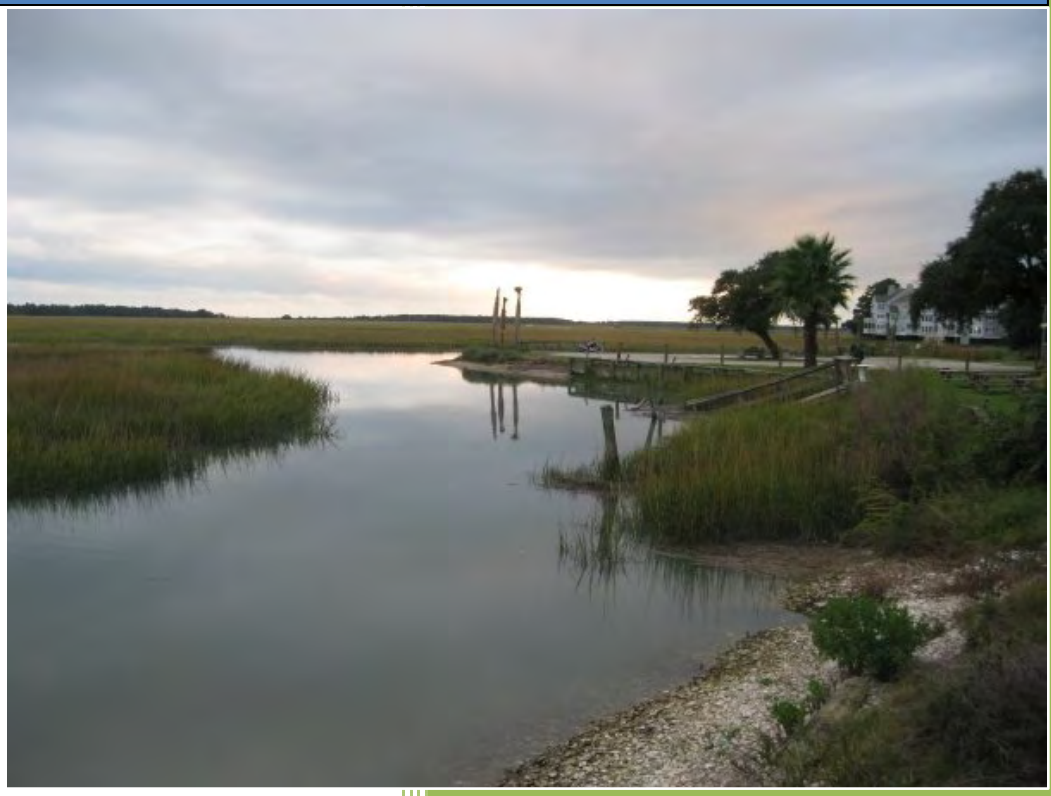
Local knowledge and available monitoring data enabled the steering committee to confidently make the above general conclusions regarding bacteria sources in Murrells Inlet. However the steering committee found it difficult to determine specific loads for each source based on existing resource management agency data. Therefore, estimated loads were used. The committee requests that SC DHEC invest resources to analyze bacteria sources at its shellfish monitoring stations and use this information and more sophisticated fate and transport hydrodynamic models to revise the TMDL and determine load allocations for each major source at key locations. This would help ensure the best chance of success for BMP implementation.

Best Management Practice Recommendations

Since there are multiple potential bacteria sources and the primary transport mechanism is via stormwater runoff a multifaceted management approach is needed. Some of the management strategies are structural such as the installation of rain barrels and incorporating constructed wetlands and bioretention systems across the landscape. Other best management practices are non-structural which may entail targeted public outreach, for example, efforts to improve proper pet waste disposal. Also, while many of the proposed best management practices can be applied across the watershed, several of the proposed management strategies are intended for a specific subwatershed based on the land use and drainage characteristics of that particular area of the community.

This watershed plan identifies several best management practices (BMPs) with varying implementation timeframes. Many BMPs will require the cooperation of multiple management agencies. Others will entail participation from the general public and the local business community. Most of the structural BMPs are intended to improve water quality at the priority monitoring stations identified in the watershed plan. Cost estimates are provided for most of the recommended BMPs. Finally, the plan includes a detailed outline of public outreach and future monitoring needs, both of which are essential to sustaining and evaluating the long-term success of all proposed watershed management initiatives and strategies.

Element A: Description of Murrells Inlet Watershed



Element A: Description of the Murrells Inlet Watershed

Introduction

The Murrells Inlet community was settled in the early 19th century and has always had a strong maritime culture, maintaining a lasting reputation as the Seafood Capital of South Carolina. Today, Murrells Inlet remains a vibrant waterfront community with several restaurants, shops, marinas, pedestrian boardwalks and public boat landings, making it a regional hub for outdoor water-based recreation. Local residents and business owners recognize the uniqueness of Murrells Inlet and are dedicated to preserving the natural resources that are so vital to the community. This watershed-based plan represents a community vision and long-term action plan to protect the shellfish harvesting areas within Murrells Inlet and the safety of the public when enjoying these natural resources.

Figure A-1 *The Murrells Inlet community is proud of its distinction as the Seafood Capital of South Carolina (Photo courtesy of Dr. Dan Hitchcock, Clemson University)*

Like most other coastal watersheds, population growth and associated development pressures have steadily influenced the natural hydrology and surrounding landscapes in the Murrells Inlet area. As these changes continue to occur, implementing appropriate land use and water resource management practices are essential to protecting the shellfish harvesting areas within the estuary.

A recent economic impact study completed by Coastal Carolina University, conservatively places the economic value of the Murrells Inlet waterfront marsh at $720 million. The report attributes the marsh as bolstering several sectors of the local economy including retail sales, particularly restaurant establishments; real estate property values; boating; fishing; accommodations and other tourism activities. This economic activity generates substantial tax revenues for both Horry and Georgetown Counties.

This watershed plan is scientifically-based and combines the economic, cultural, and environmental interests of the marsh, which is the single most important asset to the Murrells Inlet community. The plan promotes sound management strategies to sustain the value of the marsh for future generations of Murrells Inlet residents.

Figure A-2 *Shellfish are an important commodity to Murrells Inlet's seafood industry, but also play a dynamic role in tidal estuary ecosystems as well. (Photo courtesy of SC DNR)*

A primary species of concern in this watershed plan is the Eastern Oyster (*Crassostrea virginica).* Oysters are a distinct part of the local heritage and according to South Carolina Department of Health and Environmental Control's (SC DHEC) Shellfish Program, Murrells Inlet is widely recognized as the most economically important shellfish producing area along South Carolina's northern coast. Besides being valued as a commodity in the seafood industry, oyster reefs serve as vital elements in healthy and diverse estuarine ecosystems. As a keystone species, oysters form reefs that many other aquatic species depend upon as prime habitat. These reefs also affect water circulation and in many areas help prevent shoreline erosion. Oysters also have filtering capabilities which improve water quality and recycle nutrients (Tibbetts). Oyster harvesting is important to the maritime cultural identity of the Murrells Inlet community, therefore maintaining water quality that meets shellfish harvesting standards is a priority goal of this plan.

This watershed plan is a product of a yearlong iterative process facilitated by the Waccamaw Regional Council of Governments between key stakeholders representing Georgetown County, Horry County, Murrells Inlet 2020, Grand Strand Water and Sewer Authority, Georgetown County Water and Sewer District, and many others. Input was sought from concerned citizens throughout the Murrells Inlet community. Faculty and staff from Coastal Carolina University (CCU) conducted a detailed analysis of historical water quality data collected by SC DHEC and the Murrells Inlet Volunteer Monitoring Program. The Earthworks Group, Inc. provided spatial analysis technical assistance and produced several mapping exhibits of the Murrells Inlet watershed included in the document. CCU and The Earthworks Group, Inc. staff members were both fully engaged in all other stakeholder level aspects of the planning process as well. Additional consultation was sought from University of South Carolina, Clemson University, North Inlet-Winyah Bay National Estuarine Research Reserve, South Carolina Department of Natural Resources (SC DNR), National Oceanic and Atmospheric Administration (NOAA), US Army Corps of Engineers, and the Town of Bluffton.

Below are the main overarching goals that guided the watershed planning process and serve as the ultimate measure of success for the Murrells Inlet community:

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- ***Increase public awareness regarding the environmental sensitivities of the local shellfish harvesting areas and promote ways by which individuals and the community as a whole can protect local water quality.***

The first portion of the plan provides a detailed description of the Murrells Inlet watershed, along with additional background information on the Eastern Oyster. The plan then gives an overview of the laws and regulations pertaining to Shellfish Harvesting Areas in South Carolina along with a regulatory status summary for the Murrells Inlet estuary. The next section is a baseline assessment of historical water quality trends at each SC DHEC monitoring station located in Murrells Inlet.

The remainder of the plan outlines a comprehensive list of recommended best management practices for implementation in Murrells Inlet. This chapter is supplemented by an assessment of potential funding sources available for implementation. The watershed plan also emphasizes the importance of long-term monitoring and prioritizes locations and monitoring techniques to ensure that future water quality trends are carefully analyzed. Finally, the plan provides an overview of the public outreach efforts of this planning process and summarizes the targeted education strategies that will be pursued moving forward.

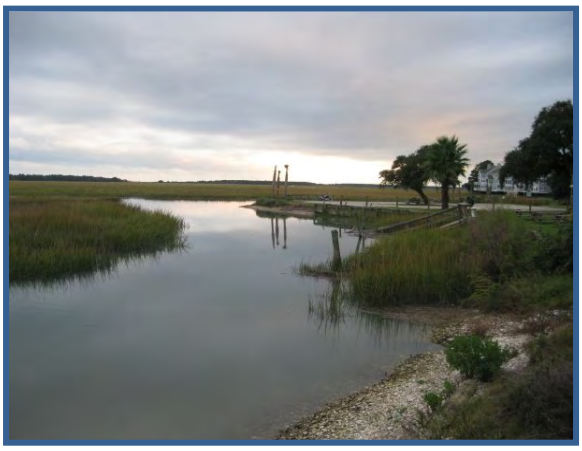


Figure A-3 *The steering committee reviewed several maps and conducted site visits to assess potential water quality concerns in the Murrells Inlet watershed. (Photos courtesy of Murrells Inlet 2020 and Daniel Newquist, Waccamaw Regional COG)*

Watershed Description

Murrells Inlet is a saltwater tidal estuary along the northeast coast of South Carolina. The watershed extends from the Huntington Beach State Park and North Litchfield portions of Georgetown County to the Garden City Beach and the southern tip of Surfside Beach in Horry County along the US Highway 17 corridor. The inlet is approximately 5.5 nautical miles north to south in length and 1.0 to 1.5 miles wide east to west from the main channel jetty to the Marsh Walk waterfront district. The tidal range varies from 4.2 to 4.5 feet with an increase during the spring tide period of 4.7 to 5.3 feet. There are several tidal creeks and manmade canals that comprise the Murrells Inlet estuary, including Main Creek, Allston Creek, Parsonage Creek, Garden City Canal, Oaks Creek, Whale Creek, and Woodland Creek (SC DHEC 2013 Shellfish Report). **Exhibit A-1** is a general map of the entire Murrells Inlet watershed.

Exhibit A-1 *General Map of the Murrells Inlet Watershed (Produced by Stephen Williams, Earthworks Group, Inc)*

Based on NOAA tidal information and LiDAR data indicating total estuary land area and channel depth, it is estimated that the diurnal tide causes approximately 2.8 billion gallons of sea water to enter and leave the inlet every 12.5 hours. This tidally-driven exchange of clean sea water provides a constant flushing effect on the inlet and the oyster beds. This effect is most pronounced in the deeper areas in the central portion of the inlet. As a result, these areas consistently meet the shellfish water quality standards. The cleansing effect of this tidal water exchange is naturally less pronounced at the extreme north and south ends of the inlet and near the shorelines. In these areas, the tidal exchange becomes more limited, due in part to sedimentation and siltation. Additionally, stormwater containing bacteria runs off the land and into the shallower portions of the inlet where less tidal flushing occurs to dilute and kill incoming bacteria. This results in higher bacteria levels in these shallower portions of the inlet.

The entire Murrells Inlet estuary watershed is approximately 9,313 acres, or 14.55 square miles. Of this total, roughly 6,322 acres is land draining into the estuary, with the remaining acreage consisting of open water, intertidal mudflats and marsh habitat typical of estuaries in the Southeast. SC DHEC estimates that 3,108 acres within the watershed are suitable habitat for the production of shellfish. The watershed consists of a wide range of land uses including high density residential, single family residential, commercial, open space, and waterfront uses such as docks and marinas. The vast undeveloped areas are primarily concentrated in the southern end of the watershed at Brookgreen Gardens and Huntington Beach State Park, which are both significant natural and cultural landmark attractions in the region.

Due to the variety of land uses and drainage patterns observed across the Murrells Inlet area, subwatersheds were delineated using topographic data from LiDAR and local knowledge of storm sewer infrastructure to examine water quality conditions on a smaller scale. **Exhibit A-2** is a map displaying all 51 subwatersheds that comprise the greater Murrells Inlet estuary drainage area. A map of each subwatershed with detailed topographies and drainage is included in **Appendix A.** Each subwatershed includes a name that corresponds to a local street or landmark. **Table A-1** is a list of all of the subwatersheds delineated in **Exhibit A-2**. The table includes an approximate subwatershed acreage; a curve number, which assesses land surface infiltration and runoff characteristics; the flow rate typical of a 2 year storm event (calculated as 4.4 inches of precipitation in a 24 hour period for the Murrells Inlet area); and length of flow path from the upper reaches of each subwatershed to the final discharge point into the estuary. There are 25 subwatersheds without a flow path length due to their location along the Murrells Inlet shoreline where runoff typically enters the inlet via overland sheet flow. Some flows entering Murrells Inlet ultimately are also attributable to groundwater baseflow discharges.

Figure A-4 and **Figure A-5** below display the varied landscape contrasts across the Murrells Inlet watershed.

Figure A-4 *Southern end of the estuary with Huntington Beach State Park in the background. (Photo courtesy of Daniel Newquist, Waccamaw Regional COG)*

Figure A-5 *Northern end of the estuary with Garden City Beach in the background. (Photo courtesy of Daniel Newquist, Waccamaw Regional COG)*

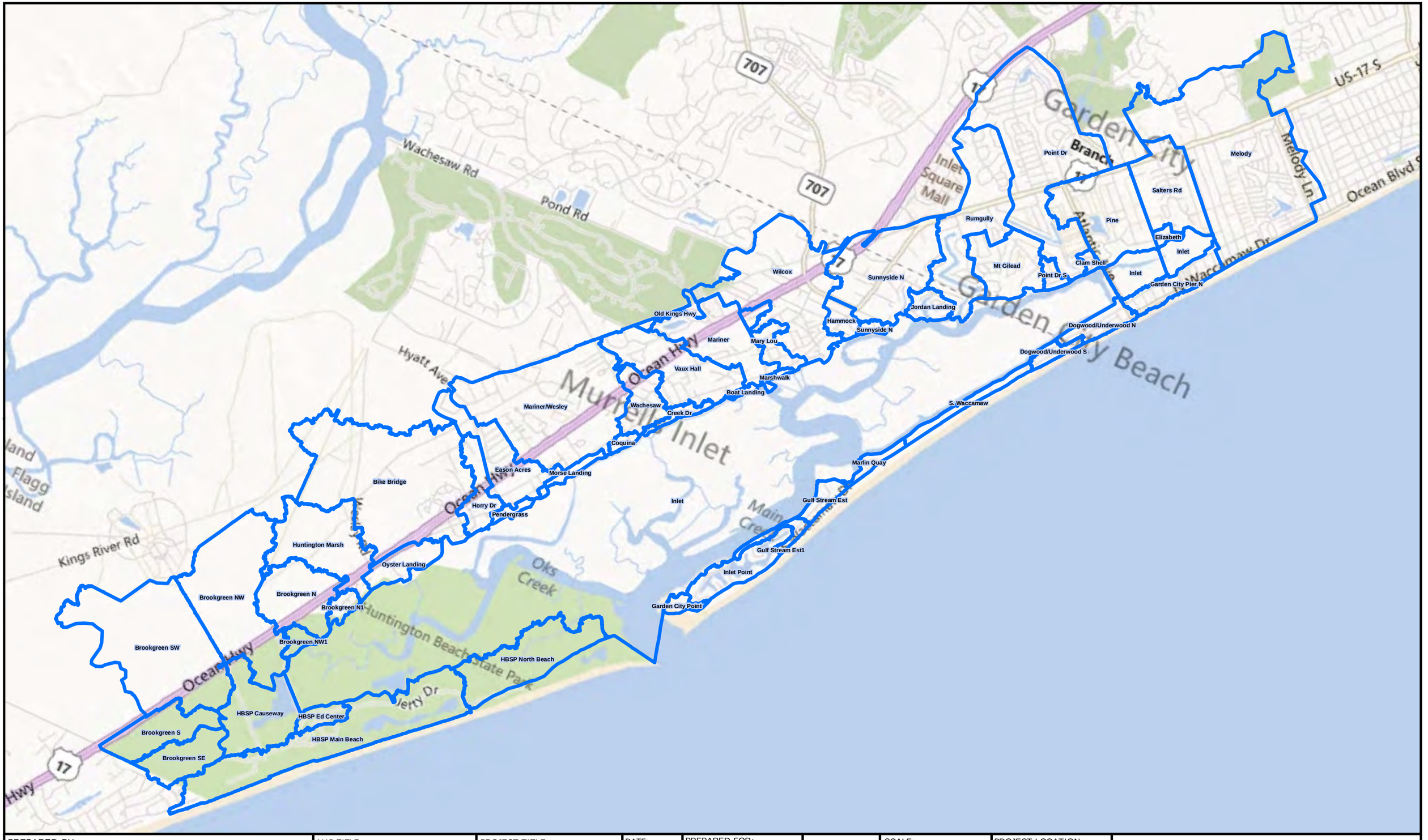
The subwatershed analysis approach provided the steering committee with a better understanding of how the fecal coliform monitoring data are related to the characteristics of adjacent subwatersheds; thus enabling the steering committee to identify where appropriate Best Management Practices (BMPs) are most beneficial. A more detailed description and analysis of the priority subwatersheds is provided in **Element D, Fecal Coliform Trend Analysis** and **Element F, Targeted Subwatershed Load Reductions**.

Natural Geomorphology- Coastal Processes

Although the Murrells Inlet watershed is a relatively small geographic area, this estuarine system is influenced by natural processes that occur on a much larger scale. It is important to have a general understanding of the unique natural features that comprise the Murrells Inlet estuary and how they are influenced by both single weather events such as hurricanes and other coastal processes along the South Atlantic Coast that occur over a long period of time.

Long-time residents have observed many distinct landscape changes over the years. As an example, prior to the construction of the jetties in the late 1970s there were two entrances into the main creek of Murrells Inlet (Douglass 1985). Locals also have noticed many changes on a much shorter timescale. Several tidal creeks have become shallower in recent years, likely caused by sedimentation deposited by tributary creeks and from shoreline erosion. Army Corps of Engineers studies also indicate that the tidal exchange and sediment pathway exchange between the Murrells Inlet estuary and the Atlantic Ocean has been altered as a result of the construction of the jetties (US ACE 2002). Ultimately, a concern is that fecal coliform and other bacteria survive longer in waterbodies with lower salinity levels and the accumulating sediment loads can provide favorable conditions for bacteria survival and propagation. Landscape-modifying processes such as drainage hydromodification, siltation, and jetty construction, all common to coastal areas need to be evaluated when considering various management options, including sediment reduction and dredging.

Figure A-6 *Historic photo circa 1940 of Garden City Beach and Murrells Inlet. Development and natural processes have altered the landscape over time. (Photo courtesy of the Georgetown County Library System.)*



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MAP TITLE:
MURRELLS INLET
WATERSHED INVENTORY

PROJECT TITLE:
MURRELLS INLET WATERSHED
MANAGEMENT PLAN

DATE:
05/16/2013

TEG PN:
121108.000:E

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SCALE:
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0 1,500 3,000
FEET

PROJECT LOCATION:
MURRELLS INLET
GEORGETOWN COUNTY
SOUTH CAROLINA

Exhibit A-2

Table A-1. Subwatersheds Draining into the Murrells Inlet Estuary

#	Basin Name	Acres	Curve Number	Flow Path Length	Discharge Rate	#	Basin Name	Acres	Curve Number	Flow Path Length	Discharge Rate
1	*Melody*	632.97	76	12081.32 ft	58.6	27	*Oyster Landing*	56.53	52	2866.88 ft	8.1
2	*Bike Bridge*	507.98	49	10536.66 ft	103	28	*Mary Lou*	47.71	80	4785.97 ft	37
3	*Point Drive*	433.67	87	11680.53 ft	97	29	*Dogwood N*	42.58	77	Overland	
4	*Mariner/ Wesley*	408.82	73	8250.53 ft	106	30	*S Waccamaw*	34.57	53	Overland	
5	*Brookgreen SW*	394.50	45	12433.27 ft	5.3	31	*Jordan Landing*	32.66	60	2054.29 ft	11
6	*HBSP Main Beach*	323.77	53	11106.46 ft	12.1	32	*Hammock*	29.07	70	2444.07 ft	19
7	*Wilcox*	315.25	70	7189.04ft	19	33	*HBSP Ed Center*	27.23	70	Overland	
8	*Brookgreen NW*	304.58	45	8734.90 ft	5.1	34	*Gulf Stream Estates*	25.97	54	Overland	
9	*Rum Gully*	243.21	69	10427.42ft	48	35	*Gulf Stream Estates 1*	20.95	54	Overland	
10	*Sunny Side N*	231.90	66	5483.09 ft	71	36	*Brookgreen N1*	20.21	71	Overland	
11	*Pine*	190.38	78	6152.61 ft	99	37	*Dogwood S*	19.60	59	Overland	
12	*Huntington Marsh*	182.62	67	6633.22 ft	30	38	*Brookgreen NW1*	19.34	32	Overland	
13	*HBSP North Beach*	171.34	23	Overland		39	*Marlin Quay*	19.01	67	Overland	
14	*Vaux Hall*	171.07	79	5901.10 ft	86	40	*Creek Dr.*	17.86	66	Overland	
15	*HBSP Causeway*	151.75	44	Overland		41	*Morse Landing*	17.45	75	Overland	
16	*Mariner*	144.84	80	5376.59 ft	85	42	*Point Drive S*	15.39	84	Overland	
17	*Salters Rd*	143.53	84	4642.73 ft	157	43	*Out*	15.23		Overland	
18	*Brookgreen N*	133.15	45	5225.25 ft	3.6	44	*Garden City Point*	14.52	52	Overland	
19	*Eason Acres*	125.70	73	7532.72 ft	55	45	*Pendergrass*	11.66	53	Overland	
20	*Mt. Gilead*	115.45	74	3591.14 ft	55	46	*Elizabeth*	10.49	71	Overland	
21	*Brookgreen S*	100.93	59	5951.92 ft	5.6	47	*Coquina*	10.10	54	Overland	
22	*Brookgreen SE*	83.80	59	4343.33 ft	5.3	48	*Hammock1*	10.09		Overland	
23	*Inlet Point*	78.37	37	Overland		49	*Clam Shell*	8.92		Overland	
24	*Garden City Pier N*	67.24	85	Overland		50	*Marshwalk*	7.43	86	Overland	
25	*Wachesaw*	67.16	81	4064.63	60	51	*Boat Landing*	4.79	61	Overland	
26	*Horry Dr.*	62.16	69	4259.48 ft	25						

Source: Data generated from mapping produced by Earthworks Group LLC

Shellfish Habitat and Public Health Concerns

Oysters have several traits that enable them to be resilient in varying conditions within intertidal estuarine systems. As a colonizing species they have high fecundity rates with a wide geographic distribution of offspring. They also display capabilities of being one of the initial occupiers of areas that have experienced changes in the physical environment, such as disturbances resulting from a large storm. Oysters are also characterized as ecosystem engineers with the ability to modify the existing physical surroundings to create a habitat niche that is more suitable for their own long-term survival (Tibbetts 2013).

While oyster populations are fairly adaptable to changing habitat conditions, in many stages of their life-cycle they are sensitive to certain environmental conditions. Eutrophic conditions due to excessive nutrient inputs are known to be lethal to oyster populations. Oyster larvae are sensitive to suspended sediments caused by siltation. Salinity levels are also known to influence development, reproduction, and feeding activity. Studies have shown that oysters grow well at a salinity level of 12.5 ppt or higher. Oyster growth is limited at salinities below 10.0 ppt and habitat is virtually non-existent below 5.0 ppt (Kennedy). While these low salinity levels are rarely observed in Murrells Inlet, it does emphasize the importance of maintaining adequate tidal flow through the Murrells Inlet estuary and minimizing stormwater runoff rates during heavy rain events.

Ecologically, oyster larvae require a suitable surface to build their reef habitats. Ideally, oyster shell should serve as the substrate for reef establishment. Other substrates such as concrete structures and shell from other species can be used to establish oyster reef habitats. Without proper management, as oysters are harvested the availability of a suitable natural reef substrate for juvenile oyster larvae becomes diminished. South Carolina Department of Natural Resources (SC DNR) has proactively managed an oyster shell recycling program, called South Carolina Oyster Restoration and Enhancement (SCORE), to help reestablish healthy oyster reef habitats across the state on an annual basis. In fact, through a partnership with Murrells Inlet 2020, the community is known for having established one of the most successful oyster shell recycling programs in the state. Further discussion on the importance of oyster reef restoration and maintenance is included in **Element E: Murrells Inlet Shellfish Assessment**. Also, since efforts such as the SC DNR SCORE program are dependent upon public awareness and participation, specific outreach recommendations are included in **Element J: Public Outreach and Education Resources.**

Figure A-7 *A strong partnership between SC DNR and Murrells Inlet 2020 has resulted in successful oyster shell recycling and habitat restoration efforts in the community. (Photo courtesy of Murrells Inlet 2020)*

One of the most significant factors influencing future shellfish harvesting activities from a public health standpoint is the presence of pathogenic bacteria in estuarine habitats. The indicator parameter that SC DHEC uses to evaluate water quality within designated Shellfish Harvesting Areas is fecal coliform concentrations. These standards are implemented nationwide under the guidance of the National Shellfish Sanitation Program overseen by the US Food and Drug Administration (FDA). The program is designed to ensure safe consumption of various shellfish products, including oysters which are frequently consumed raw. The water quality standards established to ensure safe shellfish consumption are the most stringent, being much lower than the bacteria water quality standard for recreational contact. Murrells Inlet is safe for all recreational contact uses and meets the Enterococci geometric mean standard of 35/100ml.

Fecal coliform bacteria are found in the intestines of warm-blooded animals, including humans, and serve as an indicator organism for the presence of other possible pathogens, including viruses. The presence of significant levels of fecal coliform in a waterbody indicates that a nearby source of animal or human waste has entered the environment or that contaminated sediments have been resuspended. Elevated levels of fecal coliform indicate the possible presence of other pathogenic organisms that can pose risks of disease transmission to humans who are exposed by ingesting contaminated raw shellfish. The most common waterborne diseases associated with high levels of pathogenic bacteria include *Giardiasis* and *Cryptosporidiosis*. According to the Centers for Disease Control and Prevention (CDC), *Giardia* is the most common intestinal parasitic disease in the United States. In 2010, the CDC reported 19,888 cases of *Giardiasis* nationwide. In comparison, the CDC reported 8,951 cases of *Cryptosporidiosis* in 2010. The main symptoms for both diseases include dehydration along with nausea, vomiting, fever, and diarrhea.

Another strand of bacteria, *Vibrio*, is raising public health concerns related to shellfish handling and consumption. According to SC DHEC's Bureau of Disease Control, the bacteria genus *Vibrio* normally live in warm seawater and can potentially contaminate oysters. *Vibrio* infections can be transmitted through raw consumption of oysters, with

illness symptoms similar to *Giardiasis* and *Cryptosporidiosis*. *Vibrio* can also pose serious infection risks to people who are immunocompromised. Infections can be transmitted through a skin cut and may lead to skin breakdown and ulceration or even more serious complications.

The next element describes how SC DHEC manages Shellfish Harvesting Areas by following the regulatory guidelines set forth by FDA's National Shellfish Sanitation Program. **Element B** then provides a status summary of the current Shellfish Harvesting Area classifications and an overview of the Total Maximum Daily Load for Fecal Coliform in Shellfish Waters of the Murrells Inlet Estuary issued by SC DHEC in 2005.

Figures A-8 and A-9 *The Murrells Inlet is a very dynamic estuary system as displayed by the low-tide conditions in picture on left and the extreme high tide flooding conditions that occasionally occurs in Garden City Beach and other areas of the watershed seen in picture on the right. (Photos courtesy of Murrells Inlet 2020)*

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Element B: Water Quality Standards and Regualtions

Element B: Water Quality Standards and Regulations

This element provides an overview of the existing laws and regulations that apply to the management of waters classified as Shellfish Harvesting Areas in South Carolina. The element then reviews the existing regulatory status of the Shellfish Harvesting Areas located within the Murrells Inlet estuary. Finally, a summary review of the 2005 Murrells Inlet Fecal Coliform Total Maximum Daily Load (TMDL) document is also included. The ultimate goal of this watershed plan is to outline management strategies that will improve water quality in Murrells Inlet and increase the amount of acreage meeting the Approved or Conditionally Approved shellfish harvesting classification.

South Carolina Water Quality Standards

The Murrells Inlet estuary is located in one of 25 designated Shellfish Management Areas in the State of South Carolina. Murrells Inlet is in Management Area 04, which also includes the Litchfield-Pawleys Island Estuary, located immediately south of Murrells Inlet in Georgetown County. Of the 4,364 acres of habitat suitable for the production of shellfish in Management Area 04, 3,108 of them are located within the Murrells Inlet watershed. Of the 33 active monitoring sites in Management Area 04, 24 of them are located in the Murrells Inlet estuary (SC DHEC 2013 Shellfish Report). See **Exhibit B-1** on Page 17 for a map of SC DHEC Shellfish Management Area 04 with monitoring station locations. All waters within Murrells Inlet are regulated as Shellfish Harvesting Waters (SFH). South Carolina state Regulation 61-68, Water Classifications and Standards, defines Shellfish Harvesting Waters (SFH) as:

Tidal saltwaters protected for shellfish harvesting and uses listed in Class SA and SB. Suitable for primary and secondary contact recreation, crabbing, and fishing. Also suitable for the survival and propagation of a balanced indigenous aquatic community of marine fauna and flora.

SC DHEC is granted the authority to regulate the harvesting, sanitation, handling and processing of shellfish under state law outlined in Section 44-1-140 of the Code of Laws of South Carolina, 1976 and by rules set forth in state Regulation 61-47.

SC DHEC Shellfish Management Area 04: 2013 Annual Update

Every year SC DHEC issues a report for each Shellfish Management Area across the state that updates the classifications of designated Shellfish Harvesting Waters. In accordance with the FDA National Shellfish Sanitation Program, SC DHEC utilizes the previous three years of monitoring data to establish these regulatory classifications. A minimum of 30 samples at each monitoring station within this time period is required to meet FDA's standards. There are 36 sampling dates scheduled to ensure that there are a sufficient number of valid samples in case there is a laboratory or handling

error. SC DHEC utilizes a systematic random sampling monitoring strategy to minimize bias with respect to tidal stage and weather conditions.

The designations that SC DHEC uses to classify Shellfish Harvesting Areas are Approved, Conditionally Approved, Restricted, and Prohibited. A brief description of each classification is provided below with the current number of acres of each classification as of the 2013 Annual Management Area 04 Shellfish Report. **Appendix C** provides a location description of each classification area as of the 2013 Annual Management Area 04 Shellfish Report. **Element D: Fecal Coliform Trend Analysis,** includes a summary of water quality regulatory status trends dating back to the 1992 Annual Update report for Shellfish Management Area 04.

Approved- These are areas that are normally open for the harvesting of shellfish and are safe for human consumption. Approved areas must not exceed the following water quality standards:

- *Not to exceed a Most Probable Number (MPN) geometric mean of 14/100 ml*
- *No more than 10 percent (%) of the samples exceed an MPN of 43/100 ml (Estimated 90th percentile)*

2,217 acres or 71% of the 3,108 total available shellfish acres in Murrells Inlet are currently Approved.

Conditionally Approved- These are areas that typically meet the criteria for Approved classification except under predictable conditions. Closure criteria and subsequent re-opening procedures are outlined in an area specific management plan. A high rainfall event is the most common condition that results in a temporary closure within a Conditionally Approved area.

Presently, SC DHEC does not manage any portions of the shellfish harvesting areas within Murrells Inlet as Conditionally Approved, mainly due to limited personnel resources. One of the recommendations included in **Element H: Watershed Management Measures,** is to evaluate shellfish harvesting areas within Murrells Inlet that would meet the water quality criteria and be good candidates for Conditionally Approved status, presuming additional SC DHEC resources are available and justified.

Restricted- These are areas that exceed the water quality standards for an Approved classification area and are normally closed to harvesting. Shellfish may be harvested and relayed to an Approved area for depuration via a special permit.

The fecal coliform numeric standard limits to relay shellfish located in Restricted Shellfish Harvesting Areas to Approved Shellfish Harvesting Areas are the following:

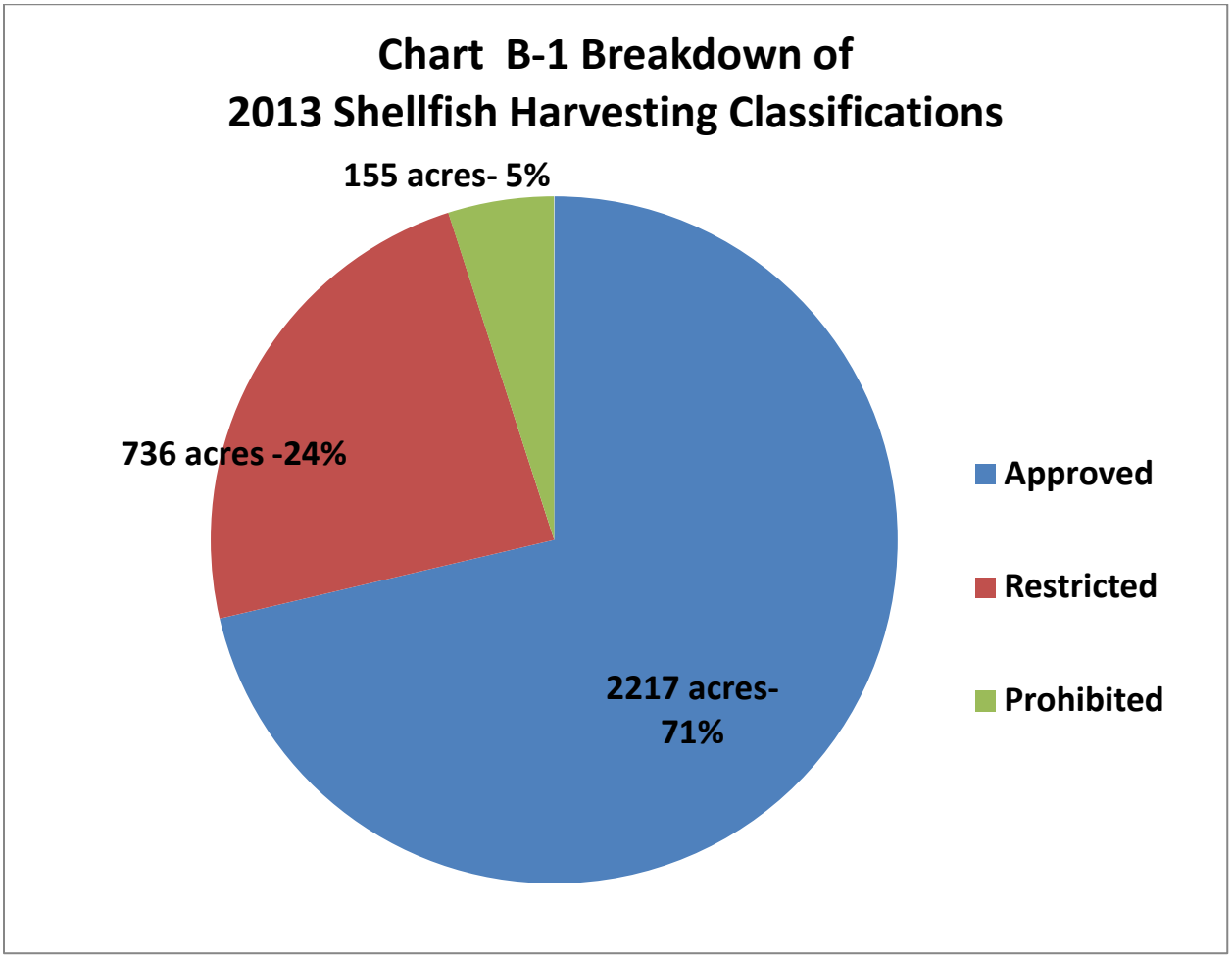
- *Not to exceed a Most Probable Number (MPN) geometric mean of 88/100 ml*
- *No more than 10 percent (%) of the samples exceed an MPN of 260/100 ml (Estimated 90th percentile)*

736 acres or 23.7% of the 3108 total available shellfish acres in Murrells Inlet are currently Restricted.

Prohibited- These are areas that are administratively closed to shellfish harvesting for any purpose related to human consumption. They are typically associated with areas adjacent to potential point sources of pollution such as a wastewater treatment plant, industrial site, or in the case of Murrells Inlet, marinas and docking facilities.

155 acres or 5.0% of the 3108 total available shellfish acres in Murrells Inlet are Prohibited by regulation due their proximity to marinas.

Chart B-1 provides a breakdown of the percentages of each classification within the Murrells Inlet watershed as of the 2013 Management Area 04 Annual Update.



The current ratio of Approved acreage versus Restricted and Prohibited acreage is well within the normal range of typical conditions found in estuaries along the coast of South Carolina. Therefore, comparatively speaking Murrells Inlet is in a good position to sustain local shellfish harvesting activities well into the future.

A location description for each active SC DHEC water monitoring station in Murrells Inlet is provided in **Table B-1** below:

Table B-1. SC DHEC Water Monitoring Stations in the Murrells Inlet portion of Shellfish Management Area 04.	
Station #	**Location**
04-01	Main Creek at Atlantic Avenue Bridge
04-02	Main Creek at Mickey Spillane's Home
04-03A	Southeast side of the Prohibited Zone near Captain Dick's Marina in Main Creek
04-03B	Northwest side of the Prohibited Zone near Captain Dick's Marina in Main Creek
04-04A	Garden City Canal due E of Entrance to Flagg Creek
04-04B	Northern Boundary of the Marlin Quay Closure Zone in Main Creek
04-04C	Western Boundary of the Marlin Quay Closure Zone in Main Creek
04-06	Allston Creek at Weston Flat
04-07	Allston Creek- Hughes Landing
04-08	Parsonage Creek at Nance's Dock
04-08A	Oyster (Carr) Landing at Huntington Beach State Park
04-16	Parsonage Creek at Chicken Farm Ditch
04-17A	Southwest Corner of the Voyager View Marina Prohibited Zone in Parsonage Creek
04-18	North Boundary of Clambank Flats POG
04-23	Main Creek at Oyster Cove
04-24	Oaks Creek at First Curve
04-25	Main Creek at Flagg Creek
04-26	Garden City Canal at the "Old Boat Wreck"
04-27	Main Creek, Opposite Entrance to Mt. Gilead Canal
04-28	Oak's Creek, Approximately 150 Meters from the Huntington Beach State Park Causeway
04-29	Oyster Cove South Branch
04-30	Oyster Cove North Branch
04-31	Woodland Creek- 100 Meters East of Mainland
04-32	Oak's Creek at Brigham Hole
Source: SC DHEC, Shellfish Management Area 04- 2013 Annual Update	

Exhibit B-1 is a map displaying the current shellfish harvesting classifications in Shellfish Management Area 04.

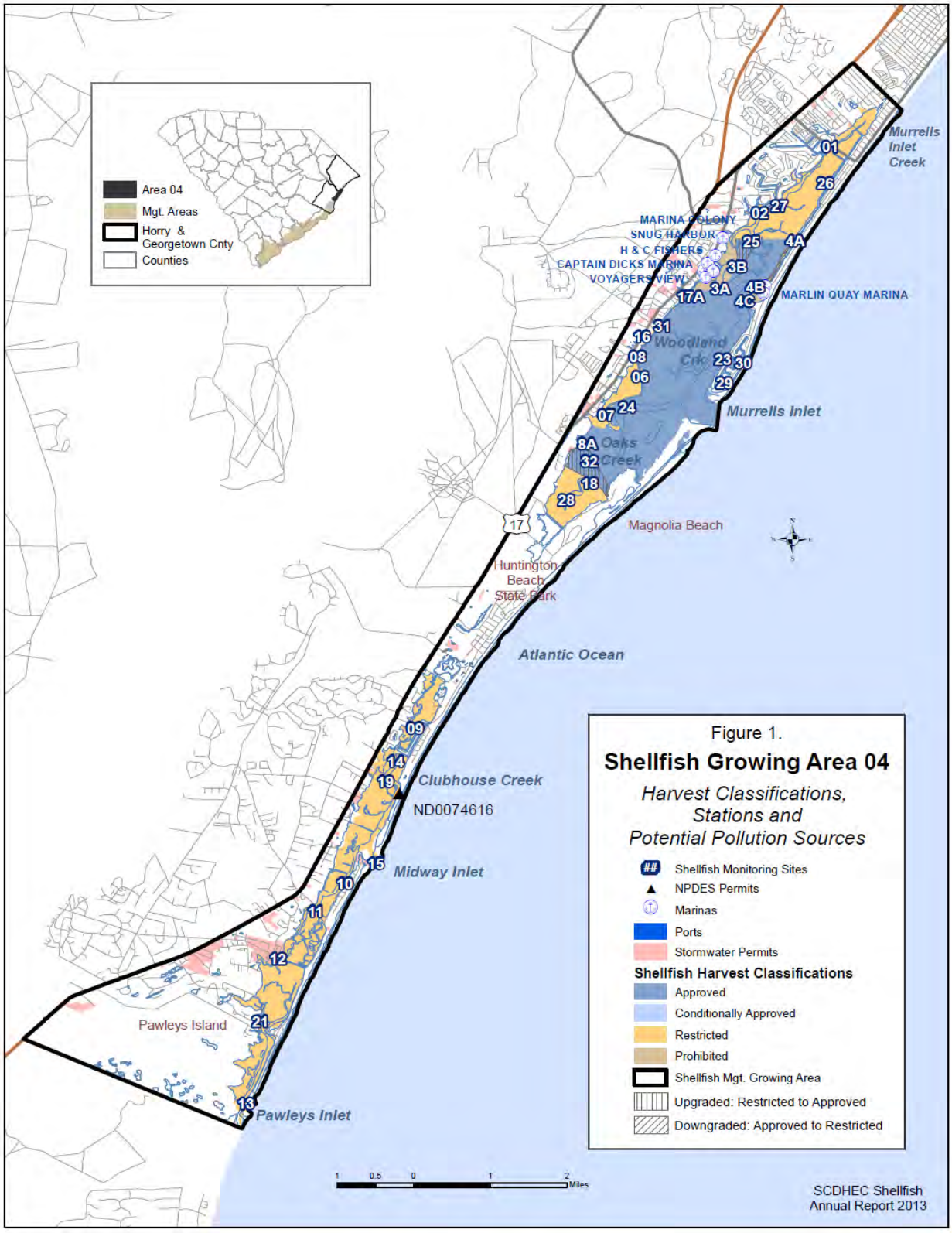


Exhibit B-1: *2013 Shellfish Classifications for SC DHEC Management Area 04*

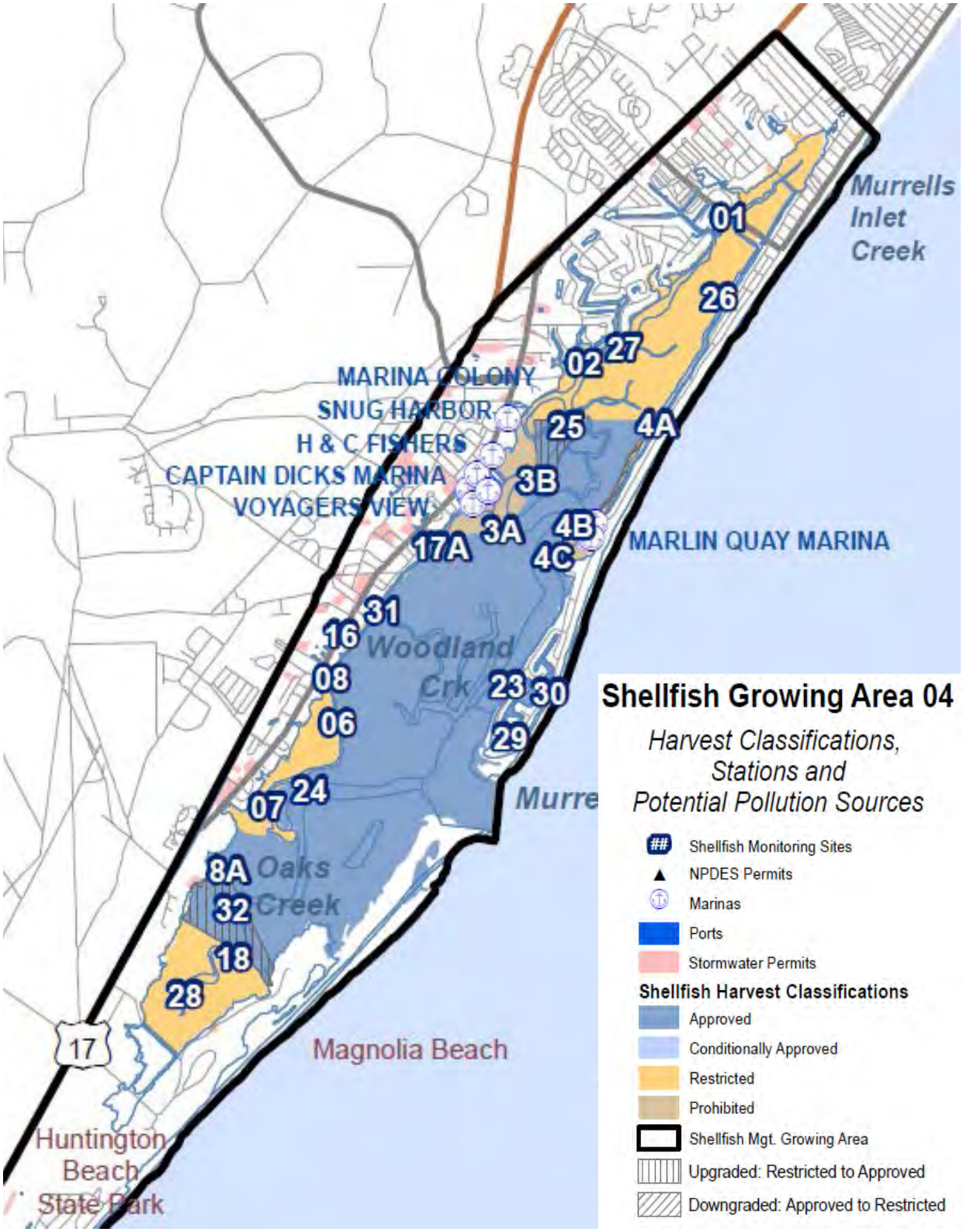


Exhibit B-2: *Murrells Inlet portion of Shellfish Management Area 04*

2005 Murrells Inlet Estuary Fecal Coliform Total Maximum Daily Load

In preparing the 2004 303(d) list of impaired water bodies, SC DHEC identified 8 out of 24 monitoring stations within the Murrells Inlet estuary that exceeded the water quality standards for fecal coliform bacteria. This led SC DHEC to the development of a TMDL for the Murrells Inlet estuary. A TMDL essentially determines the maximum amount of a pollutant that can be assimilated by a receiving waterbody without exceeding state water quality standards, in this case for waterbodies classified as Shellfish Harvesting Areas.

A description of the TMDL process on EPA's website is provided below:

> *A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that load among the various sources of that pollutant. Pollutant sources are characterized as either point sources that receive a wasteload allocation (WLA), or nonpoint sources that receive a load allocation (LA). Point sources include all sources subject to regulation under the National Pollutant Discharge Elimination System (NPDES) program, e.g. wastewater treatment facilities, some stormwater discharges and concentrated animal feeding operations (CAFOs). Nonpoint sources include all remaining sources of the pollutant as well as anthropogenic and natural background sources. TMDLs must also account for seasonal variations in water quality, and include a margin of safety (MOS) to account for uncertainty in predicting how well pollutant reductions will result in meeting water quality standards.*

Table B-2 below provides a list of monitoring sites that were included on the 2004 South Carolina 303(d) list of impaired waterbodies and subsequently in the Murrells Inlet Fecal Coliform TMDL. The Murrells Inlet TMDL calculations and findings are based on data collected by SC DHEC between September 2001 and August 2004. The table includes a summary of the geometric means and the percent of samples above the 43/100ml est. 90th percentile standard for each of the respective monitoring stations. Each of these eight sites exceeded the est. 90th percentile standard and all but monitoring stations 04-26 and 04-27 exceeded the geometric mean standard. The TMDL is also structured to focus on three separate segments of the estuary system including Main Creek, Parsonage Creek/Allston Creek, and Garden City Canal. **Element D** reviews the water quality trends for all of the monitoring stations located in Murrells Inlet.

Table B-2 Murrells Inlet SC DHEC Monitoring Stations on 2004 303(d) list			
Site #	**Location**	**Geometric Mean**	**% of Samples above 43 CFU/100ml**
Main Creek			
04-01	Main Creek at Atlantic Avenue Bridge	42.9	53%
04-01A	Main Creek at Stanley Drive	30.6	41%
04-27	Main Creek, Opposite Entrance to Mt. Gilead Canal	7.5	13%
04-02	Main Creek at Mickey Spillane's Home	13.4	22%
Garden City Canal			
04-26	Garden City Canal at the "Old Boat Wreck"	8.7	24%
Parsonage Creek/ Allston Creek			
04-08	Parsonage Creek at Nance's Dock	24.4	42%
04-16	Parsonage Creek at Chicken Farm Ditch	72.7	54%
04-06	Allston Creek at Weston Flat	14.7	25%
Source: SC DHEC, Total Maximum Daily Loads for Fecal Coliform in Shellfish Waters of the Murrells Inlet Estuary, South Carolina			

The TMDL load reductions are calculated by accounting for all waste load allocations from point sources of pollution, such as wastewater treatment plants or industrial sites, and all load allocations from various non-point sources of pollution, such as stormwater runoff. A margin of safety to account for uncertainties in the natural environment is also incorporated into the final TMDL calculation. Generally, Fecal Coliform TMDLs are expressed as reductions in colony forming units (CFUs) per day, or as percent reductions. The waste load allocation for this TMDL is set at zero since there are no permitted point source facilities that discharge effluent into receiving waterbodies of Murrells Inlet. Therefore the targeted load reductions established in the TMDL are exclusively from non-point sources of pollution. The potential non-point sources identified in the TMDL were as follows:

- *Urban and Suburban Runoff:* Due to the increased development in the surrounding Murrells Inlet area, stormwater runoff was identified as a potential fecal coliform source in the TMDL.
- *Individual Sewage Treatment and Disposal Systems (Septic Tanks):* The TMDL identified three small areas that were still being served by septic tanks. However, a SC DHEC survey conducted in 2004 only identified two malfunctioning systems out of a total of 119 known active septic systems in Murrells Inlet. The TMDL therefore did not consider septic systems or the area's sanitary sewer system to be likely and significant sources of pollution.
- *Wildlife:* The TMDL acknowledged that there are areas that support large populations of wildlife and waterfowl, particularly in the southern end of the watershed near Brookgreen Gardens and Huntington Beach State Park. These wildlife populations could be significant contributors to the fecal coliform levels

observed in Murrells Inlet. The TMDL estimates that there were 273 cats and 240 dogs residing in the watershed and therefore discounts pet waste as a significant source of fecal coliform.

- *Boat Traffic:* Given the significant level of marine activities in Murrells Inlet, the TMDL did acknowledge that onboard septage is a potential source of fecal coliform but based on a review of other studies conducted in Murrells Inlet, there was little evidence of any current impacts, and therefore was not believed to be a problem. There is not a significant amount of transient boat traffic in Murrells Inlet. Most boating activity is either day use or local commercial fishing.

Based on the TMDL results, the loading estimates for each impaired segment are outlined in **Table B-3.** The percent load reductions needed to meet the geometric mean and est. 90th percentile water quality standards are also included.

Table B-3 Estimated Average Daily Fecal Coliform Loadings and Percent Reduction Needed

Impaired Segment	Total Loading	% Reduction to Meet Geometric Mean *(1)*	% Reduction to Meet 90th Percentile *(2)*
Main Creek (04-01, 04-01A, 04-02, 04-27)	1.5x10^12	80.4%	76.5%
Parsonage Creek/Allston Creek (04-08, 04-16, 04-06)	3.4x10^11	53.5%	81.4%
Garden City Canal (04-28)	1.1x10^11	0.0%	71.4%

Source: SC DHEC, Total Maximum Daily Loads for Fecal Coliform in Shellfish Waters of the Murrells Inlet Estuary, South Carolina

TMDL footnotes: (1): The percent reduction needed to achieve the geometric mean standard at all stations within the impaired system. This value is based on the fecal coliform levels predicted by the model and, thus, will deviate from the measured in-stream values due to the simplifying assumptions made during model calibration.

(2): The average percent reduction (computed from station-specific percent reductions) needed to achieve the not to exceed standard.

TMDL Monitoring and Assessment Requirements included in SMS4 permits

Both Horry and Georgetown Counties are subject to conditions in SC DHEC's Municipal Separate Storm Sewer System (SMS4) General Permit to address stormwater discharges in urbanized areas within their jurisdiction, which includes a large portion of Murrells Inlet. A full description of the SMS4 General Permit is included in **Element G: Existing Infrastructure and Management Programs.**

The SMS4 General Permit was renewed on January 1st and requires permittees to develop a TMDL Monitoring and Assessment Plan within twelve months and must include the following information:

- *Monitoring locations, appropriate for representative data collection*

- *Explanation of why monitoring is being conducted for selected locations*
- *A description of whether the locations are representative and contribute to pollutant loads*
- *An indication the seasons during which sampling is intended*
- *The pollutant of concern or its surrogates, as a sampling parameter*
- *Description of the sampling equipment*
- *A rationale supporting the proposed monitored locations as reflective of water quality concerns to the Maximum Extent Practicable.*

Sampling must be initiated within eighteen months of the effective MS4 permit renewal date. The new SMS4 General Permit also requires permittees to develop a TMDL Implementation Plan within 48 months and address the following items:

- *Assessment of the monitoring data. Where long-term data is available, this assessment should include an analysis of the data to show trends;*
- *Prioritization of areas targeted for BMP implementation and underlying rationale;*
- *Structural and nonstructural BMPs to address the wasteload allocation. Permittees should include a brief explanation of why the BMPs are selected (e.g., expected load reductions or percent of capture)*

Post-TMDL Assessments

The Murrells Inlet TMDL was evaluated in detail as part of this watershed planning process. The project steering committee understands that the TMDL was intended to serve as a framing document for identifying areas within Murrells Inlet that are impaired and to help establish initial target goals for water quality improvement. The project steering committee seeks to continue to work closely with SC DHEC utilizing an adaptive management approach in Murrells Inlet as encouraged in the recently adopted TMDL for Wadboo Swamp and Cane Gully Branch:

The Department recognizes that adaptive management/implementation of these TMDLs might be needed to achieve the water quality standard and we are committed towards targeting the load reductions to improve water quality in Wadboo Swamp and Cane Gully Branch. As additional data and/or information become available, it may become necessary to revise and/or modify the TMDL target accordingly.

During the planning process the steering committee reviewed the 2005 Murrells Inlet TMDL with SC DHEC's TMDL staff and concluded:

- That the TMDL development procedures used by the EPA contractor differ from the preferred methods used today. In addition, documentation pertaining to the rationale, and inputs of the model used by the contractor are unavailable to duplicate the consultant's calculations and results.

- The TMDL only utilizes monitoring data from 2001-2004, which does not necessarily provide a representative data set to determine long-term water quality trends in Murrells Inlet.

This watershed plan includes a substantial amount of additional data and new information regarding the water quality trends and hydrological characteristics of Murrells Inlet warranting an evaluation of the need to revise the 2005 TMDL. The subwatershed delineations and land use coverages outlined in this plan are much more detailed, accurate, and current due to the availability of LiDAR-based topographic data and information of the subsurface stormwater infrastructure in Murrells Inlet. This enabled the project steering committee to assess areas of potential fecal coliform sources on a local scale and their pathways into Murrells Inlet. A trend analysis of SC DHEC data was conducted dating back to the initial period of record in 1967. New data sources, particularly the Murrells Inlet Volunteer Monitoring program have also become available, which may help refine source allocations and corresponding load reductions needed.

In addition, SC DHEC may utilize a cumulative probability model to calculate shellfish fecal coliform load reductions in newly issued fecal coliform TMDLs throughout the state. The project steering committee has worked closely with SC DHEC to update the estimated load reductions based on recent monitoring data and by utilizing this cumulative probability modeling technique as outlined in **Element F: Targeted Subwatershed Load Reductions**.

Finally, local resident knowledge and information gathered from partner management agencies was an integral part of this planning process. This dialogue has given the project steering committee a better insight regarding potential pollution sources cited in the 2005 TMDL from existing septic systems, various wildlife species populations, waterfowl, and pet waste that may be affecting water quality in Murrells Inlet. Further discussion and specific recommendations to revise the 2005 Murrells Inlet TMDL are included in the Administrative BMP section in **Element H: Watershed Management Measures.**

The next section **Element C: Evaluation of Potential Fecal Coliform Sources** provides a general assessment of the potential bacteria sources that may be affecting water quality. **Element D: Fecal Coliform Trend Analysis** follows with a much more detailed review of historic fecal coliform trends across the entire Murrells Inlet watershed.

Element C: Evaluation of Potential Fecal Coliform Sources

ELEMENT C: Evaluation of Potential Fecal Coliform Sources and Common Transport Mechanisms

An important first step in developing this watershed-based plan was to conduct a general assessment of the potential bacteria sources in Murrells Inlet. This assessment involved soliciting input from residents, to gain local knowledge about the community and past water quality concerns in the watershed. The steering committee also worked closely with the local water and sewer districts, SC DHEC and SC DNR Shellfish Program staff, and other technical experts to rely on their scientific understanding of Murrells Inlet and its natural processes, with a primary focus on concerns related to bacteria loads in tidal estuaries. **Appendix G** provides a summary of potential bacteria sources in Murrells Inlet that were identified by local stakeholders at a workshop hosted on November 14, 2012.

Identifying potential bacteria sources can be especially difficult because some sources can be localized such as a malfunctioning septic system, while other sources such as pet waste need to be managed in an ongoing basis and can potentially be a problem almost anywhere in the watershed. This element highlights potential bacteria sources that are common to watersheds like Murrells Inlet with an evaluation of the suspected extent of the source and locations of concern where known in Murrells Inlet. This element also discusses common transport pathways by which bacteria are entering the estuary and persisting in the environment.

Figure C-1 *Bacteria source identification mapping exercise with local stakeholders. (Photo courtesy of Daniel Newquist, Waccamaw Regional COG)*

Potential Sources of Bacteria

Residential Septic Systems- Although most residents and businesses within the Murrells Inlet watershed are connected to the centralized sewer system, there are still a few areas that rely on septic systems for wastewater disposal. While the vast majority of existing septic systems are currently functioning properly, they do require long-term maintenance and regular inspections. Ideally these areas will eventually be connected to the sewer system. In the meantime targeted education should be a priority for homeowners relying on septic systems.

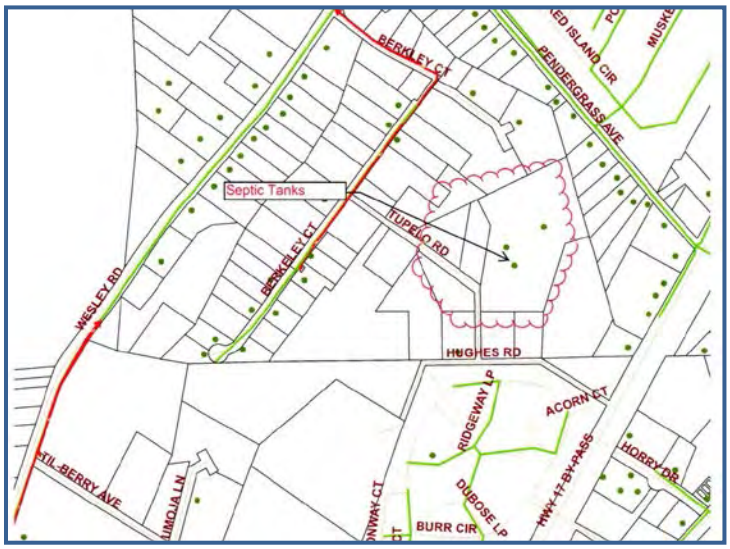
Below is a list of areas relying on septic systems located within the service areas of Georgetown County WSD and Grand Strand WSA:

Georgetown County WSD:

- *Wagon Wheel Mobile Home Park:* Located on the west side of US Highway 17 Bypass near Wesley Road, this mobile home park has approximately 60 units relying on septic systems.

- *Melton Avenue:* Located on the east side of US Highway 17 Business near the Murrells Inlet waterfront. There are only five residences on this street relying on septic systems; however, given the proximity to the Murrells Inlet waterfront close inspection of these systems is strongly recommended.

- *Tupelo Road:* Located off of Berkeley Ct. near Wesley Rd on the southwestern end of the watershed. There are three residences on this street that are relying on septic systems.



Grand Strand WSA:

- *Waterford Oaks:* Located off of Atlantic Ave just west of the Murrells Inlet shoreline. Waterford Oaks is a mobile home residential community accommodating both seasonal and long-term residents. There are approximately 150 individual dwellings within the development. Initial microbial source tracking monitoring conducted by Horry County Stormwater Department has not indicated that there are any bacteria contributions from septic systems in this community. Given the number of residences relying on septic systems and the close proximity to impaired portions of Murrells Inlet, it is imperative that these systems are regularly inspected and a contingency plan is in place in case there are septic system malfunctions in the future.

- *Pirate's Cove:* Located off of Atlantic Ave and Elizabeth Drive just west of the Murrells Inlet shoreline. Pirate's Cove is a long-term residential community on a tidally-influenced pond. Initial water quality monitoring conducted by Horry County Stormwater Department has not indicated that there are any bacteria contributions from septic systems in this community. Given the number of residences relying on septic systems and the close proximity to impaired portions of Murrells Inlet it is imperative that these systems are regularly inspected and a contingency plan is in place in case there are septic system malfunctions in the future.

Sewer Infrastructure- Centralized sewer systems consist of several components including gravity and forcemain sewer lines along with a series of pump stations that create an infrastructure network extending for several miles away from the ultimate wastewater treatment facility. The Grand Strand Water and Sewer Authority provides sewer service to the Horry County portions of the Murrells Inlet watershed. Meanwhile Georgetown County Water and Sewer District provides service to the Georgetown County areas of the watershed. Both agencies operate several wastewater treatment plants providing reliable utility services to thousands of customers. They each have documented records of environmental compliance throughout their respective agency histories as well. There are situations when a large storm such as a hurricane, an extended power outage, or some other type of an emergency situation can cause infrastructure issues resulting in sanitary sewer overflows (SSOs). Given the low-lying topography of Murrells Inlet, most of the pump stations are located near tributary creeks, which would be a direct pathway to the estuary in the event of a SSO. SC DHEC maintains a database of SSO incidents on their website at:

http://www.scdhec.gov/environment/water/wpc_sso.htm#ww_overflows

Figures C-2 and C-3: *Examples of pump stations in Murrells Inlet. The pump station on the left is located near the Point Drive Canal volunteer monitoring station and the one on the right is located near the BHR volunteer monitoring station (Photos courtesy of Dan Newquist, Waccamaw Regional COG and Dr. Dan Hitchcock, Clemson University).*

Sewer service customers also have responsibility for following proper guidance on disposing wastewater into the sanitary sewer system. In particular, problems can occur when grease is disposed of in the sewer system. Fats, oils, and grease (FOGs) can cause problems within a sewer system as they have a tendency to block sewer lines potentially leading to backup occurrences. Problems with improper FOG disposal is more common with restaurant establishments, but can also occur at single-family residences as well. Educational materials explaining the need to properly address grease management issues have been produced by Clemson University's Carolina Clear program. One of the action items recommended in **Element J** is to distribute these materials to local restaurants and vacation renters, possibly in cooperation with the SC DHEC Food Service Inspection program.

