11/09/20

Watershed-Based Plan Bushy Park Reservoir (Back River and Foster Creek Watersheds) November 2020

CELEBRATING A CENTURY OF SERVICE
1917–2017

Table of Contents

Figures

Tables

Acronyms

1. AWWA - American Water Works Association
2. BSWCD - Berkeley County Soil and Water Conservation District
3. BMP - Best Management Practices
4. CWS – Charleston Water System
5. DNR - Department of Natural Resources
6. EPA – Environmental Protection Agency
7. LID – Low Impact Development
8. NRCS – National Resource Conservation Service

9. RBC – River Basin Council
10. SCDHEC - South Carolina Department of Health and Environmental Control
11. SWP – Source Water Protection
12. SWPP (Source Water Protection Plan) – Based on AWWA G300 Source Water Protection Standard
13. STEPL – Spreadsheet Tool for Estimating Pollutant Loads
14. TBD – To be determined
15. USDA – United States Department of Agriculture
16. WBP - Watershed-Based Plan

1. Introduction and Background

a. Why Develop a Watershed Based Plan?

Effectively improving water quality requires an entire watershed approach (SCDHEC 2014). In 2018, Charleston Water System (CWS) decided the development of a Watershed-Based Plan (WBP) could serve as an integral component of the overall source water protection planning effort and applied for a 319 grant to develop such a plan for the Back River and Foster Creek Watersheds encompassing the Bushy Park Reservoir. The development and implementation of the watershed-based plan is certainly synergistic with the goals of CWS's Source Water Protection Plan which is based on AWWA's G300 Source Water Protection standard (Gullick/AWWA 2013) and is instrumental to safeguarding the long-term water quality of our primary drinking water source from urbanization and development around Bushy Park Reservoir.

There has been an obvious shift in focus from point source pollution (improved wastewater discharge regulations, combined discharges, improved treatment techniques, etc.) to nonpoint source pollution (urban stormwater runoff, agriculture, septic systems, pet waste, etc.) over the past few decades. The promulgated regulations (NPDES/TMDL, RCRA, etc. and now MS4 regulation) have followed this same pattern or shift in focus. Though the latest assessments on the nations Lakes, rivers and streams (2012 National Lake Assessment and 2008-2009 National Rivers and Streams Assessment) indicate overall worsening nutrient and trophic conditions along the Coastal Plains Ecoregion over the past few decades, the water quality data we have examined in the Back River and Foster Creek watersheds has shown that water quality (especially in regard to nutrients and bacteria) has drastically improved over the last few decades likely in large part due to point source regulation, the relocations of NPDES Wastewater Discharges out of Bushy Park Reservoir and other factors discussed in more detail in the water quality and impairment section. If these water quality improvements are going to be sustained or even improved in the presence of the increasingly urbanized landscape, it is important CWS collaborate with all of the stakeholders within the watersheds around Bushy Park to identify and mitigate nonpoint source pollution while not ignoring the potential risk from existing point-sources. This is especially true given the nature of nonpoint sources. That is to say, it usually isn't one or two individual sources of nonpoint pollution within the watershed which contribute significantly to water quality issues, but rather, it is the many smaller sources as a whole which have a cumulative effect on water quality. In the absence of major point sources of pollution within the Back River and Foster Creek Watersheds, the data points to these cumulative nonpoint sources of nutrients, sediments, bacteria, etc. as likely exacerbating eutrophic conditions within the tributaries and mesotrophic conditions of the reservoir. The increased nutrients also fuel aquatic weed growth and lead to the conditions supportive of excessive aquatic weeds, algae, cyanobacteria and their byproducts. Even though much of the two watersheds are within MS4, future 319 implementation grants could provide a mechanism for the stakeholders in and outside of the MS4 to fund and implement best management practices (BMPs).

b. Stakeholders

While the following list (table 1) covers the stakeholders we focused on during the development phase of this WBP, it is our hope that new stakeholders within the two watersheds will take advantage of the watershed-based planning effort and eligibility for 319 funding to aid the implementation of future best management practices in the watersheds. The number of supporting stakeholders has indeed grown during the development phase of this 319 plan and we anticipate this list to grow in the coming years. Thus, the development of this WBP has, and will continue to serve, as a great tool to expand our list of potential partners and stakeholders within the watershed crucial to our source water protection activities. These stakeholders will also be part of the Bushy Park Collaborative Committee outlined in our Source Water Protection Plan. The committee is composed of stakeholders most likely to influence water quality within the reservoir or interested in safeguarding or improving the water quality.

Table 1. Stakeholders

COOPERATING ORGANIZATIONS	**Letter of Commitment**	**Responsibility with Project**	**Source Water Intake Utility**
Charleston Water System		CWS is the lead organization, coordinating and drafting the WBP	X, DW
Cadmus	X	Limnology, hydrology and source water protection planning. Will advise and review the plan and help evaluate existing studies and data. Will help with load reduction calculations.	
Joint Base Charleston – Weapons Station	X	Largest multiuse land owner and collaborating stakeholder. Will share their experience developing BMPs mitigating nonpoint source pollutants.	
SUPPORTING ORGANIZATIONS	**Letter of Support**	**Support of Project**	**Source Water Intake Utility**
USGS	X	Performed several extensive water quality studies on the Back River Reservoir and Foster Creek	
SCDNR		Actively involved in aquatic weed management and familiar with natural history of the area	
SCDHEC		Have monitored sites in the watershed for several decades, responsible for TMDL, NPDES and MS4 permitting in the watershed	
Anderson Regional Joint Water System		Advising on aspects of the development of a WBP, grant application and source water monitoring	
SCANA/SCE&G (Dominion)		Utilizes raw water from the Back River Reservoir and a supporting stakeholder sharing raw water withdrawal information	X, RW
Cooper River Partners		Utilizes raw water from the Back River Reservoir and supporting stakeholder sharing raw water withdrawal information	X, RW
Berkeley County Water and Sanitation		Has a wastewater treatment facility on Back River Reservoir that maintains an NPDES discharge into the Cooper River. Providing sanitary sewer overflow data.	
HOAs		Several potential HOA (including Joint Base Charleston - Weapons Station housing) that we want to approach during the development of the WBP	
Amoco BP		Utilizes raw water from the Back River Reservoir and supporting stakeholder sharing raw water withdrawal information	X, RW
Berkeley County		Stormwater Management Department to share MS4 data and collaborate on public outreach	
Berkeley Soil and Water Conservation District	X	The Berkeley Soil and Water District has been very helpful both in providing a history of prior BMPs within the watershed as well as sharing information on public outreach efforts and helping to connect us with other stakeholders within the watershed.	

c. Description of Expertise and Experience

Charleston Water System (CWS)

CWS has performed and/or collaborated on water quality studies on Foster Creek and the Back River Reservoir dating back to the 1970's (even earlier on the Foster Creek tributary) and these studies have continued in one form or another about every decade since. These studies covered various water quality parameters commonly measured for surface waters including (but not limited to) the impaired parameter (dissolved oxygen) and related parameters (nutrients, taste and odor, etc.). Past studies also covered time of travel, water quantity, soil, and hydrological conditions, and a hydrodynamic model study is in the final stages of completion with an estimated completion in early 2021. A few of the collaborative partners for these studies included the Water Resources Commission, the United States Geological Survey, the Army Corps of Engineers, South Carolina Department of Health and Environmental Services as well as the US Department of Defense. The results of these studies and ongoing water quality monitoring shed light on long-term water quality trends which were discussed in detail in the "Water Quality and Impairment Information" section.

CWS is nearing the completion of a Source Water Protection Plan (SWPP) based on the American Water Works Association's G300 Source Water Protection Standard which has a lot of overlap with the goals of this WBP. State assessments have also been performed on all of the major water basins in South Carolina including on the Santee and Edisto Basins and on many of the watersheds and subwatersheds within these basins. CWS has studied these assessment resources and reached out to some of the most pertinent stakeholders most likely to impact water quality at the intakes. It is important to note that many other stakeholders have been working toward improving water quality conditions within the larger Cooper River Basin and even the Bushy Park watersheds (Back River and Foster Creek Watershed) prior to this watershed-based plan. Besides extensive work by the various applicable MS4s in these watersheds, other stakeholders have had a substantial impact including the Berkeley Soil and Water Conservation District, Ducks Unlimited, Lord Berkeley Land Trust and certainly others. This 319 WBP is intended to bolster these efforts through increased collaboration between all of the applicable stakeholders.

The primary CWS associate, Jason Thompson (Source Water Manager), responsible for developing this WBP holds a B.S. degree in Chemistry (The University of Tennessee at Chattanooga) and has worked as an Analytical Chemist in Charleston Water System's certified central laboratory for 13 years monitoring the many chemical and biological water quality parameters pertinent to drinking water treatment, drinking water distribution and wastewater treatment. This role has allowed him to explore how water quality changes in the raw water can affect drinking water treatability and similarly how changes in the treated water can affect water quality in the drinking water distribution system. This role also involved work monitoring the compliance of two different NPDES permits helping him gain an understanding of the potential impact of point source discharges on water quality. Finally, he designed a water quality study on the Back River Reservoir and Foster Creek looking at various nutrient and biological parameters and their correlation to algae blooms and the resulting taste and odor byproducts, MIB and Geosmin. This study aided a larger 2015 water quality study performed by the United States Geological Survey (USGS) on the Back River Reservoir and Foster Creek. His familiarity with these studies and his access and familiarity with decades of raw water quality monitoring data on the Back River Reservoir and Foster Creek has given him invaluable insight into the seasonal and long term water quality patterns, the eutrophication processes present and the potential impact of non-point and point source pollutants on these natural processes and water quality.

Cadmus

Since 2001, Cadmus has served as a prime contractor for EPA's Office of Wetlands, Oceans, and Watersheds (OWOW) and regional offices to support watershed and water quality assessment and protection. Cadmus also supports the Office of Ground Water and Drinking Water as well as the Office of Research and Development. Cadmus' team of hydrologists, watershed scientists, engineers, and chemists provide EPA and states with comprehensive support for water quality management planning, TMDL development, and effectiveness evaluation including load reduction calculations. Karen Sklenar, who is leading Cadmus' project supporting the Charleston Water System's development of a watershed and source water management program, was the Principal Investigator for the Water Research Foundation as it developed the Drinking Water Source Protection Through Effective Use of TMDL Processes. Dr. Sklenar has also facilitated meetings with state personnel in the Midwest and elsewhere to develop water quality standards for water bodies categorized as potable water supplies. Dr. Sklenar received her B.A. from Yale University and holds a Ph.D. in Environmental Engineering Science (Applied Limnology emphasis) from the University of California at Berkeley. Other Cadmus team members include: Tom Benecke, Ana Rosen and Dr. Mary Ellen Tuccillo.

The Cadmus Group has a long history of supporting activities related to the 319 program. Cadmus has an exceptional record of successful completion of projects related to TMDL development, implementation planning, and effectiveness analysis. Cadmus has developed hundreds of EPA-approved TMDLs, including many that are multi-parameter and multijurisdictional. Cadmus understands the role TMDLs and watershed management play in protecting water supplies from nutrient loading that contributes to cyanobacteria and algae growth and related water quality concerns. TMDLs are often used as the basis for watershed based plan development. A Cadmus team worked closely with water utilities and regulators across the U.S. to develop the Water Research Foundation Document Drinking Water Source Protection Through Effective Use of TMDL Processes. Cadmus supports the development of implementation-ready TMDLs by preparing practical implementation plans that outline specific actions for reducing pollutant loading to achieve the load reductions specified by the TMDL. The implementation plans meet TMDL requirements and include the Nine Key Elements of watershed-based plans for Section 319 funding. The plans recommend structural and nonstructural practices and programs to be implemented by stakeholders to achieve pollutant load allocations; a schedule for implementation; measures and milestones for tracking whether the plan has been implemented; environmental indicators of progress and an effectiveness monitoring strategy to measure progress toward meeting Water Quality Standards; a process for adaptive management; and potential sources of technical and financial support. Cadmus incorporates data used for TMDL development to guide the development of TMDL effectiveness monitoring plans, including decisions on what to sample, where to sample, and how often to sample. Existing data are highly valuable for TMDL effectiveness monitoring planning, as they provide insight into data variability and how water quality changes resulting from TMDL implementation can be detected.

Joint Base Charleston – Weapons Station (Joint Base Charleston Environmental Management Civil Engineering Squadron)

The Joint Base Charleston – Weapons Station is a uniquely qualified stakeholder as they already have an extensive staff of highly qualified individuals responsible for implementing BMPs to mitigate a variety of nonpoint and point source pollution related to the many land uses intrinsic to a military base. These land uses include residential, recreational, construction, forestry and waste management. They are also the largest land owner in the Back River/Foster Creek watershed (pink area marked on map) with a close proximity to the CWS drinking water intake. Just a few of the staff we are working with include Major Scott King (Bioenvironmental Engineering Flt Commander), Barry Lewis (Environmental Management Engineer), and Earle Folger (Environmental Management Engineer).

Berkeley County Stormwater Department

Berkeley County is familiar with many aspects of stormwater management and they manage the MS4 permit for County as well as for the cities of Goose Creek and Hanahan. They are also familiar with stormwater BMP implementation and may be aware historical areas of concern (runoff pollution sources) within their jurisdiction and potential/applicable implementation projects (BMPs). They are likely to be a great resource as CWS works with stakeholders on BMPs even within the areas not directly under the management of the county.

Joshua Huggins

Josh Huggin's had completed two internships on drinking water quality in distribution systems before beginning the internship for this project. His experience with drinking water quality coupled with his career aspirations and career focus on atmospheric studies made him a great candidate to learn about the role of watershed-based planning in source water protection. In particular, he put forth an incredible effort into learning and utilizing EPA's STEPL software to perform load calculations for most of the two watersheds covered in this WBP. His work also included extensive use of the Counties' online GIS application as well as SCDHEC's Watershed Atlas online GIS application.

SCDHEC

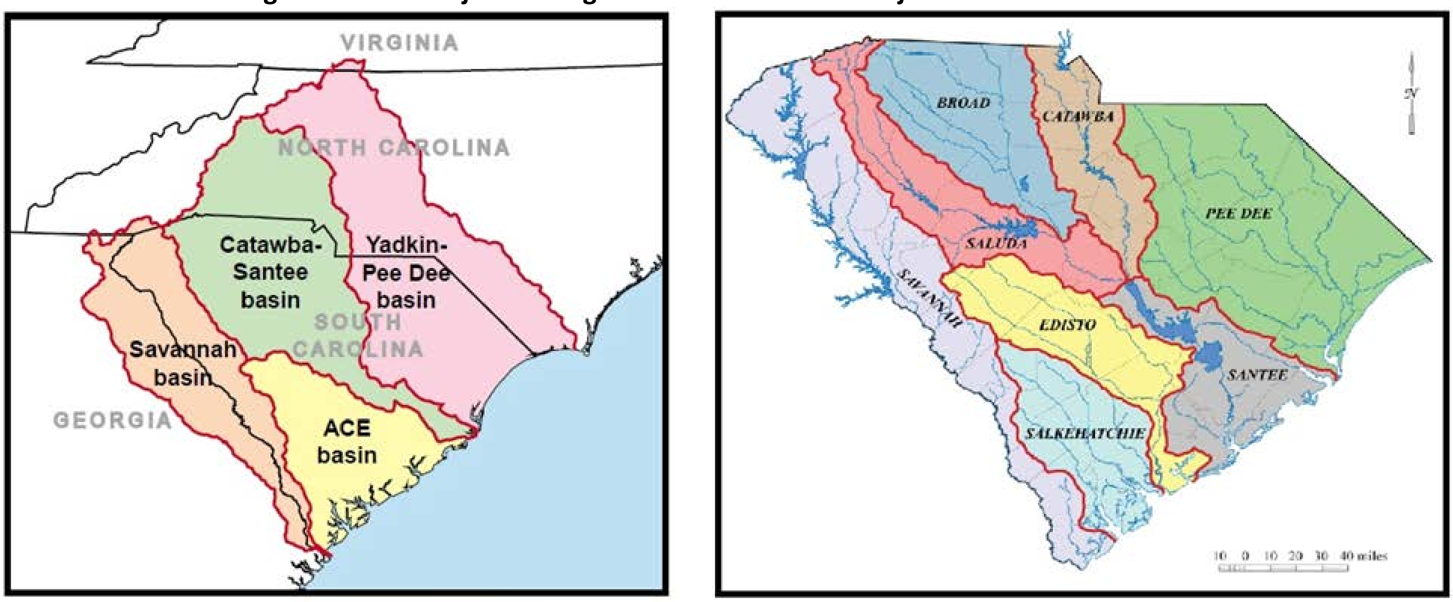
We would be remiss if we did not point out the obvious help provided by the experienced team from SCDHEC. Carmony Corley (prior Nonpoint Source Coordinator), Shea McCarthy (current Nonpoint Source Coordinator) and Jana Baxley (Grant Administrator) provided extensive help with all aspects of the grant requirements and with the quarterly reports/invoices. Amanda Ley (Watershed Manager and Watershed Atlas Coordinator) helped familiarize us with the vast information contained in the SC Watershed Atlas database online. Andy Miller (Santee Watershed Manager) helped review and guide our drafting of the WBP Report. Despite this being our first watershed-based plan, the SCDHEC team and Cadmus consulting team played a crucial role in helping CWS develop this plan. And there are countless other SCDHEC employees that contribute to water quality monitoring and assessments throughout the watersheds of South Carolina that inevitably inform these plans.

There have been many successful public outreach efforts within the watershed and some efforts to apply for prior 319 funding by the Berkeley soil and Water Conservation District. The information learned from these efforts were very helpful and they have also offered to help with future public outreach efforts where feasible.

d. Location, Watershed Delineation, and History Information

South Carolina is composed of four major drainage basins (DNR delineations on left) that are further divided into eight major river basins (SCDHEC delineations on right) as shown in figure 1. Each of the major surface-water basins have been delineated and characterized through watershed water quality assessments published by the South Carolina Department of Health and Environmental Control (https://www.scdhec.gov/environment/your-water-coast/watersheds-program/archived-watershed-water-quality-assessments).

Figure 1. DNR Major Drainage Basins and SCDHEC Major Surface-Water Basins



Major Drainage Basins of South Carolina

Major Surface-Water Basins of South Carolina

CWS's primary intake is in the Bushy Park (or Back River) Reservoir located in the Santee River Basin and the secondary intake is located on the Edisto River near Givhans Ferry State Park and is in the Edisto Basin (figure 2). The true headwaters feeding the Santee River Basin originate in the Blue Ridge Mountains of North Carolina and include the Saluda, Broad and Catawba River Basins (figure 1); therefore, water quality in each of these upstate basins has some potential to impact the raw water quality in the Santee Basin.

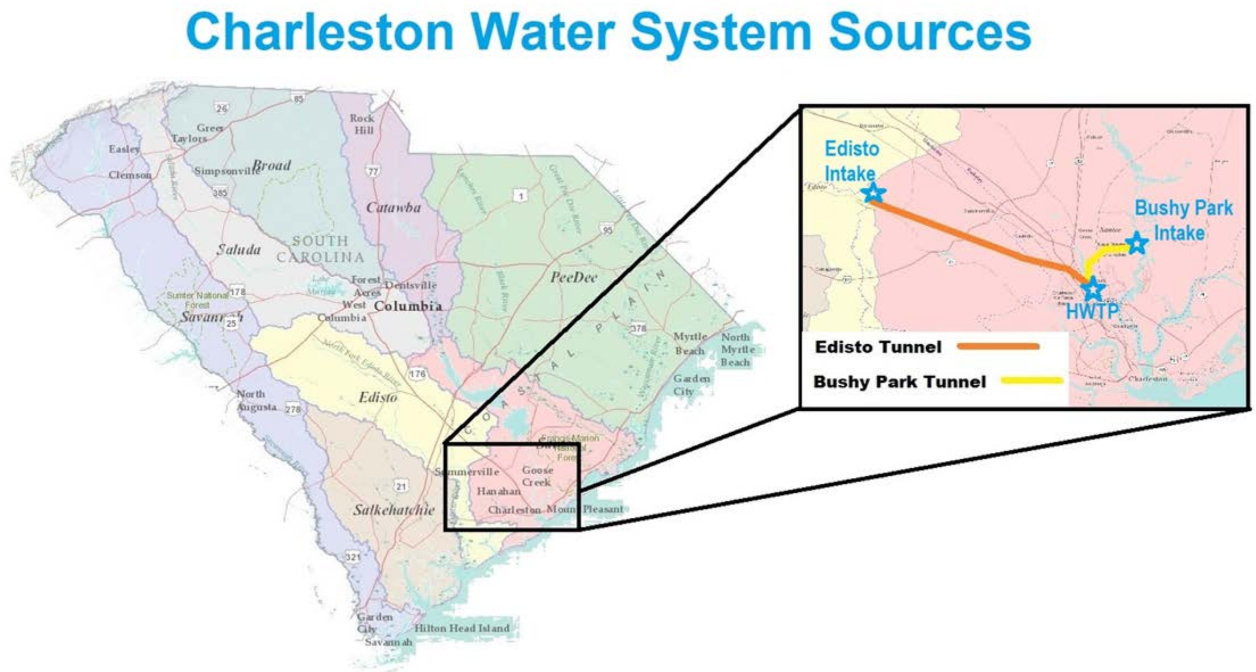


Figure 2. Location of CWS intakes within the Santee and Edisto Surface Water Basins

Figure 3 shows the focus of this Watershed Based Plan (WBP) which is the Bushy Park Reservoir and the two 12-digit HUC watersheds (Back River 030502010704 and Foster Creek 030502010703) that surround the reservoir. The two watersheds total about 49,200 acres (39,800-acre Back River and 9,370-acre Foster Creek Watershed).

