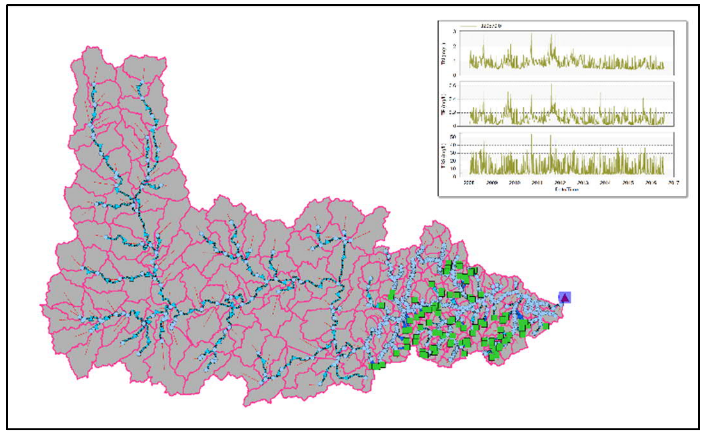

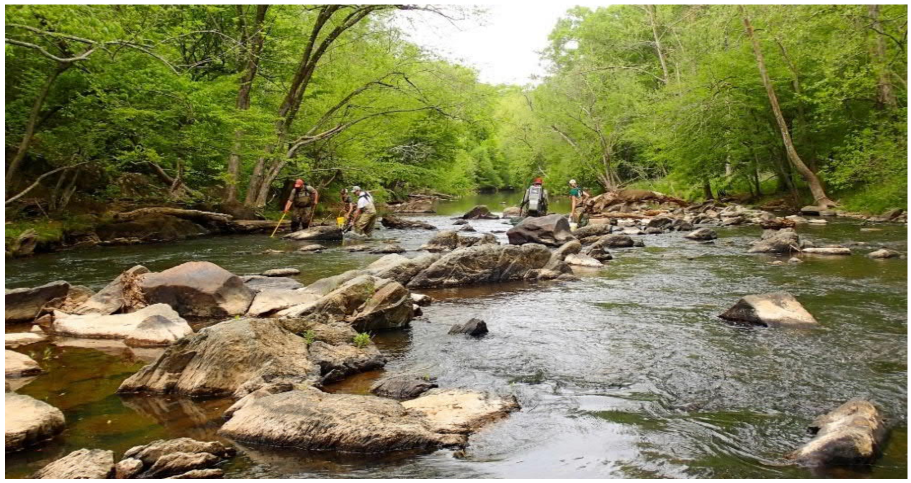

Volume I
Executive Summary

December 2018

Eno River Watershed Improvement Plan

Durham, North Carolina

PREPARED FOR:

CITY OF DURHAM

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Eno River Watershed Improvement Plan

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Acknowledgments

The Eno River Watershed Improvement Plan represents the combined effort of staff from the City of Durham, AECOM, Kimley Horn and Associates, and Three Oaks Engineering.

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Appendix

Tables

Acronyms and Abbreviations

CAPP............... Critical Area Protection Plan
City.................. City of Durham
GI .... Green Infrastructure
GIS................... Geographic Information Systems
LID................... low impact development
MS4 .... Municipal Separate Storm Sewer System
NCAC .... North Carolina Administrative Code
NCDEQ .... North Carolina Department of Environmental Quality
NCDOT .... North Carolina Department of Transportation
NCWRC .... North Carolina Wildlife Resources Commission
n.d. .... no date
NLCD.............. National Land Cover Database
NPDES .... National Pollutant Discharge Elimination System
NRCS.............. Natural Resources Conservation Service
PCSWMM..... Personal Computer Storm Water Management Model
PID .... Parcel Identification Number
RSAT............... Rapid Stream Assessment Technique
SCM .... stormwater control measure
TN.................... total nitrogen
TP..................... total phosphorus
UDO................ Unified Development Ordinance
UNRBA........... Upper Neuse River Basin Association
USACE............ U.S. Army Corps of Engineers
USEPA............ U.S. Environmental Protection Agency
WASP .... Water Quality Analysis Simulation Program
WIP .... Watershed Improvement Plan
WQI................. Water Quality Index
WS................... water supply

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1 Introduction

Clean water is essential for the health of human beings and the ecosystems that sustain wildlife, vegetation, and wetlands. To maintain clean water within its city limits, the City of Durham (City) has developed watershed plans to understand the condition of waterbodies and watersheds and to identify the most effective ways of protecting and improving water quality.

The watershed plans also allow the City to balance environmental, societal, and economic factors by integrating water quality protection and restoration with growth and land use development.

The City of Durham recently adopted the 2019-2021 Strategic Plan (City of Durham, 2018a) to achieve the City's mission to "make Durham a great place to live, work, and play" and its vision to "be a leader in providing an excellent and sustainable quality of life". The Strategic Plan contains five goals that provide the framework for implementing the Strategic Plan. This watershed improvement plan (WIP) aligns with goal #5 of the Strategic Plan, Sustainable Natural and Built Environment, and the objective to "Create a more Sustainable Durham". The WIP achieves this by supporting an increase in the amount of green infrastructure in the city, improving water quality through stormwater and land use best practices, and implementing and tracking progress of the City's Sustainability Roadmap (City of Durham, 2018b). The Sustainability Roadmap is derived from the Strategic Plan and establishes goals and measures to help Durham achieve its vision for sustainability.

Since initiating its watershed management program in 2007, the City has developed WIPs for the following watersheds:

- Ellerbe Creek (City of Durham, 2010)
- Third Fork Creek (City of Durham, 2012a)
- Northeast and Crooked Creek (City of Durham, 2013)
- Little Lick Creek (City of Durham, 2016)

The Eno River WIP continues the City's watershed program of protecting and restoring water quality.

1.1 Background

The Eno River watershed is in the Upper Neuse River Basin in central North Carolina. The watershed covers 151 square miles and spans portions of Durham and Orange Counties.

The Eno River is 33 miles long from its headwaters to its confluence with Little River. Approximately 22 miles are in Orange County and the remaining 11 miles are in Durham County. Major tributaries in the Durham County portion of the Eno River watershed are Cub Creek, Crooked Run Creek, and Warren Creek.

The study area for the WIP includes the portion of the watershed that is in Durham County and the city. The study area covers approximately 29 square miles (18,561 acres) and extends from the Durham County/Orange County boundary to the confluence of the Eno River with Little River. For the purposes of the WIP, the study area was divided into 53 subwatersheds.

All of the streams in the watershed, including the mainstem Eno River, are currently meeting their designated uses, and none are on North Carolina's list of impaired waters (NCDEQ, 2016). However, there are occasional occurrences of elevated turbidity and fecal coliform bacteria and evidence of eroded banks throughout the study area.

The Eno River flows into Falls Lake, an important source of drinking water for the City of Raleigh. Pollution from the Eno River watershed also reaches the lake. Portions of Falls Lake are listed as impaired for turbidity and chlorophyll a (NCDEQ, 2016), and Falls Lake is classified as a Nutrient Sensitive Water (NCDEQ, 2018), which requires nutrient management due to excessive growth of microscopic and macroscopic vegetation.

Falls Lake is subject to the Falls Lake Water Supply Nutrient Management Strategy (Falls Lake Rules) (NCDEQ, 2011). The Eno River watershed is also subject to the Falls Lake Rules because it is part of the Falls Lake water supply watershed (Durham City-County Planning Department, 2018).