On the residential customer side, both sewer districts noted that homeowners occasionally remove the sewer clean out caps as a means of quickly draining ponded stormwater from their yards during large storm events. This causes excess stormwater to enter the sewer system, which increases the risk of overburdening nearby pump stations which are only designed to handle wastewater flow rates typical of households and businesses. Targeted homeowner outreach is necessary to eliminate this practice and is discussed further in **Element J**.

Pet Waste- One of the most preventable sources of bacteria where individuals can make a direct impact on water quality is the proper disposal of pet waste. If pet waste is not removed, it can eventually wash into the nearest storm sewer, creek or drainage ditch and then flow towards the inlet. Warm blooded animal feces contain millions of fecal coliform bacteria and if removal is not made a community priority then it can become a significant contributor to fecal coliform impairments in Murrells Inlet.

Monitoring data collected as part of Horry County's microbial source tracking study (further discussed in **Element D**) have indicated that canine waste is a contributor of fecal coliform in the northern portion of the Murrells Inlet watershed. As a community, Murrells Inlet has a number of residential neighborhoods as well as several waterfront areas that attract vacation renters. The Murrells Inlet area is also a major outdoor recreational destination with several parks, walkways, and boat landings making it a popular place for people to bring their pets. Educating both local residents and visitors on the importance of removing pet waste and the direct linkage to the environmental sensitivities of the local estuary and shellfish habitat areas is critical. Georgetown County has been proactively addressing this issue by installing numerous pet waste disposal stations and through other public outreach initiatives. In 2012, over 11,000 pet waste bags were used at six pet waste station locations. As this will be an ongoing management need, additional public education ideas and strategies to address pet waste are explored in **Element J** of this plan.

Figures C-4 and C-5: *While efforts have been made to educate the public on the need to pick up pet waste, problems continue to be observed even near shoreline areas. Proper pet waste disposal needs to continue to be a priority in the Murrells Inlet community. (Photos courtesy of Murrells Inlet 2020)*

Wildlife and Bird Populations- The Murrells Inlet area possesses some of the region's most beautiful coastal natural habitats. Huntington Beach State Park and Brookgreen Gardens span more than two thousand acres on the south end of the Murrells Inlet watershed, providing critical habitat for an incredible diversity of wildlife species. Bird photographers and nature enthusiasts from across the country come to Murrells Inlet to observe large populations of resident and migrating bird species such as wood storks, ibises, herons, egrets, pelicans, gulls, ducks, shorebirds and even recent sightings of roseate spoonbills. The bird and mammal populations that once resided in areas that are now developed, concentrate in these undeveloped portions of the watershed. Wildlife has always contributed significantly to the natural background levels of bacteria present in the estuary. The regulator's and watershed manager's dilemma is how to effectively manage water quality in a balanced way for the benefit of all species, and not just one (e.g., eastern oyster) if by doing so proves to be detrimental to the others.

Figure C-6: *There are extensive forested areas suitable for wildlife in the watershed, particularly in the southern portions in Georgetown County. (Photo courtesy of Daniel Newquist, Waccamaw Regional COG)*

An important yet challenging aspect of regulating and managing water quality in Murrells Inlet is to accurately account for the bacteria contributions from wildlife species populations that are known to inhabit Murrells Inlet. A chart with estimated average bacteria loads for various animal species based off of information provided by NOAA's Nutrient and Coliform Loading Project is provided in **Appendix D**. By doing so, watershed managers are able to distinguish anthropogenic bacteria sources (e.g those associated with human activities) from wildlife sources where the management strategies are limited. One of the few management activities to minimize wildlife sources is to discourage feeding waterfowl and being careful not to leave pet food outdoors which can attract small mammals such as raccoons and opossums. Many strategies can also be used to discourage birds from roosting on docks and platforms adjacent to the estuary however the effectiveness of this approach is less known.

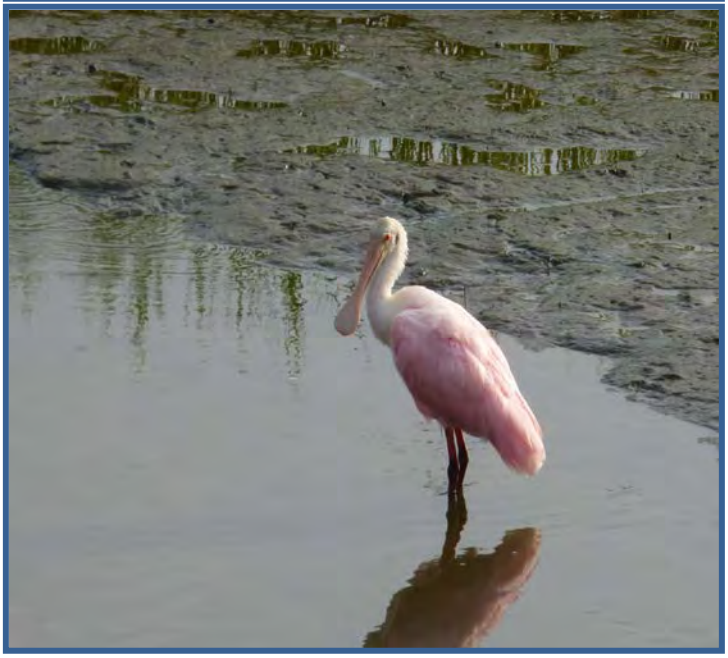


Table C-1 is a list of subwatersheds that are predominately open space areas well suited as wildlife habitat. These thirteen subwatersheds account for 1,969.75 acres or 31.2% of the 6,322.50 acres of land area that drain into the Murrells Inlet estuary. The Bike Bridge subwatershed (507.98 acres) is a transitional area between the primarily undeveloped portions of Murrells Inlet and the urbanized neighborhoods between Business Rte 17 and Bypass Rte 17. It is also worth noting that waterfowl often inhabit shoreline areas along docks and ponds in the more densely urbanized portions of Murrells Inlet.

Figures C-7 and C-8: *The Murrells Inlet estuary is populated by a wide variety of resident and migratory bird species including pelicans, wood storks, roseate spoonbills, among many others. (Photos courtesy of Gary Weinreich, Murrells Inlet Volunteer Monitoring Program)*

There are also large populations of opossums, raccoons, and other small mammals that are common to urban/suburban settings. These species can cause nuisances by foraging through trash bins, dumpsters, or around homes. Even coyote have been regularly observed in developed sections of the watershed. A periodic wildlife species inventory, which is recommended in **Element K: Water Quality Monitoring Strategic Plan**, would assist water resource managers in accurately estimating potential bacteria sources from wildlife or from domesticated animals such as dogs and feral cat colonies. It should also be noted that there are a few small farms within the watershed which keep horses, livestock, and other animals. Measures such as proper fencing or a vegetated buffer adjacent to nearby ditches and creeks would help to minimize bacteria loadings and potential impacts on water quality in the inlet.

Table C-1 Subwatersheds with Significant Land Areas Suitable for Wildlife Populations

Basin Name	Acres	Basin Name	Acres
Brookgreen SW	394.50	*Brookgreen S*	100.93
HBSP Main Beach	323.77	*Brookgreen SE*	83.80
Brookgreen NW	304.58	*Oyster Landing*	56.53
Huntington Marsh	182.62	*HBSP Ed Center*	27.23
HBSP North Beach	171.34	*Brookgreen N1*	20.21
HBSP Causeway	151.75	*Brookgreen NW1*	19.34
Brookgreen N	133.15	**TOTAL**	**1969.75 acres**

Source: Based off of subwatershed delineations produced by Earthworks Group, LLC

Legacy Sources- Murrells Inlet, like many other communities along the South Carolina coast, has undergone significant change over the past few decades. Development has altered the landscape in many areas of the watershed, with the exception of land managed by Huntington Beach State Park and Brookgreen Gardens. Some of the residential neighborhoods in Murrells Inlet were once utilized for agricultural purposes. Among the former uses include a goat farm and a chicken processing plant. Knowing that these activities occurred for long-periods of time, it is worth further investigating whether these former land uses, in addition to others, may possibly be legacy sources of bacteria. Investing monitoring resources to investigate the influence of these sites on bacteria levels is a recommendation outlined in **Element K, Water Quality Monitoring Strategic Plan.** If a study indicates that no impact exists, then watershed managers know that they can shift their efforts to other known sources.

Common Bacteria Transport Pathways

Stormwater Runoff- During a precipitation event, water flows across the ground surface and ultimately infiltrates into the groundwater system or is transported via runoff into nearby ditches and streams, eventually draining into the closest main waterbody. Most conventional storm sewer systems do not have treatment mechanisms, therefore runoff carrying debris, sediment, bacteria, or other contaminants is discharged into the aquatic environment, potentially affecting water

quality. A common problem that growing communities face is managing runoff rates and contaminant loads as development increases. Hard surfaces such as buildings and roads are impervious to groundwater infiltration, often leading to higher surface runoff rates and volumes.

Stormwater runoff can affect bacteria levels in the Murrells Inlet estuary in differing ways. First, stormwater runoff is the primary transport mechanism for any non-point source of bacteria. When stormwater runoff reaches the inlet in greater volumes and at a faster rate, a lower percentage of bacteria that exists on the land can be retained at the point of origin prior to reaching the main channel in Murrells Inlet. Another factor that may indirectly influence bacteria levels is the change in salinity balance in the estuary due to the increase of freshwater inputs. Bacteria do not survive as long in high salinity waters.

New technologies and strategies have emerged such as Low Impact Development (LID), which are designed to mimic predevelopment hydrology by retaining and treating stormwater generated onsite following a precipitation event. A few examples of LID techniques which have been implemented in Murrells Inlet are highlighted in **Element H: Watershed Management Measures.** Structural stormwater management practices such as LID are one of the main recommendations highlighted in **Element H**.

Figure C-9 *Conventional storm drain which directs runoff untreated into the nearest waterbody (Photo courtesy of Dr. Dan Hitchcock, Clemson University)*

Figure C-10 *An example of an LID practice which helps retain stormwater onsite while also providing filtration and pollutant removal benefits. (Photo courtesy of US EPA)*

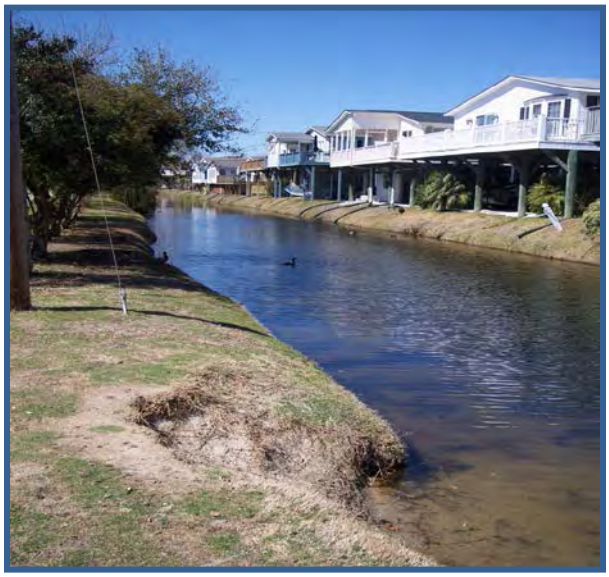
Land Use Change- A secondary impact resulting from urbanization over time is the associated increase in impervious coverage in the watershed. As discussed above, development often changes the natural hydrology in the landscape requiring investments in stormwater infrastructure. To assess changes in land use properties over time, National Aerial Photography Program (NAPP) Color Infrared aerial photographs from 1994 were compared to natural color aerial photography flown in 2012. Land use change was quantified by assessing the change in Curve Numbers.

Current land use Curve Number characteristics provided a baseline for comparative purposes against the change in land use between 1994 and 2012. The United States Department of Agriculture (USDA) Natural Resources Conservation Service (SCS) developed the Curve Number method to help determine rainfall runoff rates during storm events. Curve Numbers are calculated by evaluating the hydrologic classification given to soil groups in conjunction with the type of land use present. For example, soils with high permeability (Type A) that can retain more water during rainfall events, if found in a forested area with no impervious surfaces, would have a very low Curve Number value (e.g. 30) A 30 value means that the landscape will retain and release water from the watershed slowly. Comparatively, an area of Medium Density Residential (1/4 acre lots) land use with poorly drained soils (Type D) would have a much higher Curve Number Value (e.g. 87). Those areas would more rapidly release water if there was a lack of onsite retention. Finally, fully impervious surfaces such as asphalt parking lots, driveways, and roads are designated with the highest Curve Number (e.g. 98). These areas exhibit the highest runoff rates following rain events because water immediately begins flowing across them with no infiltration.

Exhibit C-1 displays the rate of Curve Number change for each delineated subwatershed within Murrells Inlet. **Appendix G** provides a list and a description of all of the soil types that are found in the Murrells Inlet watershed.

Drainage Ditches- As one of the primary mechanisms for stormwater runoff and sediment transport, drainage ditches have the potential to be a main conduit of bacteria loads**.** Our steering committee consulted with watershed managers in Bluffton, SC, who have undertaken a similar watershed planning project in the May River watershed. One of their main priorities has been focused on stormwater volume reduction and drainage ditch maintenance. Their watershed plan has also acknowledged the tendency of small mammals, such as raccoons and opossum to utilize drainage ditches as a freshwater source and habitat area. Similar observations have been made in the Murrells Inlet area by residents and county stormwater staff.

There are ways to minimize erosion and to reduce bacteria concentrations in the drainage ditch network. Drainage ditches can be designed to decrease stormwater flow rates and increase retention times. There are also opportunities in drainage ditches to install stormwater filtration devices to remove bacteria prior to entering the inlet. One of the major products of this watershed plan is the extensive mapping of the drainage network in each of the 51 subwatersheds within Murrells Inlet. This detailed mapping provides an inventory of the creeks, ditches, retention ponds, culverts, and catch basins that collect and convey stormwater runoff. The mapping illustrates the conveyance of hydrology within each subbasin drainage area to a specific discharge point into the inlet. The subwatershed maps were utilized in identifying possible locations within Murrells Inlet to invest in structural BMPs to minimize bacteria contributions from ditches and other key components of the stormwater infrastructure network. The list of specific BMP recommendations is included in **Element H.**



Figures C-11 and C-12: *The stormwater infrastructure system within the watershed consists of an extensive network of canals, ditches, ponds, pipes, and outfalls. In some cases, residents have attempted to address localized drainage issues by constructing small scale ditches. These practices can exacerbate erosion problems and potentially affect drainage patterns in downstream areas nearby. (Photos Courtesy of Dan Newquist, Waccamaw Regional COG and Dr. Dan Hitchcock, Clemson University)*

Sedimentation- An issue closely related to stormwater runoff is the transport and settling of sediments into creekbeds and shellfish habitat areas. Soil erosion is a natural process that occurs in every watershed to varying extents. Problems arise however if erosion occurs to a degree that negatively impacts aquatic habitat or drastically alters the hydrodynamic characteristics of a waterbody. Several stakeholders have noticed numerous changes since the construction of the jetty in 1980. The jetty structure which provides safe passageway for vessels entering the main channel of Murrells Inlet has altered the tidal flow dynamics and ultimately the soil deposition patterns in the watershed. Concerns regarding sedimentation resulting from inadequate stabilization during roadway construction and follow up maintenance have also been observed.

In Murrells Inlet, excessive sedimentation can affect the habitat quality of oyster populations. It has been observed by local residents that parts of Murrells Inlet, such as Parsonage Creek, Main Creek, and Garden City Canal have become shallower due to a significant build up of sediment. These changes have become even more pronounced in both the northern and southern end upper reaches of the watershed. The end result is that over time these areas experience diminished tidal flushing, changing the salinity balance, and possibly affecting shellfish habitat.

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MAP TITLE:
MURRELLS INLET
WATERSHED INVENTORY
Exhibit C-1
Subwatershed Analysis

PROJECT TITLE:
MURRELLS INLET WATERSHED
MANAGEMENT PLAN

DATE:
07/11/2013

TEG PN:
121108.000:E

AUTHOR:
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PREPARED FOR:
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SCALE:
1:36,000
0 1,500 3,000
FEET

PROJECT LOCATION:
MURRELLS INLET
GEORGETOWN COUNTY
SOUTH CAROLINA

Legend
Community Input
SCDHEC Monitoring
Volunteer Monitoring
Impaired: No
Impaired: Yes
SCDHEC Commercial Beds
Sub Watersheds
Approx. Hydrology

As discussed in more detail in **Element D,** bacteria are known to bind to sediment particles and can survive and even multiply in an aquatic environment over an extended period of time. Bacteria levels can increase when sediments are disturbed and become resuspended in the water column. The fine sediments are stirred from the shallow creeks by rainfall runoff, high winds, and boat traffic at low tides. The resuspended sediments, especially those less than 5 microns in diameter, carry attached bacteria into the inlet. Because of their very small diameter, they do not readily settle and remain in the water column for extended periods. (Anderson and Greoski 2010).

Figures C-13: *Substantial sedimentation has been observed in several upstream creeks and tributaries, as evidenced in this segment of Point Dr. Canal. (Photo courtesy of Dr. Dan Hitchcock, Clemson University)*

Boating- Murrells Inlet is one of the most popular recreational boating destinations along the Grand Strand and in all of South Carolina. Most of the boating activity in Murrells Inlet is limited to daytime use, with infrequent transient boat traffic. As a result, improper holding tank discharges in Murrells Inlet has not been an issue. Initial microbial source tracking data collected by Horry County Stormwater Department has not shown significant evidence of human sources of bacteria in the main channel of the inlet. However, since the potential for illicit discharge exists and incidents have occurred in the past it is important to make boaters aware of the regulations pertaining to holding tank discharges and provide other boaters the appropriate contact information to notify the Coast Guard or other relevant enforcement agencies if they suspect that an illicit discharge has occurred.

One of the consensus findings of the steering committee is the noticeable siltation that has occurred in Murrells Inlet in recent years. One cause of the sedimentation observed in Murrells Inlet is shoreline erosion resulting from excessive boat wakes. **Element I: Public Education and Outreach Resources** is structured to prioritize public awareness strategies to specific target groups, one of them being recreational boaters. Making boat owners mindful of "No Wake Zones" is important not only for public safety and private property reasons but also to ensure that the sensitive marsh and shellfish habitats are not disturbed. It may be worth examining the appropriateness of expanding "No Wake Zones" in areas known to be experiencing pronounced shoreline erosion and siltation. The Murrells Inlet area has several public boat landings. Due to the high popularity and regular use of these amenities, they are ideal locations for interpretive signs or other public awareness tools.

Figure C-14: *Murrells Inlet is one of the most popular boating destinations in the state. Boat landings can serve as good locations for public education signage regarding water quality, shellfish habitat and boating related issues such as the impacts of boat wakes. (Photo courtesy of SC DNR)*

Summary Evaluation

Following extensive discussions on potential sources of bacteria that exist in Murrells Inlet, the project steering committee has come to the following conclusions regarding the relative contributions, by rank order, of each source.

1. **Wildlife and Waterfowl:** Based on an assessment of available investigatory monitoring data including the Murrells Inlet Volunteer Monitoring program, Horry County microbial source tracking study, and the Georgetown County upstream monitoring initiative it appears that wildlife and waterfowl is the largest contributing source of bacteria in the Murrells Inlet watershed. Other visual observations such as animal tracks in creek beds, road kill frequencies, and other wildlife sightings support this finding. The estuary supports habitat for numerous waterfowl populations which maintain a noticeable presence along the shoreline throughout Murrells Inlet.

2. **Pet Waste:** As discussed earlier in this element, pet waste is recognized as a community-wide pollution concern in Murrells Inlet and is suspected to be the second largest source of bacteria. As noted, indications are that the pet waste stations are being used and are helping to eliminate significant bacteria loads from the environment. A management challenge is encouraging private landowners from picking up pet waste on their own properties.

3. **Septic Systems:** The available monitoring data indicates that the existing septic systems in Murrells Inlet are working properly and show no evidence of contributing bacteria into the estuary. However, septic systems remain a potential source and the steering committee views it as an important preventative management priority.

4. **Sewer Infrastructure:** Similarly, little evidence has indicated that the existing sewer line and pump station network is a significant source of bacteria in Murrells Inlet. A few stakeholders have expressed concerns regarding the location of several pump stations immediately adjacent to tidal creeks and tributaries and occasional odor has also been observed. Ongoing coordination with the water and sewer districts will be encouraged. One recommendation is to conduct a microbial source tracking study of the pump station inventory to assess whether human bacteria sources from the sewer network are contaminating adjacent creeks or sediments.

5. **Hobby Farms:** There are a few properties with horses and livestock in Murrells Inlet. They are not suspected to be significant sources, however local watershed managers will work with the property owners to encourage appropriate management practices such as fencing or establishing vegetative buffers along nearby shorelines.

6. **Illicit Boat Discharges:** While illicit boat discharges are a potential bacteria source, little evidence suggests that it is currently a problem. The project steering committee views it as a preventative management issue and will continue to support public outreach efforts to boaters and work with law enforcement officials to ensure that incidents are avoided in the future.

Other conclusions that the steering committee made during the bacteria source assessment were as follows:

- From a management perspective, it was agreed that addressing the listed sources on a subwatershed scale is most effective. Obviously, contributions from septic systems will be limited to specific locations within the community. Also the relative contributions of wildlife and pet waste will vary from one area of the watershed to another.

- As discussed at length in this element, an equally important aspect in managing bacteria sources involves addressing concerns related to the transport mechanisms, particularly stormwater runoff, the drainage ditch network, and sedimentation. The steering committee acknowledges that while it is not possible nor ethical to eliminate wildlife as a source, it is possible to reduce the ultimate fate and transport of wildlife sources through innovative stormwater management strategies.

The next element provides a more technical analysis of monitoring data collected by SC DHEC and the Murrells Inlet Volunteer Monitoring Program. This element serves as the principal baseline assessment that identifies bacteria trends over time and the influence of wet weather conditions on fecal coliform levels. **Element D** also provides a geographic perspective of areas that have historically shown higher levels of fecal coliform.

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Element D: Fecal Coliform Trend Analysis

ELEMENT D: Fecal Coliform Trend Analysis

One of the primary means of evaluating the environmental health of an ecosystem is through ongoing research and monitoring. As outlined in **Element B**, the State of South Carolina has collected water quality samples as part of their management decision-making framework since the early 1960s. In addition, other entities such as SC DNR, NOAA, Coastal Carolina University, and University of South Carolina have conducted numerous studies and research projects to increase the scientific understanding of coastal estuarine systems such as Murrells Inlet. More recently, Georgetown and Horry Counties have partnered with Murrells Inlet 2020 and Coastal Carolina University to initiate a volunteer monitoring program at eight sites throughout Murrells Inlet. Of the eight sites, two are located on tidal creeks, three are on small freshwater impoundments, and three are on small, free-flowing, freshwater creeks.

The monitoring information provided by each of these entities has implications on shellfish harvesting activities and is essential to protecting water quality in Murrells Inlet. As part of an adaptive management approach, long-term monitoring programs enable local watershed managers to optimize resources and employ targeted interventions. The monitoring data can and should guide decisions regarding appropriate management strategies to pursue in the watershed.

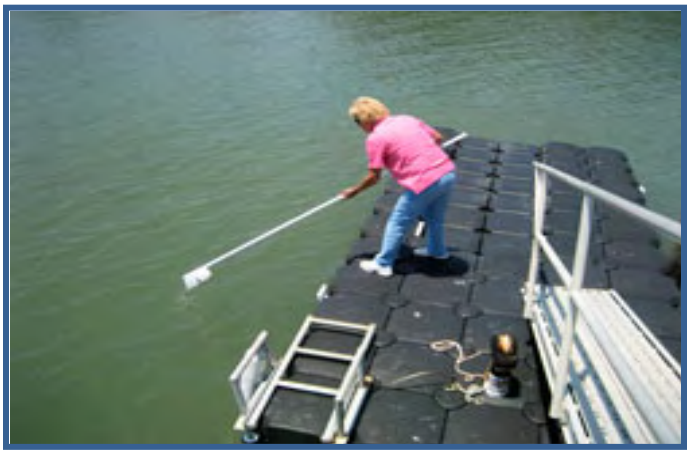


Figure D-1 *Volunteer collecting a sample as part of the Murrells Inlet Volunteer Monitoring Program. (Photo courtesy of Coastal Carolina University)*

This element is an in-depth analysis of the fecal coliform trends as reported by the SC DHEC Shellfish Program since the early 1990s. Other observations such as precipitation data collected by the National Weather Service at Brookgreen Gardens and supplemental monitoring data from the Murrells Inlet Volunteer Monitoring Program are summarized and discussed. Faculty and staff from Coastal Carolina University's Waccamaw Watershed Academy conducted the data analysis. This baseline assessment of historical water quality trends and current conditions in Murrells Inlet is the primary basis for the recommendations outlined in the remainder of this watershed-based plan.

Fecal Coliform Data Analysis Plan

The purpose of conducting a thorough review of the historical monitoring data was to answer the following key questions, each of which will be discussed in more detail later in the element:

- Which monitoring sites have had persistently elevated concentrations of fecal bacteria?
- Have the fecal coliform levels at each monitoring site increased or decreased over time?
- Are fecal coliform concentrations higher under wet or dry weather conditions?
- What factors could be influencing the time trends in fecal coliform concentrations?

The primary sources of data analyzed in this baseline assessment were the following:

- SC DHEC Shellfish Program: Fecal Coliform Monitoring Data, 1967-2012. Note that there SC DHEC utilized a new method for collecting fecal coliform data beginning in 1992.
- SC DHEC Shellfish Program: Shellfish Management Area 04, Annual Update Reports 1992-2013
- 2005 Murrells Inlet Fecal Coliform TMDL
- Murrells Inlet Volunteer Monitoring Program: E. Coli and Total Coliform Data, 2008-Present
- National Weather Service, Brookgreen Gardens Rain Gauge, Precipitation from 1958 to present.
- 2013 Horry County Microbial Source Tracking Study
- 2013 Georgetown County Upstream Monitoring Initiative

Summary of Regulatory Status Trends in Murrells Inlet

This next section reviews the regulatory status of each of the SC DHEC Shellfish monitoring stations since 1992. Both the geometric mean standard of 14MPN/100ml and the 90th percentile standard of 43MPN/100ml are analyzed. This provides a long-term perspective of which monitoring sites have regularly exceeded the standards, which sites have always met the standard, and which sites only periodically exceed the standards. As a note, as indicated in **Figure D-2** below the number of monitoring sites sampled by SC DHEC does vary periodically due to shifts in monitoring priorities and in some cases reductions in available program resources.

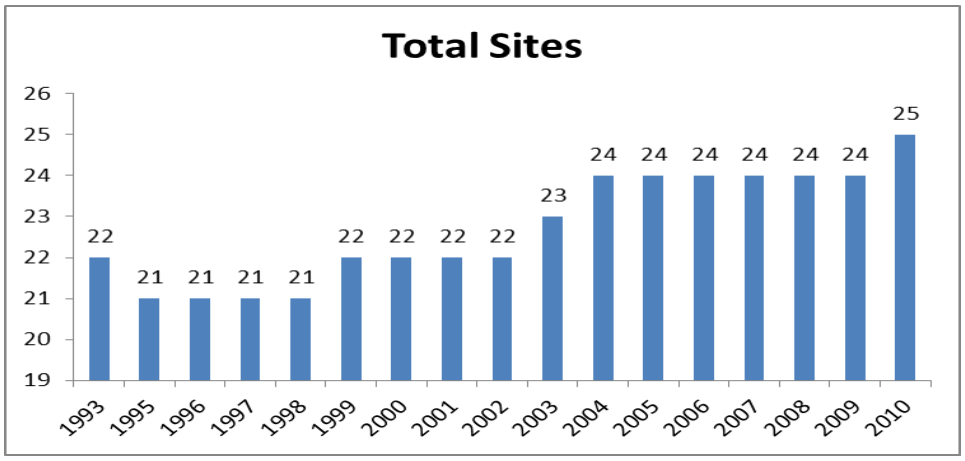


Figure D-2 *Number of monitoring sites sampled by DHEC since 1993.*

Table D-1 displays the regulatory trends for the geometric mean standard of 14MPN/100ml over the last twenty years using a three- year running statistic as presented in the annual shellfish reports. As indicated, the majority of the monitoring sites have consistently met the geometric mean standard. Sites 04-01(Main Creek at Atlantic Avenue Bridge), 04-08(Parsonage Creek at Nance's Dock), and 04-16(Parsonage Creek at Chicken Farm Ditch) have experienced fecal coliform levels above the 14MPN/ 100ml geometric mean standard on a regular basis for the past 20 years. Over this same time period monitoring site 04-26,(Garden City Canal at the "Old Boat Wreck"), 04-02 (Main Creek at Mickey Spillane's Home) and 04-27 (Main Creek Opposite Entrance to Mt. Gilead Canal) has met the geometric mean standard the majority of the time, but recently has exceeded the 14MPN/100ml threshold.

Table D-2 is an overview of the regulatory trends for the est. 90th percentile fecal coliform standard of 43MPN/ 100 ml in Murrells over the last twenty years using a three-year running statistic as presented in the annual shellfish reports. The est. 90th percentile standard is the more difficult threshold to meet, due in large part to the high temporal variability observed in fecal coliform levels. In coastal estuarine environments such as Murrells Inlet, fecal coliform concentrations are highly influenced by rain events, salinity levels, wind, tidal currents and stage, sunlight exposure, and other environmental factors, which can lead to drastic fluctuations in fecal coliform levels. The est. 90th percentile standard is a conservative limit designed to safeguard the general public from illnesses caused by consumption of raw shellfish products. Ultimately it is a difficult standard to meet but remains the targeted goal in this plan, as it is necessary in order to maximize the Approved acreage available for shellfish harvesting.

Table D-1: Geometric Mean Trends by Monitoring Site

Sites	1992-1994	1994-1996	1995-1997	1996-1998	1997-1999	1998-2000	1999-2001	2000-2002	2001-2003	2002-2004	2003-2005	2004-2006	2005-2007	2006-2008	2007-2009	2008-2010	2009-2011	2010-2012	%Over
1	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	100%
1A	O	O	O	O	O	O	O	O	*Monitoring discontinued beyond this date*										100%
2	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	O	O	O	17%
3	U	U	U	U	U	U	U	U	*Monitoring discontinued beyond this date*										0%
03A	*Monitoring not initiated until this date*								U	U	U	U	U	U	U	U	U	U	0%
03B	*Monitoring not initiated until this date*								U	U	U	U	U	U	U	U	U	U	0%
4	U	U	U	U	U	U	U	U	U	U	*Monitoring discontinued beyond this date*								0%
04A	*Monitoring not initiated until this date*									U	U	U	U	U	U	U	U	U	0%
04B	*Monitoring not initiated until this date*										U	U	U	U	U	U	U	U	0%
04C	*Monitoring not initiated until this date*										U	U	U	U	U	U	U	U	0%
5	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	0%
6	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	O	O	U	11%
7	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	0%
8	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	100%
08A	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	0%
16	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	100%
17	O	U	U	U	U	U	U	U	*Monitoring discontinued beyond this date*										13%
17A	*Monitoring not initiated until this date*								U	U	U	U	U	U	U	U	U	U	0%
18	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	0%
22	U	*Monitoring discontinued beyond this date*																	0%
23	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	0%
24	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	0%
25	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	0%
26	U	U	U	U	U	U	U	O	O	O	O	O	U	U	U	O	O	O	44%
27	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	O	O	O	17%
28	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	O	U	U	6%
29	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	0%
30	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	0%
31	*Monitoring not initiated until this date*					U	U	U	U	U	U	U	U	U	U	U	U	U	0%
32	*Monitoring not initiated until this date*																U	U	0%
%Year	23%	19%	19%	19%	19%	18%	18%	23%	18%	17%	17%	17%	13%	13%	13%	33%	28%	24%	

NOTES: O= Over Geomean Standard of 14 MPN/100ml U= Under Geomean Standard of 14MPN/100ml

Table D-2: 90th Percentile Trends by Monitoring Site

Sites	1992-1994	1994-1996	1995-1997	1996-1998	1997-1999	1998-2000	1999-2001	2000-2002	2001-2003	2002-2004	2003-2005	2004-2006	2005-2007	2006-2008	2007-2009	2008-2010	2009-2011	2010-2012	%Over
1	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	100%
1A	O	O	O	O	O	O	O	O	*Monitoring discontinued beyond this date*										100%
2	O	U	U	O	O	O	U	O	O	O	O	O	O	O	O	O	O	O	83%
3	U	U	U	U	U	U	U	U	*Monitoring discontinued beyond this date*										0%
03A	*Monitoring not initiated until this date*								O	O	U	U	U	U	U	U	U	U	20%
03B	*Monitoring not initiated until this date*								O	O	U	U	U	U	U	U	U	U	20%
4	U	U	U	U	U	U	U	U	U	O	*Monitoring discontinued beyond this date*								10%
04A	*Monitoring not initiated until this date*									U	O	U	U	U	U	U	U	O	22%
04B	*Monitoring not initiated until this date*									U	U	U	U	U	U	U	U	U	0%
04C	*Monitoring not initiated until this date*									U	U	U	U	U	U	U	U	U	0%
5	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	0%
6	O	U	U	U	U	O	O	O	O	O	O	O	U	U	O	O	O	O	67%
7	O	U	U	U	U	U	U	U	U	U	U	U	U	O	O	O	O	O	33%
8	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	100%
08A	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	0%
16	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	100%
17	O	U	O	O	O	U	U	O	*Monitoring discontinued beyond this date*										63%
17A	*Monitoring not initiated until this date*								O	O	U	O	U	O	U	U	O	O	60%
18	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	O	O	U	11%
22	O	*Monitoring discontinued beyond this date*																	100%
23	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	0%
24	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	0%
25	U	U	U	U	U	U	U	U	U	O	O	U	U	U	U	U	O	U	17%
26	O	U	U	U	O	O	O	O	O	O	O	O	O	O	O	O	O	O	83%
27	O	U	O	U	O	O	O	O	O	O	O	O	U	O	O	O	O	O	83%
28	O	U	U	U	U	U	U	U	O	O	O	U	U	U	U	O	O	O	39%
29	O	U	U	U	O	U	U	U	U	U	U	U	U	U	U	U	U	U	11%
30	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	0%
31	*Monitoring not initiated until this date*					U	U	U	U	O	O	U	U	U	U	O	O	O	38%
32	*Monitoring not initiated until this date*																U	U	0%
%Year	59%	19%	29%	29%	43%	36%	32%	41%	50%	61%	46%	33%	21%	33%	33%	46%	52%	48%	

NOTES: O= Over 90th Percentile Standard of 43MPN/100ml U= Under 90th Percentile Standard of 43MPN/100ml

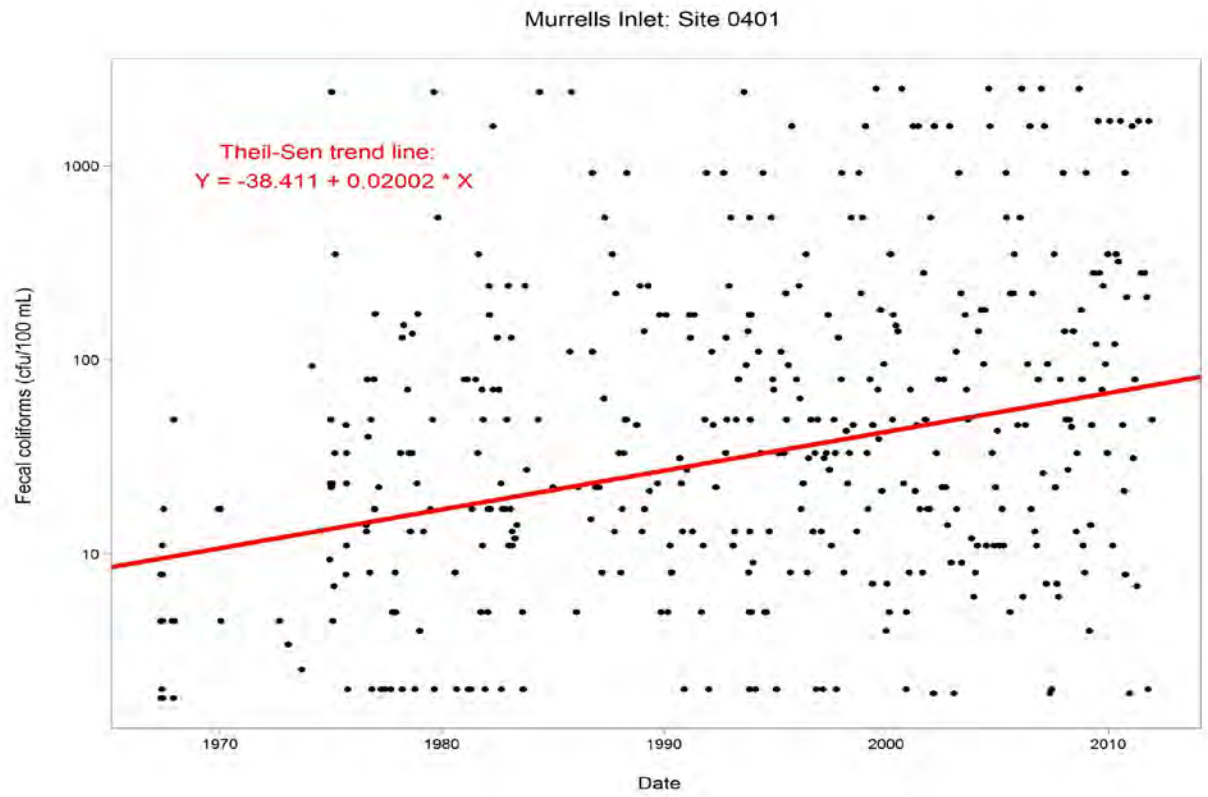


Figure D-3 *As indicated in this scatter plot of data from SC DHEC monitoring station 04-01, the variability in fecal coliform levels is quite noticeable, and can be influenced by rainfall, tide, wind and several other environmental factors. Statistical trend analysis is important in assessing the water quality trends over time in Murrells Inlet. (Graph produced by Dr. Susan Libes based on monitoring data from 1967- 2011)*

In addition to having a high frequency of contravening the geometric mean standard, monitoring sites 04-01, 04-08, and 04-16 also consistently exceed the est. 90th percentile standard throughout the period of analysis. **Element F, Targeted Subwatershed Load Reductions** further examines monitoring sites and adjacent subwatersheds that have been identified as priority areas for best management practice consideration. Due to the persistently high levels of fecal coliform, monitoring sites 04-01, 04-08, and 04-16 have been designated as Tier 1, or the highest priority sites for improvements. Other active monitoring sites that have exceeded the est. 90th percentile standard more than half of the years in this period of analysis include 04-02, 04-06, 04-17A (Southwest Corner of the Voyager View Marina Prohibited Zone in Parsonage Creek), 04-26, and 04-27. They have also been identified as priority sites in **Element F.**

Appendix D includes graphs for each monitoring station that display the fecal coliform three year running average trends (as used in the SC DHEC Shellfish Reports) over time since 1992 and their relation to both the geometric mean and the 90th percentile standard for fecal coliform. As discussed above, the tendency to exceed the 90th percentile standard is more common than exceeding the geometric mean water quality

standard. Time trend graphs were also produced for each monitoring site and are also included in **Appendix D**.

HISTORIC RAIN DATA- BROOKGREEN GARDENS

It has been documented that fecal coliform levels are strongly influenced by the frequency of rainfall events within a watershed area. The primary rain gauge in the general vicinity of Murrells Inlet used by regulatory agencies including the National Weather Service and SC DHEC is located at Brookgreen Gardens. The precise location of this rain gauge is 33.519444"N and -79.091829"W, which is outside the watershed boundary of the Murrells Inlet estuary and approximately 1.5 miles from the nearest point on the inlet at the Huntington Beach State Park causeway.

One of the primary advantages of using the Brookgreen Gardens rainfall gauge is that rainfall has been consistently recorded in daily intervals at this site since the late 1950s making it a very reliable source of data. There are some disadvantages with using Brookgreen Gardens as a sole data source for precipitation and are mentioned below:

- Location of Brookgreen Gardens is outside of the Murrells Inlet watershed boundaries.
- There has been an increase in daily missed readings in recent years resulting in larger data gaps.
- The weather conditions in Murrells Inlet can vary significantly, especially during summer thunderstorm events. Having multiple reliable rain gauges would provide a more representative data set of rainfall patterns in Murrells Inlet.

Recommendations are outlined in **Element J: Water Quality Monitoring Strategic Plan** to establish additional rain gauge sites at other locations within Murrells Inlet, perhaps even through the Community Collaborative Rain Hail and Snow Network, a citizen reported program, commonly referred to as CocoRahs.

Having a firm understanding of the effect of rainfall on fecal coliform levels is critical to the management of shellfish harvesting activities. In the past, SC DHEC has managed shellfish harvesting areas utilizing the Conditionally Approved classification for some areas that did not meet the Approved classification. A Conditionally Approved area requires a site specific management plan typically related to closure criteria during wet weather periods. **Figure D-4** displays the annual rainfall precipitation data at Brookgreen Gardens dating back to 1958. According to SC DNR's State Climatology Office, the Coastal Plain portion of South Carolina normally receives a total of 50-52 inches of rain yearly. As the graph indicates, over the last decade the area has received below average rainfall. The implications on the relationship to fecal coliform levels are multifold and are explained later in this element.

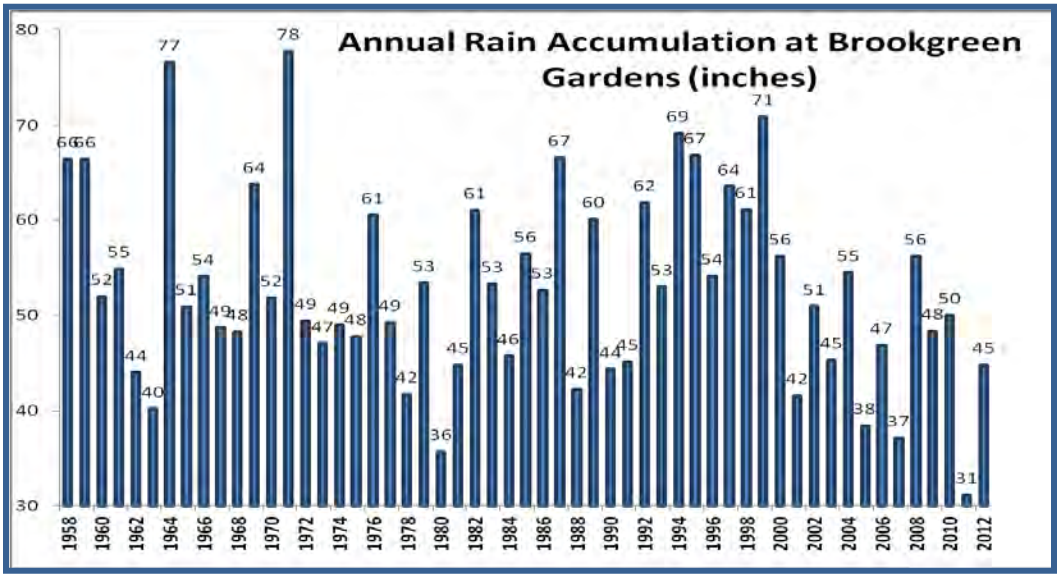


Figure D-4: *Annual Rainfall Totals at Brookgreen Gardens*

Figure D-5 displays the occurrence of significant rainfall events on an annual basis. In this baseline assessment, long-term trends at each monitoring site were analyzed based on the previous three days of wet (minimum total precipitation of 0.5") or dry (no rainfall) weather conditions, which is a typical reference timeframe in stormwater regulatory practices.

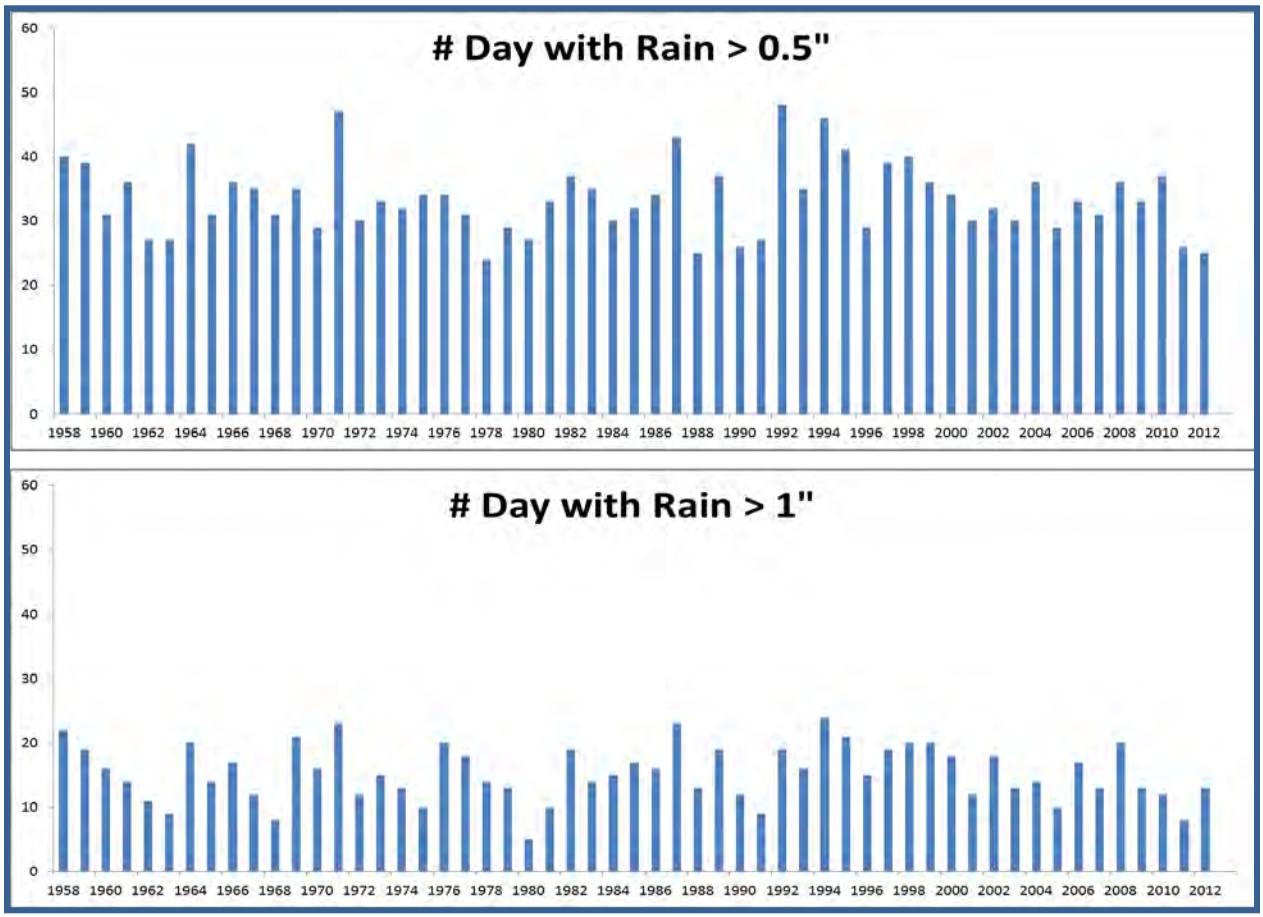


Figure D-5 *Occurrence of rain events at Brookgreen Gardens*

Summary Explanation of Fecal Coliform Data Trends

The following section provides explanations to the questions posed at the beginning of this element providing insight into the bacteria trends observed in Murrells Inlet dating back to 1992.

Which monitoring sites have had persistently elevated concentrations of fecal bacteria?

- Based on a review of the past 18 SC DHEC Management Area 04 Annual Shellfish Reports dating back to 1992, the monitoring sites which contravened the geometric mean standard most frequently were 04-01, 04-08, and 04-16. At each of these sites, the geometric mean standard was exceeded each year since 1992. Monitoring site 04-26 also exceeded the geometric mean standard on a frequent basis, representing 44% of the shellfish reports reviewed. Of note, all of these sites are in the shallower portions of Murrells Inlet where there is less tidal circulation.

- The review of the Management Area 04 shellfish reports also revealed that monitoring sites 04-01, 04-08, and 04-16 have exceeded the est. 90th percentile standard each year since 1992. Monitoring sites 04-02, 04-26, and 04-27 had a high frequency of exceeding the est. 90th percentile standard, having been above that threshold in 83% of the reports issued since 1992. Monitoring site 04-06 has exceeded the est. 90th percentile in 67% of the annual update reports. Meanwhile, 04-17a has been above the standard in 60% of the reports issued since 1992. These sites are also located in shallower areas of the inlet where there is less tidal circulation.

- Monitoring sites 04-01, 04-02, 04-08, and 04-16 have had the longest record of exceeding the est. 90th percentile and geometric mean shellfish harvesting fecal coliform standards. These sites are also currently experiencing some of the highest levels of fecal coliform as shown in **Appendix D**. All four of these sites were included in the original Murrells Inlet Fecal Coliform TMDL.

- Interestingly, the monitoring sites that form the boundaries of the Prohibited Zones surrounding the Murrells Inlet marinas (04-03A, 04-03B, 04-04B, and 04-04C) have relatively low levels of fecal coliform bacteria. The water depth near the marinas tends to be deeper allowing for more tidal circulation. SCDHEC regulations require shellfish beds within 1,000 feet of a marina to be classified as Prohibited for shellfish harvesting as a precautionary measure due to the potential for pollutants resulting from marina activities.

- The SC DHEC shellfish reports which exhibited the highest number of sites with water quality standard contraventions were from years 1992-1994, 2002-2004, and the last three reports, which incorporate monitoring data from 2008 through 2012.

Have the fecal coliform levels at each monitoring site increased or decreased over time?

To assess whether fecal coliform levels have increased or decreased over time, statistical trend tests were performed on the long-term SC DHEC monitoring data (1967-2011). Evidence for trends were explored using linear regression analysis of the data which were binned by decade and organized into boxplots. Evidence for trends were also explored using Mann-Kendall testing. Below is a summary of the observations and conclusions made based on the results of these statistical tests. The purpose of these tests was to give a weight of evidence indication of whether fecal coliform trends are increasing or decreasing at each site.

The Mann-Kendall test was also performed controlling for rainfall to examine the influence of wet weather on these time trends. It is important to note that an increasing bacteria trend does not necessarily mean that a station is located in a Restricted Shellfish Harvesting Area. Likewise, a decreasing bacteria trend does not necessarily mean that the monitoring station is located in an Approved Shellfish Harvesting Area.

- The statistical test results yielded evidence of increasing fecal coliform levels at 13 of the active monitoring sites within Murrells Inlet. The results indicated that there was a decrease in fecal coliform levels at seven active monitoring sites. In addition, there was a decreasing trend at five other deactivated monitoring sites, which are not currently being sampled.

- All of the marina sites had increasing trends.

- Some sites exhibited trends during wet and dry weather, some only during dry weather, and one only during wet weather.

Figure D-6 displays which monitoring sites have experienced increasing or decreasing fecal coliform statistical trends for the entire period of record analyzed. In addition, the figure indicates whether the trend is influenced by dry or wet weather conditions. **Appendix D** includes a chart with a summary of the statistical trends that are presented graphically in **Figure D-6**. The results show that monitoring sites with increasing trends are mostly clustered in the northern portion of the inlet. Meanwhile, sites indicating a decreasing fecal coliform trend are clustered mostly in the southern portion of Murrells Inlet.

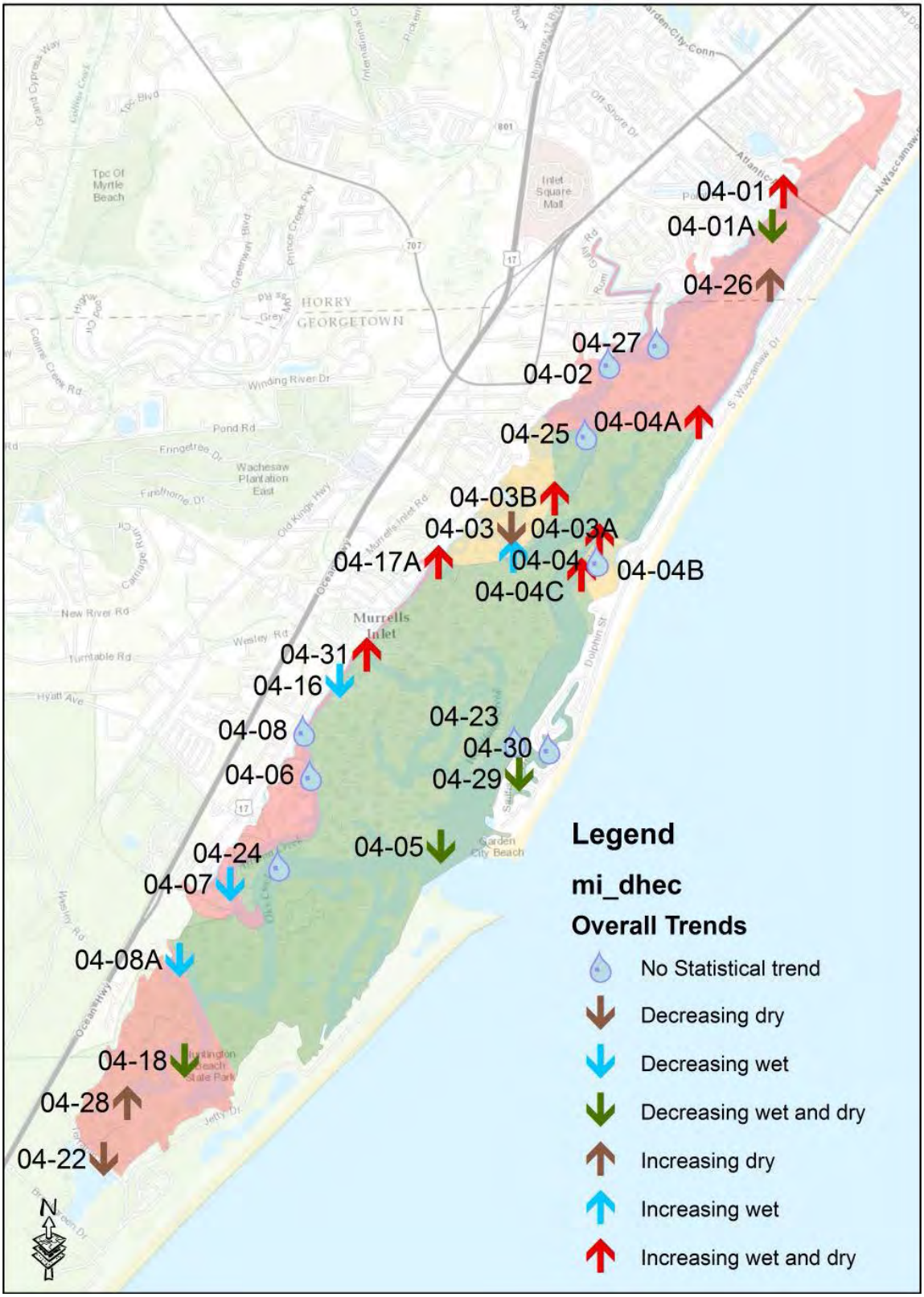


Figure D-6 *Long-term Fecal Coliform Trends in Wet and Dry Conditions*

Are fecal coliform concentrations higher under wet or dry weather conditions?

Precipitation data from the Brookgreen Gardens rain gauge were used to analyze the effect of rainfall on fecal coliform levels. The Brookgreen Gardens site is the longest running rain gauge operated by the National Climate Data Center within close proximity to Murrells Inlet. This rain gauge has also been used by state resource entities including SC DHEC in their shellfish monitoring program. The criteria used to characterize "dry weather" periods were fecal coliform samples collected within three days preceding total rainfall less than 0.5" inches. To characterize "wet weather" conditions, fecal coliform samples collected within three days following rainfall totals greater than 0.5" inches of rain was the criteria used. Statistical tests are imperative for this type of analysis to resolve trends from fecal coliform datasets that have high temporal variability. In other words, it is not uncommon for a dry weather fecal coliform reading to be higher than is typical for a wet weather fecal coliform value. A non-parametric Mann Whitney U test for differences in the wet versus dry samples from each site was performed using data from the 2000-2009 decade. In addition to rainfall, other environmental conditions such as salinity and tidal levels can also influence fecal coliform levels.

- Of the sites monitored from 2000-2009, 16 of the 28 sites had statistically significant evidence of fecal coliform concentrations being higher during wet weather as compared to dry weather. The sites with significantly higher fecal coliform levels during wet weather conditions are: 04-01, 04-01A, 04-02, 04-03B, 04-04, 04-04C, 04-06, 04-08A, 04-17A, 04-18, 04-25, 04-26, 04-27, 04-29,04-30, and 04-31. Note that fecal coliform levels at some of these sites are consistently meeting shellfish water quality standards.

What factors could be influencing the time trends in fecal coliform concentrations?

Perhaps the most critical aspect of the baseline assessment is being able to properly interpret the findings to understand the natural and anthropogenic factors that are influencing the fecal coliform trends in Murrells Inlet. Below are a few conclusions about the principal factors that influence fecal coliform levels in the Murrells Inlet watershed:

- Drought characterized by both the total annual rain accumulation and the number of rain events may have an impact on the occurrence of high fecal coliform levels. The Southeast region of the United States has experienced moderate drought conditions over the course of the past decade. It is suspected that a lower frequency of rain can lead to higher fecal coliform concentrations by increasing the concentration in the first flush of stormwater runoff during rainfall events. If runoff is the primary mechanism by which fecal bacteria are conveyed into the inlet, then higher concentrations in runoff will lead to higher concentrations in the receiving waters.

- The Murrells Inlet landscape has changed significantly over the past few decades, due to population growth and development. It is suspected that as impervious surfaces such as roadways and buildings become more prominent features in the landscape, fecal coliform levels would likely increase due to diminished retention leading to enhanced runoff. As **Table C-2** and **Exhibit C-1** illustrate, using curve numbers as an indicator of the drainage characteristics of each subwatershed, there has been a significant increase in the amount of impervious surface area in Murrells Inlet over the past ~18 years. An increase in stormwater runoff rate and volume would be expected to increase the transport of fecal bacteria from the adjacent landscape into the estuary.

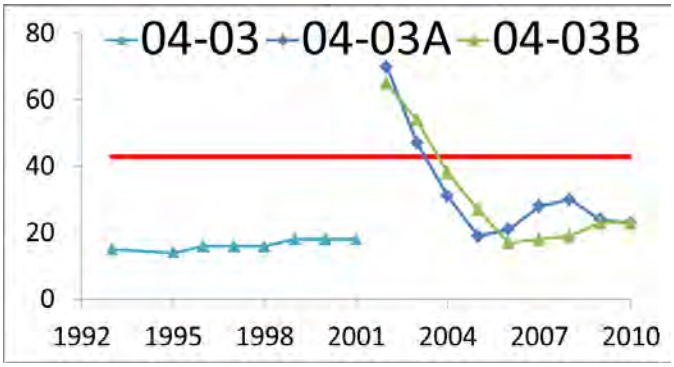
- A related factor is the stormwater infrastructure in Murrells Inlet. Increased stormwater piping and ditching has progressively altered the natural hydrology over time likely resulting in enhanced transport of fecal bacteria off the land and ultimately into Murrells Inlet. Stormwater retention facilities installed during this period of growth partially mitigates this impact to some degree.

- A consensus observation that has been made by local residents and stakeholders is the noticeable siltation that has occurred in the main channels and tidal creeks in many portions of the watershed. Parsonage Creek in particular is an area where this trend has become very pronounced, even to the point where navigation at low tide has become difficult. It has been observed that salinity plays an integral role in moderating bacteria levels in freshwater inputs, hence the importance of tidal flushing in coastal estuary systems. With shallower tidal creek channels, bacteria concentrations may have become more influenced by freshwater tributaries and ditches draining to the estuary. Resuspension of fecal coliform can also occur when sediments are disturbed especially in areas of shallow water depth.

Figure D-7 *Upper reaches of a tidal creek showing signs of sedimentation. (Photo courtesy of Dr. Dan Hitchcock, Clemson University).*

- Studies have also shown that bacteria tend to bind to sediment particles where they can survive and even propagate for long periods of time. In an aquatic environment, sediment can shield bacteria from sunlight, which reduces the rate of UV light based disinfection. The increased sediment load whether originating upstream or disturbed in the shallow creeks provides an environment more suitable for bacteria survival. These bacteria most likely have an influence on the increased fecal coliform levels measured over time, particularly at monitoring sites closest to the immediate shoreline of Murrells Inlet.

- A very striking example of how sediment loads can influence bacteria levels can be seen in the monitoring trends at Site 04-03, which is located near Captain Dick's Marina. In 2002, the marina was dredged to increase depth and improve navigability. Immediately after dredging, the monitoring data showed that the fecal coliform levels increased substantially, indicating that perhaps it occurred in response to the dredging process through resuspension of the bacteria present in the sediment. Over the next several years, the fecal coliform levels decreased significantly, likely due to the removal of the sediment which had become an ideal habitat for bacteria survival.



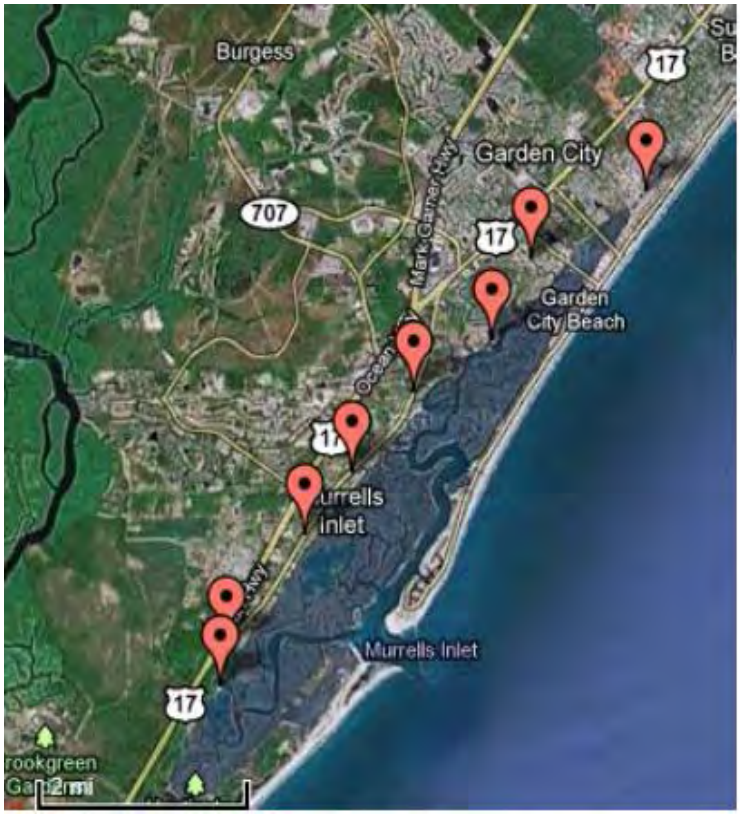
(Note that the data being plotted here are based on 3-year running est. 90th percentiles, so high values observed immediately after the dredging are propagated through the next three reporting increments, in this case 2002-2004, 2003-2005 and 2004 to 2006. The red line in the graph represents the WQS for the 90th percentile. The y axis is the fecal coliform concentration in MPN/ 100 mL)

The conclusions outlined above were integral focal points in evaluating watershed management opportunities and corresponding recommendations outlined in **Element H: Watershed Management Measures**.

MURRELLS INLET VOLUNTEER MONITORING PROGRAM

In partnership with Coastal Carolina University's Waccamaw Watershed Academy and both Horry and Georgetown counties, Murrells Inlet 2020 sponsors a volunteer water monitoring program in Murrells Inlet. Spanning both counties, volunteers have collected samples at eight sites twice monthly since 2008. **Figure D-8** displays the

locations of each of the monitoring stations. For each sample collected, the following water quality parameters are measured: dissolved oxygen, pH, temperature, salinity, conductivity, turbidity, total dissolved solids, nitrate/nitrite/ammonia, total coliform bacteria, and *E. coli*. The Murrells Inlet Water Monitoring Program is a non-regulatory programs which serves multiple purposes including engaging local residents in an educational stewardship activity. It also enables local governments to track water quality improvements following the implementation of a project and to be aware of and promptly respond to accidental emergencies or cases of illicit discharge.