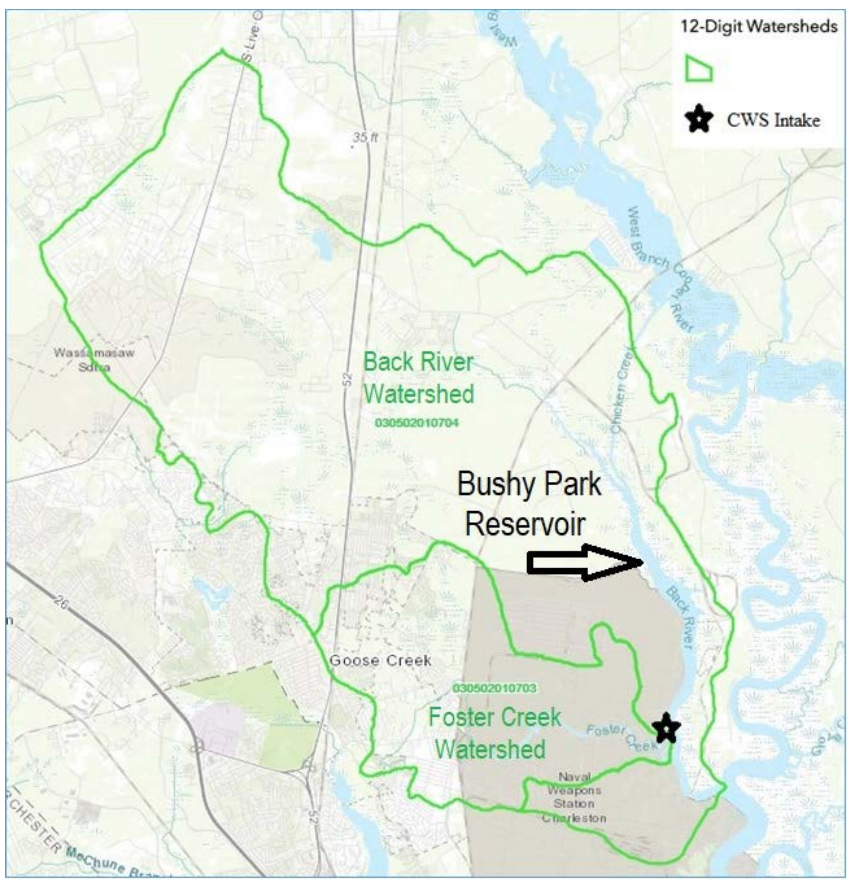


Figure 3. Back River (030502010704) and Foster Creek (030502010703) Watersheds

Bushy Park Reservoir is approximately 800 acres and is a slender, tidal reservoir located about 10 miles south of Lake Moultrie nestled between Hwy 52 and the Cooper River near the town of Goose Creek. The reservoir is fed the tidal West Branch of the Cooper River at the north end through Durham Canal, the Foster Creek tributary to the southwest and Back River tributary to the northwest. The reservoir was created in the mid-1950's to serve as a fresh water supply for industry and as a future municipal water supply for the quickly growing Charleston area. Before the Back River was dammed, Foster Creek and Chicken Creek drained into the Back River, which drained tidally toward the south into the Cooper River where the earthen dam is now located. It was at this south end of the reservoir that an earthen dam was installed to prevent the passage of water in or out of the reservoir at this point. A canal (Durham Canal) was excavated at the north end at Chicken Creek, allowing the newly created Bushy Park Reservoir to drain tidally toward the north into the West Branch of the Cooper River. Therefore, the net flow in Bushy Park during the outgoing tide is from south to north out Durham Canal while the net flow in Foster Creek continues to be from west to east toward the main body of the Bushy Park Reservoir. Figure 3 also shows Charleston Water Systems' current intake location near the point where Foster Creek drains into the main channel of the Bushy Park Reservoir at the South end of the Reservoir.

Figure 4 shows the Source Water Protection Area (SWPA) determined by SCDHEC (CWS SWA 2003) within the two watersheds. The SWPA includes a 1500-foot buffer from the main body of the reservoir, Back River tributary, Foster Creek Tributary and the many smaller wetlands and creeks feeding these tributaries. Though there are very little if any protections for the SWPA or riparian buffers in general in South Carolina, it makes sense that the SWPA should be a primary focus when considering sources of pollution (point or nonpoint) given this areas higher likelihood of affecting source water quality.

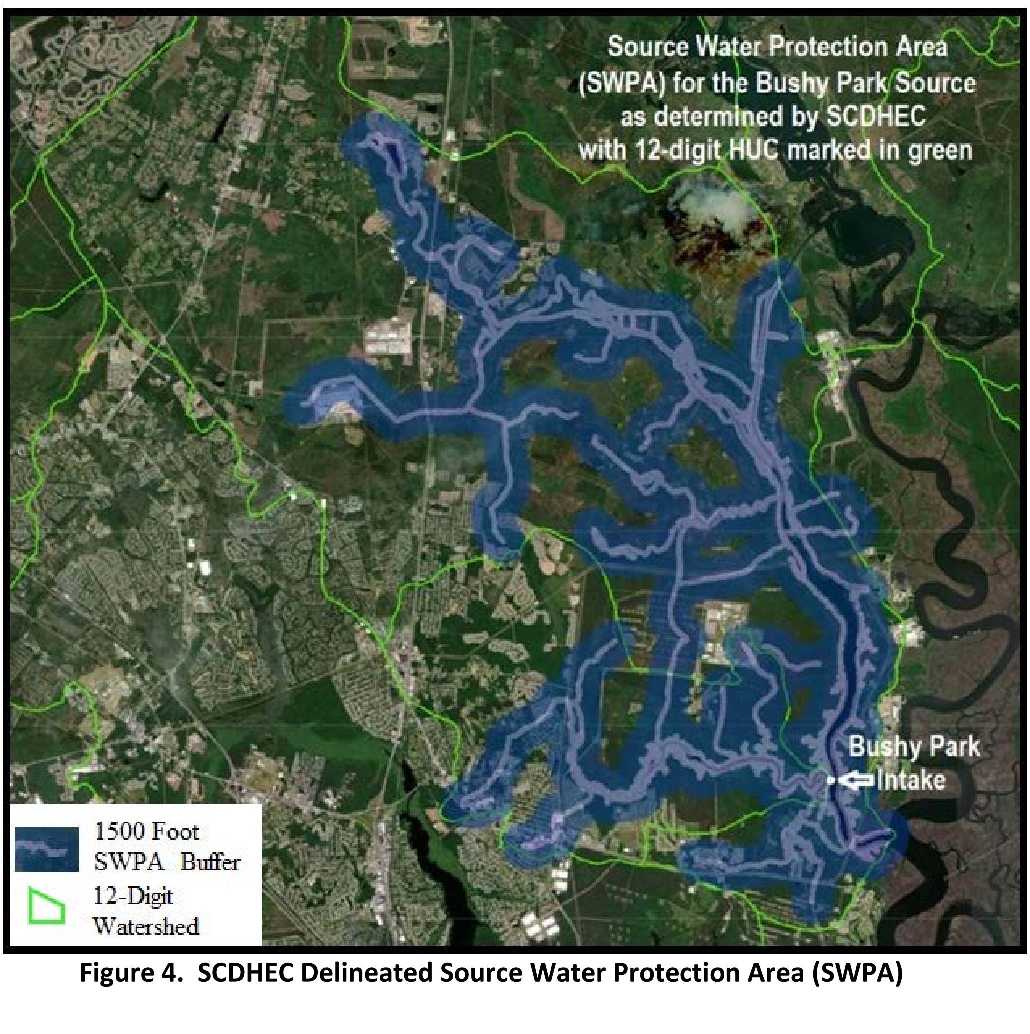


Figure 4. SCDHEC Delineated Source Water Protection Area (SWPA)

The next two closest upstream 12-digit watersheds are the West Branch Cooper River and Molly Branch 12-digit sub-watersheds, both of which are also tidal. Since we have seen a strong correlation between the water quality in Bushy Park Reservoir and Lake Moultrie, our Source Water Protection Plan will eventually expand to include a focus on the Lake Moultrie, Wadboo Creek and Lake Marion 10-digit HUC watersheds.

e. Population and Community Data, Geography and Climate

The water that enters our intake on the Back River Reservoir is treated at the Hanahan Water Treatment Plant and serves approximately 450,000 people in the Dorchester-Charleston-Berkeley tri-county area. This includes the cities/towns of Charleston, North Charleston, Hanahan, Ladson, James Island, Cainhoy, Ravenel, Meggett, and Hollywood, and serves several wholesale accounts including Johns Island (St. Johns Water Company which also serves Kiawah and Seabrook Islands), Folly Beach, Sullivan's Island, Mount Pleasant, Lincolnville and Isle of Palms. The cities of Charleston and North Charleston are located centrally in respect to the others listed and are the two most populated, each with populations over 100,000. Goose Creek, Mount Pleasant and Summerville are the next biggest and have experienced the greatest growth over the past two decades. Although, all of the cities and towns listed have seen substantial growth. The total population of the tri-county area (Charleston, Berkeley and Dorchester County) is about 800,000. The Charleston Metropolitan Area (Charleston MSA) has averaged about 20.7% of growth in the last decade which was three times faster than the U.S. average (CRDA). In fact, the Charleston MSA was the 12th fastest growing metro area in the U.S., gaining on average 50 new residents every day during 2015 (Slade). This number has decreased to about 34 people a day as of 2018, with nearly half of those settling in Berkeley County (the county surrounding our Bushy Park Reservoir source). Figure 5 compares growth in each of the cities from 2010-2018 (Slade).

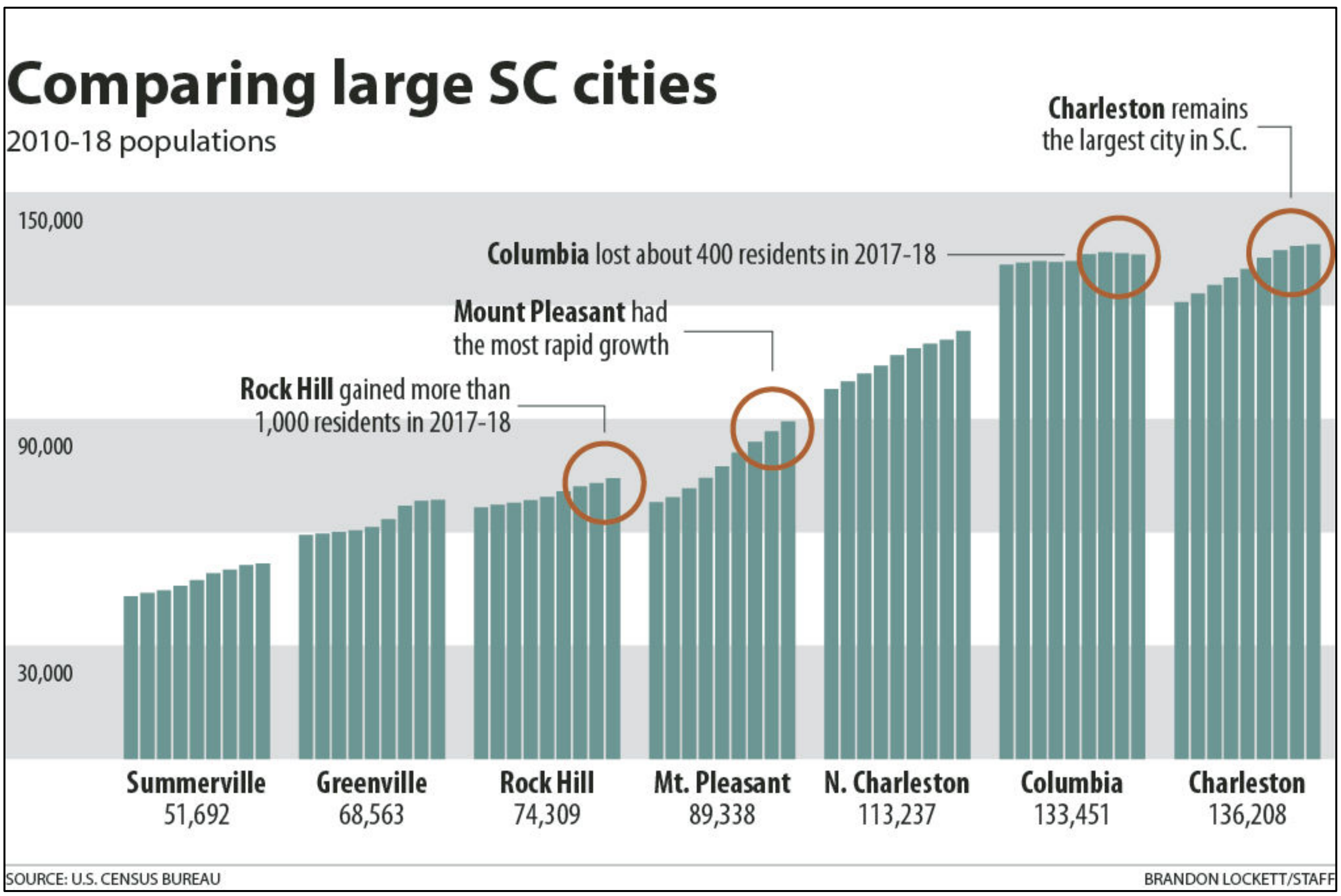


Figure 5. Population Growth Within the Cities

Charleston is a coastal community with a humid subtropical climate. The Charleston Area receives about 50 inches of rain annually with some variability due to tropical storm frequency (figure 6).

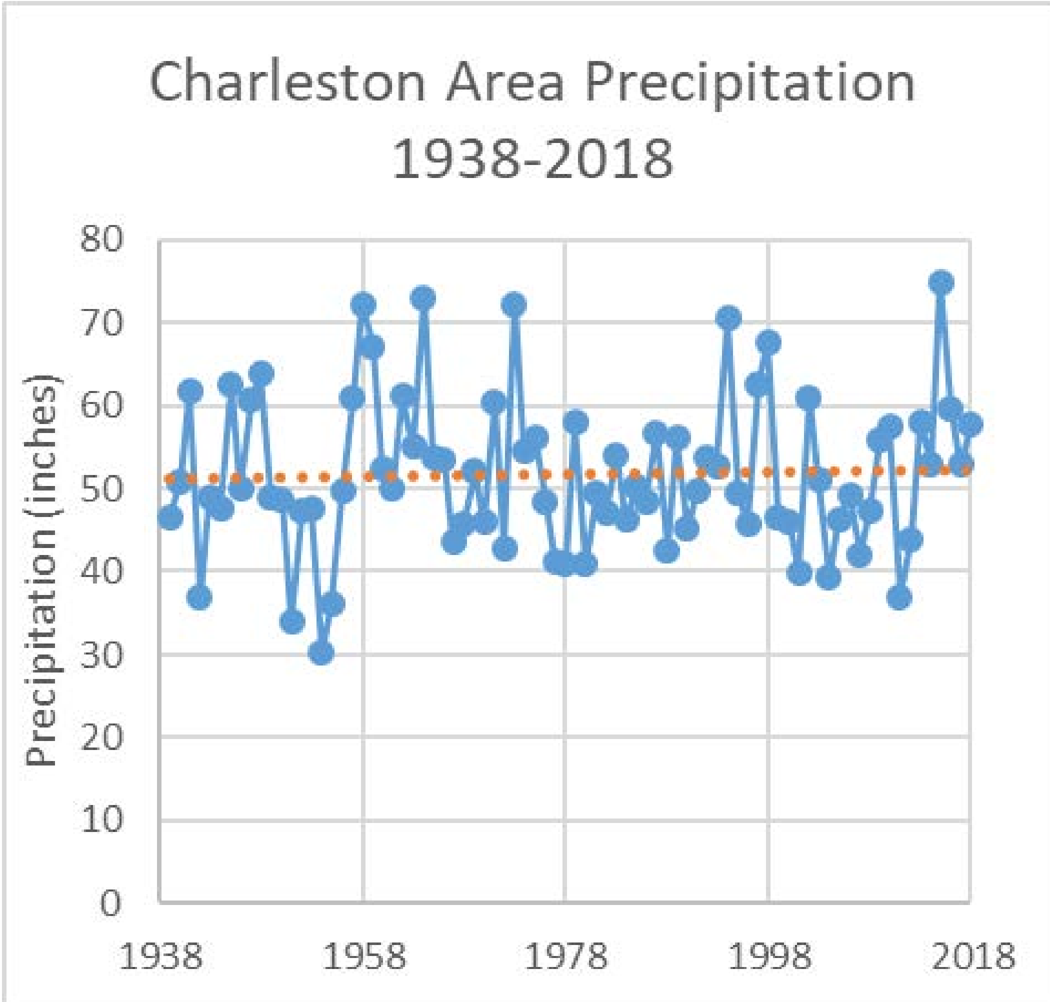


Figure 6. Charleston Area Precipitation

The official hydrologic soil group for most of the non-wetland land is either group C (for Back River Watershed) or group D (for Foster Creek Watershed), but the two watersheds likely have a mixture of the two. The soil type designates the relative permeability and runoff potential and is thus used in the calculations modeling potential runoff loading (NRCS 1986). These two soil types are the least permeable and thus result in the greatest runoff potential.

f. Land Cover

In general, the type of land cover determines the potential pollutant loading (nutrients and bacteria) to the receiving waters in the watershed. The type of land cover with the least runoff loads is forested as it drastically reduces the amount of water runoff and helps reduce soil loss and increases water absorption. However, urbanization is an inevitable part of most watersheds and the potential loading tends to increase as forested/woodland acreage is lost to development (urbanization or agriculture). The Back River/Foster Creek Watershed land cover data as of 2016 is shown in figure 7. Though much of the land immediately around the reservoir is forested or marsh, there is a considerably large and growing urban area to the west and south, industry to the east and rural to the North.

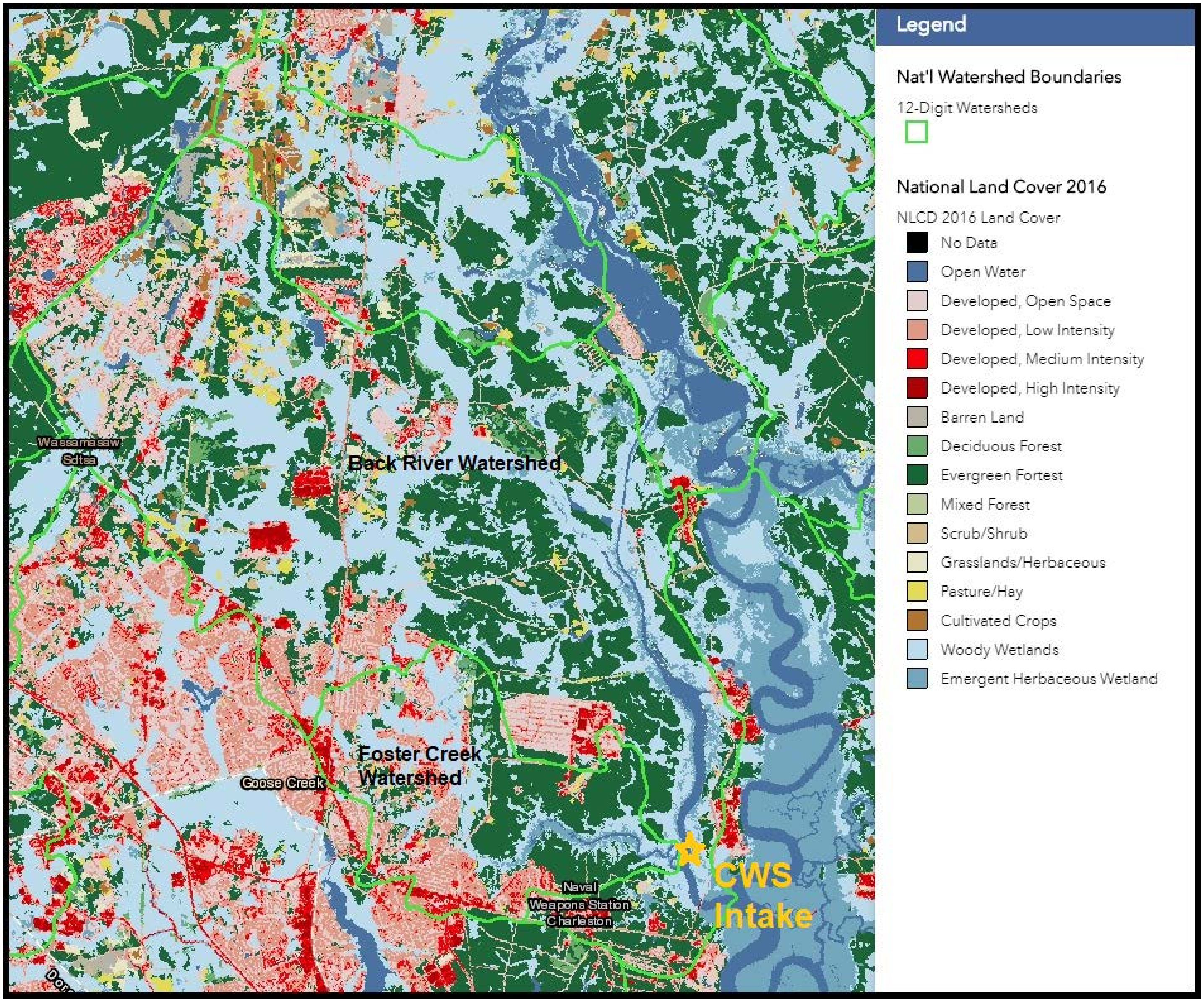


Figure 7. National Land Cover Map for the Back River and Foster Creek Watersheds

During this WBP process, land use and cover within the Back River and Foster Creek watersheds was examined by parcel (or group of parcels within neighborhoods or commercial areas) to arrive at a more accurate breakdown of the land use categories (table 2) necessary to more accurately model potential stormwater loads (Section 2.a.) for these parcels and for the watershed as a whole. The two watersheds as a whole are approximately 26 percent urban, with the remaining land mostly a combination of forested, forested wetland, nonforested wetland and water. The Foster Creek watershed has a higher density of urban land cover compared to the Back River Watershed (37% vs 25%). Back River watershed has a higher percent industrial. Agricultural land uses are likely higher than what was found during the development phase of this report, but are still likely to represent a fraction of a percent of the Foster Creek Watershed and only a few percent of the Back River Watershed.