1.2 Goals

The primary goal of the Eno River WIP is to provide a comprehensive plan for achieving and maintaining high water quality and watershed health in the Eno River watershed study area.

Additional goals of the Eno River WIP are as follows:

- Help the City address local water quality issues, federal and state requirements under the City's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit, and nutrient management strategies in the Upper Neuse River Basin
- Help the City prioritize and implement practices that will reduce nutrient loading to Falls Lake in compliance with the Falls Lake Rules
- Help the City achieve the goals set forth in their Strategic Plan and Sustainability Roadmap through helping to increase green infrastructure in the city and improving water quality through stormwater and land use best practices.

Developing the WIP included the following tasks:

- Assessment of the existing water quality and health of the streams and aquatic habitats in the Eno River watershed
- Identification of the major impacts to the health of the watershed such as pollution from point and nonpoint sources
- Identification of potential watershed improvement projects, including stormwater control measures (SCMs), and stream restoration projects based on effectiveness in reducing pollutant loads, regulatory considerations, and stakeholder goals
- Prioritization of the watershed improvement projects that were identified
- Engage residents and local watershed organizations and governmental agencies to promote the protection and enhancement of the water quality, aquatic habitats, and ecological function in the watershed.

The WIP addresses the nine elements that are required in watershed plans by Section 319 of the Clean Water Act. The elements are described in the U.S. Environmental Protection Agency's (USEPA) Handbook for Developing Watershed Plans to Restore and Protect Our Waters (USEPA, 2008). Table 1-1 lists the nine elements along with cross references to the sections of the WIP that most directly correspond to each key element.

1.3 Organization

The Eno River WIP is divided into the following three volumes:

- Volume I: Executive Summary. Project goals, watershed evaluation methods, results of the watershed improvement scenarios, recommended projects, high-priority project fact sheets, and next steps in evaluating progress.
- Volume II: Improvement Plan. Summary of the approach used to develop the WIP, data used to develop watershed models, stream and SCM inventory and assessments, watershed improvement scenarios, watershed improvement project evaluation and prioritization, public outreach and involvement efforts, recommendations, implementation schedule, and measurable milestones.
- Volume III: Technical Appendices. Reports and memoranda with more detailed information on the technical approach used in the development of the WIP than in Volume II, including field surveys and the development of modeling.

Table 1-1. USEPA's nine key elements for watershed plans and corresponding section in the WIP

Element	Description	Section in WIP
1	Identify the causes and sources of pollution	Vol. II, Sect. 2
2	Estimate pollutant loading into the watershed and expected management measures and load reductions	Vol. II, Sect. 5
3	Describe the management measures to achieve load reductions and identify the critical areas in which those measures will be implemented	Vol. II, Sect. 5 and 6
4	Estimate the associated costs, amounts of technical and financial assistance needed, and the authorities needed to implement the plan	Vol. I; Vol. II, Sect. 6
5	Implement a public information and education component that will be used to enhance public understanding of the project	Vol. II, Sect. 7
6	Provide a schedule for implementing the nonpoint source management measures identified in the plan	Vol. II, Sect. 8
7	Describe interim, measurable milestones for verifying whether nonpoint source management measures or other control actions are being implemented effectively	Vol. II, Sect.8
8	Describe a set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards	Vol. II, Sect. 8
9	Describe a monitoring plan to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under Element 8	Vol. II, Sect. 8

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2 Watershed Concerns

The Eno River watershed exhibits overall good water quality (City of Durham, 2018c and City of Durham, 2018d). Several indicators of nonpoint source impacts are evident in water quality data and field assessments. Occasional occurrences of elevated turbidity and fecal coliform bacteria and evidence of eroded banks are present throughout the study area, but the predominant impacts in the study area are located in the Warren Creek and Crooked Run Creek watersheds. The major water quality and watershed health concerns in the Eno River watershed are nonpoint sources of pollution.

As shown in Table 2-1. , primary watershed concerns and sources of pollution in the watershed are as follows:

- Stormwater runoff from impervious surfaces
- Animal waste
- Wastewater collection systems
- Illicit discharges
- Streamflow impediments
- Legacy sediment
- Degraded riparian buffer
- Degraded habitat

For more information, see the Eno River Watershed Assessment Report in Volume III, Appendix E, of this WIP.

Table 2-1. Summary of Eno River watershed pollution sources

Source	Description
Stormwater runoff from impervious surfaces	• Increased impervious cover can result in increased stormwater runoff, higher peak flows, lower base flows, and reduced groundwater recharge. • Impervious cover accounts for approximately 12% of the study area. • The percentage of impervious cover in 18 of the 53 subwatersheds in the study area was found to be above 15%. • Eleven of the 25 subwatersheds in the southern portion of the study area have relatively large amounts of impervious cover that account for between 20 and 35% of their respective subwatershed areas.
Animal waste	• Animal waste deposits from both domestic house pets and wild animals such as deer and geese are potential sources of fecal coliform. • While additional information is needed, pet waste is a potential contributor to fecal coliform exceedances in the Eno River watershed.
Wastewater collection systems	• Nutrients and fecal coliform associated with wastewater reduce water quality, contribute to growth of aquatic macrophytes, and reduce dissolved oxygen levels. • Annual loading from septic systems, sand filters, and sanitary sewer system overflows is estimated to be 2,829 lbs TN/yr and 357 lbs TP/yr within the City's jurisdiction (see Volume III, Appendix E, of this WIP). • Water quality data collected in both the Crooked Run Creek and Warren Creek subwatersheds show elevated levels of fecal coliform bacteria. Approximately one third of septic systems (597 of 1,813) and sand filters (49 of 141) in the study area are located in the Crooked Run Creek and Warren Creek subwatersheds. Approximately 20% of sanitary sewer overflows reported by the City within the study area between December 1999 and June 2016 were located in the Crooked Run Creek and Warren Creek subwatersheds.

