Smith Branch Watershed Management Plan

EPA Required Element Addendum

February 20, 2017

Introduction

The City of Columbia, South Carolina, operates a Phase 1 Municipal Separate Storm Sewer System (MS4) regulated by the National Pollutant Discharge Elimination System (NPDES) and administered by the South Carolina Department of Health and Environmental Control (SCDHEC). The City maintains compliance with the associated permit requirements to reduce pollutant loads to receiving waters to the maximum extent practicable (MEP) via the elements enacted in its Stormwater Management Plan (SWMP). Additionally, to further the overall goal of improving water quality within waterways and for downstream users, the City is resolved to implement projects likely to achieve that aim. The Smith Branch subwatershed is located almost completely within the city corporate limits. Smith Branch has an SCDHEC established Total Maximum Daily Load (TMDL) for fecal coliform and is on the SCDHEC 303(d) list of impaired waters for aquatic life/macroinvertebrates. The City is considering various approaches to reduce general nonpoint source pollution (NPS), including stream restoration, bank and gully stabilization, stream buffer planting, best management practice (BMP) retrofits, low impact development (LID), and green infrastructure projects. Many of these potential water quality improvement projects were identified in the *Smith Branch Watershed Assessment* completed for the City by McCormick Taylor in May 2016.

Smith Branch consists of 15.7 miles of open stream channel and its watershed encompasses over seven square miles. The watershed lies mostly within the northern portion of the City but also includes portions of the downtown. The watershed is highly urbanized and has an overall imperviousness of 37%, with most of the development predating stormwater control regulations. Smith Branch is the most downstream tributary included in the Lower Broad River TMDL for fecal coliform, and has been on the SCDHEC 303(d) list of impaired waters for aquatic life/macroinvertebrates continuously since its original listing in 1998. The SCDHEC water quality monitoring (WQM) station B-280 is located on Smith Branch at North Main Street in Columbia. The City maintains two additional WQM stations on the stream. Smith Branch converges with the Broad River at the upper end of the Columbia Canal, approximately 12,000 feet above the water supply intake for most of the City.

The *Smith Branch Watershed Assessment* provided a detailed and comprehensive evaluation of conditions within the stream and factors within the watershed affecting water quality. The assessment also identified 141 potential restoration projects that would improve water infiltration and storage, and improve water quality within the watershed. The City is working with stakeholders to evaluate these projects and others in an effort to prioritize them according to potential effectiveness as well as access, cost, and logistic feasibility. This document will build on the *Smith Branch Watershed Assessment* to incorporate SCDHEC and Environmental Protection Agency (EPA) guidelines for a watershed based plan in order to provide a strong framework to achieve pollutant load reduction and address water quality impairments in Smith Branch. This Watershed Based Plan will aid the City in identifying and implementing projects, beyond the requirements of the MS4 Permit, aimed at addressing the impairments and reduction goal for fecal coliform specified in the Lower Broad River TMDL. Additionally, this plan will serve as a guide towards the City's objective of improving overall water quality and quantity issues within the watershed. These objectives include reducing flooding, runoff, and erosion, improving the biological condition of the stream and habitat for wildlife within the riparian corridor, and increasing awareness and connectedness of the community to Smith Branch by improving habitat and recreational opportunities along the stream. Implementation of projects such as those described in this Plan will improve opportunities for watershed based education and outreach.

The EPA has identified nine key elements that are critical for achieving improvements in water quality. These elements are addressed to varying degrees in the *Smith Branch Watershed Assessment* and are more fully addressed in this document.

1. Pollutant Source Assessment

As noted in the TMDL, the Smith Branch watershed is highly urbanized, with 81% of land area described as urban, 15% as forest, and 2% as row crops at the at the time of its publication in 2005. The more recent land use analysis by McCormick Taylor summarized in Table 6.1 of the *Smith Branch Watershed Assessment* identifies 87% of the watershed as urban, and only 12% as forested, herbaceous, scrub – shrub, or woody wetlands. Only 1% of the watershed was identified as under cultivation for crops or hay/pasture. Data and narrative from the *Smith Branch Watershed Assessment* indicate that Smith Branch exhibits chemical, physical, and biological effects typical of highly urbanized streams.

Fecal Coliform

The presence of fecal coliform in aquatic environments indicates that water is contaminated with human or animal fecal material. The Lower Broad River TMDL states that 32 of 36 (89%) of water samples collected at WQM Station B-280 between 1998 and 2002 exceeded the 400 colony forming unit (cfu) / 100 ml SCDHEC water quality standard. The Lower Broad River TMDL identifies several potential sources for fecal coliform in Smith Branch.