12-Digit HUC	Watershed Name	Total Acres (CWS Calculated)	Forest Acres	Pastureland Acres	Urban Acres	Urban %	Urban Land Use Breakdown (%)							
							Commercial	Industiral	Institutional	Transportation	Multi-Family	Single-Family	Vacant	Open
030502010703	Foster Creek	9181	5753	0	3428	37.34	7.04	3.55	1.67	5.91	3.83	68.51	0.09	9.39
030502010704	Back River	39195	29862	22	9311	23.76	6.10	12.24	1.00	3.08	2.52	54.33	0.27	20.45
	Both Watersheds	48376	35615	22	12739	26.33								

Table 2. Estimated Land Use and Cover Determined During 2019 for this WBP

The amount of urban land cover within the Back River and Foster Creek 12-digit HUC watersheds are similar to that in the larger 10-digit HUC Cooper River Watershed reported in the 2013 Watershed Water Quality Assessment report by SCDHEC (table 3).

Percent Land Use/Cover Data from the SCDHEC Santee Basin Watershed Water Quality Assessment Report (2013)									
Applicable 10-Digit HUC	Name	Size (acres)	Agriculture Land	Forested	Forested Wetland (swamp)	Urban Land	Water	Nonforested Wetland (marsh)	Baren Land
0305020107	Cooper River	206,456	4.6	26.9	20.3	25.9	10.3	10.5	1.5
0305020102	Wadboo Creek	82,385	11.4	45.1	38.7	2.8	0.2	1.8	
0305020101	Lake Moultrie	78,638	2.9	11.6	10.3	2.5	70.4	2.1	0.2

Table 3. Land Use and Cover Data from the SCDHEC Santee Basin Assessment 2013

The largest property owner in the combined watershed is the Joint Base Charleston – Weapons Station which occupies approximately half of the Foster Creek Watershed and about a 1/5th of the Back River watershed. There are a variety of land covers on the base that include residential, commercial, recreational, forest, wetlands and water. The rest of the Foster Creek watershed is urbanized (residential and commercial) land to the West. The largest privately held property in the Back River Watershed is the 6,695 acre Medway Plantation which is protected from commercial development through conservation easements. Industrial development is mostly localized to the east side of the Back River Watershed on the land bridge located between the reservoir and the Cooper River.

Due to the runoff impact of any land development compared to the natural landscape, protective conservation easements are perhaps some of the strongest measures to protect water quality for the long-term. There are several conservation easements in and around the Bushy Park Reservoir that can be explored at https://www.conservationeasement.us/interactivemap/. The large 5,500-acre Medway parcel (2360000002) toward the north end of the reservoir and adjoining 800-acre parcel (2110002060) are currently owned by Tradeland Investors Inc. and are both under restrictive easements (the former since 1999 and the latter since 1994) held by Ducks Unlimited (figure 8).

Figure 8. Ducks Unlimited Protective Easements on the Medway Parcels

Several parcels to the East of Durham Canal that make up the 1260-acre DuPont/Dean Hall Plantation conservation parcel are currently held with the Lord Berkeley Conservation Trust (figure 9).

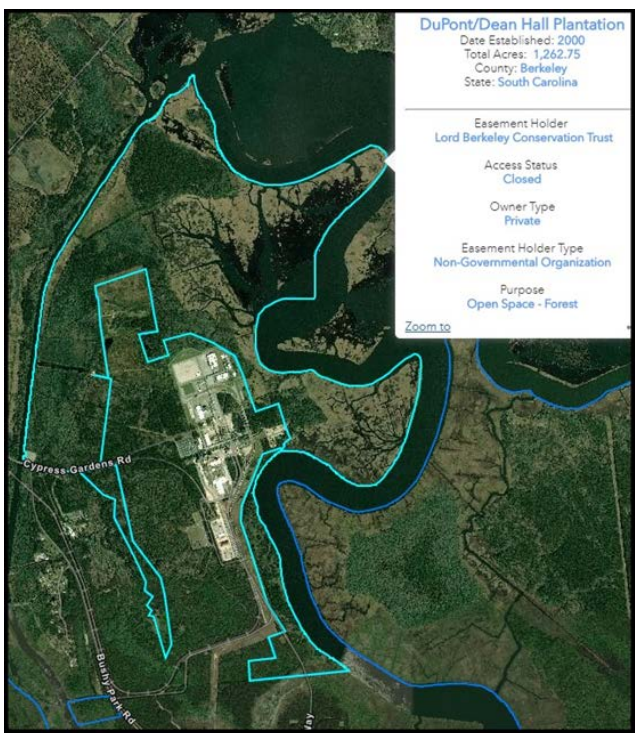


Figure 9. Lord Berkeley Conservation Trust on Dean Hall Plantation

Due to the proximity of the reservoir to the coast and the tidal nature of the low-lying area around Bushy Park Reservoir, much of the riparian areas are classified as wetland (figure 10). A recent wetland classification study was conducted by the United States Army Corps of Engineers in 2013 resulting in the following wetland classifications around the Bushy Park Reservoir (Reif p. 18).

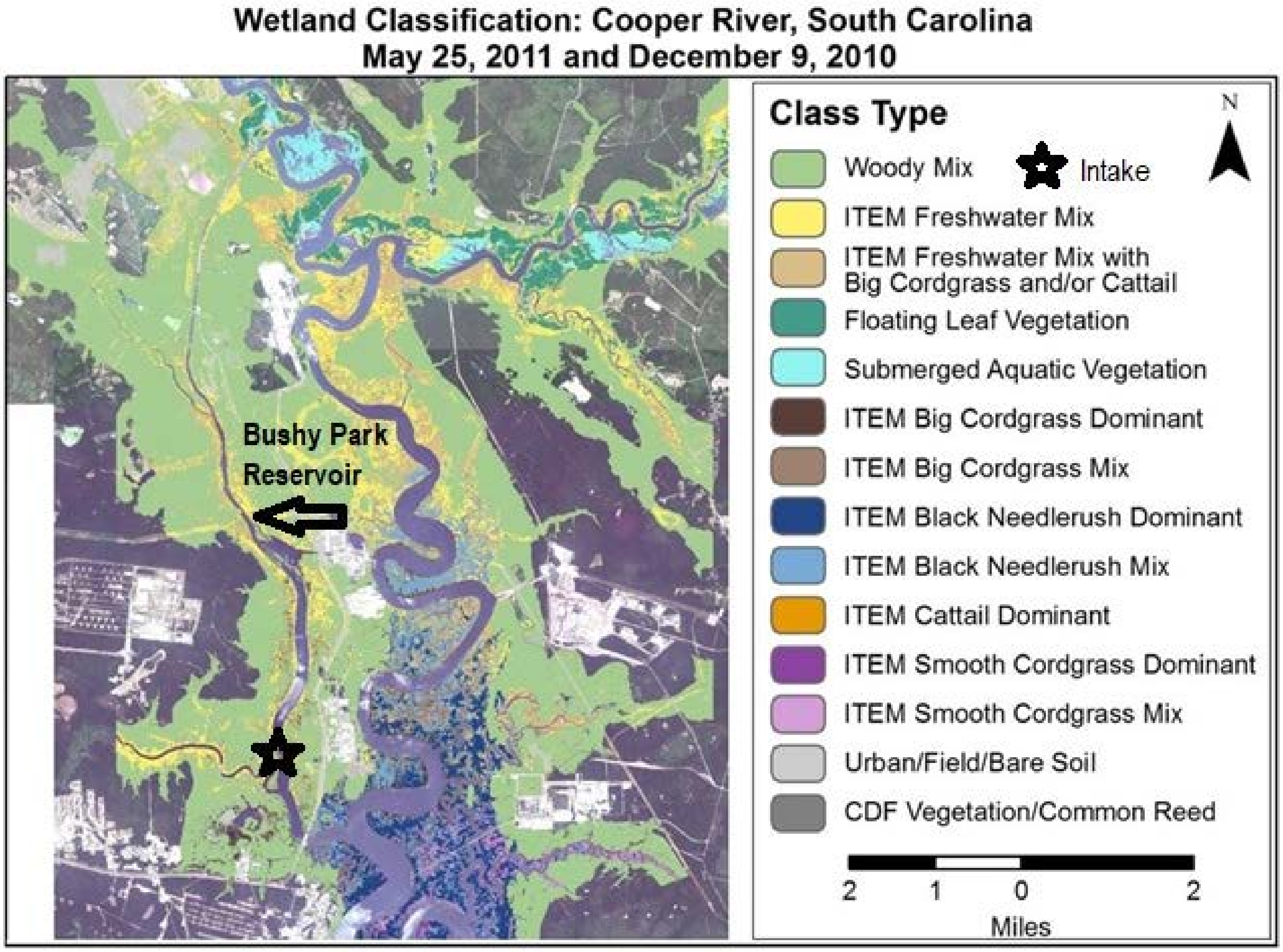


Figure 10. Wetland Classification for Bushy Park Reservoir and Surrounding Area

g. Water Quality and Impairment Information

The Back River Reservoir is mostly mesotrophic; however, eutrophic conditions (dissolved oxygen reduction and stratification) can develop in the southern end of the reservoir during late Summer as water temperatures increase. Eutrophic conditions persist most of the year in Foster Creek. It is important to understand the process of eutrophication to understand the important relationship between nutrient loads (total nitrogen and total phosphorus), the proliferation of aquatic vegetation/algae/cyanobacteria, and the impaired parameter dissolved oxygen (Schindler 2006). The latest SCDHEC water quality assessment of the Cooper River Watershed (10-digit HUC 03050201-07 encompassing the Foster Creek and Back River Reservoir watersheds) also points out there are "high amounts of natural organic material in the system" contributing to low dissolved oxygen conditions. The marsh wetland surrounding Bushy Park and Foster Creek, as well as the settled sediments within these waters, are to a large extent composed of the natural organic matter referred to in this report. These anoxic soils exert natural biological oxygen demand (BOD) on the coastal waterways. However, nutrients and sediments capable of exerting BOD via eutrophication also come from nonpoint sources such as urban runoff (pet waste, fertilizers), forestry runoff, septic systems and sanitary sewer overflows. There are currently no NPDES point source discharges directly into either Foster Creek or the Back River Reservoir (other than the CRP intake screen material), suggesting the current dissolved oxygen impairment in the Foster Creek and Back River Reservoir watersheds is due to some combination of nonpoint sources, non-NPDES point sources, and "natural organic material".

Bushy Park Reservoir and the rest of the Cooper River Watershed (8-digit HUC 03050201), minus Lake Moultrie, drain into the Charleston Harbor and are under a TMDL for Dissolved Oxygen. The 2013 TMDL (Cantrell/SCDHEC

0506-13) revised and combined the existing 2002 Cooper River-Wando River-Charleston Harbor TMDL and the 2003 Ashley River TMDL to include the Charleston Harbor, Cooper, Ashley and Wando Rivers Dissolved Oxygen TMDL and was based on the 2008 3-dimentional Environmental Fluid Dynamics Code model. The model covered the main portion of the Bushy Park Reservoir (Back River Portion), but did not cover or model Foster Creek or the Back River contributions in great detail. The TMDL study focused on NPDES wastewater discharges, NPDES stormwater discharges, non-point sources, and natural background sources.

The TMDL study determined "that regulated and unregulated stormwater and nonpoint sources do not contribute to the allowable dissolved oxygen depression on the mainstem segments including Charleston Harbor and the Cooper, Ashley, and Wando Rivers" (Cantrell/SCDHEC 0506-13, p. ii). Thus, the wasteload allocation (WLA) primarily focused on the continuous NPDES point sources. However, in the absence of wastewater NPDES point sources within the Bushy Park Reservoir and its tributaries, our watershed-based plan primarily focuses on the nonpoint sources (like stormwater) from the applicable MS4 (figure 11). The MS4 includes: Joint Base Charleston – Weapons Station (SCR031504), Berkeley County (SCR031501), and Goose Creek (SCR031502). Load calculations and water quality data support that these stormwater sources, and other nonpoint sources, are significant contributing sources of nutrients that further deplete dissolved oxygen within the reservoir, especially within the tributaries that feed Bushy Park Reservoir (Foster Creek toward the Southwest end of the reservoir and the Back River tributary toward the Northwest end of the reservoir).

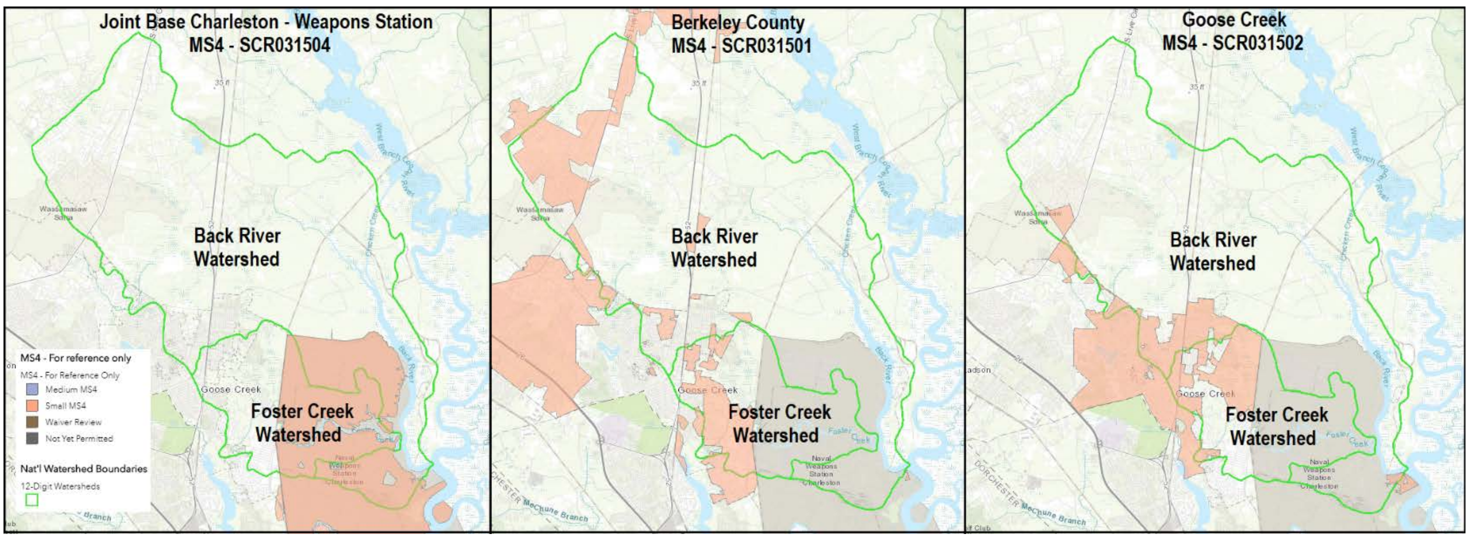


Figure 11 – MS4 Within the Back River and Foster Creek Watersheds

As was previously described, the fact that Bushy Park Reservoir is tidally influenced at the North end (through Durham Canal) to the West Branch of the Cooper River, means that the NPDES wastwater discharges upstream (or just downstream) in the Cooper River could have an impact on nutrient loading and dissolved oxygen within Bushy Park Reservoir. These discharges include Moncks Corner (SC0021598), BCWSA/Central Berkeley (SC0039764), and DAK Americas (SC0026506 and SC0048950). The extent these source do (or don't) impact the water quality within the reservoir will be discussed in more detail below.

Figure 13 shows the water quality monitoring sites. There are three SCDHEC monitoring locations (South end of Bushy Park CSTL-124, Foster Creek MD-240, and Durham Canal MD-217) within the Bushy Park Reservoir. The latter two are not currently supported and site CSTL-124 was only recently temporarily reactivated. The data for these sites is accessible online (https://www.waterqualitydata.us/).

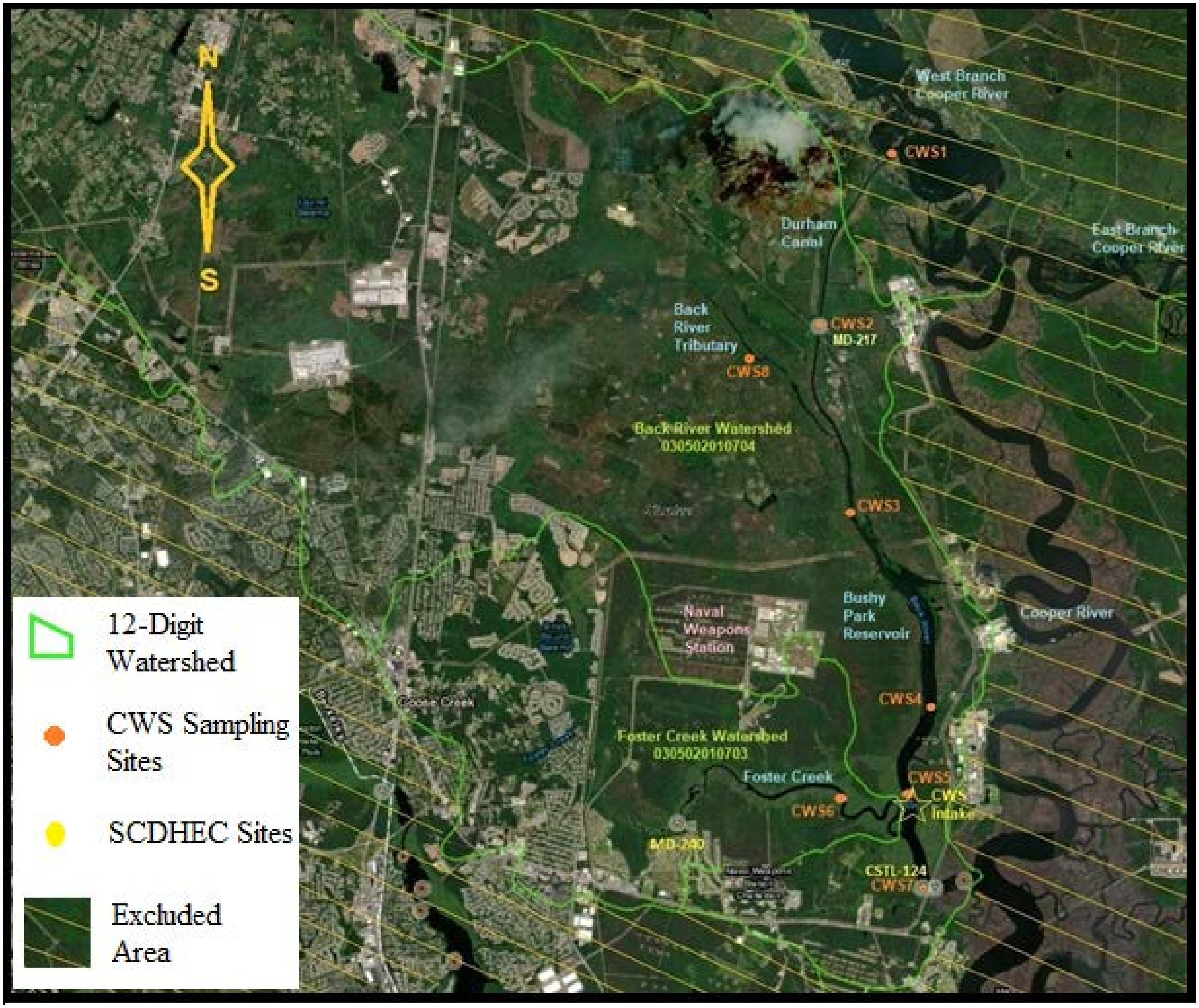


Figure 12. Watershed Water Quality Monitoring Sites

SCDHEC monitoring during the limited sampling window (1999-2007) clearly indicate Foster Creek has significantly lower dissolved oxygen compared to the main body of Bushy Park (site CSTL-12) or Durham Canal (site MD-217) as shown in figure 13.