Table 2-1 (cont.). Summary of Eno River pollution sources

Source	Description
Illicit discharges	• Examples of illicit discharges include petroleum spills, improper disposal of yard waste, public sanitary sewer overflows, and cooking related wastes like oil, grease, and food that are discharged into storm drains or enter storm drains from overland runoff. • Field biologists noted evidence of illicit discharges while performing stream assessments in the Eno River watershed including a chemical odor from a surface pond, evidence of what appeared to be an oily substance on the water surface, and a sanitary sewer leak. These observations were reported to the Public Works Department staff who investigate and resolve any illicit discharges. Illicit discharges are documented in the City's State of Streams Reports (City of Durham, 2018d).
Streamflow impediments	• Beaver dams were noted as potential water quality concerns during stream assessments. • While beaver dams may negatively impact flow and dissolved oxygen levels, they also provide positive effects in the management of legacy sediment.
Legacy sediment	• The historical record of mill dams on the Eno River suggests the presence of more than 30 gristmills during the 17th to 19th centuries on the Eno River (North Carolina State Parks, n.d.). • Legacy sediment associated with historical mill dams may be contributing to the total sediment load in the Eno River watershed (Wegmann et al., 2012 and Wegmann et al., 2013).
Degraded riparian buffer	• Degraded riparian buffers result in increased bank erosion and sediment inputs to surface waters. • In the Eno River watershed, field investigations identified more than 50,000 linear feet of stream in 35 reaches that would benefit from restoration, enhancement, or stabilization.
Degraded habitat	• The abundance and diversity of fish and benthic macroinvertebrates are impacted by the physical characteristics, substrate composition, and riparian area features of a stream. • Healthy stream habitat in the Piedmont physiographic province of North Carolina is characterized by a diversity of riffles and pools as well as healthy, riparian buffers that stabilize banks, moderate temperatures, and filter pollutants from overland runoff. • A 2014 assessment of watershed habitat in the Eno River watershed found that habitat scores were variable throughout the watershed, ranging from 50 in Cub Creek (EN6.5CC) to 92 in an unnamed tributary to the Eno River (EN12.2ERT3) (City of Durham, 2014a). Habitat scores were strongly influenced by geology and land use in the watershed. Sites in the Triassic Sedimentary Basin generally scored low while those in the Slate Belt generally scored higher (City of Durham, 2014a). In 2017, the City performed additional habitat assessments at two locations in the watershed, the Eno River mainstem at Guess Road and the Eno River mainstem at Sterling Drive and found that the instream habitat at both locations was of excellent quality at those locations (see Volume III, Appendix M, of this WIP). • Rapid Stream Assessment Technique (RSAT) assessments in the Eno River watershed revealed that, among the 49 stream miles assessed, 1% of streams are rated "excellent", 41% are rated "good", 53% are rated "fair", and 5% are rated "poor". The distribution of RSAT rating throughout the study area shows that the overall stream health is good, but that some areas are considered to be in poor health.

lbs TN/yr = pounds total nitrogen per year
n.d. = no date

3 Watershed Improvement Scenarios

One of the objectives of the Eno River WIP is to identify and prioritize improvement projects, stormwater control measures (SCMs), and stream restoration opportunities that are critical to the protection and restoration of water quality in the Eno River and its tributaries and downstream Falls Lake.

To assess the potential water quality benefits of SCMs and other practices, watershed improvement scenarios were developed and evaluated. The scenarios include practices that have demonstrated nutrient reduction (referred to as "credit") and are considered feasible in the Eno River watershed.

Developing watershed improvement scenarios for the Eno River WIP involved reviewing the modeling results in the City's previous WIPs (see Volume III, Appendix K, of this WIP), the unique conditions in the Eno River watershed, and the current nutrient crediting in North Carolina. Based on the review, the following eight scenarios were developed:

- Scenario 1: Existing Land Use with Existing SCMs (Baseline Condition). Existing conditions in the watershed including existing land use conditions and the water quality benefits provided by existing SCMs.
- Scenario 2: Future Land Use with Existing SCMs. Future conditions in the watershed assuming no new watershed improvement projects or pollution control measures.
- Scenario 3: Future Land Use with Stormwater Performance Standards for New Development. Developed to assess the impact of implementing the City's Stormwater Performance Standards for New Development Ordinance (City of Durham, 2012b).
- Scenario 4: Stormwater Performance Standards for New Development with Recommended SCM Retrofits and New SCM Projects. Expands on Scenario 3 by determining the annual pollutant load reduction that could be achieved on a watershed scale by implementing the proposed existing SCM retrofit projects and potential new SCM projects identified in the study area.
- Scenario 5: Stormwater Performance Standards for New Development with Stream Projects. Developed to quantify the annual pollutant load reductions that could be achieved on a watershed scale by implementing proposed stream projects that were identified in the stream inventory and assessment. While urban stream restoration is recognized as an eligible practice for nutrient crediting in some states, this practice is currently not recognized by NCDEQ for crediting in North Carolina.
- Scenario 6: Stormwater Performance Standards for New Development with Green Infrastructure and Low Impact Development. Developed to quantify the annual pollutant load reductions that could be achieved on a watershed scale if Green Infrastructure and Low Impact Development (GI-LID) practices were installed in residential and commercial areas that lack stormwater controls.

  The Eno River watershed contains well-drained soils throughout the western portion of the study area. Due to the increased effectiveness of GI-LID practices in areas with high soil infiltration, GI-LID practices proposed for this scenario were assigned higher implementation factors in catchments with well-drained soils than in catchments with poorly-drained soils.
- Scenario 7: Stormwater Performance Standards for New Development with Land Conservation. Developed to quantify the annual pollutant reduction that could be achieved on a watershed scale if high priority parcels (keystone and urban gem parcels) in the Eno River watershed were protected.

- Scenario 8: Combined Nonpoint Source Pollution Projects. The approaches described for Scenarios 3, 4, 5, 6, and 7 were combined to generate the results for Scenario 8.

3.1 Stormwater Management Modeling

A Personal Computer Storm Water Management Model (PCSWMM) was developed and calibrated to evaluate the scenarios. PCSWMM was selected because of its ability to simulate the existing storm drainage system in the Eno River watershed and estimate pollutant loadings and the transport of water quality constituents through the drainage system. The model was used to estimate changes in pollutant loadings associated with all scenarios except 5, 7, and 8.

3.2 Scenario Results

Results of the watershed management scenarios, presented in Table 3-1 and Table 3-2, suggest that nutrients and TSS will increase based on projected changes in future land use, but that these increases can be mitigated by implementing management practices. Table 3-1 and Table 3-2 present the changes in load within the study area as calculated from the model output at stations EN4.9ER and EN13.3ER.

TN and TP loads within the study area are expected to increase approximately 12.5% and 0.7%, respectively, based on future land use projections and the implementation of current new development standards. When evaluating the incremental change in load associated with the future land use condition with and without new development standards, new development standards reduce the incremental TN load change associated with new development by 40% (reducing the change in load associated with the future land use condition from 11,526 lb/yr to 6,986 lb/yr) and incremental TP load change associated with new development by 90% (reducing the change in load associated with the future land use condition from 722 lb/yr to 58 lb/yr).

Watershed improvements found to reduce nutrient and TSS load reductions include:

- Total Nitrogen. Stream projects were found to provide the highest TN reduction, 15.1%, in total load exported from the study area under the future land use condition. Stream projects were followed by GI-LID, SCM projects, and land conservation which provide approximately 1.9%, 1.7%, and 0.8% reduction in TN loads, respectively, under the future land use condition.
- Total Phosphorus. Stream projects were found to provide the highest TP reduction, 16.3%, in total load exported from the study area under the future land use condition. Stream projects were followed by GI-LID and SCM projects, both of which provide approximately 2.0%, and land conservation which provides approximately 0.6% reduction in TP loads under the future land use condition.
- Total Suspended Solids. Stream projects were found to provide the highest reduction in TSS, 6,476,096 lb/yr, relative to the baseline condition, followed by proposed SCM projects which provide approximately 4.7% reduction in load and GI-LID which provide approximately 4.0% reduction in TSS loads under the future land use condition.

Though stream projects were found to provide the highest overall benefit for TN, TP, and TSS, the assumptions required to calculate the water quality benefits warrant additional investigation. The estimated reduction in annual sediment loading from stream projects is higher than the average annual sediment load simulated with the PCSWMM model for the Eno River study area. As previously noted, urban stream restoration is recognized as an eligible practice for nutrient crediting under the Chesapeake Bay Nutrient TMDL framework; however, this practice is currently not recognized by NCDEQ for crediting in North Carolina.

