

Watershed Management Plan

Battery Creek Watershed – HUC 030502080501

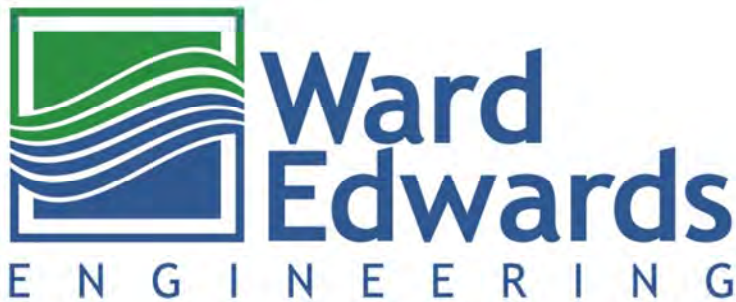
Prepared for the City of Beaufort and Beaufort County



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Prepared By:



CIVIL ENGINEERING &
LAND DEVELOPMENT
CONSULTING

PO Box 381, Bluffton, SC 29910
T 866.837.5250
F 843.837.2558
WardEdwards.com

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Executive Summary

The 9,946 acre Battery Creek watershed (HUC 030502080501) is located in Beaufort County South Carolina and spans portions of the City of Beaufort, the Town of Port Royal, and unincorporated Beaufort County. Battery Creek is a saltwater river, with no freshwater inputs other than stormwater runoff and it drains to the Beaufort River. The water quality within the watershed is generally good, with the exception of impairments for fecal coliform bacteria related to shellfish harvesting classification. Bacteria levels generally meet the recreational standards but exceed shellfish standards in portions of the river. The river has two shellfish harvesting areas listed as “restricted”, two areas listed as “prohibited” and one central area “approved” for harvesting (Figure 3-1). The restricted areas are around shellfish monitoring stations 15-19 and 15-25 (Figure 3-1). The impairment in the restricted areas is believed to be recoverable based on water quality modeling done as part of the 2006 Beaufort County Stormwater Master Plan (SWMP). The modeling results predict that the impairment around Station 15-19 in particular could benefit from water quality BMP retrofits, as the retrofits would result reduce bacteria load down to levels closer to shellfish geomean standards.

Beaufort County initiated the plan to address water quality in the Watershed. The Beaufort County SWMP identified three regional water quality retrofits that could benefit the watershed. The 2009 Regional Retrofit Study refined the retrofit plan and provided a basic implementation plan for the projects. The City of Beaufort has recently taken the initiative in efforts to address the Battery Creek impairments, committing to eliminating the impairments as they are the only water quality problems within the City boundaries. The City plans to address the impairments by partnering with Beaufort County to implement the strategies found within this Battery Creek Watershed Management Plan (WMP).

The WMP calls for many different structural and non-structural BMPs, as well as outreach and education programs. Strategies include four regional water quality retrofits, four non-regional retrofit strategies, two preservation/development policy strategies, and three education/outreach policies. An example of one of the non-regional strategies is already underway and led by Beaufort County. The County has initiated a parking lot project for its County Headquarters parking lot that involves replacing existing impervious pavement with new permeable paving. The implementation plan identifies this strategy already underway and sets a timeline for implementation of the other strategies. First among new strategies is the implementation of the Burton Hill M2 Regional Retrofit, which involves redirecting basin runoff to an existing pond just upstream, but offline of a known bacteria hotspot. The regional retrofit plan calls for the flow from the 500 acre upstream basin to be diverted to the existing pond. An outfall structure will be added to the pond to provide attenuation of the upstream runoff, and release the stored stormwater at rates less than current conditions. It is expected that the pond will provide effective removal of bacteria from the runoff.

The management strategies are expected to benefit the water quality within the watershed by reducing the amount of runoff, and thus the amount of pollutants reaching the river. The regional structural BMPs proposed will treat the runoff for bacteria before discharging runoff to the river. Non-regional strategies will help reduce the sources of bacteria by such strategies as reducing pet waste. The education and outreach strategies will improve future stormwater BMP designs. Milestones and evaluation criteria are established in the WMP. It is believed that implementation of the plan could eventually result in the restoration of shellfish harvesting from currently restricted areas.

1.0 Introduction:

Located in the South Carolina lowcountry, the Battery Creek watershed (HUC 030502080501) is approximately 9,946 acres in size and spans portions of the City of Beaufort, the Town of Port Royal, and unincorporated Beaufort County. Battery Creek is a euhaline river, with no freshwater inputs other than stormwater runoff. Battery Creek drains to the Beaufort River, which in turn drains to Port Royal Sound and the Atlantic Ocean.

1.1 Watershed Management Plan Purpose

Beaufort County commissioned a Stormwater Master Plan (SWMP) in 2006 with the intent to develop a county-wide infrastructure inventory and to recommend improvements addressing known water quantity and water quality problem areas. The study identified eight priority basins throughout the County based on documented impairments and with anticipated degradation from ongoing development. A portion of the Battery Creek watershed was one of the eight priority basins identified, based on fecal coliform bacteria impairment and a use classification of Shellfish Harvesting (SF).

The Battery Creek basin and the other seven priority basins were studied further in 2009 to develop regional water quality retrofit plans for each and to prioritize implementation of the retrofits. Battery Creek was selected as a priority watershed given the following factors:

- The river has only two small areas restricted for shellfish harvesting due to bacteria impairment. The upstream headwaters are classified for recreation use only, and bacteria levels for these areas currently meet the recreational standards.
- There are three potential regional stormwater retrofits within the Battery Creek watershed that along with non-regional management strategies, have the potential to get the entire river into full compliance.
- Ongoing monitoring resulted in identification of a bacteria hotspot located upstream of the restricted shellfish harvesting area between SCDHEC Shellfish Stations 15-19 and 15-29. One of the three potential regional stormwater retrofit project is located immediately upstream of the hotspot and could result in a significant reduction in bacteria loads reaching the impaired waters.
- The property owner of one of the regional retrofit project sites is willing to cooperate and allow the planned BMP to be constructed on his land.
- This proposed retrofit has a relatively low implementation cost compared to other regional retrofit projects.
- Battery Creek is currently the only impaired water body within the City of Beaufort's boundaries and City officials are being proactive in addressing the problems. The City has an intergovernmental agreement with the Beaufort County Stormwater Utility and the two agencies are sharing responsibilities and funding for the Watershed Management Plan.

1.2 Management Team

The development and implementation of the Battery Creek Watershed Management Plan is a collaborative effort between the City of Beaufort and Beaufort County. The Beaufort County Stormwater Utility initiated the project through its county-wide Stormwater Management Plan and further refined it in the 2011 Regional Retrofit Study. The City is motivated to implement the WMP to support its Civic Master Plan, which outlines future development and redevelopment within the City boundaries. If the impairment in Battery Creek can be addressed, then the anti-degradation stormwater standards currently in place will allow for development and re-development to occur as desired.

An intergovernmental agreement between the two participants laid the groundwork for cooperation and cost sharing. The City of Beaufort is leading the WMP implementation, with the Beaufort County Stormwater Utility providing financial and technical support. Details of the Management Team responsibilities are explained further in Section 6.

2.0 Watershed Overview

2.1 Watershed Boundary and Land Use

Located in northern Beaufort County, Battery Creek’s 9,946 acre watershed encompasses portions of the City of Beaufort, the Town of Port Royal, and unincorporated Beaufort County (Figure 2-1). Much of the outer boundary follows existing arterial roads including Ribaut Road, Parris Island Gateway, Broad River Boulevard, and Boundary Street. The overall watershed includes 4,256 acres of open water and saltwater marsh, with the remaining area being uplands and freshwater wetlands. The watershed is divided into four sub-basins based on the modeling done in the Beaufort County SWMP. Table 1 shows the overall land use for each of the four sub-basins and the totals for the watershed as a whole.

Table 1 - Battery Creek Watershed Land Use

Existing Land Use Type	Battery Creek 1	Battery Creek 2	Battery Creek 3	Battery Creek 4	Total Watershed
Agriculture/Pasture	0	0	0	0	0
Commercial	159	261	31	23	474
Forest/Rural Open	72	199	11	0	310
Golf Course	28	0	0	0	0
High Density Residential	1,340	925	129	47	2,441
Industrial	562	291	54	44	951
Institutional	46	81	15	28	170
Low Density Residential	0	1	0	0	1
Medium Density Residential	0	0	0	0	0
Open Water/Tidal	3,112	986	147	11	4,256
Silviculture	0	164	0	0	164
Urban Open	342	313	5	29	689
Wetland/Water	131	359	0	0	490
Total	5,792	3580	391	183	9,946
Urban Impervious (%)	21%	26%	35%	47%	24%

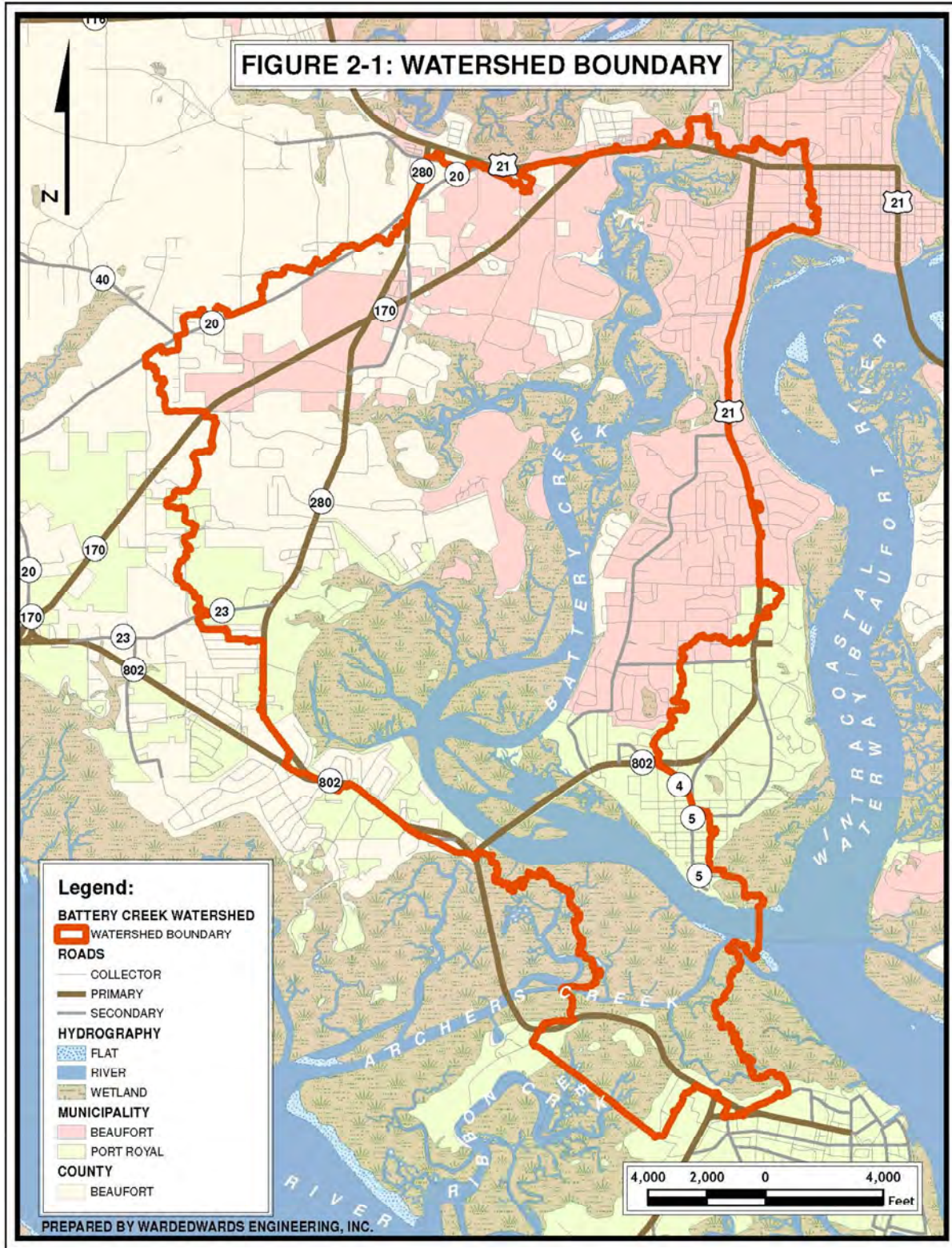


Figure 2-1 - Watershed Boundary

Battery Creek 1 is the southern portion of the watershed, where the river connects to the Beaufort River to the south and extends north to the approximate location of shellfish monitoring station 15-19. This sub-basin includes Beaufort County jurisdiction on the western end, Town of Port Royal jurisdiction to the southwest and southeast, and City of Beaufort jurisdiction to the northeast and northwest. The City of Beaufort areas are mostly small suburban single family land uses, with a few highway commercial properties as well. The Beaufort County areas are mostly rural single family residential. The Town of Port Royal's areas include suburban single family residential and highway commercial land uses. The highway commercial areas in all jurisdictions of this sub-basin are being developed and redeveloped at a moderate rate. The residential areas for the City and Town are mostly developed, although there is some infill in the newer subdivisions that haven't yet reached full build-out. The rural areas in the County could be developed at low densities or face annexation into the Town of Port Royal. Annexed properties would likely be developed at greater densities than if they were to remain in Beaufort County's jurisdiction.

Battery Creek 2 is the middle portion of the river that starts south of shellfish monitoring Station 15-19 and extends north to Station 15-32. The western portions include rural residential and highway commercial developments under Beaufort County jurisdiction. It also includes some highway commercial and suburban residential land under City jurisdiction. These areas are facing development and redevelopment pressure along the highway corridors, as well as infill of the suburban residential areas. The eastern portion of the basin is all under City jurisdiction and includes mostly suburban residential and institutional land uses. Most of these areas are fully developed, although there is some infill development possible along the highway corridor.

Battery Creek 3 is the north western portion of the headwaters and includes mostly fully developed suburban residential, although there is a portion of the basin that includes some highway commercial. These areas are redeveloping at a moderate rate.

Battery Creek 4 is the north eastern portion of the headwaters that includes the higher density, mixed-use urban areas of the City and institutional uses such as the City and County administration buildings. This area is facing rapid redevelopment and is the primary focus of the redevelopment portion of the City's Civic Master Plan.

2.2 Hydrology

Climate and Precipitation

The climate for Beaufort County and the surrounding South Carolina lowcountry is considered humid subtropical, with the average annual temperature in the mid 60's (degrees Fahrenheit). The average winter temperatures are typically in the low 50's and the summer averages in the mid 70's.

Precipitation totals are generally higher in the summer months and lesser in the fall. Thunderstorms produce much of the rainfall during the summer months, but the area is also impacted by tropical storms and hurricanes from summer to early fall.

Table 2a - Average Temperature and Rainfall for Beaufort County, 1930-2005 (SC State Climatology Office)

	Jan	Feb	Mar	Apr	May	Jun
Average Max. Temperature (F)	60.7	63.2	69.4	76.9	83.3	88.2
Average Min. Temperature (F)	39.9	41.6	47.3	54.8	63.1	69.8
Average Total Precipitation (in.)	3.37	3.12	3.91	2.81	3.58	5.62

Table 2b - Average Temperature and Rainfall for Beaufort County, 1930-2005 (SC State Climatology Office)

	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	90.3	89.2	85.1	77.5	69.5	61.7	76.3
Average Min. Temperature (F)	72.7	72.1	67.9	57.7	48.3	41.3	56.4
Average Total Precipitation (in.)	6.28	6.83	5.2	2.76	2.16	2.86	48.50

Rainfall patterns for individual storms in the Beaufort area are typically modeled assuming a SCS Type III Distribution with a 323 Peaking Factor. Measured rainfall depths for common statistical return periods are shown in Table 3. Based on a study of historical rainfall data commissioned by Beaufort County Stormwater Utility, the 95th percentile rainfall depth is 1.95 inches, meaning 95% of all storm events occurring in Beaufort County have less than 1.95 inches of rainfall.

Table 3 - Statistical Rainfall Amounts for Beaufort County

Rainfall Event	95th Percentile	2-yr	10-yr	25-yr	50-yr	100-yr
Rainfall Depth (in.)	1.95	4.5	6.9	8.4	9.7	11.0

Topography

Elevations within the watershed range from sea level up to as high as 30 feet above sea level. The elevations are generally higher, with flatter slopes in the headwaters portion of the basin, meaning there is a significant bluff adjacent to the river. This is also true for the eastern portion of the watershed where the older, single family residential developments sits. The slopes in the downstream portions and the western end of the watershed are generally more gradual, such that the uplands adjacent to the river are low and subject to occasional flooding. These lower areas have channels, likely manmade, that drain the uplands to the river. The watershed is wider, extending further from the river channel in the low areas, and is narrower in the headwaters with the high bluffs.

Soils and Groundwater

The soils in the high bluff headwaters area are generally very sandy with good drainage characteristics. They are mostly classified as Hydrologic Soil Group A and have deep groundwater conditions. For this reason, these areas developed first and are the locations for the older downtown portion of the City, or the older single family residential development. The main arterial roads are also generally located in the centers of the sandy ridges where drainage conditions are favorable. Soils in the flatter, lower areas tend to have higher clay content and groundwater elevations closer to the surface. Consequently these areas have poor drainage characteristics. As expected, the areas with poor drainage have not been developed to the extent the sandy regions have, and have historically remained natural or used for agriculture. However, as the amount of high quality vacant land has diminished, the poor quality land has begun to face development pressure. Since poor soils and high groundwater conditions produce larger amounts of runoff, providing stormwater quality controls for development in these areas is highly important.

Surface Waters

There are very few natural surface waters in the Battery Creek watershed with the obvious exception being the river itself. The river and the surrounding saltwater marsh account for 43% of the watershed area. The other surface waters within the watershed are all manmade ponds or brackish impoundments. The small freshwater ponds are mostly stormwater detention ponds, although some may have been constructed as recreational ponds or dug as borrow pits for past road construction. The other surface waters of note are freshwater wetlands located in much of the remaining natural area. Wetlands account for approximately 5% of the watershed area, and are predominantly located in the western portion of the watershed where grades are flatter and elevations are lower. The wetlands appear to be mostly interconnected jurisdictional wetlands, as opposed to small isolated pocket wetlands.

2.3 Political Boundaries and Future Land Use Plan

The future land-use within the Battery Creek watershed could be quite different than the current land-use given that the watershed contains property within the jurisdictions of the City of Beaufort, the Town of Port Royal, and unincorporated Beaufort County. Each jurisdiction has their own set of guiding documents for future growth and redevelopment. The City's Civic Master Plan will guide re-development of the areas under City Jurisdiction. The Town of Port Royal uses their Zoning Maps and Ordinances to set standards for re-development; while Beaufort County's Comprehensive Plan attempts to tie all the visions and standards together.

All three jurisdictions consider the western portion (Burton Area - Battery Creek 2 and 3) of the watershed as a "growth" area. The County's Comprehensive plan recognizes Burton as an area where the City and the Town might expand their boundaries through annexation. The City's Civic Master Plan (Draft at the time of this Study), identifies much of Burton as an Economic Development District, and provides illustrative concepts on how the area might redevelop. The concepts generally appear to have a higher density and impervious coverage than current developed and undeveloped land.

Assuming Port Royal will expand using zoning classifications similar to those of adjacent properties within the Town; properties annexed into the Town will likely have uses such as General Commercial, Mixed Use, and Highway Commercial. These are all higher density, higher impervious coverage uses when compared to the current Beaufort County zoning.

Battery Creek sub-basins 1 and 2 are entirely located within the City of Beaufort Boundary, so the future land uses in these sub-basins will be guided by the Civic Master Plan. Although currently high in density for the region, Sub-basins 1 & 2 could increase in density and impervious coverage as infill is encouraged by the City.

