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PAGES CREEK WATERSHED RESTORATION PLAN

Produced for New Hanover Soil and Water Conservation District | January 2024

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Contributing Partners:

Cape Fear Resource Conservation and Development

New Hanover Soil and Water Conservation District

New Hanover County Planning Department

New Hanover County Engineering Department

University of North Carolina at Wilmington

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prepared for

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GUIDE TO NINE MINIMUM ELEMENTS

This table serves as a quick reference guide to where the U.S. Environmental Protection Agency (EPA) nine minimum elements can be found within this watershed management plan.

EPA Nine Minimum Elements		Location in Plan
1	Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan	Section 2: Watershed Characterization Section 3: Watershed Conditions
2	An estimate of the load reductions expected from management measures	Section 4: Reduction Load Target
3	A description of the nonpoint source management measures that will need to be implemented to achieve load reductions, and a description of the critical areas in which those measures will be needed to implement this plan	Section 5: Goals Section 6: Management Strategies
4	Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan	Section 6: Funding Cost and Technical: Needs
5	An information and education component used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented	Section 6: Education and Outreach
6	Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious	Section 7: Implementation Schedule
7	A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented	Section 7: Milestones
8	A set of criteria that can be used to determine whether load reductions are being achieved over time and substantial progress is being made toward attaining water quality standards	Section 7: Evaluation
9	A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the established criteria	Section 7: Monitoring

ACRONYMS

Acronym	Definition
AIWW	Atlantic Intracoastal Waterway
CCPA	Community Conservation Assistance Program
CDP	Census Designated Place
DEQ	Department of Environmental Quality
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
HOA	Homeowner Association
HQW	High-Quality Water
HSG	Hydrologic Groups
HUC	Hydrologic Unit Code
LID	Low Impact Development
MPN	Most Probable Number
NCAC	North Carolina Administrative Code
NCDEQ	North Carolina Department of Environmental Quality
NCDMF	North Carolina Division of Marine Fisheries
NCDNCR	North Carolina Department of Natural and Cultural Resources
NCDPR	North Carolina Division of Parks and Recreation
NCDSWC	North Carolina Division of Soil & Water Conservation
NCDWI	North Carolina Department of Water Infrastructure
NCDWR	North Carolina Department of Environmental Quality, Department of Water Resources
NCNHP	North Carolina Natural Heritage Program
NDMI	Normalized Difference Moisture Index
NDVI	Normalized Difference Vegetation Index
NFWF	National Fish and Wildlife Foundation
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
ORW	Outstanding Resource Water
Plan	Watershed Restoration Plan
SAVI	Soil-Adjusted Vegetation Index
SCM	Stormwater Control Measure
TMDL	Total Maximum Daily Load
UNCW	University of North Carolina at Wilmington
USDA	U.S. Department of Agriculture


CLOSED AREA
UNLAWFUL TO TAKE
OYSTERS, CLAMS
OR MUSSELS

EXECUTIVE SUMMARY

This Watershed Restoration Plan outlines the current state of the watershed, as well as steps that should be taken to mitigate the impacts to water quality as organized by the EPA's Nine Minimum Elements of a Watershed Plan.

The Pages Creek Watershed is an important resource for freshwater and estuarine species and habitats, as well as protection of water quality in the Topsail Sound and Middle Sound Areas; however, there is a broad range of nonpoint source pollutants degrading the water quality and ecosystems. Since approximately the late 1990s, growth in the northern part of New Hanover County and subsequent land use impacts have had adverse effects on the watershed's health. Data collected by the County and stakeholders have highlighted detrimental impact of increased sediment, nutrients, and fecal coliform bacteria entering the creek.

Historically, there have been concerns regarding water quality, primarily centered around bacteria levels, particularly fecal coliform, and Dissolved Oxygen (DO). While there haven't been direct interventions by the county to address these issues, it's worth highlighting that despite ongoing development activities, there has been a gradual improvement in bacteria levels which can indicate that development itself may not be the sole cause of water quality deterioration.

In the absence of intervention, the ongoing growth in this watershed region is likely to exacerbate these trends over time. This Watershed Restoration Plan (Plan) outlines the current state of the watershed, as well as steps that should be taken to mitigate the impacts to water quality as organized by the EPA's Nine Minimum Elements of a Watershed Plan. This Plan is intended to be a living document and a springboard for planning project partners to begin to improve and preserve water quality and habitat in this watershed. Ongoing collaboration, community outreach, and regular stakeholder communication will be essential to meaningfully improve water quality and ecosystem health.


YAMAHA
Jones Brothers
BATEAU
NC 3564 WW
KEY WEST
YAMAHA

1 INTRODUCTION

This Plan should be considered a "living document" that will allow for the incorporation of new information and updated impacts on water quality in the watershed.

The purpose of this Watershed Restoration Plan (Plan) is to guide restoration efforts and improve water quality in the Pages Creek Watershed of New Hanover County, North Carolina. This Plan was developed to assess known conditions in the Pages Creek Watershed and provide a voluntary management framework for New Hanover County and its residents to address water quality issues. A major driver for the development of this Plan was the designation of Pages Creek in 2006 as "impaired" by the North Carolina Department of Environmental Quality (NCDEQ) due to exceeding criteria for fecal bacteria in shellfish-growing areas. Additionally, the New Hanover Soil and Water Conservation District identified Pages Creek as a target for improvements in their 5-Year Strategic Plan.

The document's overall goal is to identify strategies developed by partners, stakeholders, and residents aimed at mimicking predevelopment hydrologic conditions before water quality impairment becomes a significant issue. Mimicking natural drainage processes can reduce runoff and nuisance flooding and help restore water quantity and quality requirements of receiving water bodies. This Plan will provide a roadmap for project partners and other stakeholders to improve conditions, with the ultimate result of "impaired" stream segments to be removed from the 303(d) impaired water list. This Plan should be considered a "living document" that will allow for the incorporation of new information and updated impacts on water quality in the watershed.

2 WATERSHED DESCRIPTION

Due to the low elevation around Pages Creek, much of the surrounding land area is within the 1% annual chance of flood zone, including some houses and local roads adjacent to the water body.

The Pages Creek Watershed lies in northeastern New Hanover County and is part of the White Oak River Basin. The watershed contains numerous residential communities that make up the three major Census Designated Places (CDP) in the watershed: Bayshore, Ogden, and Porters Neck (Figure 1, See Appendix A for GIS Data Sources). The watershed encompasses 5,025 acres and is approximately 17.8% impervious surface. The water in the watershed flows into Pages Creek through tributaries, drainage ditches, and a variety of stormwater control measures which then flows directly into the Atlantic Intracoastal Waterway (AIWW). The percentage of residential and commercial land use has increased throughout the past decade, primarily along US 17, which has led to an increase in the volume of stormwater runoff generated throughout the watershed.

2.1 PHYSICAL AND NATURAL FEATURES

The Pages Creek Watershed flows directly into the AIWW, which is tidally influenced. Areas surrounding the creek have an average elevation of 10 feet above sea level, with the highest elevation within the watershed about 55 feet above sea level (Figure 2). The watershed's 12-digit Hydrologic Unit Code (HUC) is 030203020502 Masonboro Inlet-Mason Inlet (Table 1).