The Smith Branch watershed contains no active NPDES permitted wastewater treatment plant (WWTP) point sources that discharge fecal coliform. The TMDL does not mention sanitary sewer overflows (SSO's) as a significant contributor to fecal coliform contamination within the Smith Branch watershed and SSO occurrences have declined steadily from 45 in the 2008-2009 fiscal year to 13 in the 2014-2015 fiscal year according to City data. Various non-point sources contribute to loading of fecal coliform and other pollutants in Smith Branch, either directly or through stormwater discharge pipes from the City's MS4. The Lower Broad River TMDL identified a relationship between precipitation and higher fecal coliform concentrations at Smith Branch WQM Station B-280, suggesting that various non-point sources may be significant contributors of fecal coliform but also found exceedances during dry weather conditions, suggesting other sources. The TMDL states that a combination of MS4 point sources, failing onsite wastewater systems (OSWD) systems, leaking sewers, pets, and wildlife are the most likely sources of fecal coliform within the watershed.

The Lower Broad River TMDL estimates a population density of 15 to 30 deer per square mile within the Smith Branch watershed. A study by Yagow (1999) showed a fecal coliform production rate for deer of 347×10^{6} colony forming units (cfu)/head-day, creating a total potential fecal coliform load of 5.76×10^{10} cfu/day from deer within the watershed. Other potentially significant wildlife contributors to fecal coliform within the watershed include feral hogs, raccoons, opossums, beaver, squirrels, rabbits, rats and other small mammals, and various bird species. No population estimates were available for these wildlife species within the watershed.

The Lower Broad River TMDL estimates 612 total, or 17.1 OSWD, primarily septic systems, per 100 acres within the Smith Branch watershed. Improperly designed, constructed, or maintained septic systems can deliver nutrients and harmful fecal bacteria to nearby streams via surface and subsurface routes. The TMDL cites studies that estimate that areas with greater than 6.25 OSWD per 100 acres can be considered to have potential contamination problems, which suggests that septic systems may be a significant contributor to fecal coliform load in Smith Branch. Using the estimate of 17.1 OSWD per 100 acres the total annual fecal coliform load from septic systems within the watershed is approximately 1.95×10^{13} cfu *(load calculation based on StepL septic input page, 2, from Septic tab in WCS per Horsley and Whitten 1999*).

The Lower Broad River TMDL did not identify any populations of livestock, or any agricultural fields with manure applications which might be sources of fecal coliform within the Smith Branch watershed, however domestic pets, and dogs in particular, may be significant contributors of fecal coliform within the watershed. According to 2010 census tract data there are approximately 21,400 people occupying 5,865 households within the Smith Branch watershed. The American Veterinary Medical Association (AVMA) market research survey data for 2012 found a national average of 0.584 dogs per household, which indicates there are approximately 3,425 dogs residing within the watershed. Calculations made using SCDHEC provided Standards Engineering Practices data show that total daily production of fecal coliform from dogs within the watershed is approximately 1.4×10^{13} cfu, or 5.1×10^{15} cfu annually. Assuming a 20 percent loading rate to the stream (SCDHEC provided "Pet Waste Formulas" worksheet) the potential bacteria load to Smith Branch from dogs is approximately 1.0×10^{15} cfu annually. No estimates for waste load or fecal coliform production were available for cats or other pets but these may also be notable contributors within the watershed.

The *Smith Branch Watershed Assessment* identified six suspected unauthorized trash dump sites along the stream. Trash can introduce a variety of pollutants to a waterway. These may include bacteria if the trash includes food or fecal waste.

Urban Runoff and Stormwater Conveyance Systems

Numerous studies indicate that the amount of impervious cover in a watershed may directly affect water quality, stream flow, stream channel morphology, and instream habitat (Schueler, et. al. 2003). These studies indicate that stream quality generally declines when watershed impervious cover exceeds 10% and becomes severe when impervious cover exceeds 25%. Overall impervious cover within Smith Branch is 37%, and subwatersheds within Smith Branch contain up to 59% impervious cover. Only one of the 13 subwatersheds identified in the *Smith Branch Watershed Assessment* had less than 10% impervious cover and only three had less than 25%. Fecal coliform and a wide variety of urban non-point source pollutants may be conveyed via impervious surfaces to storm drain systems that discharge to Smith Branch and its tributaries. Additionally, high levels of impervious cover may result in increased runoff volume and peak discharge, as well as increased frequency and duration of peak discharge which result in significant physical effects on the stream system.