The methodology used to estimate load reductions from implementing stream projects required the following assumptions: (1) stream bank height is

Table 3-1. Estimated change in TN, TP, and sediment annual loads for different scenarios within the Eno River Watershed study area

		Total Nitrogen			Total Phosphorus			Total Suspended Sediment		
Watershed Management Scenario		Annual Load (lb/yr)	Incremental Change[1] (lb/yr)	Relative Difference[1] (%)	Annual Load (lb/yr)	Incremental Change[1] (lb/yr)	Relative Difference[1] (%)	Annual Load (lb/yr)	Incremental Change[1] (lb/yr)	Relative Difference[1] (%)
1	ELU	55,885	—	—	8,429	—	—	1,111,882	—	—
2	FLU	67,411	+11,526	+20.6%	9,151	+722	+8.6%	1,448,357	+336,475	+30.3%
3	FLU and NewDStds	62,871	+6,986	+12.5%	8,488	+58	+0.7%	—	—	—
4	FLU, NewDStds, and SCM Projects[2]	61,707	+5,821	+10.4%	8,301	–128	–1.5%	1,380,829	+268,947	+24.2%
5	FLU, NewDStds, and Stream Projects[3]	52,689	–3,196	–5.7%	6,998	–1,432	–17.0%	—	—	—
6	FLU, NewDStds, and GI-LID[2]	61,590	+5,705	+10.2%	8,301	–128	–1.5%	1,390,144	+278,262	+25.0%
7	FLU, NewDStds, and Land Conservation[4]	62,350	+6,465	+11.6%	8,437	+7	+0.1%	—	—	—
8	FLU, NewDStds, SCM Projects, Stream Projects, GI-LID, and Land Conservation	49,723	–6,162	–11.0%	6,574	–1,855	–22.0%	—	—	—

(1) Incremental change and relative difference are based on a comparison to Scenario 1, which represents the baseline condition.
(2) New development standards for sediment are not included.
(3) Implementing stream projects results in a reduction of 6,476,096 lb/yr sediment relative to the baseline condition. The methodology used to estimate load reductions from implementing stream projects required the following assumptions: (1) uniform and continuous stream bank height along the entire reach, (2) continuous stream bank erosion rates along the entire reach, (3) continuous soil bulk density along the entire reach, and (4) a single value for soil bulk density. The methodology is intended to be used as a high-level planning tool, and detailed evaluations of individual stream projects require more detailed field data than what was collected during the field assessments as part of this WIP. For these reasons, annual sediment loads for stream projects are not included in this table.
(4) Sediment credits are not assigned to land conservation.

"—" = not applicable
ELU = existing land use
FLU = future land use
GI-LID = green infrastructure – low impact development
lb/yr = pounds per year
NewDStds = Stormwater Performance Standards for New Development
SCM = stormwater control measure

uniform and continuous along the entire reach, (2) stream bank erosion rates are continuous along the entire reach, (3) soil bulk density is continuous along the entire reach, and (4) a single value for soil bulk density. The methodology is intended to be used as a high-level planning tool and detailed evaluations of individual stream projects require more detailed field data than what was collected during the field assessments as part of this WIP. At this time, NCDEQ has not established nutrient credits for stream projects.

The planning-level cost to implement streams projects is approximately $28 million. When compared to the cost to implement recommended SCM projects, approximately $29 million, stream projects represent a better value and should be prioritized over SCM projects based on higher pollutant reductions gained for a similar cost. Costs associated with stream projects and SCMs are based on gross assumptions and should be used for high-level planning only.

While formal nutrient load credits have not been assigned to land conservation by NCDEQ, this practice was evaluated in the Eno River watershed based on assumed credits above those initially proposed by NCDEQ. Results of this evaluation demonstrate that, compared to other management practices, land conservation will likely provide relatively small nutrient reduction credit under the Falls Lake nutrient management strategy. While this result is important with respect to compliance with the rules, land conservation provides an array of other benefits and ecosystem services that are outside the scope of this WIP; however, they are considered by the City when selecting or supporting watershed improvement practices. Given the uncertainty associated with the credits calculated under Scenario 7, land conservation should be reevaluated after NCDEQ has assigned nutrient credits to this practice.

Table 3-2. Estimated TN, TP, and sediment annual load reductions for each practice evaluated in the Eno River watershed study area

Watershed Management Practice	Annual Load Reduction					
	Total Nitrogen		Total Phosphorus		Total Suspended Sediment	
	lb/yr	Percent	lb/yr	Percent	lb/yr	Percent
Stormwater Performance Standards for New Development(1)	4,540	6.7%	663	7.2%	—	—
Structural Stormwater Control Measure Projects(2)	1,164	1.7%	186	2.0%	67,528	4.7%
Stream Projects(2),(3)	10,182	15.1%	1,490	16.3%	—	—
Green Infrastructure – Low Impact Development(2)	1,281	1.9%	187	2.0%	58,213	4.0%
Land Conservation(2),(4)	521	0.8%	51	0.6%	—	—

(1) Annual load reduction percentages are based on a comparison to Scenario 2, which represents the future land use condition without stormwater performance standards for new development.
(2) Annual load reductions (lb/yr) are based on a comparison to Scenario 3, which represents the future land use condition with stormwater performance standards for new development.
(3) Implementing stream projects results in a reduction of 6,476,096 lb/yr sediment relative to the baseline condition. Please see discussion in Section 5.3.2 of Volume II of this WIP.
(4) Sediment credits are not assigned to land conservation.

"—" = not applicable
lb/yr = pounds per year

4 Watershed Improvement Project Prioritization

Field evaluations followed by hydrologic and hydraulic modeling and water quality modeling tools were used to identify potential improvement projects throughout the Eno River watershed. The projects were prioritized to identify those that would provide the most water quality benefit.

The results of the evaluation and prioritization provide the City with a systematic and transparent method of selecting the most beneficial projects in the Eno River watershed and in Durham's other watersheds when ranked with project opportunities in previous WIPs.

A total of 97 feasible projects in the Eno River watershed, including 38 retrofits to existing SCMs, 24 new SCM projects, and 35 stream projects, were scored based on the following six categories of criteria:

- Water quality treatment: Amount of pollutant removed and associated cost-effectiveness.
- Habitat and biological integrity: Benefit to the ecological function of a stream and the stream's ability to support aquatic life.
- Stream bank protection: Ability to reduce erosion of stream banks during high flows.
- Community enhancement: Benefit to the surrounding community such as property protection, neighborhood acceptance, opportunities for public education, and proximity to schools, parks, and open space.
- Implementation issues: Difficulty and cost of implementation, including issues such as property ownership, site accessibility for construction, operations and maintenance, compatibility with existing City programs, permitting requirements, and potential environmental impacts.
- Public safety and public property considerations: Amount of flood protection or reduction.

A total of 14 criteria within the 6 categories (see Table 4-1) were used to prioritize the 97 projects. Raw scores ranging from 0 to 5, with 0 indicating no benefit and 5 indicating a significant benefit, were assigned to each project and criterion. Raw scores were adjusted using a weighting factor to create a weight-adjusted score. The weighting factor allowed an individual criterion to be more significant relative to other used in the evaluation. Additional information on the methods used to determine project scores is provided in Prioritization of Proposed Watershed Improvement Projects (see Volume III, Appendix J, of this WIP).