TABLE 1: WATERSHED 12-HUC

Watershed Name	12-HUC	12-HUC Subwatershed Name
Pages Creek	030203020502	Masonboro Inlet-Mason Inlet

Due to the low elevation around Pages Creek, much of the surrounding land area is within the 1% annual chance of flood zone, including some houses and local roads adjacent to the water body. This area is often referred to as the 100-year floodplain since this area has the likelihood of flooding once every 100 years. The 0.2% annual chance of flood zone is relatively small in comparison but extends further into residential areas surrounding the water body (Figure 3).

2.2 NATURAL CHARACTERISTICS

The North Carolina Natural Heritage Program (NCNHP) of the Department of Environmental Quality (DEQ) designates "Natural Areas" as areas of land or water that are important for the conservation of North Carolina's natural biodiversity. The NCNHP identifies these natural areas based on biological surveys by NCNHP

FIGURE 1: PAGES CREEK WATERSHED

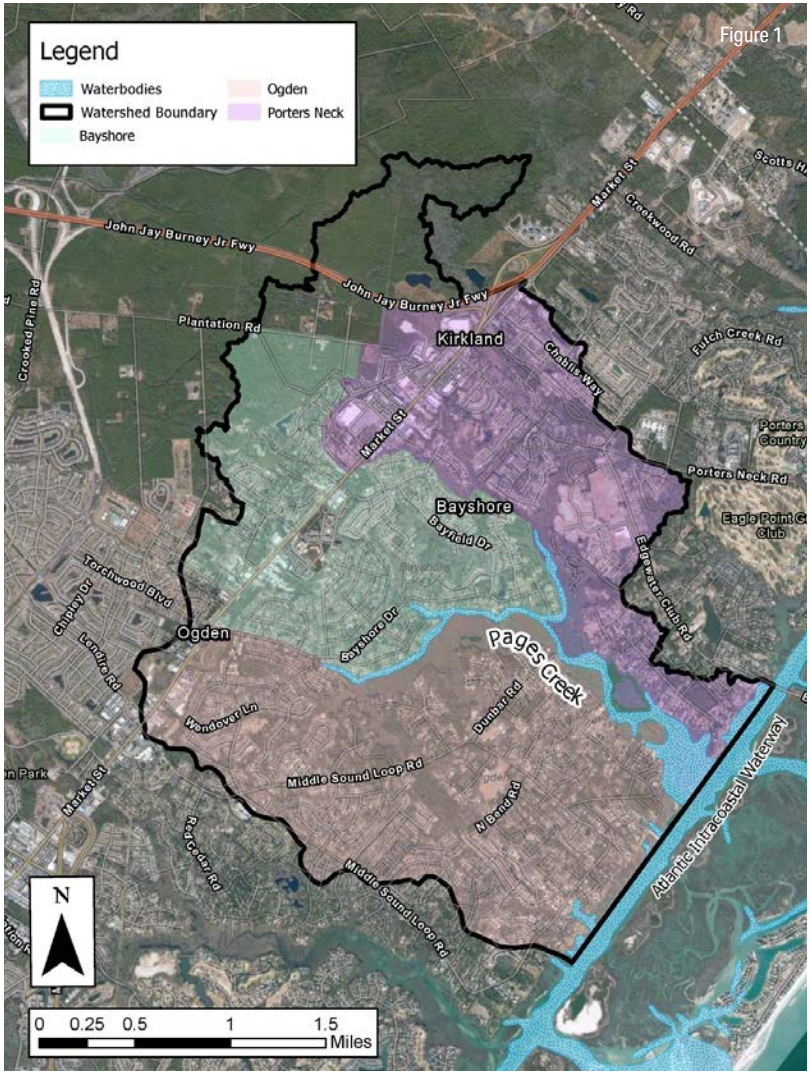
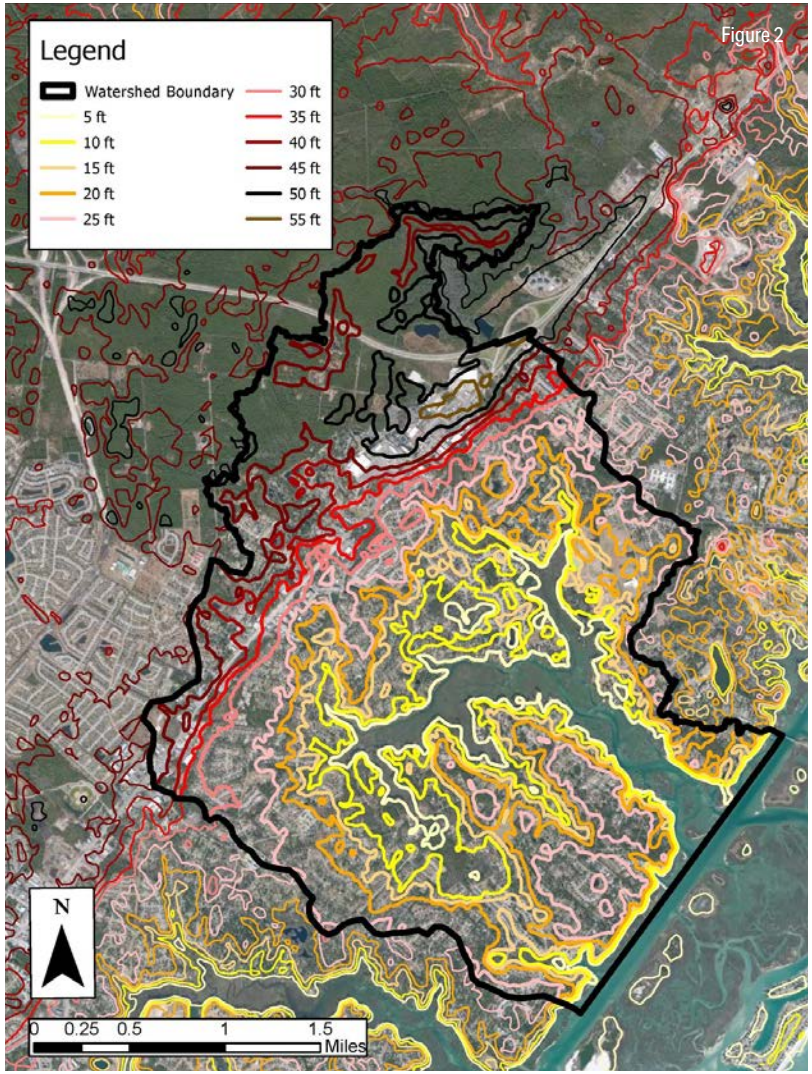


FIGURE 2: (FAR RIGHT) TOPOGRAPHIC MAP OF PAGES CREEK WATERSHED



staff and other professional biologists. The 2,500+ natural areas that the program has identified in North Carolina contain the best rare species populations, habitats, and communities. DEQ targets these conservation areas when planning for restoration projects.