1. Woodland Pond
2. Point Drive Canal
3. Rum Gully Creek
4. Marina Colony Pond
5. Harrelson's creek
6. Boat House Run creek
7. Bike Bridge creek
8. Oyster Landing Beach

Figure D-8 *Location map of the eight sampling sites of the Murrells Inlet Volunteer Monitoring Program. Site names are in order from North to South. (Courtesy of Coastal Carolina University)*

As monitoring data continues to be collected and water quality trends can be more fully analyzed, the utility of the volunteer program will become even more significant. The power of monitoring data grows as a long-term database is generated. In fact, the data set is long enough now to analyze for data trends of the five year period for which data have been collected. Finally, the volunteer monitoring program has and continues to build an informed, knowledgeable citizen base that have become advocates for water quality protection within the watershed, which is critical to supporting and funding planning and implementation activities.

The volunteer monitoring program collects data on two indicator bacteria species, *E. coli* and Total Coliform, which can provide insight into water quality conditions that may affect Shellfish Harvesting Waters within Murrells Inlet. While the FDA requires SC DHEC to monitor fecal coliform in designated Shellfish Harvesting Waters, EPA now requires *E. coli* monitoring in classified freshwaters and Enterococcus in classified saltwaters for recreational uses as they are regarded as better indicators of human health risk from water contact.

Figure D-9 *Woodland Drive Pond Volunteer Monitoring Site (Photo courtesy of Daniel Newquist, Waccamaw Regional COG)*

The eight monitoring sites were chosen to obtain a geographically representative sampling dataset from the northern to southern end of the watershed and to also investigate water quality conditions in the main tributary creeks which are the primary transport mechanisms for stormwater runoff flows from the surrounding drainage basins.

Table D-3 provides summary E. Coli data results for each monitoring site.

Table D-3 Murrells Inlet Volunteer Monitoring Program E. Coli (CFU/100ml) Statistics				
Site Name	***Closest SC DHEC Site***	***# Samples***	***Median***	***Max***
Woodland Drive Pond	*04-01*	*122*	*600.0*	*8,500.0*
Point Drive Canal	*04-01*	*121*	*67.0*	*3,667.0*
Rum Gully Creek	*04-27*	*120*	*0.0*	*433.0*
Marina Colony Pond	*04-25*	*119*	*67.0*	*4,500.0*
HS	*04-17A*	*122*	*800.0*	*9,400.0*
BHR	*04-16*	*122*	*1,650.0*	*14,400.0*
Bike Bridge	*04-07*	*121*	*200.0*	*5,250.0*
Oyster Landing Beach	*04-08A*	*120*	*0.0*	*533.0*
Source: The Murrells Inlet Volunteer Monitoring Program. Data from May 20, 2008 to October 8, 2013				

Table D-4 provides summary Total Coliform data results for each monitoring site.

Table D-4 Murrells Inlet Volunteer Monitoring Program Total Coliform (CFU/100ml) Statistics				
Site Name	***Closest SC DHEC Site***	***# Samples***	***Median***	***Max***
Woodland Drive Pond	*04-01*	*122*	*2,234.0*	*33,300.0*
Point Drive Canal	*04-01*	*121*	*533.0*	*14,400.0*
Rum Gully Creek	*04-27*	*120*	*33.0*	*7,967.0*
Marina Colony Pond	*04-25*	*119*	*500.0*	*10,400.0*
HS	*04-17A*	*122*	*4,200.0*	*33,467.0*
BHR	*04-16*	*122*	*5,200.0*	*33,000.0*
Bike Bridge	*04-07*	*121*	*1,400.0*	*34,267.0*
Oyster Landing Beach	*04-08A*	*120*	*33.0*	*5,300.0*
Source: The Murrells Inlet Volunteer Monitoring Program. Data from May 20, 2008 to October 8, 2013				

Below are some general observations on the trend analysis conducted on the available Murrells Inlet Volunteer Monitoring Program data:

- Data collected by the Murrells Inlet Volunteer Monitoring Program from July 2009 to May 2012 has shown persistent elevated levels of E. coli at the BHR, HS, Woodland Drive Pond and Bike Bridge monitoring sites.
- The Murrells Inlet Volunteer Monitoring Program has detected a declining trend in *E. coli* /Total Coliform levels for the BHR and HS monitoring sites since the monitoring program was launched in May 2008.
- In assessing the volunteer monitoring sites, four of the sites showed statistical evidence for higher *E. coli*/ Total Coliform levels during wet weather periods. These sites were Rum Gully Creek, Oyster Landing, Bike Bridge, and Marina Colony Pond.

GEORGETOWN COUNTY UPSTREAM MONITORING

The Georgetown County Stormwater Division provided funding to expand the volunteer monitoring program to include a more detailed investigation in four subwatersheds to help target future stormwater management efforts. The goal was to better understand significant variability in the bacteria levels at the volunteer monitoring sites and to help identify or rule out certain sources of bacteria. The BHR, HS, and Bike Bridge subwatersheds plus Huntington Beach State Park (added to better understand wildlife contribution) were sampled. The sampling locations were selected based on the subwatershed delineations and time of concentration flow path information outlined in the maps included in **Appendix A**. This seven month monitoring initiative was intended to help make investigatory observations, however given the limited samples collected it was not intended to provide statistically significant conclusions of the data generated.

In summary, below is a list of observational findings from this additional upstream monitoring:

- No evidence of septic tank failures or sewer line leakages were observed in any of the four subwatersheds.
- Bacteria levels have been highly variable from one sample date to the next.
- Average bacteria levels tend to be higher in close proximity to the inlet.
- Bacteria levels in undeveloped watersheds were very similar to those in residential areas.
- Prolonged rainfall seems to reduce bacteria levels as the first flush from a storm had already flushed accumulated animal waste.
- Raccoon and opossum tracks are regularly observed near drainage ditches and small streams. These tracks occurred at the same times that bacteria measurements were high, leading to the conclusion that much of the bacteria contributions, especially during periods of low flow, is the direct result of wildlife. Based on this and other observations, the steering committee infers that wildlife populations represent a significant pollutant load for fecal bacteria in the subwatersheds studied.
- It is estimated that open stormwater ponds remove on average 67% of E. coli and 86% of the total coliform bacteria entering the ponds. This is consistent with published removal efficiencies
- It is estimated that vegetated ponds provide up to 95% removal of E.coli and 75% of total coliform bacteria. This is consistent with published removal efficiencies.

Figures D-10 and D-11 *There are extensive portions of the southern end of the watershed that are heavily wooded making it ideal habitat for many wildlife species. Volunteers frequently observed raccoon tracks along creeks and nearby drainage ways. (Photos courtesy of Dr. Dan Hitchcock, Clemson University, and Gary Weinreich, Murrells Inlet Volunteer Monitoring Program)*

By using this subwatershed monitoring approach, watershed managers can assess bacteria levels upstream and downstream of various landscape features such as stormwater retention ponds as an example. This type of monitoring strategy can be very enlightening and inform decisions regarding effective stormwater management practices. Recommendations for continued utilization are outlined in **Element K: Water Quality Monitoring Strategic Plan**.

HORRY COUNTY MICROBIAL SOURCE TRACKING INITIATIVE

As monitoring technologies continue to advance, watershed managers are relying on new methods to conduct their monitoring efforts. An emerging class of monitoring techniques, known as source tracking, aims to detect chemical or microbial indicators that can more precisely identify the pollutant source of origin affecting nearby water quality conditions. Samples that are collected can be examined to determine if the genetic markers present can be traced to a particular animal species or group such as a human, dog, bird, cat, etc. Based on this information, watershed managers can better understand the sources of the bacteria, including wildlife, and determine whether reduction efforts are appropriate.

Coastal Carolina University has developed capacity through their Environmental Quality Laboratory to provide local communities with this monitoring technology. To date, source tracking has been effectively utilized to assess potential sources of pollution in the Town of Briarcliffe Acres and in the Withers Swash watershed area of Myrtle Beach. Horry County has begun to apply this monitoring approach in the Murrells Inlet watershed as well. Beginning in 2012, the Horry County Stormwater Department established nine source tracking monitoring sites at strategic locations in the upstream reaches of the watershed and in the Main Channel near Rum Gully Creek.

The initial samples have produced some important results:

- Canine signals have been high at multiple sites, with the highest concentrations occurring after a rainfall event. This provides support of a suspected source of bacteria and should lead to targeted public outreach and enforcement regarding pet waste disposal.
- Human signals have been detected in three samples to date. One of the samples was taken near the Woodland Drive Pond Volunteer Monitoring Site. This sample also detected caffeine and optical brightener levels which are human indicator chemical tracers. The other sample was taken at SC DHEC site 04-01. Optical brightener indicators were also detected at this site. An additional sample near the Point Drive Canal Volunteer Monitoring Site also showed signals for optical brighteners and caffeine, both are indicators of human sources. These are very important initial findings regarding human contributions of pathogenic bacteria, which is necessary when investigating the extent of the problem and the remedies needed to mitigate the concern.
- Bird signals were widespread across the sampling sites.

Figure D-12 below displays the locations of each of the sampling sites.

Figure D-12 *Horry County microbial source tracking monitoring site locations.*

The microbial source tracking monitoring approach is likely to continue to be a useful tool in assessing water quality conditions in Murrells Inlet in the future. Georgetown County Stormwater Department is preparing to launch a similar monitoring initiative in the upcoming year.

The analysis and findings of the monitoring initiatives outlined in this element resulted in a prioritization of subwatersheds for future watershed management recommendations. An overview of the priority subwatersheds is included in **Element F** followed by a detailed overview of recommended near-term and long-term best management practices in each of the identified subwatersheds and across the entire watershed in **Element H**.

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Element E: Murrells Inlet Shellfish and Marsh Assessment

ELEMENT E: Murrells Inlet Shellfish and Marsh Assessment

The ultimate goal of this plan is to not only reduce fecal coliform loads, improving water quality in Murrells Inlet, but to also take a broader view of the existing shellfish resources in the estuary and pursue strategies ensuring the long-term viability of harvesting activities. **Element A** provided a general overview of the ecological role of oysters in tidal estuaries. This element focuses more specifically on the long-term management of these resources.

SC Department of Natural Resources- Shellfish Management and Data Trends

The role of regulating and managing shellfish harvesting activities in the state of South Carolina is shared by SC DHEC and SC DNR. Collecting monitoring samples for the purpose of regulating shellfish harvesting activities to protect public health is the responsibility of SC DHEC. The responsibility for the long-term health of the oyster populations by managing commercial and recreational harvesting activities falls under the auspices of SC DNR. The protection and restoration of shellfish habitats is also a primary responsibility of SC DNR. The shellfish harvesting season is established by SC DNR and currently extends from October 1st to May 15th.

Presently, there are eight commercial Culture Permit areas in Murrells Inlet. There are also three designated State Shellfish Grounds and two designated Recreational Grounds. **Exhibit E-1** displays the boundaries of all of the designated shellfish grounds in relation to the SC DHEC monitoring sites and adjacent subwatershed land areas. A map of each of the individual shellfish areas is provided in **Appendix E.**

Below is a brief description of the pertinent regulations that apply to each type of shellfish grounds:

Culture Permits: Harvesting in these areas is essentially limited to the permit holder or to others that are explicitly allowed by the permit holder. Culture Permit holders pay an annual rental fee to SC DNR and must replant 50 bushels of shell or approved cultch per acre of permitted area on an annual basis. Acreage is calculated based on the actual intertidal resource.

State Shellfish Grounds: Harvesting in these grounds is allowed by commercial harvesters and recreational license holders. SC

Figure E-1 *Murrells Inlet has shellfish areas designated for both commercial and recreational harvesting. (Photo courtesy of Daniel Newquist, Waccamaw Regional COG)*

DNR manages these lands by opening and closing them on a rotational basis depending on the available shellfish stock.

Recreational Grounds: These shellfish grounds are only open to recreational license holders. In season, recreational harvesters are allowed to take up to two bushels of oysters and one half bushel of clams per day, twice in a seven day period. SC DNR manages these grounds by routinely replanting the shellfish beds as funding allows. Shells from the SC DNR shell recycling program are used for this purpose usually does not meet the annual demands. SC DNR typically purchases 40,000 or more bushels from out-of-state sources to use for replenishing recreational grounds.

Table E-1 summarizes the breakdown of the number of acres available for shellfish harvesting by the type of designated shellfish ground. The table also indicates the percentage of acreage within these designated shellfish grounds that are closed due to non-attainment of the fecal coliform water quality standard based on SC DHEC's monitoring data.

Table E-1 Murrells Inlet Shellfish Acreage Summary

	Culture Permits	Recreational Grounds	State Shellfish Ground	Total	Closed by DHEC	% closed
Current shellfish acres	68.7	11.4	26.8	106.9	20.8	19.4%
Potential shellfish acres	1308.1	243.9	660.2	2212.2	498.8	22.5%

Source: *SC DNR, Nancy Hadley*

The designated shellfish grounds in Murrells Inlet are an important cultural and natural resource to the community. Recreation Grounds R351- Clambank Flats and R355- Lachicotte Oyster Creek are the only two shellfish grounds limited exclusively to recreational harvest in Horry and Georgetown counties. There are a total of twenty designated Recreational Shellfish Grounds statewide. In terms of economic value, commercial harvesting activities have been steady on an annual basis in both the culture permit areas and in the state shellfish grounds. Due to permit holder proprietary restrictions, the annual volume and estimated dockside value is not available from SC DNR. However, the market demand for local shellfish resources is significant as indicated by the ten-year dockside harvest values for clams and oysters, summarized in **Table E-2.**

Table E-2 Ten-year Murrells Inlet Dockside Harvest Values

	Quantity- Number of Bushels	Dockside Value
Clam	10,064	$277,642.51
Oyster	36,611	$523,304.91
Total	***46,675***	***$800,947.42***

Source: *SC DNR, Nancy Hadley*

Economic Value of the Murrells Inlet Salt Marsh

It is important to assess the true economic value of the local shellfish resources in the broader context of the entire Murrells Inlet marsh. Oysters and other marine life have an integral cultural association with the Murrells Inlet estuary. Coastal Carolina University's Center for Economic and Community Development recently conducted a study to examine the economic activity within the 29576 Zip Code boundary area, which consists principally of the greater Murrells Inlet/Garden City Beach area. Another primary focus of the study was to assess the inherent economic valuation of the Murrells Inlet marsh, which the study estimates exceeds $720 million.

In addition to a long cultural history of shellfish harvesting, Murrells Inlet is known as being a very popular destination for recreational sports fishing. In fact, SC DNR estimates that 98 percent of spot, 30 percent of flounder, and 23 percent of all snapper caught statewide were in the Murrells Inlet area. Boating is another industry with major economic benefits to the Murrells Inlet community. Horry and Georgetown County records indicate that there are 2,802 registered boats in the 29576 Zip Code. Murrells Inlet is also known to have the busiest boat ramp in Horry and Georgetown counties and one of the top five busiest public boat launches in the entire state. In total, the study estimates that the marsh holds an economic value of $35,035,000 to boat owners collectively.

Figure E-2 *Murrells Inlet annual 4th of July Boat Parade is just one of many water-based events that boosts the local economy (Photo courtesy of Murrells Inlet 2020)*

The study examines several other economic sectors including real estate, the restaurant industry, and visitor spending, which all contribute to the total economic value of the Murrells Inlet marsh. The marsh, waterfowl, shellfish, and other natural features of Murrells Inlet attract people who desire to live and recreate in this area.

The study clearly illustrates that the marsh is a tremendous economic asset to several industries, subsequently generating substantial tax revenues for both counties.

The economic value of the marsh should be one of the main criteria considered when evaluating any new watershed management projects or initiatives in Murrells Inlet. Investing in efforts to protect water quality and preserve the aesthetic beauty of the estuary, not only has several environmental and public health benefits, but very likely has substantial indirect economic benefits to the community as well.

Long-term Shellfish Habitat Management: Goals and Strategies

According to SC DNR's Marine Resources Research Institute, the limiting factor to the sustainability of oyster populations is the availability of hard substrate for oyster attachment. In most areas of the state, including Murrells Inlet, oyster larvae are abundant, therefore much of the current restoration efforts are focused on oyster shell replanting. The success of replanting efforts can be affected by erosion of unprotected shorelines, which can be exacerbated by boat wakes. As discussed throughout the plan, siltation has major water quality implications as well; therefore minimizing the impacts of erosion is a major priority area in the plan's recommendations.

Below are some general goals as they relate to the sustainability of shellfish habitat in Murrells Inlet. Specific shellfish management recommendations are outlined in **Element H, Watershed Management Measures:**

- Oyster reefs and other shellfish species habitats are integral components of a healthy estuarine ecosystem. An overarching goal is to replenish shellfish grounds that are regularly harvested and protect other shellfish habitats that help stabilize shorelines and other environmentally sensitive areas within the estuary. In addition shellfish are filter feeders, therefore water quality improvements is another benefit that can be expected from restoring oyster reefs.

- Work with all relevant stakeholders to ensure that shellfish harvesting remains economically viable in Murrells Inlet. This encompasses efforts to meet the fecal coliform water quality standards in as much of the designated shellfish grounds as possible. As stated above, it also requires that the existing shellfish habitat areas remain ecologically sustainable. Therefore restoration work should be pursued as resources are available and sites are needed.

- Educate the public on the economic and ecological value of local shellfish resources. The oyster and other shellfish stocks are limited therefore public awareness regarding the effects of boat wakes, overharvesting, and bacteria contamination is vital. Engaging the public in oyster shell recycling and restoration projects is an excellent way to directly encourage long-term stewardship of Murrells Inlet's natural resources.

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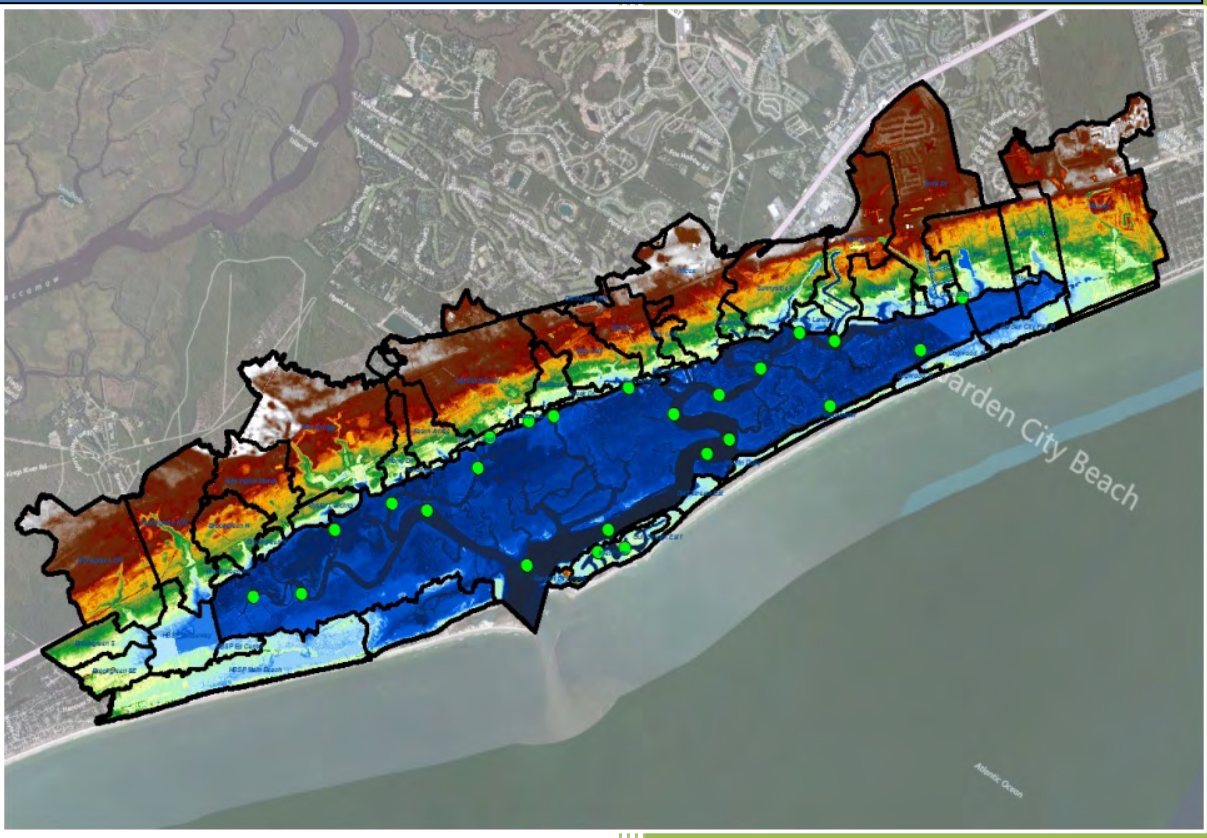
Element F: Targeted Subwatershed Load Reductions



ELEMENT F: Targeted Subwatershed Load Reductions

A review of the historical monitoring data in Murrells Inlet led the steering committee to prioritize monitoring stations to focus resources to address fecal coliform loads. Through this analysis it was recognized that several monitoring stations have remained consistently below the Shellfish Fecal Coliform water quality standard, suggesting that direct intervention is not needed in those areas. For areas determined to be of concern, the steering committee categorized the priority stations by tier.

Table F-1 outlines each of these monitoring stations listed as Tier One. Tier One sites are those that have not met the 90th Percentile nor Geometric Mean standard for the entire period of analysis. It was acknowledged by the steering committee that given the historic fecal coliform levels it will be very difficult to meet the water quality standards for site 04-01. Therefore the initial goal is to begin decreasing fecal coliform levels and establish several realistic and intermediate water quality milestones.

SC DHEC's TMDL modeling staff assisted the steering committee by providing load reduction estimates needed to meet the water quality standard using a cumulative probability statistical method based on sampling data collected from January 2007 through December 2012. These load reduction estimates are also included in the tables below.

Table F-1, Tier One SC DHEC Monitoring Stations for Fecal Coliform Load Reduction

Monitoring Sites	Adjacent Subwatersheds	Nearest Shellfish Area(s)	Cumulative Probability Load Reduction Estimate
04-01	#1 Point Dr #2 Pine #3 Melody	C372	95.3%
04-08	#1 Mariner/ Wesley #2 Morse Landing #3 Coquina	C359	83.8%
04-16	#1Mariner/Wesley #2 Coquina #3 Wachesaw	C359	93.1%

Source: This list of priority SC DHEC monitoring stations was developed by the Murrells Inlet Watershed Plan Steering Committee based on a review of the water quality baseline assessment conducted by Coastal Carolina University and watershed maps produced by The Earthworks Group, Inc. The load reduction estimates were calculated by SC DHEC's TMDL Section based on sampling data collected between January 2007 and December 2012.

Figure F-1 *The northern portion of the watershed which drains into SC DHEC site 04-01 is heavily developed and has experienced the highest levels of fecal coliform in Murrells Inlet. (Photo courtesy of Daniel Newquist, Waccamaw Regional COG)*

Table F-2 outlines each of these monitoring stations listed as Tier Two. These sites have been designated as Tier Two because they either periodically exceed the 90th percentile of Geometric Mean standard in the period of analysis or have recently shown an increase in fecal coliform levels. Site 04-28 is of particular concern because prior to the 2011 SC DHEC Shellfish Management Area 04, the samples were within the Approved water quality standard. Site 04-28 is located in the southern end of the watershed surrounded by natural undeveloped areas owned by Huntington Beach State Park and Brookgreen Gardens.

Table F-2, Tier Two SC DHEC Monitoring Stations for Fecal Coliform Load Reduction

Monitoring Sites	Adjacent Subwatersheds	Nearest Shellfish Area(s)	Cumulative Probability Load Reduction Estimate
04-06	#1 Morse Landing #2 Mariner/ Wesley #3 Coquina	C359	43.8%
04-26	#1 Dogwood S #2 Dogwood N #3 S Waccamaw	C372	59.4%
04-02	#1 Sunnyside N #2 Rum Gully #3 Jordan Landing	C372	59.2%
04-27	#1 Rum Gully #2 Mt. Gilead #3 Sunnyside N	C372	52.4%
04-28	#1 Brookgreen N #2 HBSP Causeway #3HBSP Main Beach	R351	Not analyzed for the purposes of this report

Source: This list of priority SC DHEC monitoring stations was developed by the Murrells Inlet Watershed Plan Steering Committee based on a review of the water quality baseline assessment conducted by Coastal Carolina University and watershed maps produced by The Earthworks Group, Inc. The load reduction estimates were calculated by SC DHEC's TMDL Section based on sampling data collected between January 2007 and December 2012.

Figure F-2 *The southern end of the watershed is mostly undeveloped. Sites 04-28 and 04-18 can affect shellfish closures in one of the public recreational shellfish grounds in Murrells Inlet. These factors led the steering committee to consider them priority monitoring sites for management purposes. (Photo courtesy of Daniel Newquist, Waccamaw Regional COG)*

Table F-3 outlines each of these monitoring stations listed as Tier Three. These sites have been designated as Tier Three because they fluctuate between meeting and exceeding the shellfish fecal coliform standard. The steering committee determined that with timely intervention, these sites could easily meet and continue to stay below the water quality standard.

Table F-3, Tier Three SC DHEC Monitoring Stations for Fecal Coliform Load Reduction

Monitoring Sites	Adjacent Subwatersheds	Nearest Shellfish Area(s)	Cumulative Probability Load Reduction Estimate
04-17A	#1 Vaux Hall #2 Mariner/Wesley #3 Boat Landing	C359, C362	8.8%
04-18	#1 HBSP Main Beach #2 Brookgreen N #3 HBSP Causeway	R351, S354, C352	Not analyzed for the purposes of this report
04-07	#1 Bike Bridge #2 Horry Dr. #3 Eason Acres	S357, R355	Not analyzed for the purposes of this report
04-31	#1 Wachesaw #2 Mariner/Wesley #3 Creek Dr.	C359	No reduction needed

Source: This list of priority SC DHEC monitoring stations was developed by the Murrells Inlet Watershed Plan Steering Committee based on a review of the water quality baseline assessment conducted by Coastal Carolina University and watershed maps produced by The Earthworks Group, Inc. The load reduction estimates were calculated by SC DHEC's TMDL Section based on sampling data collected between January 2007 and December 2012.

Element G: Existing Infrastructure and Management Programs

ELEMENT G: Existing Infrastructure and Management Programs

Existing Infrastructure

As the Murrells Inlet population grew and associated development increased in the surrounding area, basic utility services such as sewer and drinking water infrastructure became increasingly more important to protect the public health and the environment. The multijurisdictional nature of the Murrells Inlet watershed has required ongoing coordination between the Georgetown County Water and Sewer District (GCWSD) and Grand Strand Water and Sewer Authority (GSWSA) who operate and maintain sewer infrastructure in their respective designated service areas. An overview of the existing infrastructure, preventive maintenance measures, and long-term improvement needs for each district is provided below.

Georgetown County Water and Sewer District

The Georgetown County WSD owns and operates the Murrells Inlet Wastewater Treatment Plant (WWTP) (NPDES permit# SC0040959), which provides sewage treatment services in the Georgetown County portion of Murrells Inlet. The treatment facility is located on 1441 Pond Road, Murrells Inlet, SC. The wastewater treatment site is located outside of the Murrells Inlet estuary watershed boundaries and final treated effluent is discharged to the Waccamaw River. Flows from the Garden City Beach portion of Georgetown County are collected by GCWSD but are treated at the Schwartz WWTP facility operated by Grand Strand WSA. The Murrells Inlet WWTP was originally permitted in 1987 and currently has a treatment capacity of 2.0 Million Gallons Per Day (MGD). Based on monthly Discharge Monitoring Reports submitted to the EPA from October 2011 to September 2012, this facility currently treats an average of 0.90 MGD. Due to greater sewer demand associated with the summer tourism season, the peak month over this twelve month period was 1.129 MGD in July 2012.

The district conducts capacity studies on a regular basis to plan long-term capital improvements. A recent study in 2007 indicated that currently the Murrells Inlet WWTP facility and the principal force main sewer network are able to handle the peak wastewater loads. However, if future development occurs at a pace similar to the late 1990's to early 2000's, some sewer lines would need to be replaced to increase the flow capacity within the service network (Georgetown County WSD 2007).

Grand Strand Water and Sewer Authority

Wastewater flows from residences and commercial properties on the Horry County side of Murrells Inlet are treated at Grand Strand WSA's Schwartz WWTP. This regional facility is located in the Burgess Community of Horry County and discharges treated

effluent to the Waccamaw River. In addition to the Murrells Inlet area, the Schwartz WWTP receives wastewater from a service area extending to Coastal Carolina University/ Carolina Forest, Surfside Beach, Forestbrook, and Socastee. Grand Strand WSA also has an interlocal agreement with Georgetown County WSD to receive up to 325,000 GPD of flows from the Garden City Beach portion of Georgetown County. Presently, the Schwartz WWTP has a treatment capacity of 19.35 MGD and has a current average daily flow rate of 10.9 MGD.

Both Georgetown County WSD and Grand Strand WSA institute several preventive maintenance measures to ensure the system is running efficiently and sanitary sewer overflows and other infrastructure problems are minimized. The major forcemain pump stations are equipped with auxiliary generators to ensure continued operation during a power outage event. Each of the secondary pump stations are monitored via a network wide Supervisory Control and Data Acquisition (SCADA) system. This enables district managers to spot inconsistencies in flow measurements at a pump station and deploy maintenance personnel to inspect and repair the station as needed. The major pump stations are inspected multiple times weekly, while all secondary pump stations are typically inspected at least once per week. All pump stations are regularly inspected during storm events.

Figure G-1 *Georgetown County WSD force main pump station equipped with the SCADA monitoring system. (Photo courtesy of Dr. Dan Hitchcock, Clemson University)*

Both districts also utilize routine smoke testing and camera inspection as part of their Capacity, Management, Operations, and Maintenance (CMOM) program. The CMOM program is commonly utilized by most sewer utility providers and is essentially a comprehensive routine preventive maintenance program to ensure a highly functional sewer system. As public utility providers, Georgetown County WSD and Grand Strand WSA must coordinate their construction activities with other entities in the area that share the utility right of way. The Palmetto Utility Protection Service, authorized by the Underground Facility Damage Prevention Act is an information service that ensures that all relevant utility providers are notified when a construction project is occurring in their jurisdiction. Collective participation by all utilities and homeowners is vital in reducing the occurrence of underground utility damage. The Palmetto Utility Protection Service operates SC 811, a telephone line that property owners must call if they plan to dig.

Another important aspect of effective sewer system maintenance is educating sewer

customers on proper maintenance of their sewer connections and preventing inappropriate wastes, such as fats and grease, from being disposed via the sewer system. Improper grease disposal from restaurants, and to a lesser extent residences, can cause blockages in the sewer line and malfunctions at pump stations, increasing the potential for a sanitary sewer overflow (SSO). Recycling of cooking oils and proper operation and maintenance of grease traps are two effective BMPs that restaurants can implement.

Although the area's sewer treatment facilities currently have adequate capacity, if large amounts of stormwater enter the sanitary sewer system during a heavy storm, the collection system can become overloaded and possibly overflow to the inlet. Residents should do their part to minimize stormwater infiltration and should never open their sewer cleanout pipe as a way to quickly drain standing stormwater from their yards following significant rainfall. This additional water flowing into the wastewater system also increases the costs of wastewater treatment.

While sanitary sewer overflow events have been infrequent in the Murrells Inlet area, when they occur they have the potential to contribute significant bacteria loads to the Murrells Inlet estuary. Specific management strategies to reduce the risk of SSO events are outlined further in **Element H: Watershed Management Measures** and **Element J: Public Education and Outreach Resources** of this plan.

Georgetown County and Horry County Stormwater Management

Another critical aspect of protecting water quality is to reduce non-point sources of pollution from entering upstream tributaries and drainage ditches. This can be challenging as potential pollution sources can exist from a multitude of locations across a large drainage area. Unlike wastewater treatment facilities, non-point sources of pollution do not necessarily occur at specific and discrete locations, but rather enter local waterways from adjacent land surfaces via stormwater runoff.

The stormwater management profession has matured over time and regulations and management practices have continued to evolve to better address non-point source pollution. As part of the NPDES permitting program, the US EPA has developed regulations requiring municipalities and counties to manage stormwater runoff in designated urbanized areas within their jurisdictions. There are two main permits that focus on stormwater related concerns that apply to activities in both Horry County and Georgetown County. The first is referred to as the NPDES Construction General Permit and the other is the Municipal Separate Storm Sewer System General Permit (MS4). A brief overview of the main objectives and scope of each permit program is provided below.

Construction General Permit

This permit regulates stormwater discharges generated from construction sites and other land disturbing activities. Without proper mitigation, runoff from construction sites can cause erosion and downstream siltation. Although, fecal coliform bacteria is not a common pollutant associated with construction sites, bacteria can bind to sediments and be transported from construction sites during stormwater runoff events. Sediments can also negatively harm aquatic habitats, including oyster reefs. Over time, sediment accumulation can impact the hydrology of Murrells Inlet and reduce the tidal flushing that naturally occurs in Murrells Inlet. Tidal flushing helps maintain a proper salinity balance, which tends to moderate fecal coliform levels from freshwater flows. Sediments also have been shown to have properties that favor pathogenic bacteria survival and propagation. The Construction General Permit is designed to mitigate these types of stormwater and erosion impacts.

Figures G-2 and G-3 *Construction site activities that disturb soil can cause sedimentation problems in nearby waterways. Storm drain protection devices shown on the right can help prevent downstream water quality problems. (Photos courtesy of Horry County Stormwater Department and US EPA.)*

The permit applies to construction sites over one acre and over ½ acres if the site is within ½ mile of a coastal receiving water. Specific provisions apply to "small" construction sites between one and five acres and to "large" construction sites, which are bigger than five total acres. Permittees are not only required to control stormwater discharges from active construction sites, but must also incorporate measures to address post-construction site discharges. A major component of the permit approval process is the submission of a Stormwater Pollution Prevention Plan (SWPPP). The SWPPP identifies potential sources of stormwater pollution on the construction site with corresponding control measures to address those pollution sources. Permittees must gain approval of the SWPPP from the county and SC DHEC before initiating construction and sites are inspected regularly throughout construction to ensure compliance with the approved SWPPP.

Municipal Separate Storm Sewer System General Permit

The focus of the MS4 permit is to address stormwater discharges that drain through a permitted jurisdiction's storm sewer network, consisting of stormwater ponds, ditches, catch basins, pipes, and other conveyances. Permit conditions are based on population thresholds determined by decennial Census counts. Horry and Georgetown Counties are two of seventy small regulated MS4s areas in the state of South Carolina. The main provisions within the MS4 permit revolve around six minimum control measures. They are listed below with a short description:

- *Public Outreach and Education*: MS4 jurisdictions must educate residents on stormwater related issues and the influence of land activities and individual behaviors on the quality of nearby water resources. Horry and Georgetown Counties fulfill their obligations for this minimum measure through active participation in the Coastal Waccamaw Stormwater Education Consortium (CWSEC), which organizes public workshops, media advertising campaigns, and many other activities.

- *Public Participation/ Involvement*: This measure entails efforts to engage residents in local stormwater program development and activities. Both counties fulfill this requirement through initiatives such as the Murrells Inlet Volunteer Monitoring program, cleanups, and storm drain marking activities.

- *Illicit Discharge Detection and Elimination*: Illicit discharges constitute a wide variety of pollution sources including chemical spills, failing septic systems, illegal dumping, etc. all which can enter local waterways untreated. MS4 jurisdictions must enact ordinance provisions to detect and eliminate illicit discharges. This measure also entails a reporting and response mechanism so that the public can contact the respective stormwater department if they identify water pollution incidents.

- *Construction Site Runoff Control*: This requirement focuses on sediment and erosion control from construction sites disturbing one or more acres, or more than one-half acre when the site is located within one-half mile of a receiving waterbody. To fulfill this measure, each county has adopted a design manual with best management practices, reviews construction site plans, and conducts site inspections to ensure compliance with approved plans.

- *Post-construction Stormwater Management*: New developments generally

speaking increase the amount of onsite impervious surface area on a land parcel, which in turn results in less infiltration and a higher volume and flow rates of stormwater runoff. This measure gives each MS4 the authority to require developments to meet standards to mitigate stormwater impacts by implementing practices designed to treat, store, and infiltrate runoff onsite. New techniques such as Low Impact Development are encouraged and becoming more widely utilized.

- *Pollution Prevention/ Good Housekeeping*: The final measure focuses on implementing initiatives and strategies that reduce the potential of stormwater pollution from public facilities and public services activities, including employee training.

As mentioned in **Element B**, the SMS4 General Permit was renewed on January 1st, 2014 and entails new requirements pertaining to addressing waterbodies with an adopted TMDL. Specifically, the new permit requires permittees to develop a monitoring plan and BMP implementation schedule. Needless to say, identifying and mitigating causes of non-point source pollution entering Murrells Inlet to achieve MS4 permit compliance is a major priority for both Horry and Georgetown Counties. Since this watershed spans across both counties, ongoing collaboration is essential to protecting this natural resource. Both counties have fully supported the Murrells Inlet Volunteer Monitoring program, participate in the regional Coastal Waccamaw Stormwater Consortium, along with many other initiatives that benefit the Murrells Inlet community. This watershed-based plan includes several recommendations to build on this partnership to effectively invest in resources to protect the Murrells Inlet estuary.

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Element H: Watershed Management Measures

ELEMENT H: Watershed Management Measures

The ultimate purpose of this watershed management plan is to outline a framework for implementing management strategies that will help improve water quality and sustain productive shellfish habitats in Murrells Inlet. The recommendations detailed in this element were developed after performing an extensive examination of historical water quality and existing land uses in the watershed, as well as site visits within specifically targeted subwatersheds as prioritized in **Element F, Targeted Subwatershed Load Reductions.** The long-term aim is to utilize an adaptive management approach in Murrells Inlet where multiple strategies will be pursued. Post-implementation monitoring will serve to guide the effectiveness of each BMP and where they should be replicated in other areas of the watershed.

The first section of this element discusses best management practices that have previously been implemented in Murrells Inlet. It is important to be able to evaluate the effectiveness of various BMPs that are already in place as well as those that have been previously utilized and may or may not have been effective. Projects that have shown water quality benefits may be appropriate to apply in other portions of the watershed. The next section of the element is a list of the recommended best management practices for future implementation in Murrells Inlet. An explanation of the purpose and expected benefits of each strategy is provided. The recommendations are organized based on whether the proposed management strategies can and/or should be applied across the entire Murrells Inlet watershed such as a pet waste disposal campaign or if the recommendation is a structural BMP that is being targeted in a specific subwatershed. This element also discusses potential barriers to the implementation of these BMPs. Some common barriers include financial constraints, land availability, and community acceptance.

Figure H-1 *A wide variety of stormwater management concepts have been tried in the past. This is the remnants of a chlorine contact chamber designed to treat water draining upstream of the Bike Bridge in Georgetown County. (Photo courtesy of Dr. Dan Hitchcock, Clemson University)*

Existing or Previous Best Management Practices

This section summarizes some notable watershed management projects and initiatives that have already been implemented in Murrells Inlet. All of the following BMPs outlined in the section below serve as good demonstration projects and should continue to be encouraged moving forward.

Low Impact Development Implementation

Low Impact Development (LID) is an emerging site design approach that focuses on mimicking natural hydrological processes and preserving the ecological services of residential and commercial developments. Low Impact Development can focus on several different environmental principles, with one of the main targeted goals being the onsite management of stormwater. Several features can be employed on a development site to achieve the desired runoff reduction outcomes. They include rain barrels, green roofs, permeable pavements, strategic tree plantings, rain gardens, engineered or restored wetlands, and bioretention facilities.

Figure H-2 *Example of a constructed stormwater wetland. (Photo courtesy of Dr. Dan Hitchcock, Clemson University)*

There are examples in the Murrells Inlet area where Low Impact Development design techniques have been installed as a functional part of the landscape. Clemson's Carolina Clear program and South Carolina Sea Grant maintain an LID atlas, which profiles sites throughout the state where LID is being utilized. It is an effective outreach tool which highlights the location of LID applications and provides information on the type of LID practice that was incorporated at each site. This website is also a helpful way for water resource managers to become more familiar with LID techniques that other communities are implementing. In addition, the SC LID atlas is linked into a national database of LID projects through the Non-point Education for Municipal Officials maintained by of the University of Connecticut

Table H-1 below provides a brief description of the LID projects in Murrells Inlet that are highlighted on the Carolina Clear website or are other examples mentioned by the project steering committee:

Table H-1- Existing Low Impact Development Sites in the Murrells Inlet Community			
Location	**Type**	**Date of Installation**	**Notes**
Morse Landing Park- 4911 Hwy 17 Business	Bioretention/ Rain Garden	2009	Captures parking lot runoff adjacent to popular boat landing and park.
Bike Path near intersection of US Hwy 17 Business and US Hwy 17 Bypass	Pervious Pavement	2008	300 ft section of bike path is paved with permeable concrete.
Brookgreen Gardens entryway: 1931 Brookgreen Dr	Pervious Pavement	–	Decorative use of pervious concrete at the main entryway into Brookgreen Gardens.
Garden City (Azalea St.) Pervious Paving	Pervious Pavement	2012	Horry County used pervious pavement in the construction of a new public parking lot.
Inlet Sports Lodge	Pervious Pavement		
Boathouse Run Subdivision	Pervious Pavement/ Underground Storage and Infiltration		
SC DNR Murrells Inlet Boat Ramp	Constructed Wetland, Parking Pavers	2006	Studied as part of the Murrells Inlet Special Area Management Plan.
Jetty View Walk	Pervious walkway	2013	
Source: Clemson University, Carolina Clear Program- http://www.clemson.edu/public/carolinaclear/lidmap/			

SC DNR SCORE Program

As emphasized in previous sections, from a shellfish habitat management standpoint one of the critical needs is to maintain suitable oyster reefs established for juvenile

oyster larvae recruitment. Through the SCORE program, SC DNR restores shellfish harvesting areas with recycled and purchased oyster shell. The SCORE program has initiated two restoration sites in Murrells Inlet. One is located near the education center pier at Huntington Beach State Park. The second site is at Oyster Landing. SC DNR relies on the support of volunteer groups to accomplish the program's goals, making it another excellent public outreach opportunity. The SCORE program will continue to be an important shellfish restoration initiative in Murrells Inlet.

Public Education and Outreach Initiatives

The Murrells Inlet community has been very proactive in initiating environmental education and awareness events and campaigns. The Spring Tide cleanup event is one of the longest standing events throughout the entire state. The "Litter Makes Us Crabby" campaign has also been very effective. Murrells Inlet 2020 has been a leading organization in these efforts and maintains active engagement with regionwide initiatives through their participation in the Coastal Waccamaw Stormwater Education Consortium (CWSEC). Murrells Inlet 2020 with the assistance of CCU spearheaded the establishment of the volunteer monitoring program which has provided critical water quality data to the county stormwater departments. These public outreach programs and initiatives provide a great foundation to address other watershed management efforts that require public support or participation. Additional information about these existing programs is included in **Element J: Public Education and Outreach Resources.**

The next two sections outline considerations regarding implementation timeframes and potential barriers for each of the proposed BMP recommendations listed at the end of this element.

Implementation Timeframes

Accomplishing all of the goals outlined in this plan takes time, financial and personnel resources, and coordination between several management entities, especially given the multijurisdictional nature of Murrells Inlet. This element establishes near-term, mid-term, and long-term time frames for each recommendation. Below is a brief overview of each timeframe and some of the factors that could influence the suggested period of time.

- **Near-term**- projects that could be initiated within two years. These are typically projects that could be implemented with the coordination of existing resources and minimal capital costs.
- **Mid-term-** projects that could be initiated within three to five years. These projects may have most of the components needed for implementation but need to address one or more of the implementation barriers listed in the next section. Another factor could be the sequencing of other project recommendations based on prioritization.

- **Long-term**- projects that are anticipated to be implemented on a ~5-10+ year time horizon. These are typically projects that will require a significant allocation of capital costs, private property acquisition, extensive agreements between local governments and external agencies, and further engineering or water quality study.

Two other timeframe considerations should be made when evaluating each potential management strategy. They relate to the administrative and/or maintenance requirements associated with each project or initiative.

- **Ongoing-** Some management strategies entail more frequent administrative responsibilities, more routine inspections, or onsite maintenance. Projects that entail an ongoing commitment can include public education initiatives where the targeted stewardship message needs to be communicated on a regular basis in order to be effective. Another example of a recommendation outlined below which requires ongoing administrative responsibilities is the proposed inlet-friendly business program. While overseeing the program is not expected to be overly burdensome, a designated point of contact needs to be available to encourage new participants, answer questions, and review applications.
- **Periodic-** These management strategies typically only need annual maintenance work or inspection, or some other designated timeframe. A good example of this is shellfish restoration efforts. Restoration projects can be planned well in advance and the efforts can shift to different locations from year to year as the need is identified. Other examples of projects with periodic maintenance requirements include catch basin insert replacement, drainage ditch and retention pond maintenance, and septic system maintenance.

Possible Barriers to Implementation

The decision process for implementing watershed management projects requires an in-depth evaluation of resource constraints that may affect the timing or scale of a particular project. Below is a list of common considerations that must be factored into the feasibility of all proposed projects. Identifying these potential implementation barriers and addressing them in a coordinated way can significantly improve the success and timeliness of achieving the plan recommendations.

- **Construction Costs:** Many structural stormwater devices can entail significant capital costs. High cost projects must provide substantial water quality and other community benefits in order to justify the expense. Structural BMPs must be strategically located and be well supported by available water quality data that clearly demonstrates the need. All available design alternatives should also be evaluated to weigh other factors such as lifespan, maintenance costs, property acquisition, etc.
- **Maintenance Burden:** Often, the biggest challenge once a BMP has been implemented is ensuring that the project is working effectively. Sometimes the maintenance burden falls on the private property owner or homeowners

association. In that case, appropriate training should be provided at the outset of project implementation. Other projects require additional personnel and equipment resources from the county's public works or stormwater departments. An understanding of all necessary resource commitments in advance of project implementation is critical for long-term success.

- **Land Availability:** As emphasized throughout the plan, there are distinct land use differences across the Murrells Inlet watershed. The southern end of the Georgetown County portion of the watershed is largely protected open space owned and managed by Brookgreen Gardens and Huntington Beach State Park. The northern portion of the watershed is noticeably more urbanized, with fewer areas of undeveloped land. Some potential management options include drainage ditch modifications, construction of vegetated wetlands or retention ponds, and the encouragement of shoreline buffers. Each of these strategies requires varying acreage of available land for proper BMP design and siting. The implementation of structural BMPs on other suitable private properties will require clear communication of the purpose and expected benefits of the proposed project. Incentives should be explored to encourage participation from private landowners.

Figure H-3 *Structural BMP practices such as stormwater retention ponds and constructed wetlands require available land. This property owned by Murrells Inlet 2020 could potentially be utilized for this purpose. (Photo courtesy of Dr. Dan Hitchcock, Clemson University)*

- **Public Acceptance:** Meeting the goals of this watershed plan will require the ongoing support and cooperation of the general public. The primary objective is educating the public on the water quality and shellfish habitat issues in Murrells Inlet. Effectively conveying the economic, environmental, and cultural benefits of protecting these natural resources is vital in gaining public support for watershed management efforts. **Element J** outlines in great detail the various population groups, such as pet owners, tourists, landowners, etc. that project partners need to educate and gain support from on various BMP strategies. Similarly, encouraging local developers, architects, and engineers to incorporate new site design concepts, such as LID, needs to remain a priority.
- **Partnership Commitments:** This plan is the result of a shared desire from several local stakeholders to help improve water quality and protect shellfish habitat areas. The effort put forth by each project partner has led to a better understanding of the existing environmental conditions in Murrells Inlet and the coordination that will be needed to achieve the desired outcomes of the plan. Adaptive watershed management is an iterative and ongoing process. For each of the projects and initiatives recommended in this plan, local stakeholder entities will have different roles to play in the implementation process. As plan implementation proceeds, additional partners should be sought depending on the nature of each specific project.
- **Site-specific Considerations:** Some locations within the Murrells Inlet watershed may be suitable for certain stormwater management strategies, while others may not. For example, stormwater infiltration practices may not be appropriate at sites with poorly drained soils unless an underdrain installation is feasible, which requires sufficient elevation grade for the drain to work. Also, locations that have shallow groundwater may also inhibit these types of practices, while retention-based practices such as wet basins or constructed wetlands may prove to be more hydrographically and hydraulically effective.

For each of the proposed best management practices listed at the end of this element, an assessment of potential implementation barriers is included.

Proposed Watershed Best Management Practices

This section outlines Best Management Practices that are recommended to enhance water quality and protect shellfish habitat in Murrells Inlet. A description of the project or initiative is provided. Suspected implementation barriers, if any, are mentioned for each BMP recommendation. Finally, an implementation timeframe for each recommendation is included. Watershed-wide management strategies are listed first, followed by strategies focused on a specific subwatershed near one of the prioritized SC DHEC monitoring stations.

Watershed-Wide BMP Recommendations

The following list of BMP recommendations are designed to address bacteria sources that potentially exist throughout the entire watershed.

A. Pet Waste- One of the bacteria sources that should be the easiest to reduce is pet waste. The responsibility for eliminating this common bacteria source lies directly with individual pet owners. Watershed managers can initiate public education campaigns to remind people about the water quality impacts of pet waste and provide amenities such as pet waste stations to make pet waste disposal as convenient as possible for residents and visitors.

Recommendation A1: Continue public outreach efforts encouraging proper pet waste disposal.
Potential Barriers: The Murrells Inlet community with the assistance of many entities continues to proactively address the pet waste issue. Resources are in place and it is likely to remain a priority focus for the foreseeable future. One challenge is that Murrells Inlet has a very transient population, particularly during the peak tourism season in the summer months. Targeted outreach to these population groups is needed and cooperation will be sought from the vacation rental companies. A comprehensive overview of proposed public outreach initiatives addressing pet waste and other water quality issues is the focus of **Element J: Public Education and Outreach Resources**
Implementation timeframe: *Near-term and ongoing*

Recommendation A2: Review existing ordinances pertaining to pet waste disposal in Horry and Georgetown Counties to determine amendments that may be needed to address the issue. Evaluate strategies to improve the enforcement of existing ordinances.

Georgetown County has the following ordinance that addresses pet waste in public areas:

Sec. 4-1. - Responsibility of owner for removal of excreta deposited by animal on public property.

The owner and/or persons having custody or control of an animal or pet shall be responsible for the removal of any excreta deposited by the animal on public property, including the beachfront. Any person who violates the provisions of this section shall be fined not more that two hundred dollars ($200.00) for each offense, or sentenced to not more than thirty (30) days in jail.

Potential Barriers: Having similar ordinance language for both counties would help to address the issue across the entire watershed. The ordinance will also have its limitations as it is impractical to enforce pet waste disposal ordinances pertaining to private property.
Implementation timeframe: *Near-term and ongoing*

B. Waterfowl and Nuisance Wildlife- The salt marsh and the natural areas that extend inland throughout the Murrells Inlet community are an attractive habitat for waterfowl and other wildlife species such as raccoon, fox, opossum, and coyote. An observation by several stakeholders and residents is that wildlife and feral cats are assimilating into the residential neighborhoods and near restaurants often relying on human food. Below are some recommendations to help minimize problems associated with nuisance wildlife, feral cats, and resident waterfowl:

Recommendation B1: Create a campaign targeted at homeowners, business owners, and county government departments to properly secure their garbage cans and dumpsters. Unsecured dumpsters can attract small mammals such as raccoons and bird species such as crows and sea gulls. Each county should inspect and secure all dumpsters and garbage cans located in public areas. At public boat landings and other sites near the inlet, dumpsters should be setback as far from the shoreline as possible. Public trash cans should have secured lids and be emptied regularly (daily in the summer) to prevent overflowing, especially near shoreline areas, where wind can blow litter into the estuary.

Figure H-4 *Unsecured dumpsters can attract raccoons and feral cats. Dumpsters located near the inlet or upstream drainage ways should always be carefully secured. (Photo courtesy of Daniel Newquist, Waccamaw Regional COG)*

Potential barriers: It would be very difficult to be able to reach all residents and businesses, especially part-time residents that occupy weekly or seasonal vacation properties. This type of campaign would likely require yearly reminders. The campaign and business participation could become a component of the proposed Inlet-friendly business program.

Implementation timeframe: *Near-term and ongoing*

Figures H-5 and H-6: *Trash cans should have secured lids and be regularly emptied, especially along waterfront areas. (Photos courtesy of Murrells Inlet 2020)*

Recommendation B2: Discourage feeding waterfowl and wildlife by strictly enforce waterfowl and wildlife feeding ordinances. Feeding encourages wildlife to congregate in residential and commercial areas instead of more suitable natural habitats. Signage can be used to inform the public of existing ordinances and educate the public on the importance of this issue as it relates to water quality in Murrells Inlet.

Potential Barriers: In order to be effective, a two-prong approach is needed. First, public awareness is essential to discouraging this activity. Second, enforcing the policy across the community can be difficult.

Implementation timeframe: *Near-term and ongoing*

Figure H-7 *Feeding ducks and geese has been frequently observed throughout the community. Feeding waterfowl and wildlife should be avoided especially near stormwater ponds. (Photos courtesy of Daniel Newquist, Waccamaw Regional COG)*

Recommendation A3: Identify areas of known feral cat colonies and begin working with the counties' animal control divisions, local animal shelters, businesses, and residents to reduce the population numbers and find suitable homes for these animals. Promote the organization of a county level cat adoption or neutering/relocation campaign. Pet Smart has recently developed a grant program to support community adoption and spay/neuter programs. More details about the grant program are provided in **Element I: Potential Funding Source Evaluation.**

Potential Barriers: This type of effort requires public cooperation and ongoing coordination between the counties and local veterinary clinics and animal shelter. A direct and sustained initiative must be implemented.

Implementation Timeframe: *Mid-term*

C. **Inlet-Friendly Business Program:** A key long-term partner and stakeholder in protecting Murrells Inlet's natural resources is the business community. This includes restaurants, outdoor excursion companies, hotels and vacation rental agencies, among others. Many of these businesses are located directly on the

Murrells Inlet shoreline and they interact daily with both residents and visitors alike. They can serve as leaders on many water quality initiatives and can play a significant role in making the general public aware of the importance of protecting the local natural resources.

Recommendation C1: Create an Inlet-Friendly Business Program. Businesses can be designated as "Inlet-Friendly" by engaging in various Best Management Practices such as recycling, the use of environmentally friendly products, restaurant employee training on the proper disposal of Fats, Oils, and Grease (FOGs), making public educational materials available, investing in Low Impact Development retrofits, etc. In return, the business receives recognition for their stewardship efforts including advertising space on a dedicated "Inlet-Friendly" Business program website. A good example of a similar program in the Grand Strand area is the City of Conway, which has established a "River-Friendly Business Program".

Potential Barriers: The outreach effort to promote the program and generate initial participation could be significant. While the program does not entail too much time and effort, a firm commitment from an appropriate entity to oversee the program is necessary.

Implementation Timeframe: *Near-term and ongoing*

D. Stormwater Runoff Volume Reduction: As noted at the beginning of this element, Low Impact Development has become a more widely used approach to manage stormwater runoff. The fundamental principle and ultimate goal is to mimic pre-development hydrology and retain runoff and any potential pollutant loadings as close to the site as possible. There are multiple LID practices that can be implemented to accomplish this objective. Below are LID strategies and other stormwater runoff reduction practices that should be encouraged across the Murrells Inlet community. Other specific structural BMP practices that are intended to address stormwater management in a specific subwatershed are outlined later in the element.

Figure H-8 *Typical rain barrel adjacent to a flower garden. (Photo courtesy of Daniel Newquist, Waccamaw Regional COG)*

- **Rain Harvesting:** One simple strategy is to capture and reuse rainwater for irrigation purposes in periods between storm events. Rain barrels are easy to install and are applicable on residential homes, public facilities, and commercial buildings. Larger rain cisterns have the capacity to capture greater volumes of runoff and could be

appropriate for larger public and commercial building sites. In addition to community wide benefits, homeowners can realize water utility bill savings by using less water for irrigation. A 55-60 gallon rain barrel is generally suitable to capture the runoff generated from a 1000 sq ft roof during a 0.4" storm. A rain barrel of this size costs as low as $50 or cheaper if constructed and installed on your own (Clemson University 2011). Given the minimal expense and relative ease of installation, rain barrels are one of the most feasible retrofit stormwater management practices to implement.

Recommendation D1: Encourage homeowners to utilize rain harvesting techniques such as rain barrels to help reduce stormwater runoff rates and volumes in the watershed. An effective way to increase participation is to have a dedicated campaign to donate or sell rain barrels at discount to interested homeowners. As part of the initiative the county stormwater departments with the support of other entities such as Carolina Clear or the Coastal Waccamaw Stormwater Education Consortium could host workshops to provide instruction on proper siting, installation, and utilization of the rain barrel. These initiatives are often great public outreach and awareness opportunities to explain the watershed protection benefits of these and other stormwater management practices.

Potential Barriers: The greatest obstacle is securing a grant or sponsor to help offset the costs of rain barrel purchase to homeowners. It is also important to ensure that rain barrels are within the aesthetics guidelines of each of the homeowners associations in the Murrells Inlet area.

Implementation Timeframe: *Near-term and periodic.*

- **Tree Planting:** Murrells Inlet, just like many other communities throughout coastal South Carolina has hundreds of majestic live oak trees and other distinct palm and pine tree species, which add tremendous aesthetic, cultural and ecological value to the community. One of the main community scale benefits of tree planting is as a stormwater management amenity. Below is a short list of stormwater benefits that trees can provide in developing communities (USDA Center for Urban Forest Research 2002).

    - **Interception:** Trees with large canopies tend to have high interception capacities. Interception is the ability to briefly retain precipitation from reaching the ground surface thereby mitigating the intensity and duration of peak flow. Mature trees that hold their leaves throughout the year, such as live oaks and magnolias can intercept as many as 4000 gallons annually, depending upon the density of the tree and the occurrence and nature of rainfall events.
    - **Evapotranspiration:** Tree root systems draw moisture from the ground surface and underlying soil and then transpire water vapor through the tree's leaf canopy back into the atmosphere. Herbaceous vegetation or smaller plants other than trees are also responsible for

evapotranspiration, but usually at a lesser scale. As a result this process helps reduce runoff volumes, particularly in moderate storm events.

- **Infiltration:** Roots also play a role in increasing a soil's infiltration capacity. Infiltration is an important process in groundwater storage and recharge. Poor infiltration capacity generally results in greater runoff volumes, requiring other stormwater retention controls.
- **Minimize soil erosion:** Healthy tree canopies and root systems also help to stabilize soils, thereby reducing erosion rates.

Figures H-6 and H-7 *Maintaining tree canopies along roadways and stormwater ponds can help reduce stormwater volumes and runoff rates. (Photos courtesy of Dr. Dan Hitchcock, Clemson University, and Daniel Newquist, Waccamaw Regional COG)*

Recommendation D2: Develop a community urban forestry program. Work with arborist Rick Bauman and the local non-profit Trees for Tomorrow- A Lowcountry Legacy, founded in 2012, which has distributed hundreds of trees free of charge to residents of the Murrells Inlet area. The organization has successfully partnered with Palmetto Pride and the SC Forestry Commission to secure tree donation. More information about their projects can be found at www.lowcountrytrees.org.

Potential Barriers: Some ongoing coordination may be necessary prioritize subwatershed areas within Murrells Inlet to plant trees. Also consideration should be given to maintaining a mapping inventory of trees that are planted through the Trees for Tomorrow program.

Implementation Timeframe: *Near-term and ongoing.*

Recommendation D3: Participate in recognizable events such as Arbor Day. These events are great opportunities to bring partners together and to engage interested citizens. These events are also opportunities to educate the public on all of the benefits of tree planting including the positive impacts on water quality.
Potential Barriers: Initial effort to organize the event
Implementation Timeframe: *Near-term and periodic, (at least one event annually)*

E. Shoreline Buffers: As expressed in the Murrells Inlet Economic Activity and Marsh Valuation Study produced by Coastal Carolina University, property values immediately adjacent to the marsh are significantly higher than similar properties away from the marsh. Therefore, development pressures will always need to be a long-term management consideration in Murrells Inlet. Encouraging the establishment and maintenance of shoreline buffers is an effective BMP that removes bacteria and sediments prior to final discharge into the estuary. Buffers also help to detain and slow down runoff from developed upstream areas.

This practice can be especially beneficial to Murrells Inlet as there is a significant area of shoreline considering the size of the Murrells Inlet watershed. The subwatershed delineations indicate that out of the 51 subbasins that drain into the inlet, 25 of them are along the immediate shoreline and drain directly into the estuary via overland sheet flow. These 25 subbasins comprise a drainage area of 842.09 acres. **Exhibit H-1** highlights the subwatersheds along the immediate Murrells Inlet shoreline.

Figure H-8 *This watershed plan encourages waterfront property owners to establish a wider vegetated buffer along the immediate shoreline. (Photo courtesy of Daniel Newquist, Waccamaw Regional COG)*

Recommendation E1: Develop an incentive program to encourage waterfront property owners to establish and maintain a shoreline buffer. Incentives could include a stormwater utility fee reduction or a property tax credit. Workshops could be held to train homeowners on suitable native plants to establish in the buffer zone and long-term maintenance recommendations that may be needed. Local nurseries could be invited to these events to sell preferred native plants and answer questions on

various landscaping techniques.

Potential Barriers: Due to property constraints and varying levels of property owner willingness it is essentially impossible to establish a shoreline buffer along all waterfront properties. Therefore incremental and targeted goals should be established, perhaps by subwatershed. This could be incorporated into a targeted neighborhood/ subwatershed outreach approach recommended below.

Implementation Timeframe: *Mid-term to long-term and ongoing. Periodic assessment is recommended.*

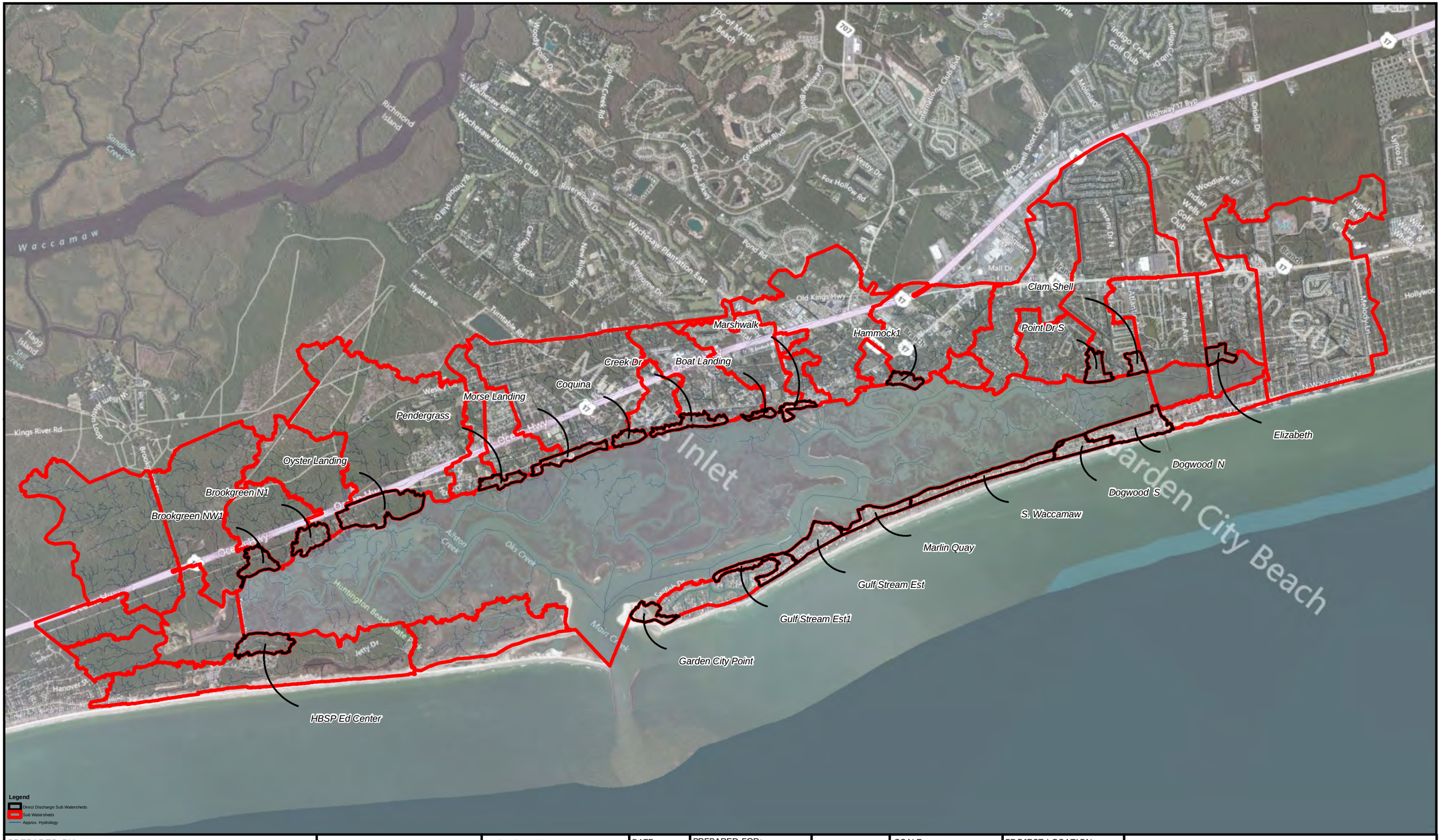
F. Targeted Neighborhood/Subwatershed Outreach Programs: As discussed throughout the plan, despite the relatively small size of Murrells Inlet, the landscape diversity from the northern to the southern end varies considerably. Utilizing the information of the subwatershed delineations, targeted outreach messages should be crafted to each neighborhood based on landscape and drainage characteristics, suspected sources of bacteria, water quality trends, and BMP possibilities that are feasible in that particular subbasin.