2.4 Baseline Monitoring Data and Water Quality Modeling

Beginning in 2007, extensive monitoring data has been collected for the Battery Creek watershed as part of the implementation of the 2006 Beaufort County Stormwater Master Plan. The SWMP recommended a County-wide monitoring plan that included five monitoring locations in Battery Creek. Over the past few years, the number and location of those stations has changed based on the observed results and the further development on the Watershed Management Plan. Two stations (BECY1a and BECY 6) located in Battery Creek 1, were abandoned due to low-variability data and one station (BECY 17) was added within Battery Creek 4 to monitor the results of a planned retrofit project. Figure 2-2 shows the past and current Beaufort County monitoring stations, as well as the State monitoring locations. Pollutants that were monitored as part of the County program include Ammonia-Nitrogen (NH₃), Biochemical Oxygen Demand (BOD₅), Total Cadmium, Chlorophyll-a, Total Chromium, Conductivity, Total Copper, Dissolved Oxygen (DO), Fecal Coliform, Total Iron, Total Lead, Total Manganese, Total Mercury, Total Nickel, Nitrate-Nitrite (NO_x), pH, Total Phosphorus, Salinity, Temperature, TKN, Total Organic Carbon (TOC), Total Suspended Solids (TSS), Turbidity, and Total Zinc. Results of past and current monitoring results can be found in the annual reports prepared by GEL Engineering, LLC on the Beaufort County Stormwater Utility website (<http://www.bcgov.net/departments/Engineering-and-Infrastructure/stormwater-management/water-quality-monitoring.php>)

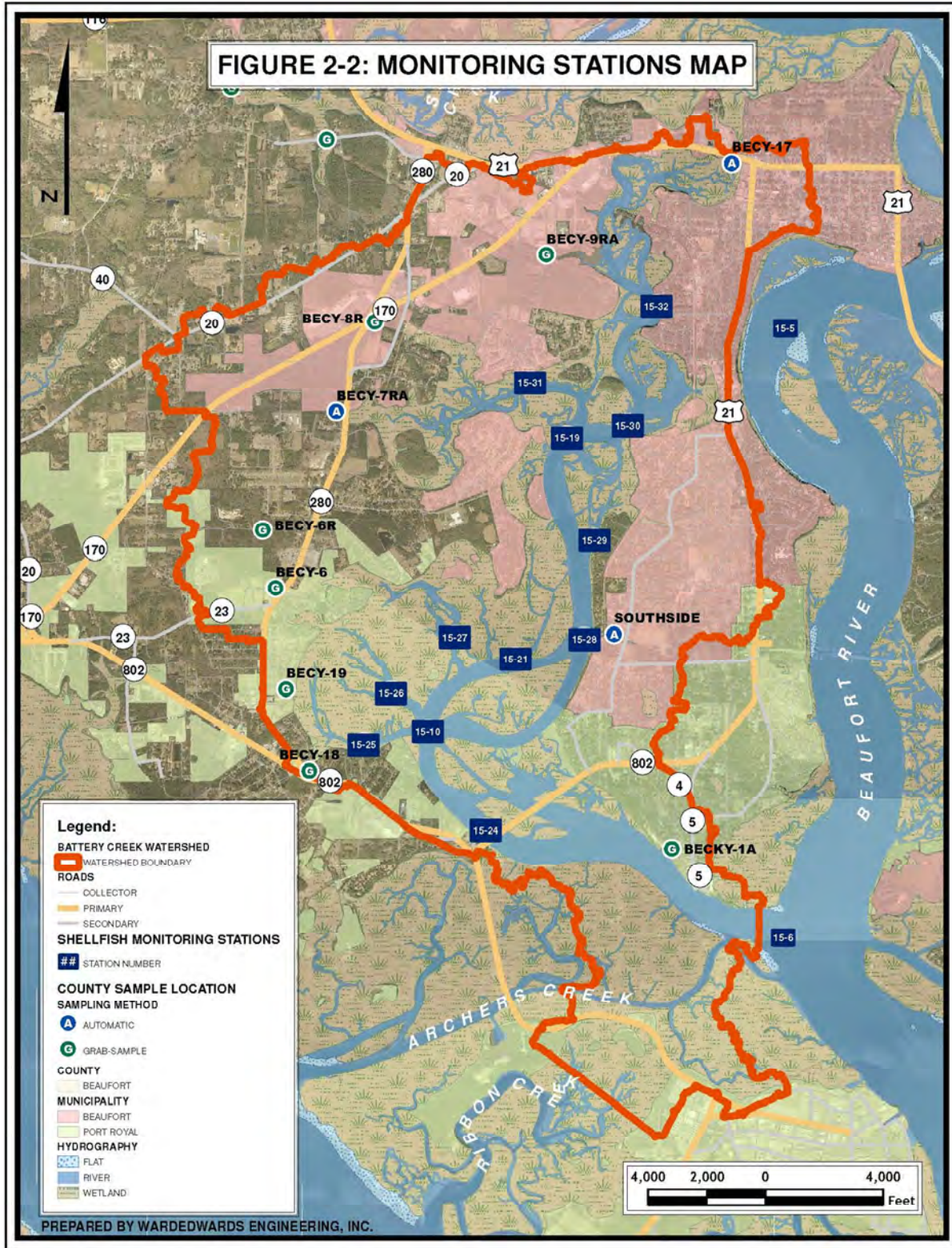


Figure 2-2 – Monitoring Station Map

Monitoring was also completed prior to 2007 for use in preparation of the 2006 SWMP and to calibrate the water quality models developed for the SWMP. The SWMP modeling involved the use of the Watershed Management Model (WMM) software and the Water Quality Analysis Simulation Program (WASP) for analysis of the Beaufort River watershed, in which the Battery Creek watershed is a sub-basin. WMM was used to estimate the average annual flow and pollutant loads for a range of pollutants. The pollutants modeled were fecal coliform bacteria, total phosphorus, total nitrogen, lead, zinc, BOD and total suspended solids. The geometric mean bacteria concentration in the flows from the uplands to the river system was estimated in the WMM. This information was used as input in the WASP model to determine the effects of tidal mixing and natural bacteria die-off in the tidal river system. Measured data such as bacteria concentrations and salinity were used to calibrate the model by adjusting parameters such as the bacteria loss rate coefficient and the tidal mixing coefficient.

The water quality modeling was executed for both existing (2006) and estimated future conditions. The results for the two conditions were compared and used to determine the watershed management needs and strategies for the SWMP, with focus on large regional retrofits. The average annual pollutant loads reaching Battery Creek as predicted by the WMM are shown for the four sub-basins in Table 4 (existing land use) and Table 5 (future land use).

Table 4 – Estimated Average Annual Loads from SWMP-WMM for Existing Land Uses

Water Quality Sub-basin	Area (acres)	Flow (ac-ft)	BOD (lb/yr)	TSS (lb/yr)	Total P (lb/yr)	Total N (lb/yr)	Lead (lb/yr)	Zinc (lb/yr)	Fecal Coliform (#/yr)
Battery Creek 1	5,792	17,281	232,000	1,770,000	9,650	80,822	397	6,047	3.36E+15
Battery Creek 2	3,580	8,843	139,000	1,300,000	5,582	49,451	221	2,613	2.56E+15
Battery Creek 3	357	1,030	17,687	165,000	579	4,390	29	347	1.42E+14
Battery Creek 4	217	539	11,481	123,000	323	2,470	18	160	8.90E+13
Total	9,946	27,693	400,168	3,358,000	16,134	137,133	665	9,167	6.15E+15

Table 5 - Estimated Average Annual Loads from SWMP-WMM for Future Land Uses

Water Quality Sub-basin	Area (acres)	Flow (ac-ft)	BOD (lb/yr)	TSS (lb/yr)	Total P (lb/yr)	Total N (lb/yr)	Lead (lb/yr)	Zinc (lb/yr)	Fecal Coliform (#/yr)
Battery Creek 1	5,792	17,595	239,000	1,790,000	9,772	81,611	402	6,119	3.34E+15
Battery Creek 2	3,580	9,698	158,000	1,350,000	5,781	51,539	231	2,795	2.52E+15
Battery Creek 3	357	1,040	17,955	166,000	583	4,420	29	349	1.43E+14
Battery Creek 4	217	566	12,093	124,000	328	2,545	18	166	9.06E+13
Total	9,946	28,899	427,048	3,430,000	16,464	140,115	680	9,429	6.09E+15
% Change over existing		4%	7%	2%	2%	2%	2%	3%	-1%

The results of the SWMP modeling show a 2% to 7% increase in all constituents except for fecal coliform, which had a predicted 1% decrease in load. It is important to note that the future conditions model assumed improved BMP coverage and efficiency for development and re-development within the Battery Creek watersheds. This improvement was expected because of the new water quality standards and volume control standards passed by Beaufort County and adopted by the City of Beaufort and Town of Port Royal.

Despite the small expected reduction in fecal coliform loads in Battery Creek, the waters would remain impaired for shellfish harvesting, meaning additional controls and management strategies are needed. To help develop strategies and to determine the most effective locations for controls, a sensitivity analysis was conducted as part of the 2006 SWP, using the established water quality models. The sensitivity model involved running a “best case” and “worst case” analysis of the sub-watersheds and comparing the two conditions. The best case scenario assumed that all existing development was served by BMPs designed to treat for bacteria, and the worst case assumed no developments are served by BMPs. The benefits of implementing retrofit BMPs are indicated by comparing the two scenarios. The results were presented by establishing a “Level of Service” based on long-term geomean fecal coliform bacteria concentrations. Information about the Level of Service criteria as presented in Section 2.6.2 of the SWMP are as follows:

- Level of Service A – River sections expected to have a long-term geomean of less than or equal to 7/100 ml and meet the geomean standard (14/100 ml) and the 90th percentile standard (43/100 ml) for any 36-sample period.
- Level of Service B – River sections expected to have a long-term geomean of greater than 7/100 ml and less than or equal to 8.7/100 ml. They are expected to meet the geomean standard (14/100 ml) for any 36-sample period and are expected to meet the 90th percentile standard in

the long-term, but the 90th percentile standard is expected to be exceeded during some 36-sample periods.

- Level of Service C – River sections expected to have long-term geomean greater than 8.7/100 ml and less than or equal to 10/100 ml. They are expected to meet the geomean standard (14/100 ml) for any 36-sample period, but are not expected to meet the 90th percentile standard in the long-term.
- Level of Service D – River sections expected to exceed the geomean standard (14/100 ml) for some 36-sample periods, and are expected to exceed the 90th percentile standard for long-term and during some 36-sample periods.

Fecal Coliform Modeling Results for the Battery Creek watershed indicate three of the sub-watersheds would not meet shellfish standards for existing or future conditions. Table 6 shows the modeling results.

Table 6 - Fecal Coliform Modeling Results for Existing and Future Conditions

Watershed Sub-basin	Modeled Geomean Concentration (#/100 ml)		Modeled Level of Service	
	Existing	Proposed	Existing	Proposed
Battery Creek 1	5.3	5.4	A	A
Battery Creek 2	9.0	9.2	C	C
Battery Creek 3	11.0	11.2	D	D
Battery Creek 4	12.2	12.4	D	D

The BMP sensitivity analysis indicated that all four watershed sub-basins would be very responsive to BMP retrofits through new development re-development. All three of the sub-basins that were less than LOS A could be improved to LOS A with complete BMP coverage. Table 7 shows the sensitivity analysis results.

Table 7 - Sensitivity Analysis Results for 100% BMP Coverage versus 0% BMP Coverage

Watershed Sub-basin	Modeled Geomean Concentration (#/100 ml)		Modeled Level of Service	
	Best Case	Worst Case	Best Case	Worst Case
Battery Creek 1	3.5	5.8	A	A
Battery Creek 2	5.0	10.8	A	D
Battery Creek 3	5.4	12.6	A	D
Battery Creek 4	5.8	14.0	A	D

Notes:

1. Best case represents existing land use with wet detention BMPs serving all existing development
2. Worst case represents future land use with no BMPs.

3.0 Pollutant Source Assessment

The pollutant of concern (Fecal Coliform) is a pollutant that can be delivered to a water body as a non-point source or point source pollutant. Based on the land use data from the 2006 Beaufort County Stormwater Management Plan, the most likely non-point source inputs into Battery Creek would be generated from Impervious Surface, Pet Waste, Land Disturbance, Failing Septic Systems, Wildlife, Silviculture, and Fertilizer & Pesticide use. There could also be point source inputs of fecal coliform into Battery Creek from industrial activities, sanitary sewer overflows, and combined sewer overflows.

3.1 Non-point Sources

Non-point source (NPS) pollution occurs when rain or irrigation water flowing over hard surfaces or loose soil, picks up pollutants and deposits them into the nearest wetland, creek, estuary or groundwater supply. The EPA has identified NPS pollution as the number one source of pollution and the nation's largest water quality problem. The most common NPS pollutants are sediment, bacteria and nutrients. Sediment is generated by land disturbing activities and can impact the estuarine habitat by smothering some benthic species, blocking out sunlight used by plankton for photosynthesis, and prolonging the survival of bacteria in the water column. Bacteria come from faulty septic systems, domestic and wild animal waste, and combined sewer overflows. A specific type of bacteria called fecal coliform is used as an indicator organism for determining how safe it is to use an estuary for recreation or shellfish harvesting. Nutrients come from fertilizer, pet waste and failing septic systems, and cause the harmful algae blooms that produce toxins that can poison fish, humans and birds.

3.1.1 Stormwater Runoff from Development

Typically an impervious percentage of 10-20% indicates that the receiving water body will show signs of decreased water and aquatic habitat quality; when using fecal coliform as an indicator. The reason for this is that runoff generated from impervious surfaces contains pollutants and increases the rate and runoff volume in the watershed. When this increased rate and volume of stormwater is delivered to the receiving water body the pollutants in the runoff are transported downstream, because the natural filtering process is unable to treat the increased rate and volume of runoff. This effect is compounded the more an area is developed, thus pollutants are carried further and further downstream. While recent updates in stormwater regulations have put an emphasis on BMPs that reduce rate and volume of runoff, the majority of the urban stormwater system in the Battery Creek watershed is not served by BMPs. (Schuler and Holland)

The installation of impervious surfaces within the Battery Creek watershed has increased as a result of development in the area, and the watershed has an impervious coverage percentage of approximately 24%. This exceeds the threshold expected to cause water quality issues in the receiving water body, and there are currently sections of Battery Creek showing a decrease in water quality. This supports the documented ecological response to exceeding the impervious coverage threshold. The City of Beaufort Civic Master Plan shows areas within the watershed that are being targeted for future development and re-development. This will further increase the impervious surface coverage of the watershed, and the risk of further water quality degradation.

3.1.2 Pet Waste

An increase in surface water pollution can result from not properly disposing of pet waste. If not collected, the pet waste will be conveyed in runoff and become incorporated into the stormwater system as a source for pollution. Pet waste contains high levels of fecal coliform as well as other bacteria, viruses and parasites that can pose a health risk. A survey by the Center for Watershed Protection revealed that 41% of respondents will rarely or never clean up after their dog (USA Today). This source of pollution can have an even bigger impact in areas that have out dated stormwater systems that do not filter the runoff through a BMP prior to discharge.

3.1.3 Construction Land Disturbance

Land Disturbance from construction activities can erode at rates 2 to 40,000 times greater than pre-construction conditions (Harbor), and the elevated rate of erosion contributes to higher levels of suspended sediments in runoff. When the sediment is deposited in the estuary it settles to the bottom, and smothers benthic species and habitat. Some of the sediment will stay suspended in the water column and block sunlight used by plankton for photosynthesis. The suspended sediments also provide a surface for bacteria to attach to that protects it from UV radiation and predation, and prolong their survival in the estuarine environment. The proper implementation and maintenance of erosion and sediment control BMPs are critical to managing the potential discharge of pollutants from construction activities. The plan for increased development and re-development in the Battery Creek watershed as described in the City of Beaufort Civic Master Plan will place this issue at the forefront of ongoing efforts to improve and preserve water quality.

3.1.4 Septic Systems

Approximately 42% of the existing developed acreage in the Battery Creek watershed is serviced by septic tanks, and it is likely that some of these tanks are failing to provide proper treatment. Reasons for septic tank failure include high water table, structural failure, unsuitable soils, direct connection between a septic tank and the receiving water, and failure to provide maintenance for the septic tank. Failing septic tanks are expected to discharge high concentrations of nutrients and bacteria; including fecal coliform. (BC Stormwater Management Plan)

3.1.5 Wildlife

Even before the development of the Battery Creek watershed, wildlife was a natural source of fecal coliform. There are however several factors that can increase the effect of wildlife once an area is developed. Upland habitat is typically the first to be developed and this change in land use forces the redistribution of wildlife to the remaining undeveloped areas. The areas left undeveloped are low lying areas that are typically classified as jurisdictional wetlands, and typically feature drainage ditches that were constructed in the past for agricultural purposes. Jurisdictional wetlands offer an attractive habitat for wildlife, the areas are extensively connected which allows wildlife to move unimpeded throughout the watershed and the mature hardwoods with a well-established understory offer forage and bedding areas. The development of the area has also provided more foraging opportunities in fertilized and irrigated residential landscaping and a reduced the predatory population. This contributes to wildlife populations that exceed the natural carrying capacity of the watershed. This could result in a

higher and more immediate input of fecal coliform due to the wildlife habitat and population existing in the same area as the watershed drainage corridors.

The loading contribution from waterfowl is one of the easiest to observe and is an immediate input of bacteria and nutrients into Battery Creek. Approximately 4,300 acres (6.7 sq. mi.) or roughly 43% of the watershed is open water or tidally influenced wetlands. These areas offer habitat and food sources that attract various species of waterfowl on a year round basis. There are also approximately 191 docks along Battery Creek that can potentially serve as bird roosting areas. The bacteria and nutrient input of wildlife is hard to quantify without population estimates or pollutant source tracking testing, but can be managed to reduce bacteria and nutrient loading in the Battery Creek watershed.

3.1.6 Agricultural

The only agricultural activity still present in the Battery Creek watershed being conducted on a large scale is pine silviculture. Silviculture practices result in moderate increases in the volume and rate of runoff as compared to a naturally wooded system. The increase is due to the periodic burning to clear underbrush that increases the risk of canopy fires, and the installation of ditch networks to improve drainage so pine saplings can become established. However, the largest threat to water quality in the silviculture practice is the process of harvesting the pine trees. Harvesting introduces a very abrupt change in the land cover characteristics and disturbs several acres at once. These activities increase the erosion rate and lead to an increase in suspended sediment in runoff.

3.2 Point Sources

3.2.1 NPDES Permits

The National Pollutant Discharge Elimination System (NPDES) Program was created by Section 402 of the Clean Water Act. The NPDES Program is administered by each state with the authority granted by the EPA. The NPDES Program requires that any point source discharge to surface waters obtain an NPDES Permit or coverage under an applicable General Permit. The most common point source discharges are produced by wastewater treatment facilities, municipal storm sewer systems, stormwater from industrial activities, and stormwater from construction sites. These discharges have the potential to increase pollutant loads and impact the water quality of the receiving water body.

3.2.2 SSOs & CSOs

In South Carolina, over the last 10 years, an average of almost 600 sanitary sewer overflows (SSOs) have been reported each year. These overflows release untreated sewage that can reach a receiving water body and cause significant water quality problems. Wastewater overflows happen for a variety of reasons. Some occur during dry weather due to blockages in the system, vandalism, construction activities, pipe failures, pumping failures, grease accumulation, root intrusion into sewer lines, a lack of proper maintenance and a myriad of other reasons. Other overflows occur during wet weather when inflow and infiltration into sewer lines overwhelms the sewer system.

The chances that an overflow will occur during wet weather increases when the sanitary and stormwater flows are incorporated into the same system. When this occurs it is called a combined

sewer system, and is typically seen in older urban areas. These combined sewer systems can cause an overflow by over inundating the sanitary sewer system with stormwater during a rain event, or they can discharge directly into a receiving water body. While SSOs are easy to identify, and any overflow greater than 500 gallons has to be reported to the SCDHEC Bureau of Water, combined sewer overflows have to be identified through field investigation and regulation of illicit connections to the storm sewer system. SSOs and CSOs contain high levels of bacteria and nutrients that greatly impact water quality, dissolved oxygen levels, and estuarine habitat.