Designated "Managed Areas" under the NCNHP is a diverse collection of properties and easements where conservation of biodiversity and ecosystem function are among the goals of the land management programs. In New Hanover County, greater than 80% of Natural Areas are protected by Managed Areas. Within Pages Creek Watershed specifically, the Pages Creek water body is a designated

FIGURE 3: FLOOD ZONES WITHIN PAGES CREEK WATERSHED

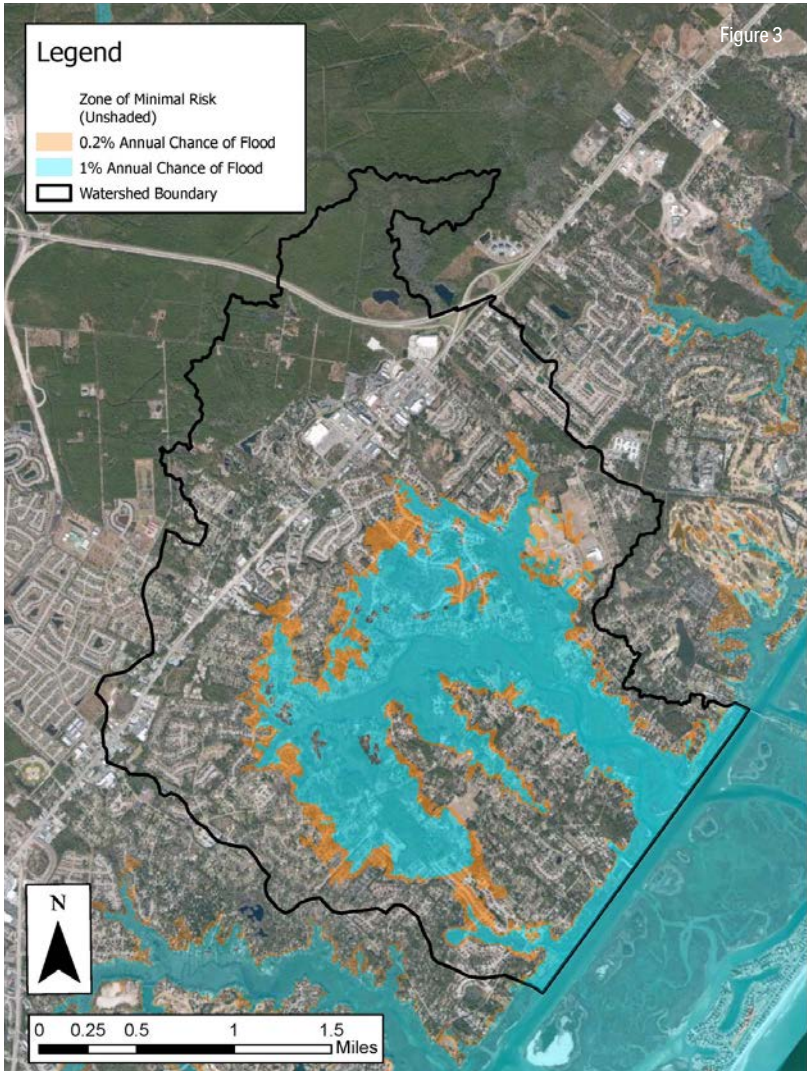
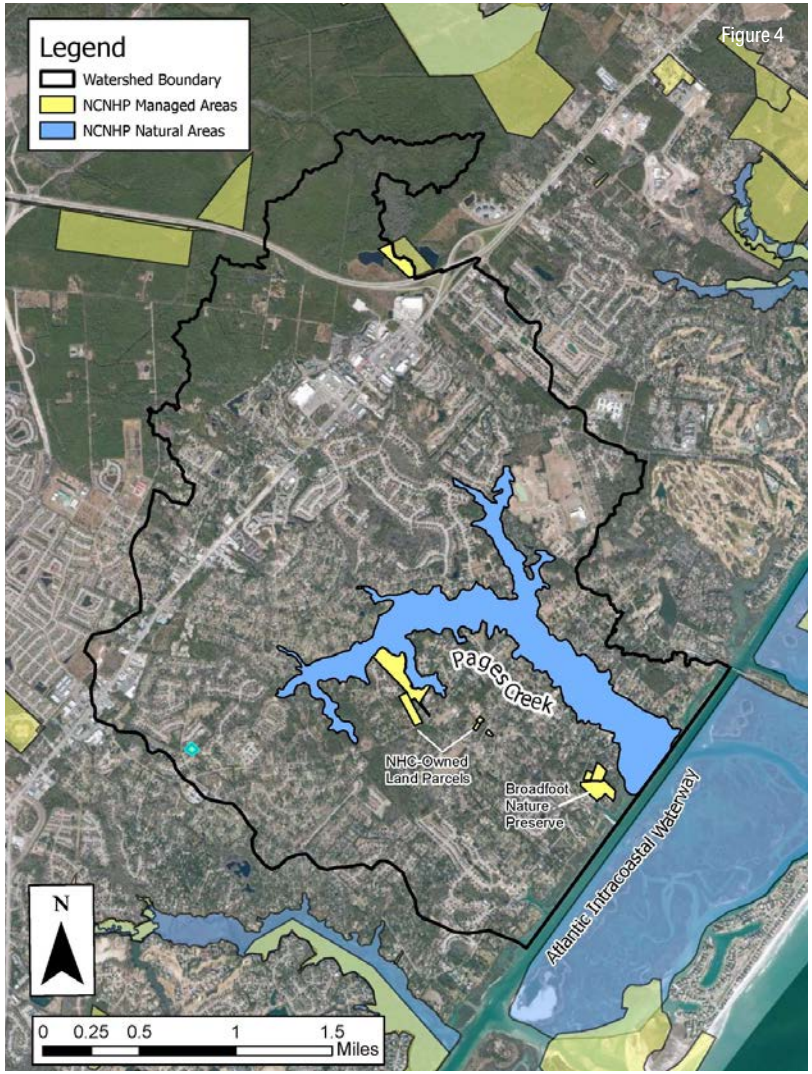


FIGURE 4: (FAR RIGHT) MAP OF DESIGNATED "MANAGED AREAS" AND "NATURAL AREAS" UNDER THE NCNHP



Natural Area under NCNHP but does not contain any Managed Areas. However, there are scattered Managed Areas within the watershed. Managed Areas include Broadfoot Nature Preserve, which is owned by the State, as well as other land parcels owned by New Hanover County that are managed for various uses (Figure 4). such as FEMA Repetitive Loss Properties and the Pages Creek Preserve, a passive nature park. The establishment of the Pages Creek Preserve was made possible through the utilization of clean water trust funds and other county funding (Figure 4).