Recommendation F1: Develop a distinct public awareness campaign highlighting individual action items residents can take to improve water quality in Murrells Inlet. The following content and design considerations should be considered:

- The overarching goals of the Murrells Inlet Watershed Plan to improve water quality in designated Shellfish Harvesting Areas should be consistently communicated in all neighborhood scale outreach efforts.
- Share positive examples of effective residential scale management strategies instead of merely pointing out negative existing conditions in any particular subwatershed.
- Be specific but concise in the messages that are conveyed. An example of a targeted outreach effort could be to encourage property owners in a subwatershed with extensive shorelines to extend vegetated buffers adjacent to the inlet. Specific guidance on buffer width, landscaping maintenance considerations should be included.
- Gain input from residents on the most appropriate means to distribute outreach materials and solicit ideas on community-scale projects that might require additional support or coordination.

Potential Barriers: The initial steps of developing specific and appropriate outreach messages are important and can take time as there may be several distinct focus areas within Murrells Inlet. A reasonable objective is to establish a designated representative within each target neighborhood or homeowners association to help develop and distribute materials and increase resident participation in neighborhood level projects and initiatives.

Implementation Timeframe: *Near-term and ongoing*



Legend

- Direct Discharge Sub Watersheds
- Sub Watersheds
- Approx. Hydrology

PREPARED BY:

EARTHWORKS
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MAP TITLE:
MURRELLS INLET
SMALL DIRECT
DISCHARGE SUB WATERSHEDS
Exhibit H-1

PROJECT TITLE:
MURRELLS INLET WATERSHED
MANAGEMENT PLAN

DATE:
01/07/2014

TEG PN:
121108.000:E

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SCALE:
1:36,000
0 1,500 3,000
FEET

PROJECT LOCATION:
MURRELLS INLET
GEORGETOWN COUNTY
SOUTH CAROLINA

Recommendation F2: Build upon existing regional and statewide outreach programs where guidance and support resources may already be available. Suggested resources to consider include Clemson's Carolina Yard program and initiatives organized by the Coastal Waccamaw Stormwater Education Consortium. Below is a brief description of the Carolina Yard program:

The Carolina Yards program is designed to provide guidance to homeowners and commercial landscapers to incorporate sustainable lawn care maintenance practices on their properties. The program follows twelve core principles focusing on several elements including plant selection, appropriate water and fertilizer use, and methods to reduce onsite runoff. Program participants can receive Carolina Yard certification for following these watershed friendly landscape practices. The Carolina Yard program is an additional opportunity for residents to minimize their individual impact on water quality in Murrells Inlet. If the program becomes well established and participation grows, the neighborhood and watershed scale impact could be substantial.

Potential Barriers: The biggest hurdle could be public acceptance, especially with property owners who are used to maintaining their lawns a certain way. Education on native plant options and the importance of water conservation and stormwater runoff control are vital initial steps.
Implementation Timeframe: *Near-term and ongoing.* One timeframe consideration is to initiate public outreach efforts and host training workshops in the late winter or early spring when many homeowners are preparing their lawns and gardens for the spring season.

G.Water and Sewer Districts: The water and sewer districts maintain an extensive network of sanitary sewer infrastructure in the Murrells Inlet watershed. This infrastructure is critical in protecting the environmental and public health of the community. Closer partnerships with the MS4 jurisdictions would be beneficial for both entities and ultimately lead to more effective and coordinated water resources management.

Recommendation G1: In addition to reporting Sanitary Sewer Overflow (SSO) incidents to SC DHEC, Grand Strand WSA and Georgetown County WSD should report these occurrences to the respective MS4 jurisdiction, Horry or Georgetown County. This ensures that the county stormwater departments are aware of the incident and avoid expending unnecessary resources to detect and eliminate suspected illicit discharges. The Volunteer Monitoring Program can help assist the water and sewer districts by identifying the extent of any water quality impacts and the ability to track water quality conditions following a SSO incident.
Potential Barriers: There should not be any problems incorporating this as part of the respective agency's SSO reporting procedures

Implementation Timeframe: *Near-term and ongoing*

Recommendation G2: Conduct a microbial source tracking study of the pump station inventory to ensure that they are not a contributing source of bacteria to the inlet. Prioritize camera sewer line inspections based on data provided during microbial source tracking initiatives. Other trends observed by the volunteer monitoring program could also be useful in prioritizing sewer line or pump station inspections.
Potential Barriers: This will entail initial coordination to reach a mutually agreeable commitment between all of the entities that need to be involved.
Implementation Timeframe: *Near-term and periodic*. This will depend on how often the county's conduct microbial source tracking monitoring studies.

H.Transportation and other Capital Improvement Projects: Given the orientation of Murrells Inlet, the main transportation network consisting of US Hwy 17 Bypass and US Hwy 17 Business, along with many of the secondary roads, serve as corridors that extend across multiple subbasins in the Murrells Inlet watershed. Therefore roadway upgrades present opportunities to incorporate best management practices that can have positive long-term hydrological and water quality impacts on the inlet. There have been many roadway repair projects which were improperly stabilized and led to significant erosion.

Figure H-9 *Example of a poorly stabilized roadway construction project resulting in significant erosion directly into one of Murrells Inlet's tidal creeks. (Photo courtesy of Dr. Dan Hitchcock, Clemson University)*

Recommendation H1: Work with SC DOT and all other roadway maintenance entities in the initial phases of roadway improvement projects to identify opportunities to incorporate stormwater BMPs into the project design.
Potential Barriers: Establishing commitments to invest in stormwater BMPs above and standard design criteria to address water quality concerns specific to the Murrells Inlet watershed.
Implementation Timeframe: *Long-term and periodic.*

I.Administrative BMPs: In order for many watershed management practices to be effective they need to be supported through governmental policies or through the context of existing regulatory programs. The following list of recommendations are administrative level action items that will help to manage the Murrells Inlet watershed iteratively and comprehensively.

Recommendation I1: Encourage SC DHEC to consider updating the 2005 Murrells Inlet Fecal Coliform TMDL. As discussed in **Element B,** new monitoring data and other information about the Murrells Inlet watershed has been analyzed that warrants an evaluation of revised load reductions for Murrells Inlet. The following is list of findings and recommendations to justify an updated TMDL:

- As **Element C** discusses, after a thorough analysis of all available monitoring data and other information, the steering committee concludes that wildlife is the predominate source of bacteria in Murrells Inlet. The Commonwealth of Virginia adopts the following policy pertaining to addressing wildlife sources:

  In some waters for which TMDLs have been developed, water quality modeling indicates that even after removal of all the sources of bacteria(other than wildlife) the stream will not attain standards under all flow regimes at all times. However, neither the Commonwealth of Virginia, nor EPA are proposing the elimination of wildlife to allow for the attainment of water quality standards. This is obviously an impractical and wholly undesirable action. While managing over-populations of wildlife remains as an option to local stakeholders, the reduction of wildlife or changing a natural background condition is not the intended goal of a TMDL.

  The project steering committee supports this type of policy regarding wildlife contributions. The committee does acknowledge that efforts can be made to reduce the transport of wildlife bacteria loads through stormwater management best management practices. However, realistically wildlife contributions will likely remain a background bacteria source in the Murrells Inlet watershed indefinitely.
- Utilize newly available data from the Murrells Inlet Volunteering Monitoring Program and other county level monitoring initiatives to allocate percentage contributions from various sources including wildlife. Use microbial source tracking as necessary to validate assigned percentage source contributions.
- Utilize newly available hydrodynamic water quality models recommended by EPA to determine the transport and fate of bacteria in estuaries.
- Determine the survival and loads of bacteria in sediments and to what extent they become resuspended during storms and high winds.

Recommendation I2: Work with SC DHEC's Shellfish Program to evaluate the potential of instituting Conditionally Approved Shellfish Classifications in Murrells Inlet. SC DHEC has previously used this classification to manage shellfish harvesting in Murrells Inlet. Based on water quality data, areas that are normally below the fecal coliform standard expect during infrequent occurrences such as heavy rain events, may be suitable for this type of classification.

Recommendation I3: Work with both counties to ensure that recommendations included in this watershed plan are incorporated into each respective county's Comprehensive Plans and other relevant planning initiatives.

Recommendation I4: Consider the establishment of a Estuary Protection Overlay Zoning District that includes provisions and incentives that encourages land use and stormwater best management practices. Provisions focused on reducing impervious coverage, tree preservation, shoreline buffer establishment, and other types of BMPs should be evaluated.

Recommendation I5: Organize an environmental law and ordinance enforcement coalition. There are many state laws and local ordinances designed to protect water quality and natural resources. They include proper pet waste disposal, wildlife feeding, illicit boat discharges, illegal dumping, illegal shellfish harvesting, etc. There are many entities responsible for enforcing these environmental regulations. A coalition consisting of Horry and Georgetown County Police, SC DNR, SC DHEC, Huntington Beach State Park, US Coast Guard, and local watershed managers could meet semiannually to discuss priority areas of enforcement and ensure that resources and responsibilities are allocated appropriately to achieve community-wide enforcement objectives.

Potential Barriers: Each of these administrative BMP recommendations will entail significant coordination with SC DHEC and county governments.
Implementation Timeframe: *Near-term and ongoing. Periodic review of existing policies is an important aspect of adaptive watershed management.*
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Shellfish and Marsh Habitat Best Management Practices

Most of the best management practices recommended in this plan address land- based bacteria sources and their stormwater transport pathways. This section outlines best management activities to pursue in the estuary to address several issues including marsh and shellfish habitat protection and restoration, tidal flushing, and boating activities.

J.Marsh and Shellfish Habitat: The salt marsh and shellfish resources are among the main focal points of Murrells Inlet's cultural heritage and local economy. These natural resources provide critical habitat for other aquatic and shorebird species, attracting sports fisherman and wildlife enthusiasts from around the country and abroad. Coastal Carolina University Economic Activity and Marsh Valuation study indicates that across all sectors, the economic value of the marsh exceeds $720 million. One of the main goals of this watershed plan is to invest in management projects and activities that will help sustain the long-term economic value of the marsh to the Murrells Inlet community. Below are a few specific habitat management activities to help protect these resources.

Recommendation J1: Continue to encourage residents and local restaurants to recycle oyster shells. Currently, SC DNR reports that they purchase imported shell substrate to meet the demand gap for shellfish ground restoration. A worthy goal would be to recycle as many bushels of oyster shell as are harvested in a given year. Also work with SC DNR and other oyster shell recycling programs to ensure that all

recycled shell remains utilized in the Murrells Inlet estuary for shellfish habitat restoration purposes. One way to encourage participation is to include recycling on the list of credited activities in the proposed Inlet-friendly business program. Ongoing education on the need for recycling and the process of habitat restoration is also important for long-term success.

Figure H-10 *Oyster shell recycling efforts have been very successful in Murrells Inlet. Clambank Landing drop-off site. (Photo courtesy of Daniel Newquist, Waccamaw Regional COG)*

Currently, there are two oyster shell recycling drop off locations in the Murrells Inlet area.

- Garden City Fire Department Station near US Hwy 17 Business and Eden Ave.
- Clambank Landing on US Hwy 17 just north of the main entrance to Huntington Beach State Park.

Potential Barriers: Sustaining the partnerships needed to promote recycling, properly quarantine shells, and then replant them at needed locations is critical and requires ongoing coordination.
Implementation Timeframe: *Continue to build off of existing programs. Periodically evaluate effectiveness of local efforts.*

Recommendation J2: Work with SC DHEC, SC DNR, and other relevant management agencies to establish a permanent shellfish habitat restoration site in the North end of the Murrells Inlet. As is well documented in Element D, the water quality particularly at SC DHEC monitoring site 04-01 has exceeded the fecal coliform water quality standard for several years. Local watershed stakeholders view this area best being served as a long-term oyster reef and marsh habitat restoration site, off-limits to shellfish harvesting. The purpose would be to restore the ecological services and benefits of a healthy estuary system. It is hoped that a sustained restoration effort would help improve water quality, stabilize the shoreline, and provide habitat for other aquatic and waterfowl species. I

Potential Barriers: A management plan may need to be developed to determine the extent of the restoration site boundaries, the roles and responsibilities of all relevant partners, long-term management activities and associated costs, etc.
Implementation Timeframe: *long-term and ongoing.*

Recommendation J3: Explore the possibility of developing a local Oyster harvester apprenticeship program. Oyster harvesting has long been a way of life in Murrells Inlet

and is a unique aspect of the local culture. The long-term sustainability of this trade is dependent upon having an economically viable industry.

Potential Barriers: The biggest obstacle to facilitating an apprenticeship program of this nature is securing the commitment from a suitable sponsoring entity. Some research should be conducted to identify similar programs in other parts of the country to get a better understanding of the resources needed to organize and potentially accredit this type of program.
Implementation Timeframe: *Mid-term to long-term*

K.Inlet Hydrology: Natural processes and human activities have progressively altered Murrells Inlet waterways and upstream hydrology. The lasting affects have been pronounced siltation in several areas of the inlet limiting boat navigability and diminishing natural tidal flushing. From a shellfish habitat standpoint the concern is two-fold. First, the sediments settling into the estuary provide suitable conditions for bacteria survival and reproduction. Second, the reduced tidal flushing alters the estuary salinity composition. Salinity is critical in moderating bacteria loads present in freshwater draining into the inlet.

Recommendation K1: Work with both counties and other state and federal agencies to secure a dredging spoils site designated for the Murrells Inlet area. Two of the proposed goals stated in Georgetown County's Comprehensive Plan related to dredging in Murrells Inlet are:

- *A plan for maintenance dredging of the creek should be developed to include known "hot spots" or areas that are prone to silting in the creek*
- *Encourage appropriate agencies to secure necessary dredge spoil sites, including offshore sites, that are needed for maintenance of marinas and channels.*

Potential Barriers: The biggest obstacle is identifying and securing an appropriate spoils site that will accommodate dredging activity for the next 50-100 years.
Implementation Timeframe: *Mid-term and ongoing*

Recommendation K2: Evaluate and prioritize the need for spot dredging in Murrells Inlet to improve navigability and restore the natural tidal hydrology. One of the stated goals of Murrells Inlet 2007 (now known as Murrells Inlet 2020) is to dredge Murrells Inlet.
Potential Barriers: Dredging projects entail a long-permitting process. These projects must be carefully studied to understand the potential environmental impacts and all of the associated cost-benefits of the project. These projects should be coordinated with the local marinas based on their scheduled dredging needs.
Implementation Timeframe: *Long-term*

Best Management Practices for Specific Subwatersheds

Given the landscape contrasts across the Murrells Inlet watershed, many management strategies are best suited for specific locations depending on land cover, drainage patterns, water quality trends, and land accessibility. The subbasin delineations

provided in **Element D** enabled the steering committee to assess the feasibility of various BMP options on a neighborhood scale. This local scale level of analysis is an effective means of prioritizing BMP siting, design criteria, and ultimate selection.

Most of the BMPs outlined below address stormwater related sources. The primary objective with this approach is to reduce stormwater runoff volume and flow rates. Another focus area is to decrease erosion rates, thereby reducing the impacts of downstream siltation. Below is a profile of the common types of BMPs that are recommended for implementation.

Engineered Filter Strips: These devices are most commonly utilized for construction site sediment control but can be designed with a flocculent additive which binds to bacteria. The devises can be adapted to various lengths and sizes, therefore they serve as a potential BMP along roadside and other drainage ditches where bacteria loads are suspected to be high. Two demonstration sites for installation have been designated for the BHR and the Bike Bridge subwatersheds. The effectiveness of the filter strips will be evaluated and future sites will be identified based on the results.

Figure H-11 *Bacteria removal media can be inserted into these engineered filter strips, which can then be installed along roadside ditch and other retrofit projects. (Photo courtesy of Daniel Newquist, Waccamaw Regional COG)*

Catch Basin Filter Inserts: One of the main components of a typical stormwater infrastructure system is a storm drain inlet. The catch basin portion of the storm drain is designed to allow stormwater to flow through the structure while allowing debris and sediment to settle into the catch basin reservoir. Catch basins do require

some routine maintenance to remove the debris and sediments in order to retain adequate storage capacity. Catch basins can be retrofitted with media filter inserts to enhance bacteria and other pollutant removal efficiency. According the EPA, catch basin insert costs range considerably, starting around $400 for a typical drop-in retrofit device to as much as $10,000 for a more permanent retrofit entailing more elaborate engineering and design.

Estimated Water Quality Benefits: Studies have indicated Total Suspended Solids removal rates of 60-97 % (US EPA National Menu of BMPs). Similar to engineered filter strips, the long-term effectiveness of bacteria removal will be assessed for future application in Murrells Inlet.

Wet Stormwater Pond: These structures detain stormwater runoff for extended periods of time creating a permanent wet pond. During the detention time, pollutants suspended in the stormwater runoff are allowed to settle out. Sunlight exposure also allows UV light to kill bacteria in the stormwater. One of the major maintenance needs of these structures is the removal of accumulated sediments at least every 10 years in order to retain the designed pond volume. To minimize the frequency of pond dredging a sediment forebay can be installed, which is designed to trap larger particles before the stormwater enters the main pond. Wet stormwater ponds are widely used BMPs for the reduction of many pollutants, including bacteria and already exist in several locations throughout the Murrells Inlet watershed.

The EPA estimates that the construction costs for a typical one-acre foot stormwater pond facility is approximately $45,700. The annual routine maintenance costs are estimated to be about 3-5% of the construction costs of the pond.

Figure H-12 *An existing stormwater pond in the Point Dr. subwatershed (Photo courtesy of Daniel Newquist, Waccamaw Regional COG)*

Estimated Water Quality Benefits: Typical bacteria removal rates expected from wet stormwater ponds are ~65% (US EPA National Menu of BMPs)

Vegetated Pond: Stormwater ponds that remain vegetated along the shoreline have shown additional water quality benefits. A vegetated buffer can help reduce erosion along the bank of the pond and provide some pollutant removal before runoff enters the pond via overland flow. Heavily vegetated buffers also discourage the congregation of many types of waterfowl such as Canada Geese near ponds, thereby reducing their direct bacteria loads.

Figure H-13 *An example of a vegetated stormwater pond in Murrells Inlet, which has been effective as reducing bacteria loads. (Photo courtesy of Murrells Inlet 2020)*

Estimated Water Quality Benefits: Based on post BMP implementation monitoring as part of the Murrells Inlet SAMP project, vegetated ponds are even more effective than traditional stormwater ponds at removing bacteria, ~70- 80 % removal rates.

Stormwater Wetlands: This type of stormwater management device removes pollutants by multiple means, primarily by physical filtration and settling of solids, and by the biological uptake of wetland plants. The greatest difference in the design of a stormwater wetland and a wet pond is the deliberate establishment of vegetation growth. This is accomplished by creating varying depth zones which can support emergent wetland species. Stormwater wetlands are commonly used BMPs and have been installed in coastal South Carolina. A suggested constructed wetland plant list for this region is provided in **Table H-2** below. The selection of plants is critical to avoid the establishment of invasive species, such as cattails and phragmites, which would require significant maintenance resources to monitor and fully remove. Other routine maintenance needs include annual inspection of the inlet and outlet

structures, along with long-term inspection of sediment accumulations, particularly in the forebay structure.

Estimated Water Quality Benefits: Typical bacteria removal rates from constructed stormwater wetlands is ~76-78% (US EPA National Menu of BMPs)

Table H-2: Suggested Plant Selection For Constructed Wetland Installation	
Low Maintenance Species	
Reeds (*Juncus effuses*)	Iris (*Iris spp*)
Umbrella Palms (*Cyperus alternifolius*)	Bulrush (*Scripus californicus*)
High Maintenance Species	
Canna lily- Red or Yellow (*Canna spp*)	Daylily (*Hemerocallis fulva*)
Elephant ear (*Colacasia esculenta*)	Iris- Blue Flag (*Iris versicolor*)
Iris- Louisiana (*Iris hexagonae*)	Iris- Yellow Flag (*Iris pseudacorus*)
Woolgrass (*Scirpus cyperinus*)	Thalia- Powdery (*Thalia dealbata*)
Source: USDA Natural Resources Conservation Service	

The EPA estimates that the construction costs for a typical one-acre foot constructed stormwater wetland is approximately $57,100. The annual routine maintenance costs are estimated to be about 3-5% of the construction costs of the wetland.

Floating Wetlands: Another structurally engineered stormwater BMP is the installation of floating wetlands. Similar to filter strips, floating wetlands have flexible design options. Floating wetlands can be a potential retrofit opportunity for conventional wet stormwater ponds as well as tidally influenced streams as well.

Estimated Water Quality Benefits: Floating wetlands are known to efficiently remove Nitrogen and Total Suspended Solids by up to 90%. It is suspected that the same biological processes can efficiently remove bacteria as well.

Figure H-13 *Example of a floating wetland*

Bioretention Systems: These stormwater management practices utilize low lying areas with suitable soils to retain and filter stormwater runoff. They can be designed and installed at various scales and are commonly utilized to treat runoff from parking lots or they can incorporated into the landscaping of residential properties or along

roadway corridors. The most significant benefit of bioretention systems is their ability to reduce stormwater volume and flow rates. The flexibility of their design and their aesthetic appeal make this BMP a suitable option for interested homeowners as well as on a neighborhood scale. Bioretention systems do require initial watering to establish plants, and periodic maintenance such as remulching and the removal of litter and dead vegetation. Selecting native plants species that can tolerate both wet and dry conditions is important for long-term effectiveness. Bioretention systems are infiltration-based practices that should only be installed if the site conditions are appropriate, including sufficient depth to groundwater, suitably drained soils, and sufficient elevation if an underdrain system must be installed.

Estimated Water Quality Benefits: Typical bacteria removal rates expected from bioretention areas are ~10-60% (SC DHEC Stormwater Management BMP Handbook)

Pervious Pavement: On a watershed scale; roadways, sidewalks, driveways, and parking lots comprise a significant proportion of the impervious surface footprint that exists in developed areas. These landscape features alter the natural hydrology of watersheds and increases volume and rates of stormwater runoff. In addition these surfaces accumulate a number of pollutants including bacteria, hydrocarbons, and debris, which get transported to nearby waterbodies following the first flush of a rain event. Pervious concrete and asphalt have become viable solutions for communities trying to reduce stormwater runoff volumes and rates. Pervious pavement products are designed to allow precipitation to seep through the pavement surface and infiltrate into the subsurface soils beneath. Pervious pavement is another infiltration-based practice that may only be appropriate in sites with suitable depth to groundwater and reasonably well-drained soil conditions.

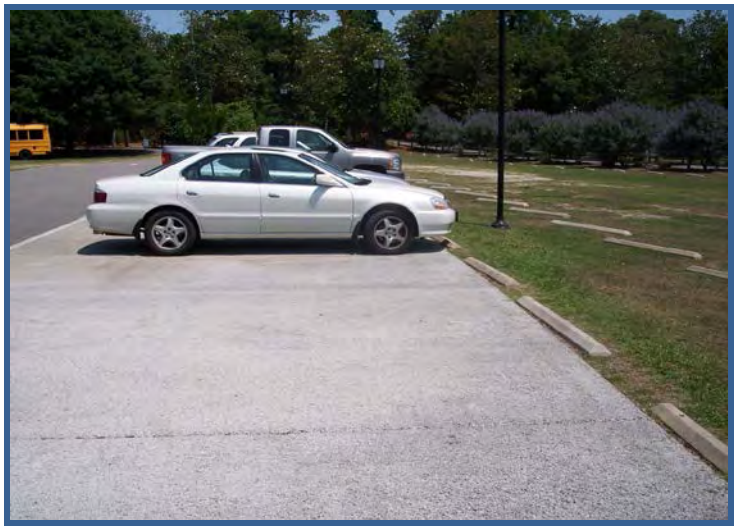

Figure H-14 and H-15 *Pervious Pavements can be installed at various scales. To the left is an example of a parking lot. To the right is the sidewalk approached the pedestrian bridge on Atlantic Ave. towards Garden City. (Photos courtesy of Daniel Newquist, Waccamaw Regional COG)*

From a practicality standpoint, pervious pavement is difficult to install as a retrofit project. However all parking surfaces have a limited useful lifespan so installations can be planned in advance to gradually replace existing asphalt parking surfaces. There are also limitations of using pervious asphalt for high volume roadway loads due to the reduced material strength as compared to conventional asphalt. In addition, the porosity of impervious pavement decreases as fine particles such as sediment build up and clog the surface, essentially reducing the infiltration capabilities of the product. Therefore one of the biggest maintenance considerations needed is to ensure that impervious pavement areas are regularly vacuumed or cleaned via a street sweeper.

Estimated Water Quality Benefits: The main benefits of pervious pavement is stormwater volume reductions and Total Suspended Solids removal, ~70-99% (US EPA National Menu of BMPs)

Drainage Ditch Maintenance/Retrofit: Drainage ditches are one of the principal means of transporting stormwater runoff from roadways and parking lots to their ultimate discharge point into Murrells Inlet. Drainage ditches can be designed to slow runoff rates and provide some pollutant removal benefits. One maintenance measure is to maintain vegetation within and along the edge of the ditch. Ditches can be modified by incorporating a two-stage design.

Estimated Water Quality Benefits: The benefits of a two-stage retrofit include decreased bank erosion and reduced suspended solids loads.

Figure H-16 and H-17: *Examples of road side ditches in Murrells Inlet. The one on the left has good vegetation established which provides pollutant removal benefits. The ditch on the right provides no runoff retention and no pollutant removal benefits. (Photos courtesy of Dr. Dan Hitchcock, Clemson University)*

Specific Subwatershed BMPs

The following section provides a list of specific best management practices recommended for implementation in the subwatersheds identified as being priorities for improvement as outlined in **Element F**. Detailed maps for all of the subwatershed comprising Murrells Inlet are located in **Appendix A.**

Melody	***Nearby Monitoring Sites***
	Tier One Site: *04-01* ***Volunteer Monitoring Site:*** *Woodland Drive Pond*
	BMP Recommendations
	➢ *Install floating wetlands in ponds within Tupelo Bay, Melody Gardens, Bermuda Bay, and Oceanside Village neighborhoods.* ➢ *Retrofit catch basins within Tupelo Bay, Bermuda Bay, and Melody Gardens neighborhoods with filter media inserts.* ➢ *Install a floating wetland at the Woodland Drive Pond* ➢ *Install bacteria media filter strip devices along roadside ditches along Woodland, Calhoun, Vista, and Seabreeze*
Pine	***Nearby Monitoring Sites***
	Tier One Site: *04-01*
	BMP Recommendations
	➢ *Install bacteria media filter strip devices along roadside ditches along Cypress, Pine, Oak, and Atlantic.* ➢ *Install a floating wetland at the Pirate Cove Pond. Note that plant selection for this wetland will need to be suitable for brackish water.* ➢ *Install catch basin inserts or redesign parking lot at the Murphy's Law shopping center.*
Salters	***Nearby Monitoring Sites***
	Tier One Site: *04-01*
	BMP Recommendations
	➢ *Install a floating wetland at the Salters Cove Pond. Note that plant selection for this wetland will need to be suitable for brackish water.* ➢ *Install bacteria media filter strip devices along the roadside ditches in Salters Cove.*

Point Dr.	***Nearby Monitoring Sites***
	Tier One Site: *04-01*
	BMP Recommendations
	➢ *Install bacteria media filter strip devices along roadside ditches along Walmart, Jamestown, Jensens.* ➢ *Install floating wetland in Point Drive Canal* ➢ *Install catch basin inserts in Krogers shopping center. Consider parking lot retrofit to incorporate bioretention or underground storage facilities.* ➢ *Install catch basin inserts in the Wal-Mart parking lot.*
Rum Gully	***Nearby Monitoring Sites***
	Tier Two Sites: *04-02 and 04-27* ***Volunteer Monitoring Site:*** *Rum Gully Creek*
	BMP Recommendations
	➢ *Install floating wetland in Rum Gully ponds.*
Sunnyside	***Nearby Monitoring Sites***
	Tier Two Sites: *04-02 and 04-27* ***Volunteer Monitoring Site:*** *Rum Gully Creek*
	BMP Recommendations
	➢ *Establish grass buffers along marshfront properties* ➢ *Install catch basin inserts along Sea Marsh Road* ➢ *Introduce a series of small weir steps within existing ditches along Van Buren Rd and across from Vintners Road to promote retention and natural process treatment within existing drainage pathways. Bacteria media filter strips could also be installed to enhance treatment*
Garden City Pier N	***Nearby Monitoring Sites***
	Tier One Site: *04-01*
	BMP Recommendations
	➢ *Install catch basin inserts along Dogwood/Atlantic*

Dogwood N	***Nearby Monitoring Sites***
	Tier Two Site: *04-26*
	BMP Recommendations
	➢ *Install bacteria filter devices along roadside ditches on Dogwood. Install inlet protection catch basin insert along roadway as well.*
Mariner Wesley	***Nearby Monitoring Sites***
	Tier One Sites: *04-08, 04-16* ***Tier Two Site:*** *04-06* ***Tier Three Site:*** *04-31* ***Volunteer Monitoring Site:*** *BHR*
	BMP Recommendations
	➢ *Obtain conservation easement from private landowner. Expose existing stream and adjacent ditches to sunlight. Add "natural steps" to promote retention as the land allows.*
Vaux Hall	***Nearby Monitoring Sites***
	Tier Three Site: *04-17A* ***Volunteer Monitoring Site:*** *HS*
	BMP Recommendations
	➢ *Obtain conservation easement from private landowner. Expose existing stream and adjacent ditches to sunlight. Add holding pond if the owner allows.*
Bike Bridge	***Nearby Monitoring Sites***
	Tier Three Site: *04-07* ***Volunteer Monitoring Site:*** *Bike Bridge*
	BMP Recommendations
	➢ *Design and install a constructed wetland on Murrells Inlet 2020 property.*

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Element I: Potential Funding Source Evaluation

Clean Water

State Revolving Fund

ELEMENT I: Potential Funding Source Evaluation

As illustrated in **Element H: Watershed Management Measures**, improving water quality and protecting Murrells Inlet's estuary resources will entail continual management efforts requiring a dedication of financial and personnel resources. The economic value of Murrells Inlet's salt marsh exceeds $720 million according to the *Economic Activity and Marsh Valuation* report prepared by CCU's Center for Economic and Community Development. The natural beauty and services provided by the estuary makes it the focal point of the Murrells Inlet economy having positive impacts on real estate values, the fisheries industry, local restaurants, and the tourism industry. As a result, in 2012 Horry and Georgetown counties generated an estimated $27.4 million in retail sales tax, hospitality fee, and accommodations tax revenues from the 29576 zip code. Investing in initiatives to preserve the long-term ecological health of the Murrells Inlet estuary will undoubtedly continue to provide substantial economic benefits to the community.

The purpose of this element is to provide guidance on the potential funding mechanisms that may be pursued as plan recommendations move forward and are ultimately implemented. The element investigates numerous funding possibilities, including several grant programs which have very specific focus areas. The long-term approach is to seek support from a diversity of local, state, federal, and private sources in order to minimize reliance on a single funding source.

Potential Funding Sources from Local, State, and Federal Agencies

US EPA: Under provisions set forth in the Clean Water Act and other federal legislation, the US EPA fulfills its agency's mission in part by administering grant programs intended to help protect water quality. Many of the grant opportunities are passed on to the states, most often overseen by SC DHEC here in South Carolina. These funding sources are outlined in the next section. Below is a list of grants awarded directly through the EPA.

- **Targeted Watershed Grant:** Initiated in 2003, this grant program is designed to encourage successful community-based watershed management approaches. The grant is intended to be awarded to communities with a broad array of engaged stakeholders and can be utilized on implementation projects to address wetland restoration, fish habitat projection, stormwater management initiatives, and public education and outreach, etc. More information can be found at: http://water.epa.gov/grants_funding/twg/initiative_index.cfm#state

- **Environmental Education Grant:** With annual funding between $2 and $3 million dollars, this grant program sponsored by EPA's Environmental Education Division awards grants to help support environmental education projects to enhance public awareness and knowledge of environmental issues. More information can be found at http://www.epa.gov/enviroed/grants.html

- **Clean Vessel Act Grant Program:** This program directs grant money towards the construction, renovation, operation, and maintenance of pumpout stations for recreational boaters and also for educational programs that inform boaters of the importance of proper disposal of their sewage. Funds are administered through the Sport Fish Restoration and Boating Trust Fund.

SC DHEC: Many of the federally established environmental programs administer grants through state environmental control agencies, which is principally SC DHEC here in South Carolina. Below is a list of common water quality management grant programs on the state level.

- **319 grants:** These funds are typically allocated to communities to address non-point source pollution issues. Periodically 319 funds have been utilized to develop community watershed plans such as this one.

- **Clean Water State Revolving Loan Fund:** This program serves as an infrastructure bank, whereby communities can secure low-interest loans to initiate capital improvement projects. They have more commonly been utilized for wastewater treatment practices but are also used to address non-point source pollution problems.

United States Army Corps of Engineers (USACE): The Army Corps' has many agency responsibilities related to water resource management. Their primary project focus areas include navigation, flood risk management, recreation, wetland mitigation, and shore protection. The Murrells Inlet jetties were constructed by the USACE and dredging projects require permit approval from the Army Corps.

- **206 Aquatic Ecosystem Restoration Program**: Established under the Water Resources Development Act of 1996 this cost-share program generally address problems resulting from past manipulation of the hydrology in and along bodies of water, including wetlands and riparian areas.

- **Estuary Restoration Act**: The purpose of this program is to promote the restoration of estuary habitat, provide assistance for and promote efficient financing of estuary habitat restoration projects, and to develop and enhance monitoring, data sharing, and research capabilities.

County Governments: Both Horry and Georgetown Counties assess a stormwater utility fee to administer the respective stormwater departments and associated infrastructure projects.

Private Foundations: Another potential source of funding is through the non-profit sector. There are several environmental organizations which support local environmental stewardship projects. There are also a few private foundations which support a variety of projects in the Horry and Georgetown County area.

- **National Fish and Wildlife Foundation:** This non-profit organization was created by Congress in 1984. It is structured to direct public conservation dollars to the most pressing environmental needs and matches those investments with private funds. The four focus areas of the organization are birds, freshwater fish, wildlife and habitat, and marine and coastal systems.

    - **Five Star Restoration Program**: This is one of the main grant programs administered through the National Fish and Wildlife Foundation. This program provides challenge grants and technical support to enable community-based restoration projects focused on stream and wetland restoration.

  More information can be found on their website at: http://www.nfwf.org

- **Bunnelle Foundation:** Francis Bunnelle created this charitable foundation in 2000 to support various causes serving Georgetown County. The focus areas of the foundation are:

    - Addressing the root causes of poverty
    - Meeting basic human needs
    - Promoting economic vitality
    - Environmental conservation
    - Encouraging positive youth development.

  The foundation has previously supported projects in Murrells Inlet sponsored by Huntington Beach State Park and Murrells Inlet 2020. More information on grant opportunities can be found at: http://www.bunnelle.org

- **Petsmart Charities**: PetSmart provides financial support to communities that have identified areas with animal welfare concerns. Petsmart focuses specifically on pet adoption and spay/neuter programs. Residents have identified multiple feral cat colonies whose populations can be better through a spay/neuter program. Coastal Carolina University received a grant to conduct a spay/neuter initiative on their campus in 2014. More information on grant opportunities can be found at: www.petsmartcharities.org.

Grants.gov: Updated grant announcements from all federal agencies is provided on Grants.gov This website should be consulted on a regular basis as implementation efforts proceed.

Element J: Public Outreach and Education Resources

ELEMENT J: Public Education and Outreach Resources

Through a number of initiatives including Murrells Inlet 2020's involvement as an education provider in the Coastal Waccamaw Stormwater Education Consortium and their leadership in establishing a volunteer monitoring program, the Murrells Inlet community has been proactive in protecting local water quality. The impetus for developing this watershed-based plan was driven by public concerns about a 2011 SC DHEC Annual Update for Shellfish Management Area #04 which resulted in a Restricted classification for harvesting areas in the southern portion of the watershed. The concern was heightened because this section of Murrells Inlet is predominately surrounded by undeveloped land owned by Huntington Beach State Park and Brookgreen Gardens.

In April 2012, the Murrells Inlet Volunteer Monitoring Program hosted an annual luncheon to recognize the volunteer water monitors and to review the data trends dating back to the inception of the program. An action item proposed at the meeting was to pursue the development of a watershed-based plan to thoroughly assess the historic data trends and coordinate short-term and long-term management strategies needed to improve water quality conditions within the watershed. Significant efforts have been made to engage residents in the development of this watershed-based plan. A steering committee consisting of business owners, long-time residents, volunteer water monitors, and other entities was organized to share local knowledge about Murrells Inlet and to provide feedback on proposed management strategies to implement in the future.

Figure J-1 *The Murrells Inlet community has proactively sought to protect the estuary's natural resources. (Photo courtesy of Murrells Inlet 2020)*

Building public awareness regarding water quality issues in Murrells Inlet and to encourage practices to prevent further degradation is an important and desired outcome of this watershed-based plan. Residents and visitors can have a tremendous influence, positively or negatively, on the long-term protection of local shellfish habitat and other natural resources that are unique to Murrells Inlet. This element provides information regarding existing public outreach programs and resources that are being utilized in the Murrells Inlet area. This element then explores additional possibilities to expand public education and outreach efforts in the watershed. The element focuses specific attention to framing public outreach messages for targeted audiences, such as restaurant owners, tourists, homeowners, pet owners, non-English speaking residents, and boat owners.

Existing Public Outreach Initiatives

There have been several effective programs aimed at addressing local and regional water quality issues in Murrells Inlet and coastal South Carolina. Similar to water quality monitoring programs, local communities have limited financial and personnel resources that they are able to dedicate to public outreach initiatives. Therefore it is most efficient to coordinate resources between various management entities in order to share costs and maximize the potential reach. Regular coordination of resources also ensures that efforts are not unnecessarily duplicated and that proposed initiatives can be vetted and shared across multiple jurisdictions as appropriate. Below is an overview of many of the existing programs and initiatives that have been vital in educating the public on water quality issues, both locally and throughout the region.

- ***Murrells Inlet 2020:*** Formed in 1997, this non-profit organization strives to improve infrastructure and beautification, provide environmental education, and preserve the creek and the traditions surrounding it. http://www.murrellsinletsc.com/

Murrells Inlet 2020 is engaged in the following activities and outreach efforts focused on public education and environmental stewardship of the Murrells Inlet estuary.

  - *Volunteer Water Quality Monitoring-* Murrells Inlet 2020 has been an integral partner in establishing and supporting the Volunteer Monitoring program in the watershed. Volunteers collect samples at eight different locations twice monthly throughout the entire year. This ongoing activity has proven to be an invaluable resource to both Horry and Georgetown counties. In addition to fulfilling obligations under the state's MS4 permitting program, the data collected has helped prioritize management efforts in the watershed. It is also an excellent hands-on learning opportunity for residents who desire to protect the water quality in Murrells Inlet. The community-based volunteer monitoring efforts in Murrells Inlet and on the Waccamaw River have been recognized both regionally and nationally as model programs.

- *Murrells Inlet 2020- The Village Scene, Inlet Happenings/Chowder Talk* Murrells Inlet 2020 maintains a website and distributes a monthly newsletter and a weekly email newsletter as a means of public communications announcing local events and community projects. Both of these resources are useful in sharing reports on the Volunteer Monitoring Program and other local environmental initiatives. Murrells Inlet 2020 also hosts semi-annual Chowder Talk public meetings, which highlight recent accomplishments, upcoming initiatives, and local issues including topics related to water quality.

- *Spring Tide-* 2013 was the 22nd annual event, making it South Carolina's biggest and longest running one day community cleanup. The event involves hundreds of volunteers and relies on support from numerous local restaurants and other sponsors. The effort engages residents in an environmental stewardship activity aimed at increasing individual and community pride in Murrells Inlet's natural resources.

Figure J-2. *Volunteers removing litter from the inlet during the 2013 Spring Tide event. (Photo courtesy of Murrells Inlet 2020)*

- *Golden Oyster Award-* As a way to publicly recognize the conservation efforts of local businesses and residents, Murrells Inlet 2020 has established the Golden Oyster Award for Environmental Stewardship in honor of Dr. Pat Worrell. Any resident can nominate an individual or business for this award which is announced at Murrells Inlet 2020's Spring Chowder Talk. A plaque honoring the Golden Oyster Award recipients is installed on the Marshwalk, providing lasting public recognition of their community stewardship contributions.

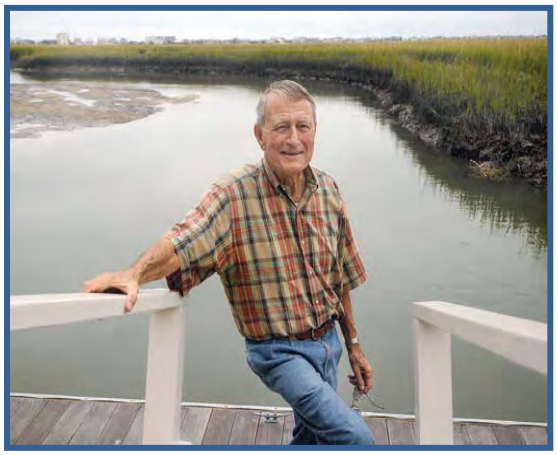

Figure J-3 *2013 Golden Oyster Award Winner Jim Wilkie (Photo courtesy of Coastal Observer)*

- ***Waccamaw Watershed Academy- Coastal Carolina University***. The Murrells Inlet community has a strong ongoing partnership with Coastal Carolina University, located nearby in Conway. Probably the most notable collaboration is with the technical support for the volunteer monitoring program, which has been in place since the spring of 2008. Coastal Carolina University faculty were also integral in the data analysis work involved in the development of this watershed plan. More information about the research and public outreach work of CCU's Waccamaw Watershed Academy can be found at https://www.coastal.edu/wwa/ Results from the Volunteer Monitoring program can be also be accessed through this site.

- ***Coastal Waccamaw Stormwater Education Consortium***- Founded in the spring of 2004, the Coastal Waccamaw Stormwater Education Consortium (CWSEC) serves to help local municipalities in Horry and Georgetown counties fulfill their public education and outreach requirements under South Carolina's Small Municipal Separate Storm Sewer System (SMS4s) permit program. The majority of the Murrells Inlet watershed, with the exception of the very southern end in Georgetown County, falls within the Myrtle Beach Urbanized Area MS4 permit boundary. The overarching goals of the Consortium's work are to:

  - *Maximize efficiency and effectiveness through coordinated and collaborative stormwater education activities.*
  - *Using a regional watershed approach, help member SMS4s meet NPDES Phase II stormwater permit requirements for public education and outreach and public involvement/participation.*
  - *Provide and exchange technical information and expertise on innovative stormwater best management practices and supporting funding opportunities.*
  - *Improve watershed and stormwater awareness in target audiences that informs decision-making and promotes behavior change to address water quality impairments.*
  - *Continue to serve as a model for collaborative stormwater education and involvement throughout the state of SC and beyond.*

  Murrells Inlet 2020 serves as one of CWSEC's Core Education Providers along with Coastal Carolina University's Waccamaw Watershed Academy, Clemson University's Carolina Clear, North Inlet Winyah Bay NERR, SC Sea Grant Consortium, and the Waccamaw Riverkeeper program. The Consortium has established itself as a vital and effective public education resource for communities along the Grand Strand area. CWSEC reaches its targeted audiences through a wide variety of activities and initiatives including BMP demonstration workshops; presentations at schools, civic groups, homeowners associations, etc; newspaper

and television media coverage; and through volunteer activities such as cleanup projects, and water quality monitoring.

This regional resource has been useful for a number of initiatives within Murrells Inlet, including spreading awareness about this watershed planning effort and providing support to the Murrells Inlet Volunteer Monitoring Program. More information about the CWSEC can be found at: http://cwsec-sc.org/

- ***North Inlet- Winyah Bay National Estuarine Research Reserve***- Situated in Georgetown County, this protected area consisting of 18,916 acres of maritime forest, and tidal marsh is one of 28 designated reserves within the National Estuarine Research Reserve System. Scientific research focused on coastal ecology and coastal management issues has benefitted communities throughout the Southeast, including Murrells Inlet. As an example, NOAA supported a study through the Urbanization and Southeastern Estuarine System (USES) initiative. This research project utilized Murrells Inlet as a case study to analyze the effects of urbanization on coastal estuaries in comparison to North-Inlet, which is a relatively undisturbed estuarine system.

  In addition, the North Inlet- Winyah Bay NERR is a leader in public outreach activities, both on the reserve property itself and externally to schools and other entities throughout the region. One of their programs is specifically geared towards grades K-12 students. Classroom activities vary from presentations on estuaries, water quality, and environmental awareness to science fair judging and career day events. Field trips are also offered on the reserve property.

  The Reserve also oversees a Coastal Training Program, which focuses on encouraging stewardship and sound management of our precious coastal resources. The intended audience for this program is local elected and appointed decision makers and professionals in relevant land use management fields, such as stormwater managers, planners, engineers, and developers. Workshops have covered topics such as LID implementation, wetlands identification and regulations, and flood hazard management. Finally, the Reserve has a stewardship program, offering classes to become a certified Winyah Master Naturalist, along with several other hands-on species monitoring and habitat management projects.

More information about research activities and public outreach initiatives supported by the North Inlet-Winyah Bay NERR can be found at: http://www.northinlet.sc.edu/

- ***Carolina Clear- Clemson University-*** Another partner that oversees several statewide public education initiatives is Clemson's Carolina Clear program. They work closely with communities and the stormwater education consortiums across South Carolina to identify public education needs and then prioritize programs and mass media campaigns to maximize the public awareness impact. Two successful examples of programs developed by Carolina Clear are the Carolina Yards program and the "We ALL Live Downstream" mass marketing campaign. More information about resources available through Clemson's Carolina Clear program can be found at: http://www.clemson.edu/public/carolinaclear/

- ***Georgetown County Water and Sewer District and Grand Strand Water and Sewer Authority-*** Both of the sewer utility districts that provide service to the Murrells Inlet area have a significant infrastructure network in place to meet the wastewater treatment needs of the community. There are a few operation and maintenance issues that necessitate public awareness and support. The avoidance of fats and grease from the wastewater stream is critical to minimizing the occurrence of Sanitary Sewer Overflows (SSOs). Another potential cause of SSOs is excess stormwater entering the system from residents who open their cleanout access outlets during major rain events. Both districts can utilize their agency websites and via bill inserts to alert residents to these and other household best management practices. While both districts use automated alarm systems for many of their pump stations, they also rely on the general public to report concerns indicative of a pump station failure or sewer pipe leak. The Grand Strand WSA website is http://www.gswsa.com/ and the Georgetown County WSD website is http://www.gcwsd.com/

- ***Coastal Conservation Association and other civic groups:*** The Coastal Conservation Association is an advocacy organization consisting primarily of recreational fisherman and outdoor sports enthusiasts who recognize the need to protect and restore coastal natural resources. There is a state chapter in South Carolina that has done exceptional education and conservation work in Murrells Inlet. They have partnered with other civic groups such as the Rotary Club to participate in SC DNR's SCORE oyster restoration projects. They have also volunteered to conduct other needed restoration or field survey activities to help fulfill the objectives outlined in this plan. More information about their various initiatives and upcoming events can be found on their website at: http://www.ccasouthcarolina.com/

- ***Friends of Huntington Beach State Park***- As noted in several other elements within this plan, the southern end of the Murrells Inlet watershed is characterized by protected open space areas, most of which are located within Brookgreen Gardens and Huntington Beach State Park. Established in 2003, the Friends of Huntington Beach State Park is a volunteer stewardship group, which strives to provide quality outdoor recreation and educational opportunities, while sustaining the integrity of the park's natural and cultural resources.

Target Populations for Specific Outreach Efforts

This next section is an overview of recommendations for targeted outreach to various population groups that live, work, or visit Murrells Inlet. Each group utilizes Murrells Inlet differently or is affected by water quality conditions in varying degrees, therefore public outreach strategies need to be designed and disseminated in an efficient way to reach all of these stakeholder groups.

Table J-1, Public Outreach and Education- Target Population Groups

Group	Education Needs
Full-time Resident Homeowners	➢ Encourage local residents to get involved in environmental stewardship activities such as the Murrells Inlet Volunteer Monitoring Program, Annual Spring Tide, etc. ➢ Educate homeowners on ways they can reduce their own impacts on water quality in Murrells Inlet. Simple efforts such as tree planting, proper pet waste disposal, installation of rain barrels, and sustainable landscaping practices can all make a difference in minimizing negative impacts associated with stormwater runoff. ➢ It is important to make all full-time residents aware of this planning effort. Community support will be necessary for several of the short-term and long-term recommendations that are outlined. In addition, the plan has a tremendous amount of information about the Murrells Inlet watershed making it a useful educational resource.

Homeowners Associations	➢ Homeowners Associations can help protect water quality in a number of ways especially with issues concerning pet waste removal, neighborhood-scale tree planting, and stormwater retention pond and ditch maintenance.
Residents Relying on Septic Systems	➢ There are not many residences relying on septic systems in the Murrells Inlet watershed, however those that exist need to be properly maintained to avoid future problems. Direct outreach should be pursued with these homeowners to ensure that they have an adequate understanding of existing laws and best practices pertaining to septic systems. ➢ A proactive approach in addressing existing septic systems enables homeowners to extend the effective use of their system and be aware of alternative wastewater treatment options as they become either feasible or necessary in order to protect water quality and public health.
Pet Owners	➢ Pet waste is one of the most preventable sources of bacteria in the Murrells Inlet watershed. It is important to make pet owners aware of the impact of pet waste on water quality in Murrells Inlet and hold them responsible for proper disposal of their pet's waste.
Visiting Tourists	➢ One of the main focuses of an educational campaign geared towards tourists, many of whom visit because of the natural beauty of the area, is to remind visitors of the environmental sensitivities of the local watershed. Visitors have their own role in ensuring the long-term protection of the Murrells Inlet estuary. Leave no trace and pet waste pick up practices should all be promoted.

Elected and Appointed Government Officials	➢ A critical target audience is the key decision makers, who hold elected office or represent local or state management agencies. Elected officials are expected to address constituent concerns regarding a wide variety of issues. A challenging reality is limited personnel and financial resources, requiring a prioritization of the most important community needs. Educating local decision makers about water quality concerns is important so that they are better able to understand the social, economic, and environmental implications of their actions or inactions on water quality related topics.
Recreational Fishermen/Boaters	➢ Fishing and boating are popular activities in Murrells Inlet and the surrounding area. Given their active use of Murrells Inlet, both groups have a significant stakeholder interest in protecting the water quality and natural resources within Murrells Inlet. Watershed managers rely on their cooperation by complying with regulations pertaining to bilge discharges, shellfish harvesting, and boat wake zones. Boaters and fishermen also have an important role in reporting fish kills, spills, and other illicit activities.
Oyster Harvesters	➢ Another critical steward of our local shellfish resources are the harvesters themselves. It is important to collaborate with both recreational and commercial harvesters to ensure that the shellfish stock remains sustainably productive and safe for the public to consume. A few of the needed outreach focus areas to shellfish harvesters are the following: ➢ The applicable laws in designated commercial permit areas and state/recreational harvesting grounds. ➢ Current water quality classifications in each of the shellfish harvesting areas within Murrells Inlet.

	➢ The need to sustain shellfish habitat. Participate in programs such as SC DNR's SCORE restoration program. ➢ An idea that has been shared by multiple stakeholders is the creation of an apprenticeship program that mentors young residents interested in the fisheries trade. Providing hands-on education and training to young residents on how to manage shellfish resources in a sustainable manner will help ensure the long-term health of the oyster reef ecosystem and retain the economic value of the local shellfish trade.
Shellfish Consumers	➢ Seafood remains in high demand in restaurants all along coastal South Carolina and is a major aspect of our local culture. The continued availability of shellfish products is contingent upon protecting local water quality and sustaining healthy clam and oyster reef habitats. The end consumer has a role in supporting efforts to protect water quality and be conscious of the habitat where shellfish are grown and harvested.
Restaurant Owners	➢ Murrells Inlet is known as the "Seafood Capital of South Carolina", and the restaurant industry has helped to shape this cultural identity of Murrells Inlet. Local restaurants have a large stake in maintaining this reputation and are therefore an essential partner in sustaining the local shellfish resources. Active participation in oyster shell recycling initiatives and SC DNR's SCORE shellfish habitat restoration program is one way they can contribute to this shared community goal. In addition, restaurants cater to a large number of visiting tourists.

Commercial Businesses	➢ Besides restaurants, Murrells Inlet has several other types of businesses, many of which are tied to the region's tourism-based economy. **Element H** promotes the creation of an Inlet-Friendly Business Program to encourage local business owners to participate in various stewardship activities. Involvement from the business community can help Murrells Inlet become known as a model ecotourism destination.
Non- English Speaking Population	➢ Another area of concern is making sure the non-English speaking population is fully aware of the restrictions regarding shellfish. If this population is unable to read and interpret sign postings related to shellfish closures they are at heightened risk of consuming shellfish with high bacteria levels. One strategy could be to place multilingual interpretive and enforcement signs in prominent locations such as the Marshwalk, Huntington Beach State Park, public boat landings, and the shellfish recycling sites.

Recommended Public Education and Outreach Strategies and Objectives

The following is a list of recommended public education and outreach strategies focused on the need to protect shellfish habitat areas and water quality in the Murrells Inlet watershed. These strategies complement the recommendations outlined in **Element H: Watershed Management Measures**.

Strategy J-1: *Continue to build upon existing partnerships to educate residents and visitors about the need to protect the water quality in Murrells Inlet and the natural resources that are unique to this community.*

Objective 1A: Keep stakeholders informed as watershed management initiatives are pursued. Maintain a list of contacts of all stakeholders who were involved in this planning process. Create a mechanism for tracking the implementation of plan recommendations and update interested individuals and entities as plan implementation milestones are met.

Objective 1B: Ensure that Murrells Inlet 2020 remains an integral partner as a designated education provider with the Coastal Waccamaw Stormwater Education Consortium.

Figure J-4 *Public meeting to share information about the watershed plan and to solicit feedback on BMP ideas. (Photo courtesy of Daniel Newquist, Waccamaw Regional COG)*

Objective 1C: Seek out new partnerships where possible such as homeowners associations, civic groups, Friends of Huntington Beach State Park, Brookgreen Gardens, and others.

Strategy J-2: *Maintain an active and visible pet waste disposal campaign in Murrells Inlet.*

Objective 2A: Prominently display reminders about regulations applicable to pet waste disposal and the importance as it relates to water quality protection.

Objective 2B: Continue to maintain pet waste stations that are located in several prominent areas including the Marshwalk. Identify additional places where pet waste stations may be needed.

Objective 2C: Work with real estate companies to educate vacation renters on the need to pick up pet waste. Remind visitors that reducing bacteria loads from pet waste and other sources is important in protecting the public health of shellfish consumers and recreational uses of our coastal waters.

Figure J-5: *Pet waste outreach materials provided by Clemson's Carolina Clear Program*

Strategy J-3: *Investigate opportunities to have permanent public awareness interpretive signs installed at prominent locations within Murrells Inlet.*

Objective 3A: Create an inventory of locations where environmental awareness signs already exist. Create a list of desired interpretive signs by type and location based on the impact the proposed sign can have on meeting the education needs for each targeted population group listed in **Table J-1**.

Objective 3B: Pursue space within the new Murrells Inlet Community Center where public education materials can be displayed.

Objective 3C: Work with entities such as Brookgreen Gardens, Huntington Beach State Park, and local marinas to discuss the feasibility of installing temporary or permanent public education materials at their respective locations.

Strategy J-4: *Encourage resident involvement in hands-on volunteer opportunities in the Murrells Inlet watershed.*

Objective 4A: Recruit additional residents to get involved with the Murrells Inlet Volunteer Monitoring program. This program has been a tremendous resource to both Horry and Georgetown counties in their respective watershed management efforts. These volunteers are knowledgeable environmental stewards of the Murrells Inlet watershed.

Objective 4B: Develop an adopt a stream or watershed program that corresponds to the main tidal creeks adjacent to the eight volunteer monitoring sites.

Objective 4C: Continue to promote the annual Spring Tide event hosted by Murrells Inlet 2020. These types of volunteer events draws positive attention to the environmental and economic importance of protecting Murrells Inlet.

Objective 4D: Recruit additional volunteers to assist in oyster shell recycling and reef habitat restoration through programs such as SC DNR's SCORE program and Coastal Carolina University's Coastal Oyster Recycling and Restoration Initiative (CORRI).

Objective 4E: Work closely with the Coastal Conservation Association and other local civic groups such as the Rotary Club to organize community volunteer activities such as shellfish habitat restoration, litter cleanup, public awareness surveys, etc.

Figure J-6 *Volunteers with the Coastal Conservation Association working on an oyster reef restoration project. (Photo courtesy of the Coastal Conservation Association)*

Strategy J-5: *Utilize both traditional media outlets as well as emerging technologies to increase public awareness regarding water quality issues affecting Murrells Inlet.*

Objective 5A*:* Direct attention to the online pollutant source mapping tool developed by Coastal Carolina University. This tool was utilized during the planning process to allow the general public to share their water quality concerns at specific locations within the Murrells Inlet watershed. This interactive tool could serve similar purposes during future planning or survey initiatives.

Objective 5B: Utilize social media websites such as facebook to share announcements regarding volunteer opportunities, news from the Volunteer Monitoring program or other water quality management initiatives in Murrells Inlet. Coordinate social media announcements with other partner stakeholders.

Objective 5D: Continue to utilize public outreach slogans such as "Litter Makes Us Crabby", which has proven effective in the past.

Strategy J-6: *Educate property owners on ways to reduce impacts of stormwater runoff during significant rain events.*

Objective 6A: Simple strategies such as the installation of rain barrels, rain gardens, pervious pavement, and appropriate trees can help reduce the rate of stormwater runoff from individual lots ultimately making a significant difference on a neighborhood and community wide scale. Explaining the benefits of these practices and directing homeowners to convenient and affordable resources entails a sustained outreach effort.

Objective 6B: Install demonstration projects at public facilities and parks. As MS4 permit holders, each county has a leadership responsibility to ensure that local waterbodies are meeting the state water quality standards. Each county can serve as a model for progressive watershed management by incorporating Low Impact Development and other best management applications into the design of public parks and facilities.

Strategy J-7 *Explore opportunities to educate the public on water quality issues at all appropriate local community events.*

Figure J-7 *Murrells Inlet hosts numerous community events throughout the year including an annual oyster roast. These events are good public outreach opportunities. An educational display board highlighting findings included in this plan has been created for this purpose (Photo courtesy of Murrells Inlet 2020)*

Objective 7A: The annual Spring Tide event has been a successful volunteer cleanup effort. Continue to grow the Fall Haul event now in its third year, which coincides with SC DNR's statewide RiverSweep/BeachSweep campaign held the third weekend of September shortly after the peak tourism season.

Objective 7B: Continue to host annual Volunteer Monitoring Program data workshops to present the findings to the volunteer monitors and to other interested stakeholders, including the local media.

Objective 7C: Continue to use the semi-annual Murrells Inlet 2020 Chowder Talk events as a way to highlight watershed management accomplishments and share announcements regarding upcoming initiatives.

Objective 7D: Work with local event organizers to seek opportunities to setup educational displays focused on water quality initiatives in Murrells Inlet.

Strategy J-8: *Develop a targeted educational campaign directed at the tourist population.*

Objective 8A: Tourism is one of the core sectors of the local Murrells Inlet economy. The waterfront views, natural beauty, and the variety of outdoor recreation opportunities are the key elements that make Murrells Inlet a popular draw. A worthwhile endeavor would be to brand Murrells Inlet as an ecotourism destination and establish sustainability goals among the key stakeholders in the local tourism industry. An existing example is the designation of Morse Park Landing as a South Carolina National Heritage Corridor site. More information about this statewide natural and cultural tourism initiative can be found at http://www.scnhc.org Murrells Inlet should also evaluate the potential for similar designations with the Southeast Coast Saltwater Paddling Trail, www.secoastpaddlingtrail.com

Objective 8B: A key to reaching out to tourists is to partner with businesses such as restaurants, outdoor excursion companies, and real estate companies that regularly interact with visitors. Providing educational materials through these outlets is an effective means of reaching the largest number of visitors.

Objective 8C: Work directly with Brookgreen Gardens and Huntington Beach State Park, both popular local tourist destinations, to develop educational displays and/or programs to spotlight the need for continued protection of the natural resources within Murrells Inlet. As these landmarks are both known for their scenic natural beauty and have existing educational programs and resources, they could be ideal partners in specific public outreach efforts focused on water quality and shellfish management in Murrells Inlet.

Figure J-8 *Huntington Beach State Park has a nature center which hosts numerous activities to educate visitors about the local ecology. (Photo courtesy of Huntington Beach State Park)*

Strategy J-9: *Provide guidance and assistance to homeowners relying on septic systems to ensure that they continue to function properly.*

Objective 9A: Coordinate outreach activities with EPA's septic smart week initiative. This can serve as a yearly refresher to residents regarding proper septic system maintenance and warning signs of malfunction. Information on EPA's septic smart initiative can be found online at:
http://water.epa.gov/infrastructure/septic/septic-smart-week-2013.cfm

Objective 9B: Hold periodic workshops with residents to inform them of the options and costs associated with connecting to the centralized sewer system versus long-term septic system maintenance and eventual replacement. Coordinate these efforts with Georgetown County WSD, Grand Strand WSA, and SC DHEC.

Strategy J-10: *Coordinate all public outreach efforts into a comprehensive, community-wide mass media campaign aimed at promoting individual stewardship practices to protect Murrells Inlet.*

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Element K: Long-term Water Quality Monitoring Needs

ELEMENT K: Long-term Water Quality Monitoring Needs

An integral tool in long-term adaptive watershed management is having a comprehensive water monitoring program in place. Water quality monitoring provides critical data essential to water resources management decision making processes. While monitoring does entail a dedication of time and resources, it provides the scientific data used to develop and design watershed management initiatives or projects. Water resource managers utilize monitoring programs to identify areas with elevated contaminant levels and draw better conclusions as to what the source of the pollutants could be. Monitoring also provides watershed managers with an important evaluation tool to assess the effectiveness of remediation and prevention efforts.

The effectiveness of a monitoring program is highly dependent on the long-term collection of accurate representative samples. Consistent sampling provides data users and ultimately key decision makers the ability to assess trends over time. Data continuity is also important in detecting situations where future samples indicate sudden and noticeable deviations from typical water quality conditions within a waterbody.

This long-term monitoring plan identifies future needs to enhance existing water quality monitoring efforts and outlines a logical protocol on how the data obtained can be optimally utilized.