Aquatic Life Impairment

Smith Branch is on the SCDHEC 303(d) list as impaired for aquatic life use support due to degradation of the compositional and functional integrity of the benthic macroinvertebrate community. A variety of possible stressors have been identified that can contribute to a paucity of macroinvertebrate numbers and taxa in aquatic ecosystems. These stressors affect water quality, habitat, or both, and include high or low pH, low dissolved oxygen (DO), heavy metals, toxic organics (herbicides, pesticides, other) temperature, sediment, nutrients, and flow.

Potential stressors were evaluated for likelihood of impairment to macroinvertebrates and other aquatic biota in Smith Branch and placed in one of the following three categories:

> **Least Probable Stressors**: Potential stressors with no apparent impact in Smith Branch according to data and observations, and data indicates no or very few SCDHEC water quality exceedances.
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> **Possible Stressors**: Potential stressors with data or observations suggesting the possibility of negative impacts to macroinvertebrates and other aquatic biota, or with insufficient data but instream, riparian, or watershed conditions suggesting the possibility of a direct link to aquatic life impairment.
>
> **Most Probable Stressors**: Potential stressors with conclusive data or observations linking them to impairment of macroinvertebrate and aquatic life populations and species diversity.

Least Probable Stressors: PH, Dissolved Oxygen, Temperature

Macroinvertebrates require a suitable range of pH in order to thrive, which is reflected in SCDHEC's standards requirements for a pH range of 6.0 to 8.5. SCDHEC has not determined pH excursions to be a problem at water quality sampling site B-280 in Smith Branch, and in almost two years of monitoring data at 15 minute intervals the City has found very few sample measurements deviating from this range in either of its two water quality monitoring stations.

Low dissolved oxygen levels within a stream can result in anoxic sediment conditions that adversely affect most macroinvertebrate species. SCDHEC sample readings reported from the EPA Storage and Retrieval Data Warehouse (STORET) and almost all readings from the City's two monitoring stations are well above the SCDHEC minimum standard of 4.0 mg/L. Excessive nutrient loads in water can stimulate growth of phytoplankton, filamentous algae or cyanobacteria which can lead to eutrophication and subsequent low dissolved oxygen levels. SCDHEC does not have standards for nutrients in streams but the *Smith Branch Watershed Assessment* did not find significant evidence of eutrophication within the stream.

Stream temperature increase is a typical response to increased development and impervious surface area within a watershed due to water flow over streets, parking lots, and other dark, solar energy absorbing hard surfaces, due to decreased stream shading from riparian vegetation, and due to general increased temperatures in highly urban areas. While it is likely that there has been some temperature increase within Smith Branch in comparison with historic conditions, monitoring by SCDHEC and the City shows that stream temperature has not exceeded the state standard of 90 degrees Fahrenheit.

Possible Stressors: Metals, Oil and Grease, Other Chemicals

The potential for a wide variety of chemical contaminants with varying levels of toxicity to enter the stream from stormwater runoff and other sources is concomitant with the highly urban nature of the Smith Branch watershed. Among these pollutants are oils, greases and metals from roadways and other sources, herbicides and pesticides from landscape maintenance, and volatile organic compounds and various other chemicals from industrial areas, gas stations, and railroad tracks. Little or no monitoring is conducted for these pollutants with the exception of metals including cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, and zinc which have been measured by SCDHEC at Station B-280 on Smith Branch. Concentrations of these metals did not violate SCDHEC water quality standards at the time of sampling. The City and other governmental organizations conduct inspections of industrial sites and monitor for spills and releases of toxic chemicals throughout Columbia, but the potential still exists for some undetected stream inputs due to the diverse uses of the highly urbanized watershed.

Most Probable Stressors: Flow, Sediment, Habitat Alteration

High levels of imperviousness within a watershed, inadequate forested stream buffer, and stream channel alterations such as bridges, culverts, and channelization will drastically alter stream flow conditions, riparian and instream habitat, and erosion and sediment transport, all of which can be detrimental to macroinvertebrate populations. The *Smith Branch Watershed Assessment* found overall imperviousness within the watershed to be approximately 37%, significantly greater than the 25% threshold for severe stream quality degradation indicated by many studies (Schueler 2003). It is well documented that streams with highly impervious watersheds exhibit “flashy” streamflow responses to precipitation, with higher and more rapid peak discharge and a greater total runoff volume than those in undeveloped watersheds. Additionally, streams in highly impervious watersheds exhibit increased magnitude, frequency, and duration of bankfull flows and decreased base flow. These flow alterations cause changes to stream channel morphology over time. Typical responses to these altered flows are an enlargement of the cross sectional area of the stream through channel incision and widening, and a resultant disconnection of the stream from its floodplain. Flow alterations due to highly impervious watersheds negatively impact stream habitat for macroinvertebrates by reducing stream habitat diversity and structure and decreasing channel roughness and sinuosity.