3.2.3 Fertilizer & Pesticides

The leading applicators of fertilizer in Beaufort County are the agriculture and golf industries. These two land use groups are not found in significant sizes in the Battery Creek watershed, however the application of fertilizer on residential landscapes is a wide spread practice. While the application of fertilizer in residential areas is done on a smaller scale than in the agricultural and golf industry, the homeowner is typically unaware of the proper application rate. This typically leads to the over application of fertilizer, and during a rain events, the excess nutrients are picked up by runoff. When the excess nutrients are carried to the receiving water body they encourage the growth of harmful algae blooms that release toxins that are poisonous to fish and humans, lower dissolved oxygen levels, and block UV radiation.

The NPDES General Permit covering pesticide application is required for applicators who exceed a specific quantity annually, and is commonly needed for agriculture, golf course and right of way maintenance operations. Without the presence of agriculture or large golf courses in the watershed, the application of pesticides are most commonly used for utility and road right of way maintenance, and residential landscaping. The application of pesticides by the professional community is regulated and the requirement of training reduces the chance that they will over apply. An individual resident will not approach the application quantity requiring coverage under the NPDES General Permit, but they are often unaware of the proper application rate and tend to over apply. With the application of any pesticide it is un-avoidable that some of that pesticide will end up in the receiving water body, and negatively impact water quality and the estuarine ecosystem.

4.0 Watershed Goals and Objectives

The goals and objectives for the Battery Creek watershed have been established jointly by Beaufort County and the City of Beaufort. The goals and objectives are based on the City's vision for growth and redevelopment established in the Civic Master Plan and based on the goal of having no impaired water bodies within the City limits. The goals and objectives from the County's perspective are based on their leadership in water quality efforts established by the Beaufort County Stormwater Utility and based on support of the County's Comprehensive Master Plan. The Stormwater Utility's Vision and Mission Statements extend to the Battery Creek watershed:

- Beaufort County Stormwater Utility Vision Statement – “Efficient Utility Addressing the Stormwater Needs of the County, while Protecting its Water Resources”
- Beaufort County Stormwater Utility Mission Statement – “Dedicated to the management, construction, maintenance, protections, control, regulation, use and enhancement of stormwater systems and programs in Beaufort County in concert with other water resource management programs.”

The City and the County have entered into Intergovernmental Agreements (IGA) for general stormwater management as well as for management of the Battery Creek watershed specifically. Based on the IGA goals, specific watershed goals and objectives were set.

Watershed Goals

- Protect the Battery Creek watershed and the outstanding natural water resources.
- Develop partnerships for safeguarding of the watershed.
- Improve water quality in Battery Creek
- Regional retrofits within the Battery Creek watershed will be model projects for implementation in other developed and developing watershed within the County

Watershed Objectives

1. Meet the appropriate water quality standards for fecal coliform bacteria in portions of the river classified for recreation use waters and in portions classified for shellfish harvesting.
2. Treat runoff from existing developments that currently have no stormwater BMPs by installation of large regional stormwater BMPs.
3. Reduce impact of future growth and redevelopment by promoting low impact designs using development ordinances, stormwater regulations, and professional development education programs for engineers and developers.
4. Protect and restore critical natural resources such as isolated wetlands, jurisdictional wetlands, and stream buffers.
5. Reduce bacteria loads from domesticated pets

With the goals and objectives in mind, management strategies designed to achieve the objectives were developed. The strategies are described in detail in Section 5.

5.0 Management Strategies

Management strategies were developed to meet the established goals and objectives. The strategies were based on methods currently being implemented in other portions of the County such as the Okatie and May River watersheds. The Beaufort County Stormwater Utility has implemented many projects throughout the County with varying degrees of success. The strategies listed below are ones that have been implemented with some positive results, whether major or minor. Strategies with lesser success rates are still valuable when approached with the belief that multiple smaller returns will eventually add up to greater returns over time. However, projects with higher rates of return will be the initial focus of the implementation plan.

Many of the management strategies will focus on stormwater runoff volume reduction. Increases in stormwater volume from development are believed to be contributing to higher bacteria counts in the saltwater rivers. Higher bacteria measurements have been observed with lower salinities in estuarine water bodies and it is believed to be related to higher fecal coliform mortality rates in higher salinities. Previous stormwater regulations required the analysis of pre-post peak discharge rates, but not pre-post volume control. The likely result of these standards is that land development over the past twenty years is producing large slugs of freshwater discharges in high volumes inconsistent with natural pre-development hydrology and hydraulics. Monitoring by Beaufort County has also noted high fecal coliform counts occurring in discharge from wetlands and open space areas. It is suspected that increases in volume and concentration of flow through natural wetland systems may be transporting natural re-growth bacteria to the receiving waters. For these reasons, Beaufort County enacted a stormwater volume control ordinance in 2009 to supplement the existing water quantity and quality standards.

The first phase of the Volume Control Ordinance required all new development to limit post-development runoff volume for the 95th percentile storm to pre-development rates. The second phase of the Ordinance, passed in 2011, required residential lots that have been subdivided but no yet built to provide on-lot volume control BMPs. The purpose of this ordinance is to reduce the runoff volume impact from developments that were approved prior to the Volume Control Ordinance but haven't yet been constructed. The first two phases of the Volume Control Ordinance were anti-degradation efforts, meaning they would only prevent volume related water quality issues from getting worse. In order to improve existing water quality problems, retrofits of existing developments and strategies that reduce the existing runoff volumes will be needed.

5.1 Regional Structural Stormwater BMPs

Large structural stormwater BMPs will be used as regional BMPs to serve existing developments that currently have no stormwater treatment controls. These BMPs will receive and treat the runoff prior to discharging it back to the receiving waters. The design of the BMPs will focus on treatment of bacteria and runoff volume reduction, however, it is expected that they will benefit water quality for other pollutants as well. Many of the planned retrofits are projects that resulted from the County Stormwater Master Plan and the subsequent Regional Retrofit Study.

5.1.1 Battery Creek West M1

This BMP site is located in the Battery Creek West M1 hydrologic sub-basin, which is a portion of the Battery Creek 1 Water Quality Basin. The service area for the BMP is approximately 500 acres and has a variety of land uses including, a par 3 golf course, an outdoor flea market, a convenience store/gas station, single family residential, mobile home parks, a borrow pit, and a Beaufort Jasper Water and Sewer Authority waste water treatment facility. Figure 5-1 shows the Battery Creek West M1 sub-basin location within the Battery Creek 1 basin.

The Regional Retrofit Study reviewed property within the sub-basin suitable for a regional retrofit BMP, and determined that a large parcel containing the golf course (Giffords Golf) to be most feasible. The large amount of land available in the wooded area of the site would be well suited to a regional stormwater detention pond. Ponds have been found to be effective in treating stormwater for bacteria removal in Beaufort County. Ponds can also be designed to reduce flashy discharges of runoff volume. When used as a source for irrigation reuse, or when designed using littoral shelves, the ponds can also reduce the total runoff volume. Being fairly close to the downstream sub-basin discharge point would allow the pond to serve the majority of the 500 acre sub-basin, which currently has little to no stormwater treatment. Figure 5-2 shows the proposed pond location within the sub-basin and Figure 5-3 shows the proposed pond size and configuration.

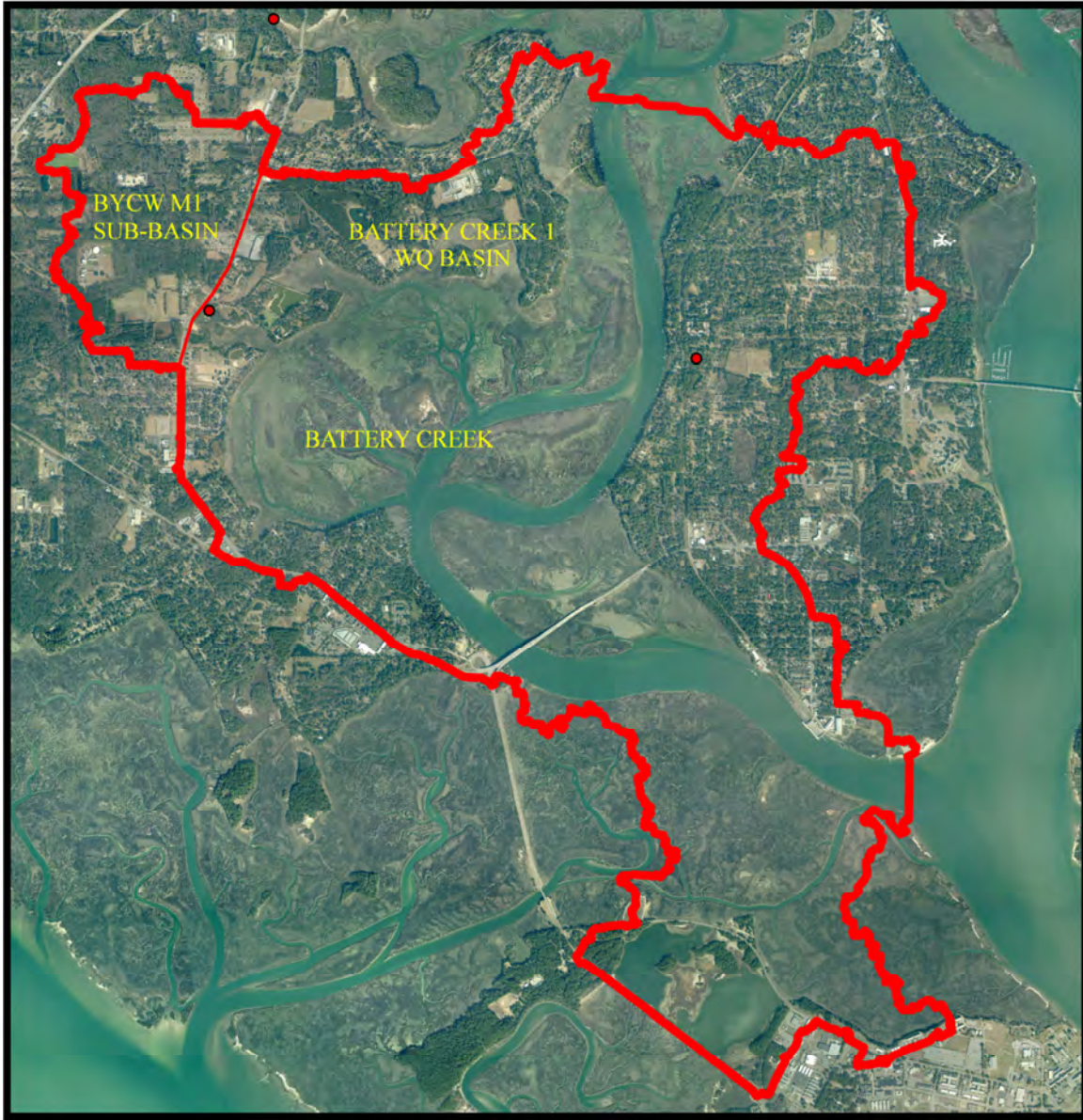


Figure 5-1 – Battery Creek West M1 Sub-basin

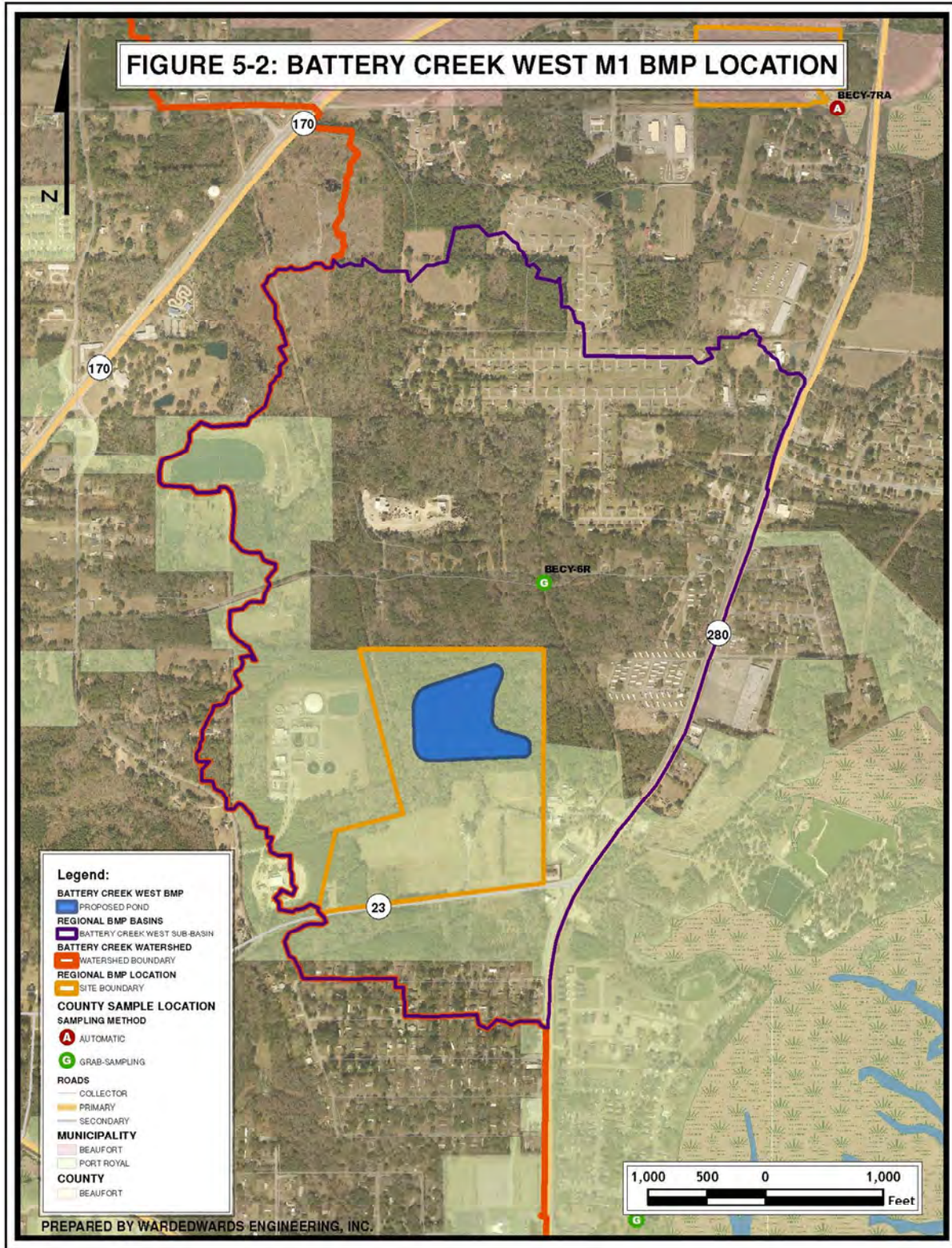


Figure 5-2 - Battery Creek West M1 Regional Retrofit Location

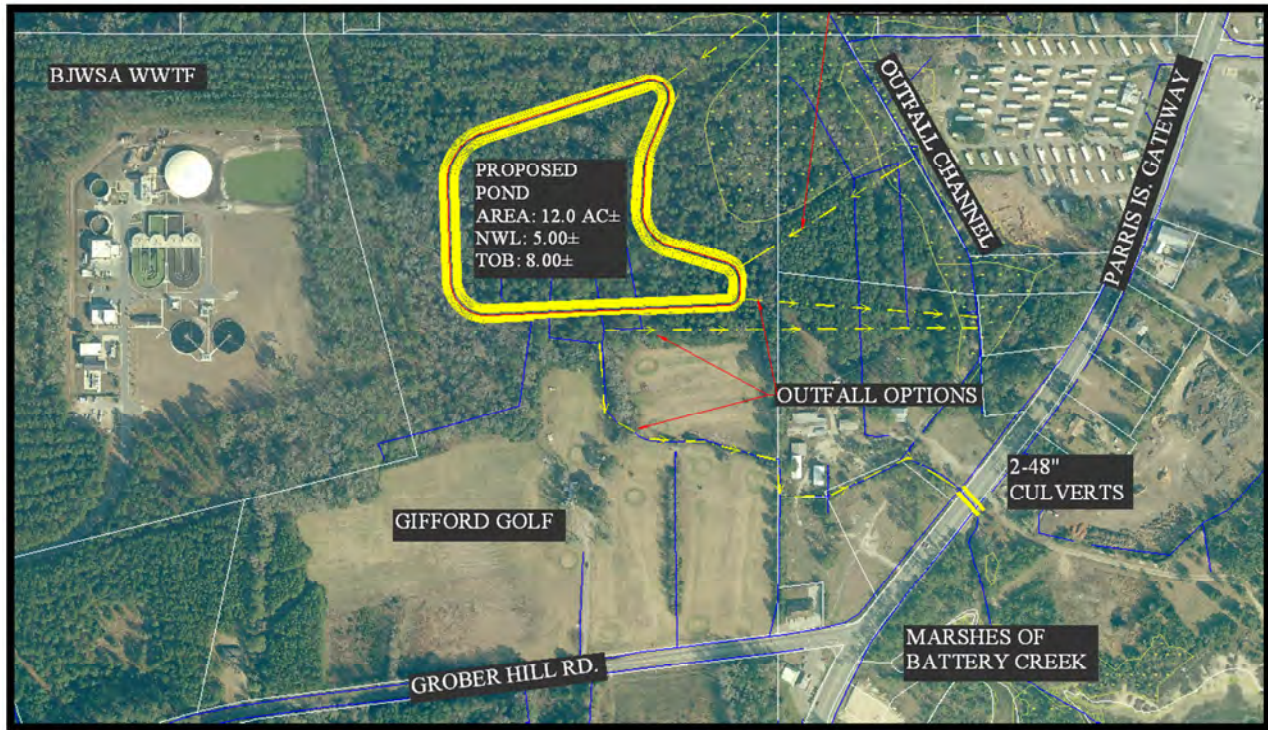


Figure 5-3 - Battery Creek West M1 Proposed Regional Pond Layout

There are a number of design challenges associated with this site and the proposed BMP that were identified in the Regional Retrofit Study. These design challenges will have to be addressed in a feasibility study prior to implementation of the BMP:

- The large variation in ground elevations on the site will require careful location of the pond and attention to the grading of the pond boundary. The pond grading will control the available storage and thus the effectiveness of the BMP.
- The site elevations also pose an obstacle to conveying the runoff between the pond and the existing outfall channel. There are multiple options for inlet and outlet routes and the ones ultimately selected will depend on the results of ground-run survey, the ease of permitting, the acquisition of drainage easements, and the feasibility of making downstream improvements. It will be important to locate the inlet and outlet away from each other such that flow through the pond will not short circuit, as short circuiting will reduce the effectiveness of the pond in treating the stormwater.
- The pond design will have to include an emergency overflow weir sized to limit peak pond stages and to prevent flooding upstream of the pond. Design of the weir and the outfall will have to account for potential impacts to downstream property.

- Access for temporary construction and long term maintenance will have to be considered. Access may have to go through adjacent property in order to prevent impact to the golf course operation.
- All components including the pond location, pond layout, outfall location, and access road will require approval from the affected property owners. The design must provide sufficient buffers from adjacent property lines and wetlands.

Detailed information on the proposed BMP sizing calculations and predictive modeling analyses are presented in the Regional Retrofit Study. Results of the conceptual modeling analyses estimate an 80% reduction in peak flow rate and a 9% reduction in runoff volume at the Battery Creek outfall. These results are for the 95th percentile storm assuming high tide conditions in the river. Table 8 shows the peak stage results, comparing the rates at the outfall to the river, at the pond, and just upstream of the pond. Table 9 shows the 95th percentile storm runoff volume modeling results at the outfall to the river.