Using the criteria listed in Table 4-1, 15 high-priority SCM projects and 15 high-priority stream projects were selected. The high-priority SCM projects consist of 12 retrofits to existing SCMs and 3 new SCM projects (Table 4-2). The high-priority stream projects include 7 reaches proposed for restoration, 6 reaches proposed for Enhancement I, and 2 reaches proposed for Enhancement II (Table 4-3), as defined by the U.S. Army Corps of Engineers (USACE) (USACE, 2003). Fact sheets for the high-priority projects are provided in Volume I, Appendix A, of this WIP.

Table 4-1. Prioritization criteria with scoring ranges and weighting factors

Category	Criteria	Score Range	Weighting Factor	Results of Score x Weighting Factor
Water quality treatment	Nitrogen	0 – 5	2	0 – 10
	Phosphorus	0 – 5	2	0 – 10
	Sediment	0 – 5	1.5	0 – 7.5
	Fecal coliform	0 – 5	1.5	0 – 7.5
Habitat and biological integrity	Habitat/biology	0 – 5	3	0 – 15
Stream bank protection	Stream bank protection	0 – 5	2	0 – 10
Community enhancement	Property protection	0 – 5	1	0 – 5
	Property owner and neighborhood acceptance	0 – 5	1	0 – 5
	Public education	0 – 5	1	0 – 5
Implementation issues	Property ownership	0 – 5	1	0 – 5
	Accessibility for construction and operations and maintenance	0 – 5	1	0 – 5
	City program compatibility	0 – 5	1	0 – 5
	Permitting/adverse environmental impacts	0 – 5	1	0 – 5
Public safety and public property considerations	Public safety and public property	0 – 5	1	0 – 5
		Total Possible Score		0 – 100

Table 4-2. High-priority SCM projects in the Eno River watershed

Project ID	Project Description	Sub-watershed[1]	SCM Drainage Area (ac)	Annual Load Reduction (lbs/yr) TN	TP	Sediment	Total Capital Cost (2018 Dollars)[2]	Total Project Prioritization Score (100 Max)
ER_SCM_00060[3]	Convert Existing Dry Pond to Pocket Wetland	—	8	24	3	632	$249,000	82.5
ER_SCM_00055	Water Quality Improvements to an Existing Wet Pond	ER11	8	32	7	3,153	$282,000	81.0
ER_SCM_ENO0102	Water Quality Improvements to an Existing Wet Pond	ER41	13	37	7	1,802	$346,000	81.0
ER_SCM_ENO0101	Water Quality Improvements to an Existing Wet Pond	ER39	28	88	18	4,560	$661,000	78.0
ER_SCM_00047	Convert Existing Dry Pond to Constructed Wetland	ER24	6	17	3	983	$248,000	77.5
ER_SCM_ENO0123	New Wet Swale	ER38	12	12	2	893	$130,000	75.5
ER_SCM_00167	Water Quality Improvements to an Existing Wet Pond	ER11	15	43	9	4,900	$271,000	70.0
ER_SCM_00152	Water Quality Improvements to an Existing Wet Pond	ER07	13	34	7	3,774	$247,000	70.0
ER_SCM_ENO0113 – ER_SCM_ENO0114[4]	Convert Two Adjacent Existing Dry Ponds to One Pocket Wetland	ER38	6	17	2	794	$217,000	69.5
ER_SCM_00023[3]	Convert Existing Dry Pond to Pocket Wetland	—	7	16	2	838	$267,000	68.5
ER_SCM_ENO0170	New Pocket Wetland	ER20	7	12	2	680	$312,000	67.5
ER_SCM_ENO0148	New Pocket Wetland	ER35	5	16	3	928	$330,000	65.5
ER_SCM_00206	Convert Existing Dry Pond to Constructed Wetland	ER08	12	16	2	849	$328,000	65.5
ER_SCM_00332	Convert Existing Dry Pond to Pocket Wetland	ER38	6	12	2	662	$180,000	65.5
ER_SCM_00321	Convert Existing Dry Pond to Pocket Wetland	ER39	11	18	2	377	$253,000	65.5
Totals			156	392	70	25,824	$4,321,000	

(1) For more information, see Volume II, Exhibit 3, of this WIP.
(2) Total capital costs consist of administrative, engineering, surveying, permitting, land acquisition, construction, and construction administration costs and 20 years of annual maintenance.
(3) ER_SCM_00060 and ER_SCM_00023 are located within City limits near the Orange County and Durham County boundary in a small portion of the study area outside of the 53 subwatersheds that were used to support pilot study area selection and modeling decisions. Additional information is presented in in Volume III, Appendix E, of this WIP.
(4) ER_SCM_ENO0113 and ER_SCM_ENO0114 are adjacent SCMs and could be combined into a single project. This would reduce cost relative to implementing two individual projects. In the table, the drainage area, annual load reductions, and cost have been combined for the two projects. The score is for the project that scored higher (ER_SCM_ENO0113).

Table 4-3. High-priority stream improvement projects in the Eno River watershed

Project ID	Project Description	Sub-watershed	Stream Reach Length (ft)	Annual Load Reduction (lbs/yr) TN	TP	Sediment	Total Capital Costs (2018 Dollars)(1)	Total Project Prioritization Score (100 Max)
ER_STREAM_2019	Stream Restoration	ER32	4,938	3,346	320	1,392,863	$2,920,000	83.5
ER_STREAM_2072	Enhancement I	ER23	2,146	147	38	165,061	$1,051,000	76.4
ER_STREAM_1021(2)	Enhancement I	ER38	2,621	293	76	329,693	$1,199,000	72.5
ER_STREAM_2039(3)	Stream Restoration	ER10	1,935	3,010	628	2,732,600	$1,162,000	70.5
ER_STREAM_2075(4)	Stream Restoration	ER05	480	204	3	12,684	$319,000	69.5
ER_STREAM_1026	Enhancement I	ER35	1,870	47	12	52,969	$890,000	68.7
ER_STREAM_2038(3)	Enhancement I	ER11	1,654	728	188	818,024	$1,349,000	67.5
ER_STREAM_2013	Enhancement II	ER37	2,847	56	14	62,559	$1,160,000	65.9
ER_STREAM_2053(5)	Enhancement I	ER17	664	33	9	37,382	$330,000	63.4
ER_STREAM_2042(6)	Stream Restoration	ER08	921	179	3	12,326	$827,000	61.5
ER_STREAM_2045(4)	Stream Restoration	ER07	745	268	1	5,427	$449,000	61.5
ER_STREAM_1086	Stream Restoration	ER41	800	165	1	6,318	$488,000	58.5
ER_STREAM_2041(6)	Stream Restoration	ER08	942	243	2	9,054	$846,000	57.5
ER_STREAM_2054(5)	Enhancement II	ER17	1,720	147	38	165,335	$572,000	57.3
ER_STREAM_1023(2)	Enhancement I	ER38	1,526	43	11	48,417	$699,000	56.5
Totals			25,810	8,911	1,346	5,850,711	$14,261,000	

(1) Total capital costs consist of administrative, engineering, surveying, permitting, land acquisition, construction, and construction administration costs and 20 years of annual maintenance.
(2) ER_STREAM_1021 and ER_STREAM_1023 are adjacent reaches and could be combined into a single project. This would reduce cost relative to the cost of two individual projects.
(3) ER_STREAM_2039 and ER_STREAM_2038 are adjacent reaches and could be combined into a single project. This would reduce cost relative to the cost of two individual projects.
(4) ER_STREAM_2075 extends beyond the length provided in the table. Field assessment of the reach was stopped due to beaver activity. This reach is a part of the old Eno River bend prior to construction of the Eno River Canal. If this project is considered, the entire Eno River bend area should be reassessed. Additionally, ER_STREAM_2075 could be combined with ER_STREAM_2045 to form a single project. These reaches are on the same stream but separated by one large parcel (Hanson Aggregates Southeast – PID: 178019).
(5) ER_STREAM_2053 and ER_STREAM_2054 are adjacent reaches and could be combined into a single project. This would reduce cost relative to the cost of two individual projects.
(6) ER_STREAM_2042 and ER_STREAM_2041 are adjacent reaches and could be combined into a single project. This would reduce cost relative to the cost of two individual projects.