The process of channel enlargement from increased flows during precipitation events causes increased erosion of bed and bank material which increases sediment load in the stream. Increased stream sediment has a detrimental effect on macroinvertebrate habitat, feeding, and respiration. Studies have also shown a link between turbidity, TSS and fecal coliform (Irvine, et al 2009, Mallin, et al. 2009). The *Smith Branch Watershed Assessment* identified 27,565 linear feet of stream bank erosion within the stream network. Data from the City's two water quality monitoring stations on Smith Branch indicate that turbidity, a measure of suspended solids in the water, is often elevated during storm events.

Loss of riparian vegetation can also increase erosion and stream sedimentation and decrease the amount of cover, including large woody debris (LWD). LWD provides macroinvertebrate habitat directly and indirectly by redirecting flows to produce more complex instream habitat. The *Smith Branch Watershed Assessment* identified 52,593 linear feet of inadequate forested buffer. Macroinvertebrate monitoring data from SCDHEC at the Smith Branch monitoring station described instream macroinvertebrate habitat as poor, with low amounts of rootpacks, leafpacks, woody debris and few aquatic plants. Sedimentation scores varied from moderate to severe in different years of monitoring.

Bridges and culverts can alter stream flow, causing pooling and scour if unable to accomodate increased flows from a largely impervious watershed. These alterations can impact stream habitat and sediment transport by causing localized stream channel bed and bank erosion, or localized sediment deposition. Channelization of a stream with concrete lining impedes natural stream processes and conditions that provide varied habitat and cover for macroinvertebrates, and impedes aquatic plant growth and stream interaction with groundwater and natural streambed substrate, which together can alter stream flow, habitat, water chemistry, and stream productivity in ways that may adversely impact aquatic macroinvertebrates. Extensive piping of streams common in older urbanized environments effectively eliminates habitat for most aquatic species, including macroinvertebrates. Much of the Smith Branch watershed was developed decades ago and these manmade features are common within the stream network.

Figure 1. Eroded streambank in Earlewood Park

2. Estimated Load Reductions

This watershed plan includes consideration of stream restoration and bank stabilization projects, stream buffer planting, stormwater management construction and retrofit projects, and a variety of Green Infrastructure / LID projects. The Spreadsheet Tool for Estimating Pollutant Load (STEPL) was used to estimate pollutant load reductions for some of the pollutant reduction projects likely to be implemented within the watershed. STEPL results show that restoration of a typical severely eroded section of gully and associated streambanks within the Earlewood Park initial project phase area would reduce nitrogen load by 0.5 pounds, phosphorus by 0.2 pounds, and biochemical oxygen demand by 1.0 pounds per year per linear foot, while sediment load would be reduced by 0.4 tons per year per linear foot. Approximately 200 linear feet of severely eroded and 550 linear feet of moderately eroded streambanks were identified within Earlewood Park. 27,565 linear feet of eroded streambank were identified throughout the Smith Branch watershed.

1. Gully dimensions in the different watersheds

Watershed	Gully	Top Width (ft)	Bottom Width (ft)	Depth (ft)	Length (ft)	Years to Form	BMP Efficiency (0-1)	Soil Textural Class	Soil Dry Weight (ton/ft3)	Nutrient Correction Factor	Annual Load (ton)	Load Reduction (ton)
W1	Gully1	12	3	8	1	75	0.95	Sandy clay	0.045	0.85	0.0360	0.0342

2. Impaired streambank dimensions in the different watersheds

Watershed	Strm Bank	Length (ft)	Height (ft)	Lateral Recession	Rate Range (ft/yr)	Rate (ft/yr)	BMP Efficiency (0-1)	Soil Textural Class	Soil Dry Weight (ton/ft3)	Nutrient Correction Factor	Annual Load (ton)	Load Reduction (ton)
W1	Bank1	1	8	3. Severe	0.3 - 0.5	0.4	0.95	Sands, Loamy sands	0.055	0.85	0.1760	0.1672
W1	Bank2	1	8	3. Severe	0.3 - 0.5	0.4	0.95	Sands, Loamy sands	0.055	0.85	0.1760	0.1672

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)	%N Reduction	%P Reduction	%BOD Reduction	%Sed Reduction
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	%	%	%	%
W1	104.4	18.5	460.8	2.8	0.5	0.2	1.0	0.4	103.9	18.4	459.8	2.4	0.5	1.0	0.2	13.4
Total	104.4	18.5	460.8	2.8	0.5	0.2	1.0	0.4	103.9	18.4	459.8	2.4	0.5	1.0	0.2	13.4

Table 1. STEPL input and load reduction output for typical severely eroded section of gully and streambank in Earlewood Park.