Existing Water Quality Monitoring Resources

The two most comprehensive monitoring programs active in Murrells Inlet are SC DHEC's shellfish monitoring program and the Murrells Inlet Volunteer Water Quality Monitoring Program. A thorough trend analysis of data collected by these programs is included in **Element D**. The SC DHEC monitoring program is used to update the status of shellfish harvesting classifications, which has regulatory implications on what areas are allowed to be harvested in a given period of time. The Volunteer Monitoring Program is designed to assess the contributions of tributaries carrying land-based stormwater runoff into the estuary. The baseline assessment outlined in **Element D** helped to prioritize areas of primary concern, which in turn informed the evaluation of recommended Best Management Practices outlined in **Element H**. The SC DHEC monitoring data and the Murrells Inlet Volunteer Monitoring program will continue to be essential resources in guiding future watershed management efforts in Murrells Inlet.

Identification of Gaps in Available Data Sources

Throughout this planning process, the steering committee searched and reviewed numerous data sources to gain a better understanding of the hydrology, historic weather trends, land use changes, wildlife habitats, and water quality conditions in Murrells Inlet. Through our extensive analysis, several potential data needs that could

be utilized in future management decisions were discovered. The identification of these data gaps is vital in determining necessary investments in long-term monitoring within Murrells Inlet.

- **Wildlife Populations**. One of the main potential sources of fecal coliform contamination identified in the Murrells Inlet TMDL is contributions from local wildlife populations. During the community stakeholder meetings, observations on waterfowl and other wildlife species were solicited. There was a notable emphasis on the prevalence of small mammals such as feral cats and raccoons in residential neighborhoods and the presence of waterfowl species in several stormwater ponds. Representatives from Huntington Beach State Park also described recent population shifts for species such as red fox and coyote in the southern portions of the watershed. In addition, other committee members suspected that wild hogs have begun to inhabit this portion of Georgetown County as well.

Figure K-1 *Raccoons and other small mammals are abundant in both the undeveloped southern end of the watershed as well as in residential areas in Murrells Inlet. (Photo courtesy of Murrells Inlet 2020)*

The steering committee reviewed GAP analysis data produced by the US Fish and Wildlife Service which seeks to estimate various wildlife populations based on the given habitat of a particular area. The data provided were primarily focused on the list of state and federal Rare, Threatened, and Endangered species that inhabit South Carolina. In addition, the data were published at an ecoregion scale, which precluded analysis at the scale needed for the Murrells Inlet watershed.

It would be beneficial to collect a comprehensive survey of existing wildlife populations at least once every ten years, perhaps on a county level. This information would be beneficial to multiple entities and would enable watershed managers in Murrells Inlet to account for population changes in waterfowl species, native species such as deer and raccoon, and nuisance species such as wild hogs. In the meantime one strategy being pursued is the use of microbial source tracking to identify human and non-human sources of bacteria that are entering local waterways. Having an accurate estimate of bacteria loadings from wildlife species is important in determining whether to focus management strategies on eliminating preventable bacteria sources as opposed to minimizing the transport of wildlife bacteria sources off the land to minimize downstream water quality impacts in shellfish habitat areas.

- **Rain Data.** An environmental variable that influences both single fecal coliform sample measurements and long-term trends is rainfall patterns. The baseline assessment of water quality trends included in **Element D** utilized the rain gauge at Brookgreen Gardens to evaluate the correlation of wet weather trends on fecal coliform levels. This rain gauge represents the longest continuous data set in general proximity to Murrells Inlet. It is also utilized by the National Weather Service and SC DHEC as part of their respective programs.

Figure K-2: *Rain intensity and duration can vary considerably in the Murrells Inlet area. Given the known correlation between rain patterns and observed fecal coliform levels, having accurate precipitation data is very useful (Photo courtesy of Murrells Inlet 2020)*

During steering committee discussions, there were some limitations noted by solely using the Brookgreen Gardens rain gauge for data analysis purposes. These limitations are summarized below:

- An obvious limitation is that the Brookgreen Gardens rain gauge is actually located outside of the delineated boundaries of the Murrells Inlet watershed and is approximately 1.5 miles from the closest SC DHEC monitoring station in Murrells Inlet.
- By relying on a single rain gauge, water resource managers are dependent upon the responsible entity to measure precipitation totals on a daily basis and have the data accessible in a timely manner. Having multiple rain gauge sites helps limit data gaps and correct for any measurement or recording errors.
- A unique aspect of the Grand Strand area is that weather patterns are highly variable over a small geographic area, even between the immediate coastline and slightly inland towards the Waccamaw River, where the Brookgreen Gardens rain gauge is located. Summer weather patterns are unpredictable as thunderstorms can produce heavy rain in one area and very little or no precipitation just a short distance away. It would be beneficial to expand the number of rain gauge stations along the immediate coast extending from the Garden City Beach portions of the watershed to Huntington Beach State Park in Georgetown County. A

weather station was recently installed at Crazy Sister Marina near the Marsh Walk.

- **Soil Samples:** As mentioned in other elements, siltation has been commonly observed in many areas of Murrells Inlet, causing gradual but noticeable changes in local hydrology and the navigability of several creeks within the inlet. The sediments that get transported to the estuary can have direct impacts on shellfish and other aquatic species habitats. Fecal coliform are able to bind to soil particles and contribute to bacteria loads entering the inlet. Often, the levels of bacteria present in the sediment loads are not observed until they become resuspended in the water column after a disturbance from boat wakes or following dredging activity. As of yet there are no comprehensive studies in Murrells Inlet where soil bacteria sampling has been conducted. Sampling soils in areas where there may be a suspected source of bacteria could lead to targeted management or remediation efforts. It would also be worthwhile to analyze spoils following future dredging projects to determine to what extent bacteria are being harbored by sediments entering Murrells Inlet.

Long-term Monitoring Strategies and Objectives

This section outlines a set of recommended strategies and corresponding objectives to continue to maximize the utility of monitoring as an integral part of future watershed management decision making processes.

Strategy K-1: *Continue to review and analyze monitoring data collected by the SC DHEC Shellfish Monitoring Program.*

Objective 1A: The SC DHEC monitoring data and annual shellfish reports have the most significant regulatory implications on watershed management within Murrells Inlet. These data are used to classify shellfish harvesting designations throughout the state. The project partners should regularly analyze the data and inform relevant stakeholders about key trends. The Annual Shellfish Management Area 04 Report is a good reference that lists changes in shellfish classifications.

Objective 1B: Work with SC DHEC staff to evaluate the possibility of developing a Conditionally Approved shellfish classification protocol in portions of Murrells Inlet. These areas would be limited to SC DHEC monitoring sites that are meeting water quality standards the majority of the time and are only exceeding standards in predictable conditions including 24 hour rainfall patterns. A candidate area for the Conditionally Approved shellfish classification could be the southern end near Huntington Beach State Park, which seems to be influenced by the periodic release of freshwater into the salt marsh at the main road causeway.

Objective 1C: Remain attentive to new monitoring requirements that may be mandated by the SMS4 stormwater permit program or through other environmental regulations. Also be aware of any changes to water quality standards implemented by SC DHEC or the FDA National Shellfish Sanitation Program. As an example, the

updated SMS4 permit, effective January 1st, 2014, required new monitoring requirements and assessment provisions for those waters with an approved TMDL.

Strategy K-2: *Continue to invest resources in the Murrells Inlet Volunteer Monitoring Program.*

Objective 2A: Maintain efforts to recruit new volunteers to participate in this monitoring program. One of the primary goals of this program is to educate residents about water quality issues in Murrells Inlet. Since the inception of the program in 2008, the volunteer monitoring program has been an effective way to enhance community stewardship of the Murrells Inlet estuary.

Objective 2B: Maintain a strong collaborative partnership with both counties and Coastal Carolina University to ensure that the program continues to provide quality data in a timely manner. Solicit input from all partner entities on ideas to expand monitoring to new sites and when initiating special projects, such as upstream monitoring studies.

Objective 2C: Provide updates to community residents about the results and trends of the volunteer monitoring data. Continue hosting an annual data workshop with the volunteers and other relevant stakeholders. In addition, other avenues for sharing data results such as the Murrells Inlet 2020 Chowder Talk series and the Village Scene and Inlet Happenings newsletters should be pursued.

Objective 2D: Ensure that there is continued funding available to maintain a permanent volunteer monitoring site at the Woodland Drive Pond in Garden City.

Strategy K-3: *Maintain a comprehensive approach in the prioritization of monitoring resources.*

Objective 3A*:* Ensure that there are a sufficient number of rain gauges actively recording precipitation totals in Murrells Inlet. During the development of the baseline assessment for this plan, it was recognized that there were limitations in the available rainfall data in Murrells Inlet. The only rain gauge with an adequate period of record is located at Brookgreen Gardens. Given the intermittent nature of rainfall along the Grand Strand coast, it would be beneficial to install additional rain gauges in Murrells Inlet. Initial efforts could be made to participate in the CoCorahs program, which seeks volunteer residents and businesses to collect and report daily rainfall totals at their sites.

Objective 3B: Conduct periodic wildlife surveys every ten years to get a sense of current species populations and where habitats may be expanding. This information can be very useful to account for background bacteria levels in the watershed. Cost-sharing arrangements should be pursued since this survey would benefit multiple stakeholder entities.

Objective 3C: A valuable output of this planning project is a complete delineation of all the subwatersheds draining into the Murrells Inlet estuary. As a result, targeted monitoring can be conducted to assess potential bacteria sources in a defined subbasin location. Initial monitoring upstream of the Bike Bridge, HS, and BHR volunteer monitoring sites helped to identify BMP opportunities in the Georgetown County portion of the watershed. It also helped determine an action plan for initiating microbial source tracking in the southern end of Murrells Inlet. This type of monitoring approach utilizing the subwatershed delineations is recommended for future initiatives.

Figure K-3: *The subwatershed delineations have already been utilized to establish the framework for the upstream monitoring initiative in Georgetown County.*

Objective 3D: As part of this planning process, a land use change and curve number analysis was conducted to characterize the drainage characteristics in the subwatersheds which flow into Murrells Inlet. To continue to have an accurate sense of local drainage patterns it is recommended that this type of assessment is conducted on a routine basis, perhaps once every ten years.

Objective 3E: Conduct a comprehensive soil analysis, including the presence of fecal indicator bacteria, at strategic locations throughout Murrells Inlet. The goals of this project would be to identify the extent to which bacteria binds to various soil types and which areas in Murrells Inlet are experiencing the most pronounced erosion and siltation. This study should be timed with any future dredging activities that are

scheduled to correlate the data obtained in upstream locations with sediments that are removed from the estuary.

Objective 3F: To better understand the hydrodynamics of the Murrells Inlet estuary system consider conducting a dye or marker test to determine exact flow paths from the upper tidal creeks through the main channel out to the Atlantic Ocean. This type of study would also provide insight on the spatial and temporal influence of tidal flushing throughout the estuary.

Objective 3G: Use site-specific monitoring as a tool to evaluate the success of watershed projects or initiatives that are pursued in Murrells Inlet. Pre- and post-project monitoring can be particularly useful in determining the effectiveness of structural BMP projects, where certain water quality benefits are expected. Monitoring following other types of projects such as dredging could also provide very useful information.

Objective 3H: Continue to collaborate with research institutions such as NOAA, Coastal Carolina University, University of South Carolina, Clemson University, North Inlet –Winyah Bay NERRS and others to pursue research opportunities to expand knowledge regarding the water quality, natural resources, and coastal processes affecting the Murrells Inlet estuary.

Objective 3I: Continue to use microbial source tracking as a tool in identifying specific bacteria sources in the watershed. The steering committee recommended using microbial source tracking to determine whether there are any human source contributions from sewer lift stations, which are generally located in low-lying areas near tidal creeks.

Objective 3J: Maintain a data archive specific to Murrells Inlet that is readily accessible to watershed managers, elected officials and other decision makers, and to other stakeholder interest groups. The archive should be reviewed and updated annually or as otherwise needed. Information resources that should be added to the archive include:

- SC DHEC monitoring data and annual shellfish reports
- Murrells Inlet Volunteer Monitoring annual reports and presentations
- SC DNR SCORE project updates
- News media reports on watershed initiatives including Spring Tide event, Volunteer Monitoring, etc.
- Scientific research projects from state and federal management agencies and local universities.
- Engineering reports of major infrastructure projects led by Army Corps of Engineers, SC DOT, Grand Strand WSA, Georgetown County WSD, Horry County, Georgetown County, or other relevant agencies.
- Updated mapping including Shellfish Harvesting Classification, land use change, etc.

- Case studies about various watershed initiatives from other regions that may be applicable to Murrells Inlet.

Objective 3K: Knowing that other coastal communities face the same challenges of protecting their shellfish harvesting areas, it would be beneficial to share information and experiences with other management entities across the state on an ongoing basis. There are likely numerous examples of effective BMPs and lessons learned that neighboring communities could potentially apply in their own water quality management efforts. During this planning process, the steering committee consulted with stormwater managers from the Town of Bluffton who have undertaken similar efforts to address fecal coliform impairments in Shellfish Harvesting Areas in the May River watershed.

Objective 3L: Maintain a long-term adaptive management approach and review plan on a regular basis and update as needed.

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Element L: Integrative Watershed Management

ELEMENT L: Integrative Watershed Management

The previous elements in this watershed plan discuss a wide variety of specific watershed topics as they pertain to the Murrells Inlet estuary. Many of the topics overlap and are interrelated and must be considered holistically in long-term watershed management efforts. This chapter provides three matrix tables to summarize locations, costs, water quality benefits and an implementation timeframe for the recommended BMPs. **Table L-1** provides details of the structural BMPs that have been recommended for the priority subwatersheds outlined in Element F. **Table L-2** outlines the anticipated water quality benefits and cost considerations for small-scale BMPs or administrative BMPs that apply across the entire Murrells Inlet watershed. Finally **Table L-3** provides a timeframe for BMP implementation with notes concerning implementation feasibility. These tables serve to summarize the BMPs recommended in this watershed plan. More detailed BMP descriptions and purposes can be found in **Element H**. Also note that all of the public awareness and education recommendations are found in **Element J.**

Table L-1 provides estimated load reduction benefits for structural BMPs recommended in Element H. The first step is to estimate the bacteria load from each of the drainage areas from each of the listed priority subwatersheds. This was calculated utilizing the time of concentration and flow rate information for each subwatershed outlined in **Table A-1**. As emphasized throughout the plan, bacteria loads vary tremendously based a number of factors including dry or wet weather conditions, mobile nature of bacteria sources, seasonal population trends, etc. Therefore, it should be noted that the pollutant loads are merely estimates and will be influenced as these conditions change. The 80% removal rate goal was selected based on targeted load reduction rates outlined in the 2005 Murrells Inlet Fecal Coliform TMDL and the bacteria removal rates that can be expected from the structural BMPs that were selected. Cost estimates are included based on proprietary quotes and on similar constructed stormwater pond projects previously installed in Georgetown County.

Table L- 1: Priority Subwatershed Summary Structural BMP Matrix

Subwatershed	Potential Bacteria Source(s)	Area (acres)	Flow rate (cubic feet/second)	Estimated Bacteria Load Concentration (cfu/100ml)	Estimated Total Daily Bacteria Loads (cfu/day)	80% Target Load Reduction (cfu removed per day)	BMPs	% Load Reduction Anticipated	Cost Estimate
Melody	➢ Waterfowl ➢ Wildlife ➢ Pet Waste ➢ Sewer pump stations	633.0	58.6	36	3.20E+14	2.56E+14	Install floating wetlands at Woodland Drive Pond and in Tupelo Bay, Melody Gardens, Bermuda Bay, and Oceanside Village	Traditionally used to remove nutrients. Pilot site needed.	$16,370 to install three 10x20ft modules (proprietor quote)
							Install bacteria filter inserts in catch basins in Tupelo Bay, Bermuda Bay, and Melody Gardens neighborhoods	Center for Watershed Protection estimates 80% removal	~ $300 per insert, varies by size and design (EPA reference and proprietor quote)
							Install bacteria filter strip devices along roadside ditches on Woodland, Calhoun, Vista, and Seabreeze.	Center for Watershed Protection estimates 80% removal	$1,200- 160lf of 8” prefilled strip. (proprietor quote)
Pine	➢ Waterfowl ➢ Pet Waste ➢ Sewer pump stations/ Atlantic Ave crossing	190.4	98.9	36	8.71E+14	6.96E+14	Install bacteria filter strip devices along roadside ditches on Cypress, Pine, Oak, and Atlantic.	Center for Watershed Protection estimates 80% removal	$1,200- 160lf of 8” prefilled strip. (proprietor quote)
							Install a floating wetland at Pirate Cove Pond	Traditionally used to remove nutrients. Pilot site needed	$16,370 to install three 10x20ft modules (proprietor quote)
							Install bacteria filter inserts in catch basins at Murphy’s Law shopping center	Center for Watershed Protection estimates 80% removal	~ $300 per insert, varies by size and design (EPA reference and proprietor quote)
Salters	➢ Waterfowl ➢ Pet Waste	144.5	156.7	36	1.38E+15	1.11E+15	Install a floating wetland at Salters Cove Pond	Traditionally used to remove nutrients. Pilot site needed	$16,370 to install three 10x20ft modules (proprietor quote)
							Install bacteria filter strip devices along roadside ditches in Salters Cove neighborhood	Center for Watershed Protection estimates 80% removal	$1,200- 160lf of 8” prefilled strip. (proprietor quote)
Point Dr.	➢ Waterfowl ➢ Wildlife ➢ Pet Waste ➢ Sewer pump stations ➢ Septic Systems- Waterford Oaks	433.7	97.2	36	8.56E+14	6.85E+14	Install bacteria filter strip devices along roadside ditches along Walmart, Jamestown, and Jensens	Center for Watershed Protection estimates 80% removal	$1,200- 160lf of 8” prefilled strip. (proprietor quote)
							Install floating wetland in Point Drive Canal	Traditionally used to remove nutrients. Pilot site needed	$16,370 to install three 10x20ft modules (proprietor quote)
							Install bacteria filter inserts in catch basins at Kroger’s and Walmart shopping center parking lots	Center for Watershed Protection estimates 80% removal	~ $300 per insert, varies by size and design (EPA reference and proprietor quote)
Rum Gully	➢ Waterfowl ➢ Pet Waste	243.2	48.4	36	4.26E+14	3.41E+14	Install floating wetland in Rum Gully ponds	Traditionally used to remove nutrients. Pilot site needed	$16,370 to install three 10x20ft modules (proprietor quote)
Sunnyside	➢ Waterfowl ➢ Pet Waste ➢ Septic Systems- Melton Ave	231.9	70.9	26	4.51E+14	3.61E+14	Install bacteria filter inserts at catch basins along Sea Marsh Road	Center for Watershed Protection estimates 80% removal	~ $300 per insert, varies by size and design (EPA reference and proprietor quote)
Garden City Pier N	➢ Waterfowl ➢ Pet Waste ➢ Sewer- Atlantic Ave. crossing	67.2	Overland Flow				Install bacteria filter inserts in catch basins along Dogwood/Atlantic	Center for Watershed Protection estimates 80% removal	~ $300 per insert, varies by size and design (EPA reference and proprietor quote)
Dogwood N	➢ Waterfowl ➢ Pet Waste	42.6	Overland Flow				Install bacteria filter inserts in catch basins along Dogwood	Center for Watershed Protection estimates 80% removal	~ $300 per insert, varies by size and design (EPA reference and proprietor quote)
Mariner/Wesley	➢ Wildlife ➢ Feral Cats ➢ Pet Waste	408.9	106.2	16	4.16E+14	3.32E+14	Installation of a vegetated stormwater pond	80% removal based on existing vegetated pond in Murrells Inlet.	$34,000 per pond acre x 1.5 acres= $51,000
Vaux Hall	➢ Wildlife ➢ Feral Cats ➢ Pet Waste	171.1	86.3	16	3.38E+14	2.70E+14	Installation of a vegetated stormwater pond	80% removal based on existing vegetated pond in Murrells Inlet.	$34,000 per pond acre x 1.5 acres= $51,000
Bike Bridge	➢ Wildlife ➢ Septic Systems- Tupelo Rd	508.0	102.5	16	4.01E+14	3.21E+14	Installation of a vegetated stormwater pond	80% removal based on existing vegetated pond in Murrells Inlet.	$34,000 per pond acre x 1.5 acres= $51,000

Table L-2 highlights several non-structural and watershed-wide BMPs which are recommended in Murrells Inlet. An exact load reduction estimate is difficult to quantify for many of these BMPs however the anticipated water quality benefits are described in the table.

Table L-2 Non-Structural and Watershed-Wide BMPs Expected Water Quality Benefits and Cost Estimates

BMP	Expected Water Quality Benefits	Cost Estimates/Considerations
Pet Waste Stations	Direct reduction in bacteria loads. Increased public awareness and stewardship. The existing stations have been well utilized and provide an effective strategy to reduce pet waste load reductions.	Typical cost is $150 to $200 to install each station. Georgetown County has six stations in Murrells Inlet. The addition of six stations in Horry County would cost ~$2,000. Bags cost approximately 5 cents each. In 2012, 12,000 bags were used at the six stations in Georgetown County. Annual expected costs to maintain six new stations would be ~$600.
Rain Barrel Installation	Indirect benefits include a reduction in stormwater runoff rates and volumes which is a primary bacteria transport mechanism in the watershed	According to Clemson's Carolina Clear Program, a typical 50-60 gallon residential rain barrel can cost as low as $35-$45 through conservation organization initiatives. With a target goal of installing 100 per year, the annual cost would be $3,500-$4,500. Homemade rain barrels can be constructed for as low as $20 a piece. An individual purchase at a retail home and garden center can exceed $150 per rain barrel.
Tree-Planting	Primary indirect benefit is to help reduce stormwater rates and volumes	In-kind donations. Partner with local non-profit Trees for Tomorrow.
Feral Cat Spay/Neuter Program	Moderate population size of existing feral cat colonies which in the long-term will lead to a direct reduction in bacteria loads.	Pet Smart Charities offers a free-roaming cat spay/neuter grant assistance program with awards up to $200,000 for a two-year initiative.
Dumpster and Trash Can Maintenance Campaign	Discourages wildlife from urban areas within the watershed. It is important not to attract wildlife near shoreline areas to minimize direct bacteria loads in the Inlet.	Can be incorporated into existing water quality awareness efforts.
Shellfish Habitat Restoration Projects	Oysters and other shellfish species have a very important ecological role in estuarine environments. From a water quality perspective, their reefs help stabilize shorelines areas, which reduces erosion. They also help to filter and circulate water.	US Army Corps of Engineers estimates that oyster reef construction costs approximately $10,000 per acre using oyster shell as the base material. Costs are reduced with the use of volunteers to replant oyster shells. Local shellfish recycling efforts may also help to reduce costs.

Inlet Dredging	Improve salt water exchange in areas of Murrells Inlet, which have become silted in over time. An adequate salt water/freshwater balance can help moderate fecal coliform levels.	If Georgetown County upland disposal site is utilized the expected cost of mechanical dredging would be $10-20 per cubic yard.
Revise TMDL	A more accurate TMDL that accounts for the specific load contributions from each of the identified bacteria sources is critical to select appropriate BMPs in the watershed.	Will require dedicated personnel resources from SC DHEC to complete a full TMDL revision.
Inlet Friendly Business Program	Incentive program to encourage local businesses to adopt practices to help protect water quality and raise public awareness.	Modest staff time (~100 hours per year) for sponsoring organization anticipated once program is established.
Sewer District/County Stormwater Coordination	Sharing information among sewer districts and county stormwater departments can help alert one another to problems that may be occurring to efficiently address fecal coliform contributions.	No additional costs expected
Environmental Law Enforcement Coalition	Better coordination among the various management and enforcement agencies can help to prioritize enforcement needs within the watershed, which may change from year to year.	No additional costs expected
Reinstitution of Conditionally Approved Shellfish Classifications	Allows management of shellfish resources based on more recent water quality conditions rather than taking a year to year approach.	Contingent upon sufficient personnel resources in SCDHEC's Shellfish Program
Designate northern portion of Murrells Inlet as a shellfish habitat restoration area	The northern end of Murrells Inlet has chronically high levels of fecal coliform. Restoring and protecting oyster reef habitats will improve water filtration, which in turn is anticipated to reduce fecal coliform levels.	Minimal administrative costs anticipated. Restoration costs will vary from year to year.
Shoreline Buffer Incentive Program	Shoreline buffers can help stabilize shorelines, reduce erosion rates, and remove pollutants prior to discharge into the inlet. Reducing sedimentation will diminish a primary transport mechanism for bacteria.	Minimal administrative costs anticipated. Only additional costs for property owners would be if initial native species plantings were desired.
Establish Estuary Protection Overlay Zoning District	Would establish requirements and incentives to incorporate stormwater management BMPs in the site design for new development and retrofit projects. Could significantly mitigate hydrological changes often associated with urban development by reducing erosion and promoting stormwater retention, infiltration, and rain harvesting. `	County stormwater and planning department staff time to develop ordinance language.

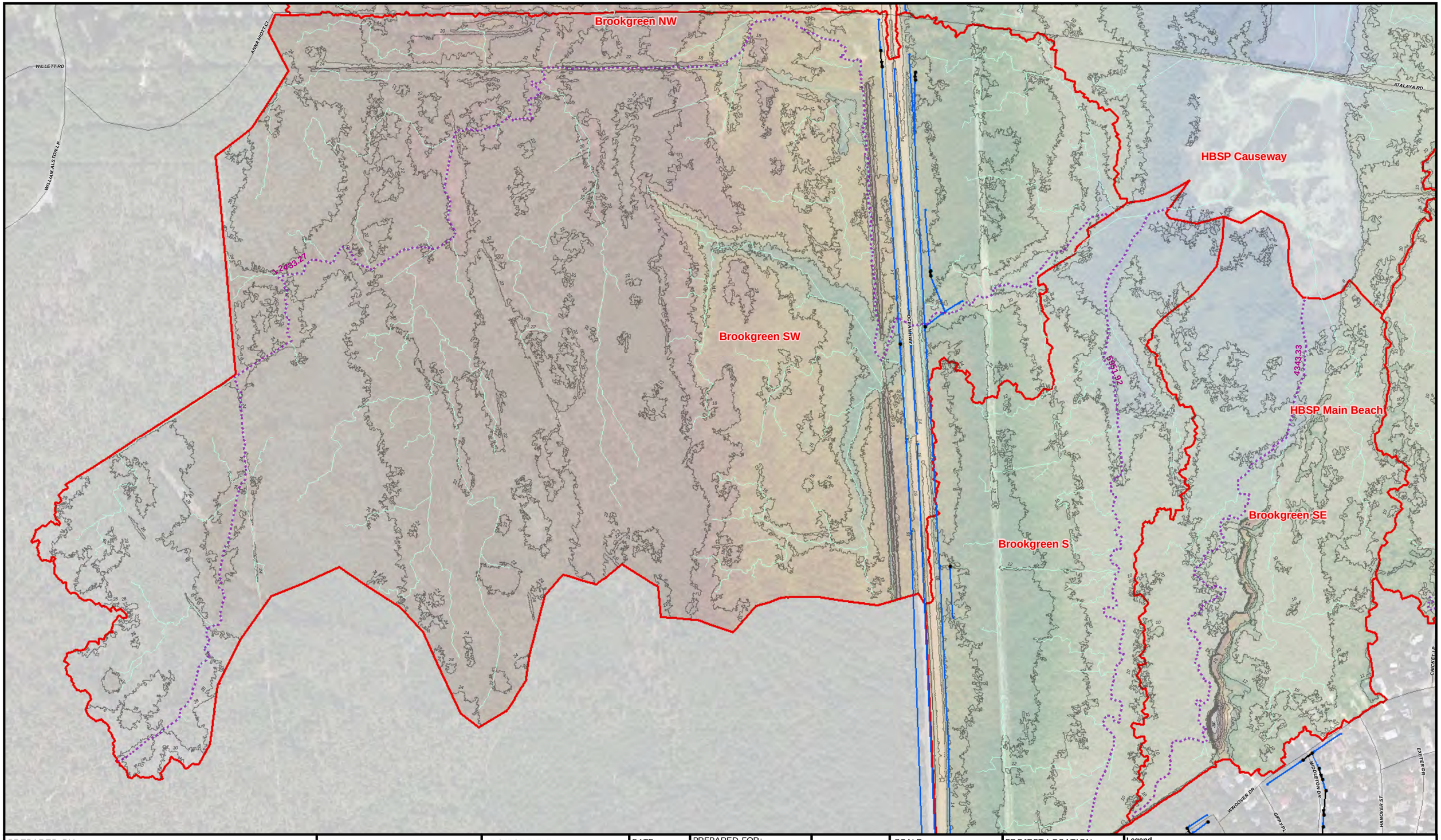
Table L-3 provides a snapshot of the anticipated implementation timeframe for each of the recommended structural and Non-structural BMPs. Notes are provided to outline any additional considerations that may influence the expected timeframe.

Table L-3 Best Management Practices- Implementation Schedule						
BMP	**Location/Target Audience**	**Within Two Years**	**3-5 Years**	**5-10 Years**	**10+ Years**	**Notes**
Structural BMPs						
Floating Wetlands	**Melody Subwatershed**- Tupelo Bay, Melody Gardens, Bermuda Bay, and Oceanside Village. Also at the Woodland Drive Pond	Select and install at pilot site ✓			Complete installation and evaluate need at other sites. ✓	Initially install at one location as a demonstration site before widespread application across the watershed.
	Pine Subwatershed- Pirate Cove Pond.					
	Salters Cove Subwatershed- Salters Cove Pond					
	Point Dr. Subwatershed- Point Drive Canal					
	Rum Gully Subwatershed- Rum Gully neighborhood ponds.					
Catch Basin Inserts	**Melody Subwatershed**- Tupelo Bay, Bermuda Bay, and Melody Gardens neighborhoods		✓			Additional locations should be evaluated periodically.
	Point Drive Subwatershed- Wal-Mart parking lot					
	Sunnyside Subwatershed- Sea Marsh Road					
	Garden City Pier N Subwatershed- install along Dogwood/Atlantic (inlet protection)					
Bacteria Media Filter Strips	**Melody Subwatershed**- roadside ditches along Woodland, Calhoun, Vista, and Seabreeze	Select and install at pilot site ✓			Complete installation and evaluate need at other sites. ✓	Initially install at one location as a demonstration site before widespread application across the watershed.
	Pine Subwatershed- roadside ditches along Cypress, Pine, Oak, and Atlantic					
	Salters Subwatershed- roadside ditches in Salters Cove neighborhood					
	Point Drive Subwatershed- roadside ditches along Walmart, Jamestown, and Jensens					
	Dogwood N Subwatershed- roadside ditches along Dogwood.					
Drainage Ditch Modification	**Sunnyside Subwatershed**- Introduce series of small weir steps along Van Buren rd.		✓			Ditch within Mariner/Wesley drains through private property, which may extend implementation timeframe. Conservation easement incentives should be considered.
	Mariner/Wesley Subwatershed- Expose existing stream and ditches to sunlight and at small natural steps to promote retention as land allows.					
Constructed Wetland/Vegetated Pond	**Bike Bridge Subwatershed**- On Murrells Inlet 2020 property		✓			Proposed site in the Vaux Hall subwatershed is located on private property, which may extend implementation timeframe. Conservation easement incentives should be considered.
	Vaux Hall Subwatershed					
Parking Lot Bioretention	**Pine Subwatershed**- Murphy's Law Shopping Center			✓		
	Point Dr. Subwatershed- Krogers Shopping Center					
Watershed Wide BMPs						
Pet Waste Stations	Currently, there are six pet waste stations maintained in Georgetown County. Prioritize new installations in Horry County.	✓				Evaluate the need for new stations every 2-3 years.
Rain Barrel Installation	Businesses, public buildings, and homeowners	✓				This should be an ongoing effort. Target goal of 100 new installations per year.
Tree Planting	Shorelines, parking areas, street corridors, and interested residents and Homeowners Associations	✓				This should be an ongoing effort. Target goal of 1,000 new tree plantings per year. Local non-profit Trees for Tomorrow planted 2,400 trees in their first year as an organization.
Feral Cat Spay/Neuter Program	Focus on areas with known colonies with property owner permission		✓			Grant opportunities are available through Pet Smart Charities.
Dumpster and Trash Can Maintenance Campaign	Particularly important near waterfront areas.	✓				Particular emphasis should be made to empty trash cans daily during peak summer season.

Shellfish Habitat Restoration Projects	Identify priority locations in a 5 year strategic plan	✓				Organize at least one restoration project with the assistance of volunteer groups on an annual basis.
Inlet Dredging	Sedimentation has restricted navigation and affected tidal flow exchange in several portions of Murrells Inlet				✓	
Non- Structural/Administrative BMPS						
Revise Murrells Inlet TMDL			✓			Critical task needed to implement effective structural BMPs based on an accurate load reduction estimate by bacteria source.
Inlet-Friendly Business Program			✓			Refer to the City of Conway as a good example nearby.
Sewer District/ County Stormwater Department Coordination	Any pertinent information about locations of major infrastructure improvement or sanitary sewer overflow incidents.	✓				Coordination should be ongoing. Relevant data or information collected by the respective stormwater departments should be reciprocated and passed on to the sewer districts as well.
Organize an Environmental Law Enforcement Coalition			✓			This coalition should consist of relevant local, state, and federal agencies including but not limited to the US Coast Guard, SC DHEC, SC DNR, Huntington Beach State Park, Horry and Georgetown Counties.
Reinstitute Conditionally Approved Shellfish Classifications in Murrells Inlet	Principally in the southern end near the freshwater impoundment at Huntington Beach State Park			✓		State-level funding and personnel resources is the biggest obstacle preventing sooner implementation.
Designate northern portion of Murrells Inlet as shellfish habitat restoration area				✓		The concept behind this proposal is to restore the natural functions and ecological services of oyster reef and marsh habitats in this portion of Murrells Inlet. The reefs would provide filtration and water circulation which would help improve water quality conditions. Harvesting would remain restricted to protect public health.
Shoreline Buffer Incentive Program	Mostly applies to properties along the Murrells Inlet waterfront but should also be promoted for properties adjacent to stormwater ponds, canals, and creeks.			✓		
Establish Estuary Protection Overlay Zoning District	An inherent challenge is the multijurisdictional nature of the Murrells Inlet watershed, requiring mutual agreement and coordination in order to implement watershed-wide.			✓		The provisions included in the zoning overlay district would be tailored to enhance water quality protection in Murrells Inlet. Focus areas could include the incorporation of pervious surfaces, utilization of rain harvesting devices, shoreline buffer establishment and/or appropriate landscaping designs.

Appendices

APPENDIX A: Murrells Inlet Subwatershed Maps



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MAP TITLE:
MURRELLS INLET WATERSHED BASED PLAN - SUBWATERSHEDS

FIGURE

PROJECT TITLE:
MURRELLS INLET
WATERSHED BASED PLAN

DATE:
09/01/2013

TEG PN:
121108.000:E

AUTHOR:
SWILLIAMS

PREPARED FOR:
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P.O. Box 1357
Murrells Inlet, SC 29576

SCALE:
1:6,000
0 250 500
FEET

PROJECT LOCATION:
MURRELLS INLET
GEORGETOWN COUNTY
SOUTH CAROLINA

Legend

Volunteer Monitoring
Elevated Fecal
- No
- Yes

SCDHEC Monitoring
- No Determination
- Declined
- Improved
- No Change
- Sub Watersheds
- Approx. Hydrology
- Time of Conc. Flow Path
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- Catch Basin
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- Emergency Overflow
- Discharge Point
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- Pump Stations
- Road Centerlines
- 2ft Contours

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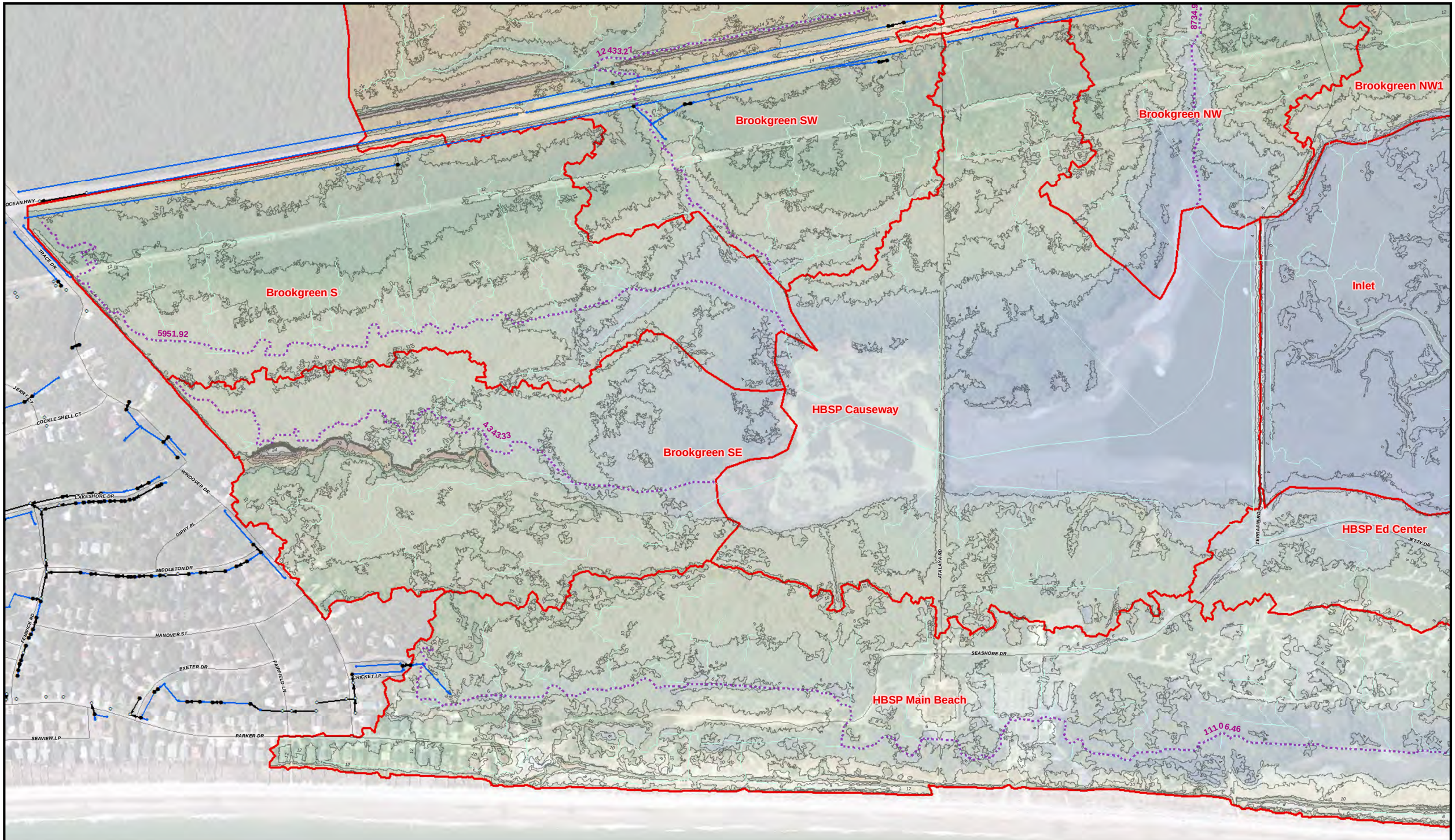

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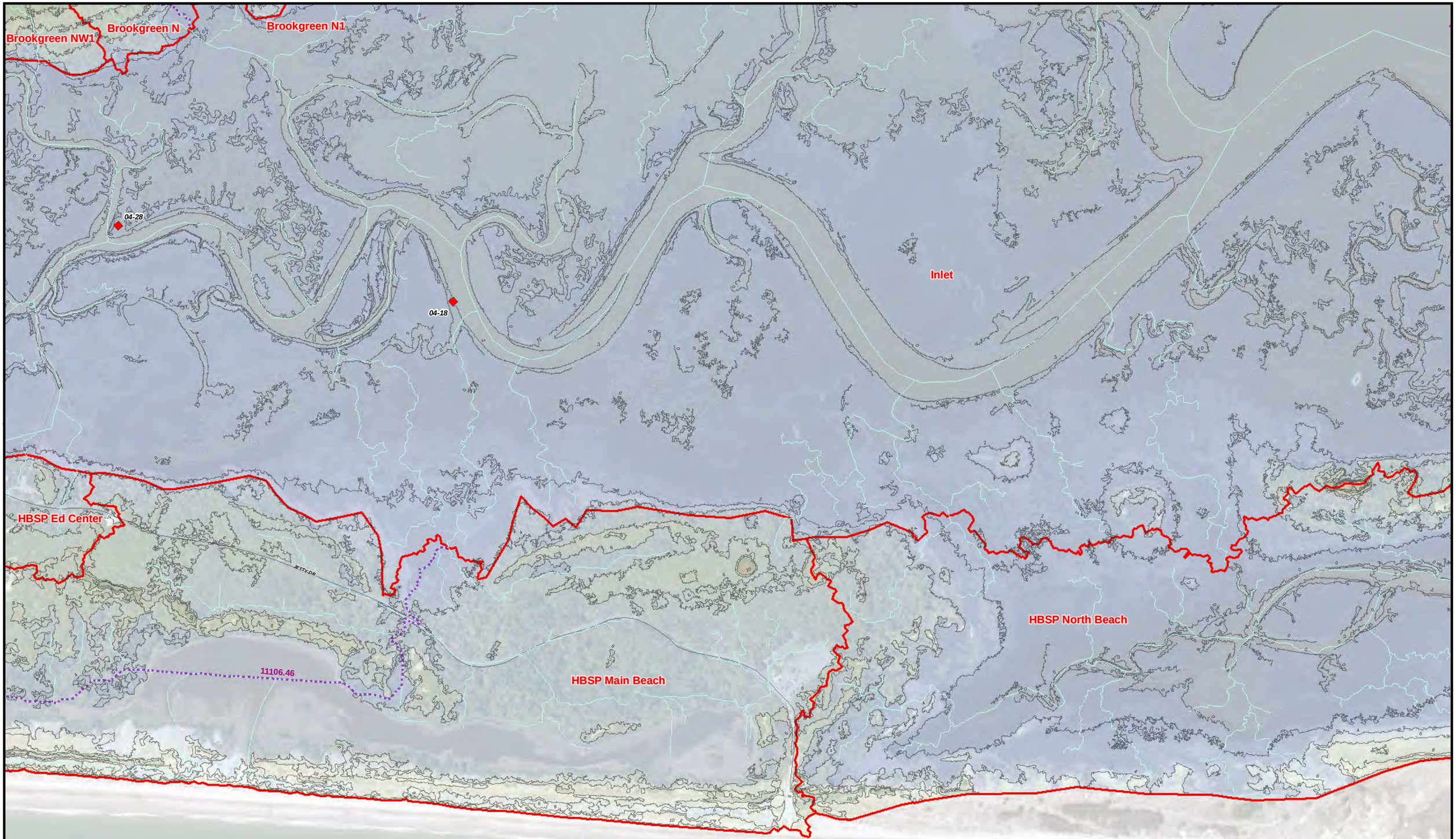

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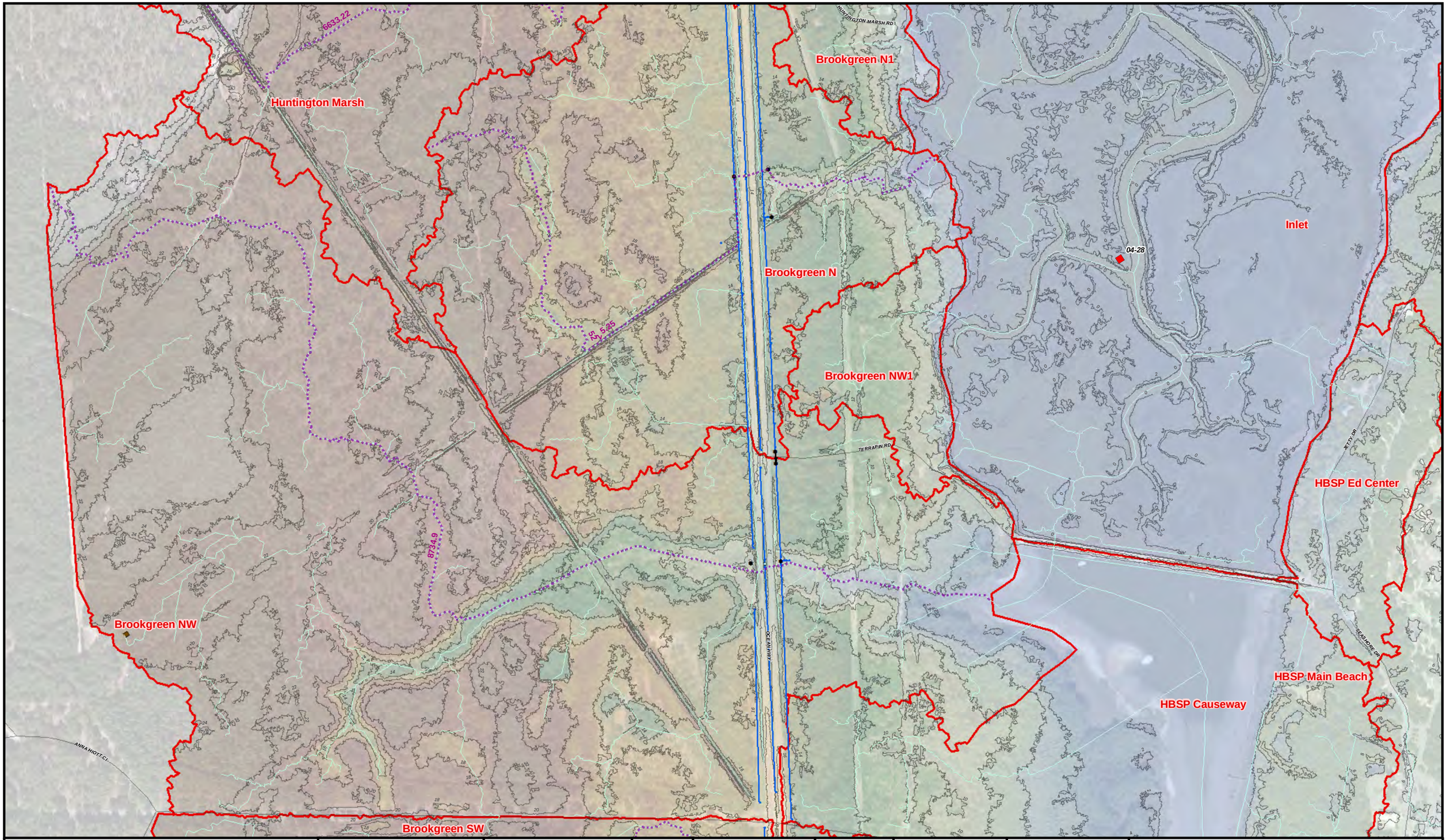

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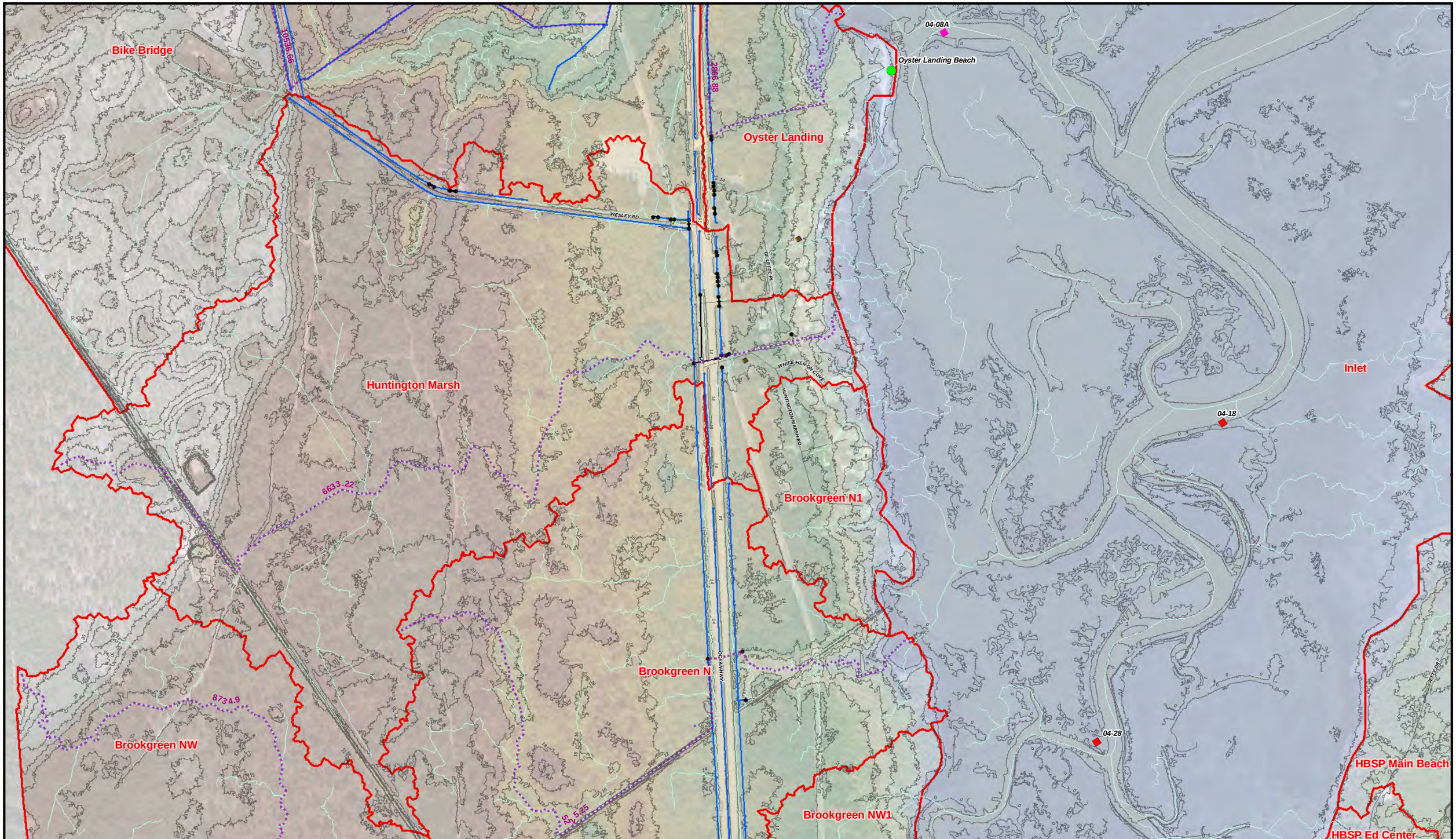

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SCDHEC Monitoring
- No Determination
- Declined
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- No Change
- Sub Watersheds
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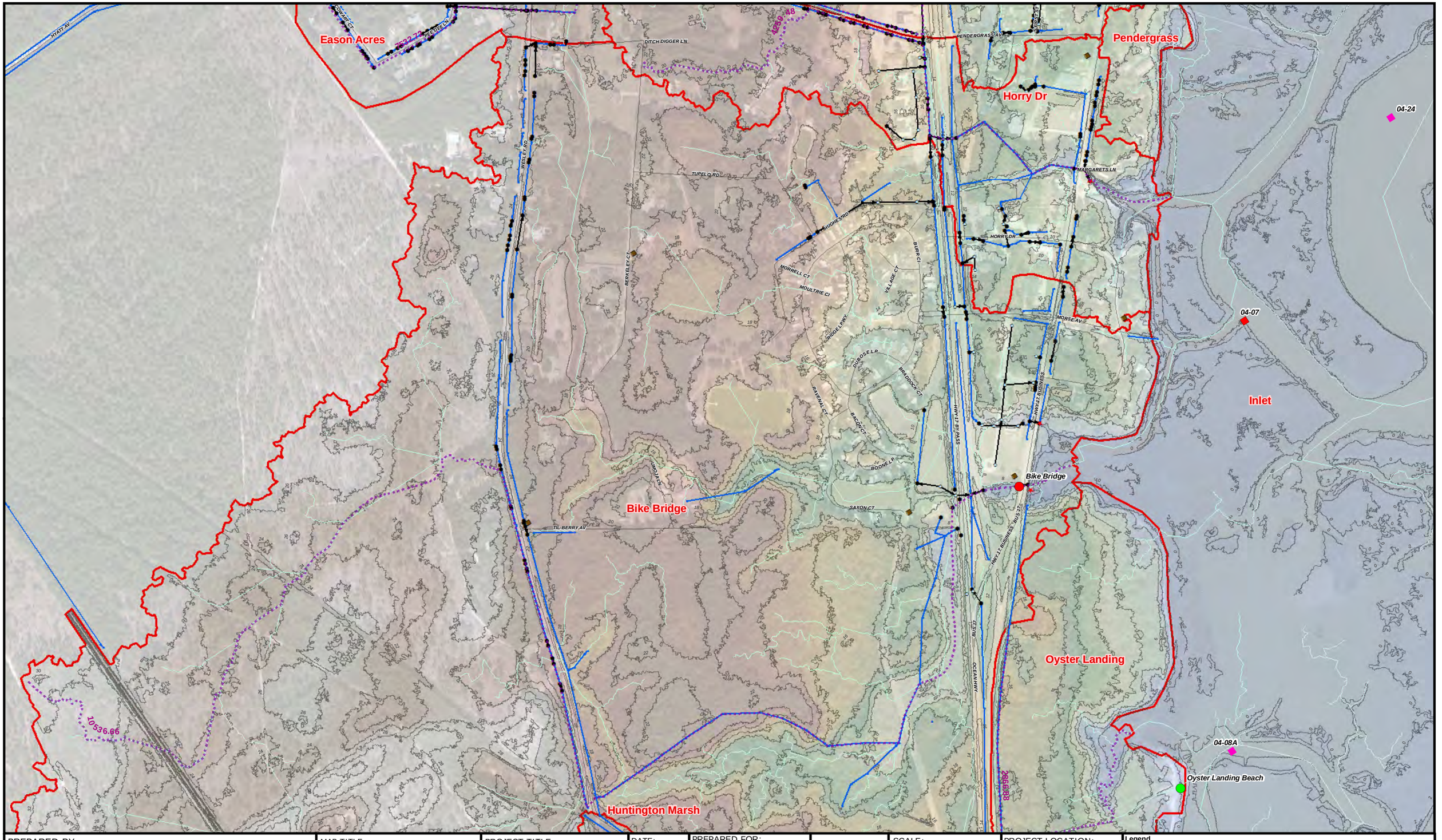
Low : -4.52



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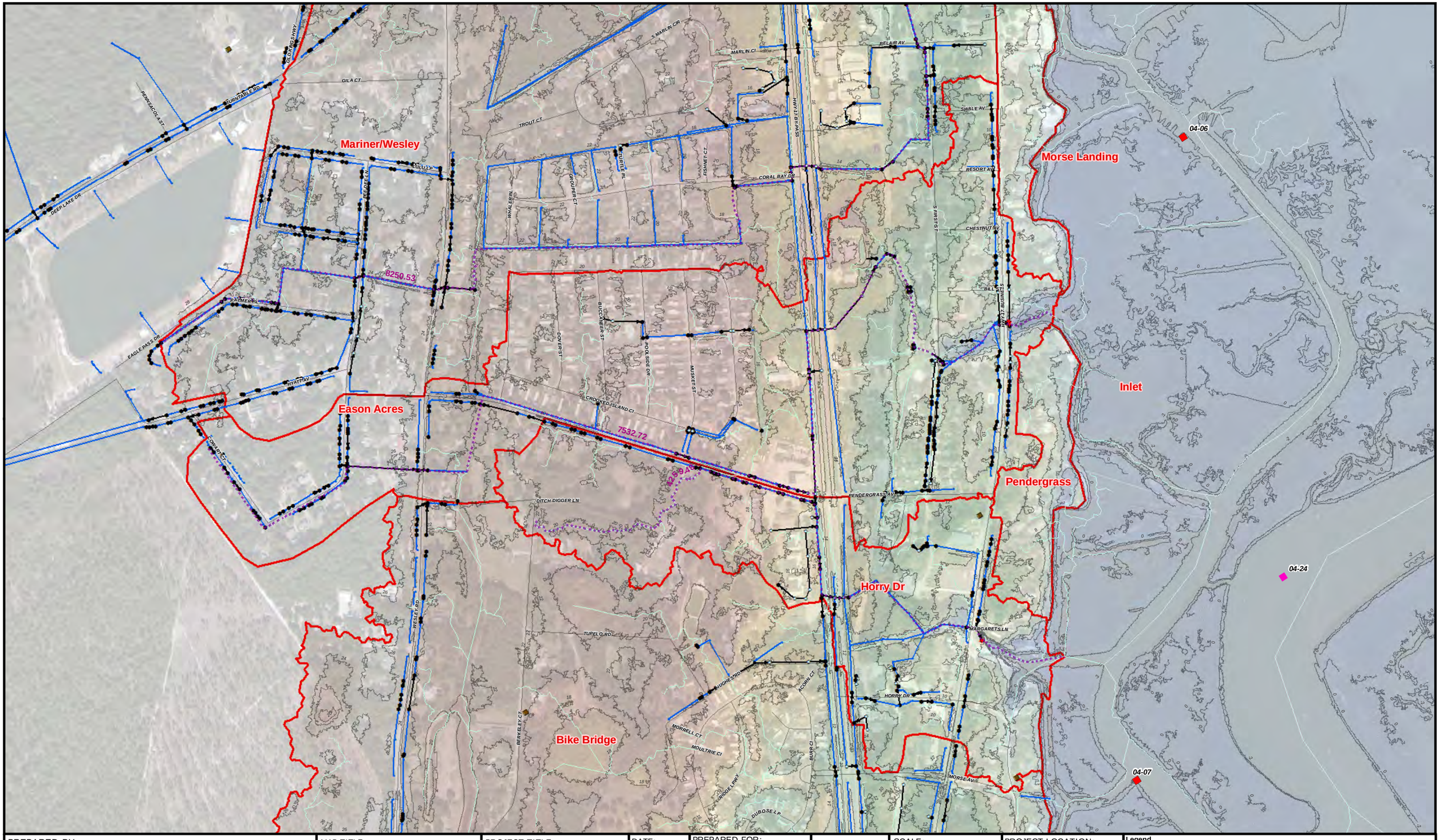

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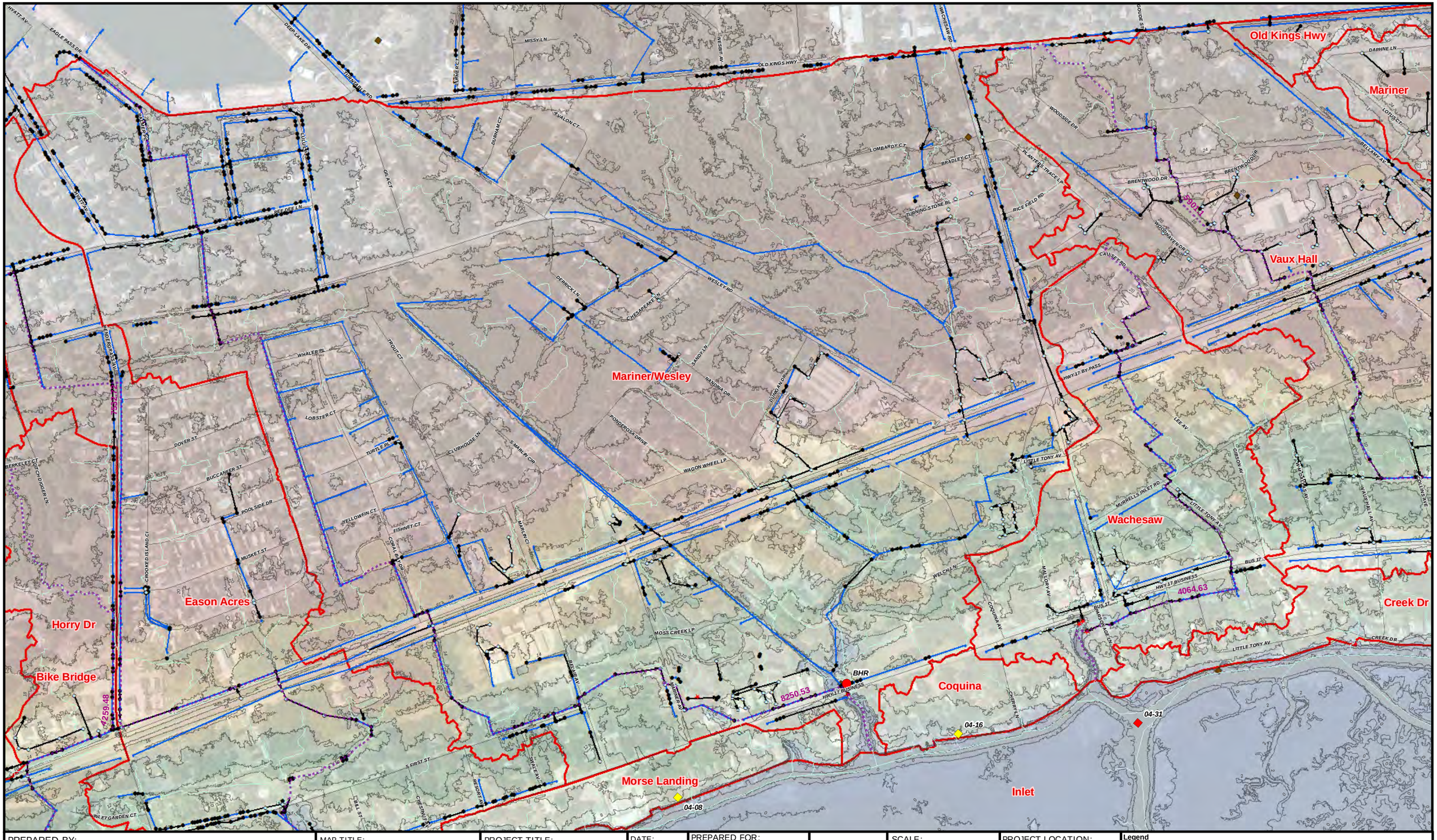

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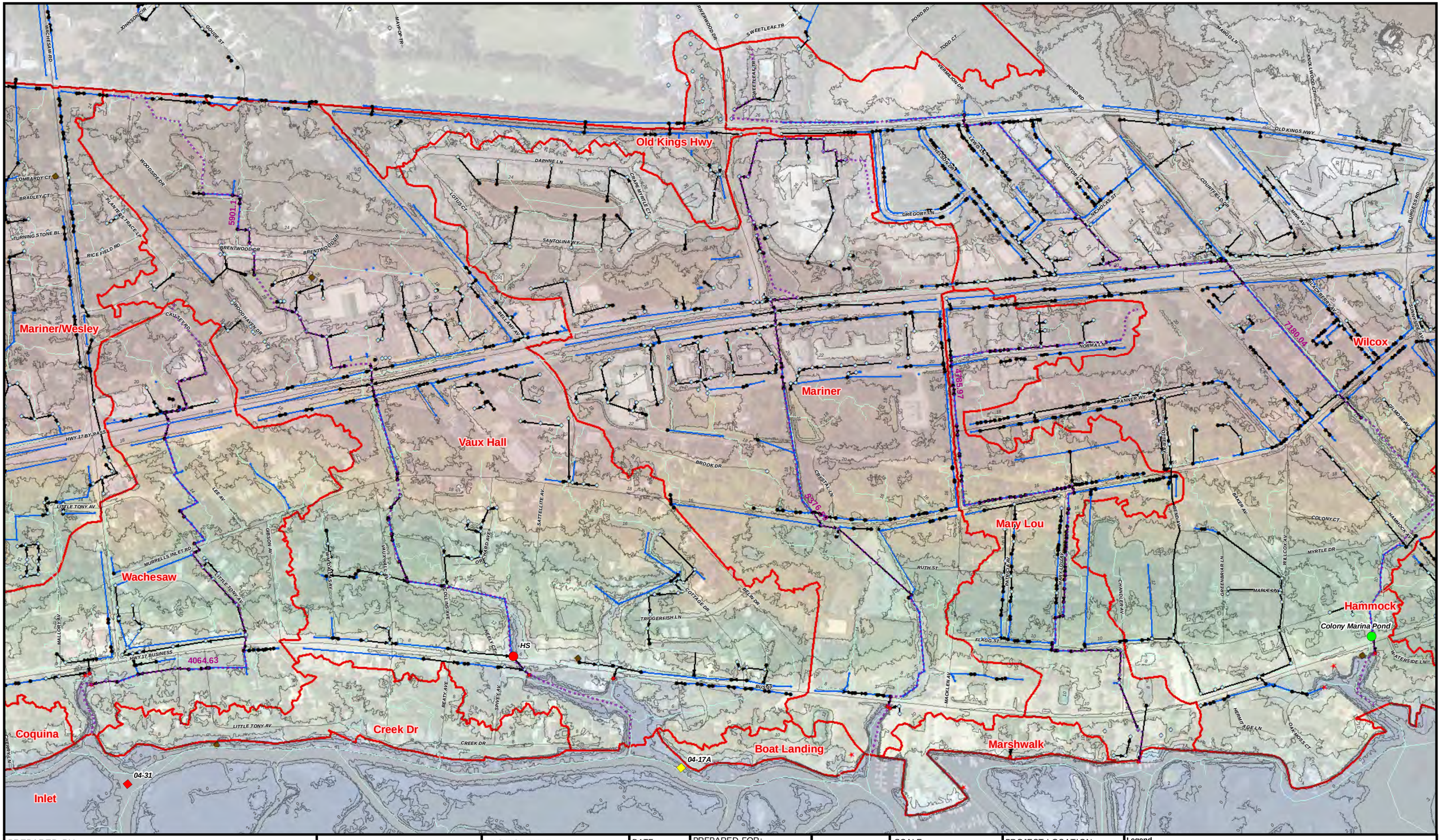