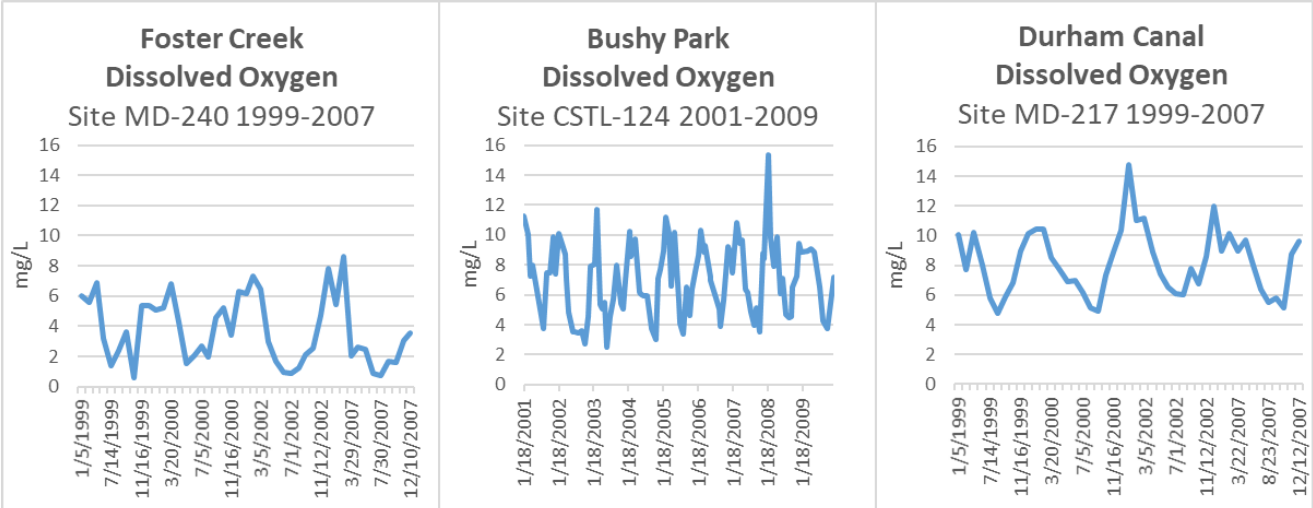


Figure 13. Dissolved Oxygen from SCDHEC Monitoring

Greater water movement within Durham Canal and main body of Bushy Park compared to the Foster Creek tributary may partially explain this pattern in dissolved oxygen. However, higher loading in Foster Creek could also contribute to this pattern and in fact, the total phosphorus and total nitrogen data collected at the same time confirm much higher nutrients in the Foster Creek tributary (figure 14).

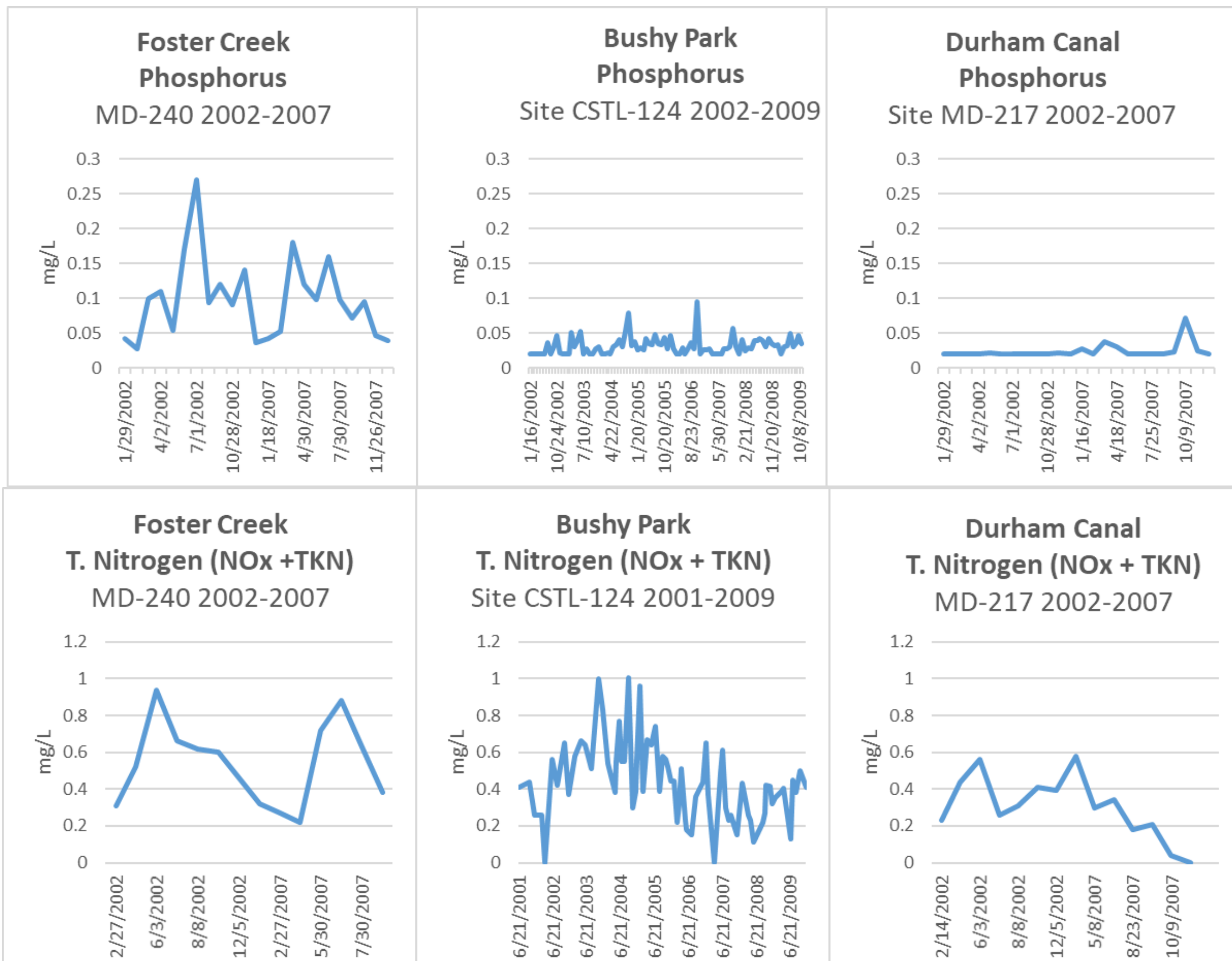


Figure 14. Total Phosphorus and Total Nitrogen from SCDHEC Monitoring

The pattern of decreased dissolved oxygen and increased nutrients in Foster Creek as compared to Bushy Park and Durham Canal has been confirmed with every study performed on the Reservoir dating back to the late 1970's (WRC Report 124 and 130). These higher numbers were primarily blamed on wastewater discharges into Foster Creek until 1983, when the wastewater discharges were moved to the Cooper River (JJ&G 1988 p. 37). Despite improvement in the water quality in Foster Creek after 1983 (USGS Report 2017-5050 p.9), the pattern of higher nutrient loads in Foster Creek compared to the other sites studied has persisted as shown in every study since. These studies and samplings included a CWS study performed in 2013 and the 2013-2015 USGS studies (Report 2018-5010, Report 2017-5050). The USGS compiled in table 4 shows Foster Creek (CWS-6) again had the lowest dissolved oxygen and highest phosphorus and nitrogen. The CWS study showed the same pattern.

Statistical Summary of the September 2013 - April 2015 Bushy Park Reservoir Study by USGS										
		Dissolved Oxygen (mg/L)			Total Phosphorus (mg/L)			Total Nitrogen (mg/L)		
Site	n	Median	25%	75%	Median	25%	75%	Median	25%	75%
CWS-1 (Cooper River)	4	7.7	6.2	9.9	0.030	0.014	0.034	0.35	0.32	0.38
CWS-2 (Durham Canal)	5	6.5	6.3	9.4	0.025	0.016	0.028	0.33	0.31	0.38
CWS-3 (Above Williams)	6	7.6	5.8	9.1	0.026	0.025	0.039	0.36	0.32	0.51
CWS-4 (Below Williams)	9	5.9	5.6	8.4	0.027	0.024	0.037	0.35	0.34	0.40
CWS-5 (CWS Intake)	12	5.6	5.1	7.6	0.041	0.040	0.046	0.43	0.39	0.48
CWS-6 (Foster Creek)	6	3.0	1.8	6.1	0.065	0.044	0.074	0.47	0.44	0.54
CWS-7 (Lower Landing)	6	5.7	4.4	7.4	0.041	0.034	0.047	0.46	0.40	0.47

Table 4. Dissolved Oxygen, Total Phosphorus and Total Nitrogen from the Latest USGS Study

The lower phosphorus and nitrogen levels in Durham Canal during these studies would also appear to eliminate the wastewater discharges (NPDES regulated sources) in the Cooper River as the most significant contributors to nutrient loads to Bushy Park Reservoir at least during the studies. In the absence of wastewater point source discharges within the Bushy Park Reservoir and the tributaries draining into it (Foster Creek and the Back River), this WBP aims to examine and mitigate the nonpoint sources of nutrient and bacterial loading (from runoff, septic systems, etc.) to these tributaries which contribute directly and indirectly to the eutrophic conditions (decreased dissolved oxygen year around) observed in the tributaries and the mesotrophic conditions (decreased dissolved oxygen Mid to Late-Summer) observed within the main body of Bushy Park despite the likely positive influence of increased water movement from both tidal flows and raw water withdrawals.

The latest data from the CWS Reservoir-wide routine sampling (table 5) began in March 2019 not only continues to confirm lower dissolved oxygen in Foster Creek, but also shows the Back River tributary exhibits similarly low dissolved oxygen impairment as the Foster Creek tributary when compared to the rest of the reservoir. This data confirms past observations that the tributaries are eutrophic while the main body is mostly mesotrophic.

Dissolved Oxygen (mg/L) - Bushy Park Reservoir Sampling by Charleston Water System										
	3/21/19	4/11/19	6/11/19	7/19/19	8/22/19	10/1/19	1/23/20	3/13/20	5/12/20	7/14/20
CWS-1 (Cooper River)	9.6	8.1	5.8	5.4	5.1	6.3	10.8	9.4	NA	5.3
CWS-2 (Durham Canal)	8.9	8.2	5.7	4.5	3.6	5.4	10.7	8.0	7.8	5.1
CWS-3 (Above Williams)	8.7	9.0	6.9	4.5	4.6	5.7	10.7	9.3	7.7	4.7
CWS-4 (Below Williams)	NA	8.4	5.7	4.4	6.0	5.3	10.1	7.9	8.6	5.9
CWS-5 (CWS Intake)	8.0	8.5	5.3	4.3	4.1	5.5	10.6	8.2	6.8	5.2
CWS-6 (Foster Creek)	6.9	7.5	3.3	0.6	2.8	1.9	8.9	5.1	3.2	0.8
CWS-7 (Lower Landing)	8.9	9.1	5.3	4.0	4.6	6.3	9.2	7.5	7.0	3.4
CWS-8 (Back River Trib.)	7.0	2.5	1.2	2.1	1.7	2.6	10.3	5.1	3.2	0.5

Table 5. Dissolved Oxygen from CWS Reservoir Routine Monitoring

The following diagram (figure 15) highlights the total phosphorus data from all the prior sampling events and studies over the past 50 years represented as box and whisker plots. These plots indicate the spread of the total phosphorus data during each study window within different portions of the reservoir. In nearly every study, the total phosphorus is higher in the tributaries than in the main body of the reservoir and lower still in Durham Canal. The total phosphorus has also decreased at most of the monitored sites since the 1970's.

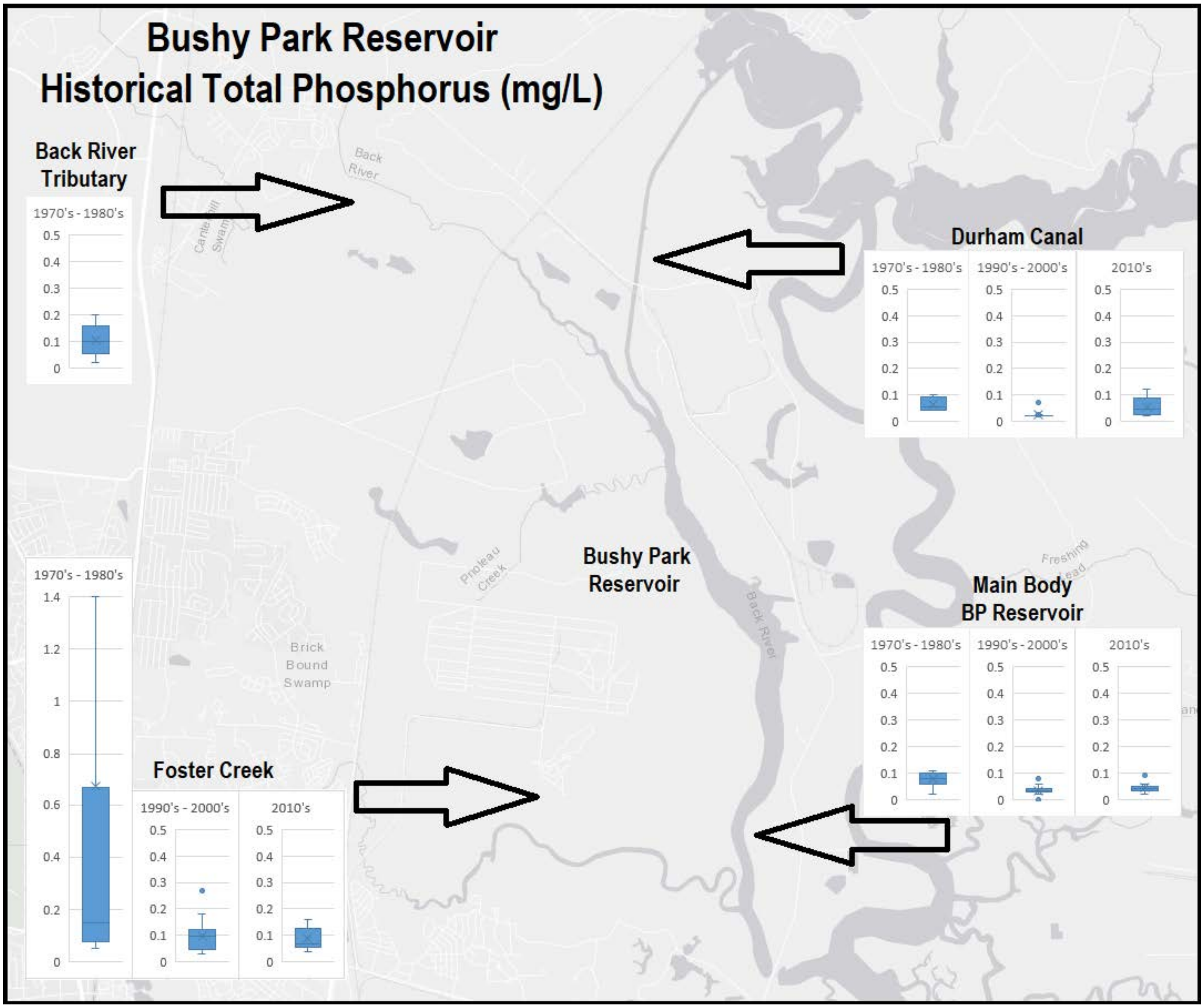


Figure 15. Box and Whisker Plots of Historical Total Phosphorus Data

A similar diagram (figure 16) below highlights the dissolved oxygen data from prior sampling events and studies represented as box and whisker plots. These plots indicate the spread of the dissolved oxygen data during each study window within different portions of the reservoir. In nearly every study, the dissolved oxygen is lower in the tributaries than the main body of the reservoir and higher still in Durham Canal. The dissolved oxygen has also increased or remained relatively steady since the 1970's.

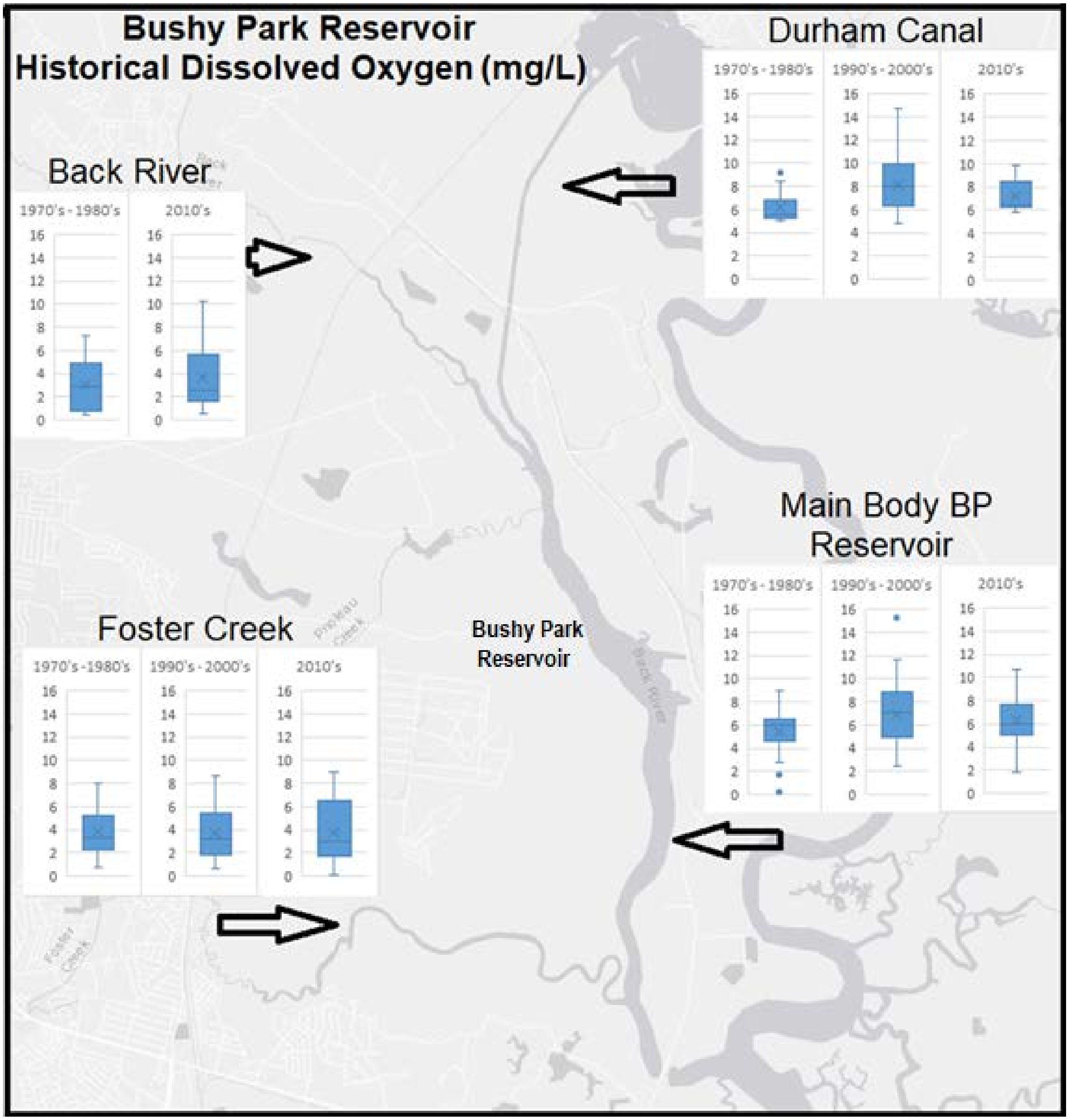


Figure 16. Box and Whisker Plots of Historical Dissolved Oxygen Data

Despite the persistent pattern of eutrophic conditions in the tributaries verses mesotrophic conditions within the main body shown during past and recent studies, the studies indicate an overall pattern of improving water quality especially in regard to nutrients and dissolved oxygen since the 1970's. The improvement in nutrients (decreasing trend) and dissolved oxygen (increasing or sustained trend), despite increased urbanization, is likely in large part due to:

1. NPDES regulation.
2. Consolidation of the 8 wastewater treatment plants previously discharging to the reservoir into the early 1980's.
3. Movement of the wastewater outfalls from the reservoir into the Cooper River.
4. Increase water movement due to a combination of tidal flow through Durham Canal and raw water withdrawals begun by the Williams Power Station (built in the 1970's).
5. Improved stormwater regulation and management within the applicable MS4.