The STEPL model was used to calculate pollutant removal efficiencies for a buffer/filter strip in degraded riparian areas within an urban setting similar to that within and surrounding Earlewood Park. Model results show that buffer replacement along 300 linear feet of stream with 10 acres of runoff area would reduce nitrogen load by 13.9 pounds, phosphorus by 2.4 pounds, and biochemical oxygen demand by 67.3 pounds per year. Sediment load would be reduced by 0.6 tons per year. Approximately 1000 linear feet of degraded riparian buffer were identified within Earlewood Park and 52,593 linear feet of degraded stream buffer were identified throughout the Smith Branch watershed.

2. Urban landuse distribution

Landuse	Commerci	Industrial	Institutiona	Transporta	Multi-Fami	Single-Family	Urban-Cul	Vacant (de	Open Space
W1	0	0	0	0	0	5	0	0	5

3. Selected urban BMPs

Landuse	Commerci	Industrial	Institutiona	Transporta	Multi-Fami	Single-Family	Urban-Cul	Vacant (de	Open Space
W1	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	Vegetated Filter Strips	0 No BMP	0 No BMP	Vegetated Filter Strips

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)	%N Reduction	%P Reduction	%BOD Reduction	%Sed Reduction
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	%	%	%	%
W1	34.7	5.2	133.3	0.8	13.9	2.4	67.3	0.6	20.8	2.9	66.0	0.2	40.0	45.3	50.5	73.0
Total	34.7	5.2	133.3	0.8	13.9	2.4	67.3	0.6	20.8	2.9	66.0	0.2	40.0	45.3	50.5	73.0

Table 2. STEPL input and load reduction output for vegetated filter strips with 10 acre runoff area in Earlewood Park.

SCDHEC provided standard numbers for pollutant load by land use (From Shaver, et al., 2007) provided an estimated load of 3.76 x 10^{10} bacteria per year for a 10 acre low density residential area. A literature review (Appendix A) conducted to determine bacteria removal efficiencies for the BMP's used in the STEPL analysis was used to calculate load reductions for each BMP scenario. Buffer restoration would reduce bacteria load by an average of 32.7%, or 1.23 x 10^{10} annually.

The STEPL model was also used to calculate pollutant removal efficiencies for bioretention and constructed wetland BMP's in a 10 acre urban subwatershed with land use representative of that on the north side of Earlewood Park adjacent North Main Street. Model results show that wetland detention for this runoff area would reduce nitrogen load by 23.1 pounds, phosphorus by 3.1 pounds, and biochemical oxygen demand by 147.4 pounds per year. Sediment load would be reduced by 0.9 tons per year. Bioretention for this area would reduce nitrogen load by 10.7 pounds and phosphorus by 5.8

pounds per year. Bioretention in this subwatershed would reduce sediment load by 58%, or 0.6 tons per year according to the *National Pollutant Removal Performance Database* and the *International Stormwater Best Management Practices (BMP) Database*.

2. Urban landuse distribution

Landuse	Commercial	Industrial	Institutiona	Transporta	Multi-Fami	Single-Family	Urban-Cult	Vacant (de	Open Space
W1	2.5	0	0	0	0	5	0	0	2.5
W2	2.5	0	0	0	0	5	0	0	2.5

3. Selected urban BMPs

Landuse	Commercial	Industrial	Institutiona	Transporta	Multi-Fami	Single-Family	Urban-Cult	Vacant (de	Open Space
W1	Wetland Detention	0 No BMP	0 No BMP	0 No BMP	0 No BMP	Wetland Detention	0 No BMP	0 No BMP	Wetland Detention
W2	LID/Bioretention	0 No BMP	0 No BMP	0 No BMP	0 No BMP	LID/Bioretention	0 No BMP	0 No BMP	LID/Bioretention

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)	%N Reduction	%P Reduction	%BOD Reduction	%Sed Reduction
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	%	%	%	%
W1	53.6	7.1	234.0	1.1	10.7	3.1	147.4	0.9	42.9	4.0	86.6	0.3	20.0	44.0	63.0	77.5
W2	53.6	7.1	234.0	1.1	23.1	5.8	0.0	0.0	30.6	1.4	234.0	1.1	43.0	81.0	0.0	0.0
Total	107.2	14.3	468.1	2.2	33.8	8.9	147.4	0.9	73.5	5.3	320.6	1.4	31.5	62.5	31.5	38.8

Table 3. STEPL input and load reduction output for wetland detention and bioretention with 10 acre runoff area in Earlewood Park.