Table 8 - Battery Creek West M1 Peak Flow Results - 95th Percentile Storm

Location	Model Node Name	Pre Max Inflow (cfs)	Post Max Inflow (cfs)
Battery Creek	BYCW_M-3	37.57	7.25
Upstream of Pond	BYCW_M-23	40.91	40.91
Pond	POND_BCW	N/A	38.76

Table 9 - Battery Creek West M1 Pre-Post Volume Comparison for 95th Percentile Storm

Node	Model Node Name	Pre Volume High Tide (acre-ft)	Post Volume High Tide (acre-ft)
Battery Creek	BYCW_M-3	19.10	17.40

The cost to implement this BMP will be relatively high compared to other regional BMPs identified in the watershed. The Regional Retrofit Study estimated around \$4,100,000, although the costs could be reduced if the material excavated from the pond is suitable as fill material for any nearby construction projects.

BMP Implementation Priority

This BMP site is upstream of one of the two impaired areas in Battery Creek (Station 15-25), so it would be a high priority to implement given the watershed management objective of achieving the shellfish harvesting standards. Without this BMP, any other improvements for the shellfish restricted area would have to come through non-regional BMPs or through water quality improvements to upstream or downstream areas. Improvements to adjacent areas may provide secondary benefits to Station 15-25 by reducing the fecal counts reaching the area through tidal action. High cost of construction and

difficulty acquiring the needed property/easements could be an impediment to implementation for this regional retrofit. Overall, when considering the high cost of construction, this project is rated as a medium priority project. Additional information on implementation recommendations are presented in Section 6.1

5.1.2 Grober Hill M2

Grober Hill M2 hydrologic sub-basin is a portion of the Battery Creek 2 Water Quality Basin. The sub-basin for the proposed BMP is approximately 500 acres in size and primarily includes single family developments and undeveloped land. The only other uses in the sub-basin are the SCDOT/SCDMV complex, a small mini-storage business, and two churches. It appears that the majority of the single family developments in the sub-basin pre-date all stormwater control regulations, as there are no detention ponds visible in the aerial photos. The SCDOT/DMV does have a detention pond, but it is unknown as to what standards it was designed. The two churches also appear to pre-date current stormwater standards and appear to have no structural BMPs. Figure 5-4 shows the water quality sub-basin and the Battery Creek 1 basin boundaries.

The Regional Retrofit Study reviewed property within the sub-basin suitable for a regional retrofit BMP, and determined that a large vacant parcel along Goethe Hill Road to be most feasible. The size of the site and its proximity to the sub-basin's main outfall channel would be well suited to a regional stormwater detention pond. As stated in Section 5.1.1, ponds have been found to be effective in treating stormwater for bacteria and can be designed to reduce flashy discharges of runoff volume. Being fairly close to the downstream sub-basin discharge point would allow the pond to serve the majority of the 500 acre sub-basin, which currently has little to no stormwater treatment. Figure 5-5 shows the proposed pond location within the sub-basin and Figure 5-6 shows the proposed pond size and configuration.

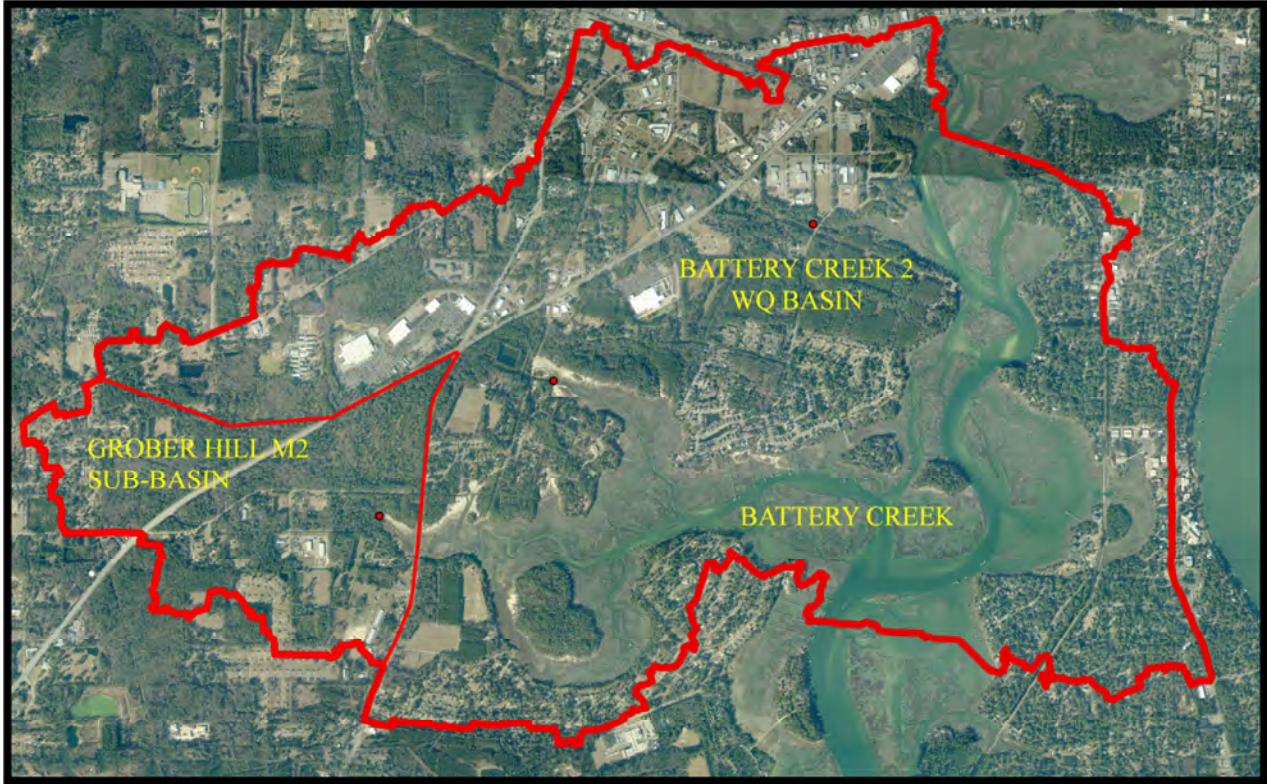


Figure 5-4 - Grober Hill M2 Sub-basin

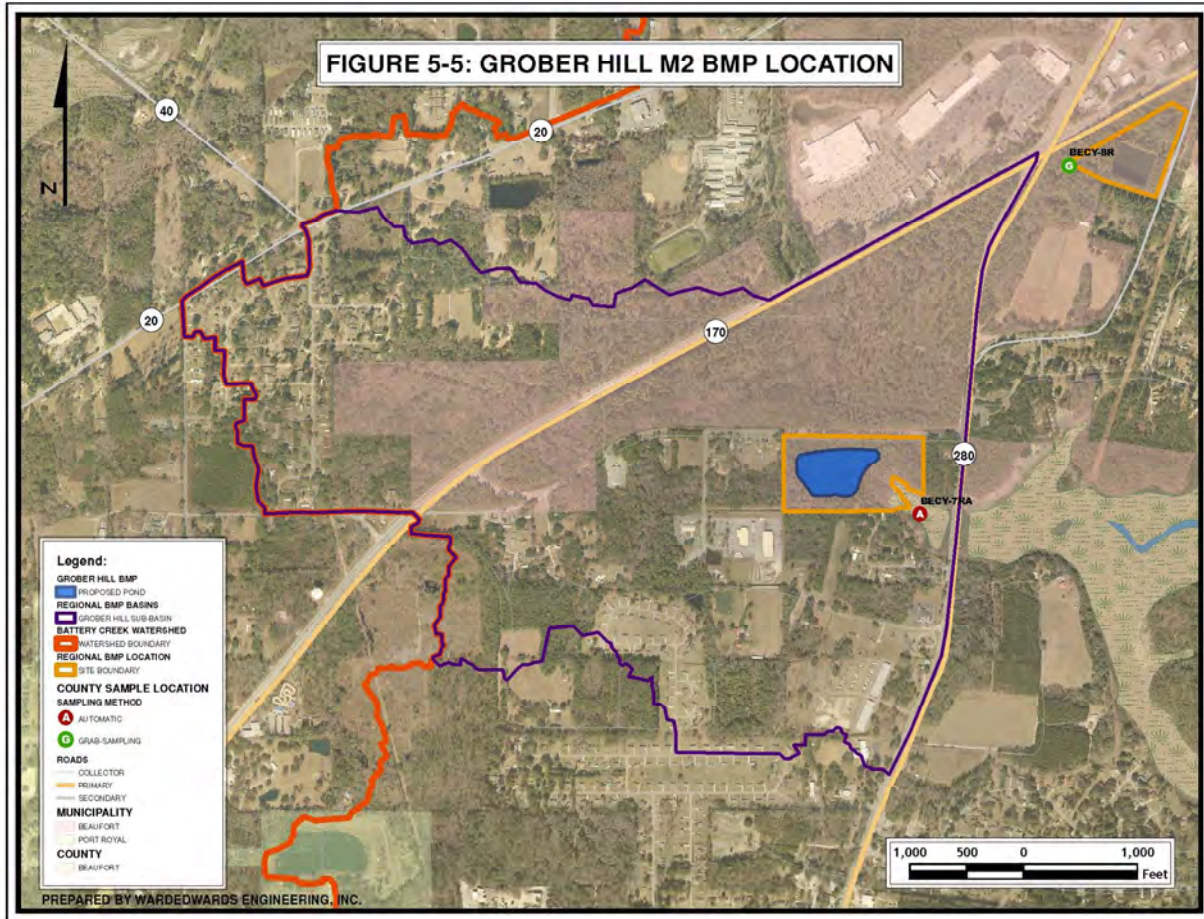


Figure 5-5- Grober Hill M2 BMP Location



Figure 5-6 - Grober Hill M2 Proposed Regional Pond Layout

The owner of the proposed BMP site is Myrtle Bush Farms. Dr. John Gray is associated with Myrtle Bush Farms and owns other property being considered for BMPs within the Battery Creek watershed. Dr. Gray was contacted as part of the Regional Retrofit Study to gauge his willingness to help with the regional BMPs. It is believed that Dr. Gray is marketing the Goethe Hill Road property for development although he seemed to be willing to consider working with Beaufort County on using the property for a regional BMP. Use or acquisition of the property will have to be further negotiated for the project to move forward. There are also a number of design challenges associated with this site and the proposed BMP that were identified in the Regional Retrofit Study. These design challenges will have to be addressed in a feasibility study prior to implementation of the BMP:

- The existing ground elevations and the elevations on the adjacent parcel may require portions of the pond banks to be constructed as berms. The berms would be needed in order to prevent stormwater from ponding on offsite property.
- The pond design will have to include an emergency overflow weir sized to limit peak pond stages and to prevent flooding upstream of the pond.
- The pond will collect inflow from four different inflow points. Pretreatment of the inflow in sediment forebays is preferred, but will require special consideration to properly capture all four inlets.

- Access for temporary construction and long term maintenance will have to be provided from Goethe Hill Road. The access location will be dependent on the conceptual pond layout and will require approval from SCDOT.
- Excavation of the pond will result in a large amount of soil that will need to be used or disposed of offsite, which will drive up the construction costs.
- The outfall channel is likely tidally influenced, which must be accounted for in the pond design.

Detailed information on the proposed BMP sizing calculations and predictive modeling analyses are presented in the Regional Retrofit Study. Results of the conceptual modeling analyses estimate an 87% reduction in peak flow rate and a 33% reduction in runoff volume at the Battery Creek outfall. These results are for the 95th percentile storm assuming high tide conditions in the river. These are more efficient results compared to the Battery Creek West M1 retrofit, particularly for volume control. Table 10 shows the peak stage results, comparing the rates at the outfall to the river, at the pond, and just upstream of the pond. Table 11 shows the 95th percentile storm runoff volume modeling results at the outfall to the river.

Table 10 - Grober Hill M2 Peak Flow Results - 95th Percentile Storm

Node	Model Node Name	Pre Max Inflow (cfs)	Post Max Inflow (cfs)
Battery Creek	GH_M-11	71.44	9.16
Upstream of Pond	GH_M-21	78.72	79.13
Pond	POND_GH	N/A	76.34

Table 11 - Grober Hill M2 Pre-Post Volume Comparison for 95th Percentile Storm

Node	Model Node Name	Pre Volume High Tide (acre-ft)	Post Volume High Tide (acre-ft)
Battery Creek	GH_M-11	31.5	21.2

The cost to implement this BMP will be less than the Battery Creek West M1 project but higher than some of the other regional BMPs identified in the watershed. The Regional Retrofit Study estimated around \$2,500,000, although the costs could be reduced if the material excavated from the pond is suitable as fill material for any nearby construction projects.

BMP Implementation Priority

This BMP site is upstream of one of the two impaired areas in Battery Creek (Station 15-19), so it would be a high priority to implement given the watershed management objective of achieving the shellfish harvesting standards. Without this BMP, any other improvements for the shellfish restricted area would have to come through non-regional BMPs or through water quality improvements to upstream or downstream areas. Improvements to adjacent areas may provide secondary benefits to Station 15-19 by reducing the fecal counts reaching the area through tidal action. However the high cost of construction and difficulty acquiring the needed property/easements could be an impediment to implementation. Overall, this project is considered a high priority project. Additional information on implementation recommendations are presented in Section 6.1

5.1.3 Burton Hill M2

Burton Hill M2 hydrologic sub-basin is a portion of the Battery Creek 2 Water Quality Basin. The sub-basin for the proposed BMP is approximately 470 acres in size and primarily includes a mixture of uses such as single family residential, multifamily residential, highway commercial, a middle school and undeveloped land. It appears that the majority of the single family developments in the sub-basin pre-date all stormwater control regulations, as there are no detention ponds visible in the aerial photos. The highway commercial and multifamily residential developments have detention ponds, but it is unknown as to what standards they were designed. The middle school does not have ponds, although there is a dry detention basin that may provide some water quality treatment. Figure 5-7 shows the water quality sub-basin and the Battery Creek 1 basin boundaries.

The Regional Retrofit Study reviewed property within the sub-basin suitable for a regional retrofit BMP, and determined that a piece of property between Robert Smalls Parkway and Old Jericho road containing an existing pond to be most feasible. The existing pond is just upstream of the sub-basin outfall, but offline from the main outfall channel. The size of the site and its proximity to the sub-basin's main outfall channel would be well suited to a regional stormwater detention pond. It was discovered through correspondence with the property owner that the pond was constructed decades ago and was intended to be used as a wastewater treatment pond. However, the pond was never used as intended due to public sewer being extended to the area, so the pond has served simply as a recreational amenity. The regional retrofit plan calls for the flow from the 500 acre upstream area to be diverted to the existing pond. An outfall structure will be added to the pond to provide attenuation of the upstream runoff, and release the stored stormwater at rate less than current conditions. It is expected that the pond will provide effective removal of bacteria from the runoff. The pond should also reduce the volume of freshwater reaching the salt water river. Figure 5-8 shows the proposed pond location within the sub-basin and Figure 5-9 shows the proposed pond size and configuration.

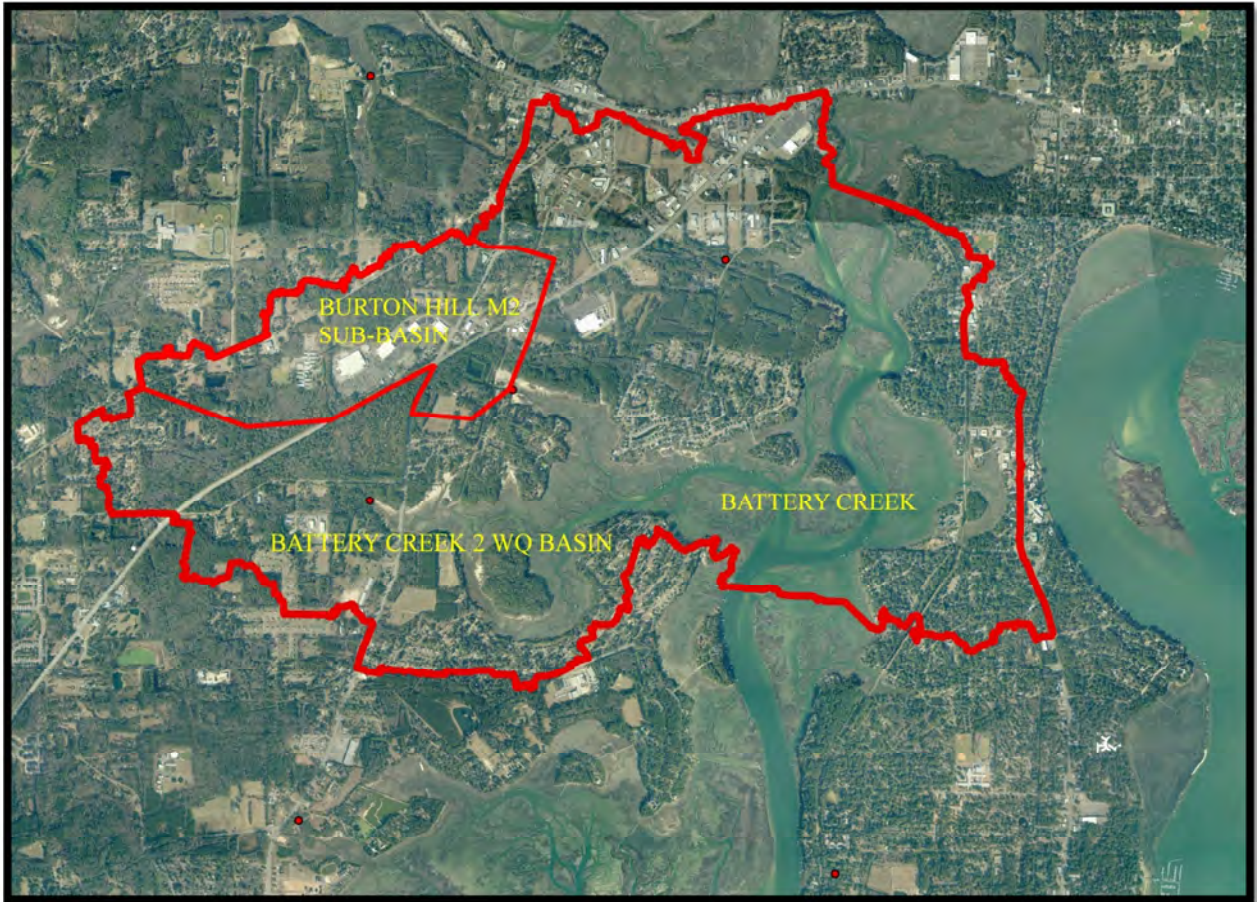


Figure 5-7 - Burton Hill M2 Sub-basin

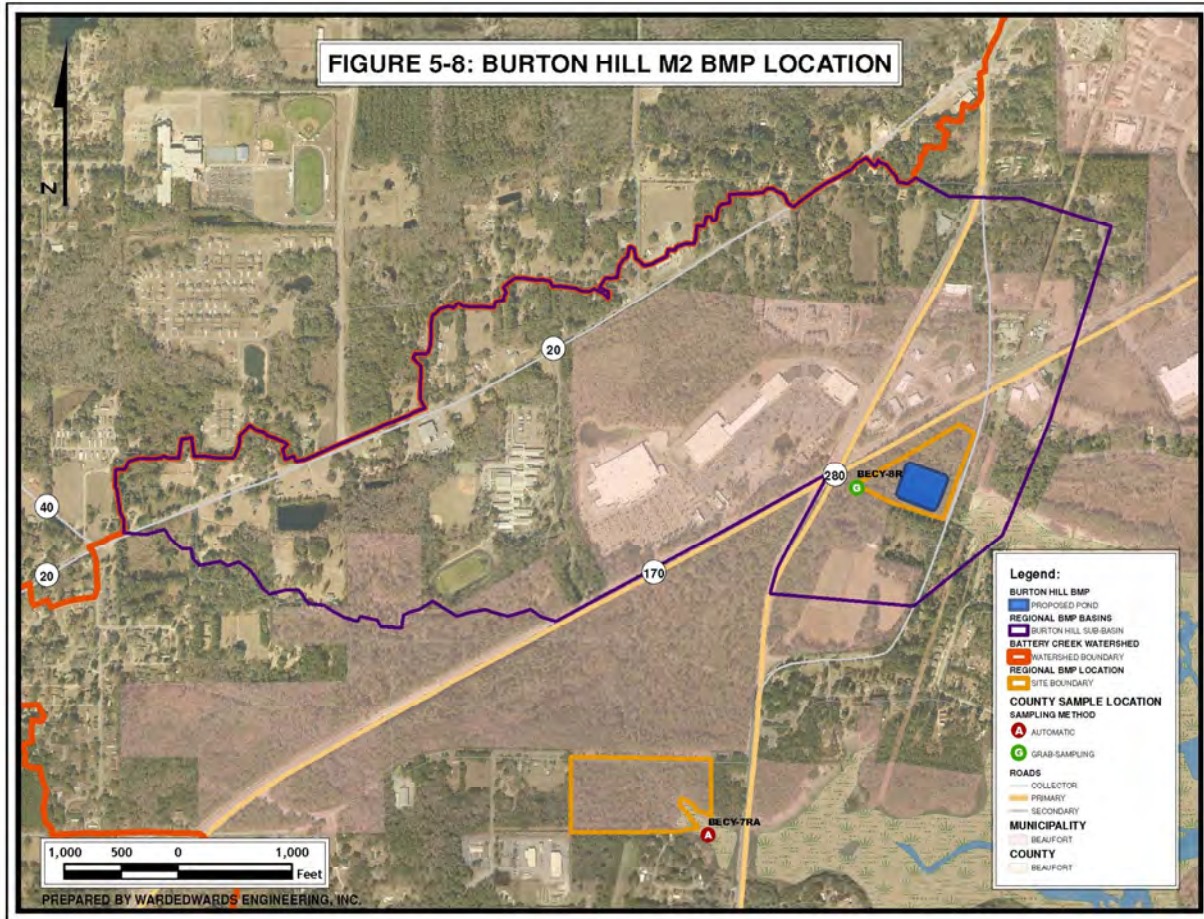


Figure 5-8 - Burton Hill M2 Regional Retrofit Location



Figure 5-9 - Burton Hill M2 Proposed Regional Retrofit Layout

Dr. John Gray, the owner of the property containing the existing pond and outfall channel, was contacted as part of the Regional Retrofit Study to gauge his willingness to help with the regional BMPs. The primary concept discussed was the use of the existing pond to capture and treat runoff from the adjacent channel. Dr. Gray expressed some concerns about the concept and mentioned some conditions should it be pursued:

- The property and pond's recreational uses should not be impacted.
- The overall quality of the pond should not be degraded.
- Trash and litter should be captured upstream and not be allowed to enter the pond.
- Access to the pond for maintenance must be provided in an unobtrusive location, preferably from Old Jericho Road on the northeast corner of the pond.