CWS hopes the development of a Watershed-Based Plan will not only serve as a means of maintaining the water quality within the reservoir, but as the next step in improving water quality by increasing our understanding of the sources of pollution within the two watersheds and more importantly, opening the stakeholders within them to 319 implementation funding.   The eligibility to apply for and potentially utilize 319 Implementation grants for future BMP projects is crucial to incentivizing projects that could further improve water quality and minimize the impact of continued urbanization in the two watersheds.

Continued water quality monitoring throughout the reservoir and water column is needed to better understand and monitor the long-term water quality trends, understand the sources of pollution, determine the most appropriate BMPs, and measure the impact of implemented BMPs. Though routine reservoir wide sampling is an important step, continuous monitoring via sonde units would help to evaluate diurnal and/or tidal trends and thus true dissolved oxygen maximums and minimums at any given location within the reservoir and may eventually help to serve as early detection of any significant water quality changes, especially during adverse weather conditions such as during drought, hurricanes or any other wind, rain and/or flooding event. Continuous monitoring may also help monitor and respond to algae or cyanobacterial blooms as the expanded data collection sheds more light on the relationships between these blooms and the other water quality parameters able to be monitored.

Perhaps one of the greatest insights from the USGS study was the longitudinal plots of the reservoir showing seasonal patterns in water quality and specifically stratification seen in the Summer verses the Winter (figure 17). Though prior data had indicated some stratification, the USGS data presented as longitudinal plots better characterizes this stratification throughout the reservoir and highlights the different water quality seen in the deeper and more stagnant (less water movement) portions of the reservoir to the South verses the shallower and less stagnant (more water movement) portions of the reservoir to the North especially during Summer months. Dissolved oxygen was considerably lower in the deeper and more stagnant portions likely exacerbated by the close proximity of this deeper portion of the reservoir to Foster Creek.

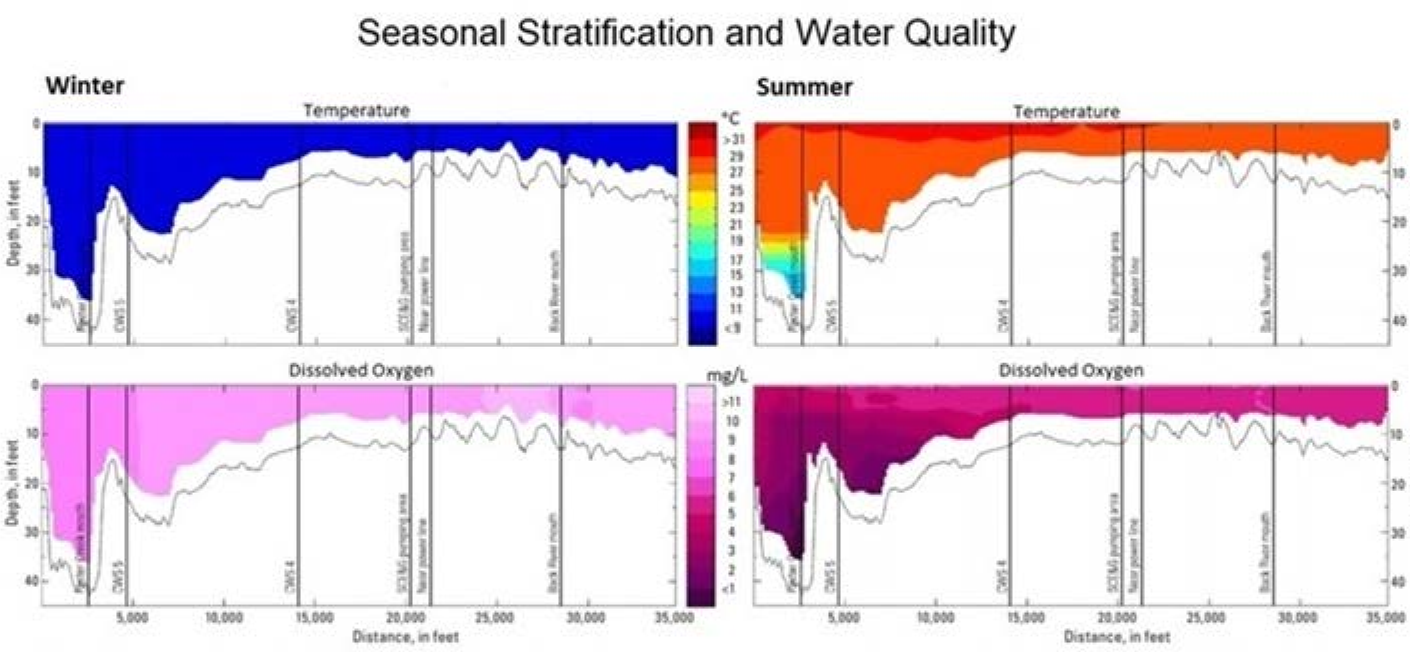


Figure 17. Longitudinal plots of Bushy Park Reservoir (south end on left, north end on right) of temperature and dissolved oxygen. Jan 2015 and July 2014

Beyond management of dissolved oxygen impairment by minimizing eutrophication, nutrient control plays an important role in mitigating the potential for algae/cyanobacteria blooms within Foster Creek and Bushy Park Reservoir. Cyanobacterial blooms tend to favor nutrient rich, still or slow-flowing water with good light penetration (low color and turbidity). Nutrient (total phosphorus and total nitrogen) availability is a key risk factor for HAB formation (EPA 822-B-08-001). Though both of the above nutrients can play key roles in supporting blooms, the ability of some cyanobacteria to fix nitrogen (using inorganic and organic sources) means total phosphorus is generally considered more limiting for the control of blooms. SCDHEC has set the numeric nutrient criteria at 0.09 mg/L total phosphorus and 1.5 mg/L total nitrogen (R.61-68, Water Classifications and Standards 2014). However, the more conservative EPA recommendations of 0.008-0.020 mg/L total phosphorus and 0.32-0.41 mg/L total nitrogen for ecoregion 14 subecoregion 63 (EPA 822-B-01-011) may be a more appropriate target range to further limit the potential for the formation of algae or cyanobacteria blooms given the use of the reservoir as a drinking water supply. The lower EPA values were determined by measuring and calculating the 25th percentile of lakes and reservoirs in ecoregion XIV subecoregion 63 for a decade. These values are said to roughly approximating the 75th percentile for a reference population. These recommended nutrient levels are very low and emphasize the importance of addressing all sources of nutrient pollution.

2. Pollutant Sources (Element 1)

As was previously mentioned in the land use section (Section 1.f.), the type of land cover generally determines the potential pollutant loading (nutrients, sediments, bacteria, etc.) to the receiving waters in the watershed. These pollution loads often occur indirectly from runoff during precipitation events, but may also be through direct discharges such as with failing septic systems. The type of land cover with the least runoff loads is forested as it drastically reduces the amount of water runoff and helps reduce soil loss and increases water absorption. However, development (via urbanization and agriculture) are an inevitable part of most watersheds and the potential loading tends to increase as forested/woodland acreage is lost the various types of development. Relative levels of pollution are compared in table 6.

Relative Levels of Pollution in Streams Throughout the U.S.			
WQ Parameter	Urban Areas	Agricultural Areas	Undeveloped Areas
Nitrogen	Medium	Medium-high	Low
Phosphorus	Medium-high	Medium-high	Low
Herbicides	Medium	Medium-high	Low
Pesticides	Medium-high	Low-medium	Very low
Metals	High	Medium	Very low
Toxic Organics	High	Medium	Very low
Source: USGS, 1999			

*EPA. Fundamentals of Urban Runoff Management. 2nd Edition. 2007. p. 3-55

Table 6. Relative Pollutant Loads

The following Google Earth Images (figure 18) highlights the extent of development within the watershed over the past several decades. As the number of residential areas (and commercial properties servicing these residents) increase, there is a considerable increase in runoff pollution and other nonpoint sources of pollution.

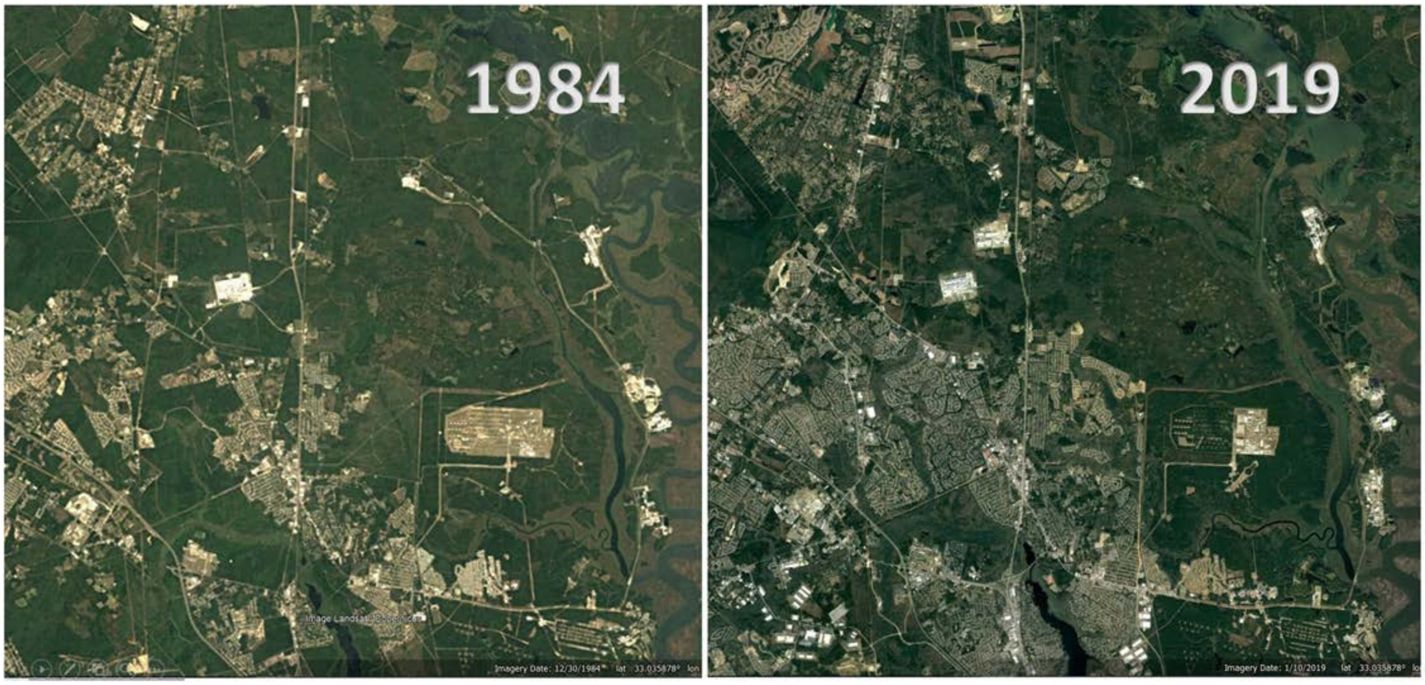


Figure 18. Urbanization Across Both the Back River and Foster Creek Watersheds Since 1984

In an effort to better understand the potential contributions of nonpoint source pollution from the two watersheds covered in the WBP and potential load reductions from BMPs, CWS used EPA's STEPL (Spreadsheet Tool for Estimating Pollutant Load) model software to calculate total nitrogen, phosphorus, BOD and sediment loads per year (EPA Suggested Load Tools 2018). Though the excel based STEPL software is relatively easy to learn from the guidance documents provided (EPA STEPL 2019) and from the help provided by SCDHEC staff, the size of the two watersheds and lack of detailed land use percentages within these watersheds (especially relating to the urban land use breakdown) meant considerable time would be needed to research, investigate, delineate and input the land cover and uses for most of the 49,200 acres of combined watershed.

Joshua Huggins was hired as an intern with the primary task of delineating land use/cover within the two watersheds using a combination of SCDHEC's Watershed Atlas, Berkeley County's Online GIS Database and STEPL. After nearly three months of work, he had researched and investigated the current land uses and pollutant loads for every parcel (or group of parcels) covering 98 percent (48,376 acres) of the total 49,183 acres of Back River and Foster Creek Watersheds. These parcel delineations did not include the reservoir and thus likely explains why the CWS reported acreage is smaller than the SCDHEC reported acreage. While this individual parcel load approach isn't necessary if the land use percentages are already known for the watersheds (or are just going to be estimated), this approach allowed us to arrive at a more accurate breakdown of all the land types, and specifically the urban land use percentages, within each watershed (table 7) needed to utilize STEPL to more accurately model watershed loads. This approach also gave us more information about loads on each parcel (or group of parcels) for when examining loads and load reductions for BMPs on specific parcels.

12-Digit HUC	Watershed Name	Total Acres (CWS Calculated)	Forest Acres	Pastureland Acres	Urban Acres	Urban %	Urban Land Use Breakdown (%)							
							Commercial	Industiral	Institutional	Transportation	Multi-Family	Single-Family	Vacant	Open
030502010703	Foster Creek	9181	5753	0	3428	37.34	*7.04*	*3.55*	*1.67*	*5.91*	*3.83*	*68.51*	*0.09*	*9.39*
030502010704	Back River	39195	29862	22	9311	23.76	*6.10*	*12.24*	*1.00*	*3.08*	*2.52*	*54.33*	*0.27*	*20.45*
	Both Watersheds	48376	35615	22	12739	26.33								

Table 7. Urban Land Use Breakdown

Stormwater runoff (specifically from urban areas) and septic systems were determined to likely be the most significant sources of nonpoint source pollution to the Back River and Foster Creek watersheds. The following sections go into further detail into these and the other nonpoint sources identified. This plan will be updated as needed to cover new sources of nonpoint source pollution so that mitigating BMPs can be considered.

a. Stormwater Runoff

Table 8 summarizes the STEPL modeled total stormwater pollutant loads from all land uses within the two watersheds and compares the total load arrived at by adding all of the parcel loads verses the load calculated using the total watershed acres and CWS determined urban land use percentages or breakdown. The former serves as a verification of the latter. The latter loads using the total watershed acreage and urban breakdown will be used going forward so that load reductions from watershed-wide BMPs can more easily be calculated.

Watershed	SCDHEC Reported Size (Acres)	CWS Reported Size (Acres)	Total Stormwater Loads (Adding Parcel Loads)				Total Stormwater Loads (Using CWS Reported Watershed Size and CWS Determined Urban Breakdown)			
			N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)
Foster Creek Watershed	9370	9181	32411	6283	130498	715	32345	6263	130353	701
Back River Watershed	39813	39195	74787	15575	282548	1645	74533	15467	282219	1550
Both Watersheds	49183	48376	107197	21858	413046	2360	106878	21730	412572	2251

Table 8. Stormwater Runoff Loads from STEPL Calculations in the Two Watersheds

Since STEPL does not yield bacterial runoff load estimates, table 9 shows the loads derived from Horner (1992) which were used to estimate fecal coliform loads.

Pollutant Loading (kg/ha-yr) Ranges for Various Land Uses								
Land-Use Category		TSS	TP	TN	Pb	In	Cu	FC
Road	Minimum	281	0.59	1.3	0.49	0.18	0.03	7.1 E+07
	Maximum	723	1.50	3.5	1.10	0.45	0.09	2.8E+08
	Median	502	1.10	2.4	0.78	0.31	0.06	1 .8E+08
Commercial	Minimum	242	0.69	1.6	1.60	1.70	1.10	l.7E+09
	Maximum	1,369	0.91	8.8	4.70	4.90	3.20	9.5E+09
	Median	805	0.80	5.2	3.10	3.30	2.10	5.6E+09
Single family Low density Residential	Minimum	60	0.46	3.3	0.03	0.07	0.09	2.8E+09
	Maximum	340	0.64	4.7	0.09	0.20	0.27	1.6E+l0
	Median	200	0.55	4.0	0.06	0.13	0.18	9.3E+09
Single family High density Residential	Minimum	97	0.54	4.0	0.05	0.11	0.15	4.5E+09
	Maximum	547	0.76	5.6	0.15	0.33.	0.45	2.6E+l0
	Median	322	0.65	5.8	0.10	0.22	0.30	1.5E+l0
Multifamily Residential	Minimum	133	0.59	4.7	0.35	0.17	0.17	6.3E+09
	Maximum	755	0.81	6.6	1.05	0.51	0.34	3.6E+l0
	Median	444	0.70	5.6	0.70	0.34	0.51	2.1E+l0
Forest	Minimum	26	0.10	1.1	0.01	0.01	0.02	1 .2E+09
	Maximum	146	0.13	2.8	0.03	0.03	0.03	6.8E+09
	Median	86	0.11	2.0	0.02	0.02	0.03	4.0E+09
Grass	Minimum	80	0.01	1.2	0.03	0.02	0.02	4.8E+09
	Maximum	588	0.25	7.1	0.10	0.17	0.04	2.7E+l0
	Median	346	0.13	4.2	0.07	0.10	0.03	1.6E+ 10
Pasture	Minimum	103	0.01	1.2	0.004	0.02	0.02	4.8E+09
	Maximum	583	0.25	7.1	0.015	0.17	0.04	2.7E+ 10
	Median	343	0.13	4.2	0.010	0.10	0.03	1.6E+ 10
Source: Horner, 1992								

*EPA. Fundamentals of Urban Runoff Management. 2nd Edition. 2007. p. 3-64

Table 9. Pollutant Loading for Various Land Uses

Horner's study used data collected in the Pacific Northwest and therefore these loads may differ some from those experienced in the Southeast United States. It is also important to point out that fecal coliform loads (counts/ha-yr) vary between a minimum of 7.1E+07 (for roads) to maximum of 3.6E+10 (multifamily residential). In other words, all land uses have a significant theoretical bacterial (fecal coliforms) load contribution. Even forest, which typically represents a baseline of sorts with the least contribution of pollutants has a fecal coliform load of 4.0E+09 counts/ha-yr. Due to the relatively small difference in fecal loads regardless of developed land use, we averaged the median loads (counts/ha-yr) from commercial (5.6E+09), single family (low density 9.3E+09 and high density 1.5E+10), and grass (1.6E+10) to come up with a calculated urban load value of 1.15E+10 counts/ha-yr (or 4.65E+09 counts/ac-yr). This number is very close to the fecal coliform load rate (4.12E+09 counts/ac-yr) SCDHEC used in the TMDL plan for Big Swamp (SCDHEC Tech. Doc. No. 016-06 p 3-4) to represent built-up or developed land with most of the fecal coliform loads coming from domestic animals (cats, dogs, etc.). We also used the forest median load of 4.0E+09 counts/ha-yr (or 1.62E+09 counts/ac-yr) and pasture median load of 1.6E+10 counts/ha-yr (or 6.48E+09 counts/ac-yr). These loading rates were multiplied by the urban, forested and pasture acres to determine fecal loads across the two watersheds (table 10).

Fecal Load Rates from Horner 1992 (counts/ha-yr)											
			*Fecal Coliform in counts/ha-yr, not kg/ha-yr								
Median Commercial =	5.6E+09		*Averaged median loads from commercial, low and high single family and grass for developed or urban load								
Median Single Family Low Density =	9.3E+09		*Used the urban, forest and pasture load rates to get loads and converted from ha-yr to ac-yr								
Median Single Family High Density =	1.5E+10		*Loads per day (vs per year) are shown for reference								
Median Grass =	1.6E+10										
	4.59E+10	÷ 4 =	1.15E+10	counts/ha-yr							
Developed or Urban =	1.15E+10		1.15E+10	x	1 ha	=	4.65E+09	counts/ac-yr	or	1.27E+07	counts/ac-day
	counts/ha-yr		ha-yr		2.47 ac			for urban			for urban
Forest =	4E+09		4E+09	x	1 ha	=	1.62E+09	counts/ac-yr	or	4.44E+06	counts/ac-day
	counts/ha-yr		ha-yr		2.47 ac			for forest			for forest
Pasture =	1.6E+10		1.6E+10	x	1 ha	=	6.48E+09	counts/ac-yr	or	1.77E+07	counts/ac-day
	counts/ha-yr		ha-yr		2.47 ac			for pasture			for pasture

Watershed	SCDHEC Reported Size (Acres)	CWS Reported Size (Acres)	Urban Acres (%)	Total Stormwater Loads				
				N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)	Fecal Coliform Load
Foster Creek Watershed	9370	9181	37.34%	32345	6263	130353	701	2.52E+13
Back River Watershed	39813	39195	23.76%	74533	15467	282219	1550	9.18E+13
Both Watersheds	49183	48376	26.33%	106878	21730	412572	2251	1.17E+14

Table 10. Modeled Stormwater Loads from Both Watersheds with Fecal Coliform

Urban Runoff

Urban stormwater runoff (table 11) appears to be the largest nonpoint contribution of nutrients, sediment and bacteria to the Foster Creek and Back River Tributaries which feed Bushy Park Reservoir. As was previously pointed out under Land Use, both the Back River and Foster Creek watersheds have been experiencing considerable urbanization with many new neighborhoods under construction even during the development of this WBP with a similar growth in commercial land to support the growing residential population.