Literature review indicated that a stormwater wetland would reduce bacteria from a 10 acre low density residential runoff area by 79.3%, or by 2.98×10^{10} annually, and that a bioretention area would reduce bacteria by 64.5%, or by 2.43×10^{10} annually.

3. Pollutant Management Measures

The City has or is in process of developing a variety of regulations, incentives, and public outreach efforts designed to protect water quality and quantity impacts to Smith Branch and other waterways. Existing regulations prohibit direct inputs of trash, oils and greases, and harmful chemicals to stormwater and waterways. Other regulations control water quality and quantity impacts to the City's waterways from construction projects and a water quality buffer ordinance provides water quality and baseflow benefit to jurisdictional streams and wetlands. The *City of Columbia Best Management Practice (BMP) Design Manual* describes citywide planning and design requirements that control rate and volume of runoff and pollutant release from construction sites, as well as more stringent requirements for flood problem areas, impaired waters and waters with TMDL's, and critical water bodies, including the Smith Branch watershed. The City encourages nonstructural stormwater management which is detailed in the *Stormwater Better Site Design* section of the BMP manual. And the City's stormwater utility fee encourages developers of commercial, industrial, and multi-family housing units to minimize impervious area on their properties. The City is in process of identifying Special Protection Areas within each of its watersheds, which will have additional requirements and incentives for increased stormwater management, and is developing details for utility fee credits in order to further encourage better stormwater management practices and stormwater related education.

The City maintains a robust program aimed at reducing sources of harmful bacteria to its waters. These include requirements for hook up to the City's sanitary sewer system to remove septic systems within the City, educational outreach and oil and grease recycling to prevent SSO's, and ordinances and storm drain marking to prevent trash dumping in waterways and storm drains. The City provides covered trash and recycling bins to all residents to prevent bacteria from entering stormwater from residents trash and debris. The City's "Trash The Poop" program is designed to reduce bacterial loading to its waterways from pet waste sources. The program provides education and outreach through signage and various area media outlets describing the importance of proper disposal of pet waste. The program also provides free pet waste stations to interested groups that meet requirements for pledged maintenance and usage. Some proposed watershed improvement projects identified by the City will reduce bacterial loads to Smith Branch directly, while others will provide increased visibility of signage and other education and public involvement efforts to reduce local water quality degradation. An LID proposed for the first phase of watershed improvement projects to be implemented will intercept stormwater runoff from a popular dog park in Earlewood Park and signage placed nearby will provide an excellent opportunity to provide education to the public on the relationship between pet waste and water quality. The City has a pet waste ordinance to allow for enforcement of proper pet waste disposal.

Table 8.1 of the *Smith Branch Watershed Assessment* describes 141 watershed improvement projects, and the City has identified several others within the watershed. These include stream restoration and bank stabilization projects, stream buffer planting, stormwater management construction and retrofit projects, and a variety of Green Infrastructure / LID projects. The City evaluated these projects with stakeholders for feasibility, efficacy, and eligibility for Section 319 grant funding. Factors considered in this evaluation included subwatershed ranking in the *Smith Branch Watershed Assessment*, property ownership, cost, logistical constraints, and likelihood of long term water quality improvement. Projects within City property were determined to be most favorable for an initial project phase. The City and stakeholders identified a number of projects within Earlewood Park that would significantly decrease pollutant loads to Smith Branch from sources within the park. Some of these projects include stream bank stabilization and stream restoration on an unnamed tributary to Smith Branch exhibiting severe erosion, riparian buffer planting along sparsely vegetated streamside areas in the park, construction of bioretention or other green infrastructure projects to treat stormwater runoff from the dog park near Smith Branch, limiting stream access points and mulching steep hillsides in areas of high recreational use near streams and rerouting portions of dirt or gravel paths and maintenance roads near park waterways. The high visibility of projects constructed within Earlewood Park offer excellent opportunities for outreach and education (described below) that are expected to build public support for water quality improvement projects throughout the watershed. As construction of projects in Earlewood Park proceeds, the City will work with partners to evaluate and prioritize future water quality improvement projects according to the same criteria.

4. Identification of funding and technical assistance needs as well as potential sources

Funding Sources

The City of Columbia enacted legislation in 2003 which established a Stormwater Utility and associated fees. Stormwater Utility Fees are used to fund operations and maintenance of storm drainage structures/conveyances, stormwater Capital Improvement Projects (CIP), and personnel costs. The stormwater CIP budget is anticipated to be the source of City funding for completion of projects under this Plan. Based on current Stormwater Utility revenues, and expected costs of completing projects under this Plan, the City should be well positioned to provide at least the minimum required matching funds for grant-funded projects.