The City of Beaufort has had further discussions with the property owner about granting an easement to modify the pond and outfall. Dr. Gray is still in agreement with the concept as long as the design addresses his conditions. Use of the property will have to be further negotiated as the preliminary design is prepared and prior to final permitting. Site visits have yielded some physical concerns and challenges that will have to be addressed during the preliminary design phase:

- The existing channel is tidally influenced, with water surface elevations that could vary several feet. At the time of the site visit it was near low tide and the water level in the ditch was at least 2 ft lower than the level in the pond. This means capturing flow from the ditch will require adjusting the normal pond level down a couple feet and require the installation of a backflow preventer on the outfall pipe.

- Since it is tidally influenced, the channel may be classified at critical area or jurisdictional wetlands, making it more difficult to permit required impacts.
- There are three separate outfall pipes discharging to the channel near the highway intersection. This will make it more difficult to capture the inflow and remove trash via a manufactured hydrodynamic separator.
- The available elevation head between the three inflow pipes and the pond normal water level will have to be checked to determine if a hydrodynamic separator is feasible.

Detailed information on the proposed BMP sizing calculations and predictive modeling analyses are presented in the Regional Retrofit Study. Results of the conceptual modeling analyses estimated a 35% reduction in peak flow rate and a 4% reduction in runoff volume at the Battery Creek outfall. These results are for the 95th percentile storm assuming high tide conditions in the river. These are less efficient results compared to the Grober Hill M2 retrofit; however, this location has much higher bacteria counts meaning a greater load reduction could results despite less efficiency. Table 12 shows the peak stage results, comparing the rates at the outfall to the river, at the pond, and just upstream of the pond. Table 13 shows the 95th percentile storm runoff volume modeling results at the outfall to the river.

Table 12 - Burton Hill M2 Peak Flow Results - 95th Percentile Storm

Node	Model Node Name	Pre Max Inflow (cfs)	Post Max Inflow (cfs)
Battery Creek	BH_M-5	42.88	27.86
Upstream of Pond	BH_M-21	44.66	52.20
Pond	POND	N/A	27.96

Table 13 - Burton Hill M2 Pre-Post Volume Comparison for 95th Percentile Storm

Node	Model Node Name	Pre Volume High Tide (acre-ft)	Post Volume High Tide (acre-ft)
Battery Creek	BH_M-5	28.40	27.20

The cost to implement this BMP will be much less than the Battery Creek West M1 project and the Grober Hill M2 project. Using the existing pond will significantly reduce the cost of construction compared to the other projects requiring new ponds. The Regional Retrofit Study estimated around \$740,000 for construction of the BMP.

BMP Implementation Priority

This BMP site is upstream of Station 15-19 which is one of the two impaired areas in Battery Creek. Monitoring by Beaufort County has indicated a bacteria hotspot just downstream of the proposed BMP site. Beaufort County Monitoring Station BECY-8r measures counts greater than 160,000 CFU/100ml on multiple occasions. Given the known hotspot and relatively low cost to implement, the Burton Hill M2 retrofit would be considered highest priority. Additional information on implementation recommendations are presented in Section 6.1

5.1.4 Southside Park

Southside Park is located in the eastern portions of the Battery Creek 1 water quality sub-basin near the corner of Battery Creek Road and Southside Boulevard. It is the site of the former City of Beaufort wastewater treatment plant that was taken over by Beaufort Jasper Water and Sewer Authority and then decommissioned. The entire treatment infrastructure has been removed, the ponds have been filled, and the environmental cleanup has been completed. The 50 acres of land is under the ownership of the city and has been designated as a community park. The City has been working on plans for the park and has identified the park as a key opportunity to provide regional stormwater management for the surrounding area, which primarily consists of older single family homes. Stormwater treatment concepts that could be integrated into the park plans include ideas such as created wetlands, bioswales, and detention ponds. The park is situated downstream of the Arthur Horne Nature Preserve, a large natural wetland that currently serves as stormwater management for much of the area. Any stormwater infrastructure proposed for the park could serve as additional treatment for the discharge from the Nature Preserve, providing a treatment train approach to the regional water quality treatment. The plans for the park will have to be developed further and will require much public input. Budgets will have to be developed and funding will also be needed before the project can move forward beyond the current conceptual state.

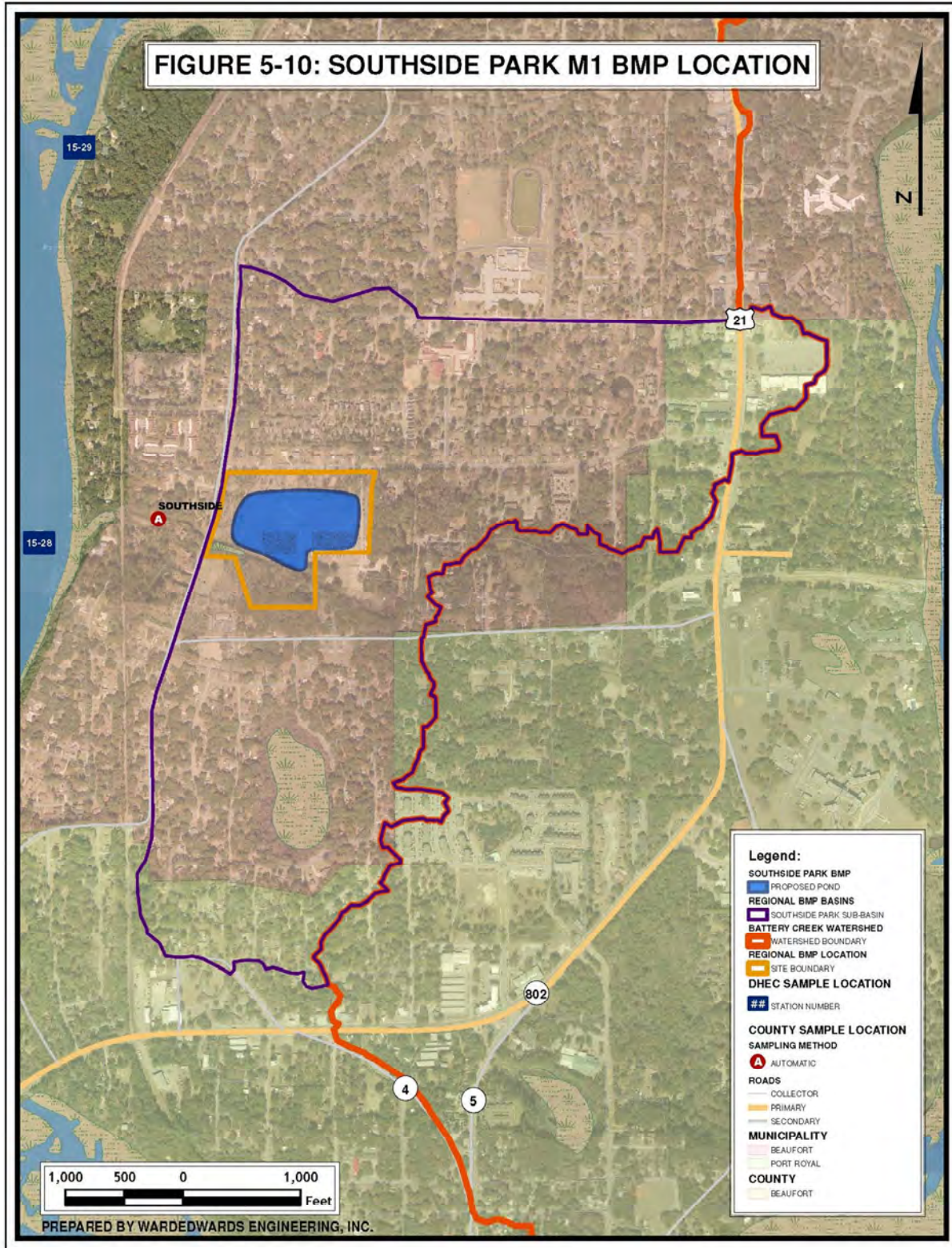


Figure 5-10 - Southside Park Retrofit Location

5.2 Non-Regional BMPs

5.2.1 Beaufort County Headquarters Parking Lot

Beaufort County's Headquarters is located at the corner of Ribaut Road and Boundary Street in the very top of the headwaters of the Battery Creek watershed. It is within Battery Creek 4 water quality sub-basin, which currently meets the fecal coliform water quality standards for recreational use. The Headquarters complex is comprised of five buildings including the Sheriff's office, the County Detention Center, the County Courthouse, The County Council Chambers, and office space for many of the other essential services. The buildings and parking lot sit directly adjacent to the marshes of Battery Creek, and are served by two small detention ponds. The facility was built prior to many of the newer stormwater standards, including the Volume Control Ordinance.

Although Battery Creek 4 currently meets the fecal coliform standards for recreational uses, it exceeds the standards for shellfish harvesting. This would normally not be a concern except that it is upstream of areas that are classified and impaired for shellfish harvesting. The flashy introduction of the freshwater to the saltwater river could extend the bacteria lifespan to durations sufficient for tidal flushing to transport bacteria downstream to the impaired shellfish areas. A reduction in the runoff volume from the Headquarters parking lot should help reduce the amount of bacteria reaching the impaired sections of the river.

Beaufort County developed a plan to retrofit the existing parking lot by replacing impervious pavement with pervious pavement, thus reducing the volume of runoff from the site. The plan also calls for installation of four rain gardens within the existing parking lot islands, and the removal of raised curb to allow sheet flow to pervious landscaped islands. This project will serve as a pilot project and demonstration of potential retrofit projects throughout the County. Beaufort County has been collecting monitoring data (monitoring station BECY-17) just downstream of the parking lot and will continue to monitor it after construction is complete. The pre-post comparison will give an idea of the effectiveness of the permeable paving retrofit and indicate whether or not it is an effective use of funds.

At the time of this report, the project has been designed and procurement for construction services will begin soon. The project is being funded by the Beaufort County Stormwater Utility, which has been collecting funds reserved for retrofit projects such as this one.

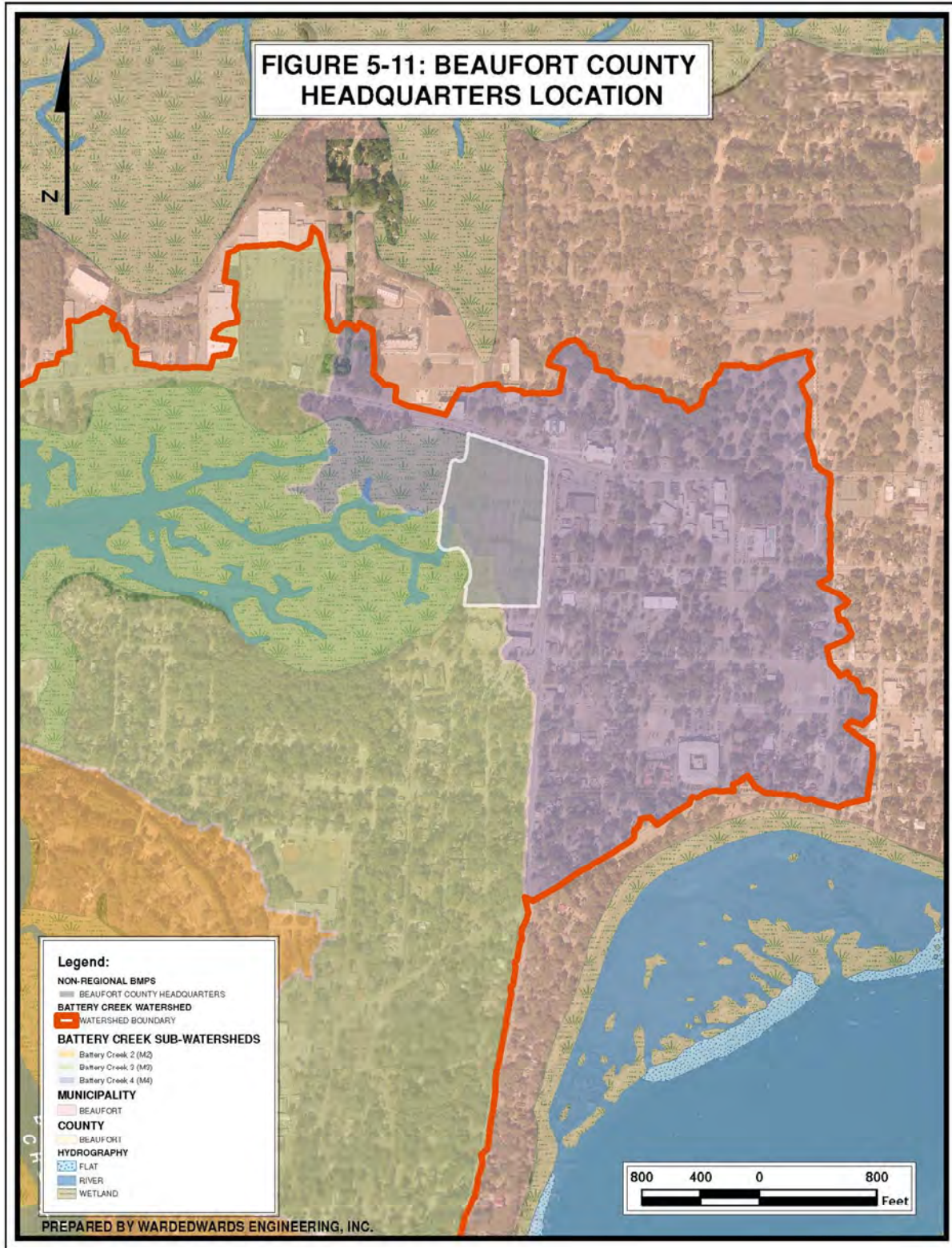


Figure 5-11 - Beaufort County Headquarter Parking Lot Retrofit

5.2.2 Existing Parking Lot Retrofits

There are many existing parking lots within the Battery Creek watershed that could be retrofitted to provide additional water quality treatment and to reduce the stormwater runoff volumes. The County's Headquarters project will demonstrate the effectiveness of replacing existing impervious surfaces with permeable paving and the benefit of including bioretention/rain gardens within parking islands. The results of the County project may also provide good construction costs to demonstrate the cost-benefit ratio of such retrofits.

It is expected that areas within the watershed with sandy soils classified as Hydrologic Soil Groups A and B will be best suited for parking lot retrofits. Figure 5-12 shows areas within the watershed with A and B soils.