Watershed	CWS Reported Size (Acres)	Urban Stormwater Loads				
		N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)	Fecal Coliform Load (counts/yr)
Foster Creek Watershed	9181	29628	4914	123604	674	1.59E+13
Back River Watershed	39195	63547	10096	254758	1452	4.33E+13
Both Watersheds	48376	93175	15009	378362	2126	5.92E+13

Table 11. Urban Stormwater Loads

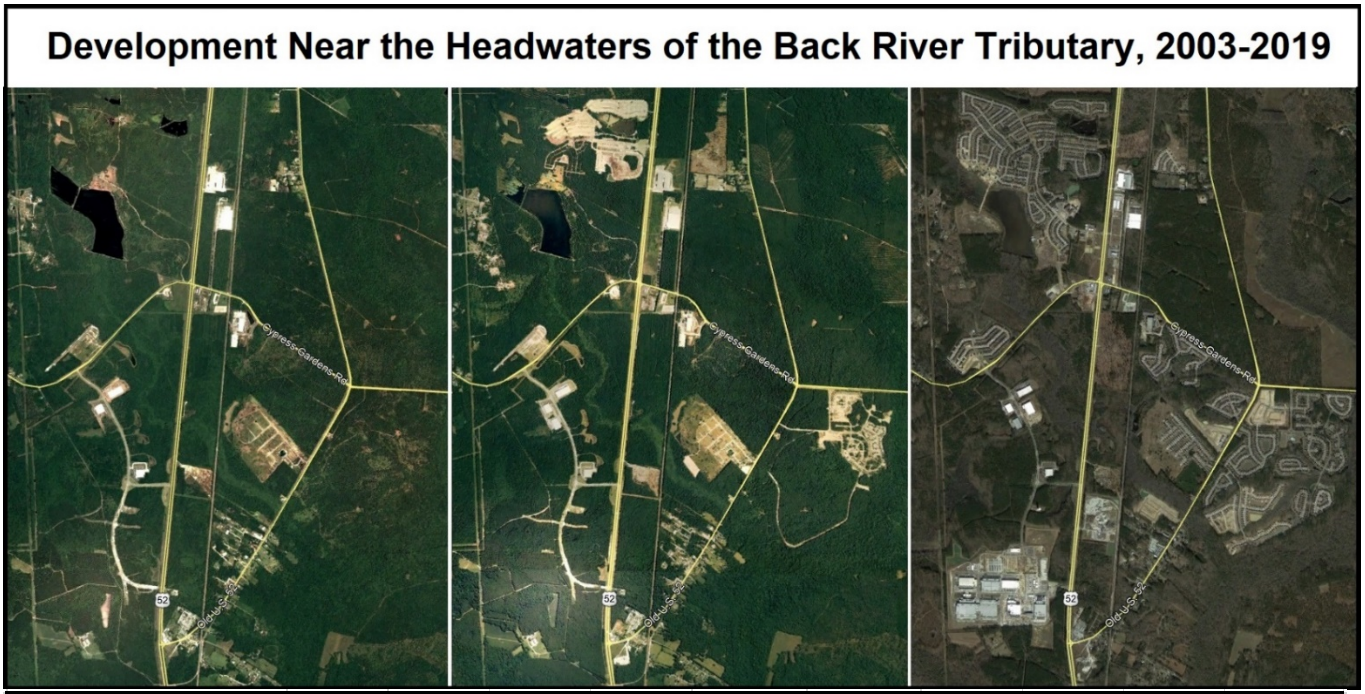
Much of the urbanization has been near the headwaters of the Foster Creek and Back River Tributaries. Fortunately, these neighborhoods were required to be built with modern stormwater BMPs. In general, stormwater BMPs are usually required for any land disturbance greater than an acre (NACWA 2018), but these requirements generally increase as the size of disturbed land increase. Some of the neighborhoods and BMP infrastructure were still under construction as of the completion of this plan. The following picture and table (table 12) highlights about 900 acres of addition neighborhoods added near the headwaters of Foster Creek and the modeled loads with and without the current BMPs.

Development Near the Headwaters of Foster Creek, 2003-2019

Development - Foster Creek Trib.		Total Load - no BMP				BMP Type	Total Load - with BMP			
Description	Total Acres	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)		N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)
Coker's Crossing	141	729	133.8	3305.4	16.6	Wet Pond	475.3	74.4	3305.4	6.7
Sophia Landing	93	514.7	93.6	2339.7	11.7	Wet Pond	334.6	51.5	2339.7	4.7
Brickhope Greens South	12	86.3	15.7	392.3	2	Wet Pond	56.1	8.6	392.3	0.8
Brickhope Greens Central	8	57.5	10.5	261.6	1.3	Wet Pond	37.4	5.8	261.6	0.5
Brickhope Greens West	19	136.7	24.8	621.2	3.1	Wet Pond	88.8	13.7	621.2	1.2
Brickhope Greens North	36	258.9	47.1	1177	5.9	Wet Pond	168.3	25.9	1177	2.4
Liberty Hall South Complex	106	762.4	138.6	3465.6	17.3	Wet Pond	495.6	76.2	3465.6	6.9
Liberty Hall Main Complex	193	1388.2	252.4	6310.1	31.6	Wet Pond	902.3	138.8	6310.1	12.6
Liberty Village	136	772.8	114.1	2906.3	17.8	Not Done	772.8	114.1	2906.3	17.8
Hayden Hollow	47	338.1	61.5	1536.6	7.7	Wet Pond	219.7	33.8	1536.6	3.1
Hayden Ponds	46	297.5	54.9	1346.7	6.8	Wet Pond	194.2	30.7	1346.7	2.8
Hayden Hill	77	426.2	77.5	1937.2	9.7	Wet Pond	277	42.6	1937.2	3.9
Montague Plantation Rd	8	193.4	32.2	599.5	4.8	Not Done	193.4	32.2	599.5	4.8
	922	5962	1057	26199	136		4216	648	26199	68

Table 12. Development Near the Headwaters of Foster Creek, 2003-2019

The following picture and table (table 13) highlights about 1200 acres of addition neighborhoods added near the headwaters of the Back River Tributary and the modeled loads with and without the current BMPs. The existing BMPs were shown to illustrate the importance of including stormwater BMPs in new construction to reduce the loads from these developments and to highlight what has been done verses what further BMPs may be possible to lead to even further load reductions.



Development - Back River Tributary		Total Load - no BMP				BMP Type	Total Load - with BMP			
Description	**Total Acres**	**N Load (lb/yr)**	**P Load (lb/yr)**	**BOD Load (lb/yr)**	**Sediment Load (t/yr)**		**N Load (lb/yr)**	**P Load (lb/yr)**	**BOD Load (lb/yr)**	**Sediment Load (t/yr)**
Foxbank Plantation	412	2204.8	380.9	9825.4	49.1	Wet Pond	1436.6	211.7	9825.4	19.8
Cypress Grove	73	337.3	62.9	1522.2	7.8	Wet Pond	221.1	35.7	1522.2	3.2
Strawberry Station	128	448.2	67.8	1627.7	10.5	Not Done	448.2	67.8	1627.7	10.5
Fairmont Neighborhood	61	291.4	54.1	1317	6.7	Not Done	291.4	54.1	1317	6.7
Fairmont South	130	328.4	64	1337.3	7.9	Not Done	328.4	64	1337.3	7.9
Spring Grove Plantation	411	1929.4	358.7	8717	43.9	Wet Pond	1263	202.9	8717	17.9
Northwest Spring Grove Plar	41	191	35.6	862.3	4.4	Wet Pond	125.2	20.2	862.3	1.8
	1256	**5731**	**1024**	**25209**	**130**		**4114**	**656**	**25209**	**68**

Table 13. Development Near the Headwaters of the Back River Tributary, 2003-2019

Since many of the newer neighborhoods above already have stormwater retention (or are in the process of building them), the additional BMPs outlined in this WBP for these areas will be targeted public outreach covering subjects such as septic systems maintenance, rain barrels, pet waste, proper disposal of chemicals, avoid/minimize use of fertilizers/pesticides and maintenance of ponds, etc.

There are also several older neighborhoods and rural communities that were built before modern stormwater regulations and BMP practices were in place. Some of these neighborhoods may have sufficient undeveloped space to allow for the addition of modern stormwater BMPs or low impact development (LID) retrofits. In fact, Berkeley County has incorporated impact fee reduction incentives within their stormwater plan covering voluntary BMPs and LIDs which may be of particular interest to larger parcels. The older neighborhoods will also be targeted for the public outreach above, but will additionally be have outreach regarding the septic system replacement initiatives.

Many of the stormwater ditches at the head waters of Foster Creek were recently upgraded, however these upgrades may have been more focused on increased water transportation and flood reduction, rather than runoff load reduction (slowing or absorbing water into the landscape).

Similarly, additional stormwater retention BMPs may also be able to be implemented around industrial areas and a salvage yard. Many of these areas were also constructed before modern stormwater BMP requirements were enacted and in some cases even relatively modern facilities may lack adequate BMPs given their potential runoff loads possible. A few specific sites closer to the head waters of Foster Creek and Back River probably should be further assessed and/or storm water plans developed to if load reductions are adequate.

The industrial parks to the east of the reservoir are of some concern due to the excess amounts of chemicals stored on the sites and some risk of runoff pollution. However, this risk from runoff is largely mitigated as the facilities are required to have extensive stormwater management strategies and in most cases the stormwater from the sites are collected in retention ponds currently discharged to the Cooper River rather than Bushy Park Reservoir.

Forest Runoff

The largest land cover within the two watersheds is forested with much of the forested area undergoing silviculture. Table 14 shows the modeled runoff loads from the forested areas. Due to the higher content of forests and silviculture activities, it is important these areas be considered for BMPs as well.

Watershed	CWS Reported Size (Acres)	Forest Stormwater Loads				
		N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)	Fecal Coliform Load (counts/yr)
Foster Creek Watershed	9181	2717	1349	6750	27	9.32E+12
Back River Watershed	39195	10782	5356	26801	97	4.84E+13
Both Watersheds	48376	13500	6704	33551	124	5.77E+13

Table 14. Forest Stormwater Loads

The Joint Base Charleston – Weapons Station is largely forested (~6000 acres) with a significant portion of this forested land being actively management by their forestry group. Underbrush is managed by controlled burns. When not being harvested, the forested area is used for training and some access by base personnel to hunt is permitted. Care is exercised to make sure riparian areas are not harvested to prevent excess erosion. However, much of the forested area is low lying and is either adjacent to or within forested wetlands. Much of the ground remains soft most of the year and erosion of the many access roads is challenging to manage. The base has worked to add gravel/ROC to the most heavily traveled access roads while limiting access to others. They have also worked on culverts and drainage around the roads. These projects have been a part of their budget many years, but budget constraints have prevented them from covering all of the projects and problem areas despite their best efforts (Figure 19). It is possible 319 funding could help supplement their department of defense funding and help bolster their efforts to add more gravel/ROC, improve culverts and further limit heavy vehicle access.

Figure 19. Forestry Access Roads on Joint Base Charleston – Weapons Station

There are several other parcels within the two watersheds that appear to have some level of silviculture based on satellite images that may also have opportunities for BMP implementation. It is likely that similar challenges are present on other silviculture sites and thus it will be important to explore similar opportunities to fund and implement BMPs on these other properties. These include, but are not limited to:

- SC Generating Company forestry land TMS 1960000089 ~248 acres and part of 1960000078 ~758 acres
- Fairmont Pines TMS 2110002009 ~371 acres
- Matthews-Strawberry Forestry land TMS 2110002008 ~74 acres
- Robin Hollow TMS 2120001010
- Mead TMS 2110001001
- Nash-Nexton Holdings TMS 1950000124
- Medway Plantation Parcel

Pasture Runoff

Animal feed plots and pasture areas represent a very small portion of the two watersheds. During our investigations, we learned of a small horse pasture among the many recreational areas on the Joint Base Charleston - Weapons Station. The pasture is about 22 acres and has on average about 12 horses. The current facilities can house up to 16 horses. Some BMP opportunities may exist and thus it would be advantageous to get the Charleston NRCS representatives input on the site. We also believe there are some horses on the Medway Plantation and we hope to work with the Medway management team to assess and implement potential improvements where possible in the future. Table 15 shows the pastureland identified during the initial WBP. We anticipate adding more pastureland loads as we get a chance to visit some of the other agriculture properties within the Back River Watershed.

Watershed	CWS Reported Size (Acres)	Pastureland Stormwater Loads				
		N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)	Fecal Coliform Load (counts/yr)
Foster Creek Watershed	9181	0	0	0	0	0.00E+00
Back River Watershed	39195	204	16	660	1	1.43E+11
Both Watersheds	48376	204	16	660	1	1.43E+11

Table 15. Pastureland Stormwater Loads

b. **Septic Systems:**

Aging, overloaded or poorly maintained septic systems can serve as a significant pollution source (EPA 2002 p. xiv). Besides bacteria, septic systems contribute nutrients which may further deplete dissolved oxygen in Bushy Park Reservoir and may contribute to algae or cyanobacteria blooms and their byproducts. Within the Back River and Foster Creek Watersheds, there are approximately 1,214 septic systems (1157 within Back River, 56 within Foster Creek, and 1 on the base) with the greatest concentration along the Northwest boundary of the Back River Watershed (figure 20).

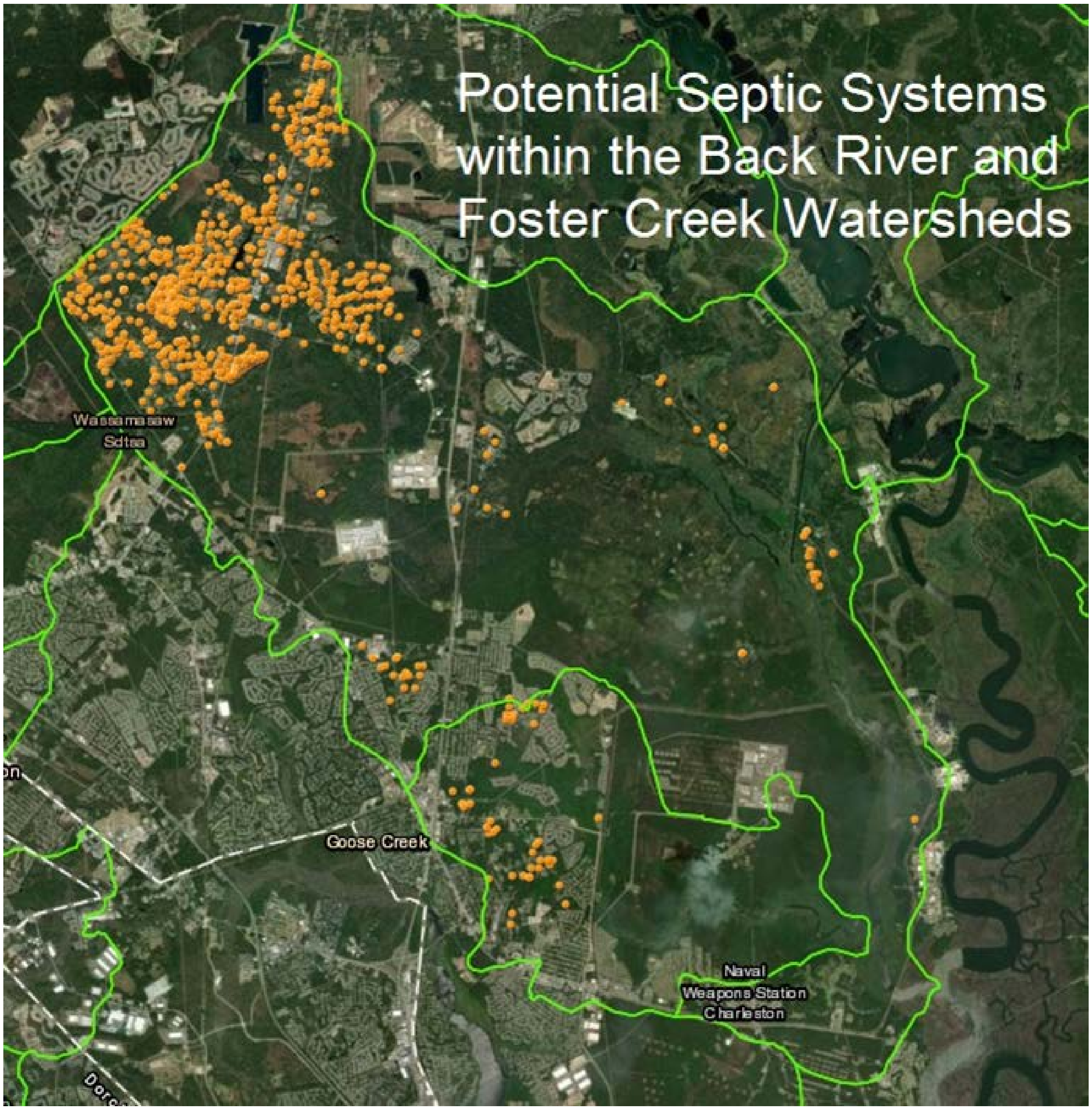


Figure 20. Septic Systems within the Back River and Foster Creek Watersheds

We believe failing septic systems are likely account for the second largest pollutant load second only to stormwater runoff. The density of these septic systems in combination with the high concentration of urban growth may help explain the lower dissolved oxygen seen in the Back River tributary (and Foster Creek) as compared to the rest of the reservoir. Given the age of some of the older communities with septic systems, it is likely many of the systems have exceeded their typical life spans. Some sources give failure rates as high as 20% (EPA 2002 p.1-4). Based on a 20% failure rate, up to 243 of the 1,214 septic systems could be failing and contributing to the water quality impairment. The estimated loads from these failing septic systems was calculated using STEPL (table 16). These loads make up a substantial contribution to the overall nutrient loads to the watershed.

Watershed	Approx. Septic Systems	Septic System Loads				
		N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)	Fecal Coliform Load (counts/yr)
Foster Creek Watershed	57	354	139	1447	0	2.76E+11
Back River Watershed	1157	7194	2818	29375	0	5.59E+12
Both Watersheds	1214	7548	2956	30822	0	5.87E+12

Table 16. Septic System Loads

The existing soil types (group C and D which are the least permeable or most impervious) are not ideal for septic systems to begin with and may present some challenges to replacing systems as they may not exhibit acceptable percolation rates (NRCS 2009). In such cases, above ground systems may be needed. More work is needed to assess the condition of these septic systems and to determine the extent 319 implementation funds (and other funding sources) that may be able to help assess, repair, replace and/or tie-in (to existing collection systems) these septic systems given that most of the septic systems are located within MS4. This will require a considerable amount of coordination between Berkeley County's Stormwater, Berkeley County Water and Sewer and CWS, but such an effort would help address both the goals of the 319 program and MS4 regulation. As previously discussed, there will also have to be some public education component to reach homeowners/businesses with failing septic systems which the Berkeley County Soil and Water Conservation District may be able to help with.

c. Wastewater NPDES and other SCDHEC Regulated Permits

As has been previously mentioned, there are relatively few SCDHEC regulated permits within the two watersheds (figure 21) and no wastewater discharges directly into Bushy Park Reservoir and its tributaries (Back River and Foster Creek). The only two NPDES permits (besides the previously covered MS4) were general NPDES permits for JW Aluminum (permit SCG250105 to west) and Cooper River Partners (Lanxess Corporation SCG646018 to southeast) which are shown on figure 21. The latter is for screened materials from their raw water intake. There is some potential for infrequent Sanitary Sewer Overflows (SSO), but water quality monitoring shows these to be infrequent and they are communicated in the rare instances that they occur. And though there is some potential for NPDES wastewater discharges in the upper portion of the West Branch of the Cooper River, the previously shared Durham Canal water quality data shows that these sources have historically not been major contributors to the dissolved oxygen impairment in Bushy Park. This could change as urbanization forces these wastewater plants to expand their treatment capacities.

- Century Aluminum of SC "land applications-provisional" permit ND0082805
- NPDES discharge from CRP for the backwash from the raw water intake they have near our intake
- NPDES permit for JW Aluminum Company
- Lower Berkeley County WW Plant - Discharges into the Cooper River rather than Bushy Park, but could have some minor impacts due to stormwater runoff from their plant into the Back River Watershed.