5 Public Outreach and Involvement

Public involvement is a critical component of the watershed planning process. Residents bring local knowledge that informs the watershed planning process. Their input is invaluable in developing a comprehensive plan.

A variety of tools were used to engage and inform the public, key stakeholders, City staff, and elected officials. The tools included three public information sessions, a City-hosted project webpage, social media, project fact sheets, educational radio spots, and three educational videos.

5.1 Public Information Sessions

Three public information sessions were hosted between 2017 and 2018. The sessions were held at key milestones to provide an update on the project progress and receive input from attendees on important topics.

The first public information session was held on March 21, 2017. During this session, residents were introduced to the project and the City's watershed planning program. The presentation included water quality challenges, federal and state regulations (e.g., NPDES permit, Falls Lake Rules) that drive the watershed planning program, goals of the Eno River WIP, and progress made in the first 9 months of the project, including preliminary results from stream and SCM field visits.

The second public information session was held on November 2, 2017. This session included a summary of the project objectives, results of the fish study and aquatic vegetation study that were conducted in the Eno River, description of computer modeling and prioritization of the SCM and stream restoration projects, and the anticipated next steps. An interactive game focusing on environmental science knowledge of the Eno River was available for children in attendance. An online survey was used to better understand the residents' use of Eno River's recreational opportunities and their perception of the water quality in the Eno River watershed. The survey provided insightful information for the project team in understanding how respondents use and value water resources in the Eno River watershed.

The third and final public information session was held on July 31, 2018. The goal of this session was to present the results of watershed modeling, SCM and stream restoration projects prioritization, watershed management scenarios, and overall project recommendations. The presentation also included results of public survey conducted during the second public meeting and included a discussion on how public input was incorporated in the project prioritization process. To facilitate discussion and receive public comments, the draft WIP was available for review at the meeting. A final survey was conducted to evaluate the effectiveness of public outreach and information sessions performed during the project.

5.2 Eno Watershed River Improvement Plan Webpage

A City-hosted webpage was used to communicate progress and schedule updates, field activities, public information session dates, and key documents to the public during the project. The project website is available at http://durhamnc.gov/2890/Eno-River-Watershed-Improvement-Plan.

5.3 Eno River Watershed Improvement Plan Social Media Updates

Social media tools, including Facebook (https://www.facebook.com/durhamncstormwater/) and Twitter (@DurhamStormH2O), were used to communicate important WIP progress updates, links to educational videos, and volunteer events in the watershed.

5.4 Project Fact Sheets

Three project fact sheets were developed in conjunction with the public information sessions to provide summaries of project progress and key findings. The fact sheets, one of which was provided in both Spanish and English, were presented to residents at information sessions and posted to the project webpage.

5.5 Educational Radio Spots

A radio spot was developed in Spanish and broadcast on the channel La Ley 101.1FM to reach the Spanish-speaking population. The radio message focused on best practices when using paint brushes to prevent paint pollution. The recorded message is available at: https://durhamnc.gov/2890.

5.6 Educational Videos

Three high-quality educational videos were prepared during the project. These videos, described below, and other videos developed by the City are available at the following link: https://www.youtube.com/playlist?list=PL5760F8572BE4AD39.

- “The River Starts in your Backyard” introduces the concept of a watershed and how the daily activities of residents have the potential to convey pollutants to a stream or river if not managed properly. The video provides simple tips for homeowners such as pet waste cleanup, checking sewer leaks, and planting native vegetation to prevent backyard pollutants from getting washed into waterways. This video is available at the following link: https://youtu.be/CdgevXy5cyM.
- “Proper Paint Disposal” highlights the importance of managing paint pollution by providing simple tips such as washing brushes indoors and properly disposing of paint cans. This video is available at the following link: https://youtu.be/UOEpBtx5QL0?list=PL5760F8572BE4AD39.
- “Green Stormwater Infrastructure” promotes the practice of green stormwater infrastructure and displays some of the key projects and partnerships developed by the City. This video is available at the following link: https://youtu.be/um2dRkrxUEY.

6 Watershed Improvement Plan

Achieving and maintaining water quality goals and watershed health in the Eno River watershed will depend on the implementation of measures such as pollution controls, management practices, and strategies designed to mitigate bacteria, sediment, nutrients, metals, low dissolved oxygen, and flow impacts.

These measures will help to achieve water quality goals and restore and maintain the physical, chemical, and biological integrity of the receiving waterbodies by:

- Reducing or avoiding pollutant inputs
- Controlling discharges that could alter natural hydrology
- Mitigating other stressors that may contribute to impairment

Watershed protection requires creative water quality improvement projects and effective partnerships with state and local agencies, watershed associations, and stakeholder groups to implement the projects. The City leads and supports a number of projects and programs that protect and enhance the Eno River. The recommendations presented in this section add to these initiatives and highlight opportunities for future consideration. Additional information on each recommendation is provided in Volume II, Section 8, of this WIP.

6.1 High-Priority SCM Projects

Of the 62 possible SCM projects, 38 are retrofits to existing SCMs and 24 are new SCMs. Based on the prioritization criteria presented in Section 4, 12 retrofits to existing SCMs and 3 new SCMs were selected as high priority. The 15 projects are listed in Table 4-2.

These projects provide the most cost-effective reduction of pollutant load contributions from stormwater runoff. If implemented, the SCMs could reduce the existing impacts of increased peak flows, excess nutrients, metals, and low dissolved oxygen present in portions of the Eno River watershed, specifically in Warren Creek and Crooked Run Creek.

6.2 High-Priority Stream Improvement Projects

Thirty-five stream improvement projects were identified as feasible watershed improvement projects in the Eno River watershed. The 15 high-priority stream improvement projects that were selected based on the prioritization criteria are presented in Table 4-3.

If implemented, these projects would help re-establish general stream and river structure, function, and self-sustaining behavior by helping to increase aquatic habitat and fauna diversity and decrease streambank erosion. These benefits are linked to aspects of stream restoration projects that incorporate natural channel design concepts such as modification of channel dimension, pattern, and profile. Stream enhancement and stream stabilization are narrower in scope than stream restoration and focus on improving the floodplain and streambank areas, respectively.

6.3 Green Infrastructure and Low Impact Development Opportunities

Green infrastructure is a type of stormwater management that tries to protect, restore, or mimic the natural water cycle. Specifically, green infrastructure combines elements of the natural environment and traditional stormwater drainage systems to improve water quality and restore ecosystems. Green infrastructure can refer to behaviors, practices, devices, as well as the design of stormwater systems. This type of stormwater management can be promoted through providing guidelines for landscaping that take advantage of ecological benefits provided by natural processes.