TABLE 2: SOIL TYPES PER USDA NRCS

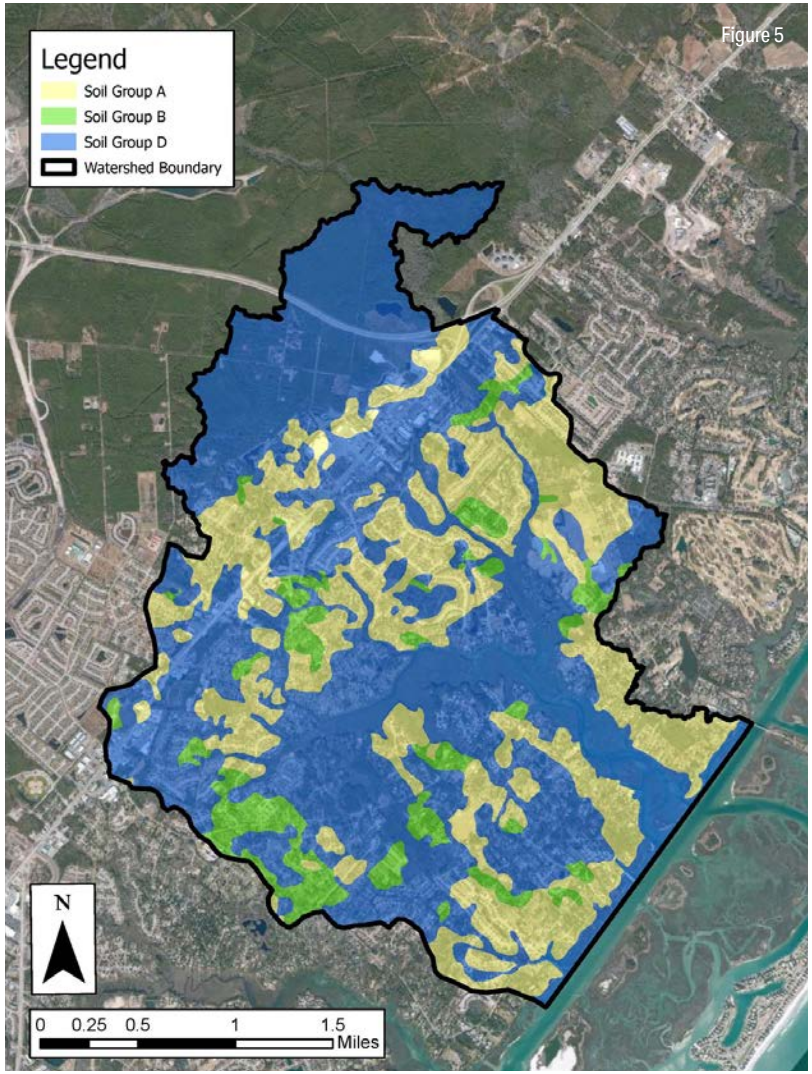
Soil Group	Soil Type	Infiltration Rate	Water Transmission
Group A	Sands, loamy sands, or sandy loams	High when thoroughly saturated	Deep, well to excessively drained sands or gravels with high rate of water transmission
Group B	Silt loams or loams	Moderate when thoroughly saturated	Moderately deep to deep, moderately well to well drained soils with moderately fine to moderately course textures
Group C	Sandy clay loams	Low when thoroughly saturated	Moderately fine to fine texture horizon that impedes downward movement of water
Group D	Clay loams, silty clay loams, sandy clays, silty clays, or clay	Low when thoroughly saturated; highest runoff potential	Nearly impervious material covered by shallow soils under soils with a claypan or clay layer at or near the surface

FIGURE 5: (FAR RIGHT) SOILS MAP OF PAGES CREEK WATERSHED

2.2.1 SOILS

The Natural Resources Conservation Service (NRCS) Web Soil Survey, developed by the U.S. Department of Agriculture (USDA), has designated four hydrologic groups ([HSG]; Groups: A, B, C, and D) based on soil characteristics and infiltration potential. The Pages Creek Watershed is characterized by three different soil types (A, B, and D). Pages Creek is predominantly Group D hydrologic soil, which contains clay and has the highest potential for runoff (Figure 5). Soil surveys are important in determining runoff volume rates and determining sites for potential infiltration projects.

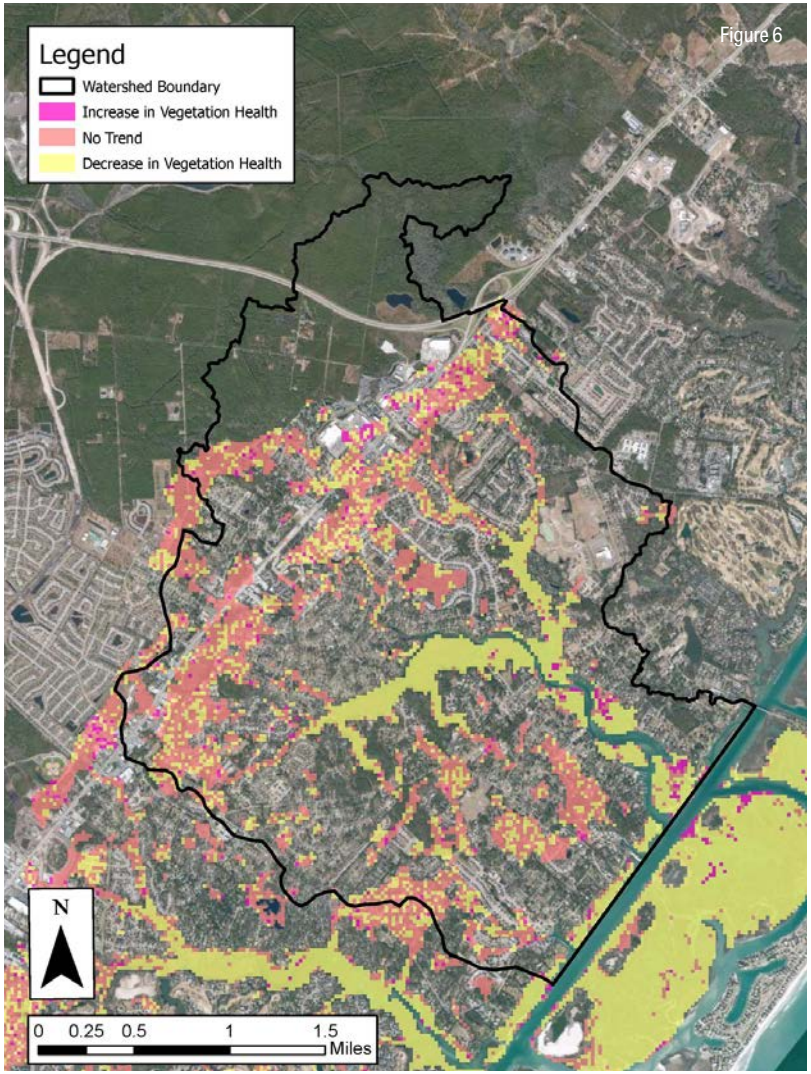
Soils classified under Group A have the highest infiltration potential and are often the quickest draining soils, while soils classified under Group D have the highest runoff potential. It is possible to have a soil type that has characteristics from two hydrologic groups; for example, a soil can be designated as Group A/D, which means it has characteristics of both Group A and Group D. This is due to the changing nature of the soil when it is fully saturated by water. Once a hydraulic threshold is reached, the soil type converts to another HSG because of the change in the soil's available water capacity. Soil group descriptions per USDA NRCS are provided in Table 2.



2.2.2 WETLAND AND VEGETATION HEALTH

Identifying wetlands that are experiencing a decrease in productivity can be useful to understand where management strategies can be introduced to restore vegetation in a watershed. The vegetation's productivity in wetland areas can be identified