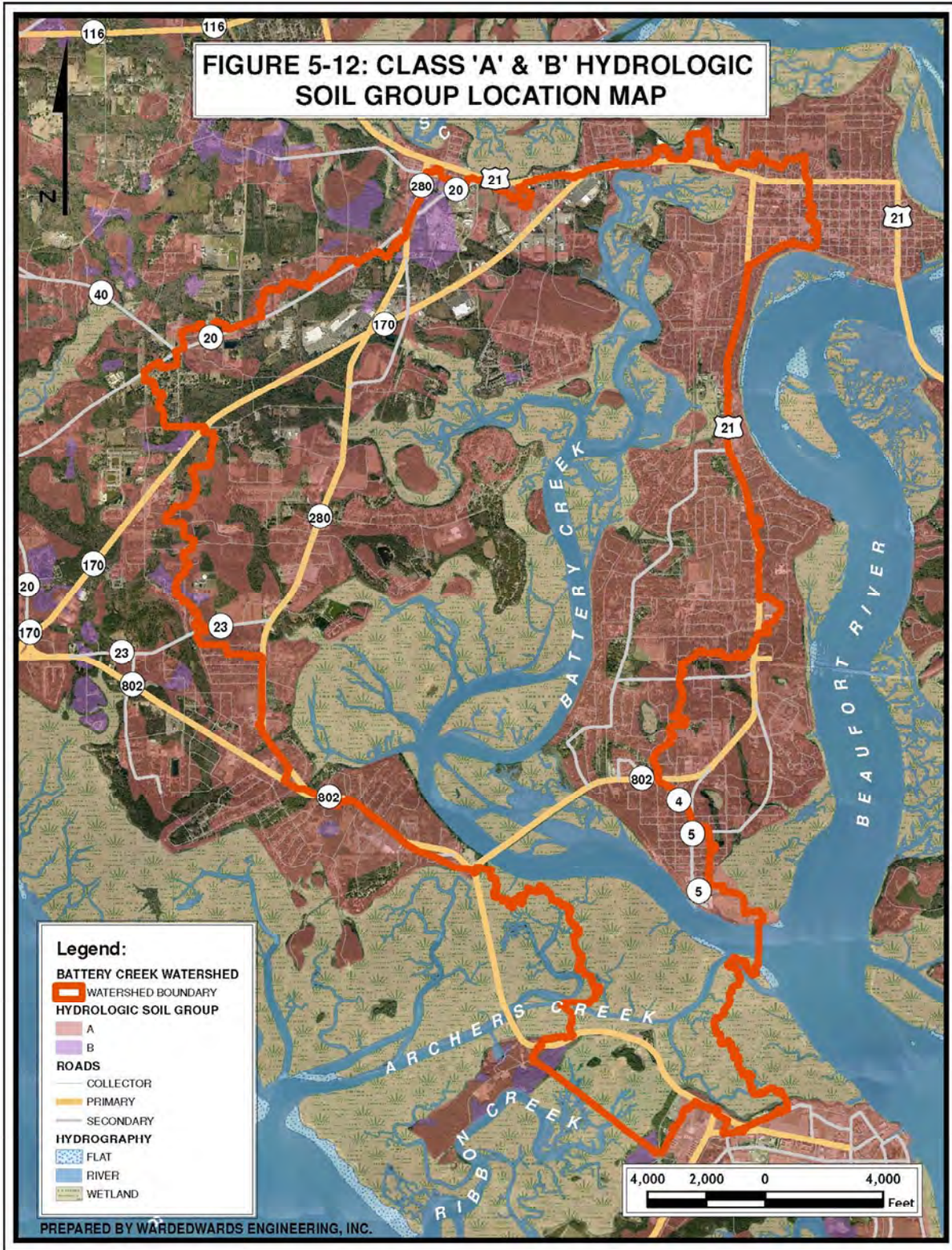


Figure 5-12 - Potential Infiltration BMP locations based on Soil Classification

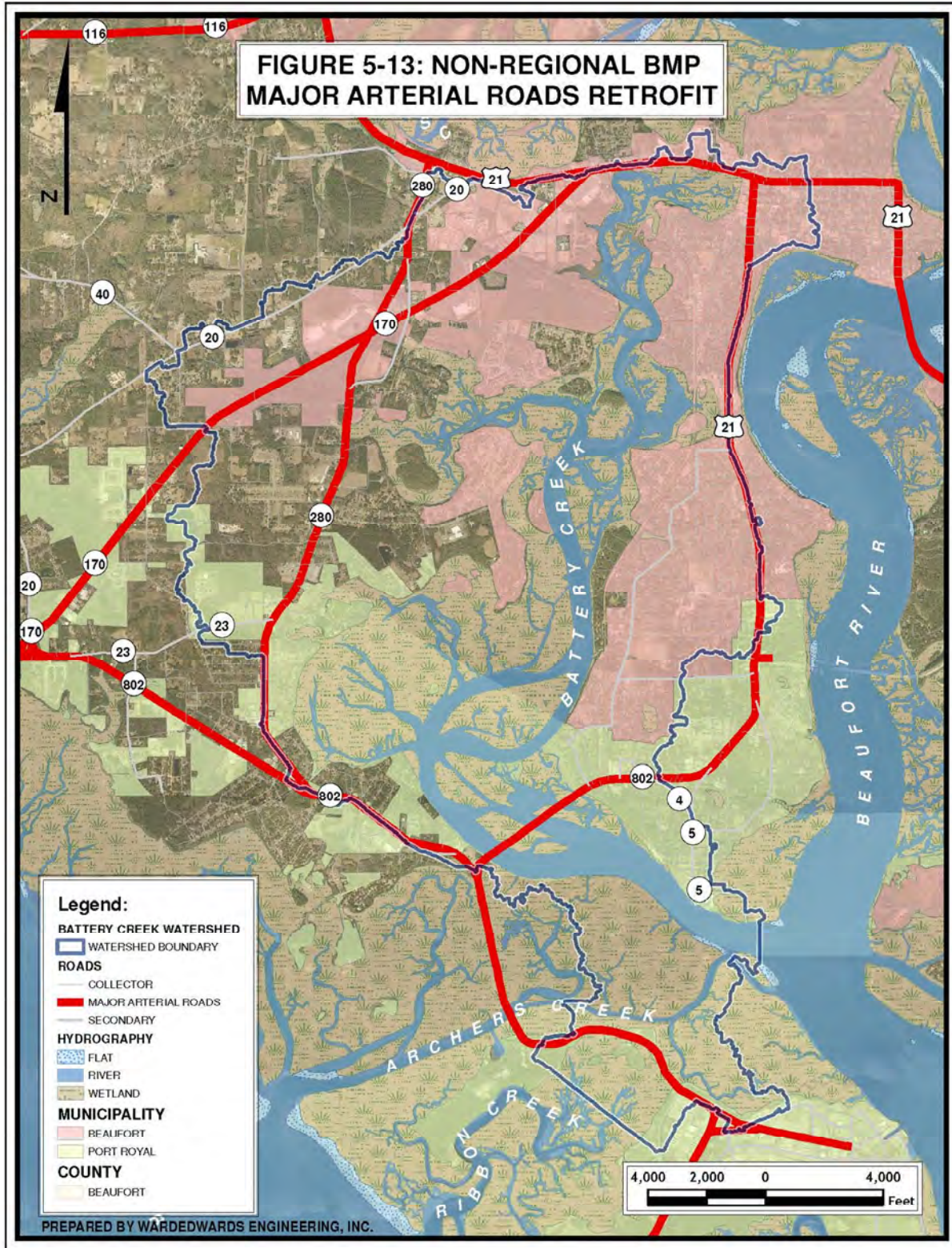


Figure 5-13 - Major Arterial Roads Suited for Non-Regional Retrofits

5.2.3 Existing Road Retrofits

The outer boundary of the Battery Creek watershed tends to generally follow the major arterials running through Beaufort and Port Royal, including Robert Smalls Parkway, Ribaut Road, Parris Island Gateway, and Boundary Street. All of these roads are four lanes divided by paved medians and edged with curb. All were constructed or widened prior to current water quality standards, meaning that most of the stormwater runoff is collected and discharged directly to the receiving waters. This also means there are opportunities to incorporate non-regional BMPs into the road systems that will make small improvements in the runoff treatment and will reduce the runoff volumes reaching Battery Creek.

Potential non-regional improvements to existing roads include:

Removal of paved medians:

The most direct method of reducing the stormwater runoff rates and volumes is to reduce the amount of impervious surfaces generating the runoff. Removal of portions of the paved medians is likely the only way to reduce the amount of impervious area for the highways without affecting the level of service for the roads. Replacing the paved medians with landscape medians will eliminate left turning movements at many of the fronting parcels; however this is sometimes desired by traffic engineers as it often improves safety and function of the roadway. This is only possible through careful traffic management planning by providing alternate left turn ingress and egress points for the affected parcels. Beaufort County and the Town of Port Royal partnered for the implementation of such a plan for Ribaut Road between Edinburgh Avenue and Paris Avenue by removing portions of the paved median and installing a raised landscaped median. The purpose of the project was to improve traffic safety by limiting left turn movements to the main intersections, but the project also resulted in around a half an acre reduction in impervious area over a third of a mile length of road.

Similar projects could be implemented as traffic master plans are developed for the streets within the watershed. Opportunities to reduce the amount of impervious area should be encouraged by the City of Beaufort, Town of Port Royal, and Beaufort County. The City has one such project in the works that will incorporate stormwater quality and volume reduction components. The City has plans to redesign Boundary Street from the intersection with Ribaut Road, west to the intersection with Robert Smalls Parkway. The redevelopment plan calls for removal of the center paved median, replacing it with a 16 ft wide raised landscape median and narrowing each of the four travel lanes by 1 foot each. This will result in less pavement within the travel area of the road. The plan also calls for widening of the sidewalks by a couple of feet each and the future addition of a frontage road; however the design of the frontage road in particular will incorporate stormwater BMPs meeting the current water quality and volume control BMPs. The net result of the project should be an improvement to water quality and a reduction in volume for stormwater leaving the existing Boundary Street right-of-way. This project is being funded by a 1% Transportation Sales and Use Tax collected by Beaufort County and a Federal TIGER Grant awarded by the U.S. Department of Transportation.

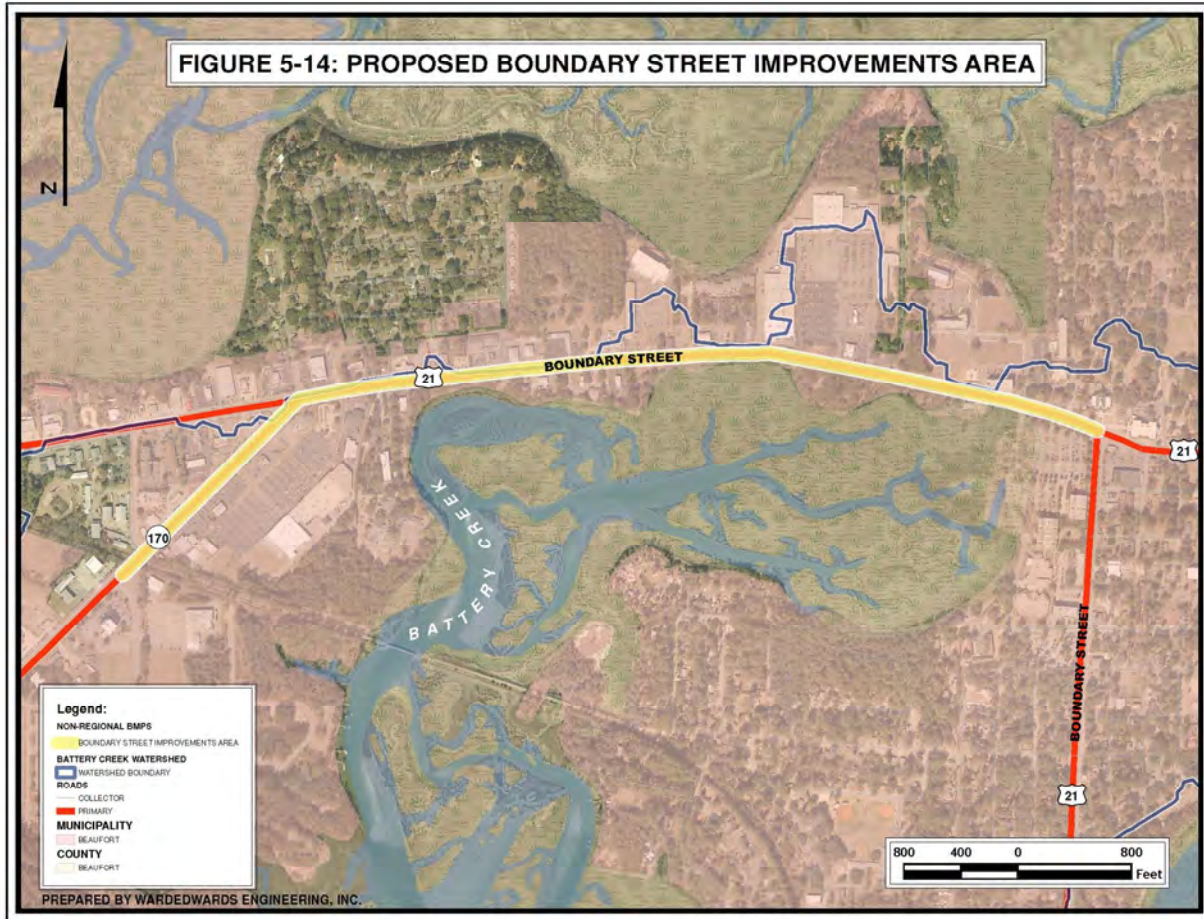


Figure 5-14 - Future Boundary Street Improvement Limits

Tree Boxes/Bioretenention Boxes

The use of tree boxes or bioretention boxes is an effective method of addressing stormwater quality from existing streets and parking areas in highly urbanized areas. The boxes replace existing curb inlets with an inlet that incorporates landscaping such as trees or small shrubs. The boxes use an engineered soil media and carefully selected plants that function similar to bioretention systems or rain gardens. Collected runoff is temporarily stored in the soil media where it can be dissipated by infiltration and evapotranspiration. The boxes are sized to collect runoff from the smaller, more frequent storm events, while allowing the large runoff events to bypass and discharge normally to the storm sewer collection system. There are proprietary products available such as the *Filterra* box or systems can be custom designed. The boxes can be retrofitted alongside the existing curb inlets as shown in Figure 5-15; however it is unknown if these systems have yet to be used within SCDOT right-of-way, so permitting with SCDOT may be a challenge. These systems may be more useful and easier to implement on privately owned roads or roads owned and maintained by Beaufort County.

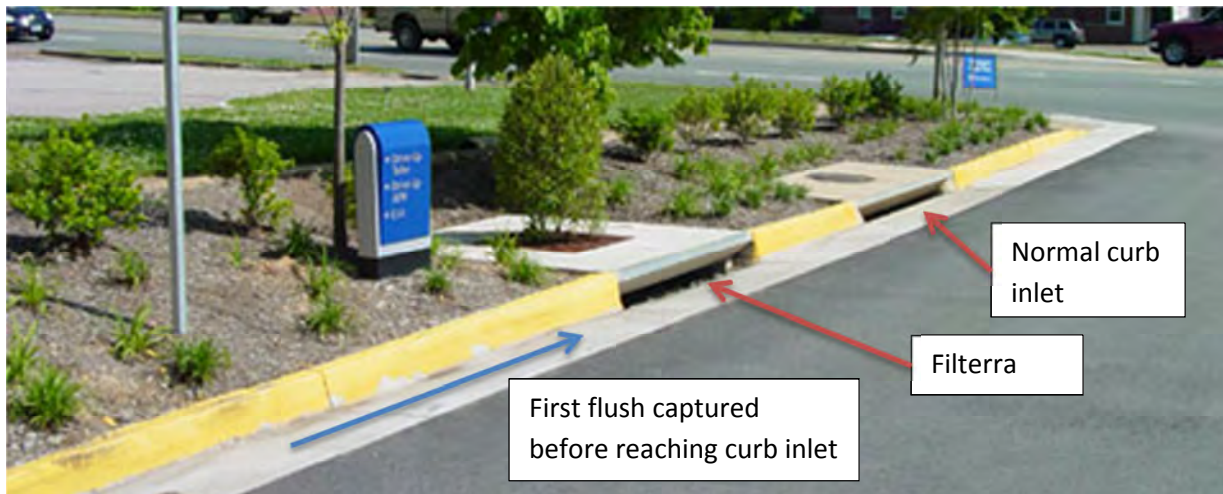


Figure 5-15 Typical *Filterra* installation (Picture from *Filterra* website)

Hydrodynamic separators and media filters

Hydrodynamic separators and media filters are proprietary water quality devices that can be connected to existing and proposed storm sewer collection systems. Hydrodynamic separators use baffles, veins and weirs to create vortices that facilitate deposition of suspended particles. They are effective at removing trash and sediment from runoff but their effectiveness at removing other pollutants is highly variable, depending on the installation, the pollutant concentrations, the type of pollutant, and the pollutants' interaction with sediment particles. Specifically, hydrodynamic separators are typically only effective for fecal coliform removal if the bacteria is attached to or associated with sediment particles. Given this, hydrodynamic separators are not likely to be used to directly achieve the goal of meeting the fecal coliform standards, but may be incorporated into designs to address secondary water quality concerns.

Media filters are another type of structure similar in function to hydrodynamic separators that are installed within a storm sewer collection system and are intended to treat the collected runoff. However, these structures include filtering components using sand or other proprietary media. Many units use replaceable cartridge filters within the structures, targeted to pollutants of concern. This makes them more effective than hydrodynamic separators at treating for bacteria. They are most effective for smaller drainage areas with low discharge flows. They also require more hydraulic head to operate properly, which is a challenge in the Beaufort and lowcountry region. They can be expensive to install, with high up-front materials costs, and can also be expensive to maintain due to media replacement costs. Use of hydrodynamic separators and media filters may not be feasible for this watershed, but will remain as a consideration given the right circumstances.

End of pipe improvements

The stormwater collection systems for the road each have a series of outfall points to the receiving waters or to ditches that drain to the receiving waters. There may be opportunities to install BMPs at the outfall points where the pipes do not discharge directly to saltwater critical area. These end of pipe improvements could include BMPs such as small wet detention systems, created wetlands, existing wetland enhancements, or bioswales. The type and size of the BMP would be dependent on topography and the amount of upland area available.

For areas where pipes discharge to freshwater wetlands, wetland enhancements would be the preferred BMP. The goal of enhancements is to modify the discharge from the freshwater wetland such that additional runoff from smaller storm events is stored in the wetland and dissipated through evapotranspiration. Improving the wetlands to increase the evapotranspiration will reduce the runoff volume reaching the receiving waters. Beaufort County has a regional retrofit project involving wetland enhancement in the Okatie River watershed. Referred to as “Okatie East”, the project will enhance a large freshwater wetland system to reduce runoff volume. The project will be monitored to determine the effectiveness in improving water quality for bacteria impairments. If found effective, then the wetland enhancements will be used on smaller, non-regional scales in other watersheds throughout the County, such as the Battery Creek watershed.

Locations for end of pipe improvements currently have not been identified. An inventory and evaluation of all road drainage systems will need to be conducted to identify, catalogue and prioritize opportunities. Cooperation with SCDOT and adjacent property owners will be critical for these types of retrofits.

5.2.4 Cistern/Rain Barrel Programs

As discussed in Section 2.1, most of the residential areas within the Battery Creek watershed were constructed prior to the current stormwater quality regulations. For example, the some of the older developments in the Mossy Oaks area (eastern portions of Battery Creek 1 & 2) were constructed 30 to 40 years ago and do not drain to detention ponds or other BMPs. In areas where regional BMPs are not an option, the use of cisterns or rain barrels would help reduce runoff volume from these residential rooftops. Cisterns are generally more effective than rain barrels because they provide greater storage

volume and can capture runoff from multiple storms that occur in short periods; where rain barrels might fill up and not be drained prior to the next storm. However, cisterns are more expensive and require more installation space. Rain barrels are easier to implement by the homeowners without professional help. The use of rain barrels and cisterns by homeowners is usually dependent on education programs and material giveaway programs. This option will likely require some funding by the Management Partners to implement on a wide scale. Unfortunately, the success and rate of return of these programs are difficult to evaluate. Do to the funding needs and the difficult evaluation, implementation of a rain barrel program may remain a low priority.

5.3 Preservation and New Development Policies

As discussed on Section 2.3, the undeveloped portions of the watershed will face development pressure in the near and extended future. The rural portions of Battery Creek sub-basins 1 & 2 could be annexed into the City of Beaufort or Town of Port Royal and be developed at greater densities than allowed in unincorporated Beaufort County. The City and Town are also encouraging redevelopment and infill within the more urban areas of sub-basins 1 & 2. Given that the watershed will continue to increase in impervious percentage, having sound policies for preservation of natural resources and for development practices is critical to anti-degradation of the watershed.

5.3.1 Preservation Policies

Beaufort County, the City of Beaufort, and the Town of Port Royal have historically been progressive in their policies on natural resource preservation. All three groups have ordinances that require natural open space preservation for developments, including stream and perimeter buffers. All value preservation of trees, wetlands, and other natural resources. At the time of this document, the three groups are engaged in the process of implementing new Form Based Codes for development and re-development; however, the preservation policies should continue in the new codes. Among the many goals of the Form Based Code is the desire to create communities that preserve rural areas by clustering mixed use development and by encouraging infill rather than greenfield development.

Beaufort County citizens as a whole have been progressive about land preservation as well, and have voted for the Rural and Critical Lands Program, first enacted by Beaufort County in 2000. The program earmarks tax revenue for the preservation of identified parcels throughout the County. Preservation is achieved by fee simple purchase of land, purchase of conservation easements, and purchase of development rights. Overall, the program has preserved over 21,000 acres in Beaufort County and 13.59 acres within the Battery Creek Watershed.