Technical assistance

The City Stormwater Management Program is housed in the City's Engineering Department, which employs engineering and scientific personnel capable of providing in-house technical support for projects. The City would likely procure a consultant to design, and a contractor to construct, projects under this Plan. Selected consultants and contractors would provide specialized experience in addition to that of City personnel. Based on in-house and contract personnel to be assigned to these projects, the City will have high level of technical expertise available for these projects.

5. Outreach Strategy

The first projects to be implemented per this watershed management plan are expected to be constructed in the City's Earlewood Park, which offers numerous opportunities for public engagement and education. Earlewood Park is one of the City's most heavily used parks, with a nationally-ranked Frisbee golf course, amphitheater, playground, nature trail, baseball and softball field, basketball and tennis courts, a dog park, and a new community center. Each of these amenities offers an opportunity for public education.

Educational Workshops

Throughout the course of the project, City stormwater staff will offer workshops to both professionals and residents to discuss erosion control. These workshops will break down issues with erosion and the impacts it can have on surrounding landscapes. Attendees will also learn appropriate steps to take when dealing with erosion, including appropriate landscaping practices and managing run-off. Workshops will also address non-point source pollution and mitigation for improved water quality. The City stormwater department will partner with the City's Department of Parks and Recreation to publicize the workshops.

Topics to be covered with residents and professionals will include:

- Rain gardens
- Planting native plants
- Stream and pond buffers
- Stormwater BMPs
- Watershed planning

Local schools and community groups could also benefit from workshops on water quality in the Smith Branch watershed system. The City stormwater staff will work with partner organizations and the City's Department of Parks and Recreation to host activities for kids in the summer camp program at the Park. They will also work with local school groups to use Earlewood Park and the project area as part of the Columbia River Rangers educational outreach program. Sustainable Midlands, who teaches the program on behalf of the City, will use the stream as a teaching location for lessons on riparian habitats and water quality.

Topics to be covered with school groups will include:

- What is a watershed?
- Riparian habitats
- Non-point source pollution (sources and impacts)
- Water quality monitoring (hands-on water sampling and educational activities)
- BMPs for storm water (high school level engineering)
- Erosion and erosion controls (high school level engineering)

Signage

The first phase project area is expected to be located within Earlewood Park and include Smith Branch and its tributaries. The stream has several crossings as part of the Park's nature trail and Frisbee golf course. You must also cross the stream to access the basketball and tennis courts and the main travel artery through the park crosses the project area twice. The nature of the stream's placement gives us the opportunity for educational kiosks and signage throughout the project area.

Educational signage on the foot paths that cross the stream can address water quality, erosion, and erosion control, as well as landscaping features and native plants. Messaging about water pollution and run-off will be targeted toward pet owners who frequent the park and can reinforce messaging already in place throughout the City of Columbia. Erosion and erosion control will be addressed and will offer information that homeowners can use, including landscaping practices that can minimize erosion and suggestions for native plants that can help maintain hills and banks on their property.

Signage will also be placed along the roadway where it crosses both Smith Branch and the base of the tributary stream. Because these signs will be viewed by residents driving through, they will contain short messaging that identifies the stream and encourages residents to help prevent pollution.

Community Meetings
The City's stormwater staff will work with the Earlewood Community Citizen's Organization (ECCO) to plan a workshop for the surrounding community. The workshop will include

- An outline of the project and its impacts on park use
- Discussion of erosion and erosion controls
- Water quality issues and goals
- Community impact and involvement
- Community education opportunities

City staff will also keep ECCO up to date on the project by attending neighborhood association meetings as needed once the project moves forward.

6. Timeline of Implementation Events

Project Activity	**Time Frame (Quarters)**											
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
Implement monitoring plan, project outreach and education												
Earlewood Park Restoration / BMP Project 1												
Project 1 design												
Request for proposal / Project 1 construction												
Work with stakeholders to determine second Earlewood Park project												
Earlewood Park Restoration / BMP Project 2												
Project 2 design												
Request for proposal / Project 2 construction												
Evaluation of Project 1 implementation and water quality results												
Work with stakeholders to determine third Earlewood Park project												
Earlewood Park Restoration / BMP Project 3												
Project 3 design												
Request for proposal / Project 3 construction												
Evaluation of Project 2 implementation and water quality results												
Work with stakeholders to evaluate potential for projects outside of Earlewood Park												

7. Milestones

The City will provide management through at least the initial phase of projects implemented under this watershed management plan. Management will include oversight of project planning, design, and construction with quarterly reporting of progress toward project milestones. Milestones for individual projects may include measurements such as percentage completion, linear feet of stream restoration / bank stabilization completed, or acres of buffer planting. Milestones for grouped smaller projects may include percentage completion or number of LID's implemented.