Green infrastructure practices are frequently incorporated into City projects through research projects and grants, partnerships with local organizations, and by working with other City departments. The City recently published the Sustainability Roadmap (City of Durham, 2018b) which identified implementing green infrastructure practices as a strategy to protect and restore Durham's natural resources and ecosystem. Low Impact Development (LID) is implemented through the Stormwater Performance Standards for Development (City of Durham, 2012b) and the Durham City-County UDO (Durham City-County Planning Department, 2018).

The extent to which GI-LID practices are successfully implemented depend on soil type and existing land uses. GI-LID practices are both easier to implement and more effective in well-drained soils. Due to the presence of soils with low conductivity in some portions in the Eno River watershed, green infrastructure practices are not appropriate in all areas of the watershed. Approximately 62% of the Eno River watershed study area consists of well-drained soils (hydrologic soil groups A and B).

Evaluating the water quality benefit associated with implementing GI-LID involved the use of implementation factors (Table 6-1). Higher implementation factors were used in portions of the watershed with well-drained soils. For low density residential and medium density residential land uses, this implementation factor was calculated using data from the City's Residential Green Infrastructure Analysis (ReGIn Analysis) for the Eno River watershed (City of Durham, 2017). The implementation factors for high density residential and commercial land uses were determined based on a visual assessment and review of aerial imagery.

The GI-LID analysis was based on the assumption that residential areas will receive rain gardens, commercial areas will receive bioretentions, and that all feasible GI-LID practices identified would be fully implemented. Additionally, it was assumed that no GI-LID would be implemented in areas already receiving treatment by an SCM, in new development areas, and on agriculture, forest, parks and open space, water, institutional, industrial, roads, and very low density residential land use areas.

PCSWMM results show that using GI-LID controls reduces total nitrogen by 1.9% and total phosphorus by 2.0%, compared to Scenario 3 (future land use with stormwater performance standards for new development ordinance).

Table 6-1. Implementation factors used to assess GI-LID practices in Scenario 6

	Hydrologic Soil Group	
Land Use	A and B	C and D
Commercial	7%	5%
High Density Residential	17%	15%
Medium Density Residential	22%	20%
Low Density Residential	25%	23%

6.4 Protection and Preservation of High-Quality Streams

A total of 30 stream reaches were identified for preservation in the Eno River study area. The streams were selected based on the characteristics of each reach and expected water quality benefits, including improved habitat diversity, pollutant filtering, and stream protection during high flow events.

Stream preservation involves implementing protective mechanisms, such as acquisition, conservation easements, or restrictive covenants, in perpetuity on stream buffers to establish or maintain long-term ecological protection. Preservation of high-quality streams has been shown to have greater success in maintaining aquatic functions and to be less expensive than stream restoration (Young et al., 2016).

6.5 Protection and Preservation of High-Quality Riparian Areas

While a significant portion of the riparian buffers along the mainstem of the Eno River and its tributaries are already protected through public ownership or development restrictions, additional opportunities for protection exist. The City's Critical

Area Protection Plan (CAPP) identifies privately owned parcels with high-quality riparian buffers that could be prioritized for conservation or protection. These buffers protect and maintain vegetative systems along streams and provide biological and hydrologic benefits by diffusing and treating stormwater runoff.

For the Eno River WIP, the CAPP was updated to include a list of priority parcels and areas marked for protection in the Eno River watershed. A total of 45 keystone and 3 urban gem properties were identified in the study area. See Volume III, Appendix F of this WIP for definitions of keystone and urban gem properties.

Eight of the 45 keystone properties are in the Warren Creek subwatershed. The two highest scoring keystone properties in the Warren Creek subwatershed (PID 177587 and 177597) contain multiple streams draining to Warren Creek and are contiguous parcels less than 500 feet from the West Point on the Eno City Park. Five of the proposed SCM projects are in the identified keystone properties (ENO 0129, ENO 0135, ENO 0157, ENO 0165, and ENO 0166).

Ten of the 45 keystone properties are in the Crooked Run Creek subwatershed. Two large keystone properties (PID 182907 and 183002) in the Crooked Run Creek subwatershed are adjacent to the George L. Carrington Middle School and provide a unique opportunity for conservation adjacent to an existing public school. One SCM project (ENO 0176) and one SCM retrofit opportunity (ER SCM 00047) are on the school's property.

The three urban gem properties identified in the watershed provide opportunities for headwater stream protection immediately upstream of identified keystone properties. By incorporating these urban gems into conservation plans, the City has an opportunity to preserve entire stream reaches draining directly to the Eno River.

A complete list of keystone properties and urban gems identified in the Eno River watershed is provided in Volume III, Appendix F, of this WIP.

6.6 Continuation of Existing City Programs and Practices

The City's Stormwater & GIS Services Division is actively engaged in many activities that improve and protect watershed and water quality conditions in the Eno River watershed. Examples of activities that help the City manage stormwater and reduce pollutants of concern in the Eno River watershed include:

- Upper Neuse River Basin Association (UNRBA) and Falls Lake nutrient reevaluation
- Illicit discharge detection and elimination
- Post-construction runoff control
- Watershed protection ordinances
- Water quality and biological monitoring
- Wastewater treatment improvements
- Stormwater research
- Flood prevention and mitigation
- Environmental education programs
- Collaboration among City departments

Additional information on each program is presented in Section 8.1 of Volume II of this WIP.

6.7 Evaluating Progress

Progress toward protecting water quality in the Eno River and its tributaries is taking place through an adaptive management framework in which new information is used to inform actions needed to protect or restore water quality. The adaptive management process begins with implementing and tracking existing controls, programs, and practices that improve water quality. Through monitoring and assessment of conditions in the watershed, the City assesses the effectiveness of these controls and progress toward achieving the desired water quality conditions. This information is then used to adjust project implementation plans as needed.

Current monitoring and assessment tools used to protect the Eno River watershed and implement nutrient management strategies for Falls Lake are presented in Table 6-2. Because the Eno River is currently achieving its designated uses, no additional controls are required to address water quality concerns within the watershed beyond those required to comply with the Falls Lake nutrient management strategy.

Table 6-2. Information used to track the effectiveness of controls in the Eno River watershed