As the Form Based Codes are prepared and as the County and Municipalities set development priorities, the following preservation strategies should be considered:

- Riparian buffers along the Battery Creek critical area and along the intermittent channels conveying runoff to the river
- Wetland preservation and buffers
- Transfer of Development Rights Program
- Continuation of the Rural and Critical Lands Program

5.3.2 New Development Policies

The most recent and perhaps most significant change to development policies is the stormwater volume control standards adopted by Beaufort County. As discussed in Section 5.0, the Volume Control standards were implemented in three phases and are intended to address water quality problems associated with non-point source pollution from land development. The first phase passed in 2009, requires all new development to limit post-development runoff volumes equal to or less than pre-development volumes. These standards apply to all projects regardless of use or size. The second phase, enacted in 2011, applies to residential lots that were subdivided prior to the 2009 Volume Ordinance, and have not been constructed yet. The third phase is the regional retrofit projects for existing developments discussed in Section 5.1. The City of Beaufort and Town of Port Royal have entered into Inter-Governmental Agreements with Beaufort County, such that the County's volume control standards will apply to developments within the respective municipality. Applying the volume control standards to new development will provide anti-degradation in the watershed. Applying volume control to re-development of existing non-conforming sites and to retrofit projects will help improve water quality in the watershed. Other potential new development policies that Beaufort County, the City of Beaufort, and the Town of Port Royal should consider include:

- Incentives or requirements for permeable paving in parking lots. The current development ordinances encourage permeable paving for sites to meet the maximum allowable impervious percentage requirements, but don't provide incentives to far reduce the overall impervious area. The Town of Bluffton's development ordinance requires that for sites with A or B soils, 50% of parking must be permeable paving. This typically results in lesser effective impervious percentages and less runoff volume.
- Incentives or requirements for recessed parking islands containing bio-swales or bio-retention. This requirement is best applied to sites with A and B soils, and can reduce runoff volumes through infiltration and evapotranspiration.
- Incentives or requirements to capture stormwater for irrigation reuse. This concept can be used for small and large projects alike and can also be used in large residential or commercial subdivisions. It is a very effective method to reduce runoff volumes reaching the receiving waters. There are a number of large planned communities in the Bluffton, SC area that have been using water from the stormwater detention ponds as irrigation for golf courses and residential common areas. Measured irrigation use data has demonstrated that millions of gallons a year are used from the ponds, significantly reducing the discharge to the nearby waters.

5.4 Policies and Outreach

There are additional policies and outreach not associated with new development that can make an impact on water quality. Policies and outreach require public involvement during the development in order to ensure public buy-in. The following policies should be considered for implementation by Beaufort County, the City of Beaufort, and the Town of Port Royal:

5.4.1 Homeowner Education and Policies

- **Pet Waste Education:** Pet waste is a recognized contributor to non-point source pollution, although the relative contribution compared to other sources is highly variable. It is difficult to estimate the exact magnitude that pet waste contributes to fecal coliform counts because of the many factors such as pet density, location, topography, land cover, and interaction with wildlife waste. Source tracking efforts within Beaufort County to quantify the relative contribution of pet waste versus wildlife waste has been inconclusive so far. Regardless, controlling pet waste through collection and proper disposal can make a positive impact on bacteria contamination. It is also one of the main ways for community members to be directly and actively involved in protecting their rivers. Education programs should inform residents of the importance of cleaning up after pets and the proper locations for its disposal. Policies that can be enacted include signage and pet waste stations at public parks, the creation of dedicated dog parks, and pet waste program requirements for planned development.
- **Septic Maintenance:** The failure rates of septic systems are quite high in areas where soils are inadequate or where there are elevated groundwater conditions. System failures can result in untreated sewage reaching the nearby surface waters, resulting in high fecal coliform counts. Septic systems should be inspected every three to five years and cleaned as needed to prevent system failures. Education programs can remind homeowners to have their systems inspected and pumped. They can also instruct owners on proper waste disposal and on septic friendly products. However, the effectiveness of education programs is difficult to assess, so other policies may be needed. Septic questionnaires and inspection policies could allow municipalities identify failing septic systems. However, residents often don't participate in the questionnaires and are reluctant to allow inspections of property. A more effective and less divisive policy is to simply work with the local sewer utility to extend public sewer to areas not served by septic. Public sewer extensions can be targeted to areas with poor soils and high groundwater elevations. Furthermore, ordinances for new development should prohibit new septic systems in areas where public sewer extension is feasible.
- **Rain Barrel Giveaway/Cost Supplement:** Rain barrel giveaways or cost supplement programs can be a good way to get homeowners to use rain barrels. Such a program was done in the May River watershed in Bluffton, SC with good participation from residents. Beaufort Jasper Water and Sewer Authority has done reduced cost sale of rain barrels to encourage wise water use and reduce use of potable water being used for irrigation. However, installation of rain barrels does not guarantee their proper use. If homeowners are not using the captured water, the barrels can quickly fill and be bypassed during subsequent rain events. For this reason, rain barrel programs may not be the most effective use of funds beyond the educational and water quality awareness benefits.
- **Riparian Buffer Education for Homeowners:** With much of the banks of Battery Creek containing residential property, education to homeowners on the proper maintenance of riparian buffers could be effective in preserving and improving water quality in the river. Beaufort County, the City of Beaufort, and Port Royal already have policies on buffer preservation, but individual homeowner knowledge of those requirements are often lacking. Buffers are occasionally cleared

of natural vegetation and replanted with turf grasses. Enforcement of the buffer policies is often difficult, as the only way the buffers are usually visible is from the water. Local officials often rely on neighboring citizens to inform them of possible buffer violations. Additional education efforts should be considered through homeowner workshops, correspondence with POA, and through the Beaufort County Stormwater Utility outreach program.

5.4.2 Illicit Discharge Ordinances and Inspection Plan

Beaufort County, the City of Beaufort, and the Town of Port Royal currently do not have illicit discharge ordinances, nor do they conduct routine inspections for illicit discharges. Although this is not expected to be a major contributor to the fecal coliform bacteria, the effect cannot be determined if it is not being examined. All three organizations should develop illicit discharge ordinances and inspection programs. Inspections could initially focus on the impaired watersheds such as Battery Creek, and later be expanded to County-wide as the MS4 permit requirements begin.

5.4.3 Engineer/Designer/Contractor/Owner Education Programs

Proper selection and design of stormwater BMPs by land planners, engineers and developers will be important to meeting watershed anti-degradation goals. There are a number of organizations such as the Center for Watershed Protection that offer frequent webcast on a variety of BMP design subjects. Over the past few years, the Beaufort County Stormwater Utility has hosted broadcast sessions of these webcast for local professionals and residents at no cost. This is an effective education program that takes advantage of recognized national experts. It is recommended that Beaufort County continue to offer these webcasts for the following subjects:

- Design of BMPs for volume control
- Selection and design of BMPs for effective pollutant removal
- Urban retrofit design
- Rainwater harvesting
- Sediment and erosion control
- Bioretention/rain garden design, installation and maintenance

5.5 Estimated Pollutant Reduction

The Beaufort County Stormwater Master Plan (SWMP) included extensive water quality modeling of basins throughout the County, including the Battery Creek watershed. Modeling of the Battery Creek watershed was included as part of the overall model for the Beaufort River watershed, although the results were presented with smaller sub-basins delineated from the whole watershed. As discussed in previous sections, Battery Creek water quality modeling was performed assuming four separate sub-basins, numbered 1 through 4. The three regional retrofits originally proposed in the SWMP were proposed in water quality sub-basins Battery Creek 1 and Battery Creek 2. Battery Creek 1 includes the Battery Creek West M1 regional retrofit. Battery Creek 2 includes the Grober Hill M2 and the Burton Hill M2 regional retrofits.

As part of the County SWMP, the Watershed Management Model (WMM) was used to estimate the average annual runoff flows and the average annual loads of common pollutants including fecal coliform

bacteria, total nitrogen, total phosphorus, lead, zinc, BOD and total suspended solids. The geometric mean bacteria concentrations in the runoff from the watersheds to the tidal rivers were also calculated in the WMM. The flows and concentration results were used in the Water Quality Analysis Simulation Program (WASP) which accounted for tidal mixing and bacteria loss within the saltwater rivers. The models were done for existing and future conditions. Future conditions were modeled for many different scenarios, including assumed worst case (no BMPs), assumed best case (100% BMP coverage), and for the proposed regional BMPs implemented. The best-case/worst-case scenario modeling was discussed in Section 2.4 of this report, but some of the results are repeated below.

The water quality modeling for the future conditions included estimated load reduction for the regional retrofit projects and for reduced septic tank coverage area. Table 14 and Table 15 show the estimated changes in septic tank coverage used between the existing conditions and assumed future conditions.

Table 14 - Water Quality Septic Tank Coverage - Existing Conditions

Existing Land Use Type	Battery Creek 1 (%)	Battery Creek 2 (%)	Battery Creek 3 (%)	Battery Creek 4 (%)
Commercial	68 %	35%	0%	0%
High Density Residential	39%	56%	0%	0%
Industrial	18%	48%	0%	0%
Institutional	2%	3%	0%	0%
Low Density Residential	0%	0%	0%	0%
Medium Density Residential	0%	0%	0%	0%
Total	35%	48%	0%	0%

Table 15- Water Quality Septic Tank Coverage - Future Conditions

Existing Land Use Type	Battery Creek 1 (%)	Battery Creek 2 (%)	Battery Creek 3 (%)	Battery Creek 4 (%)
Commercial	52 %	17%	0%	0%
High Density Residential	39%	56%	0%	0%
Industrial	18%	47%	0%	0%
Institutional	1%	2%	0%	0%
Low Density Residential	0%	0%	0%	0%
Medium Density Residential	0%	0%	0%	0%
Total	30%	34%	0%	0%

The average annual pollutant load results from the WMM for the existing conditions and future conditions are presented in Table 4 and Table 5 respectively in Section 2.4. The results include the full range of standard pollutants. Table 5-8 shows the existing level of service related to fecal coliform contamination for the four Battery Creek water quality sub-basins based on monitoring results. It includes the associated SCDHEC monitoring stations, and the geomean and 90th percentile concentrations. Table 5-9 shows the modeled results comparing the level of service for the existing and future land use conditions. Note that the modeled results for existing conditions are close to the observed results from Table 5-8. The model results for the future conditions do not account for future retrofits or other management strategies. The results show an expected increase in geomean concentrations as the land use changes from development and re-development. Note that the level of service for sub-basins 3 & 4 are based on shellfish standards, although the two areas are only classified for recreational use. If the levels of service were based on recreational standards, both sub-basins would be Level of Service A, meaning they would meet SCDHEC requirements. Regardless of meeting the use classification, reductions to the bacteria levels in sub-basins 2 & 3 are desired due to expected impacts on the downstream sub-basins from transport of contaminants via tidal flushing.

Table 16 - Existing Level of Service for Battery Creek Sub-basins from WMM Results

Water Quality Sub-Basin	SCDHEC Monitoring Stations	Fecal Coliform Concentrations				Level of Service
		Long Term Average		Maximum 36-Sample Values		
		Geomean (#/100 ml)	90 th Percentile (#/100 ml)	Geomean (#/100 ml)	90 th Percentile (#/100 ml)	
Battery Creek 1	15-10, 15-21	5.6	23	6.6	33	A
Battery Creek 2	15-19	8.5	49	11.4	75	C
Battery Creek 3	None	N/A	N/A	N/A	N/A	N/A
Battery Creek 4	None	N/A	N/A	N/A	N/A	N/A

Table 17 - Fecal Coliform Modeling Results Comparing Existing and Future Conditions Assuming No New BMPs

Water Quality Sub-Basin	Fecal Coliform Concentrations			
	Modeled Geomean Conc. (#/100 ml)		Modeled Level of Service	
	Existing	Future	Existing	Future
Battery Creek 1	5.3	5.4	A	A
Battery Creek 2	9.0	9.2	C	C
Battery Creek 3	11.0	11.2	D	D
Battery Creek 4	12.2	12.4	D	D

The locations and proposed BMPs have been refined since the release of the SWMP, however the modeling has not been refined. It is expected that the refined BMPs will produce higher reductions than predicted by the model results. The original model results and predicted pollutant reductions are presented in Table 18. The pollutant reduction results for the Grober Hill and the Burton Hill retrofits are combined since they are both within the same water quality sub-basin. Estimated pollutant reductions are provided for fecal coliform bacteria only, as it is the impairment within the Battery Creek. Reductions for other pollutants are expected as well, but not modeled as part of this plan.

The predicted Levels of Service assuming the regional BMPs are implemented are presented in Table 19. Note the improved Level of Service expected for Battery Creek 2. Full explanation of the modeling approach and results are presented in Section 2 and Section 8 of the 2006 Beaufort County Stormwater Master Plan, available from the Beaufort County Stormwater Utility.

Table 18 - Predicted Pollutant Reductions from Regional Retrofit Projects (from original SWMP)

Water Quality Basin ID	Regional Retrofit Site	Fecal Coliform Load (#/yr)	Fecal Coliform Removal (#/yr)	Existing Water Quality Basin Load (#/yr)	Water Quality Basin Bacteria Load Reduction (%)	Water Quality Basin Bacteria Geomean (#/100 ml)	Geomean with Regional Retrofits (#/100 ml)
Battery Creek 1	Battery Creek West M1	9.38E+13	7.50E+13	3.36E+15	2%	1635	1598
Battery Creek 2	Grober Hill M2	1.55E+14	2.99E+14	2.56E+15	12%	1673	1477
	Burton Hill M2	2.19E+14					

Table 19 - Regional BMP Analysis Results and Predicted Levels of Service

Water Quality Sub-Basin	Modeled Geomean Conc. (#/100 ml)		Modeled Level of Service	
	Existing	Future With Regional BMPs	Existing	Future with Regional BMPs
Battery Creek 1	5.3	5.1	A	A
Battery Creek 2	9.0	8.2	C	B
Battery Creek 3	11.0	10.5	D	D
Battery Creek 4	12.2	11.7	D	D

Load reductions were modeled for regional retrofits and for reduced septic tank use coverage only; however the other management strategies are expected to produce load reductions as well. Expected load reductions for fecal coliform are highly variable and generally unpredictable, particularly for non-regional BMPs and educational programs. Given the unpredictability in bacteria reductions, estimates for the non-regional BMPs were not made; however implementation of these strategies are of no less importance than the regional retrofit BMPs. The implementation plan, timeline, and milestones are presented in Section 6 of this report.

The pollutant removal predictions provided in Table 18 account only for the benefits from the regional retrofit BMPs. The other management strategies are expected to provide some benefit as well, but quantifying those benefits as percent removal efficiencies is difficult. Research into the benefits of the non-regional BMPs and management strategies was conducted Instead, typical pollutant reduction percentages are provided in Table 20.

Table 20 - Typical Pollutant Removal Percentages for Non-Regional BMPs, Policies, and Outreach

Strategy	Estimated Removal Effectiveness
Parking Lot Retrofits – Permeable Paving	Dependent on amount of impervious area reduced - Proportional to % impervious reduction
Parking Lot Retrofits – Bioretention*	70% removal for service area
Existing Road Retrofits – Pavement area reduction	Dependent on amount of impervious area reduced - Proportional to % impervious reduction
Existing Road Retrofits – Bioswales*	70% removal for service area
Cistern/Rain barrel Programs	Unknown – likely proportional to runoff volume reduction
Homeowner & Professional Education Programs	Unknown –Expected to improve BMP design, installation, and maintenance of BMPs
Illicit Discharge Ordinances and Inspection	Unknown – Possibly large benefits dependent on illicit discharges discovered

*Bioretention and Bioswale removal efficiency based on Beaufort County *Manual for Stormwater Best Management and Design Practices*

6.0 Watershed Plan Implementation

6.1 Phased Implementation Plan and Timeline

A phased implementation plan was developed while keeping in mind the primary objective of meeting the appropriate water quality standards for fecal coliform bacteria in portions of the river classified for recreation use waters and in portions classified for shellfish harvesting. The implementation strategy is to focus initially on projects that will produce the best results for the least cost. The regional retrofits projects generally have high costs, but are also expected to produce good results, particularly in the sub-basins containing the shellfish harvesting prohibited areas. The phasing also considers strategies that will take time to implement, such as programs that will require public input, or retrofit projects that will require landowner cooperation. Projects such as these that will take longer to implement will begin early in the phasing process, but will finish later in the process as well.

The Phased Implementation Plan includes twelve strategies/projects, broken down into short-term, mid-term, and long-term actions. Short-term actions are expected to be implemented within 1 to 2 years. These are generally time sensitive actions or actions needed to lay the ground-work for future actions within the individual strategy. Mid-term actions are expected to occur within the next 2 to 4 years, assuming the preceding short term actions have been completed. They generally involve program development for the longer-lived projects or securing funding and/or public support. Long-term actions are expected to occur 5 or more years away. They are often evaluation components of the short-lived projects or implementation of the longer-lived strategies. Long-term strategies are subject to the most change as short-term strategies and shorter lived projects alter the watershed needs.

1. **County Administration Building Parking Lot Retrofit:** This project has been underway for more than a year now, with design and permitting complete. Beaufort County is in the process of procurement for the construction services, and work is expected to begin within months of the date of this report. Funding for this project will be provided by funds saved through the Beaufort County Stormwater Utility.
Short-term actions: Project procurement and construction. Begin water quality monitoring after completion of construction.
Mid-term actions: Maintain water quality monitoring. Analyze water quality monitoring results and track maintenance expenses. This information will be used to evaluate the cost-benefit ratio of replacing existing impervious pavement with new permeable paving. The results will be used as part of educational programs and to evaluate future pavement retrofit projects. If successful, similar projects should be considered for areas such as the parking lot for Cross Creek Shopping Center and the Beaufort Plaza. Projects such as these will require public-private partnerships or incentive programs.
Long-term actions: None
2. **Burton Hill M2 Regional Retrofit:** This project is the lowest cost regional retrofit and is located upstream of one of the most significant bacteria hotspots based on County monitoring data. Beaufort County and the City of Beaufort have been in contact with the property owner, and he appears to be willing to cooperate.

Short-term actions: Complete design and permitting. Begin construction

Mid-term actions: Monitor water quality results. This information will be used to determine the effectiveness of the regional retrofits and evaluate the pursuit of future regional retrofit projects.

Long-term actions: Continue monitoring water quality results.

3. **Illicit Discharge Ordinance:** Beaufort County, the City of Beaufort, and the Town of Port Royal should all implement illicit discharge ordinances to their respective codes. Following adoption of the new ordinances, inspection and enforcement plans should be developed. The City of Beaufort is listed as a likely MS4, so illicit discharge enforcement will likely be a requirement of the new permit, which could be applicable to the Town and portions of the County as well.

Short-term action: Begin writing ordinances and start process of adoption.

Mid-term action: Develop inspection and enforcement plan

Long-term action: Implement and maintain inspection and enforcement

4. **Septic System Program:** This program mainly involves encouraging the extension of public sewer into areas currently served by septic systems. Beaufort Jasper Water and Sewer Authority currently has a financing program to allow homeowner to spread the cost of connecting to public sewer out over a longer period of time. Infrastructure costs can be high and are typically born by BJWSA. CBDG funds may be available to extend sewer infrastructure into needy areas.

Short-term action: Identify specific areas within the watershed that are currently served by septic and that would be well served by public sewer

Mid-term action: Identify grants and funding sources. Develop partnerships between BJWSA and the respective municipality to drive implementation. Look for public-private partnership opportunities to fund projects.

Long-term action: Implement funded sewer extension projects.

5. **Professional Education Program:** The Beaufort County Stormwater Utility has been offering free broadcasts of water quality related webcasts for residents and site development professionals. These webcast benefit the area by improving awareness and knowledge of stormwater best management practices. The County should continue to offer these education programs and should look for other opportunities to educate the local professionals.

Short-term action: Continue current webcast education program

Mid-term action: Promote the webcasts to other professionals that may benefit from knowledge.

Long-term action: Identify other education opportunities

6. **Existing Road Retrofits:** There may be many opportunities to incorporate water quality BMPs into planned road widening and improvement projects. The Boundary Street redevelopment project is already a road project planned by the City that can incorporate retrofits. As other projects arise, Beaufort County Stormwater Utility should promote inclusion on water quality retrofits.