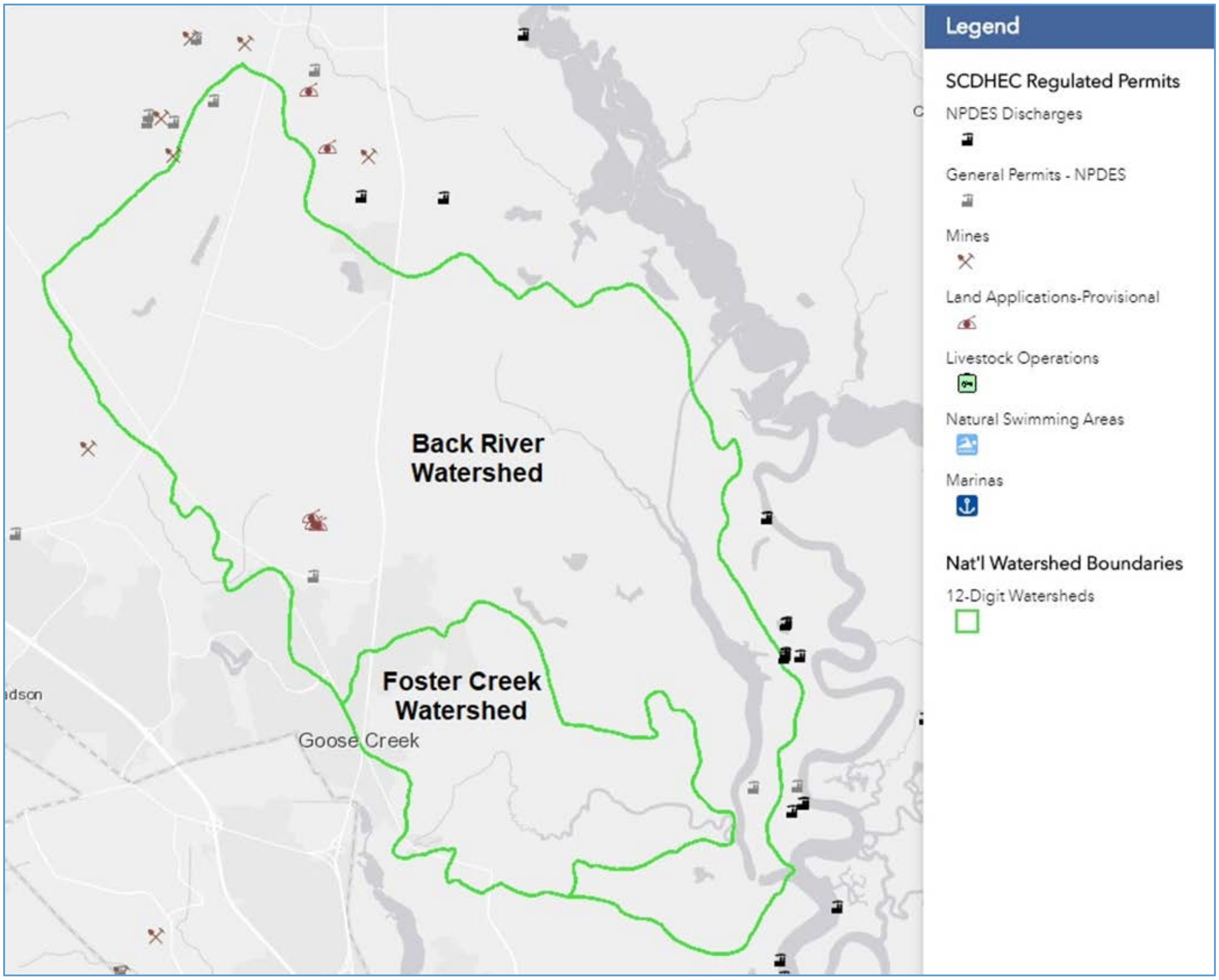


Figure 21. SCDHEC Permits within the two Watersheds

d. Construction - Neighborhoods and Road Projects

The Berkeley County Stormwater Department has a relatively new, but well-supported stormwater program which includes inspections of new construction activities. Whenever CWS visited active construction sites in neighborhoods under construction, silt fencing and other erosion control measures were always in place. The newer neighborhoods also had what appeared to be sufficient stormwater retention measures including a mix of wet and dry ponds. In addition, many of the stormwater ditches between these newer neighborhoods and Foster Creek along Henry Brown Boulevard and Liberty Hall Road have been upgraded during road projects over the past few years (figure 22).

Figure 22. Improved Drainage Between New Neighborhood and Foster Creek

Given the constantly changing nature of residential construction, we found it hard to accurately calculate all of the loads due to the rate of change on each property. Several neighborhoods were under construction and the sites had to be visited to determine current land cover since the neighborhood foot prints had changed drastically since the last aerial images and many of the neighborhoods were only partially shown or completely missing from the latest 2016 NLCD. The point of this section is to highlight that within a watershed undergoing significant population growth, there are likely ongoing infrastructure projects like these that certainly represent temporary loads to the watershed even though the loads may be harder to quantify.

e. **Hydromodification:**

There had been some erosion present at the dam and parking lot area at the south end of the reservoir made worse by damages received during recent tropical storm events. In 2019, Berkeley County made considerable riprap improvements (figure 23) and plans to repave the parking lot in the near future. Due to this recent work, this area likely no longer represents an erosion problem and therefore doesn't likely warrant any additional BMPs in the near future.

Figure 23. New Riprap to Bushy Park Reservoir Dam and Boat Landing

f. **Recreational Boating:**

There are three boat landings servicing Bushy Park Reservoir and its tributaries. Some of these landings lack restroom facilities or have minimal trash receptacles. Therefore, littering and use of the nearby woods as restrooms has been a problem as is evident by the amount of toilet paper within these areas.

g. **Historical Pollutants:**

"Natural Loading" from organic matter within the wetland marshes was referenced in the harbor TMDL, though this was not quantified. It is also likely that some organic matter buildup within Foster Creek occurred prior to the wastewater discharges being consolidated and moved to the Cooper River in the mid-1980's. However, this would not explain the drastically lower dissolved oxygen measurements seen in the Back River Tributary.

3. Estimated Loads Tables (Element 2)

Table 17. Total of Nonpoint Source Pollutant Load Identified in this WBP

Total Watershed Pollutant Loads (Using CWS Reported Watershed Size and CWS Determined Urban Breakdown)				
N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)	Fecal Coliform Load (counts/yr)
114427	24686	443394	2251	1.23E+14

*This is the total of the stormwater loads (table 18) and estimated failing septic system loads (table 22).

Table 18. Total Stormwater Runoff Loads

Watershed	SCDHEC Reported Size (Acres)	CWS Reported Size (Acres)	Urban Acres (%)	Total Stormwater Loads				
				N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)	Fecal Coliform Load
Foster Creek Watershed	9370	9181	37.34%	32345	6263	130353	701	2.52E+13
Back River Watershed	39813	39195	23.76%	74533	15467	282219	1550	9.18E+13
Both Watersheds	49183	48376	26.33%	106878	21730	412572	2251	1.17E+14

*This is the total of the urban, pastureland and forest stormwater runoff loads. The individual components of stormwater are shown in tables 19-21.

Table 19. Urban Runoff

Watershed	CWS Reported Size (Acres)	Urban Stormwater Loads				
		N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)	Fecal Coliform Load (counts/yr)
Foster Creek Watershed	9181	29628	4914	123604	674	1.59E+13
Back River Watershed	39195	63547	10096	254758	1452	4.33E+13
Both Watersheds	48376	93175	15009	378362	2126	5.92E+13

Table 20. Pastureland Runoff

Watershed	CWS Reported Size (Acres)	Pastureland Stormwater Loads				
		N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)	Fecal Coliform Load (counts/yr)
Foster Creek Watershed	9181	0	0	0	0	0.00E+00
Back River Watershed	39195	204	16	660	1	1.43E+11
Both Watersheds	48376	204	16	660	1	1.43E+11

Table 21. Forest Runoff

Watershed	CWS Reported Size (Acres)	Forest Stormwater Loads				
		N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)	Fecal Coliform Load (counts/yr)
Foster Creek Watershed	9181	2717	1349	6750	27	9.32E+12
Back River Watershed	39195	10782	5356	26801	97	4.84E+13
Both Watersheds	48376	13500	6704	33551	124	5.77E+13

Table 22. Septic System Loads in Watersheds (Assuming 20% Failure Rate)

Watershed	Approx. Septic Systems	Septic System Loads				
		N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)	Fecal Coliform Load (counts/yr)
Foster Creek Watershed	57	354	139	1447	0	2.76E+11
Back River Watershed	1157	7194	2818	29375	0	5.59E+12
Both Watersheds	1214	7548	2956	30822	0	5.87E+12

4. Best Management Practices (Element 3)

Due to the fact that Charleston Water System owns very little of the land around Bushy Park Reservoir and in the two watersheds covered in this WBP, CWS is heavily reliant on the other stakeholders within the watershed (who either own land or have jurisdiction) to support the WBP and be open to the implementation of BMPs. Therefore, the potential BMPs able to be implemented are heavily dependent on the amount of collaboration received and the reasonable scope of the BMPs. There are a wide variety of BMPs other than the ones listed that could help improve water quality and that may yet be the subject of future revisions of this WBP. The following link has an exhaustive list of BMPs for reference.

http://southatlanticalliance.org/wp-content/uploads/2013/12/GSAA-CoastWaterQualityBMPs_October2015.pdf

If all of the best management practices below were implemented, table 23 summarizes what the modeled load reductions could be. The fecal load reductions are likely underestimated and thus are likely closer to the nutrient and BOD reductions. Averaging all of the load reductions yields about a 14% average reduction in load with implementation of the following BMPs/LIDs and includes eventually addressing all of the estimated failing septic systems.

Table 23. Total Load Reductions

Nonpoint Source Pollutant Loads and Load Reductions	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)	Fecal Coliform Load (counts/yr)
Total Watershed Pollutant Loads	114427	24686	443394	2251	1.23E+14
Load Reductions from BMPs	16302	4610	49877	431	5.87E+12
Percent Load Reduction	14.25%	18.67%	11.25%	19.16%	4.78%

BMP 1: Public Education

The public education component is perhaps the most important part of the watershed-based plan since it not only seeks to education the public about the connection between water quality, stormwater management and their potential role in mitigation pollution, but it is also a critical component of many of the implementable BMPs. Section 6 outlines the public education plan in more detail and to the extent there is a public education component within the specific BMPs, it is discussed with those BMPs. Costs associated with public education include print materials for mailers/flyers, public meeting materials, etc. The amount of 319 funding received will determine the amount of the watershed able to be reached. If insufficient funds are able to be gathered between 319 funding and stakeholder budgets, a more targeted communication strategy will be employed giving priority to the public education components specific to the implementation of BMPs and for the residents/business at the headwaters of the Foster Creek and Back River Tributary.

BMP 2: Pet Waste Collection Sites

A good example of combining public education and a potential BMP is in the case of implementing pet waste collection stations. The stations can include signs which highlight the importance of proper disposal of pet waste, but also allow the means to accomplish this. These stations could be implemented in parks and even common areas within neighborhoods if the HOA will agree to their placement and will help maintain them. There are approximately 20 neighborhoods at the headwaters of Foster Creek and the Back River Tributary that would benefit from pet waste collection locations. At an estimated cost of $250 each for signage, materials and coordination efforts, the total cost would likely be about $5,000.

BMP 3: Septic Systems

The first step for the septic system would be to perform condition assessments along with feasibility for replacement verses tie in to the wastewater collection system. Based on preliminary conversations with Berkeley County staff, it is likely replacement (rather than tie-ins) will be the primary mode for addressing poorly performing septic systems. Septic system installers and pump out companies may be able to help identify failed septic systems as they are likely to be servicing such systems on a regular basis. A component of the assessment will be utilizing public outreach to find failing systems. The highest concentration of older septic systems is in the Whitesville area (figure 24) along Highway 17A in the northwest portion of the Back River Watershed which will allow a more focused/targeted public outreach effort in this area specific to septic system replacement. The public outreach component relating to septic systems will likely involve a combination of targeted mailers/flyers, door hangers and community meetings within the neighborhoods where there are higher densities of older septic systems. If an active HOA or civic association is present, that may also provide another opportunity for outreach. SCDHEC may be able to help with communication as they are responsible for inspections and permitting.

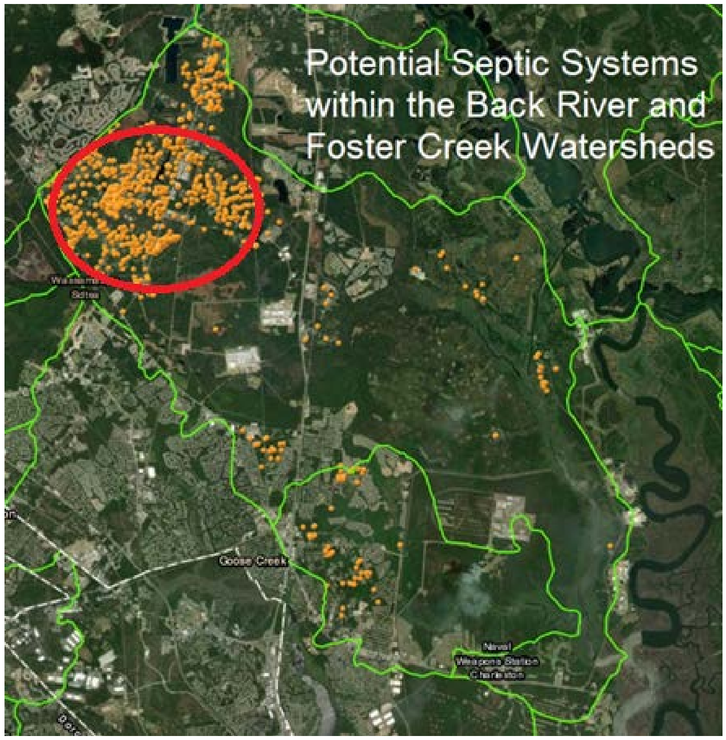


Figure 24. Septic Systems in Whitesville Area

Based on a 20% failure rate, up to 243 of the 1,214 septic systems could be failing (table 24). A better estimate of the failure rates (and thus total loads) will be determined after more assessment work, but we would like to target addressing 10% (or ~ 24) of the estimated 243 failing systems (~24) within three years thus resulting in a 10% reduction in loads from the failing septic systems (table 25). For every additional 24 septic systems fixed, a similar additional load reduction would be likely. We will plan to continue to address all of the estimated failing septic systems as long as funding (budgets and 319 implementation grants) and septic system owner participation allows.

Sources	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)	Fecal Coliform Load (counts/yr)
Septic	7548	2956	30822	0	5.87E+12

Table 24. Total Septic System Loads

N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)	Fecal Coliform Load (counts/yr)
746	292	3047	0	6.E+11

Table 25. Septic System Load Reduction for 24 Repaired Systems

At an estimated cost of $5000 per system, the estimated cost to replace 24 systems is approximately $120,000. These costs are anticipated to be covered by a combination 319 Grants, Berkeley County Stormwater and the residents needing new systems. The Berkeley County Soil and Water Conservation District has also tentatively offered to cover the cost of the first septic system in 2021 to serve as a success story to help with community messaging as we look illicit further participation in the replacement program. This combination of funding should help subsidize septic system repairs/replacements for residents interested in repairing their system, but that may lack the funds to do so. It is also possible that a table of funding levels could be established based off on income to make sure that those least able to contribute get the greatest funding levels as was done with Horry Counties program.

BMP 4: Stormwater Retention and Retrofits to Older Neighborhoods

The MenRiv neighborhood (figure 25) on the Joint Base Charleston – Weapons Station is one example of an older neighborhood which could have stormwater load reductions (and further flood control) with the addition of stormwater retention ponds, swales, etc. Unlike many of the older neighborhoods that lack adequate undeveloped areas, there may be several undeveloped areas within the neighborhood to implement further stormwater retention BMPs/LIDs. However, any additional stormwater BMPs would likely require extensive planning to weigh costs, benefits and feasibility. The modeled loads and load reductions from a few possible BMPs/LIDs are covered below (table 26) and include wet ponds, wetland detention, grass swales and rain barrels. There are many other BMPs/LIDs worth considering and even the addition of rain barrels could lead to worthwhile load reductions such as dry detention facilities, infiltration trenches, bioretention, underground detention, level spreaders and riparian buffers.

Figure 25 - MenRiv Neighborhood

MenRiv Neighorhood	Total Acres	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)	BMP Type	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)
	405	2694	462	11597	61	Wet Ponds	822	192	0	32
						Wetland Detention	470	188	6727	41
						Infiltration Swales	1175	278	0	48
						LID - Rain Barrels	94	17	427	2

Table 26 - MenRiv Neighborhood Load Reductions

BMP 5: Stormwater Retention Retrofit to Salvage Yard or Other Industrial Areas

The Blue and Gold Salvage Yard is an example of an existing industrial area that could be considered for further stormwater retention especially given the high percentage of impervious surfaces and potential loads. Additional BMPs/LIDs may not only reduce nutrients and sediment, but may also help mitigate many other pollutants possible from salvage yards. Figure 26 and table 27 highlight the loads and a few examples of BMPs/LIDs with potential load reductions.

Figure 26 - Blue and Gold Salvage Yard

Salvage Yard	Total Acres	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)	BMP Type	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)
	315	3809	381	17712	71	Wet Ponds	1333	171	0	43
						LID - Infiltration Swales	1905	248	0	64
						LID - Cistern & Rain Barrels	533	53	2480	10
						Wetland Detention	762	168	11159	55

Table 27 - Blue and Gold Salvage Yard Loads and Potential Reductions

There are several other industrial areas within the watersheds that appear to be good candidates for further stormwater retention given that existing stormwater retention may not be adequate for modern stormwater standards and that open space is present around the industrial areas. The addition of stormwater wet ponds to all of the industrial areas could add up to a significant load reduction (table 28).

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	E. coli Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	E. coli Reduction
	lb/year	lb/year	lb/year	t/year	Billion MPN/y	lb/year	lb/year	lb/year	t/year	Billion MPN/ye
Foster Creek	32699.6	6401.3	131800.6	700.8	0.0	548.5	112.8	0.0	22.6	0.0
Back River	81727.1	18285.0	311593.6	1549.7	0.0	4445.8	914.6	0.0	182.9	0.0

Table 28. Wet Pond Load Reductions from Industrial Areas

BMP 6: Rain Barrels Program and/or Cisterns

Berkeley County Stormwater already participates in a rain barrel sales program with the Clemson Extension through their partnership with the Carolina Clear Program which holds annual events for rain barrel sales. Similarly, they also provide a stormwater utility fee credit for cisterns on non-residential parcels. Charleston Water System has asked Berkeley County to be included in future events and we will add rain barrels as a topic of our community outreach within the entire watershed, including on the Joint Base Charleston - Weapons Station.

Though it may seem like trivial load reductions to add a combination of cisterns and rain barrels to residential areas, the addition of these low impact development practices to even 10% of the residential areas could result in a 6.5% capture volume and the following load reductions (table 29).

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	E. coli Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	E. coli Reduction
	lb/year	lb/year	lb/year	t/year	Billion MPN/y	lb/year	lb/year	lb/year	t/year	Billion MPN/ye
Foster Creek	32699.6	6401.3	131800.6	700.8	0.0	127.9	23.3	581.4	2.9	0.0
Back River	81727.1	18285.0	311593.6	1549.7	0.0	211.1	38.4	959.3	4.8	0.0

Table 29. Rain Barrel and Cistern Load Reductions

BMP 7: MS4 Storm Water Management and Related Public Education

As previously mentioned, there are three applicable MS4 covering a significant portion of the two watersheds. Within the last decade, Berkeley County developed and implemented a new stormwater program covering two of the three applicable MS4 (Berkeley County 2018). An innovative component of their stormwater program is that BMP implementation is incentivized by allowing for some stormwater impact fee reduction if applicable BMP or LID measures are implemented. The stormwater impact fee savings can be significant for larger properties. The program is new, but it is hoped more entities will take advantage of this incentive over the coming years as Berkeley County gets the message out about this incentive.

A more collaborative public education campaign led by local stakeholders (CWS, Berkeley County Stormwater, Joint Base Charleston – Weapons Station and the Berkeley County Soil and Water Conservation District) will help bolster the efforts by all the MS4 and will help communicate the connection between urbanization, stormwater, surface water quality and drinking water quality to residents. This public education component is covered in BMP #1 and outlined in Section 6 and will likely serve as a means to increase awareness of the stormwater impact fee reduction incentive program as a side point to the many other watershed topics covered.

The county maintains a website where much of the information can be found including the specifics and history of the ordinance.

Ordinance: https://www.berkeleycountysc.gov/drupal/dept/engineering/storm/links

History: https://www.berkeleycountysc.gov/drupal/dept/engineering/storm

- 2006 SCDHEC issued NPDES General Permits for Stormwater discharges from regulated small municipal separate storm sewer systems (MS4) which Berkeley County is.
- 2008 Berkeley County was granted permission to discharge stormwater to receiving waters in the state from its regulated area subject to the permit requirements
- 2014 The current permit became effective replacing the 2006 permit.
- 2014 The Stormwater Utility Ordinance was adopted
- 2015 the County entered into an intergovernmental agreement with the city of Goose Creek (and Hanahan), obligating the County to manage the municipal MS4s and making the cities subject to the County's stormwater ordinances and manual.
- 2018 The Stormwater Utility Ordinance was amended to establish the permanent fee rate structure.