Category	Collected or Reported Information	Implementation Schedule
Water quality	Ambient water chemistry is collected monthly at five locations in the Eno River watershed, and WQI and water quality analyses are reported annually in the City's State of Our Streams Report (City of Durham, 2018d). Water quality data are available through the City's web portal (http://www.durhamwaterquality.org). Chemical water quality monitoring is also performed by NCDEQ and UNRBA (ends 2018) throughout the Eno River watershed.	Monthly monitoring and annual reporting
Benthic community and freshwater mussels	Biological data including benthic macroinvertebrate data have been collected by the City and NCDEQ. The City has collected benthic macroinvertebrate data at two stations on the Eno River. Freshwater mussels have been assessed by NCDEQ.	Every other year
Fish community	The City conducted quantitative and qualitative fish surveys at four sites in the Eno River in 2017. This information will serve as a reference and baseline for future surveys.	2017
Aquatic vegetation	The City performed an aquatic vegetation survey for invasive aquatic plants in the Eno River (City of Durham, 2014b). Surveys have also been performed by the Eno River Association, NC Wildlife Resource Commission, and NC State University (Eno River Hydrilla Management Task Force, 2018).	2013 and 2016
Nutrient loading	Portions of the Falls Lake Watershed Analysis Risk Management Framework (WARMF) model, including the Eno River watershed, were updated in 2018. The model provides nutrient loading and source characterization for the Eno River watershed. Future updates will be used to support the Falls Lake Nutrient Management Strategy.	2018 and future updates
Sediment chemistry	The City conducted a comprehensive water quality study for the Eno River watershed between July 2013 and June 2014 that included sediment sampling (City of Durham, 2014a). This information will serve as a reference and baseline for future sediment sampling.	2014
Streamflow and flooding	Streamflow and stage are recorded at three USGS gage locations along the Eno River mainstem. The City manages a flood warning gage monitoring system for portions of the Eno River watershed.	Ongoing
SCM retrofits	The City maintains a database of all SCMs installed by the City or others within the city under the Stormwater Performance Standards for Development Ordinance (City of Durham, 2012b) as well as completed SCMs that were not installed under these requirements.	Ongoing with frequent updates
SCM retrofits (potential)	The City tracks potential or proposed SCM retrofits and new SCMs identified through watershed planning studies and on an annual basis, selects projects for CIP funding.	Ongoing with frequent updates
SCM maintenance	The City tracks SCM inspection and maintenance actions for all SCMs.	Ongoing with frequent updates
GI-LID Development	The City tracks the implementation of and GI-LID practices throughout the city.	Ongoing with frequent updates

CIP = capital improvement plan
GI-LID = green infrastructure – low impact development
SCM = stormwater control measure

7 References

City of Durham. 2010. Ellerbe Creek Watershed Improvement Plan. Prepared by Brown and Caldwell. Accessed June 28, 2018, at https://durhamnc.gov/954/Ellerbe-Creek-Watershed-Improvement-Plan.

City of Durham. 2012a. Durham Third Fork Creek Watershed Management Plan. Accessed June 30, 2018, at https://durhamnc.gov/970/Third-Fork-Creek-Watershed-Improvement-P.

City of Durham. 2012b. Stormwater Performance Standards for Development. Durham City Code, Chapter 70, Article X, Sections 70-736 through 70-749. Accessed June 29, 2018, at https://library.municode.com/nc/durham/codes/code_of_ordinances?nodeId=PTIICOOR_CH70UT_ARTXSTPESTDE.

City of Durham. 2013. Northeast and Crooked Creek Watershed Improvement Plan. Prepared for the City of Durham. Prepared by Brown and Caldwell.

City of Durham. 2014a. Eno River Watershed Implementation Plan Data Collection. Department of Public Works. Accessed June 27, 2018, at https://durhamnc.gov/DocumentCenter/View/5748/EnoRiverRFPaddendum1f.

City of Durham. 2014b. Eno River Aquatic Vegetation Survey: Submerged Aquatic Vegetation Survey for Hydrilla verticillata (hydrilla), Podostemum ceratophyllum (riverweed), and Myriophyllum aquaticum (parrot feather) in the Eno River near Durham, NC. Department of Public Works. Accessed June 27, 2018, at https://nc-ipc.weebly.com/eno-river-hydrilla-project.html.

City of Durham. 2016. Little Lick Creek Watershed Improvement Plan. Department of Public Works. Accessed June 30, 2018, at https://durhamnc.gov/960/Little-Lick-Creek-Watershed-Plan.

City of Durham. 2017. Technical memorandum on Cluster Selection Criteria, GIS Analysis, & Program Recommendations. Small Scale Residential Stormwater Control Retrofits in Durham (City contract #13499). Department of Public Works, Durham, NC.

City of Durham. 2018a. FY 2019-2021 Strategic Plan. Accessed August 22, 2018, at https://durhamnc.gov/183/Strategic-Plan.

City of Durham. 2018b. Roadmap to Sustainability. Accessed August 22, 2018, at https://durhamnc.gov/822/Sustainability-Energy-Management.

City of Durham. 2018c. "Water Quality Web Data Portal: City of Durham." Public Works Department. Accessed July 26, 2018, at http://www.durhamwaterquality.org.

City of Durham. 2018d. "State of our Streams". Public Works Department. Accessed August 22, 2018, at http://durhamnc.gov/708/State-of-Our-Streams.

Durham City-County Planning Department. 2018. Unified Development Ordinance. Accessed June 29, 2018, at https://durham.municipal.codes/UDO.

NCDEQ. 2011. Falls Water Supply Nutrient Strategy. 15A NCAC 02B .0275 – .0282 and amended .0235 and .0315. Accessed June 29, 2018, at https://deq.nc.gov/about/divisions/water-resources/water-planning/nonpoint-source-planning/falls-lake-nutrient-strategy#Rules and Implementation.

NCDEQ. 2016. Standard Operating Procedures for the Collection and Analysis of Benthic Macroinvertebrates. Version 5.0. Division of Water Resources.

NCDEQ. 2018. “Classifications and Standards”. Accessed June 27, 2018, at https://deq.nc.gov/about/divisions/water-resources/planning/classification-standards.

North Carolina State Parks. n.d. “Eno River State Park.” Accessed May 25, 2017, at https://www.ncparks.gov/eno-river-state-park/activities.

USACE (U.S. Army Corps of Engineers). 2003. Stream Mitigation Guidelines. Accessed July 5, 2017, at http://portal.ncdenr.org/c/document_library/get_file?uuid=ab4ccad4-5cbe-45f3-979f-ab3fe35d21a1&groupId=61581.

USEPA (U.S. Environmental Protection Agency). 2008. Handbook for Developing Watershed Plans to Restore and Protect our Waters. EPA 841-B-08-002. Available at https://www.epa.gov/sites/production/files/2015-09/documents/2008_04_18_nps_watershed_handbook_handbook-2.pdf.

Wegmann, Karl W., C.L. Osburn, R. Q. Lewis, I.M. Peszlen and H. Mitasova. 2013. Legacy Sediments and Stream Water Quality: Estimating Volume, Nutrient Content, and Stream Bank Erosion in 303(d)-Impaired Waterways of the North Carolina Piedmont. Report No. 435. Water Resources Research Institute of The University of North Carolina. Accessed August 24, 2018, at https://repository.lib.ncsu.edu/bitstream/handle/1840.4/8190/NC-WRRI-435.pdf?sequence=1&isAllowed=y.

Wegmann, Karl W., R.Q. Lewis, and M.C. Hunt. 2012. Historic mill ponds and piedmont stream water quality: Making the connection near Raleigh, North Carolina. In Eppes, M.C., and Bartholomew, M.J., eds., From the Blue Ridge to the Coastal Plain: Field Excursions in the Southeastern United States: Geological Society of America Field Guide 29, p. 93–121, doi:10.1130/2012.0029(03). Accessed August 24, 2018, at https://www.researchgate.net/publication/234402580_Historic_mill_ponds_and_piedmont_stream_water_quality_Making_the_connection_near_Raleigh_North_Carolina.

Young, Ben, Lydia Olander, and Amy Pickle. 2016. “Use of Preservation in North Carolina Wetland and Stream Mitigation.” NI WP 17-04. Durham, NC: Duke University. Accessed June 29, 2018, at https://nicholasinstitute.duke.edu/sites/default/files/publications/ni_wp_17-04_0.pdf.

Appendix A:
Fact Sheets for Recommended High-Priority Projects

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