FIGURE 6: TRENDS IN OVERALL HEALTH OF VEGETATION OVER A 7-YEAR PERIOD (2014 – 2021) WITHIN PAGES CREEK WATERSHED

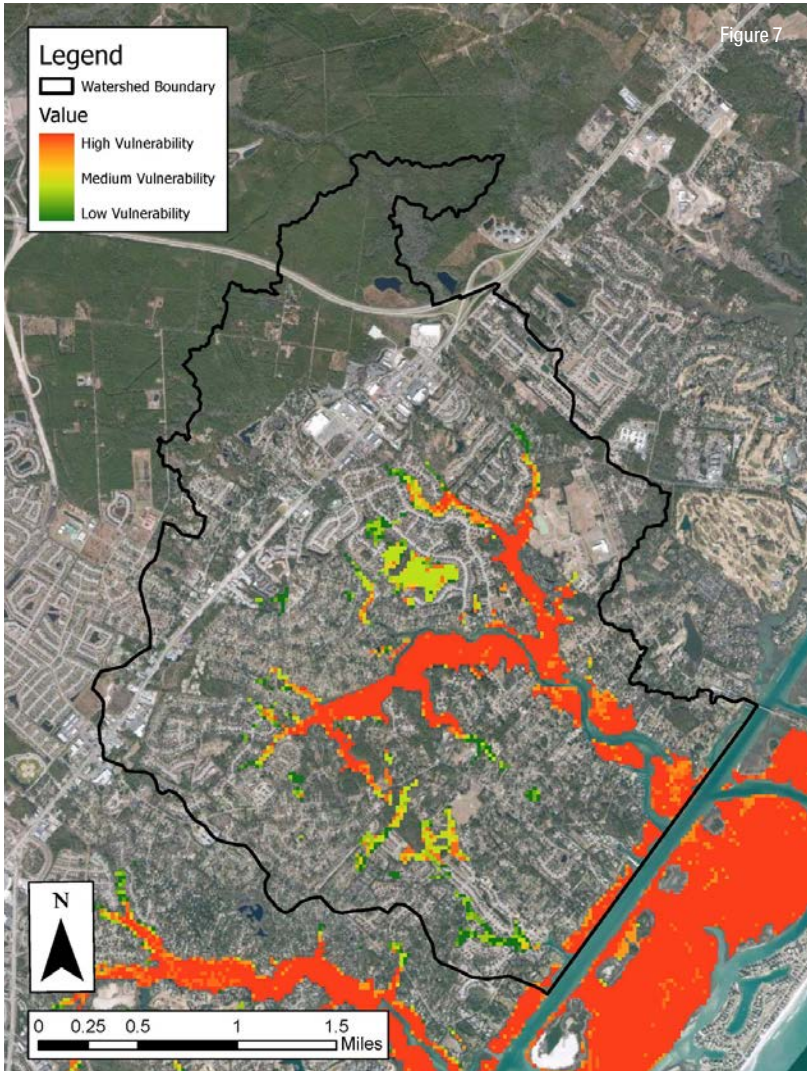


through a vegetative health assessment such as a Normalized Difference Vegetation Index (NDVI). This involves using multispectral imagery, a technique that UNCW Masters' graduate, Greer Shivers, and Dr. Narcisa Pricope, Professor of Geography and Geospatial Science, used in the Pages Creek area (Shivers, et al. 2022). According to their research, NDVI is a widely used index to determine vegetation density based on highlighting the spectral properties of chlorophyll present. Other previous research has shown that assessing the chlorophyll concentrations in vegetation acts as a measure of productivity, as healthy vegetation requires chlorophyll to photosynthesize (Schultz et al., 2016). Shivers, et al. 2022, indicates that using the NDVI method to measure the health of vegetation based on the ability to perform photosynthesis can indicate an ecosystem's sensitivity to hazards. The healthier and more productive the vegetation is in a wetland area, the less sensitive the wetland area will be to hazards such as high tide flooding and sea level rise. Multispectral data was collected over a time period of 7 years, from 2014 – 2021, in Pages Creek Watershed, and the NDVI method was used to calculate trends in overall wetland vegetation health (Figure 6).

Aside from vegetation health, overall wetland vulnerability is a key indicator of where management strategies can best be utilized within a watershed. Shivers, et al. 2022 were able to analyze overall wetland vulnerability within the Pages Creek Watershed. Once the NDVI was calculated, as shown in Figure 6, two additional indices were calculated using multispectral imagery, including Soil-Adjusted Vegetation Index (SAVI), which determines vegetation density, and the Normalized Difference Moisture Index (NDMI), which indicates vegetation moisture levels.

Once the NDVI, SAVI, and NDMI were calculated from the multispectral imagery data, they were combined to obtain an overall health index. This value was then combined with the level of exposure and sensitivity of wetland areas to flood hazards. The result is an index of overall wetland vulnerability. Therefore, areas that are highly vulnerable are those that display both high flood

FIGURE 7: WETLAND VULNERABILITY WITHIN PAGES CREEK WATERSHED (SOURCE: SHIVER, ET AL. 2022)



risk and exposure to flood hazards, as well as decreasing trends in vegetative health. These areas indicate where stormwater management strategies and nature-based solutions to flooding can produce the greatest benefit to the area. Figure 7 displays the overall wetland vulnerability index of wetlands in and around Pages Creek Watershed.

TABLE 3: SIMPLIFIED LAND USE CATEGORIES BY ACREAGE OF THE WATERSHED

Land Use Class	Acreage
Land and Water Areas (undeveloped land, water areas, marshes)	1,593
Agricultural or Forestry	148
Manufacturing (boat and ship construction/lumber)	22
Services (medical offices, government offices, auto repairs, churches, schools, banks)	128
Trade (restaurants, bars, convenience stores, car sales, other retail)	67
Transportations Utilities (gas, self-storage, marinas, utilities)	30
Residential	2,173
Not Coded	864
Total	**5,025**