Evaluation of milestones for outreach and education will also be reported. Measurements of implementation of education and outreach may include numbers of number of new pet waste stations installed, number of pet waste bags used, amount of cooking oil collected at the City's recycling facilities, number of SSO's, number of rain barrels distributed and installed, number of signs installed, number of storm drains marked within the watershed, and numbers of attendees at meetings and events.

8. Pollutant Reduction Criteria

The City will use monitoring data to determine pollution reduction progress of projects within Smith Branch watershed. Smith Branch has fecal coliformand biological impairments within the watershed. The City will use data before, during and after a project's completion to evaluate the progress of pollution reduction. Monitoring will include TSS and bacterial sampling. The City will also use continuous monitoring sondes that already exist within Smith Branch to evaluate pollution reduction. Pollution reduction targets will be evaluated based on TSS and bacterial sampling. Individual projects completed within Smith Branch watershed will be assessed based on the pollution reduction progress of those specific interim targets.

9. Monitoring Strategy

The City currently has two continuous monitoring locations on Smith Branch. One is located in Earlewood Park near North Main Street. The second location is located just east of the intersection of Clement Road and Mountain Drive (See attached map). The sites were installed in June 2015 with YSI 6600 sondes. These sondes take a data point every fifteen minutes. Each station collects data for pH, turbidity, dissolved oxygen, specific conductivity, temperature, stage and rain fall. This continuous monitoring allows the City to see real time conditions of Smith Branch and analyze data trends.

The City will conduct bi-monthly grab samples for fecal coliform, total carbon, total phosphorus, and total nitrogen just downstream of the project above the confluence with Smith Branch, and in Smith Branch itself downstream from the project for projects directly on or adjacent to Smith Branch. Samples will be taken pre- and post-mitigation to evaluate the work completed. The City will also use current monitoring equipment (YSI 6600) to conduct weekly in stream monitoring for temperature, specific conductivity, pH, dissolved oxygen, and turbidity. Furthermore, the City will work with volunteer groups involved in the "Adopt A Stream" program to recommend monitoring stations below the project sites which can monitor invertebrate populations as well as other parameters. The City maintains a rain gauge in Earlewood Park and will analyze rain events and determine how the project work helped with water quality and quantity. Using these methods, the City will use multiple monitoring tools readily available to calculate the effectiveness of the project to water quality of the unnamed tributary that flows into Smith Branch.

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Appendix A

Literature Review of Bacteria Removal Efficiencies for Selected Best Management Practices

Paper	# studies	bacteria removal (%)	Bacteria removal x # studies	BMP	Type	Weighted ave efficiency
International Stormwater BMP Database 2012 addendum	3	61	183	Bioretention	ent	
International Stormwater BMP Database 2012 addendum	3	71	213	Bioretention	e coli	
International Stormwater BMP Database Summary Report 2014	3	61	183	Bioretention	ent	
International Stormwater BMP Database Summary Report 2014	4	65	260	Bioretention	e coli	
Total	**13**		**839**			**64.5**
International Stormwater BMP Database 2012 addendum	2	28	56	Buffer strip	fc	
EPA - Reducing Bacteria With BMP's	1	50	50	Buffer strip	bacteria	
Pennington et al.	1	37	37	Buffer strip	bacteria	
Rifai	18	32	576	Buffer strip	total bact	
Total	**22**		**719**			**32.7**
Birch et al.	1	76	76	Wetland	fc	
International Stormwater BMP Database 2012 addendum	3	19	57	Wetland	e coli	
International Stormwater BMP Database 2012 addendum	5	53	265	Wetland	fc	
International Stormwater BMP Database Summary Report 2014	4	61	244	Wetland	ent	
International Stormwater BMP Database Summary Report 2014	5	53	265	Wetland	e coli	
International Stormwater BMP Database Summary Report 2014	5	91	455	Wetland	fc	
National Pollutant Removal Performance Database, V3	40	78	3120	Wetland	bacteria	
Davies and Bavors	1	79	79	Wetland	fc	
Hathaway et al.	1	98	98	Wetland	fc	
Hathaway et al.	1	56	56	Wetland	fc	
Hathaway et al.	1	96	96	Wetland	e coli	
Hathaway et al.	1	33	33	Wetland	e coli	
Hathaway et al.	1	49	49	Wetland	ent	
Hathaway et al.	1	61	61	Wetland	ent	
Hathaway et al.	1	0	0	Wetland	e coli	
Hathaway et al.	1	45	45	Wetland	e coli	
Rifai	82	88	7216	Wetland	bacteria	
Total	**154**		**12215**			**79.3**