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Rumgully
Jordan Landing
Sunnyside N
Wilcox
Hammock1
Hammock2
Mary Lou
Mariner
Old Kings Hwy
Inlet
Colony Marina Pond
5483.09
2054.29
2444.07
7180.04
4785.97
5376.59
04-25
04-02

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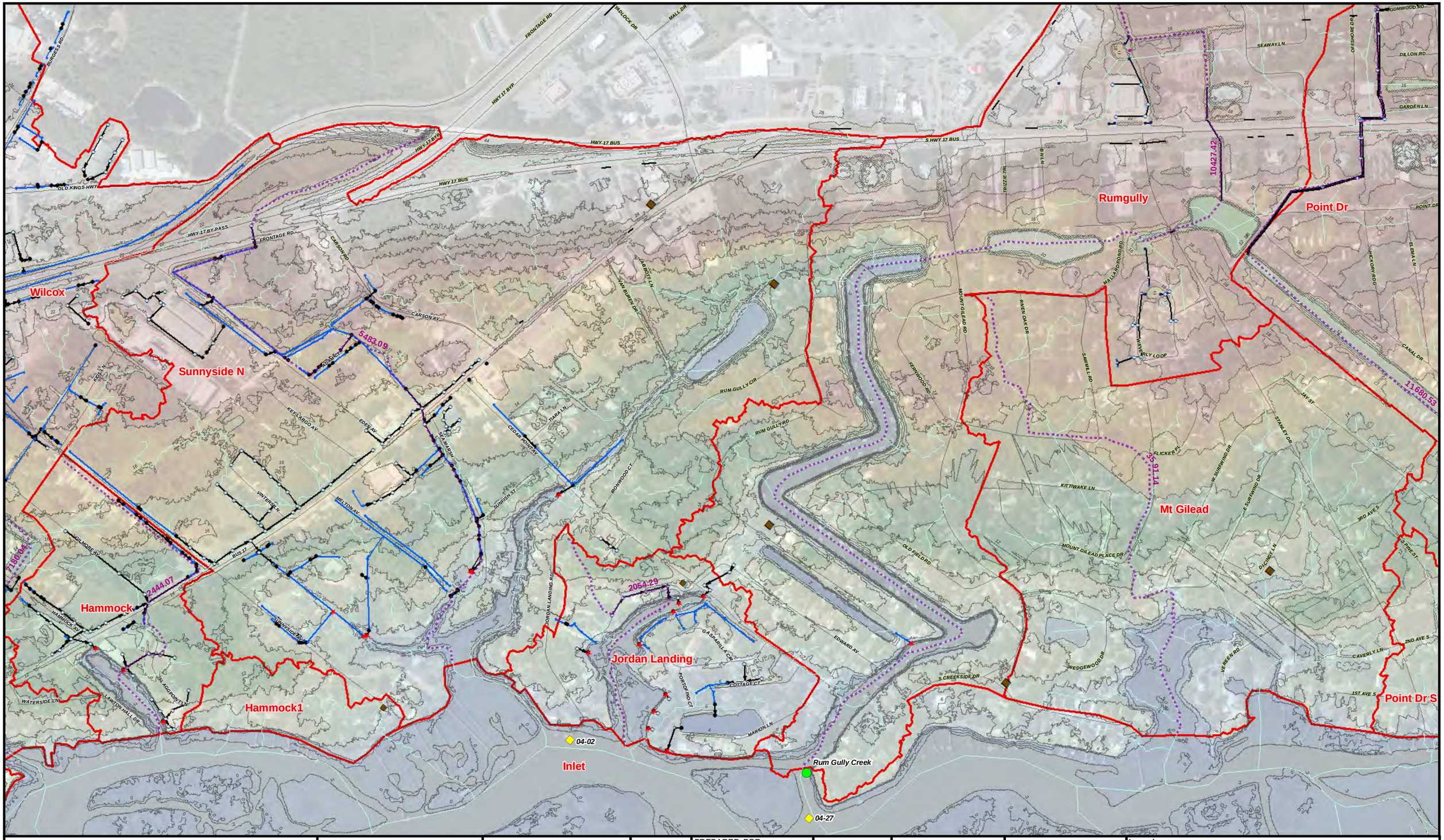

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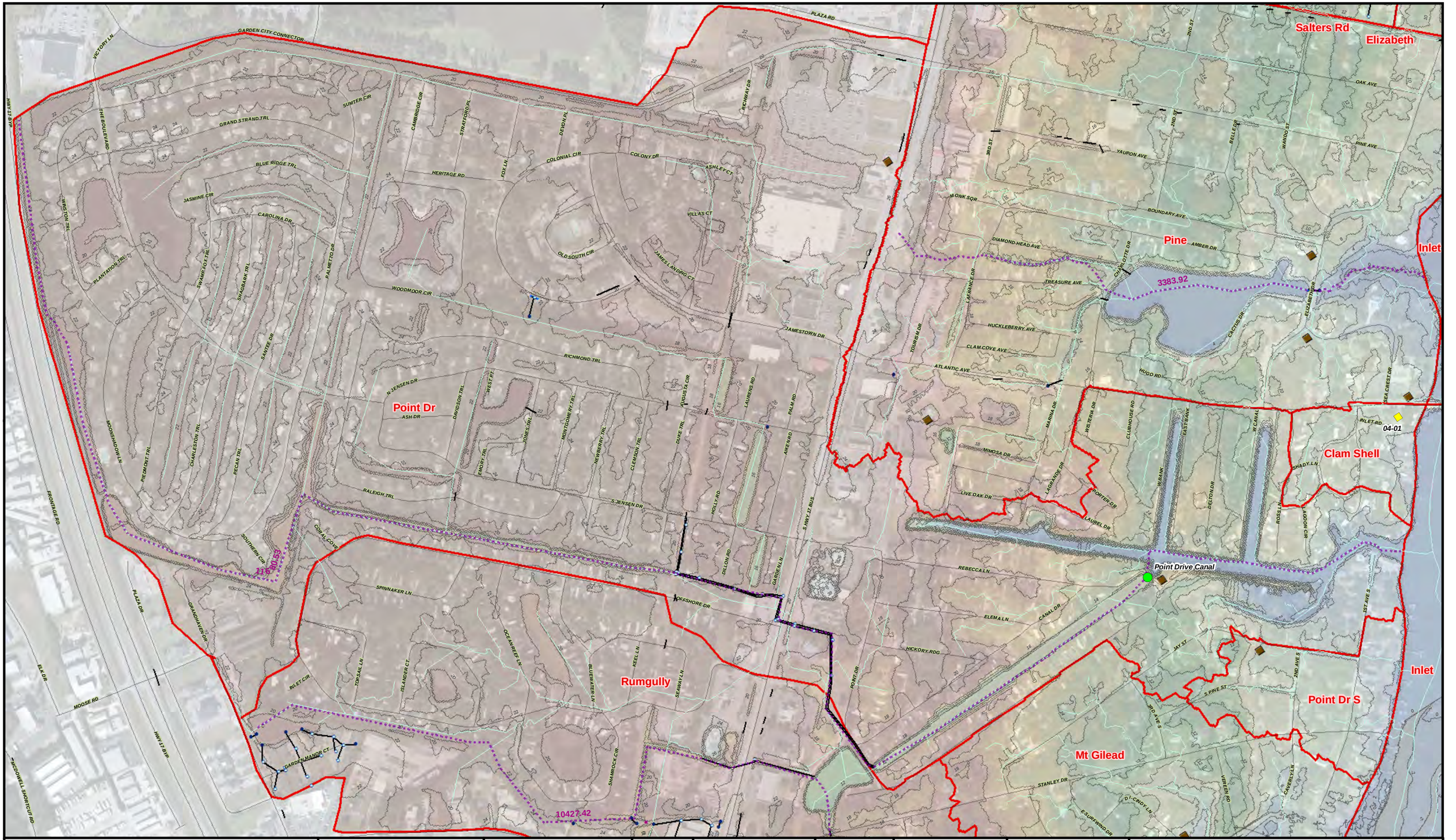

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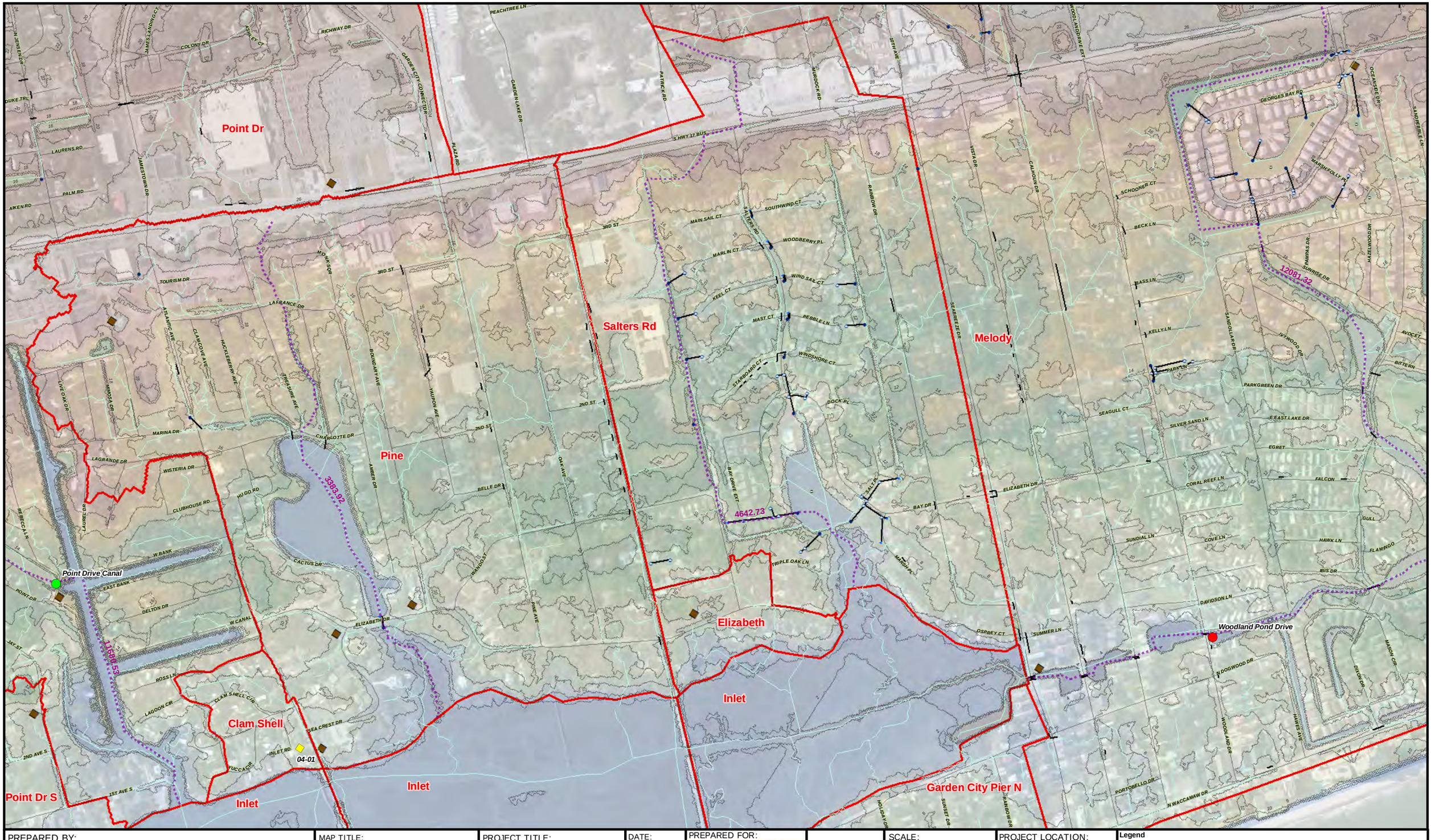

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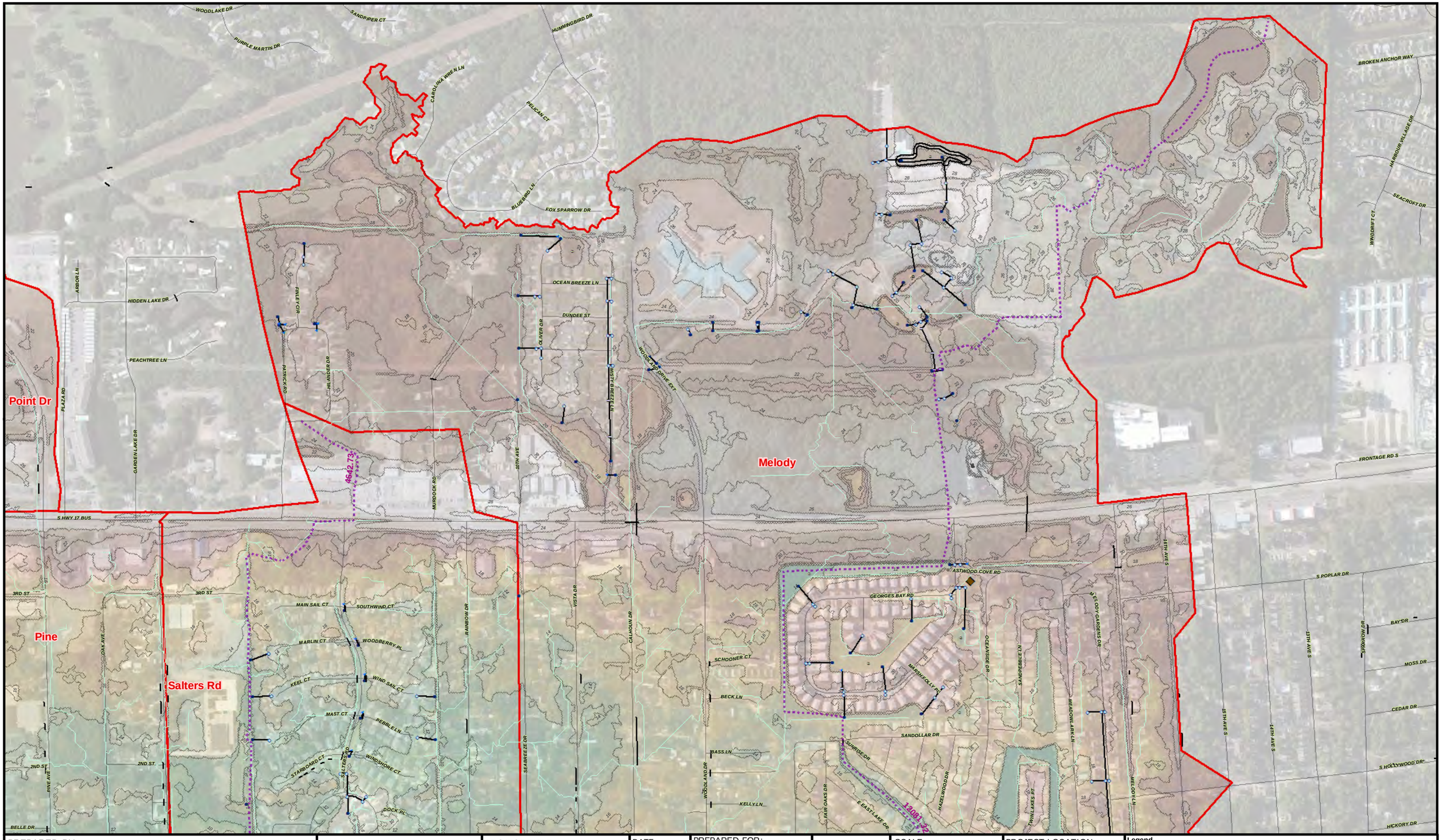

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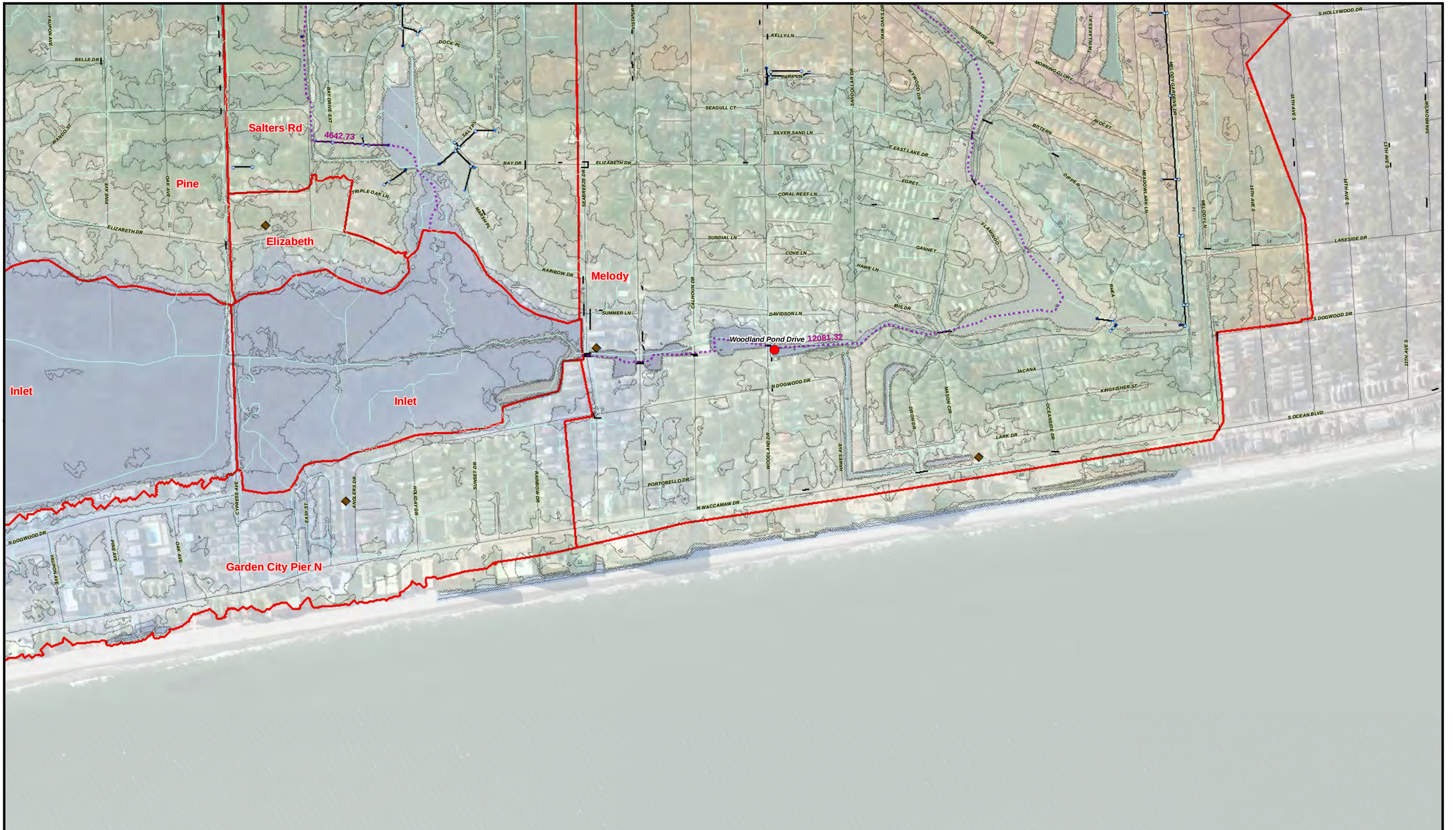

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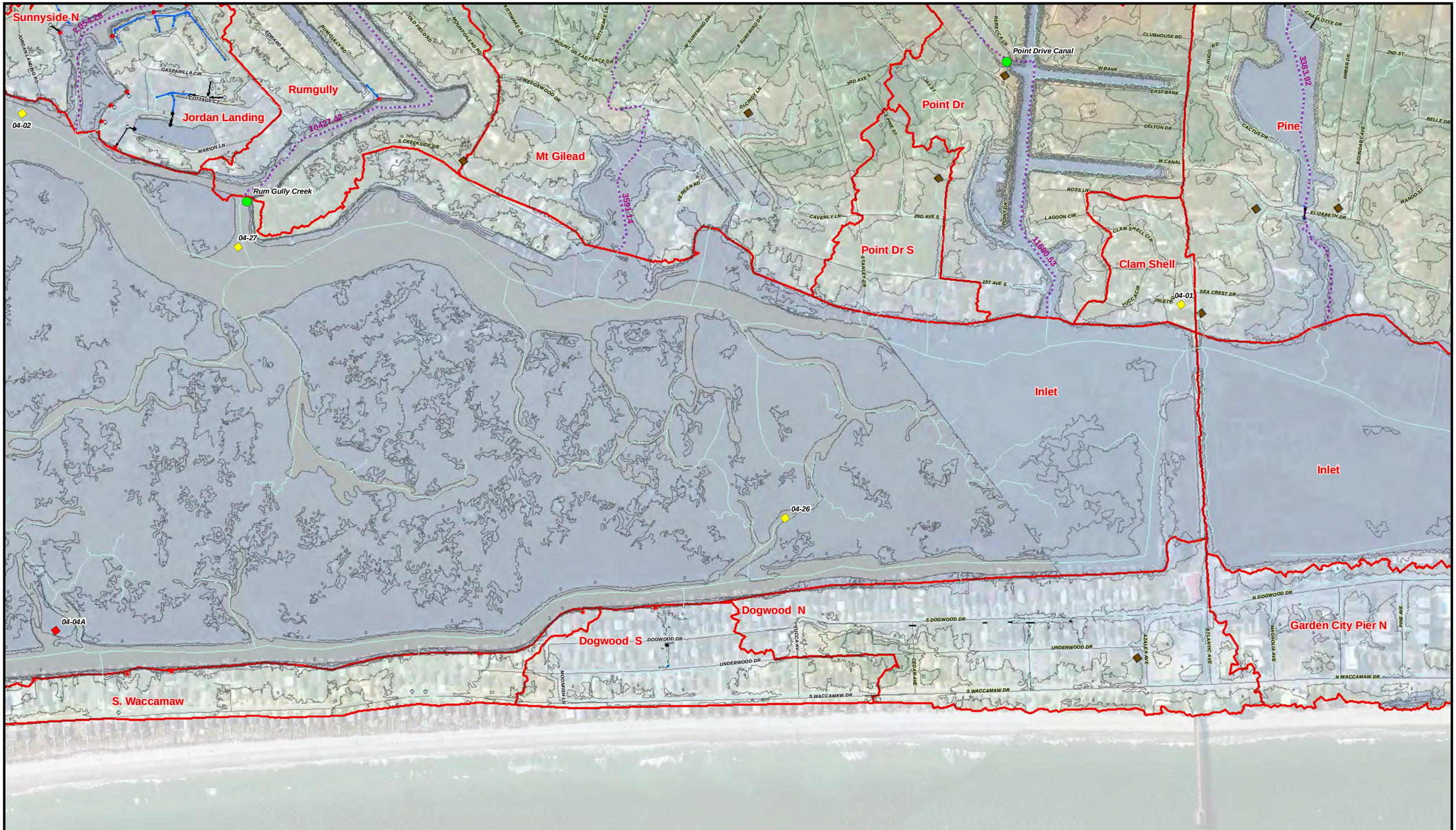

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APPENDIX B: State Water Classifications and Standards

Below is the definition of Shellfish Harvesting Waters as written in State Regulation 61-68. Water Classifications and Standards. An outline of the standards for each regulated water quality parameter is also included.

Shellfish Harvesting Waters *are tidal saltwaters protected for shellfish harvested and uses listed in Class SA and Class SB. Suitable for primary and secondary contact recreation, crabbing, and fishing. Also suitable for the survival and propagation of a balanced indigenous aquatic community of marine fauna and flora.*

Quality Standards for Shellfish Harvesting Waters, South Carolina Regulation 61-68	
Items	**Standards**
A. Garbage, cinders, ashes, oils, sludge, or other refuse	*None Allowed*
B. Treated wastes, toxic wastes, deleterious substances, colored or other wastes except in A. above.	*None allowed or in combination with other substances or wastes in sufficient amounts to adversely affect the taste, color, odor, or sanitary condition of clams, mussels, or oysters for human consumption; or to impair the waters for any best usage as determined for the specific waters which are assigned to this class.*
C. Toxic pollutants listed in the appendix of State Regulation 61-68	*As prescribed in Section E of Regulation 61-68*
D. Stormwater, and other nonpoint source runoff, including that from agricultural uses, or permitted discharge from aquatic farms, and concentrated aquatic animal production facilities.	*Allowed if water quality necessary for existing and classified uses shall be maintained and protected consistent with antidegradation rules*
E. Dissolved Oxygen	*Daily average not less than 5.0 mg/l with a low of 4.0 mg/l*
F. Fecal Coliform	*Not to exceed an MPN fecal coliform geometric mean of 14/100 ml; nor shall the samples exceed an MPN of 43/100ml*
G. Enterococci	*Not to exceed a geometric mean of 35/100 ml based on at least four samples collected from a given sampling site over a 30 day period; nor shall a single sample maximum*

	exceed 104/100ml. Additionally, for beach monitoring and notification activities for CWA Section 406 only, samples shall not exceed a single sample maxiumum of 104/100ml
H. pH	*Shall not vary more than 3/10 of a pH unit above or below that of effluent-free waters in the same geological area having a similar total alkalinity and temperature, but not lower than 6.5 or above 8.5*
I. Temperature	*As prescribed in Section E. 12 of Regulation 61-68*
J. Turbidity	*Not to exceed 25 (NTUs) provided existing uses are maintained*
SC DHEC may designate prohibited areas where shellfish harvesting for market purposes or human consumption shall not be allowed, consistent with the antidegradation rule, Section D.1.a of Regulation 61-68.	

APPENDIX C: Location Descriptions of the 2013 Shellfish Harvesting Area Classifications

The following is a list of the current classifications as of the 2012 Shellfish Management Area 04 Annual Update, which incorporates monitoring data collected between January 1st, 2010 and December 31st, 2012.

Prohibited:

1. Those waters within approximately 1000 feet of Captain Dick's/Voyager View (closed) Marinas;
2. Those waters within approximately 1000 feet of the docking facilities at Bovines and Snug Harbor;
3. Those waters within approximately 1000 feet of Marina Colony;
4. Those waters within approximately 1000 feet of the Marlin Quay Marina.

Conditionally Approved:

Currently, SC DHEC does not manage any of the Shellfish Harvesting Areas within the Murrells Inlet estuary as Conditionally Approved.

Restricted:

1. Garden City Canal in its entirety south from station 04-04A to the marina closure zone at Marlin Quay Marina;
2. All portions of Main Creek and the adjacent creeks and flats south-west of station 04-25 to the mainland through the high marsh along Flagg Creek to the Prohibited closure boundary east of Marina Colony;
3. All waters of Parsonage Creek extraneous of marina closure zones;
4. All small feeder creeks and marsh adjacent to the mainland and Allston Creek extending from the northern end of Allston Creek to a point 200 meters south of Hughes Landing;
5. Allston Creek in its entirety, from Parsonage Creek canal to Oaks Creek (near Station 04-24). Where not included in a previous description, this will also include all tributary creek mouths and marshlands within approximately 75 feet of Allston Creek;
6. Portions of marshlands and flats adjacent to and northwest of Allston Creek (near Station 04-07); and
7. Those waters southwest of an imaginary line extending from Huntington Beach to intersect with the south-west boundary line of State Shellfish Grounds S354 and continuing to the mainland including Public Shellfish Grounds R351.

Approved:

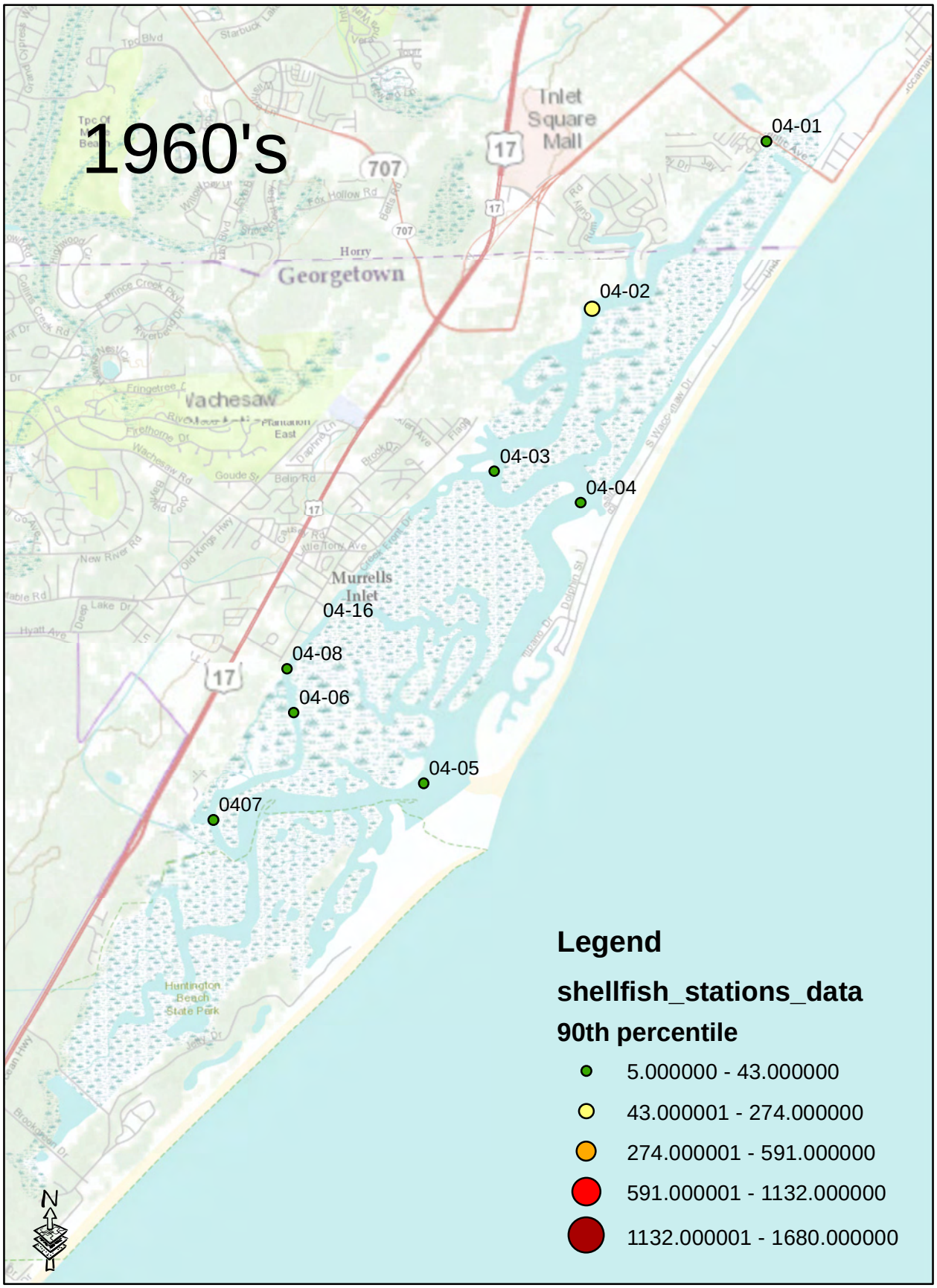
1. Those portions of the Main Creek, including Oyster Cove, extending from the Murrells Inlet Jetty to Station 04-03A;

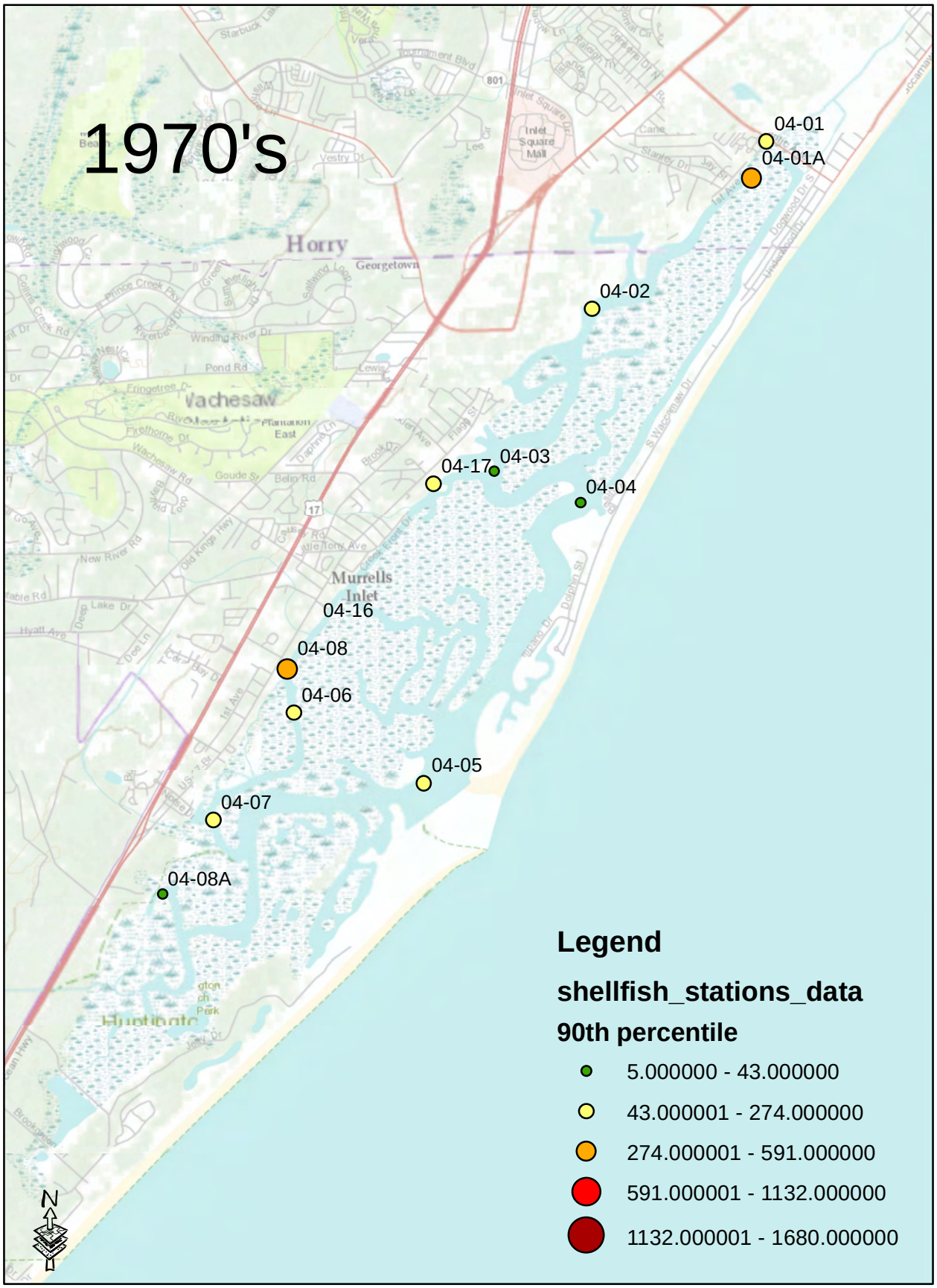
2. Culture Permit Area 356;
3. Those portions of Oaks Creek and areas adjacent to Drunken Jack Island from the Murrells Inlet jetty and southern portions of the estuary including Culture Permit C352 and Public Shellfish Ground S354 and R355;
4. All portions of the central part of the Murrells Inlet estuary excluding any portions of Parsonage Creek, Allston Creek and any portion of Captain Dick's-Voyager View Marina closure zone;
5. C370 and portions of C371 east of the Main Creek excluding the Marina Colony closure zone.

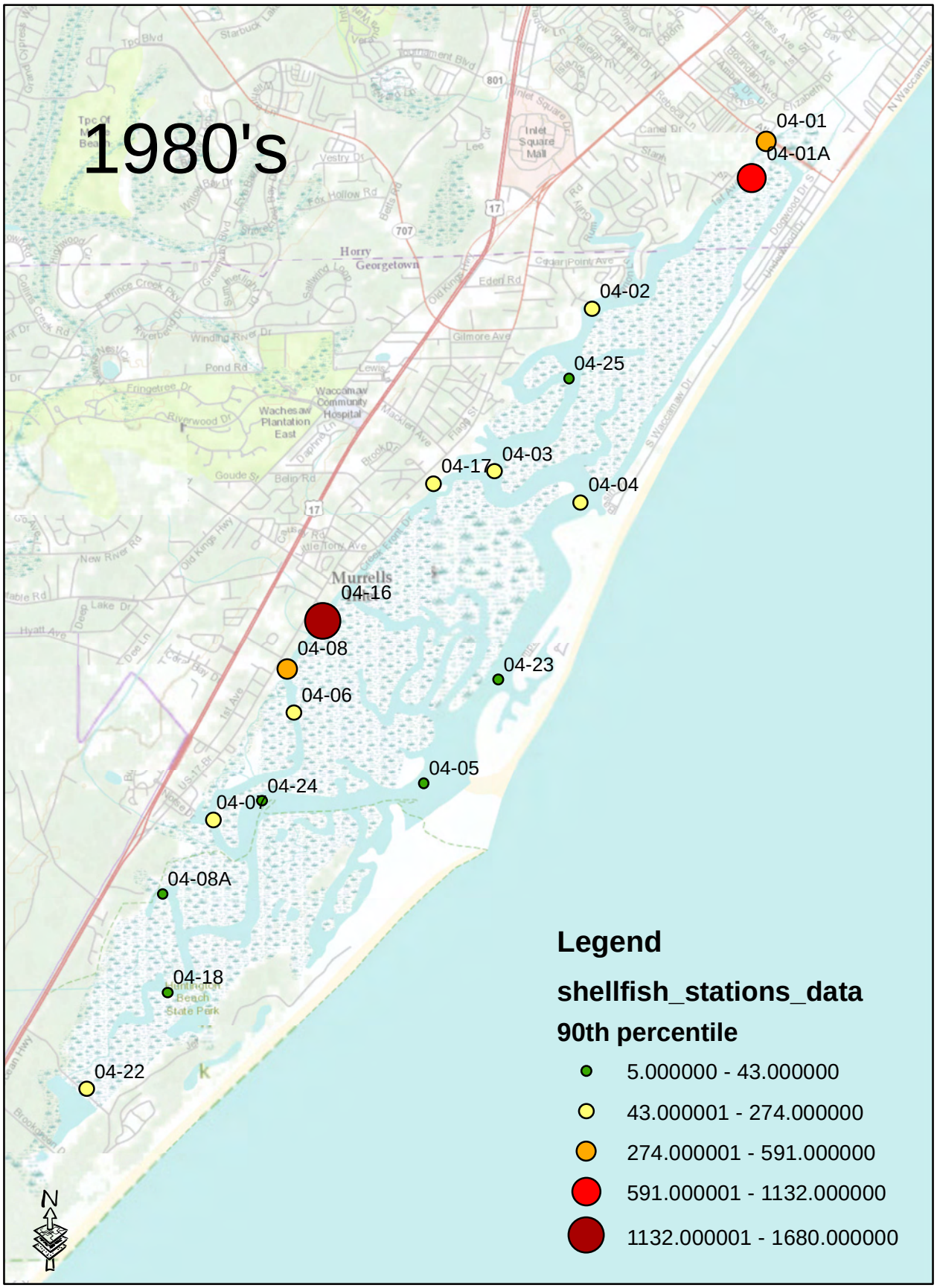
APPENDIX D: Fecal Coliform Data Graphs and Tables

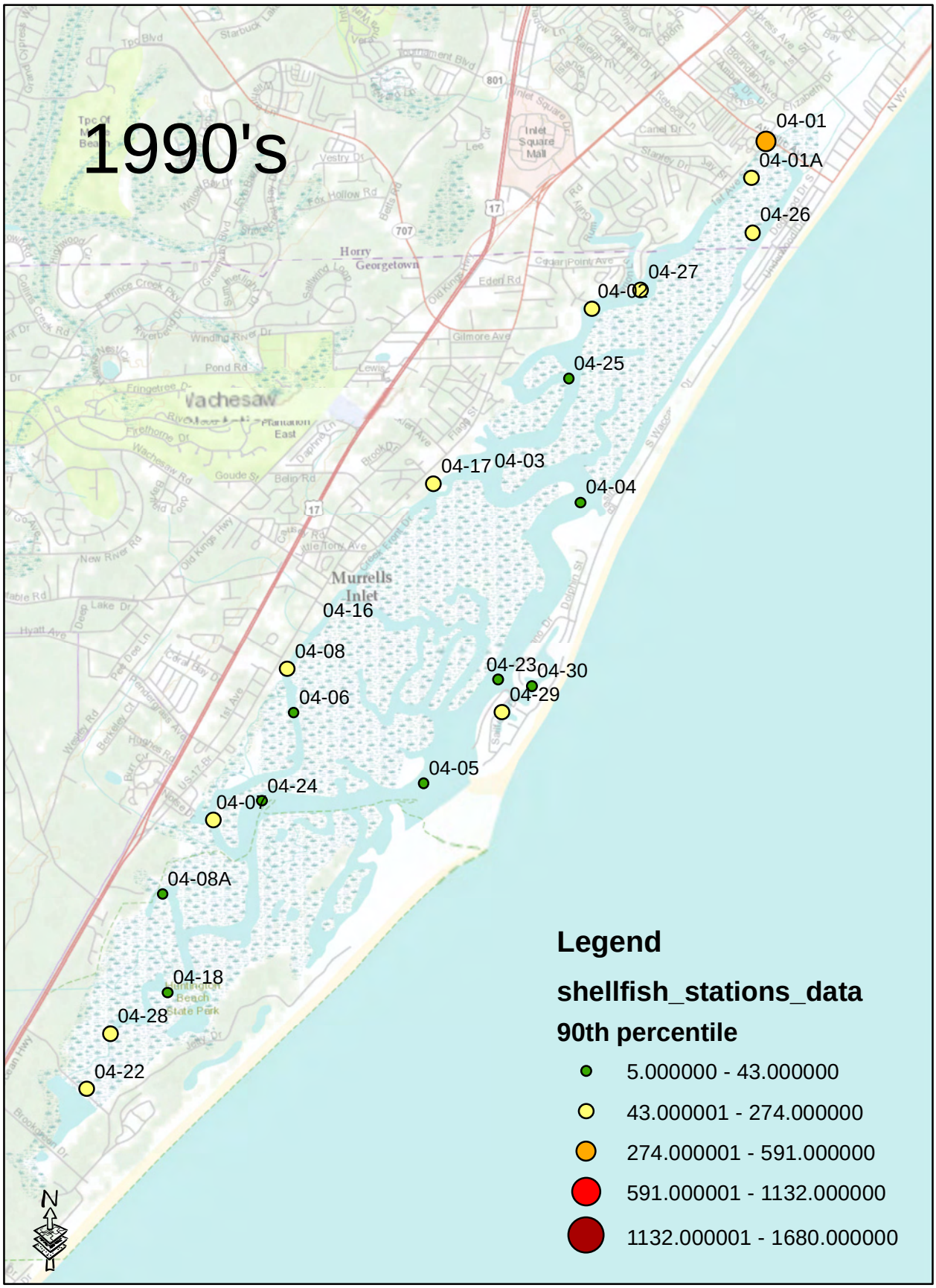
Below is a series of maps that displays the fecal coliform trends for each SC DHEC monitoring station by decade since the program was instituted in the 1960s. The series of maps shows that additional monitoring sites were added periodically since the establishment of the monitoring program. As an example, site 04-01 has been monitored since the 1960s, meanwhile samples were not collected at monitoring site 04-26 until the 1990s.

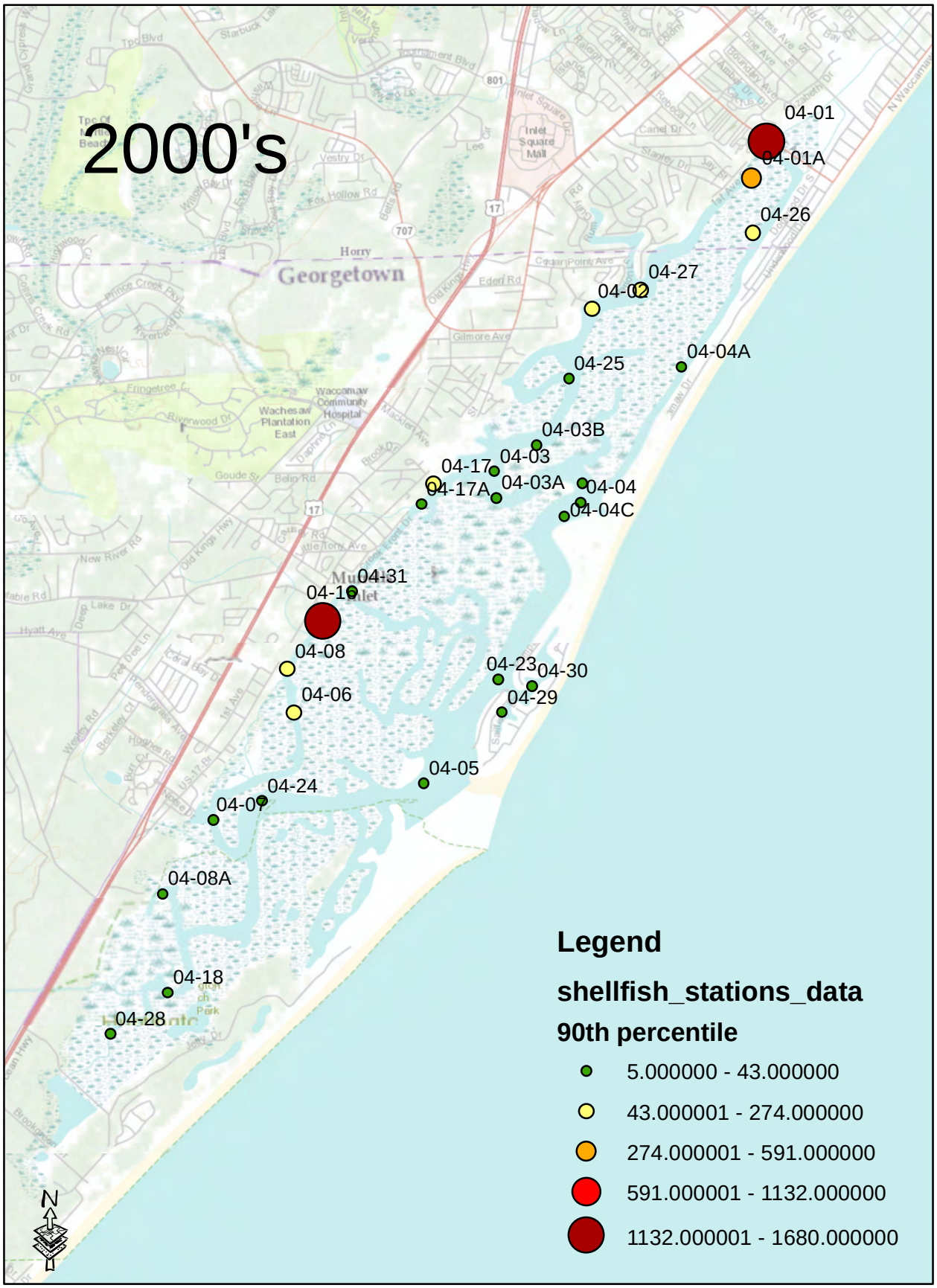
This Appendix also includes graphs showing the fecal coliform trends over time at each monitoring station. Appendix Table D-1 provides a summary of statistical trends in wet and dry weather conditions for each monitoring site. In addition a graph illustrating relative fecal coliform contributions from various animal species is also provided.

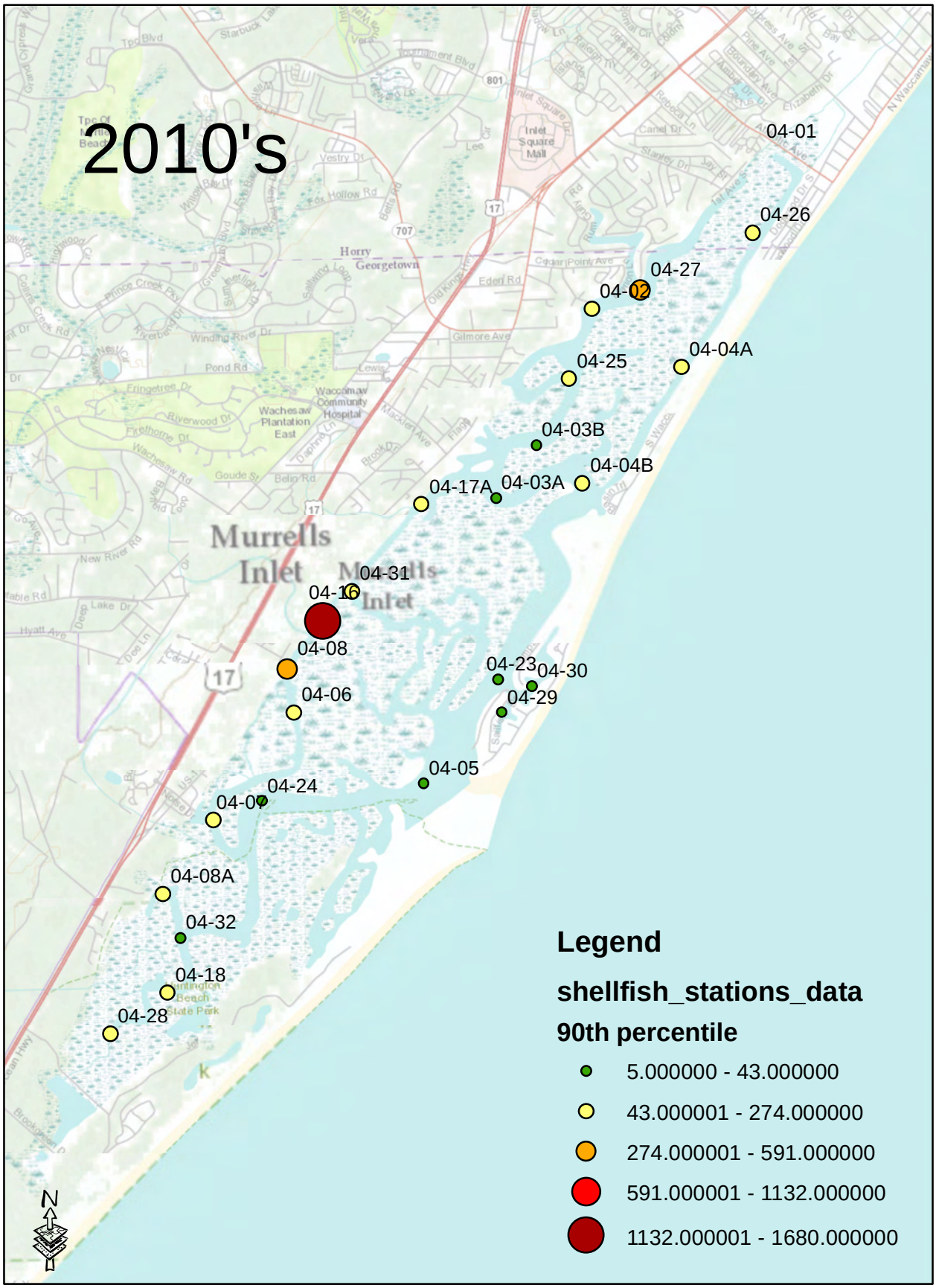

1960's
Inlet Square Mall
Georgetown
Horry
Waccamaw
Murrells Inlet
Huntington Beach State Park
04-01
04-02
04-03
04-04
04-16
04-08
04-06
04-05
0407
Legend
shellfish_stations_data
90th percentile
5.000000 - 43.000000
43.000001 - 274.000000
274.000001 - 591.000000
591.000001 - 1132.000000
1132.000001 - 1680.000000
N


1970's
04-01
04-01A
04-02
04-03
04-17
04-04
04-16
04-08
04-06
04-05
04-07
04-08A
Horry
Georgetown
Murrells Inlet
Legend
shellfish_stations_data
90th percentile
5.000000 - 43.000000
43.000001 - 274.000000
274.000001 - 591.000000
591.000001 - 1132.000000
1132.000001 - 1680.000000
N

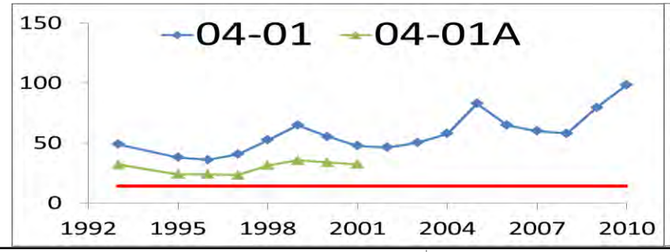

1980's
04-01
04-01A
04-02
04-25
04-03
04-17
04-04
04-16
04-08
04-23
04-06
04-05
04-24
04-09
04-08A
04-18
04-22
Legend
shellfish_stations_data
90th percentile
5.000000 - 43.000000
43.000001 - 274.000000
274.000001 - 591.000000
591.000001 - 1132.000000
1132.000001 - 1680.000000

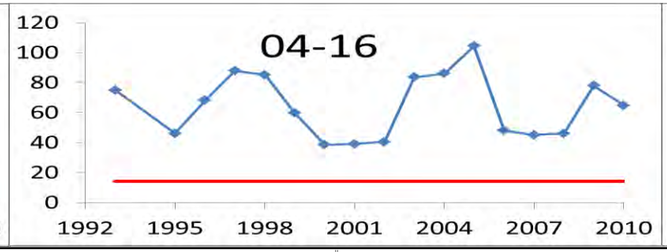

1990's
04-01
04-01A
04-26
04-27
04-02
04-25
04-17
04-03
04-04
04-16
04-08
04-23
04-30
04-29
04-06
04-05
04-24
04-09
04-08A
04-18
04-28
04-22
Legend
shellfish_stations_data
90th percentile
5.000000 - 43.000000
43.000001 - 274.000000
274.000001 - 591.000000
591.000001 - 1132.000000
1132.000001 - 1680.000000

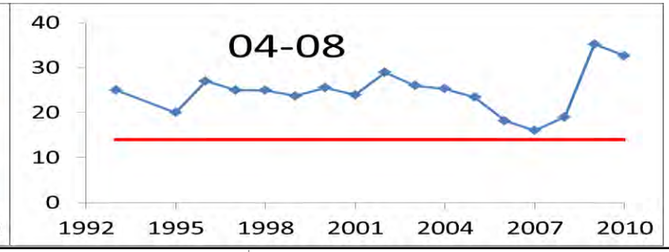

2000's
04-01
04-01A
04-26
04-27
04-02
04-25
04-04A
04-03B
04-17
04-03
04-17A
04-03A
04-04
04-04C
04-31
04-10
04-08
04-23
04-30
04-06
04-29
04-05
04-24
04-07
04-08A
04-18
04-28
Legend
shellfish_stations_data
90th percentile
5.000000 - 43.000000
43.000001 - 274.000000
274.000001 - 591.000000
591.000001 - 1132.000000
1132.000001 - 1680.000000

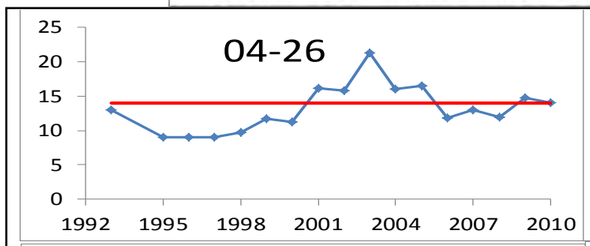

2010's
04-01
04-26
04-27
04-02
04-25
04-04A
04-03B
04-04B
04-17A
04-03A
04-31
04-16
04-08
04-23
04-30
04-06
04-29
04-05
04-24
04-09
04-08A
04-32
04-18
04-28
Legend
shellfish_stations_data
90th percentile
5.000000 - 43.000000
43.000001 - 274.000000
274.000001 - 591.000000
591.000001 - 1132.000000
1132.000001 - 1680.000000
N

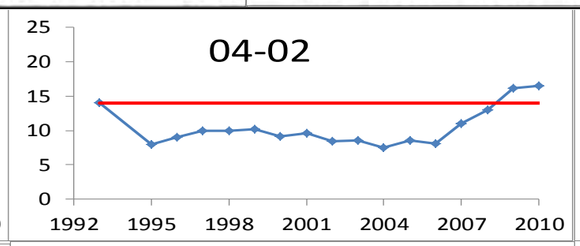
Fecal Coliform Trends by Monitoring Site- Geometric Mean Standard

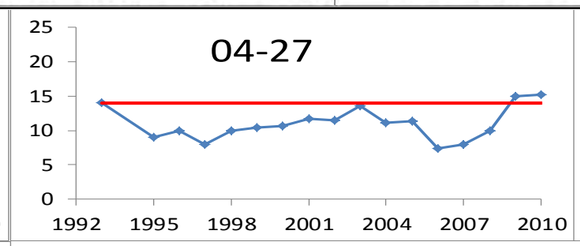


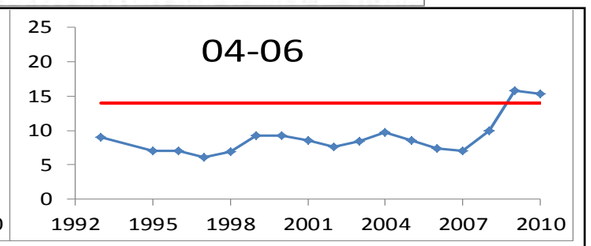


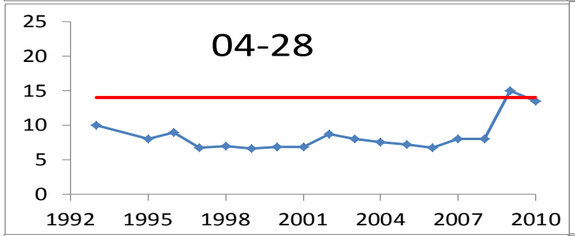


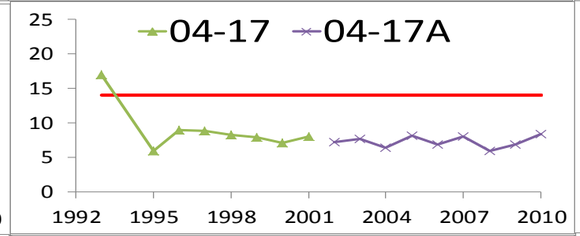


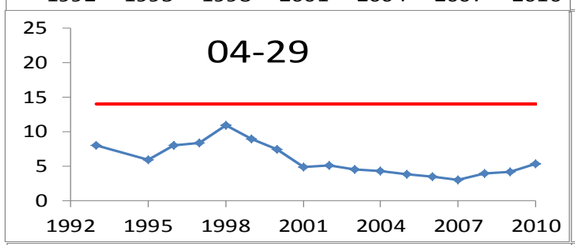


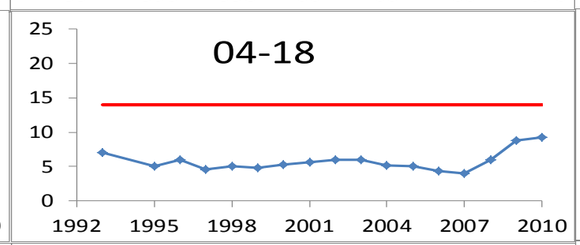


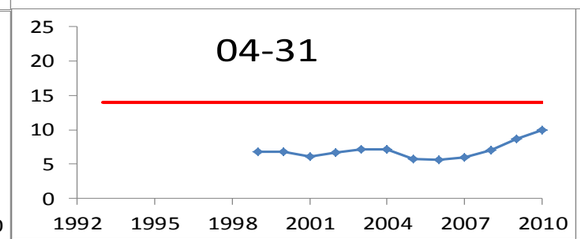


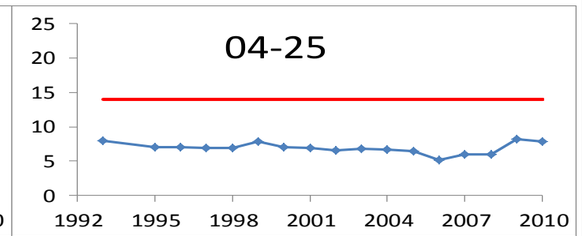


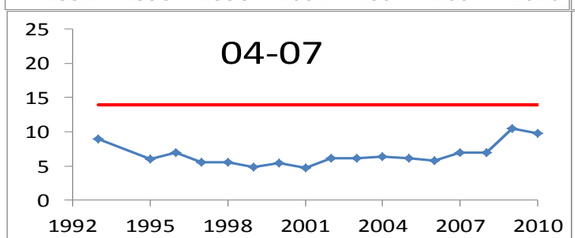


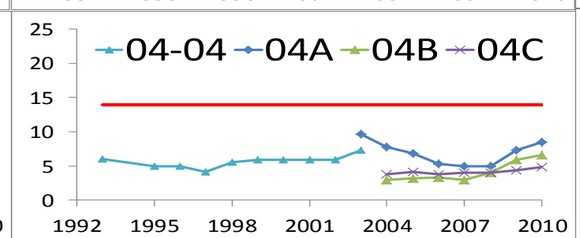


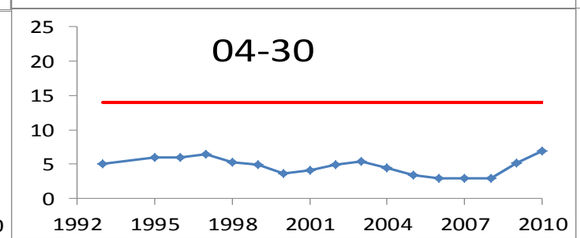


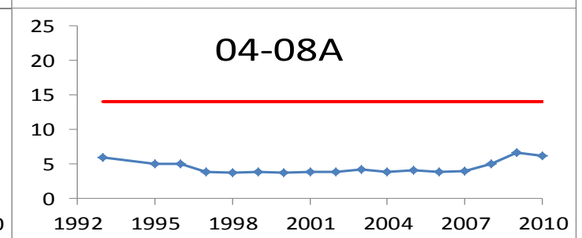


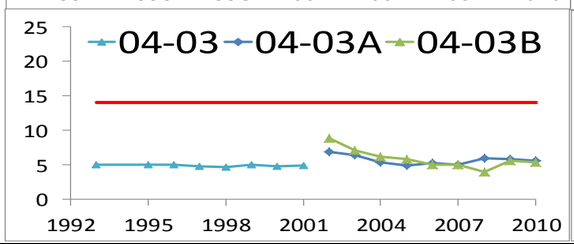


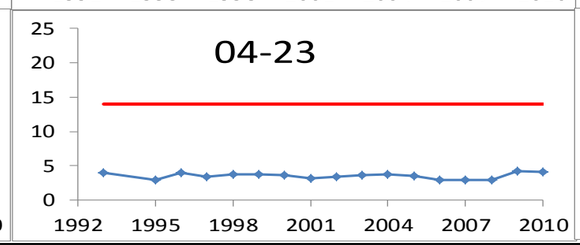


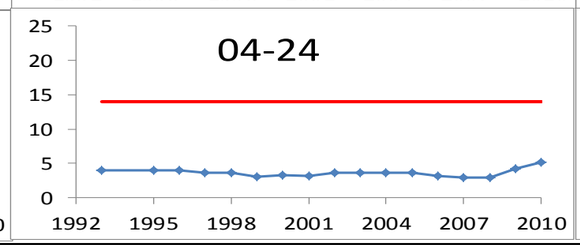


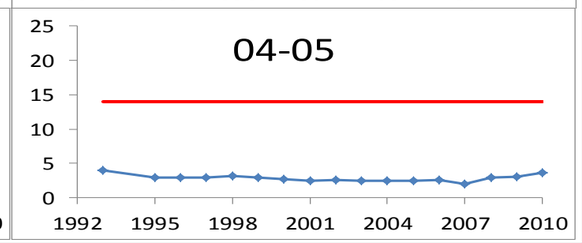




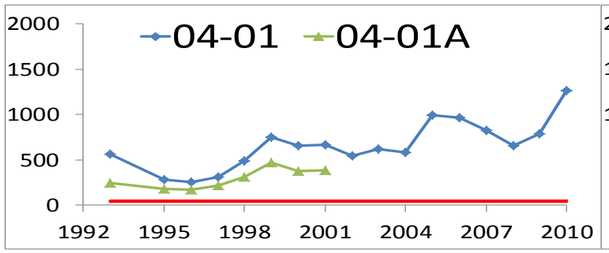


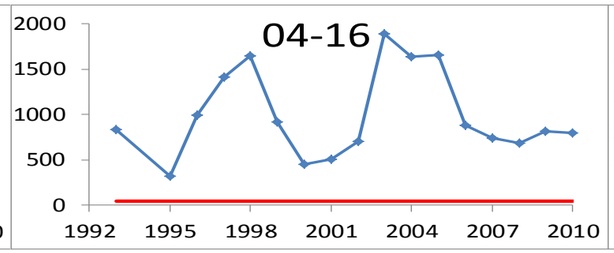


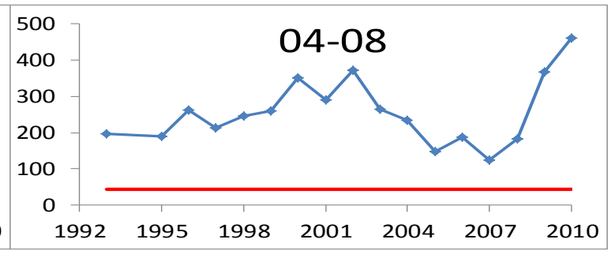


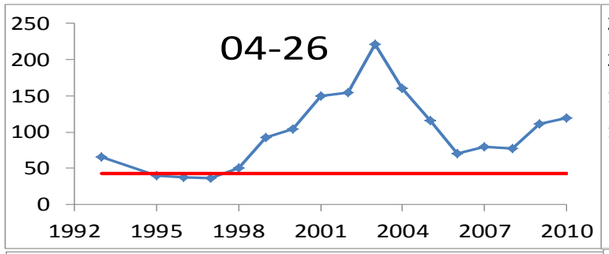


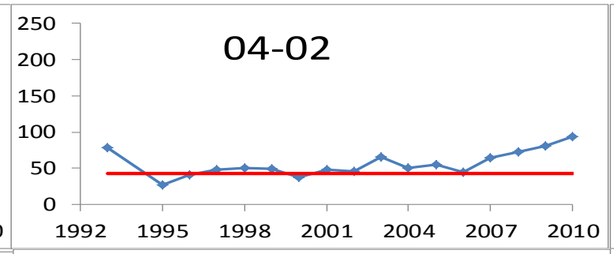
Fecal Coliform Trends by Monitoring Site- 90th Percentile Standard