Source: New Hanover County Comprehensive Plan, 2016

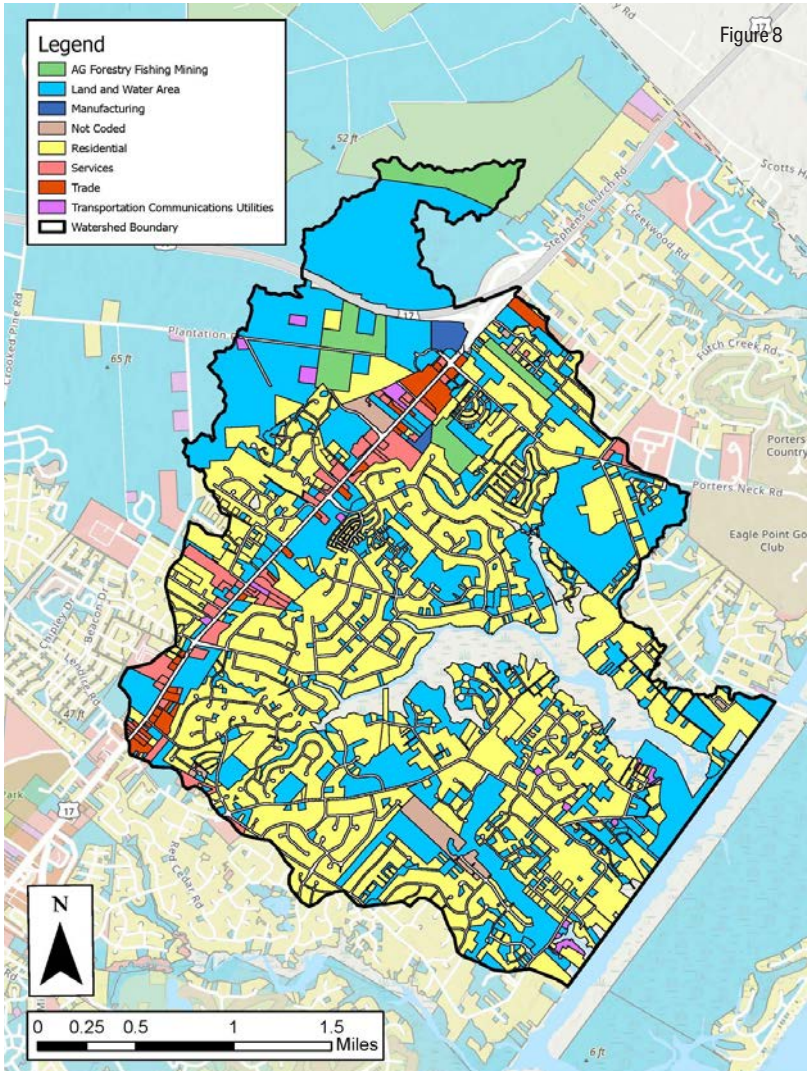
2.3 LAND USE

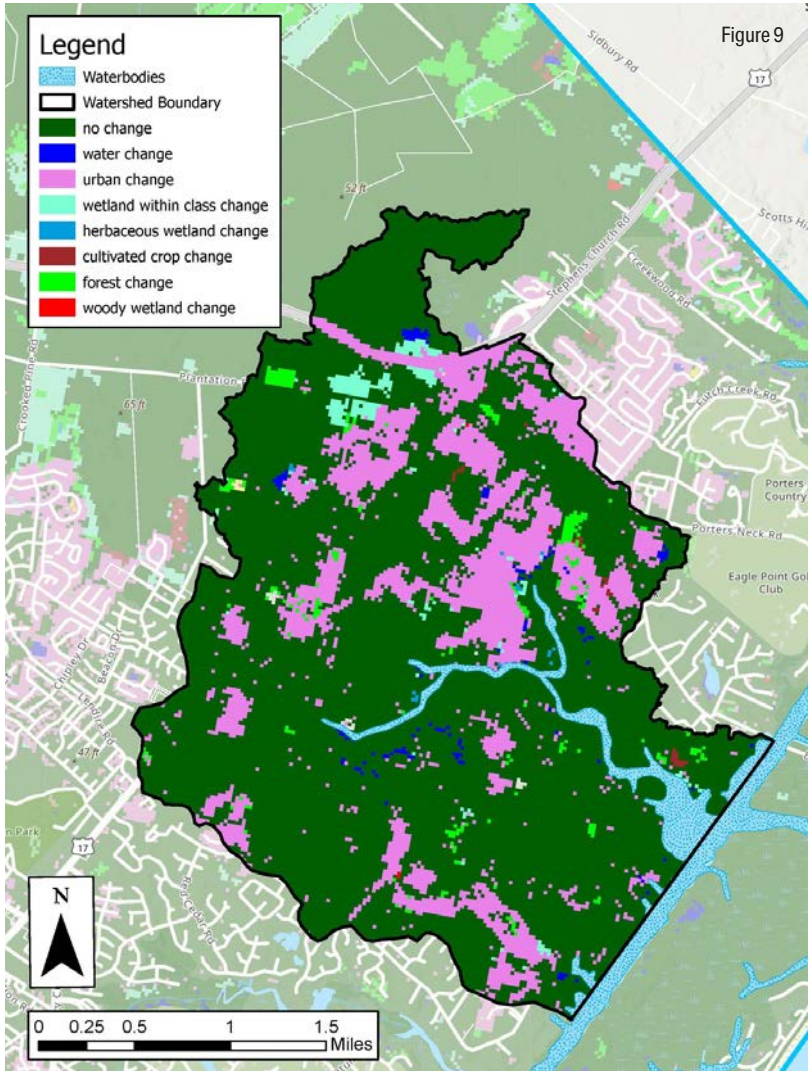
The Pages Creek Watershed contains three major suburbs that are each classified by the U.S. Census Bureau as a CDP: Bayshore, Ogden, and Porters Neck (see Figure 1). Since 1940, New Hanover County's population has more than quadrupled (New Hanover County Comprehensive Plan, 2016). Much of the population growth was seen following completion of Interstate 40 in 1990 and, since then, the areas within and surrounding Pages Creek have become more developed with a variety of residential and commercial properties.

New Hanover County's latest data, derived from 2016 records, reveals that it spans approximately 144,000 acres, encompassing both land and water areas. As stated in the New Hanover County Comprehensive Plan (2016), the land area accounts for around 126,000 acres (87%) of the total. Specifically within the Pages Creek

FIGURE 8: LAND USE CLASSIFICATIONS WITHIN PAGES CREEK WATERSHED

FIGURE 9: (FAR RIGHT) CHANGE IN LAND USAGE (FROM 2001–2019) WITHIN PAGES CREEK WATERSHED





Watershed, nearly 2,173 acres, equivalent to 43% of the watershed, consist of undeveloped land and water areas. Residential is the predominant developed land use within the watershed, as seen in Table 3. Figure 8 provides a visual depiction of the land uses, while Figure 9 displays change in land usage for the past two decades within the Pages Creek Watershed.

Land use changes can be indicative of a shift to or from a land use type or a change in intensity within a particular land use type. For example, "urban change" can indicate a shift from natural area to new urban development in that area or it can indicate a lower

intensity developed area converting to a higher intensity developed area. Increased urban development can contribute to an increased impervious surface area where runoff is generated with little to no opportunities for treatment or infiltration. Development patterns and an impervious surface area are an important consideration when evaluating runoff conditions in the Pages Creek Watershed. Relatively large proportions of impervious areas, particularly "connected" impervious areas that do not route runoff to pervious infiltration areas before draining directly to Pages Creek, can be a prominent indicator of watershed health or impairment.

While exact land use changes for each parcel is unknown at this scale, it is relevant to note that a large portion of Pages Creek Watershed has seen no change in land use for the past two decades.

3 WATERSHED CONDITIONS

Surface waters of the Pages Creek Watershed have been classified by NCDEQ as Class SA, as these waters should be able to support recreational and commercial shellfishing uses.

3.1 WATER QUALITY

The State of North Carolina uses various methods to measure water quality. This Plan integrates two of those methods: NCDEQ's surface water classification system, which is reported on EPA's impaired waters 303(d) list, and swimming usage tier scale system.

NCDEQ's surface water classifications are applied to all water bodies, including streams, rivers, and lakes. These classifications are also called Designated Uses Water Quality Classifications, as they define the best uses to be protected within these waters. For example, a water body may be protected for its drinking water supply or for recreational use, such as swimming or fishing. Both state and federal agencies use surface water classifications to manage and protect all surface waters in North Carolina. Each classification has associated protection rules to protect any special characteristics, as well as standards that are used to determine if the designated uses are being protected (for example, if a water body specifically has fish and wildlife or water quality to protect). Depending on the water body's classification, some types of activities or developments adjacent to the water body may be restricted.

Surface waters of the Pages Creek Watershed have been classified by NCDEQ as Class SA, as these waters should be able to support recreational and commercial shellfishing uses. This classification is outlined in the North Carolina Administrative Code (NCAC), as seen in Table 4. All Class SA waters carry a supplemental designation of High-Quality Water (HQW), and some have the classification of Outstanding Resource Water (ORW) (a subset of HQW). Pages Creek is classified as SA: HQW, and the AIWW, where it feeds into Pages Creek, is classified as SA: ORW (Figure 10). These designations are dependent on the resource value present at the time of classification. HQW indicates waters that are rated excellent based on biological and physical/chemical characteristics or nursery areas designated by the Marine Fisheries Commission, and this classification is intended to give extra protection to valuable freshwater and marine ecosystems. ORWs are intended to protect unique and special waters having excellent water quality and being of exceptional state or national ecological or recreational significance.