Short-term action: Incorporate water quality BMPs in the Boundary Street Redevelopment plan

Long-term action: Monitor new road projects and promote the inclusion of retrofit BMPs

7. **Homeowner Education Program:** Topics recommended for the homeowner education program include pet waste disposal, septic system maintenance, and buffer maintenance. The Beaufort County Stormwater Utility has an education component to its administration, so the most efficient use of funds would be to continue the current education program and to incorporate the recommended subjects.
Short-term action: Renew or refresh current Beaufort County Stormwater Utility
Long-term action: Evaluate and refine education program based on homeowner reactions and needs.
8. **New Development Policies:** The new policies identified that may be of some benefit to anti-degradation efforts include incentives/requirements for permeable paving, requirements for recessed parking islands, and incentives for irrigation reuse. Incorporating these new policies could be difficult and a lengthy process. It will likely take input from the public and will likely receive push-back from the development community. Not all policies recommended may be feasible or adoptable, and there may be other policies not mentioned that may be appropriate.
Short-term action: Gauge reaction from development community, politicians, and general public on new development standards
Mid-term action: Develop ordinance language and plan how to best incorporate into existing codes. Consider other policies as needed.
Long-term action: Adopt new development policies as feasible
9. **Southside Park Regional Retrofit:** This project is linked to City of Beaufort plans to provide a neighborhood park on the old Southside wastewater treatment plant site. The project is dependent upon citizens' needs and desires for the park, as well as funding for construction and ongoing maintenance. Should the park be developed, it will include a pond that will serve as a regional water quality retrofit.
Short-term action: Gauge interest of public for park development
Mid-term action: Perform additional feasibility study. Identify funding sources and grant opportunities. Prepare conceptual design of proposed BMP.
Long-term action: Implement BMP
10. **Grober Hill M2 Regional Retrofit:** This project is the second retrofit project located in the Battery Creek 2 sub-basin and is upstream of a known hotspot. It will be expensive to implement but should have some measurable benefit to the water quality. Given the cost, it may be best if this project were to happen after the Burton Hill M2 retrofit is complete and after monitoring results have indicated the benefits to the river.
Short-term action: Gauge interest of property owner to participate in the retrofit
Mid-term action: Perform additional feasibility study. Identify funding sources and grant opportunities. Acquire easements or property needed.
Long-term action: Implement BMP if monitoring results from previous work necessitates additional retrofits
11. **Battery Creek West M1 Retrofit:** This is the regional retrofit proposed for the Battery Creek 1 sub-basin and is the most expensive retrofit to construct. The feasibility of this retrofit will depend on the acquisition of the land needed. Give the implementation challenges and the

cost, it is advisable that this retrofit follow after the previous regional retrofits if they fail to produce the improvements expected.

Short-term action: Gauge interest of property owner to participate in the retrofit.

Mid-term action: Perform additional feasibility study. Identify funding sources and grant opportunities. Acquire easements or property needed.

Long-term action: Implement BMP if monitoring results from previous work necessitates additional retrofits

12. **Rain barrel/cistern program:** The cost-benefit of this program is uncertain, given that residents often don't utilize and maintain the systems. However, it may be worth pursuing in time as homeowner become better educated on stormwater and water quality.

Short-term action: None

Mid-term action: Identify funding sources and partnerships to provide material costs and installations education to homeowners

Long-term action: Implement give-away or cost sharing program.

6.2 Partnership Responsibilities and Funding

Beaufort County Stormwater Utility has led the water quality improvement efforts for the Battery Creek watershed and for other watersheds throughout the County. They developed the Stormwater Master Plan that set the groundwork for the water quality monitoring that has occurred since 2007. The SWMP also provided the water quality modeling that helped predict the watersheds that might be best suited to regional water quality retrofits, and that provided the estimated pollutant reductions presented in Section 6.5. The stormwater Utility has been collecting stormwater fees for all properties within Beaufort County and using that money to lead improvements to water quality throughout. The Utility partners with the four Municipalities in the County through Inter-Governmental Agreements. 95% of the fees collected within the Municipalities by the Utility are distributed back to the Municipalities for their use in addressing drainage concerns.

The City of Beaufort has assumed responsibility for the water quality of the headwaters of Battery Creek, and the impairments around shellfish monitoring station 15-19. The City's goal is to get the impaired area into compliance with SCDHEC shellfish standards, and maintain the quality and compliance of portions of the watershed within the City boundaries. The County Utility will continue to lead and support water quality efforts throughout the Battery Creek watershed, and will work with the Town of Port Royal to address the impairments around shellfish stations 15-10, 15-25, and 15-26. The Utility has led efforts to adopt more stringent water quality standards for development such as the runoff volume control requirements, and will continue to lead policies and programs related to water quality standards. The Utility has also led and will continue to lead water quality education programs throughout the County.

Beaufort County will administer the Battery Creek Watershed Management Plan through the Stormwater Utility, creating partnerships with the City or the Town as needed to implement strategies. The primary funding source for most projects will come directly or indirectly from the fees collected by the Stormwater Utility. The Utility has a reserve account, which can be used to directly fund projects

such as the regional retrofits. Fees collected by the Utility and sent to the City or Town may also be used by the respective municipality to fund projects. Other funding sources for projects may include grants such as the 319 Grant Program, or support from local conservancy groups such as the Port Royal Sound Fund. The Beaufort County Rural and Critical Lands program may be able to acquire land needed for the regional retrofits, reducing the funds needed from the Utility for property or drainage easements.

Table 21 outlines the proposed strategies, the areas to which they will apply, the parties responsible for implementing the strategy, the estimated costs, and the potential funding sources. The estimated costs are conceptual in nature and are intended for project programming and budgeting purposes only. Costs for the Burton Hill M2, Grober Hill M2, and the Battery Creek West M1 retrofit projects are from the Regional Retrofit Study prepared by Ward Edwards in 2011. Other costs provided are based on the best available information at the time of this report and subject to change. Costs should be re-evaluated and updated as milestones are reached and implementation phases are completed.

Table 21 - Partnership Responsibilities and Potential Funding Sources

Management Strategy	Location	Responsible Parties	Estimated Cost	Potential Funding
County Administration Parking Retrofit	Battery Creek 4 water quality sub-basin	Beaufort County	\$350,000	County Stormwater Utility Fund
Burton Hill M2 Regional Retrofit	Battery Creek 2 water quality sub-basin	Beaufort County and City of Beaufort (50%-50% shared cost)	\$740,000	County Stormwater Utility Fund + City Public Works Budget + 319 Grant
Illicit Discharge Ordinance	County-wide	Beaufort County, City of Beaufort, & Town of Port Royal for respective jurisdiction	\$75,000 annual for inspectors & equipment	County Stormwater Utility Fund
Septic System Program	Battery Creek Watershed	Beaufort County	Unknown – Project dependent	Beaufort Jasper Water and Sewer Authority Capital Improvements + CBDG
Professional Education Program	County-wide	Beaufort County	\$5,000 annual	County Stormwater Utility – Education Budget
Existing Road Retrofits	Battery Creek Watershed	Beaufort County, City of Beaufort and Town of Port Royal for respective jurisdiction	Unknown – Project dependent	Included in road construction costs – Example: County Transportation funding for Boundary Street
Homeowner Education Programs	County-wide	Beaufort County	\$15,000 annual	County Stormwater Utility – Education Budget
New Development Policies	County-wide	Respective Jurisdiction	N/A	N/A
Southside Park Regional Retrofit	Battery Creek 1 sub-watershed	City of Beaufort	\$2,000,000	City Public Works Budget + Grants
Grober Hill M2 Retrofit	Battery Creek 2	City of Beaufort and Beaufort County – Share responsibility to be determined	\$2,500,000	County Stormwater Utility Fund + City Public Works Budget + Grants
Battery Creek West M1 Retrofit	Battery Creek 1	Beaufort County	\$4,100,000	County Stormwater Utility Fund + Grants
Rain Barrel / Cistern Program	Battery Creek Watershed	Respective Jurisdiction	\$40,000	County SW Utility Fund or respective municipality budget

6.3 Interim Implementation Milestones

The Phased Implementation Plan as presented in Section 6.1 is separated into short-term, mid-term, and long-term actions, thus creating the overall implementation timeline. The actual implementation schedule will likely vary from the plan presented in Section 6.1 and will be highly dependent on funding, cooperation of property owners, permitting requirements, public input, and success/failure of preceding efforts. The schedule and implementation plan should be reevaluated and revised annually based on overall progress. Interim milestones provided below will be used to track the project success and to revise the implementation plan to aid in progression.

Interim Milestones

Year 1 – 3:

- Complete construction of County Administration Building parking lot retrofits
- Begin and complete construction of Burton Hill M2 Regional Retrofit project
- Adopt illicit discharge ordinance
- Identify areas targeted for extension of public sewer
- 4 to 6 webcasts per year for professional education
- Inclusion of water quality retrofits in Boundary Street improvements
- Continuation of current Stormwater Utility education/outreach plan
- Complete list of potential development policy revisions for Beaufort County, the City of Beaufort, and the Town of Port Royal
- Refined plans and budgets for Southside Park retrofits
- Decision from property owner on participation with Grober Hill M2 Regional Retrofit
- Decision from property owner on participation with Battery Creek West M1 Regional Retrofit
- Yearly updates to Battery Creek Watershed Management Plan

Years 3 – 6:

- Continue monitoring downstream of County Administration Building parking lot.
- Identify other potential parking lot retrofits including public/private partnerships for improvements to existing shopping centers and commercial developments
- Monitor water quality downstream of Burton Hill M2 Regional Retrofit
- Begin inspection and enforcement of illicit discharges
- Plan and fund sewer extension projects with BJWSA
- Continue 4 to 6 webcasts per year for professional education, adjusted with new webcast providers for a variety of knowledge
- Identify other potential road retrofit projects
- Continuation of current Stormwater Utility education/outreach plan
- Develop ordinance language and plan how to best incorporate into existing codes.
- Complete design and permitting of Southside Park Pond
- Complete feasibility study and prepare conceptual design of Grober Hill M2 Regional Retrofit

- Complete feasibility study and prepare conceptual design of Battery Creek West M1 Regional Retrofit
- Identify funding sources and partnerships for rain barrel program
- Yearly updates to Battery Creek Watershed Management Plan

Year 6 and beyond:

- Continue monitoring downstream of Burton Hill M2 Regional Retrofit
- Continue inspection and enforcement of illicit discharges
- Implement funded sewer extension projects
- Continue 4 to 6 webcasts per year for professional education, adjusted with new webcast providers for a variety of knowledge
- Identify and implement other potential road retrofit projects
- Continuation of current Stormwater Utility education/outreach plan
- Implement development ordinance revisions
- Complete construction of Southside Park Pond
- Complete design, permitting and construction of Grober Hill M2 Regional Retrofit
- Complete design, permitting and construction of Battery Creek West M1 Regional Retrofit
- Implement rain barrel program
- Yearly updates to Battery Creek Watershed Management Plan

7.0 Watershed Plan Evaluation

7.1 Evaluation Criteria

The primary goal of the Watershed Management Plan is to address impairments for fecal coliform bacteria at two areas within the river currently restricted for shellfish harvesting. Given this, the primary evaluation criteria will be compliance with shellfish standards for bacteria at SCDHEC monitoring stations 15-19, 15-25, 15-26, and 15-10. If these areas are removed from “restricted” classification and moved to “approved”, then the management plan could be considered a success. However, there are a number of other criteria that could be used to evaluate interim success and demonstrate the management plan is tracking with sufficient progression. The below list includes the primary evaluation criteria discussed above along with interim evaluation criteria.

Primary Evaluation Criteria:

- Area between shellfish monitoring stations 15-19 and 15-29 currently classified as “Restricted” re-classified to “Approved”
- Area surrounding shellfish monitoring stations 15-25, 15-26 and 15-10 currently classified as “Restricted” re-classified to “Approved”
- De-listing of Battery Creek from the 303(d) Impaired Water body List

Interim Evaluation Criteria:

- Gradual decrease and stabilization in fecal coliform bacteria counts at Beaufort County monitoring stations BECY-17 after completion of the Beaufort County Administration Building parking lot retrofit.
- Gradual decrease and stabilization in fecal coliform bacteria counts at Beaufort County monitoring stations BECY-8ra after completion of the Burton Hill M2 Regional retrofit.
- Gradual decrease and stabilization in fecal coliform bacteria counts at Beaufort County monitoring stations BECY-7ra after completion of the Grober Hill M2 retrofit.
- Gradual decrease and stabilization in fecal coliform bacteria counts at Beaufort County monitoring stations BECY-6 after completion of the Battery Creek West M1 Regional retrofit.

7.2 Monitoring Plan

Beaufort County currently has a monitoring plan in place based on the original recommendations of the County Stormwater Master Plan. The monitoring plan has been revised over the years based on the refinement of the Regional Retrofit Study and analysis of the monitoring results. The monitoring has been conducted by GEL Engineering LLC since its inception. The current monitoring plan will continue to be funded by the Beaufort County Stormwater Utility, but will transition operation to the recently established University of South Carolina Beaufort lab. USCB will replace GEL Engineering as the party responsible for collecting and analyzing the data, but Beaufort County will remain in control of selecting monitoring locations. The County will pay the lab for the monitoring services and is also purchasing specialized equipment for the lab’s operation.

The locations originally chosen for monitoring by the County was based on the water quality sensitivity analysis modeling completed as part of the SWMP. Also considered were the existing levels of service for water quality sub-basins, and the future land use classifications. The SCDHEC monitoring stations are located in open water locations, so it was decided that the County monitoring efforts would focus on tributary and BMP monitoring. The initial County program included 14 grab sample locations and 8 automatic samplers throughout the County. For the Battery Creek watershed, there were originally four sampling locations, all of them collected as grab samples. The sampling locations have changed over the years as the monitoring plan was optimized. The locations currently being monitored in the Battery Creek Watershed include BECY-7ra (Grober Hill M2), BECY-8r (Burton Hill M2), BECY-9ra (Salem Road), and BECY-17 (County Admin Buildings). Past monitoring stations in the watershed that have been abandoned include BECY-1a (mouth of Battery Creek) and BECY-6 (Battery Creek West M1).

All of the locations currently being monitored by the County are sampled for Ammonia-Nitrogen (NH₃), Biochemical Oxygen Demand (BOD₅), Total Cadmium, Chlorophyll-a, Total Chromium, Conductivity, Total Copper, Dissolved Oxygen (DO), Fecal Coliform, Total Iron, Total Lead, Total Manganese, Total Mercury, Total Nickel, Nitrate-Nitrite (NO_x), pH, Total Phosphorus, Salinity, Temperature, TKN, Total Organic Carbon (TOC), Total Suspended Solids (TSS), Turbidity, and Total Zinc. Samples are collected following a storm event that is greater than 0.1 inches in magnitude per hour and that occur at least 72 hours from a previously measurable storm event. Sampling is done once a month provided there is a qualifying rain event each month. Summaries of past results can be found in the annual reports prepared by GEL Engineering, LLC on the Beaufort County Stormwater Utility website (<http://www.bcgov.net/departments/Engineering-and-Infrastructure/stormwater-management/water-quality-monitoring.php>)

Note that the monitoring station downstream of the proposed Battery Creek West M1 Regional Retrofit was abandoned (BECY-6) a couple of years of monitoring data was first collected. It was removed due to low variability in the data, and the budget for that location was used to monitor elsewhere. When the Battery Creek West M1 retrofit is constructed, it is recommended that sampling at the BECY-6 location resume in order to provide a way of comparison to the data originally collected and to evaluate the effectiveness of the BMP. Table 22 lists the past and present sampling locations. Figure 7-1 shows the current and past monitoring stations, as well as the recommended future monitoring locations.

Table 22 - Past and Present Sampling Locations and Type of Sampling

Sampling Station Name	Location	Sampling Method	Purpose	Current Status
BECY-1a	Mouth of Battery Creek near connection to Beaufort River	Monthly Grab after 0.1 inches/hour of rainfall	Trend Analysis	Abandoned due to low variability
BECY-6	Battery Creek West M1 Regional Retrofit	Monthly Grab after 0.1 inches/hour of rainfall	Trend Analysis and Future BMP evaluation	Abandoned due to low variability. Recommended resuming after BMP construction
BECY-7ra	Grober Hill M2 Regional Retrofit	Monthly Grab after 0.1 inches/hour of rainfall	Trend Analysis and Future BMP evaluation	Active
BECY-8r	Burton Hill M2 Regional Retrofit	Monthly Grab after 0.1 inches/hour of rainfall	Trend Analysis and Future BMP evaluation	Active
BECY-9ra	Salem Road	Monthly Grab after 0.1 inches/hour of rainfall	Trend Analysis	Active
BECY-17	County Admin Center Parking Lot	Monthly Grab after 0.1 inches/hour of rainfall	Trend Analysis and Future BMP evaluation	Active

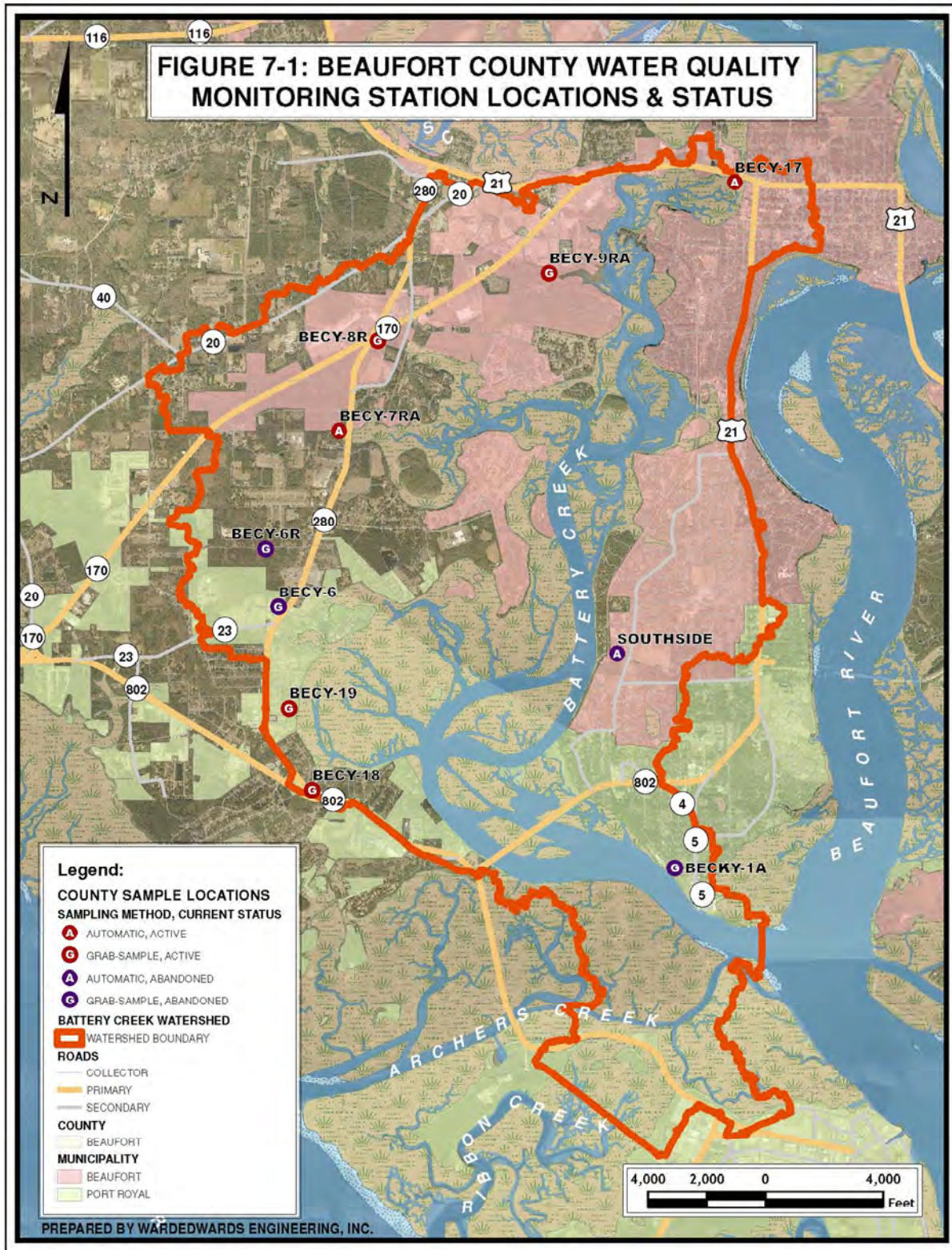


Figure 7-1- Past, Present, and Future Beaufort County Water Quality Monitoring Stations

List of References:

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