It is important to point out that there are some BMPs that may not be fundable through the 319 program because they may already be part of, and required within, existing MS4 management programs. However, there are many general urban retrofits like pervious pavement, underground retention, bio-retention treatment trains, some water quality inlets, etc. that may still be fundable. this does not negate the importance of collaboration with all of the stakeholders inside and outside of the MS4 to realize water quality objectives. This is particularly the case when public educational materials and messaging will inevitably overlap.

BMP 8: Joint Base Charleston - Weapons Station Silviculture BMPs

The following BMPs may help supplement current management activities on the Joint Base Charleston:

- Gravel/ROC addition to muddy road beds
- The addition of drainage elements like culverts or repairing existing culverts
- Improved gates to further limit heavy vehicle access which further degrades access roads

BMP 9: Horse Stables and Pasture

More work is needed to assess the potential for BMPs (and their reductions) at the stables. We would propose working with the Charleston NRCS representative to determine pollution sources, applicable BMPs and then assess the load reductions possible. An example of a simple BMP would be the use of a buffer with optimal grazing to minimize soil erosion and animal waste runoff. Table 30 shows the potential reductions for nutrients alone, though significant sediment and fecal coliform reductions are likely. Other possible BMPs include filter strips, covered waste storage/bins, composing, and rotating grazing areas.

N Reduction	P Reduction	BOD Reduction	Sediment Reduction	E. coli Reduction
lb/year	lb/year	lb/year	t/year	Billion MPN/ye
73.2	9.9	0.0	0.0	0.0

Table 30. Pastureland Buffer Load Reductions

BMP 10: Restrooms and Refuse Collection at all Boat Landings

Even if the restroom facilities were just porta lets as have been done at other boat landings across the Lowcountry, the presence of these facilities would help discourage the use of the surround wooded area to satisfy these purposes. The porta lets and refuse collection would also help reduce the amount of litter on these sites. Due to the landings each being owned by different entities, more work is needed to elicit the appropriate support and approval to accomplish this BMP.

BMP 11: Porous/Pervious Pavements

Most residents have seen industrial areas and are familiar with the large amounts of impervious concrete surfaces common in these areas. However, many do not realize that even residential and commercial areas contribute significantly to the amount of impervious surfaces by the many concrete and asphalt driveways, roads and parking lots that make up the transportation infrastructure. If just 10% of the parking lot, road and driveway surfaces were converted to porous pavement it could result in the following load reductions (table 31).

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	E. coli Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	E. coli Reduction
	lb/year	lb/year	lb/year	t/year	Billion MPN/y	lb/year	lb/year	lb/year	t/year	Billion MPN/ye
Foster Creek	32699.6	6401.3	131800.6	700.8	0.0	664.6	72.0	0.0	15.9	0.0
Back River	81727.1	18285.0	311593.6	1549.7	0.0	1127.1	116.2	0.0	26.3	0.0

Table 31. Pervious Pavements Load Reductions

BMP 12: Constructed Wetland and Swales

Given the relatively small grades of the surrounding area around Bushy Park and within the two watersheds, there are likely opportunities to construct wetlands and swales to help slow and absorb drainage. Swales in particular can be used in applications when there are relatively little open space available for BMPs or LIDs. There was a considerable amount of open area within the two watersheds, especially around the Back River Watershed, where swales could be implemented. With swales mitigating runoff from these open spaces, the following load reductions could be realized (table 32).

N Reduction	P Reduction	BOD Reduction	Sediment Reduction
lb/year	lb/year	lb/year	t/year
141.5	35.4	1132.1	21.5
653.0	163.3	5224.0	99.0

Table 32. Swale Load Reductions

Other BMPs for Consideration

- **Land Conservation and Protective Easements -** Due to the runoff impact of any land development compared to the natural landscape, protective conservation easements are perhaps some of the strongest measures to protect water quality for the long-term. As previously discussed under the section, Land Use, there are several parcels already under protective easements. However, we would like to continue to work with the land owners to explore putting more parcels under protective easements or at least determine a collaborative mechanism ensure development of these parcels take into account the overall goals of the TMDL, this WBP and CWS's overall source water protection goals.
- **Stream Restoration and Riparian Buffers –** Though there were no obvious areas where stream erosion was taking place from our research, there are likely ditches or banks in need of riprap or riparian vegetation.
- **Rain Gardens –** Rain gardens are great in that they can be small enough for many residents to utilize and may also complement larger greenspaces such as parks or even be present on larger commercial and industrial properties as retrofits.

5. Funding and Technical Assistance for Implementation (Element 4)

Many of the same supporting and collaborating stakeholders who helped CWS with the development of this plan would be instrumental to the implementing the necessary BMPs. And in fact, most of these entities have already been active within the watershed in addressing nonpoint source pollution via management of their own Stormwater MS4 permits and/or have components of their budgets devoted to supporting public education and NPS BMPs. CWS, Berkeley County Stormwater and the Berkeley Soil and Water Conservation District all have budget components dedicated to public outreach and Joint Base Charleston – Weapons Station has previously budgeted money for silviculture erosion projects. The development of this plan has served to expand our understanding of the sources of pollution within the watershed and more importantly ways all of the stakeholders can work together to mitigate through additional BMPs. It is our hope that this plan will help focus efforts and bolster budgets to make BMP implementation more feasible and increase the effectiveness of these efforts. Table 23 shows some of the BMP projects and potential 319 grant requests, although the total amount needed for any given project and the 319 implementation funds potentially requested will be more accurately determined during future implementation grant requests. The preliminary implementation plan includes seeking funding for public outreach, septic system replacement, silviculture erosion BMPs and rain barrels. It is possible the Bushy Park Collaborative Committee will determine other 319 implementation opportunities and the plan will be updated accordingly.

Proposed 319 BMP Implementation Funding					
BMP	**Best Management Practice**	**Description**	**Year**	**Total**	**319 Grant(s)**
1	Public Education	Print Materials and Signage	2021	$80,000	$40,000
2	Pet Waste Collection Sites	Signage and Material	2021	$5,000	$2,500
3	Septic System Replacements	Construction Costs	2022-2023	$120,000	$72,000
4	MenRiv Neighborhood Retrofits	Construction Costs	2025	TBD	TBD
5	Blue and Gold Salvage Yard Retrofits	Construction Costs	2025	TBD	TBD
6	Rain Barrel Program	Rain Barrel Supplies	2023	$10,000	$5,000
7	Storm Water Management within MS4	Coordinated Public Outreach	NA	NA	NA
8	JBC Forestry Road Improvements	Labor and Materials	2022	$100,000	$50,000
9	JBC Horse Stable BMPs	Construction Costs	2023	TBD	TBD
10	Restrooms and Refuse at Boat Landings	Materials and Construction	2023	TBD	TBD
11	Porous/Pervious Pavements in Parking lots	Construction Costs	2026	TBD	TBD
12	Constructed Wetland and Swales for Open Spaces	Construction Costs	2026	TBD	TBD

Table 33. Implementation Funding

More investigation is needed to determine the benefits, feasibility and cost of some of the larger retrofit BMP projects. This is especially the case with stormwater retention BMPs that may be possible on some sites with little to no current stormwater BMPs. Most of these efforts will require extensive collaboration with the perspective county, stormwater staff and land owners and thus the details will need to be worked out in order to arrive at the level of detail needed to apply for implementation funding.

Though water quality monitoring has not traditionally been reimbursable or funded through the 319 program, EPA (and SCHDEC) should consider these efforts as eligible at some point in the future as they are certainly a crucial component for utilities and any stakeholder to successfully develop and implement a successful WBP, let alone monitoring and measuring progress to determine the effectiveness of implemented BMPs and the success of the overall plan. This is especially the case given the lack of continuous data sets from state and federal partners. Without incentivizing and enabling a monitoring component, these plans will continue to be much more qualitative than quantitative endeavors by design.

6. Education and Outreach Strategy (Element 5)

CWS has already updated the CWS website to include information on this grant process and public education talking points and has approached several stakeholders within the watershed with a shared interest in increased collaboration around public education efforts. The existing efforts would likely benefit from a more collaborative approach given the overlapping messages and connection between urbanization, stormwater, surface water and drinking water. Public education to targeted audiences within the two watersheds would be a critical element to help residents understand their potential role to mitigate pollution (pet waste, avoid/minimize fertilizers, herbicides and pesticides, proper disposal of trash and chemicals, etc.) and improve source water quality. Each of these efforts would benefit from additional 319 implementation funding given the size of the watersheds and the number of residents/business within them. Some of the other BMPs (rain barrels, septic systems, etc.) will also have public education componenents that can be incorporated into this plan. Several public education efforts between CWS and the other stakeholders within the watersheds would be needed and could include:

- Flyers/Mailers by CWS with the residents/businesses CWS serves within the Foster Creek Watershed
- Flyers/Mailers by Berkeley County to the residents it serves within the two watersheds (depending on the number of mailers and budget constraints, it may be necessary to do more targeted mailers given the size of the watershed)
- Home Owner and Civic Associations will be targeted either through their social media pages or via presentations at their meetings with an emphasis on neighborhoods at the headwaters of Foster Creek and Back River (table 13) or those communities most likely to have failing septic systems.
- Several public community meetings throughout Berkeley County coordinated by CWS, the Berkeley Soil and Water Conservation District and Berkeley County Stormwater. The public meetings may be delayed due to covid-19 restrictions.
- CWS has spoken at several schools in the Charleston area and CWS may be able to do similar presentationssimilarly also be an effective way to teach kids about the water cycle, the wider implications of our footprint and environmental stewardship within Berkeley County
- Collaboration with the Joint Base Charleston - Weapons Station team on public outreach on the base
- Increased signage in green spaces and parks to remind those using these areas what they can do to improve water quality
- CWS continues to support the efforts of the Ashley Cooper Stormwater Education Consortium which is currently implementing a stormwater outreach strategy through 2023 (ACSEC 2018)
- CWS also participates in stakeholder processes within the basin and across the state as opportunities present themselves. These committees/councils not only help CWS continue to be at the forefront of collaborative efforts across the state, but also provide an avenue for CWS to encourage other stakeholders to utilize watershed planning through programs like EPA’s 319 program. In fact, the first annual workshop held by the recently established SCAWWA Source Water Protection Committee in 2019 largely focused on the 319 program, SCDHEC resources that support this program, and Watershed-Based Planning efforts across the state.
  - Edisto and Santee River Basin Council
  - Drought Committee
  - Harmful Algae Bloom Taskforce
  - SC AWWA Source Water Protection Committee
- CWS has already developed a list of potential stakeholders within the basin willing to consider BMP implementation as part of the development of this WBP. However, more land owners may need to be approached, and further BMP projects considered, to accomplish the overall goals of the WBP and thus further modifications of this plan may be needed. As this list of willing stakeholders grows, and BMPs are implemented, it will be crucial CWS continue to support these stakeholders in their efforts where possible. This may include helping to respond to RFP for 319 Implementation Funding, research and collaborative public outreach.

7. Timeline of Implementation and Milestones (Elements 6 and 7)

2021

- **Develop coordinated public outreach strategy (BMP #1, 2, 3, 6 and 7) and possibly apply for implementation funding in support of the plan** – CWS, Berkeley County, the Berkeley Soil and Water Conservation District, and Joint Base Charleston staff to develop and begin implementing a five year (2021-2026) coordinated and collaborative public outreach strategy around the connection between urbanization, stormwater, surface water quality and drinking water quality and supporting the implementation of BMPs (septic system replacement, pet waste collection sites, rain barrel program, etc.).
- **Apply for implementation funds for pet waste collection sites** – A minimum of 20 potential locations have already been identified.
- **Public Outreach for, and Assessment of, Septic Systems (BMP #1 and #3)** - Berkeley County Stormwater, the Berkeley County Soil and Water Conservation District, and CWS to reach out to the older neighborhoods and communities most likely to contain the highest density of failing septic systems to develop a preliminary list of candidates for septic system replacement and in order to assess the septic system failure rate and therefore the number of systems in need of repair/replacement in preparation for applying for a 319 implementation grant in 2022 or 2023.

2022

- **Implementation of the public outreach strategy (BMP #1 Continued) –** timeline details to be added based on strategy developed in 2021, but these are likely to be focused on septic system replacement and the previously listed neighborhoods at the headwaters of Foster Creek and Back River (table 13) through mailers and literature/presentations to the HOA for those neighborhoods.
- **Submit RFP septic systems replacement (BMP #3 continued)** - CWS, Berkeley County Stormwater and the Berkeley County Soil and Water Conservation District to apply for 319 implementation funds for septic system replacement of approximately 24 septic systems during 2022 and possibly into 2023.
- **Submit RFP JBC silviculture (BMP #8)** - JBC staff (with help of CWS as needed) to apply for 319 implementation funds to match the Joint Base Charleston - Weapons budgeted funds for road improvement, culvert drainage and access control for the forested land.

2023

- **Implementation of the public outreach strategy to include rain barrels (BMP #1 and 6) –** timeline details to be added based on strategy developed in 2021, but likely to begin including messaging around rain barrels
- **Horse stables assessment on Joint Base Charleston (BMP #9) -** CWS to work with JBC staff and NRCS staff to determine if BMPs are needed at the horse stables and what those BMPs might be. Once done, either 319 or other funding may be needed and the implementation timeline will be updated to include any applicable BMPs and implementation grant requests if needed.
- **Implement restrooms and refuse collection at boat landings –** Depends on approvals and support, but this is the target date for accomplishing this.

2024

- **Implementation of the public outreach strategy (BMP #1 Continued) –** timeline details to be added based on strategy developed in 2021.
- **Reassess further septic system replacements (BMP #3 Continued)** - Continue working with Berkeley County on addressing septic systems based:
    - the findings of the 2021 assessment work
    - the number of remaining failing septic systems
    - the success of the first septic system grant initiative in 2022 & 2023

2025

- **Implementation of the public outreach strategy (BMP #1 Continued) –** timeline details to be added based on strategy developed in 2021.
- **Inventory potential stormwater retrofits (BMP #4 and 5) -** Work with Berkeley County Stormwater and Joint Base Charleston staff to assess further opportunities for nonpoint source BMP implementation especially on properties constructed before modern stormwater best management practices. Two possible parcels include the large salvage yard and older MenRiv neighborhood.
- **Visit new properties to inventory new BMPs to add to the WBP (BMP #11 and 12) -** Meet with other properties (Medway Plantation, other silviculture properties, commercial and or industrial sites, etc.) within the watershed to determine further opportunities for BMP implementation.
- **Implementation of the public outreach strategy (BMP #1 Continued) –** timeline details to be added based on strategy developed in 2021.

2026

- **Perform a follow-up assessment of the collaborative public outreach strategy developed in 2021** - to determine if the goals were met and what gaps may still exist.
- **Compile the water quality data and reassess water quality trends** - to determine if water quality objectives in respect to the impaired parameter (dissolved oxygen) and related parameters (total phosphorus and total nitrogen) are being met (sustained, improving, worsening, etc.).
- **Revise the WBP and potential BMPs not yet implement or new BMPs opportunities discovered (BMP #11 and 12)**- We are hoping to find stakeholders willing to implement swales and porous/pervious pavements before 2026 and swales may be a more feasible retrofit for older neighborhoods, industrial and commercial sites (BMP #4 and 5) when adequate land is available. This implementable will be based on:
    - updated water quality data assessment
    - any new BMP projects identified over the last five years
    - any remaining projects not yet implemented

8. Load Reduction Evaluation Criteria (Element 8)

It is important that any evaluation criteria be based on those accepted and established by SCDHEC (which are generally based on the recommendations of EPA) given the potential expensive of implementing BMPs and monitoring water quality even with the potential help of implementation grants such as that from the 319 program. It is also important to keep in mind parameters which may be related, or even correlative to the impaired parameter, especially when the related parameters have been shown to directly impact the impaired parameter. Such is the case with nutrients which lead to and exacerbate eutrophication and decreased dissolved oxygen. For this reason, the evaluation criteria we suggest include both dissolved oxygen and nutrients (total phosphorus and total nitrogen). SCDHEC outlines water quality standards for various water classifications in regulation 61-68 (SCDHEC 2014). According to regulation 61-69 (SCDHEC 2012), Back River (or Bushy Park Reservoir and its tributaries) are classified as FW (fresh water) waters with specific dissolved oxygen and nutrient criteria.

Dissolved Oxygen

The dissolved oxygen criteria for FW waters:

- a daily average of not less than 5.0 mg/L
- with a low (or minimum) of 4.0 mg/L

Nutrients

The nutrient criteria for FW waters:

- Total Phosphorus not to exceed 0.09 mg/L
- Total Nitrogen not to exceed 1.5 mg/L

The dissolved oxygen criteria are currently not met at various points within the main body of the reservoir or its tributaries hence the impaired status in regard to dissolved oxygen. The important role of nutrient control to dissolved oxygen (eutrophication) is complicated, but well established, and the role of nutrients in feeding aquatic weed, algae and cyanobacteria is obvious. Ideally the development of this plan in combination with efforts by the applicable MS4 would help to prevent further deterioration of the dissolved oxygen condition and may eventually lead to the reservoir being delisted as impaired in regard to dissolved oxygen and help mitigate the need for substantial increased treatment costs at the drinking water plant.

CWS will utilize the latest 2013-2015 USGS study dissolved oxygen and nutrient data as a baseline for current water quality conditions as of the formation of this WBP. If water quality conditions (measured by CWS and/or SCDEHC) in respect to dissolved oxygen and nutrients (total phosphorus and total nitrogen) trend toward further degradation compared to the levels established in the USGS study, all sources of pollution (point and nonpoint) will need to be re-examined more closely and further BMPs potentially implemented.

9. Monitoring Strategy (Element 9)

Dissolved oxygen (impaired parameter) and nutrients (total phosphorus and total nitrogen) will need to be monitored to assess the overall trend in water quality (EPA 2016). SCDHEC publishes a monitoring strategy for the state of SC that covers as much monitoring as current funding allows (SCDHEC 2019). Since the three SCDHEC monitoring sites within Bushy Park Reservoir are not currently supported and since it is unlikely that data from just these three sites could adequately paint a clear picture of water quality conditions across the entire reservoir and its tributaries, the routine reservoir water quality monitoring performed by CWS will be a crucial component of the monitoring strategy for Bushy Park. The frequency of reservoir testing is dependent on staffing, but generally occurs every other month or more frequently as needed.

The reservoir monitoring utilizes a calibrated YSI ProDSS sensor for many of the parameters with the remaining analysis being performed in the CWS central laboratory. The following water quality parameters are currently monitored:

<u>YSI ProDSS Sensor</u>

- temperature
- dissolved oxygen
- specific conductivity
- pH
- chlorophyll-A
- phycocyanin
- secchi disk

<u>CWS Central Laboratory</u>

- turbidity
- color
- TOC
- MIB
- geosmin

However, CWS is also considering the addition of total phosphorus and total nitrogen to this routine testing, but doing so will depend upon budget approval and economic conditions during subsequent years since the samples will likely need to be outsourced to a contract lab. It will be hard to determine the trajectory of water quality within the reservoir in regard to the dissolved oxygen impairment and to assess the success of BMP implementation by either the WBP or MS4 in the absence regular nutrient monitoring. Bacterial sampling may also be added especially during field investigations of ditches to better understand the specific overland sources of runoff pollution (pet waste, septic systems, etc.). And finally, CWS is developing a plan to install water quality sonde units at several points in the reservoir.

10. Conclusion

Providing safe drinking water begins with the source and we felt the development of this watershed-based for the Back River and Foster Creek watersheds was a critical component of our source water protection plan as a means for identifying nonpoint source pollution and identifying and funding the mitigating of these sources in collaboration with the major stakeholders within the two watersheds. Through much collaboration with the staff at SCDHEC, Joint Base Charleston – Weapons Station, Berkeley County Stormwater and Berkeley Soil and Water Conservation District, we have arrived at a plan that identifies a variety of significant pollution sources and a suite of best management practices to address them collaboratively over the coming years. And now with the development of this plan, all stakeholders within the watershed should be eligible to apply for future 319 implementation funding. Charleston Water also looks forward to working with these partners to develop a more coordinated and collaborative public outreach strategy around the connection between urbanization, stormwater, surface water quality and drinking water quality. It is possible significant load reductions can be realized from the implementation of this plan and we hope these load reductions (especially in regard to nutrients) will not only lead to improvement in the dissolved oxygen conditions within the tributaries and main body of the reservoir, but also lead to better control of aquatic weed, algae and cyanobacteria and their byproducts. Continued reservoir monitoring will not only shed light on the effectiveness of future implemented BMPs, but also whether additional BMPs need to be implemented. It is inevitable as development continues, that new source of pollution may arise. In such cases, this plan can be updated to include the new sources, potential BMPs and the stakeholders willing to implement them.

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