Despite the Pages Creek Watershed being classified as SA waters, the watershed has been identified to have poor water quality

TABLE 4: NORTH CAROLINA WATER QUALITY STANDARDS IN CLASS SA WATERS

15A NCAC 2B.0221 specifics on water quality standards in Class SA waters: Shellfishing For waters to be approved as a Class SA area of harvest for direct consumption, the following criteria must be met:	
1	The shoreline survey indicates there are no significant sources of contamination
2	The area is not so contaminated with fecal coliform that consumption of the shellfish might be hazardous
3	The area is not so contaminated with radionuclides or industrial wastes that consumption of the shellfish might be hazardous
4	The median fecal coliform Most Probable Number (MPN) or the geometric mean MPN of water shall not exceed 14 per 100 milliliters, and the 90th percentile shall not exceed 43 per 100 milliliters (per five tube decimal dilution) in those portions of areas most probably exposed to fecal contamination during most unfavorable hydrographic conditions

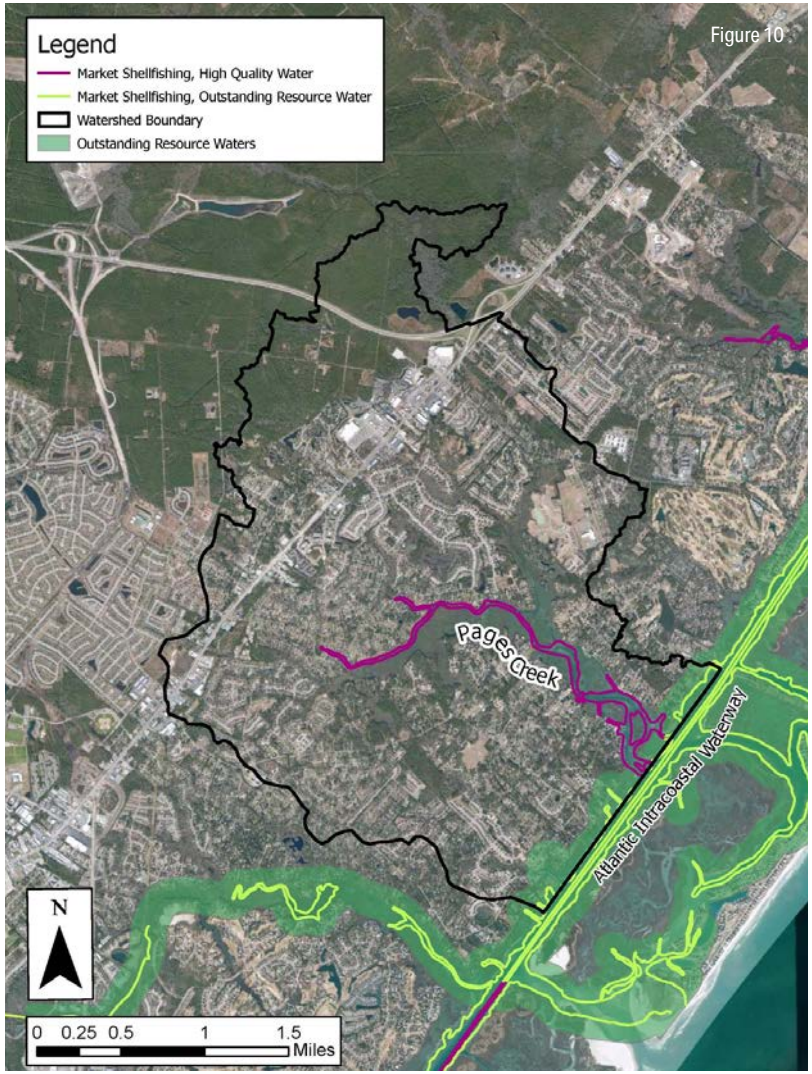


FIGURE 10: (FAR RIGHT) DESIGNATED USES WATER QUALITY CLASSIFICATIONS FOR PAGES CREEK WATERSHED

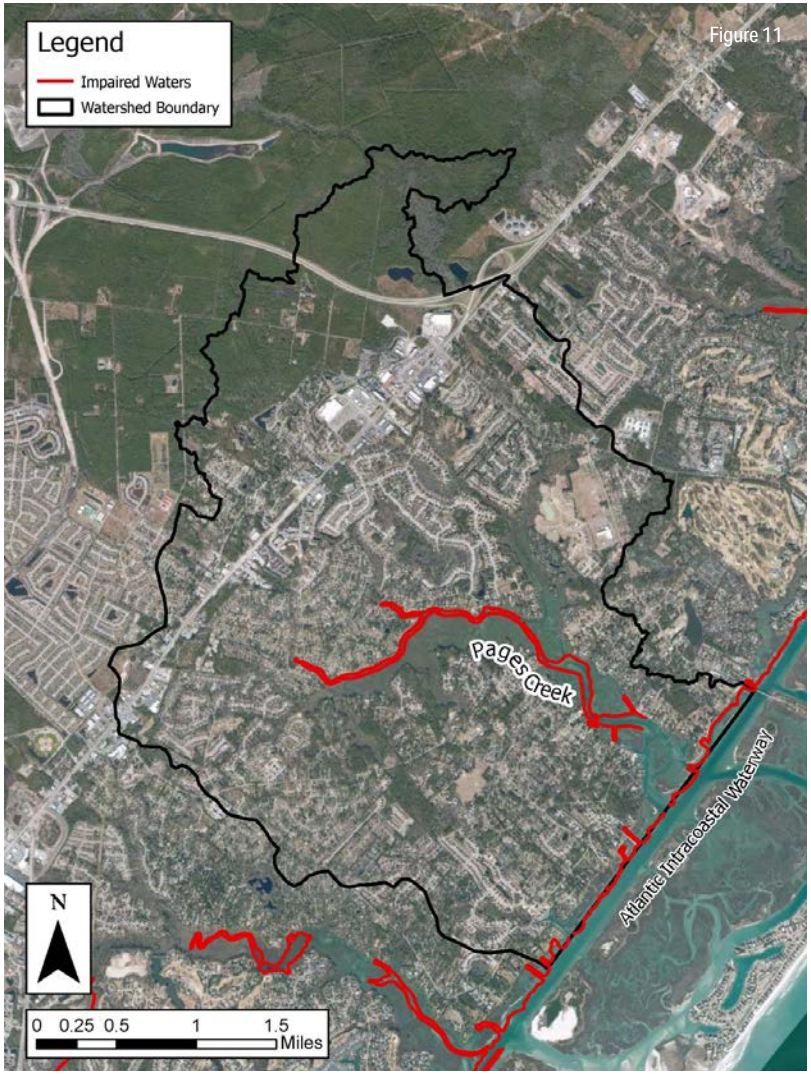
that may affect fish, shellfish, and the community. Under 15A NCAC 2B.0221 specifics on water quality standards in Class SA waters, fecal coliform should not exceed geometric mean 14/100 milliliter (ml), and not more than 10% of samples shall exceed geometric mean 43/100 ml in those areas most exposed to fecal contamination during the most unfavorable hydrologic and pollution conditions (Table 4).

Pages Creek has been listed on EPA's 303(d) list of impaired waters since being identified as exceeding the criteria for impaired waters by NCDEQ in 2002. States may use a variety of ways to determine whether or not a water body meets the water quality standards for the 303(d) list. However, federal regulations say that states must evaluate "all existing and readily available information" in developing their 303(d) lists, meaning that states cannot purposely disregard relevant data regarding water quality. Pages Creek was listed by NCDEQ due to the prohibited shellfish-growing area status resulting from fecal coliform bacteria (NCDEQ) (Figure 11).