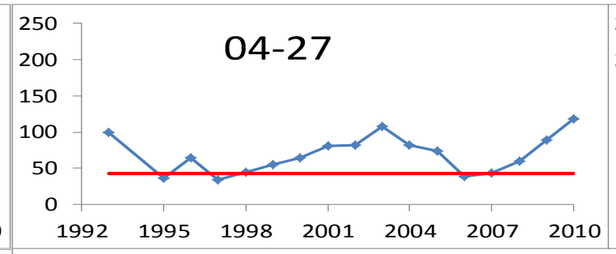


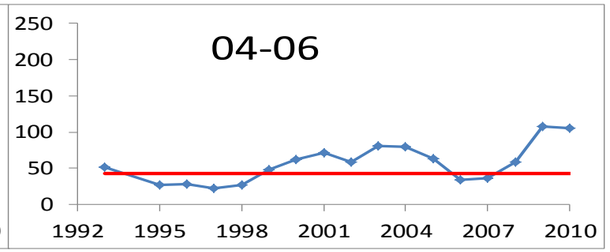


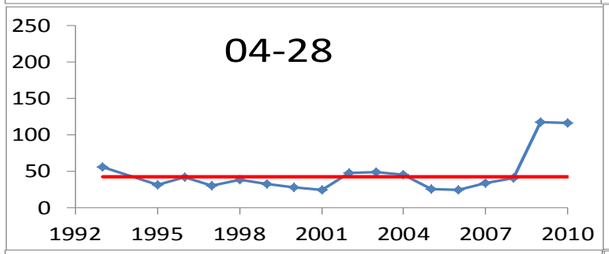


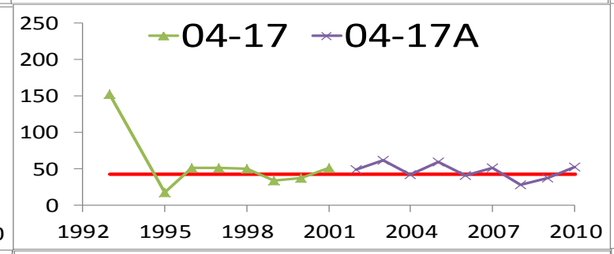


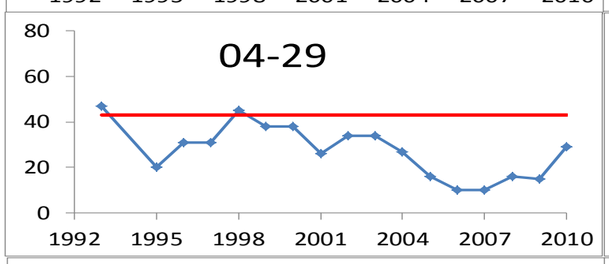


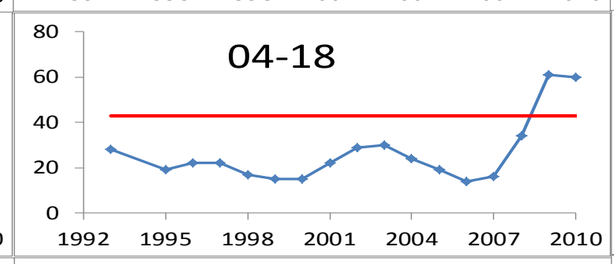


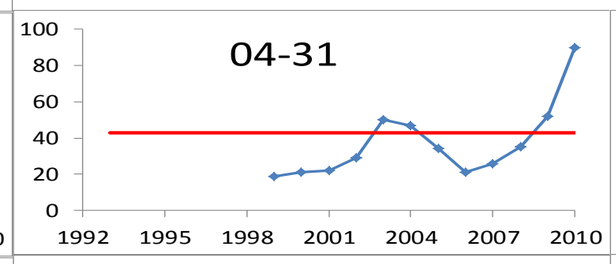


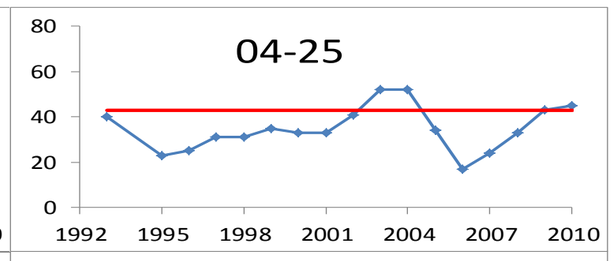


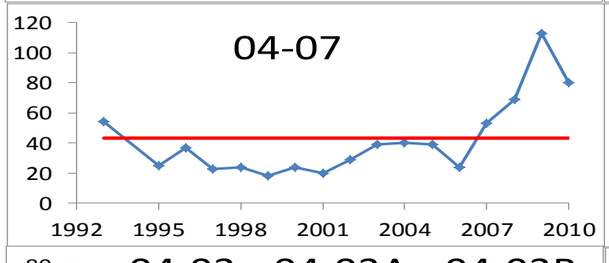


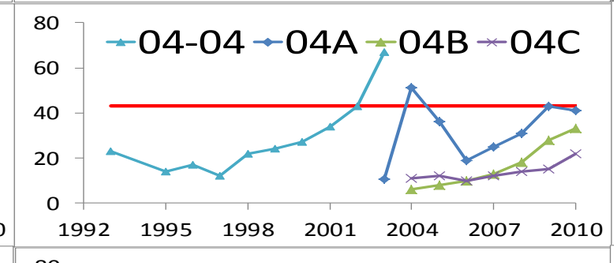


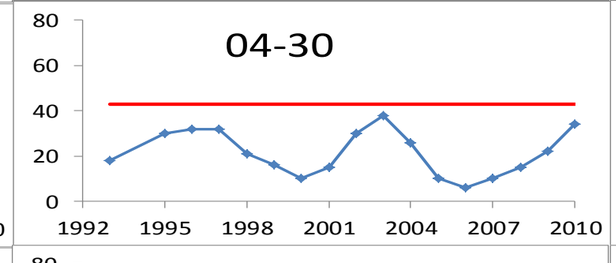


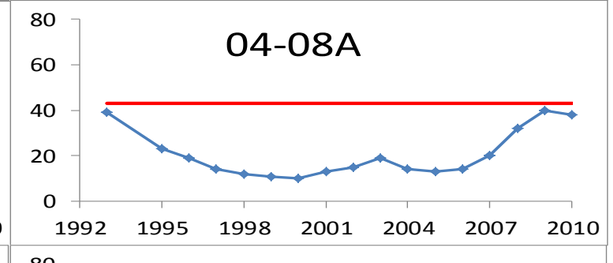


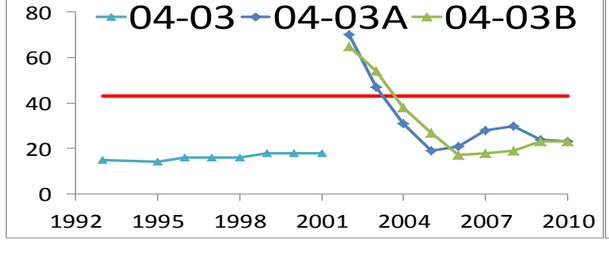


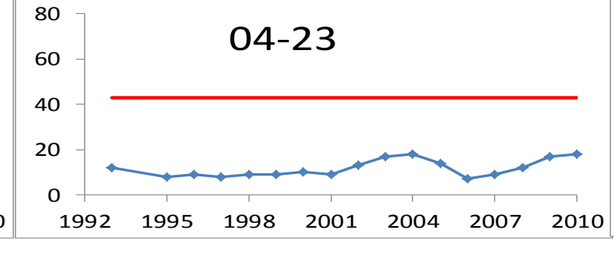


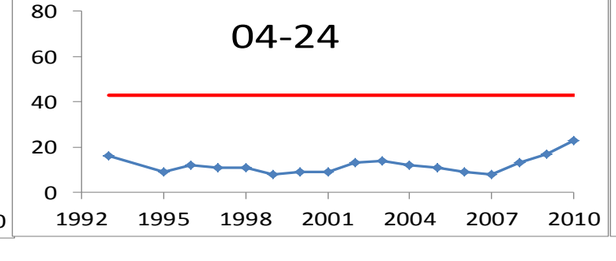


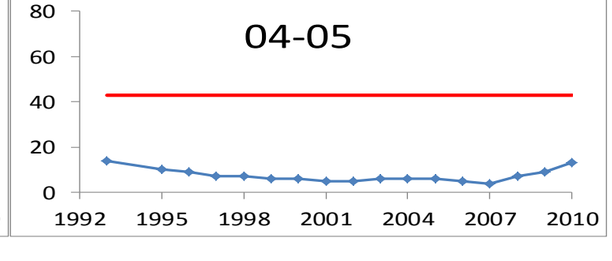






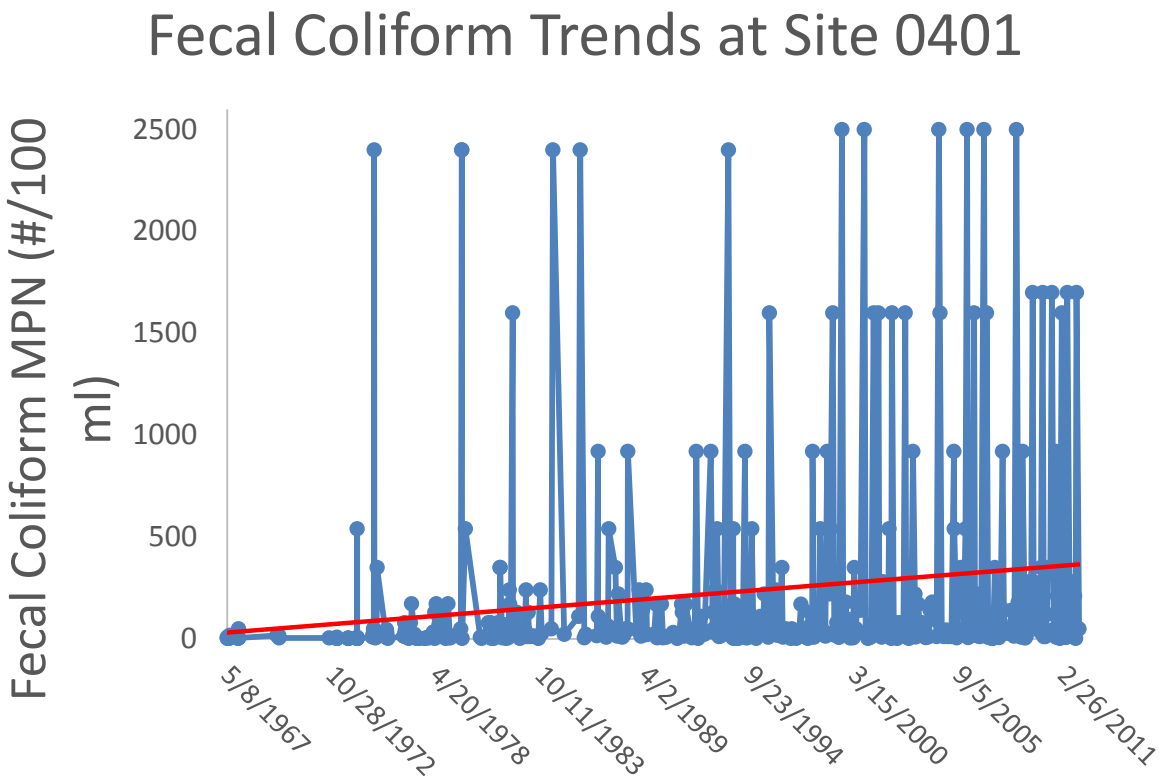


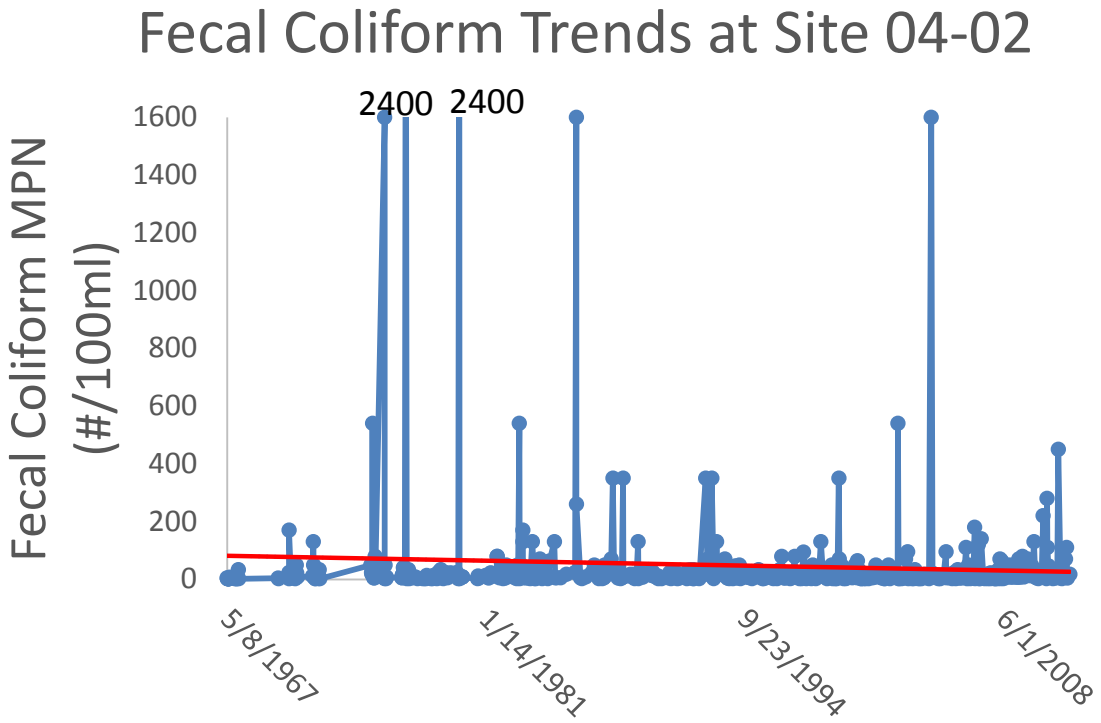


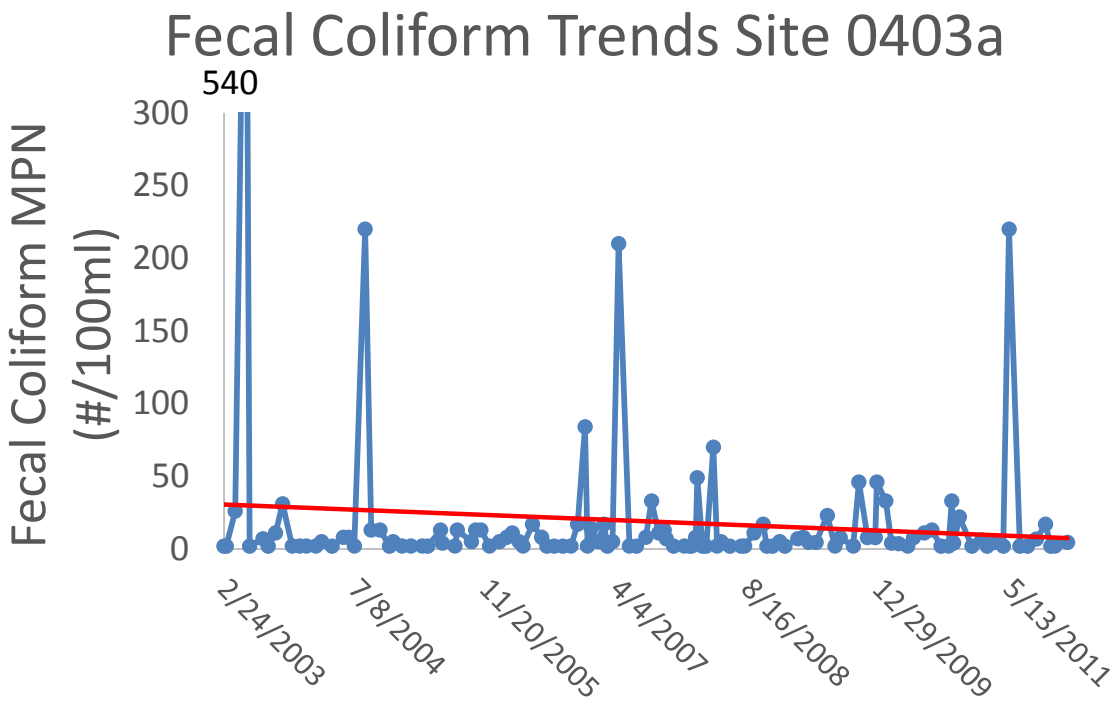


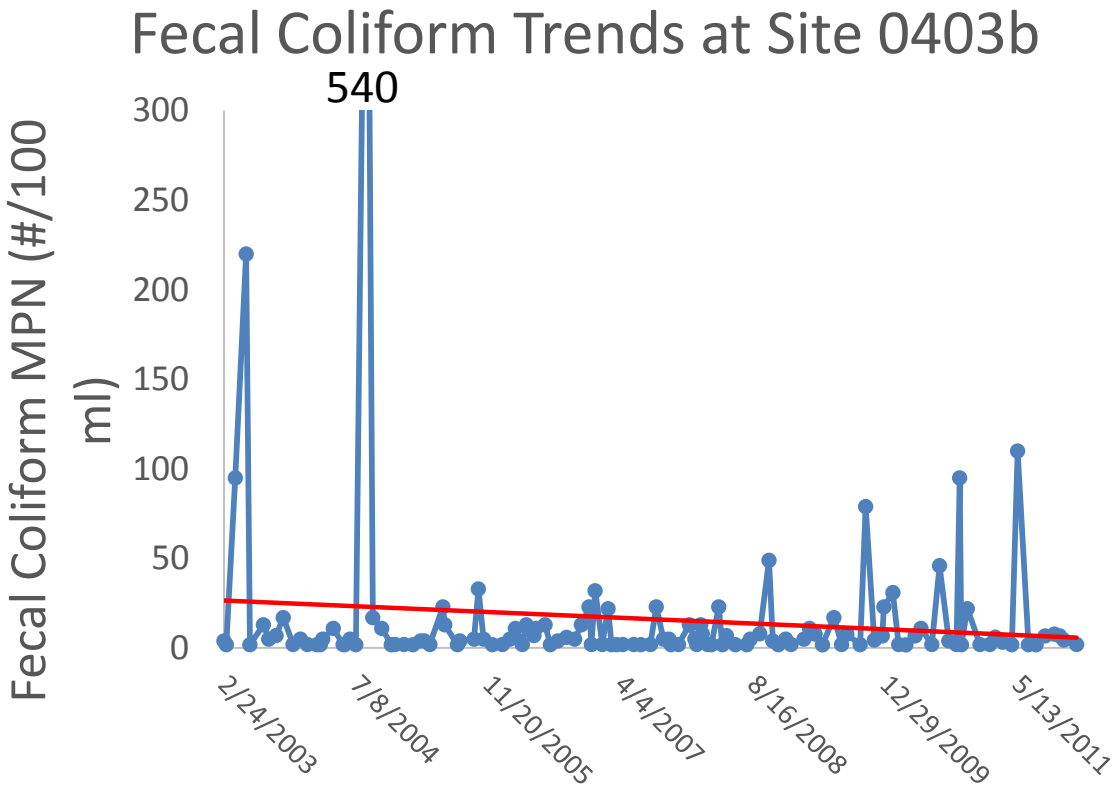
Appendix D-3, Overall Fecal Coliform Statistical Trends- Murrells Inlet Watershed															
Monitoring Site	Linear Regression of Log Transformed									Monitoring Site	Mann Kendall Trends				
	Dry				Rain> 0.5 In				Overall Trends		w/rain	Slope	Dry	Slope	Overall Trends
	1 Day	2 Day	3 Day	Trend	1 Day	2 Day	3 Day	Trend							
04-01	0.11	0.08	0.07	↑↑	0.01	0.13	0.09	↑	Increasing wet and dry	04-01	0.00	0.92	0.00	1.21	Increasing total + dry
04-01A	-0.02	-0.02	-0.01	↓	-0.03	-0.01	-0.02	↓	Decreasing wet and dry	04-01A	0.03	-0.56	0.10	-0.64	Decreasing
04-02	0.01	0.01	0.01		0.00	0.00	0.00			04-02	0.43		0.11	0.03	Increasing dry
04-03	0.00	0.00	-0.01	↓	-0.01	0.00	0.00		Decreasing dry	04-03	0.26		0.95		
04-03A	-0.01	0.00	0.00		0.17	0.02	0.02	↑	Increasing wet	04-03A	0.79		0.35		
04-03B	0.00	0.01	0.03	↑↑	0.18	0.00	0.00	↑	Increasing wet and dry	04-03B	0.62		0.39		
04-04	0.00	0.00	0.00		0.00	0.01	0.01			04-04	0.91		0.19		
04-04A	0.03	0.05	0.04	↑	0.21	0.08	0.04	↑	Increasing wet and dry	04-04A	0.28		0.28		
04-04B	0.07	0.01	0.02	↑↑	0.07	0.30	0.21	↑	Increasing wet and dry	04-04B	0.02	0.03	0.02	0.32	Increasing total and dry
04-04C	0.00	-0.01	0.04	↑	0.39	0.05	0.03	↑	Increasing wet and dry	04-04C	0.69		0.49		
04-05	-0.01	0.01	0.00	↓↓	-0.03	-0.02	-0.02	↓	Decreasing wet and dry	04-05	0.00	0.00	0.05	0.00	No evidence for trend
04-06	0.01	0.00	0.01		0.00	0.00	0.00			04-06	0.53		0.04	0.06	Increasing dry
04-07	0.00	0.00	0.00		-0.04	-0.04	-0.02	↓	Decreasing wet	04-07	0.01	0.00	0.21		No evidence for trend
04-08	0.01	0.00	0.01		0.00	0.00	0.00			04-08	0.86		0.30		
04-08A	0.00	0.00	0.00	↓	-0.08	-0.05	-0.01	↓	Decreasing wet	04-08A	0.00	0.00	0.19		No evidence for trend
04-16	0.00	0.00	0.00		0.00	-0.03	-0.03	↓	Decreasing wet	04-16	0.31		0.51		
04-17	-0.01	-0.01	-0.01	↓↓	0.01	0.00	-0.01		Decreasing dry	04-17	0.00	-0.08	0.05	-0.10	Decreasing total +dry
04-17A	0.03	0.04	0.09	↑	0.06	0.02	0.00	↑	Increasing wet and dry	04-17A	0.21		0.19		
04-18	-0.01	0.00	-0.01	↓	-0.09	-0.02	-0.01	↓	Decreasing wet and dry	04-18	0.03	0.00	0.62		No evidence for trend
04-22	-0.01	-0.03	-0.17	↓↓	?	0.02	0.02		Decreasing dry	04-22	0.44		0.31		
04-23	0.00	0.00	0.00	oo	0.01	-0.01	-0.01			04-23	0.00	0.00	0.02	-0.01	Decreasing dry
04-24	0.00	0.00	0.00		0.00	0.00	0.00			04-24	0.00	0.00	0.11	-0.01	Decreasing dry
04-25	0.00	0.00	0.00		0.00	-0.01	-0.01			04-25	0.10	0.00	0.14		No evidence for trend
04-26	0.02	0.03	0.06	↑↑	0.00	0.01	0.01		Increasing dry	04-26	0.44		0.10	0.22	Increasing dry
04-27	0.00	0.01	0.01	oo	0.04	0.00	-0.01			04-27	0.61		0.90		
04-28	0.02	0.03	0.04	↑	-0.01	-0.01	-0.02	↓	Increasing dry	04-28	0.94		0.56		
04-29	-0.05	-0.07	-0.05	↓↓	-0.13	-0.11	-0.05	↓	Decreasing wet and dry	04-29	0.00	-0.02	0.00	-0.07	Decreasing total and dry
04-30	0.00	0.00	0.00		-0.03	0.00	0.00	↓		04-30	0.06	0.00	0.49		
04-31	0.03	0.05	0.04	↑↑	0.18	0.06	0.03	↑	Increasing wet and dry	04-31	0.41		0.11	0.11	Increasing dry
04-32	Monitoring began at this site in 2011. Not enough data available to reliably detect long-term statistical trends.														
Notes:															

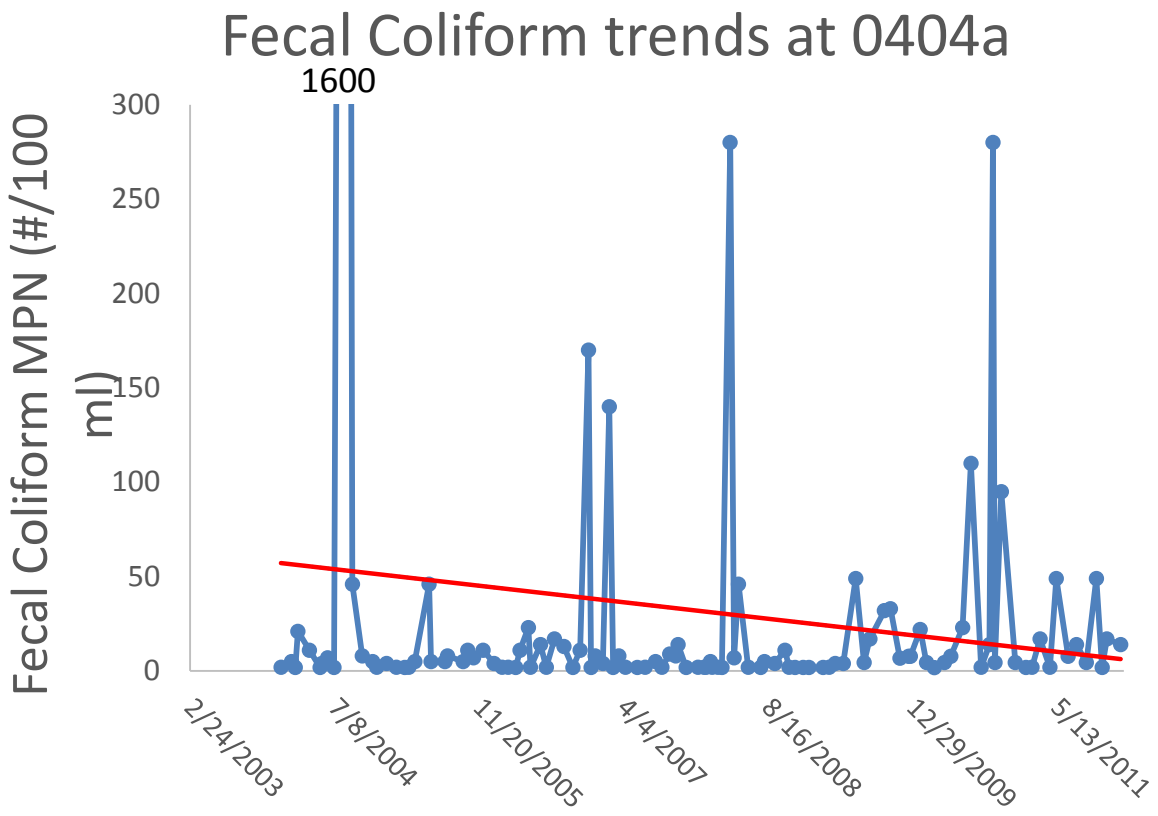
Fecal Coliform Temporal Trend Graphs

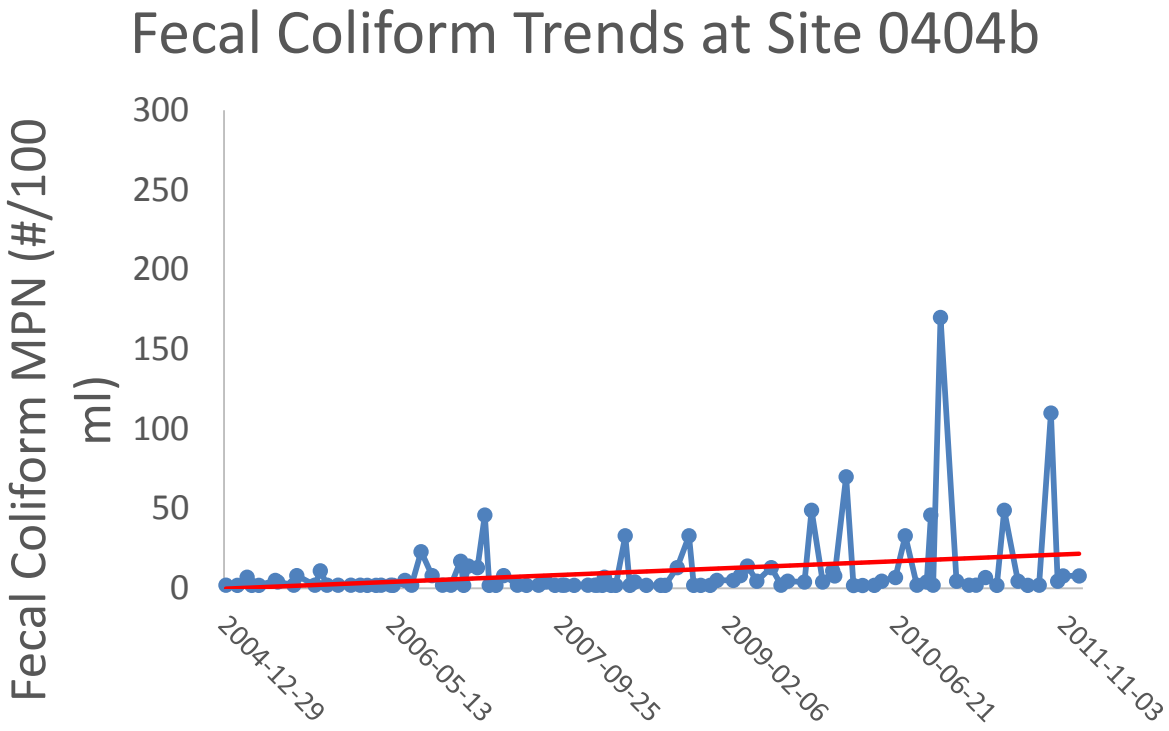


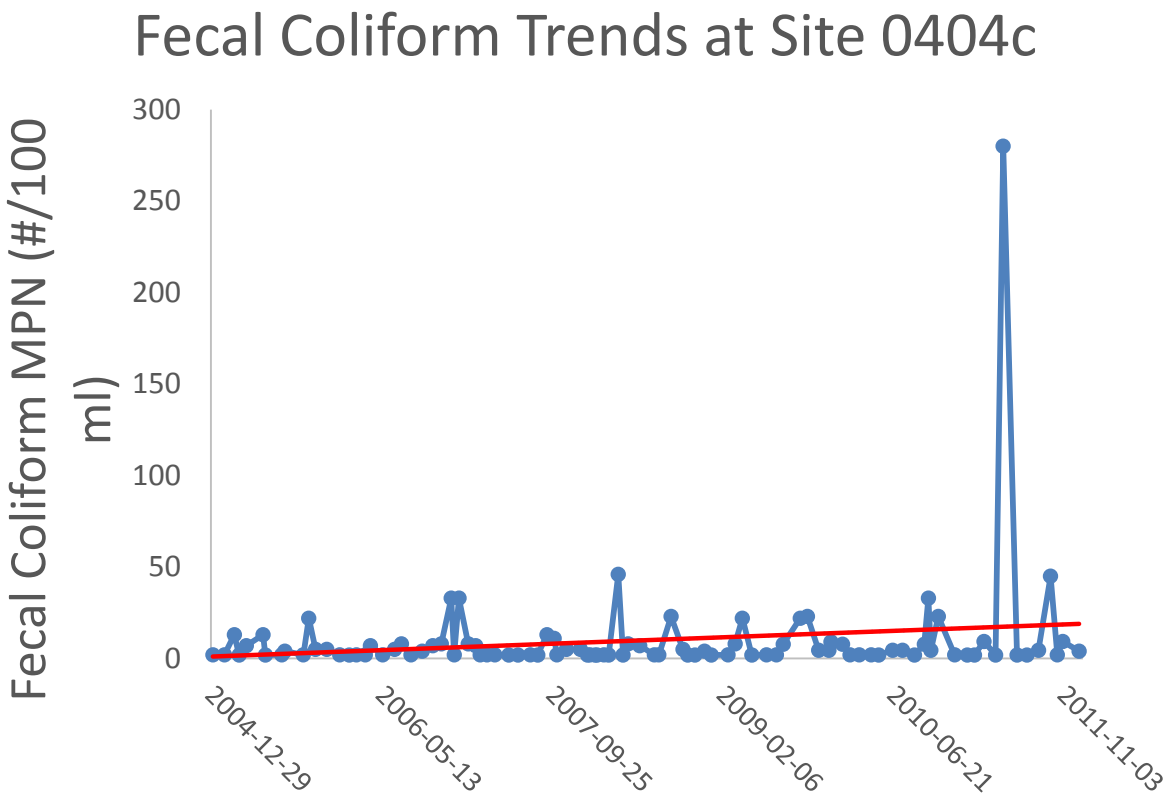


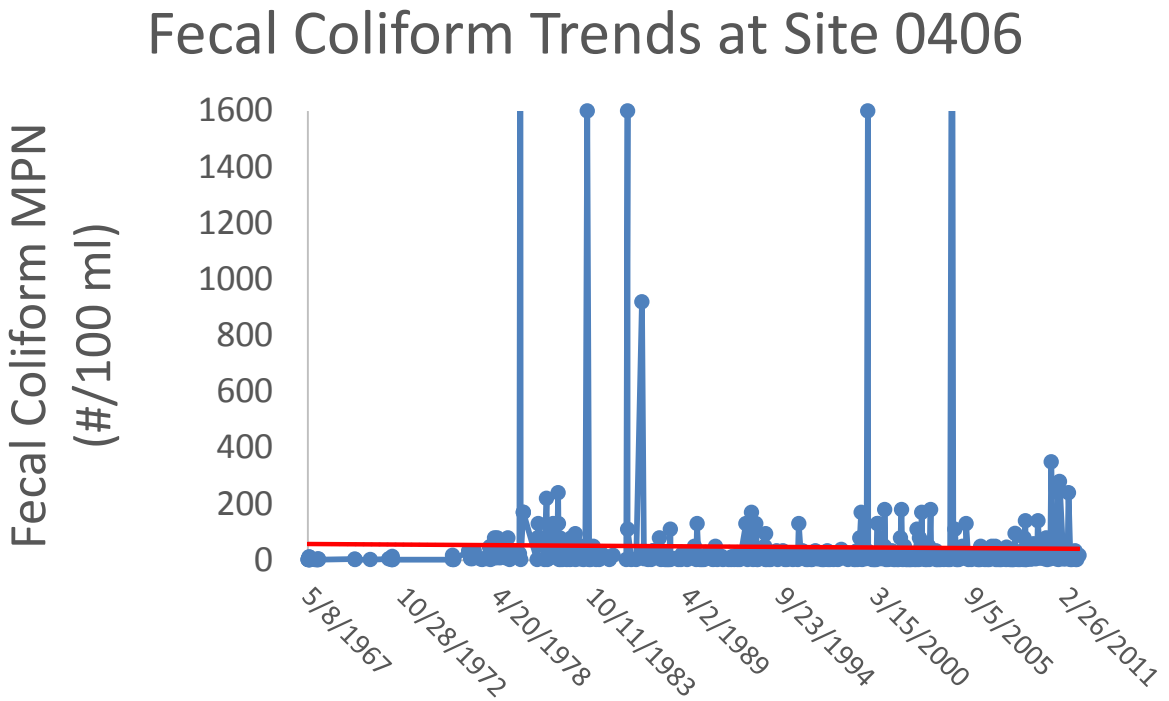

Fecal Coliform Trends Site 0403a
540
Fecal Coliform MPN (#/100ml)
300
250
200
150
100
50
0
2/24/2003
7/8/2004
11/20/2005
4/4/2007
8/16/2008
12/29/2009
5/13/2011

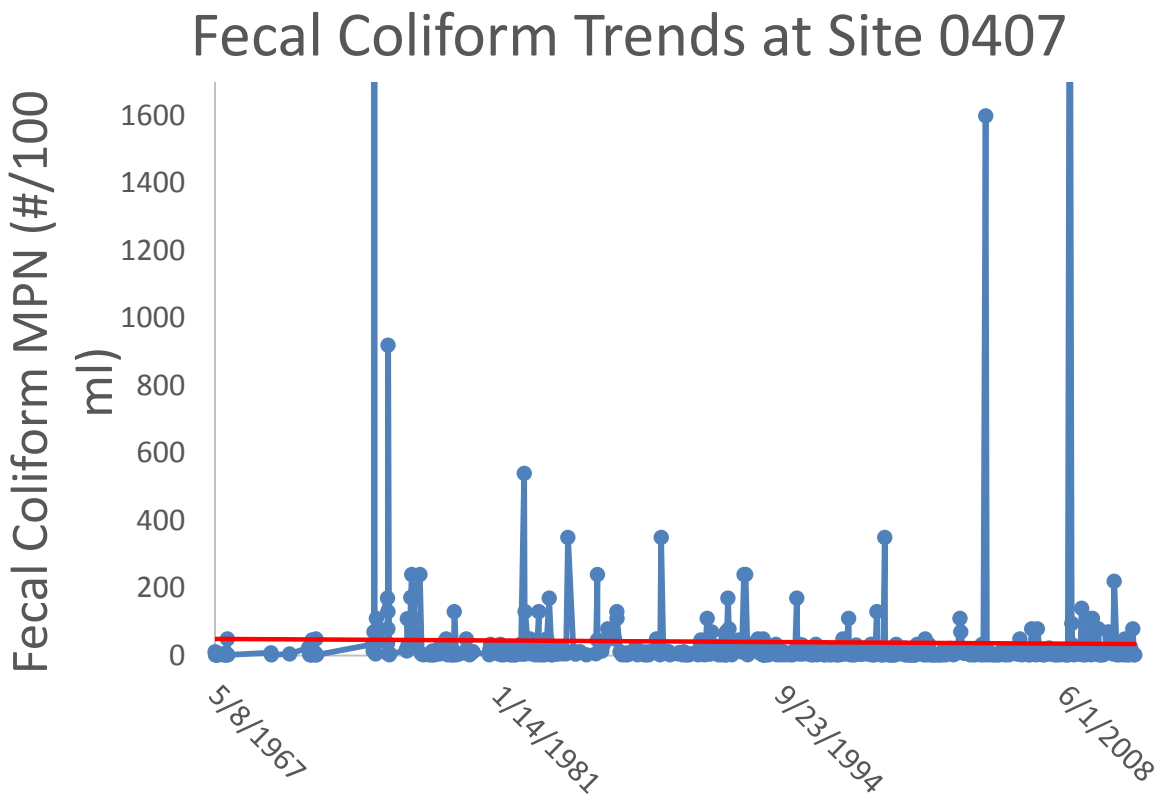

Fecal Coliform Trends at Site 0403b
540
Fecal Coliform MPN (#/100 ml)
300
250
200
150
100
50
0
2/24/2003
7/8/2004
11/20/2005
4/4/2007
8/16/2008
12/29/2009
5/13/2011

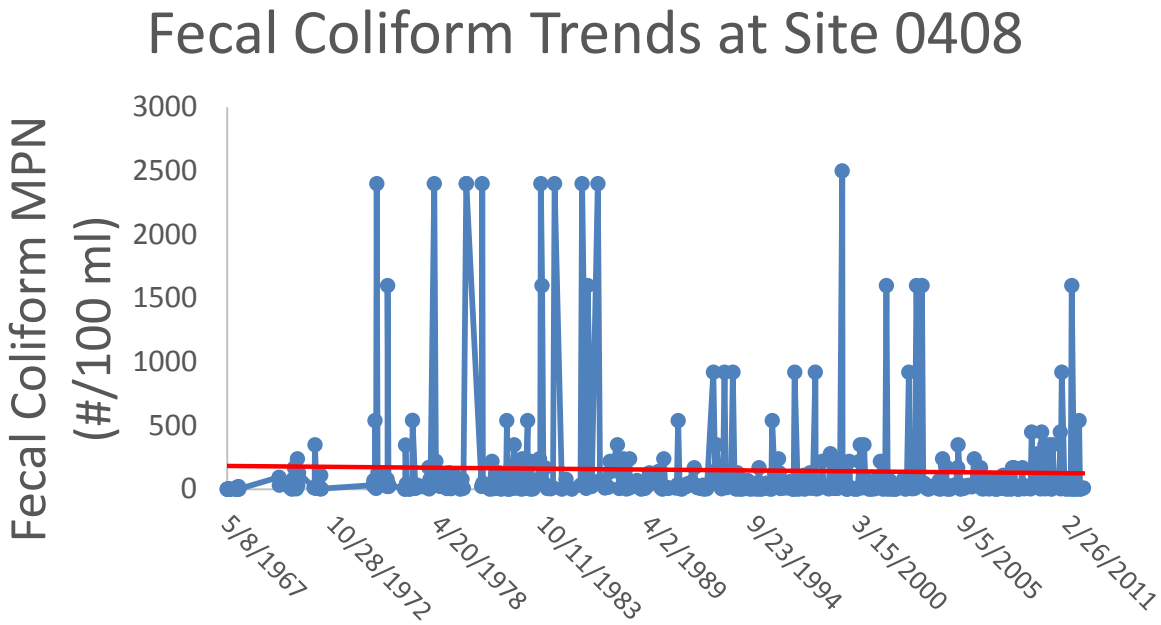

Fecal Coliform trends at 0404a
1600
Fecal Coliform MPN (#/100 ml)
300
250
200
150
100
50
0
2/24/2003
7/8/2004
11/20/2005
4/4/2007
8/16/2008
12/29/2009
5/13/2011

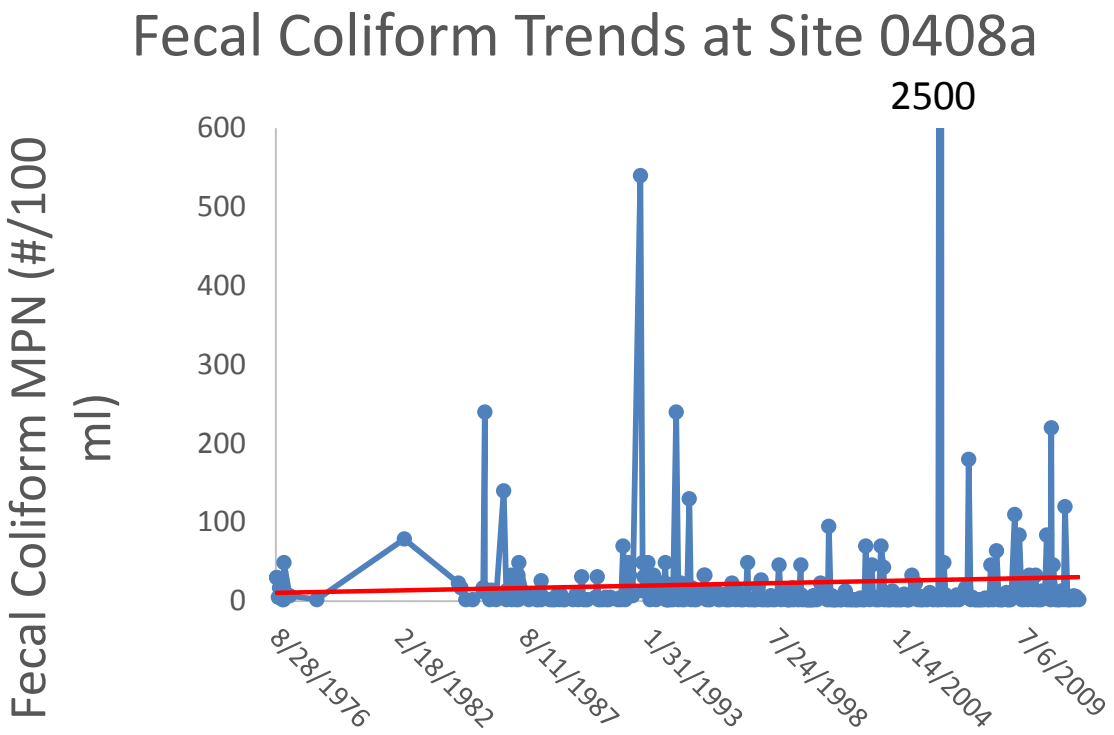

Fecal Coliform Trends at Site 0404b
Fecal Coliform MPN (#/100 ml)
300
250
200
150
100
50
0
2004-12-29
2006-05-13
2007-09-25
2009-02-06
2010-06-21
2011-11-03

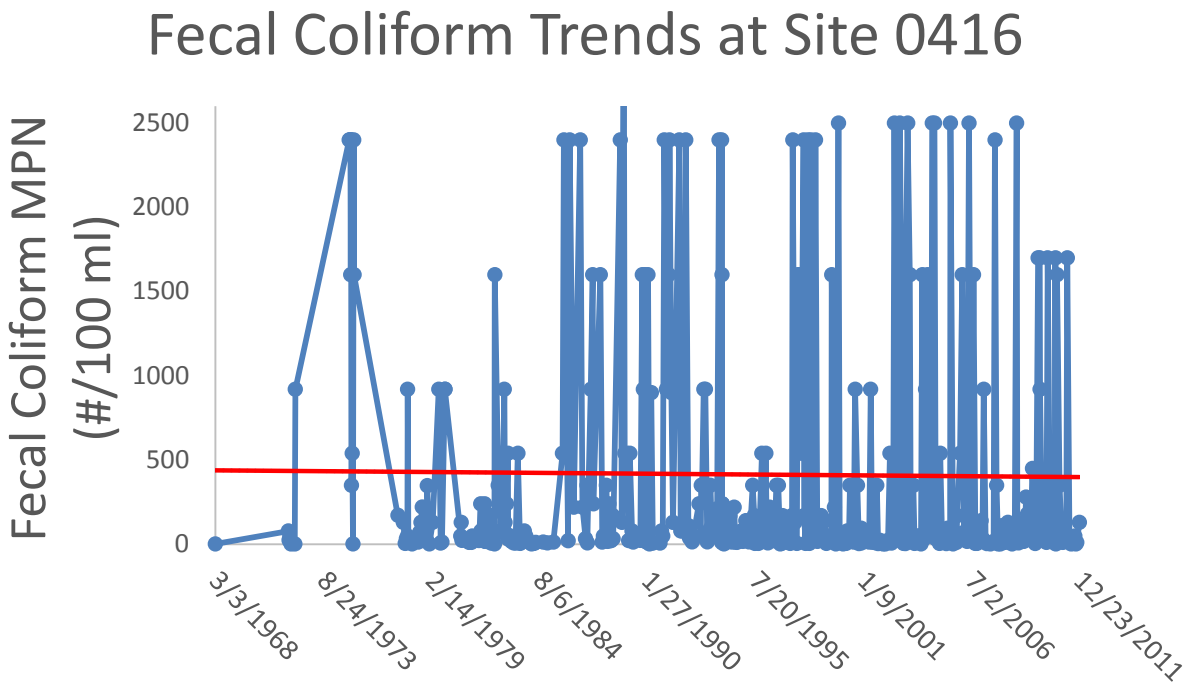

Fecal Coliform Trends at Site 0404c
Fecal Coliform MPN (#/100 ml)
300
250
200
150
100
50
0
2004-12-29
2006-05-13
2007-09-25
2009-02-06
2010-06-21
2011-11-03

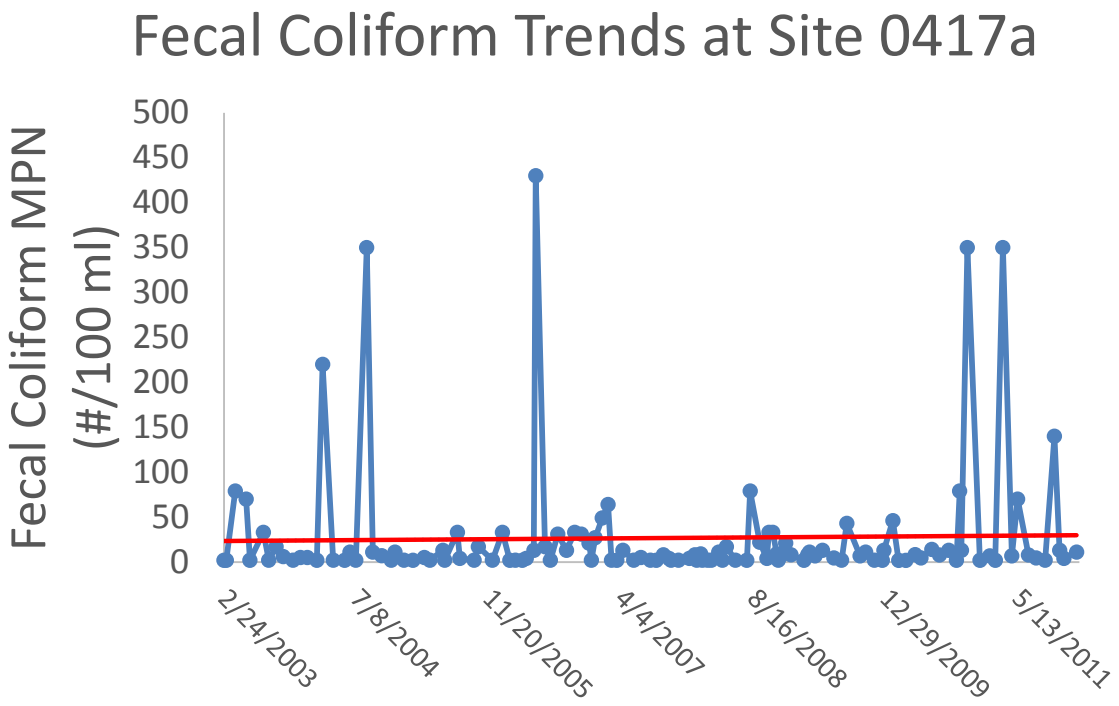

Fecal Coliform Trends at Site 0406
Fecal Coliform MPN (#/100 ml)
1600
1400
1200
1000
800
600
400
200
0
5/8/1967
10/28/1972
4/20/1978
10/11/1983
4/2/1989
9/23/1994
3/15/2000
9/5/2005
2/26/2011

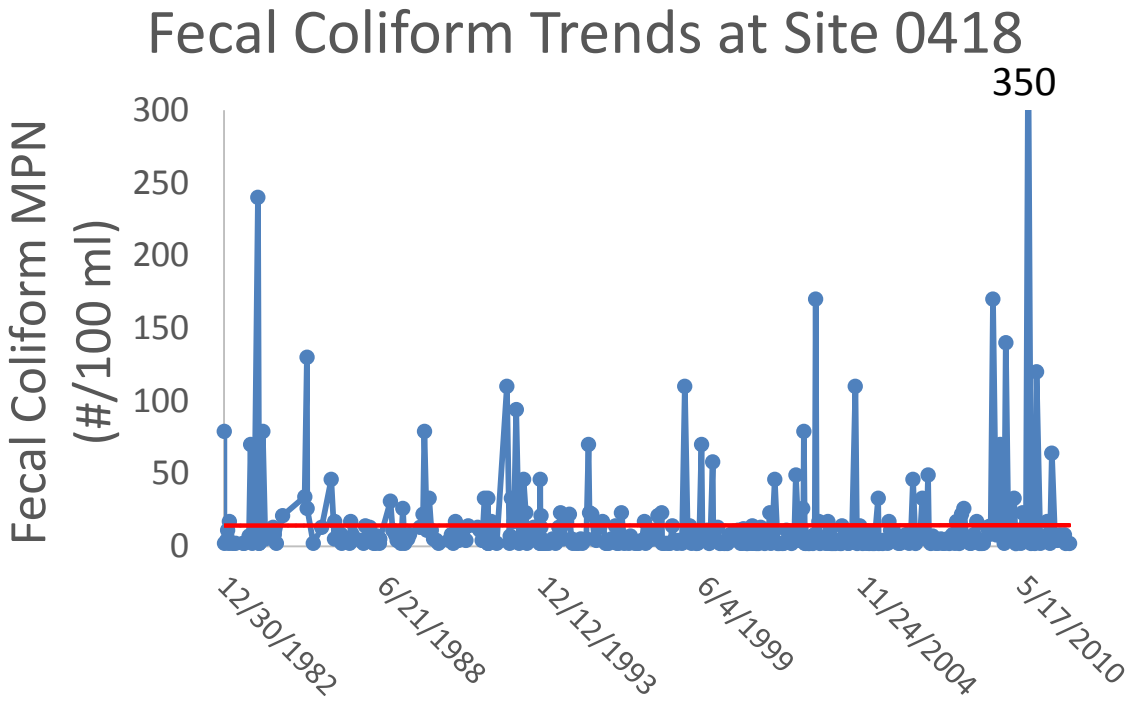

Fecal Coliform Trends at Site 0407
Fecal Coliform MPN (#/100 ml)
1600
1400
1200
1000
800
600
400
200
0
5/8/1967
1/14/1981
9/23/1994
6/1/2008

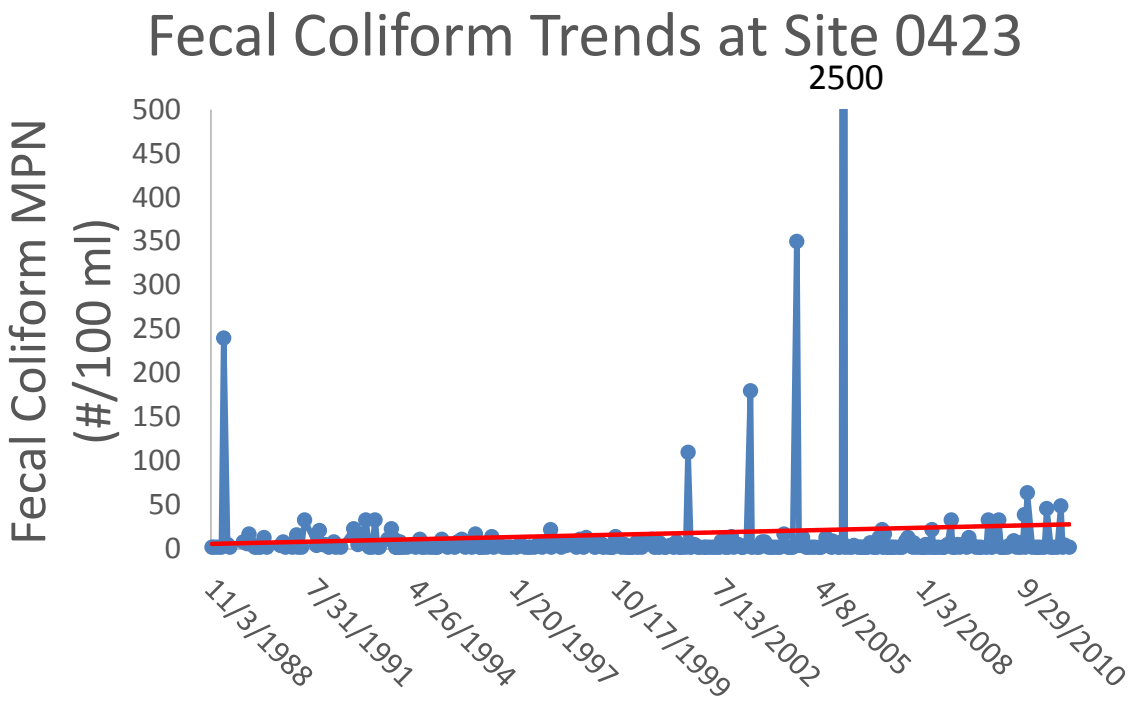

Fecal Coliform Trends at Site 0408
Fecal Coliform MPN (#/100 ml)
3000
2500
2000
1500
1000
500
0
5/8/1967
10/28/1972
4/20/1978
10/11/1983
4/2/1989
9/23/1994
3/15/2000
9/5/2005
2/26/2011

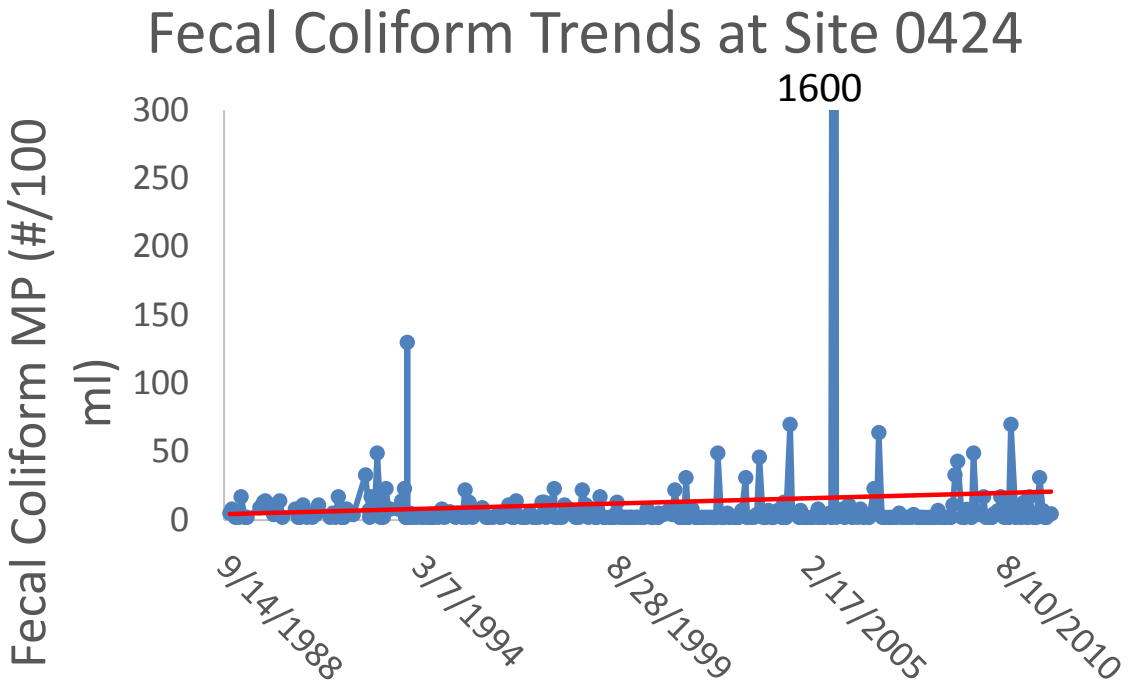

Fecal Coliform Trends at Site 0408a
Fecal Coliform MPN (#/100 ml)
2500
600
500
400
300
200
100
0
8/28/1976
2/18/1982
8/11/1987
1/31/1993
7/24/1998
1/14/2004
7/6/2009

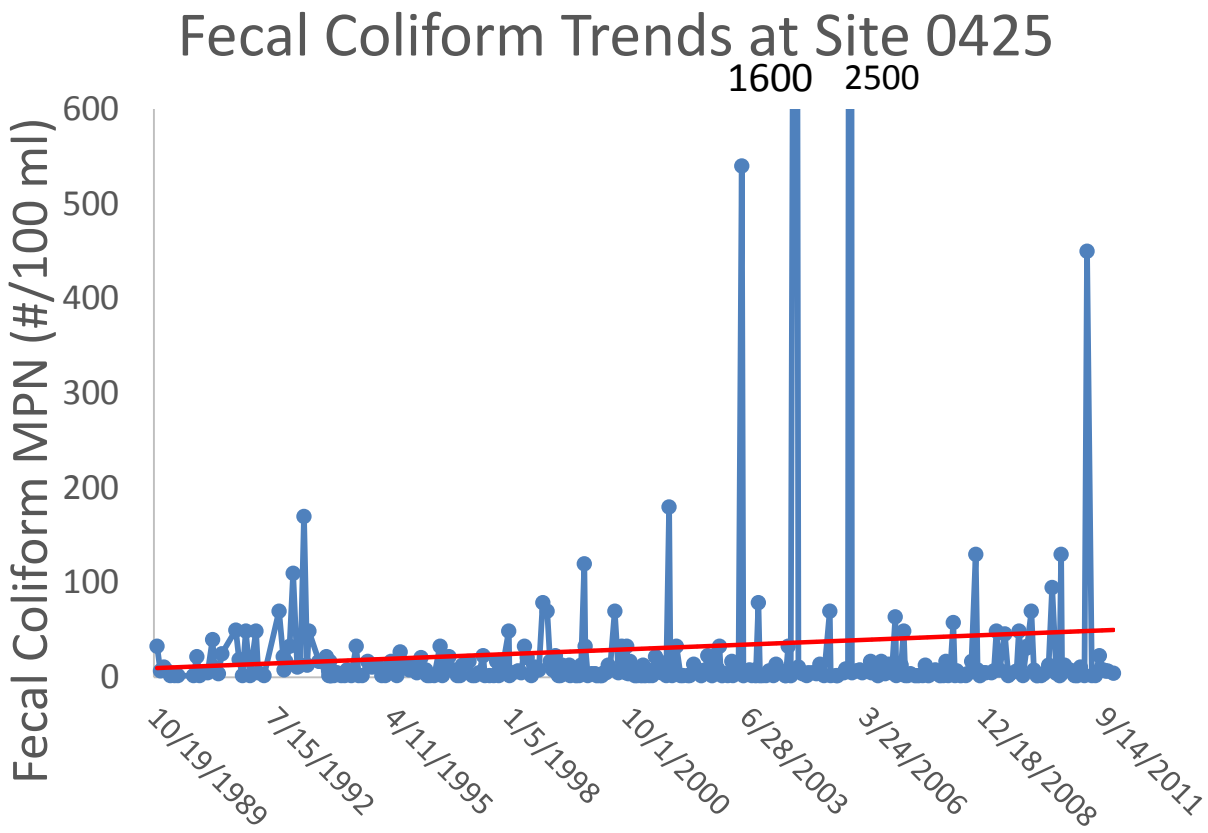

Fecal Coliform Trends at Site 0416
Fecal Coliform MPN (#/100 ml)
2500
2000
1500
1000
500
0
3/3/1968
8/24/1973
2/14/1979
8/6/1984
1/27/1990
7/20/1995
1/9/2001
7/2/2006
12/23/2011

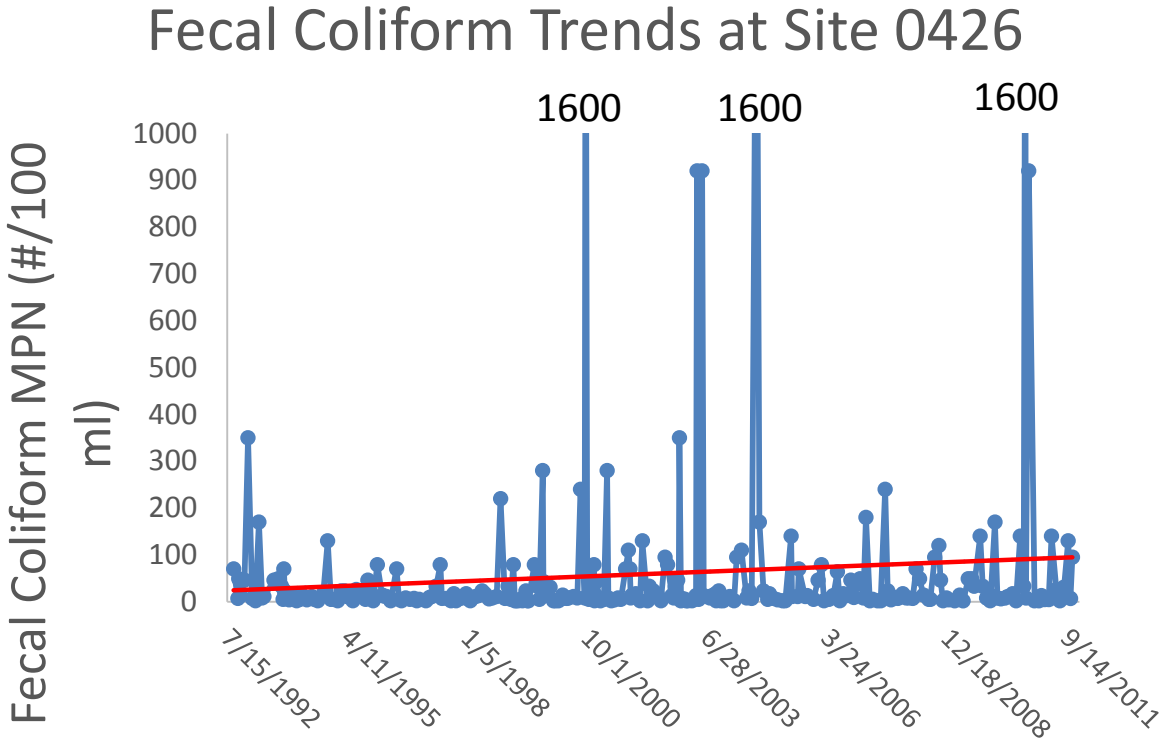

Fecal Coliform Trends at Site 0417a
Fecal Coliform MPN (#/100 ml)
500
450
400
350
300
250
200
150
100
50
0
2/24/2003
7/8/2004
11/20/2005
4/4/2007
8/16/2008
12/29/2009
5/13/2011

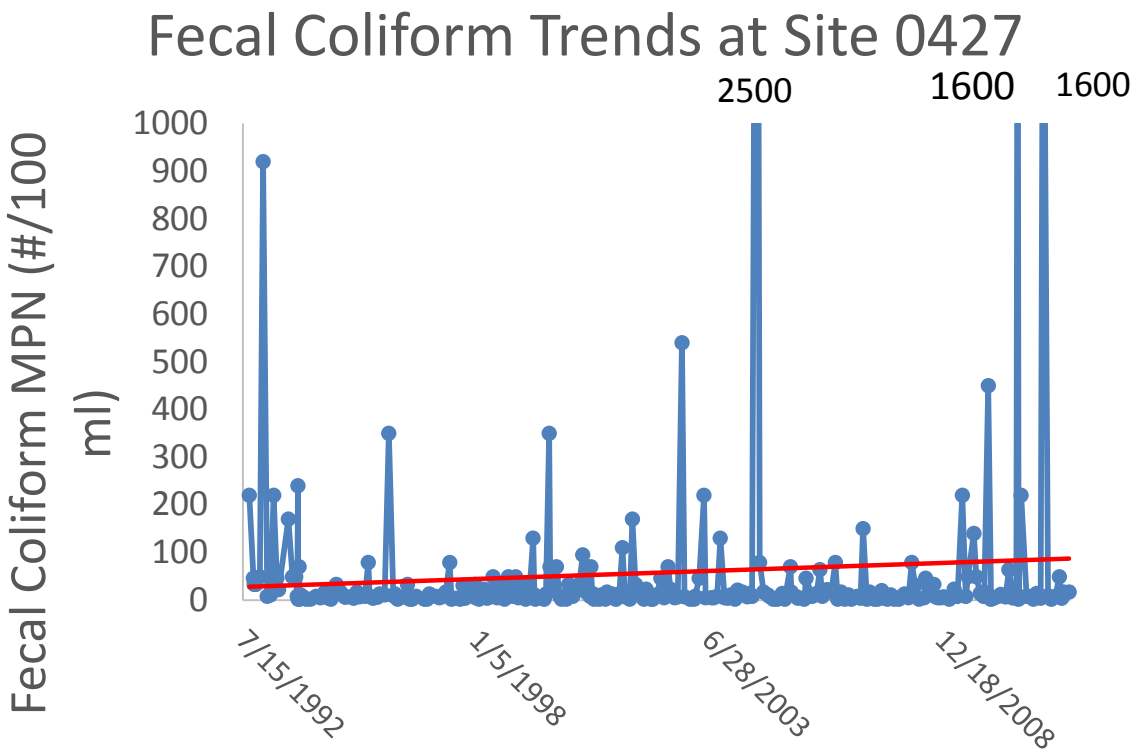

Fecal Coliform Trends at Site 0418
Fecal Coliform MPN (#/100 ml)
350
300
250
200
150
100
50
0
12/30/1982
6/21/1988
12/12/1993
6/4/1999
11/24/2004
5/17/2010

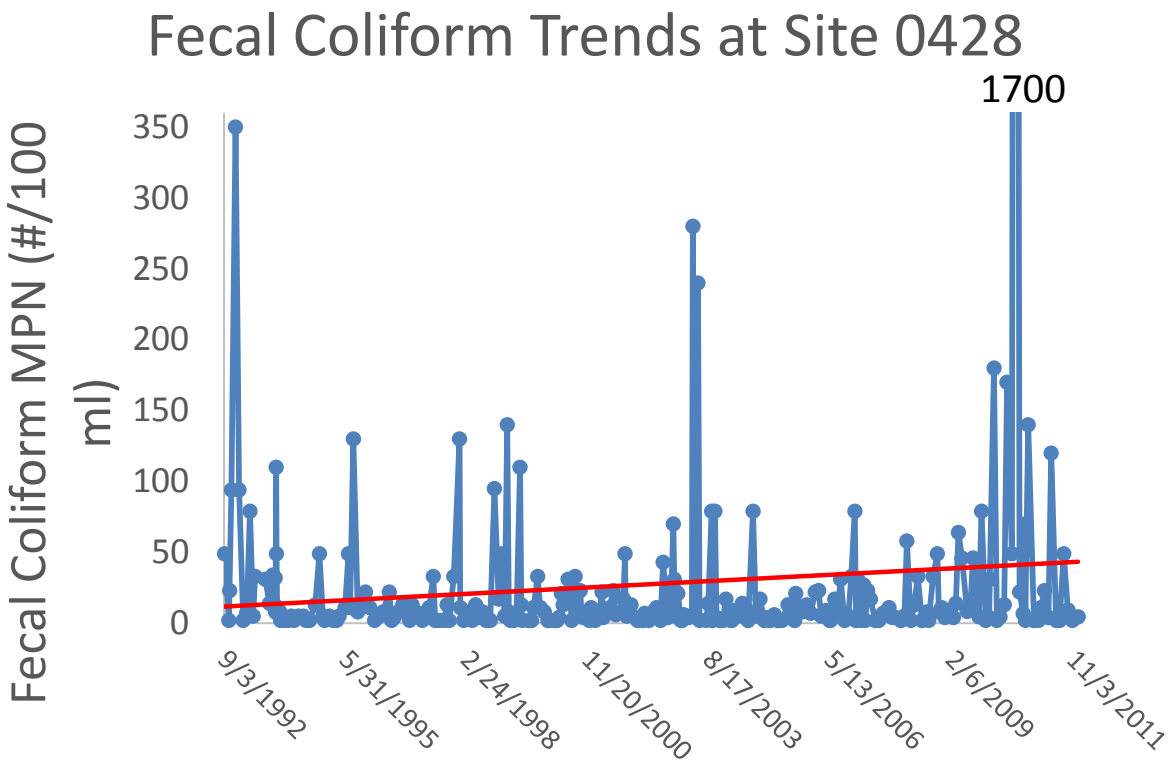

Fecal Coliform Trends at Site 0423
2500
Fecal Coliform MPN (#/100 ml)
500
450
400
350
300
250
200
150
100
50
0
11/3/1988
7/31/1991
4/26/1994
1/20/1997
10/17/1999
7/13/2002
4/8/2005
1/3/2008
9/29/2010

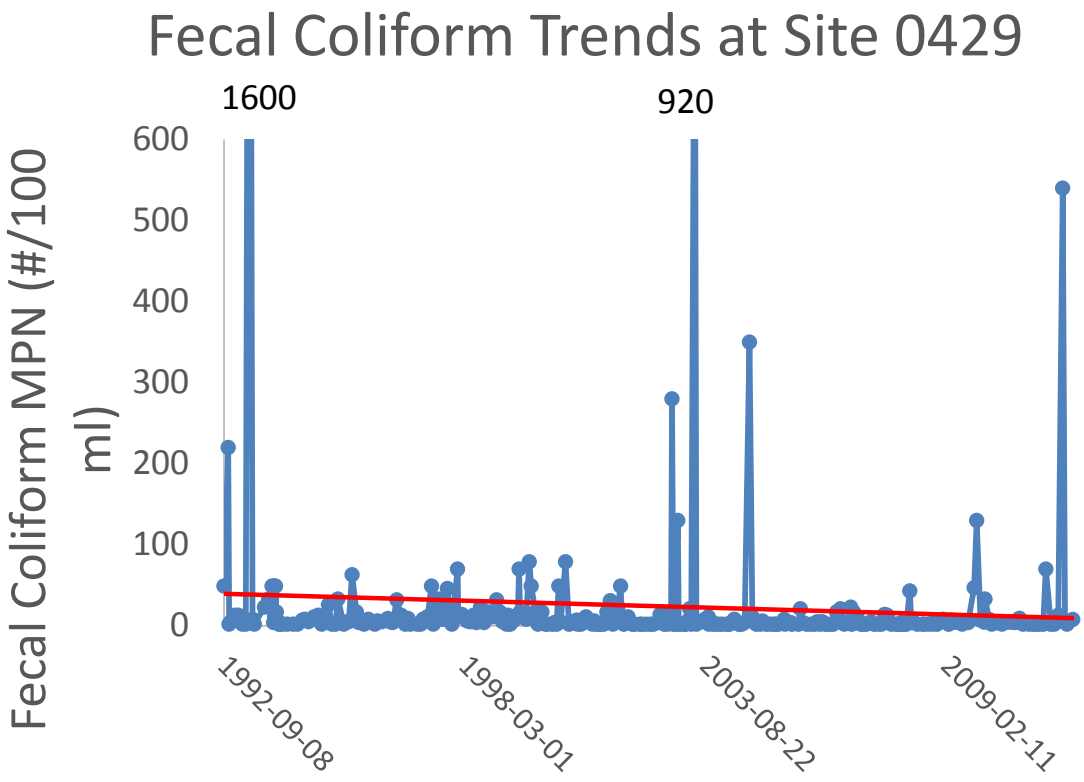

Fecal Coliform Trends at Site 0424
1600
Fecal Coliform MP (#/100 ml)
300
250
200
150
100
50
0
9/14/1988
3/7/1994
8/28/1999
2/17/2005
8/10/2010

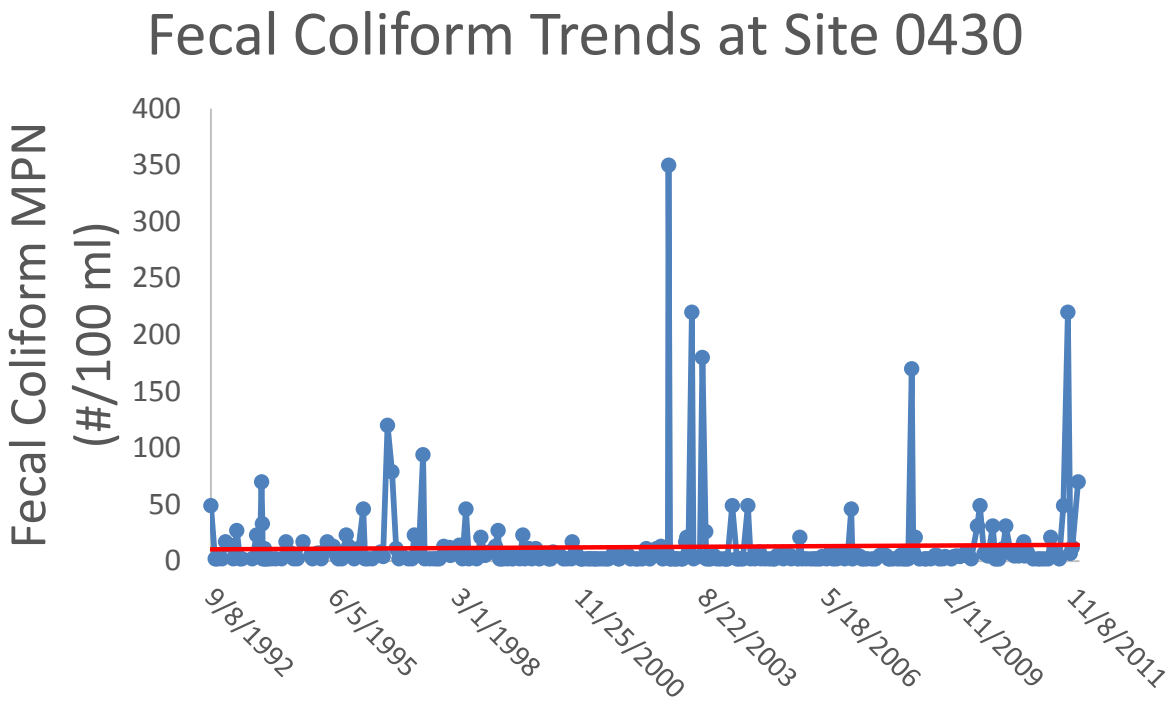

Fecal Coliform Trends at Site 0425
1600
2500
Fecal Coliform MPN (#/100 ml)
600
500
400
300
200
100
0
10/19/1989
7/15/1992
4/11/1995
1/5/1998
10/1/2000
6/28/2003
3/24/2006
12/18/2008
9/14/2011

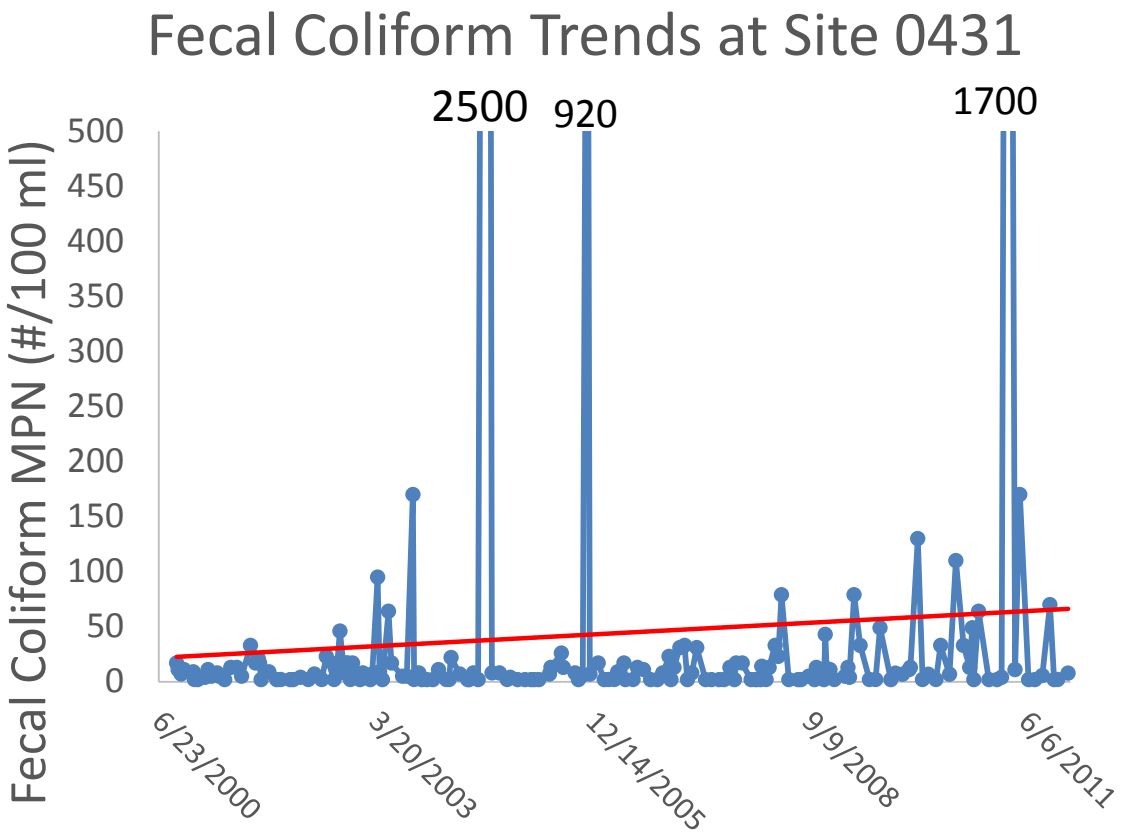

Fecal Coliform Trends at Site 0426
1600
1600
1600
Fecal Coliform MPN (#/100 ml)
1000
900
800
700
600
500
400
300
200
100
0
7/15/1992
4/11/1995
1/5/1998
10/1/2000
6/28/2003
3/24/2006
12/18/2008
9/14/2011


Fecal Coliform Trends at Site 0427
Fecal Coliform MPN (#/100 ml)
2500
1600
1600
1000
900
800
700
600
500
400
300
200
100
0
7/15/1992
1/5/1998
6/28/2003
12/18/2008


Fecal Coliform Trends at Site 0428
Fecal Coliform MPN (#/100 ml)
1700
350
300
250
200
150
100
50
0
9/3/1992
5/31/1995
2/24/1998
11/20/2000
8/17/2003
5/13/2006
2/6/2009
11/3/2011


Fecal Coliform Trends at Site 0429
1600
920
Fecal Coliform MPN (#/100 ml)
600
500
400
300
200
100
0
1992-09-08
1998-03-01
2003-08-22
2009-02-11


Fecal Coliform Trends at Site 0430
Fecal Coliform MPN (#/100 ml)
400
350
300
250
200
150
100
50
0
9/8/1992
6/5/1995
3/1/1998
11/25/2000
8/22/2003
5/18/2006
2/11/2009
11/8/2011


Fecal Coliform Trends at Site 0431
2500
920
1700
Fecal Coliform MPN (#/100 ml)
500
450
400
350
300
250
200
150
100
50
0
6/23/2000
3/20/2003
12/14/2005
9/9/2008
6/6/2011

Average Bacteria Loadings from various Animal Species:

Bacteria per gram of feces

Animal	*log CFU/ g feces*			
Canada Geese	2.6	4.6		
Cat	6.8	6.9	6.9	
Chickens	6.1	7.0		
Chipmunk	5.2			
Cow	-0.1	5.4	5.4	7.0
Dog	6.9	7.4	7.4	
Ducks	5.9	7.5	7.5	
Horse	2.2			
Human	7.1			
Mouse	8.0			
Muskrat	7.4			
Pigeon	8.2			
Pigs/Hogs	6.5	6.5	7.0	
Rabbit	0.0	1.3		
Rat	5.5			
Sheep	2.1	7.2		
Tree Frog	8.0			
Turkeys	5.5			
Whistling swans	6.4			

Min	-0.1
Max	8.2
Median	6.7

Bacteria per animal per day

Animal	*log CFU/day*				
Beaver	6.6				
Chickens	8.1	8.4			
Cow	7.0	9.7	9.7	11.0	11.0
Deer	8.5	8.7			
Ducks	8.1	9.4	10.0		
Geese	8.9	10.7			
Horse	8.6				
Human	9.3	9.3			
Pigs/Hogs	9.9	10.0			
Raccoon	8.1				
Sheep	10.1	10.3			
Turkeys	8.0	8.1			

Min	6.6
Max	11.0
Median	9.3

From: The Nutrient and Coliform Loading Project. Center for Coastal Environmental Health and Biomolecular Research. NOAA. http://www.chbr.noaa.gov/ncl/

APPENDIX E: SCDNR Designated Recreational/ State Shellfish Grounds and Commercial Permit Areas

Acreage
Subtidal: 8.5
Intertidal: 19.3

CULTURE PERMIT C371

LOCATION: Portions of Main Creek and Garden City Canal.
COUNTY: Georgetown

C371 is within SCDHEC Shellfish Management Area 4. These areas are subject to closure at any time. Please call (843)285-1618.

Legend

SHELLFISH HARVEST BOUNDARIES

- AREA OF INTEREST
- NEIGHBORING AREAS
  - C000 = COMMERCIAL CULTURE PERMIT
  - S000 = STATE SHELLFISH GROUNDS
- SHELLFISH MANAGEMENT AREAS (SCDHEC)

WATER QUALITY BOUNDARIES (SCDHEC)

- PROHIBITED
- RESTRICTED
- CONDITIONALLY APPROVED

N
W E
S

0 0.125 0.25 0.375 0.5 Miles

0 0.25 0.5 0.75 1 Kilometers

PRODUCED BY:
SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES
OFFICE OF FISHERIES MANAGEMENT
SHELLFISH MANAGEMENT SECTION
08/2012

PERMITTEE:Chris P. Nance
and Cynthia C. Nance
P. O. Box 2480
Murrells Inlet, SC 29576
(843) 651-8706

Acreage
Subtidal: 10.5
Intertidal: 2.6

CULTURE PERMIT C370

LOCATION: Portions of Whale Creek.
COUNTY: Georgetown

C370 is within SCDHEC Shellfish Management Area 4. These areas are subject to closure at any time. Please call (843)285-1618.

Legend

SHELLFISH HARVEST BOUNDARIES

- AREA OF INTEREST
- NEIGHBORING AREAS
  - C000 = COMMERCIAL CULTURE PERMIT
  - S000 = STATE SHELLFISH GROUNDS
- SHELLFISH MANAGEMENT AREAS (SCDHEC)

WATER QUALITY BOUNDARIES (SCDHEC)

- PROHIBITED
- RESTRICTED
- CONDITIONALLY APPROVED

N
W E
S

0 0.125 0.25 0.375 0.5 Miles

0 0.25 0.5 0.75 1 Kilometers

PERMITTEE: William A. Chandler,
Thomas M. Chandler Jr., Joseph A. Chandler
P. O. Box 1970
Murrells Inlet, SC 29576
(843) 651-7999

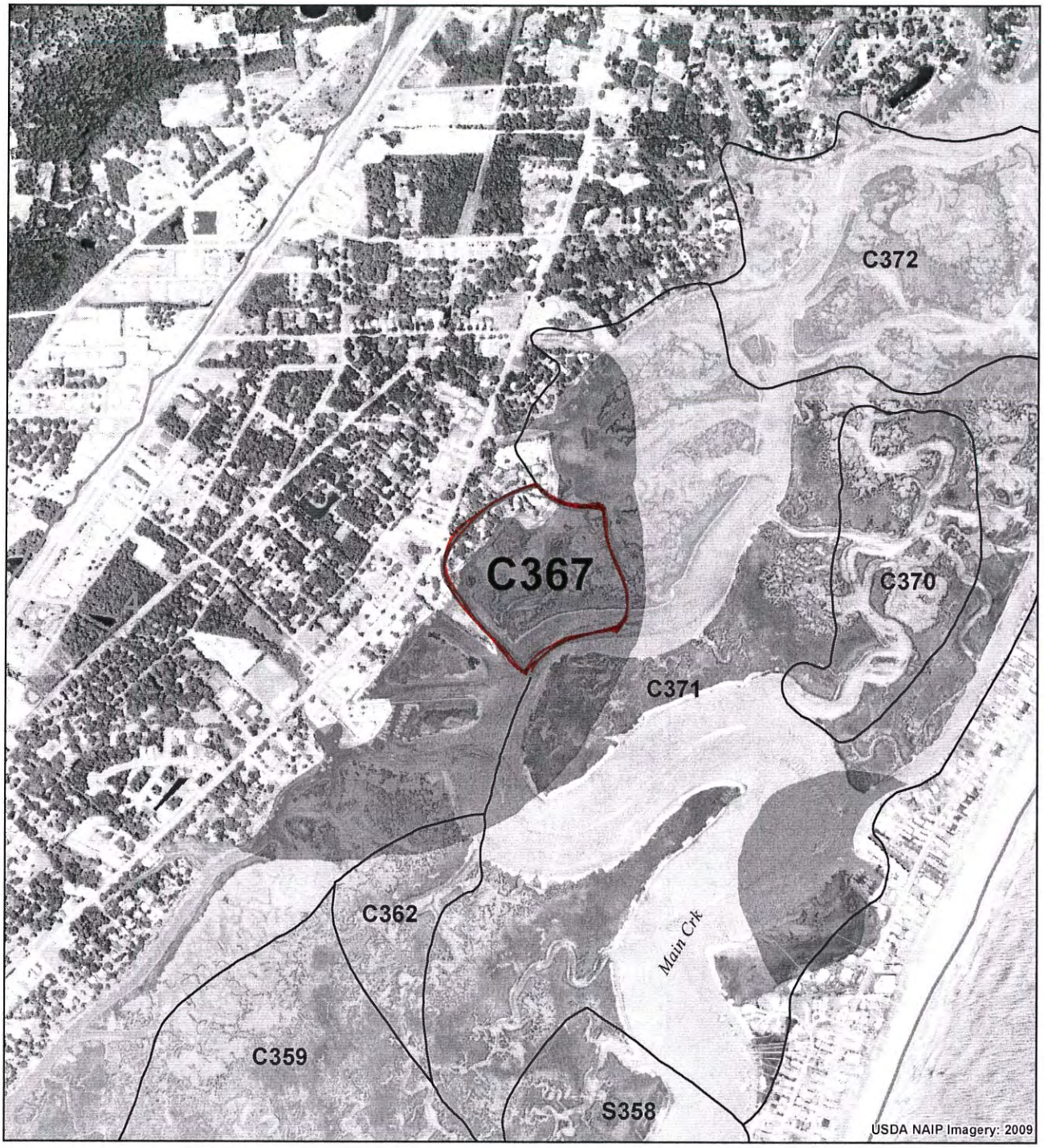
PRODUCED BY:
SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES
OFFICE OF FISHERIES MANAGEMENT
SHELLFISH MANAGEMENT SECTION
08/2012

Acreage
Subtidal:
Intertidal: 3.1

CULTURE PERMIT C367

LOCATION: Portions of Main Creek and Salt Creek.
COUNTY: Georgetown

C367 is within SCDHEC Shellfish Management Area 4. These areas are subject to closure at any time. Please call (843)285-1618.



Legend

SHELLFISH HARVEST BOUNDARIES

- AREA OF INTEREST
- NEIGHBORING AREAS
  - C000 = COMMERCIAL CULTURE PERMIT
  - S000 = STATE SHELLFISH GROUNDS
- SHELLFISH MANAGEMENT AREAS (SCDHEC)

WATER QUALITY BOUNDARIES (SCDHEC)

- PROHIBITED
- RESTRICTED
- CONDITIONALLY APPROVED

N
W E
S

0 0.125 0.25 0.375 0.5 Miles

0 0.25 0.5 0.75 1 Kilometers

PERMITTEE: Albert Hitchcock
P. O. Box 626, 512 Fox Hollow Road
Murrells Inlet, SC 29576
(843) 651-5778

PRODUCED BY:
SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES
OFFICE OF FISHERIES MANAGEMENT
SHELLFISH MANAGEMENT SECTION
08/2012

Acreage
Subtidal:
Intertidal: 1.2

CULTURE PERMIT C362

LOCATION: Portions of Main Creek and unnamed tributary.
COUNTY: Georgetown

C362 is within SCDHEC Shellfish Management Area 4. These areas are subject to closure at any time. Please call (843)285-1618.

Legend

SHELLFISH HARVEST BOUNDARIES

- AREA OF INTEREST
- NEIGHBORING AREAS
  - C000 = COMMERCIAL CULTURE PERMIT
  - S000 = STATE SHELLFISH GROUNDS
- SHELLFISH MANAGEMENT AREAS (SCDHEC)

WATER QUALITY BOUNDARIES (SCDHEC)

- PROHIBITED
- RESTRICTED
- CONDITIONALLY APPROVED

N
W E
S

0 0.125 0.25 0.375 0.5 Miles

0 0.25 0.5 0.75 1 Kilometers

PRODUCED BY:
SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES
OFFICE OF FISHERIES MANAGEMENT
SHELLFISH MANAGEMENT SECTION
08/2012

PERMITTEE: Chris Nance
Cedar Hill Landing
P. O. Box 2480
Murells Inlet, SC 29576
(843) 651-8706

Acreage
Subtidal:
Intertidal: 3.7

CULTURE PERMIT C352

LOCATION: Portion of Oaks Creek.
COUNTY: Georgetown

C352 is within SCDHEC Shellfish Management Area 4. These areas are subject to closure at any time. Please call (843)285-1618.

Legend

SHELLFISH HARVEST BOUNDARIES

- AREA OF INTEREST
- NEIGHBORING AREAS
  - C000 = COMMERCIAL CULTURE PERMIT
  - R000 = RECREATIONAL GROUNDS
  - S000 = STATE SHELLFISH GROUNDS
- SHELLFISH MANAGEMENT AREAS (SCDHEC)

WATER QUALITY BOUNDARIES (SCDHEC)

- PROHIBITED
- RESTRICTED
- CONDITIONALLY APPROVED

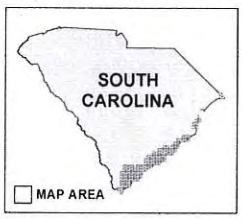
N
W E
S

0 0.125 0.25 0.375 0.5 Miles

0 0.25 0.5 0.75 1 Kilometers

PRODUCED BY:
SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES
OFFICE OF FISHERIES MANAGEMENT
SHELLFISH MANAGEMENT SECTION
08/2012

PERMITTEE: Nance's Creekfront Restaurant
LLoyd Milliken
P. O. Box 44
Murrells Inlet, SC 29576
(843) 651-2696

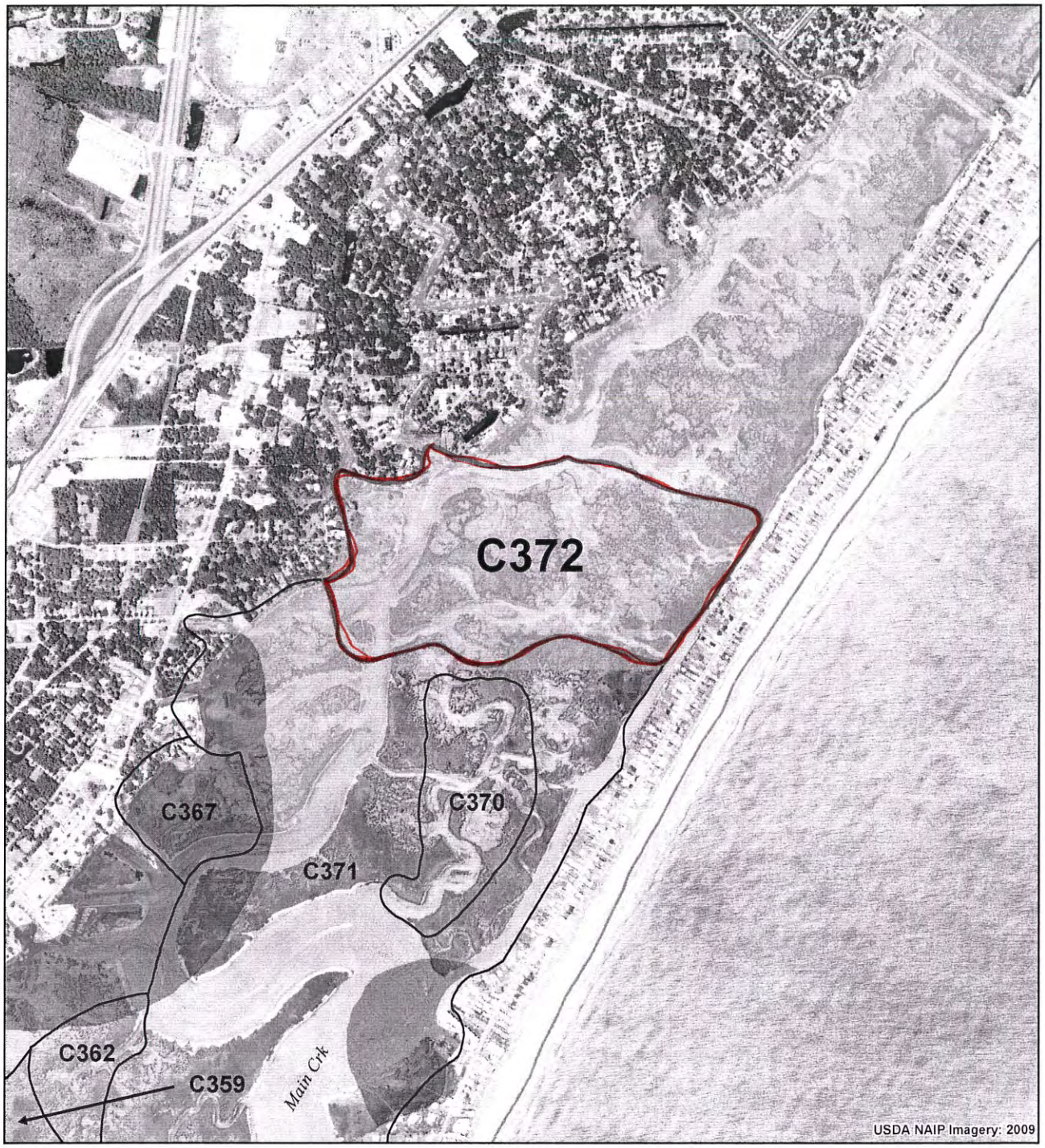


Acreage
Subtidal:
Intertidal: 7.6

CULTURE PERMIT C372

LOCATION: Portions of Main Creek.
COUNTY: Georgetown

C372 is within SCDHEC Shellfish Management Area 4. These areas are subject to closure at any time. Please call (843)285-1618.



Legend

SHELLFISH HARVEST BOUNDARIES

- AREA OF INTEREST
- NEIGHBORING AREAS
  C000 = COMMERCIAL CULTURE PERMIT
- SHELLFISH MANAGEMENT AREAS (SCDHEC)

WATER QUALITY BOUNDARIES (SCDHEC)

- PROHIBITED
- RESTRICTED
- CONDITIONALLY APPROVED

N
W E
S

0 0.125 0.25 0.375 0.5 Miles

0 0.25 0.5 0.75 1 Kilometers

PRODUCED BY:
SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES
OFFICE OF FISHERIES MANAGEMENT
SHELLFISH MANAGEMENT SECTION
08/2012

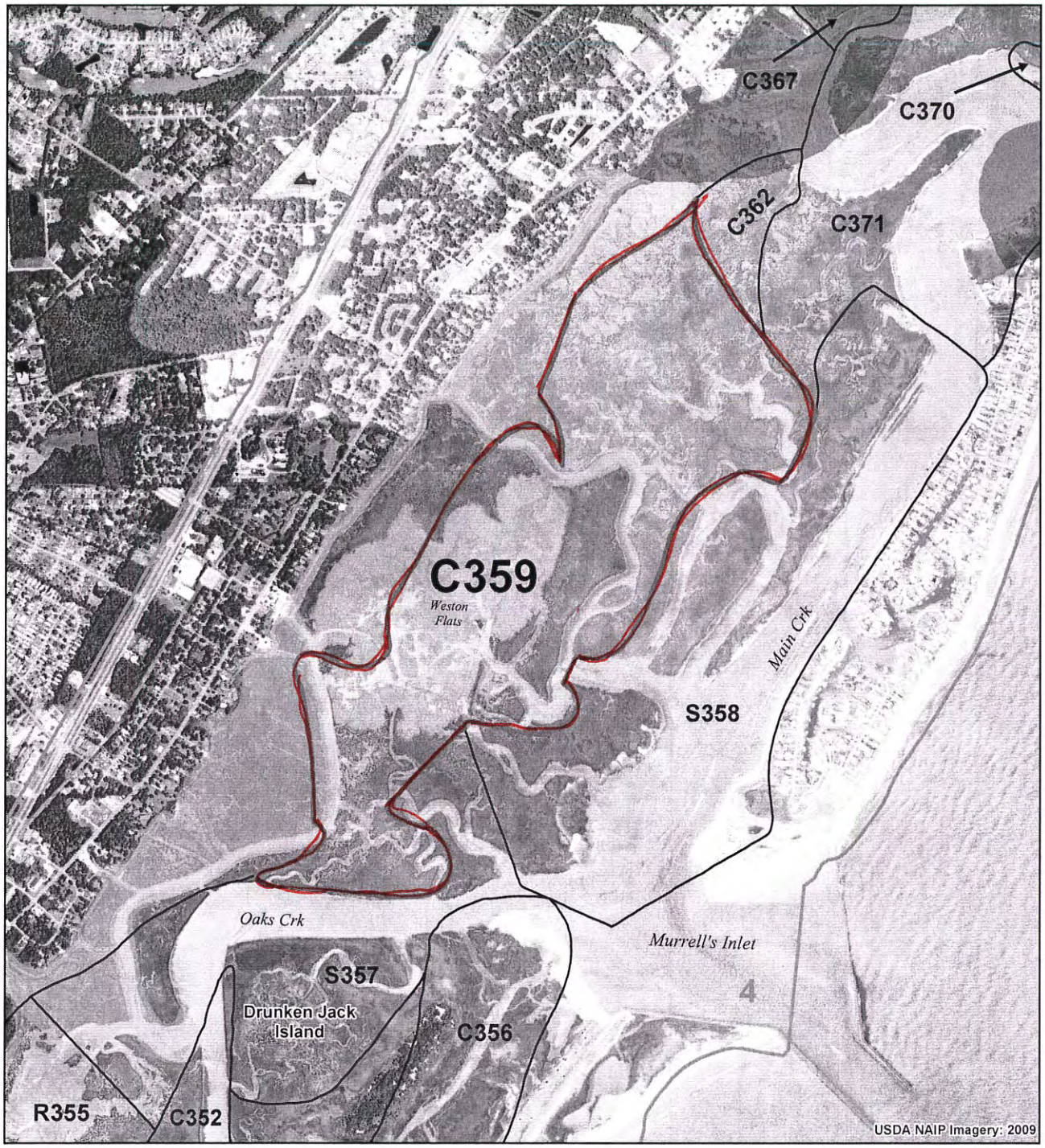
PERMITTEE: Nance's Creekfront Restaurant
LLoyd Milliken
P. O. Box 44
Murrells Inlet, SC 29576
(843) 651-2696

Acreage
Subtidal:
Intertidal: 33.2

CULTURE PERMIT C359

LOCATION: Portions of Weston Flats.
COUNTY: Georgetown

C359 is within SCDHEC Shellfish Management Area 4. These areas are subject to closure at any time. Please call (843)285-1618.



Legend

SHELLFISH HARVEST BOUNDARIES

- AREA OF INTEREST
- NEIGHBORING AREAS
  - C000 = COMMERCIAL CULTURE PERMIT
  - R000 = RECREATIONAL GROUNDS
  - S000 = STATE SHELLFISH GROUNDS
- SHELLFISH MANAGEMENT AREAS (SCDHEC)

WATER QUALITY BOUNDARIES (SCDHEC)

- PROHIBITED
- RESTRICTED
- CONDITIONALLY APPROVED

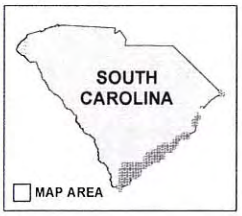
N
W E
S

0 0.125 0.25 0.375 0.5 Miles

0 0.25 0.5 0.75 1 Kilometers

PRODUCED BY:
SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES
OFFICE OF FISHERIES MANAGEMENT
SHELLFISH MANAGEMENT SECTION
08/2012

PERMITTEE: Nance's Creekfront Restaurant
LLoyd Milliken
P. O. Box 44
Murells Inlet, SC 29576
(843) 651-2696



Acreage
Subtidal:
Intertidal: 1.2

CULTURE PERMIT C356

LOCATION: Unnamed creek between Drunken Jack Island and Oaks Creek and the south jetty.
COUNTY: Georgetown

C356 is within SCDHEC Shellfish Management Area 4. These areas are subject to closure at any time. Please call (843)285-1618.

Legend

SHELLFISH HARVEST BOUNDARIES

- AREA OF INTEREST
- NEIGHBORING AREAS
  - C000 = COMMERCIAL CULTURE PERMIT
  - R000 = RECREATIONAL GROUNDS
  - S000 = STATE SHELLFISH GROUNDS
- SHELLFISH MANAGEMENT AREAS (SCDHEC)

WATER QUALITY BOUNDARIES (SCDHEC)

- PROHIBITED
- RESTRICTED
- CONDITIONALLY APPROVED

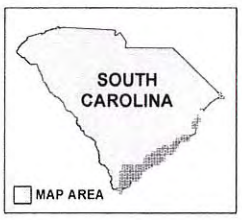
N
W E
S

0 0.125 0.25 0.375 0.5 Miles

0 0.25 0.5 0.75 1 Kilometers

PRODUCED BY:
SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES
OFFICE OF FISHERIES MANAGEMENT
SHELLFISH MANAGEMENT SECTION
08/2012

PERMITTEE: Chris Nance
Cedar Hill Landing
P. O. Box 2480
Murells Inlet, SC 29576
(843) 651-8706

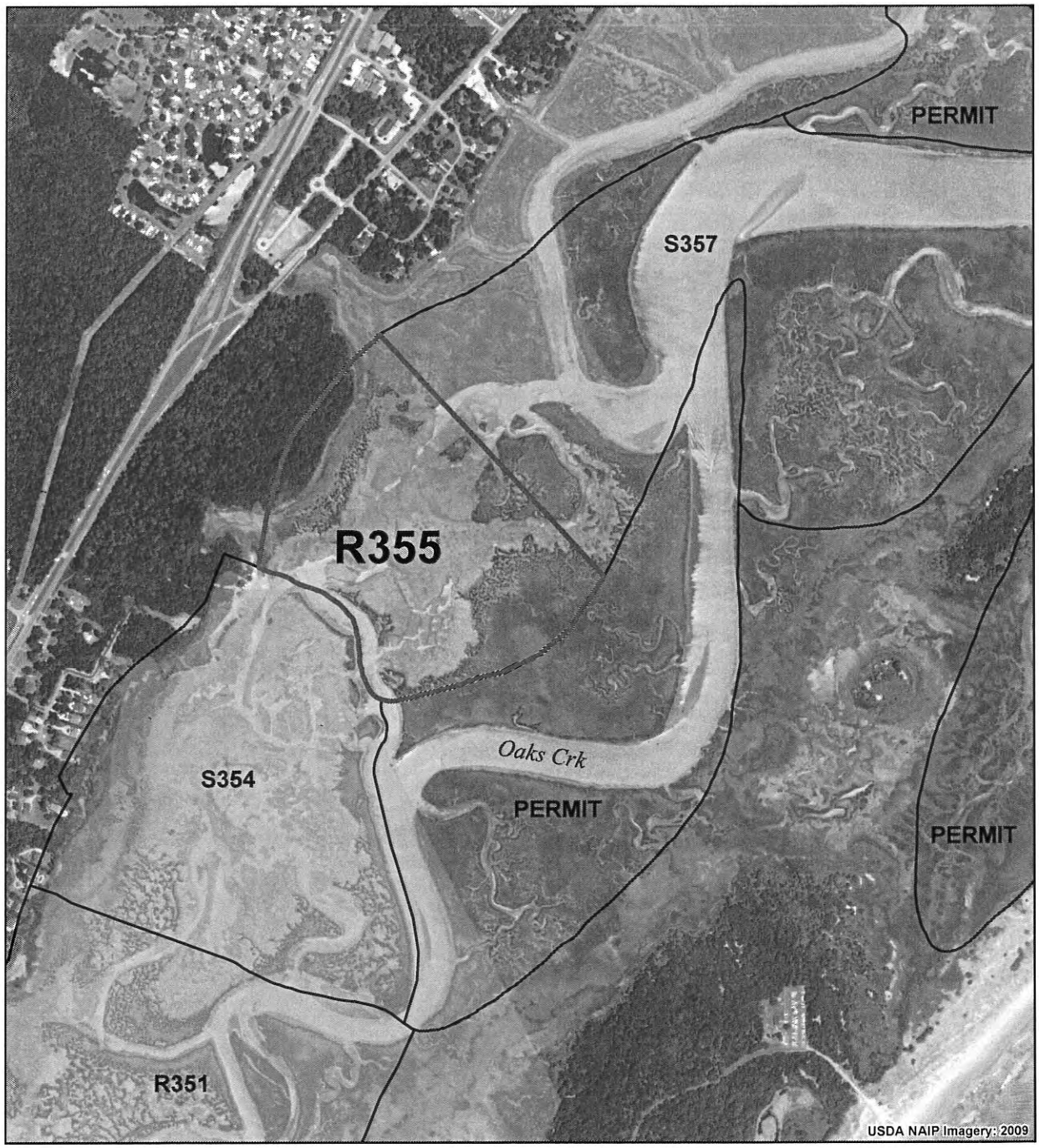


Lachicotte Oyster Factory PSG - R355

R355 is within SCDHEC Shellfish Management Area 4. These areas are subject to closure at any time. Please call (800)285-1618

Clams - Partially Closed SCDHEC
Oysters - Partially Closed SCDHEC

LOCATION: Portion of a tributary of Oaks Creek
COUNTY: Georgetown



Legend

SHELLFISH HARVEST BOUNDARIES

- R061
- NEIGHBORING AREAS
  - PERMIT = COMMERCIAL PERMIT
  - R000 = RECREATIONAL SHELLFISH GROUND
  - S000 = STATE SHELLFISH GROUND

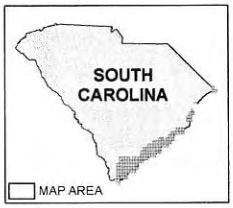
WATER QUALITY (SCDHEC)

- PROHIBITED
- RESTRICTED
- CONDITIONALLY APPROVED

N
W E
S

0 500 1,000 1,500 2,000 Feet

0 100 200 300 400 Meters



PRODUCED BY:
SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES
OFFICE OF FISHERIES MANAGEMENT
SHELLFISH MANAGEMENT SECTION
08/2012

Drunken Jack Island S357

S357 is within SCDHEC Shellfish Management Area 4. These areas are subject to closure at any time. Please call (800)285-1618

SHELLFISH SEASON
2012 - 2013

Legend

SHELLFISH HARVEST BOUNDARIES

- AREA OF INTEREST
- NEIGHBORING AREAS
  - C000 = COMMERCIAL CULTURE PERMIT
  - R000 = RECREATIONAL SHELLFISH GROUND
  - S000 = STATE SHELLFISH GROUND
- SHELLFISH MANAGEMENT AREAS (SCDHEC)

WATER QUALITY (SCDHEC)

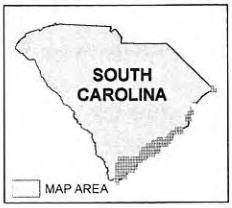
- PROHIBITED
- RESTRICTED
- CONDITIONALLY APPROVED

N
W E
S

0 1,000 2,000 3,000 4,000 Feet

0 200 400 600 800 Meters

Location: Portions of Oaks Creek, and Allston Creek
County: Georgetown



PRODUCED BY:
SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES
OFFICE OF FISHERIES MANAGEMENT
SHELLFISH MANAGEMENT SECTION
08/2012

Murrells Inlet S358

S358 is within SCDHEC Shellfish Management Area 4. These areas are subject to closure at any time. Please call (800)285-1618

SHELLFISH SEASON
2012 - 2013

Legend

SHELLFISH HARVEST BOUNDARIES

- AREA OF INTEREST
- NEIGHBORING AREAS
  C000 = COMMERCIAL CULTURE PERMIT
  S000 = STATE SHELLFISH GROUND
- SHELLFISH MANAGEMENT AREAS (SCDHEC)

WATER QUALITY (SCDHEC)

- PROHIBITED
- RESTRICTED
- CONDITIONALLY APPROVED

N
W E
S

0 1,000 2,000 3,000 4,000 Feet

0 200 400 600 800 Meters

Location: Main Creek
County: Georgetown

PRODUCED BY:
SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES
OFFICE OF FISHERIES MANAGEMENT
SHELLFISH MANAGEMENT SECTION
08/2012

APPENDIX F: Stakeholder Bacteria Source Identification Workshop Summary

Steering Committee Workshop- November 14, 2012

In the early phases of the Watershed Plan project, the project coordinators hosted a workshop with the community steering committee to receive their input on the location and potential sources of fecal coliform pollution that is entering the Murrells Inlet estuary. The project coordinating team utilized a 3'x 12' aerial map highlighting the watershed boundaries, current shellfish harvesting area classification, and locations of the eight sites that are part of the Murrells Inlet volunteer monitoring program. Participants marked locations on the map where they suspected sources of bacterial pollution may be impacting water quality in Murrells. At each location, the participant provided a detailed description of the pollution concern. This workshop was very beneficial for several reasons. Collectively, the community steering committee has an extraordinary level of familiarity with Murrells Inlet and some very valuable local insight and knowledge on the history of the community. They were able to provide incredibly useful background information on various development patterns, public investments including the jetty system, major storm impacts, etc. The workshop facilitated an excellent communication exchange between community stakeholders and the project coordinating team. The mapping exercise enabled the project coordinating team to easily document steering committee input. Below is a summary of participant feedback received during the watershed map workshop:

SILTING:

- Silting is occurring because of boat traffic and resulting waves which erode shorelines. Because of dredging which introduces silt into flow stream with no way to purge it from upper reaches of creeks. Silting is detrimental to the growth of oysters. ***(Watershed Wide)***

DREDGING:

- Dredging should be done in some areas where silting has obstructed flow and the ability to purge. Dredging should only be done at falling tides. ***(Parsonage Creek should be a priority creek)***

DEVELOPMENT:

- High density development is a major contribution of pollution and zoning considerations toward limiting high density along creek front should be made.

PET WASTE:

- Despite efforts to provide pet waste bags and trash cans, this remains a problem in several areas throughout the watershed.
- Fish cleaning near bike bridge volunteer monitoring site.
- Site of kennel
- Problems with loose dogs in the Mt. Gilead neighborhood

WATERFOWL/ WILDLIFE:

- Several stormwater ponds throughout the watershed attract large and concentrated waterfowl populations. There are several areas where waterfowl approach vehicles indicative of previously being fed.
- Reports of wild hog population colonizing Brookgreen Gardens and Huntington Beach State Park area.
- Major geese populations in the stormwater ponds near the Inlet Square Mall
- Several feral cat colonies have been noticed in various locations throughout the community.

FLOODING/DRAINAGE:

- Residential yards have a tendency to flood on spring tides and Noreaster storm events.
- Drainage from Brookgreen Gardens via Rose Branch Creek under US Hwy 17
- General lack of flushing during tidal flow. Growing problem over time.

SEWER INFRASTRUCTURE/ SEPTIC ISSUES:

- Reported sewer pipe leak along Atlantic Ave. in Garden City
- There are still areas serves by septic tanks.

LEGACY ISSUES:

- Possible former sewer lagoon near Bay Harbor?
- Former spoil site for dredging.
- Former Goat Farm
- Former Chicken Farm/Processing Plant.

HUNTINGTON BEACH STATE PARK/ BROOKGREEN GARDENS AREA:

- Dump station at North Beach parking lot

APPENDIX G: Murrells Inlet Soil Profile

This appendix provides a description of the soils that are present in the Murrells Inlet watershed. Soils have a wide variety of characteristics erosion rates and permeability. These factors can give watershed managers a general sense of the drainage traits of various areas within the watershed. These soil characteristics are also one of the primary determinants of whether an area is suitable to septic systems or limitations which could impact residential and commercial development. Finally, assessing the underlying soil types helps stormwater managers to select, site, and design various structural BMPs.

Soil Groups Present in the Murrells Inlet Watershed					
Soil Type	Acreage	Erosion Factor (K)	Hydrological Soil Group	Features Affecting	
				Septic System	Drainage
Beaches	56.95				
Blanton	12.67	0.10-0.20	A	Moderate: wetness	Deep to water
Bohicket:	2000.15	0.24-0.28	D	Severe: flooding, ponding, percs slowly	Ponding, percs slowly, flooding
Centenary	1025.78	0.10	B	Severe: wetness, poor filter	Cutbanks cave
Chipley	974.98	0.17	B	Severe: wetness, poor filter	Cutbanks Cave
Echaw	150.15	0.10	B	Severe: wetness, poor filter	Cutbanks cave
Hobcaw	40.32	0.17-0.24	D	Severe: ponding	Ponding
Johnston	21.20	0.17-0.20	D	Severe: flooding,	Ponding, flooding,

				ponding, poor filter	cutbanks cave.
Kenansville	68.08	0.15	A	Moderate: wetness	Deep to water
Lakeland	1612.97	0.17	A	Severe: poor filter	Deep to water
Leon	973.51	0.17-0.20	B/D	Severe: wetness	Slope, cutbanks cave
Lynn Haven	35.98	0.15-0.20	B/D	Severe: wetness	Cutbanks cave
Newhan	618.85	0.10	A	Severe: poor filter	Deep to water
Ogeechee	212.02	0.10-0.15	B/D	Severe: wetness	Favorable
Rutlege	117.80	0.17	B/D	Severe: ponding, poor filter	Flooding, cutbanks cave
Udorthents	11.49	0.10-0.15	B	Severe: wetness	
Witherbee	22.86	0.10	B	Severe: wetness,poor filter	Cutbanks cave
Yauhannah	11.03	0.17-0.24	B	Severe: wetness	Favorable
Yemassee	134.49	0.10-0.20	C	Severe: wetness	Severe, cutbanks cave
Yonges	23.63	0.17-0.20	D	Severe: wetness, percs slowly	Favorable

Notes:

Hydrological groups classifications indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. They are one factor utilized in determining runoff curve numbers. Below are the basic classifications with a general description.

Hydrologic Soil Group Chart		
Hydrologic Soil Groups	**Soil Texture**	**Infiltration/ transmission Characteristics**
A	Sand, loamy sand, or sandy loam	Low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sand or gravel and have a high rate of water transmission (greater than 0.30in/hr)
B	Silt loam or loam	Moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to coarse textures. These soils have a moderate rate of water transmission. (0.15-0.30in/hr)
C	Sandy clay loam	Low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission. (0.05-0.15 in/hr)
D	Clay loam, silty clay loam, sandy clay, silty clay or clay	High runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay sould with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0.0-0.05 in/hr)
Source: USDA, Natural Resources Conservation Service.		

K Factor Description: The K factor is used to assess the erodibility of each soil type. The primary physical factors that affect soil erodibility are particle size, organic matter, structure, and permeability. These soil characteristics effect the general texture of the soil which are described in the table below. Note that the lower the K factor value, the less erosive the soil type.

General Description of Soil Texture Types and Associated K Factor Ranges		
Soil Type	Description	Typical K Factor Range
Fine textures (Clays)	Resistant to detachment because of aggregation	0.05-0.15
Coarse textures (Sands)	Easily detached, but low runoff, because large, dense soil particles are not easily transported.	0.05-0.20
Medium textures (Loams)	Moderately detachable, moderate to high runoff.	0.25-0.45
Silts	Easily detached, high runoff. Small, easily transported sediment.	0.45-0.65
Source: USDA, Natural Resources Conservation Service.		

APPENDIX H: Georgetown and Horry County Council Resolutions

Georgetown County Council Resolution

Georgetown County
South Carolina

Agenda Item

Item:	9b
Issue under Consideration:	Resolution No. 2012-17 - Consideration of approval and execution of a resolution in support of the development and implementation of the Murrells Inlet Watershed Management Plan coordinated by the Waccamaw Regional Council of Governments.
Current Status:	Waccamaw Regional Council of Governments has submitted to SCDHEC an application for a grant to help fund the development of a watershed management plan.
Points to Consider:	1) The Murrells Inlet community suffers from chronic fecal coliform water quality contamination and closed shellfish harvesting beds due to pollution violations. 2) SCDHEC has completed a Total Maximum Daily Load (TMDL) for fecal coliform reduction required for Murrells Inlet Estuary waters. 3) Georgetown County's MS4 permit requires the county to take steps to monitor and identify pollutant sources, and implement measures to reduce fecal coliform contamination. 4) The citizens and businesses and stakeholders of Murrells Inlet Estuary have committed to undertake a multi-jurisdictional effort led by the Waccamaw Regional Council of Governments to develop a watershed management plan. 5) The watershed management plan implementation will be to achieve compliance with state water quality standards, re-open closed shellfish harvesting beds, and sustain Murrells Inlet's nature-based economy and identity
Financial Impact:	No financial impact

Options:	Option 1: Adopt the resolution and commit to be a lead cooperator in the development and implementation of a watershed management plan for Murrells Inlet Estuary. Option 2: Deny this request
Recommendations:	Adopt the resolution and commit to be a lead cooperator in the development and implementation of a watershed management plan for Murrells Inlet Estuary.
Department:	Public Services / Stormwater

COUNTY OF GEORGETOWN)
)
STATE OF SOUTH CAROLINA)

RESOLUTION NO. 2012-17

RESOLUTION IN SUPPORT OF THE DEVELOPMENT AND IMPLEMENTATION OF A MURRELLS INLET WATERSHED MANAGEMENT PLAN

WHEREAS, the Murrells Inlet community in Horry and Georgetown Counties enjoys a thriving economy based on fishing and tourism, has long been considered to be the most economically important shellfish producing area along South Carolina's northern coast, and is commonly known as the Seafood Capital of South Carolina; and

WHEREAS, the Murrells Inlet Estuary suffers from chronic fecal coliform water quality contamination and closed shellfish harvesting beds due to state water quality standard violations; and

WHEREAS, the South Carolina Department of Health and Environmental Control (SCDHEC) has completed a Total Maximum Daily Load (TMDL) technical report for fecal coliform reduction required for Murrells Inlet Estuary waters to comply with state water quality standards; and

WHEREAS, Georgetown County must comply with provisions in its permit (#SCR034301) under the State of South Carolina NPDES (National Pollutant Discharge Elimination System) General Permit for Storm Water Discharges from Regulated Small Municipal Separate Storm Sewer Systems (MS4s), which requires that Georgetown County take steps to monitor and identify pollutant sources leading to fecal coliform contamination in Murrells Inlet and implement measures to reduce those sources according to the TMDL technical report findings; and

WHEREAS, the citizens and businesses and stakeholders of Murrells Inlet Estuary have committed to undertake a multi-jurisdictional effort led by the Waccamaw Regional Council of Governments to develop a watershed management plan, which will include identification of pollutant sources, prioritization of appropriate best management practices to address those pollutant sources, and preparation of cost estimates for implementing those best management practices; and

WHEREAS, the Waccamaw Regional Council of Governments has been awarded a grant from SCDHEC to help fund the development of such a watershed management plan; and

WHEREAS, the intention of watershed management plan implementation will be to achieve compliance with state water quality standards, re-open closed shellfish harvesting beds, and sustain Murrells Inlet's nature-based economy and identity;

NOW, THEREFORE BE IT RESOLVED that Georgetown County Council commits to be a lead cooperator in the development and implementation of a watershed management plan for Murrells Inlet Estuary.

AND IT IS SO RESOLVED, this 23rd day of October, 2012.

GEORGETOWN COUNTY COUNCIL

_____
Johnny Morant, Chairman, District 7

_____
Jerry Oakley, District 1

_____
Ron Charlton, District 2

_____
Leona Myers-Miller, District 3

_____
Lillie Johnson, District 4

_____
Austin Beard., District 5

_____
Bob Anderson, District 6

ATTEST:

_____
Theresa Floyd, Clerk to Council

Horry County Council Resolution

COUNTY OF HORRY)
)
STATE OF SOUTH CAROLINA)

RESOLUTION R-75-12

RESOLUTION IN SUPPORT OF THE DEVELOPMENT AND IMPLEMENTATION OF A MURRELLS INLET WATERSHED MANAGEMENT PLAN

WHEREAS, the Murrells Inlet community in Horry and Georgetown Counties enjoys a thriving economy based on fishing and tourism, has long been considered to be the most economically important shellfish producing area along South Carolina's northern coast, and is commonly known as the Seafood Capital of South Carolina; and

WHEREAS, the Murrells Inlet Estuary suffers from chronic fecal coliform water quality contamination and closed shellfish harvesting beds due to state water quality standard violations; and

WHEREAS, the South Carolina Department of Health and Environmental Control (SCDHEC) has completed a Total Maximum Daily Load (TMDL) technical report for fecal coliform reduction required for Murrells Inlet Estuary waters to comply with state water quality standards; and

WHEREAS, Horry County must comply with provisions in its permit (#SCR035104) under the State of South Carolina NPDES (National Pollutant Discharge Elimination System) General Permit for Storm Water Discharges from Regulated Small Municipal Separate Storm Sewer Systems (MS4s), which requires that Horry County take steps to monitor and identify pollutant sources leading to fecal coliform contamination in Murrells Inlet and implement measures to reduce those sources according to the TMDL technical report findings; and

WHEREAS, the citizens and businesses and stakeholders of Murrells Inlet Estuary have committed to undertake a multi-jurisdictional effort led by the Waccamaw Regional Council of Governments to develop a watershed management plan, which will include identification of pollutant sources, prioritization of appropriate best management practices to address those pollutant sources, and preparation of cost estimates for implementing those best management practices; and

WHEREAS, the Waccamaw Regional Council of Governments has been awarded a grant from SCDHEC to help fund the development of such a watershed management plan; and

WHEREAS, the intention of watershed management plan implementation will be to achieve compliance with state water quality standards, re-open closed shellfish harvesting beds, and sustain Murrells Inlet's nature-based economy and identity;

NOW, THEREFORE BE IT RESOLVED that Horry County Council commits to be a lead cooperator in the development and implementation of a watershed management plan for Murrells Inlet Estuary.

AND IT IS SO RESOLVED this 13th day of November 2012.

HORRY COUNTY COUNCIL

H. Tom Rice, Chairman

Harold G. Worley, District 1

Brent J. Schulz, District 2

Marion D. Foxworth, III, District 3

Gary Loftus, District 4

Paul D. Prince, Jr., District 5

Robert P. Grabowski, District 6

James R. Frazier, District 7

Carl H. Schwartzkopf, District 8

W. Paul Prince, District 9

Jody Prince, District 10

Al Allen, District 11

ATTEST:

Patricia S. Hartley, Clerk to Council

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