3.1.1 SHELLFISH CLOSURES

Section 303(d) of the Clean Water Act requires that states assess surface waters and compile a list of those that have become polluted to the point that they no longer support their use classification. Each monitored waterbody in North Carolina receives an assessment every two years and is categorized into EPA's 303(d) list integrated report categories. The assessment is conducted

FIGURE 11: DESIGNATED IMPAIRED WATERS ON THE 303(D) LIST IN PAGES CREEK WATERSHED



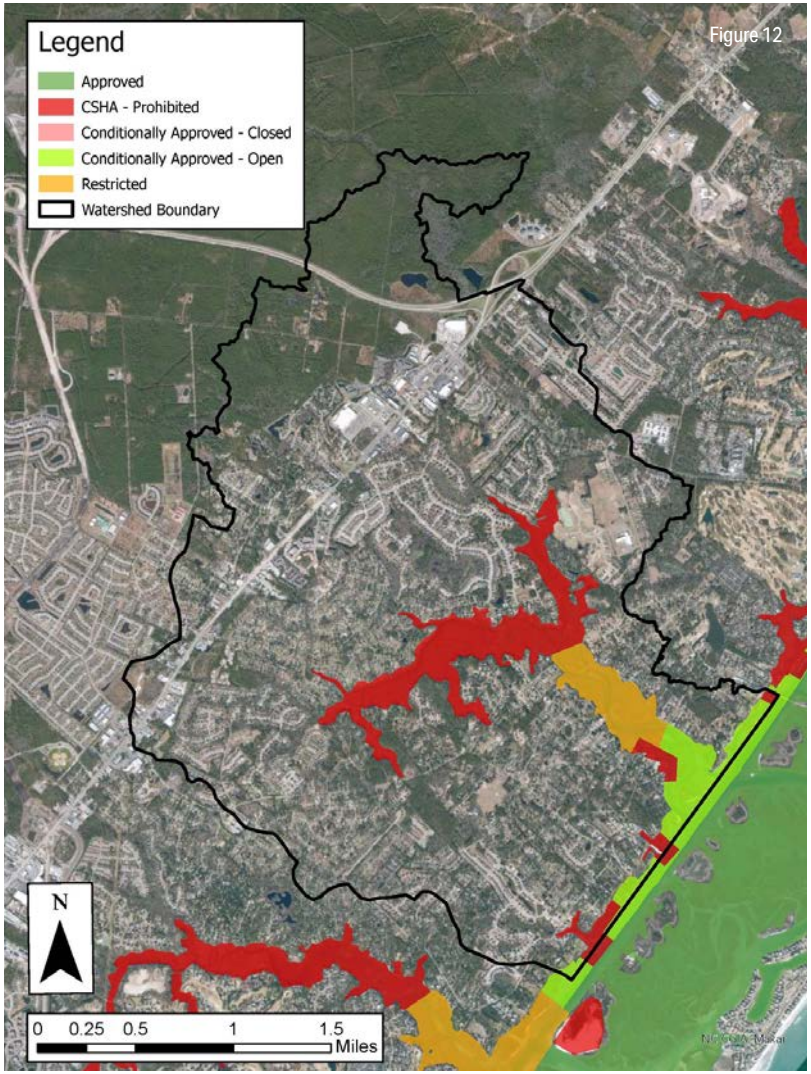
through collecting water quality data and comparing each water quality sample collected to the appropriate North Carolina water quality standard. Stormwater runoff can contain high bacterial counts, and the continuation of high counts throughout Pages Creek has degraded water quality to a level that no longer meets the standards for the water's designated uses (Figure 12). This has led to waters within the watershed being placed on the 303(d) list, where Pages Creek is listed as a Category 5 Impaired Waterway (see Table 5). All states are required by Section 303(d) to develop a Total Maximum Daily Load (TMDL) program for water bodies that are impaired (too polluted to maintain their beneficial uses).

The North Carolina Division of Marine Fisheries (NCDMF) is responsible for classification of all coastal waters for suitability of shellfish harvesting, specifically for human consumption.

TABLE 5: TABLE 5. EPA 303(D) LIST INTEGRATED REPORT CATEGORIES

Category/ Subcategory	Description
Category 1	Meets tested standards for clean water. All designated uses are supported, no use is threatened
Category 2	Waters of concern. Available data and/or information indicate that some, but not all, designated uses are supported
Category 3	Insufficient data. There is insufficient available data and/or information to use to support a determination
Category 4	Polluted waters that do not require a TMDL. Available data and/or information indicate that at least one designated use is not being supported or is threatened, but a TMDL is not needed
Category 4a	Has a TMDL. A state-developed TMDL has been approved by EPA or a TMDL has been established by EPA for any segment-pollutant combination
Category 4b	Has a pollution control program. Other required control measures are expected to result in attainment of an applicable water quality standard in a reasonable period of time
Category 4c	Is impaired by a non-pollutant. The non-attainment of any applicable water quality standard for the segment is the result of pollution and is not caused by a pollutant
Category 5	Polluted waters that require a TMDL or other Water Quality Improvement project. Available data and/or information indicate that at least one designated use is not being supported or is threatened and a TMDL is needed

FIGURE 12: SHELLFISH HARVEST CLASSIFICATIONS OF WATERBODIES IN PAGES CREEK WATERSHED



Shellfish-growing waters within the state can receive one of four classifications: Prohibited, Restricted, Approved, or Conditionally Approved (furthermore, areas classified as Conditionally Approved can then be deemed "open" or "closed" temporarily).

- Prohibited areas are completely off limits for shellfish harvesting.
- Restricted areas are areas in which the waters can be used for harvest at certain times as long as the shellfish are subjected to further cleansing prior to being readily available for human consumption.
- Approved areas are areas that are consistently open to shellfish harvesting.
- Conditionally Approved areas are areas in which the waters are open to shellfish harvesting only temporarily under certain conditions. Conditions for approval may include dry weather when stormwater runoff is not having an impact on surrounding water quality or other unique conditions as seen fit by NCDMF.

Since 2007, the New Hanover Water Quality Monitoring Program has been assessing water quality conditions within Pages Creek. Pages Creek is monitored monthly at three locations to characterize the creek's physical, chemical, and biological conditions, including turbidity, dissolved oxygen, chlorophyll-a, and enterococci. Pages Creek has maintained a "Poor" enterococci rating during most of the last 12 years. The 2021–2022 water quality monitoring report can be accessed at 2021-2022 Final Report (nhcgov.com).

As of March 2023, the New Hanover County Water Quality Monitoring Program submitted a budget amendment request to conduct additional l water quality testing in the Pages Creek Watershed to target the geographic location of bacteria entering into the creek. Specifically, this funding will enable the County to take two samples each from 20 new monitoring sites. The County plans to test these additional sites to identify where inputs of pollutants into Pages Creek are coming from and narrow in on a smaller geographic area in which to focus water quality management strategies on the future. The three current monitoring sites can be seen in Figure 14. Figure 13, displays the enterococci

FIGURE 13: ENTEROCOCCI RATING FOR PAGES CREEK DURING ALL REPORTING PERIODS

Source: New Hanover County Planning Department

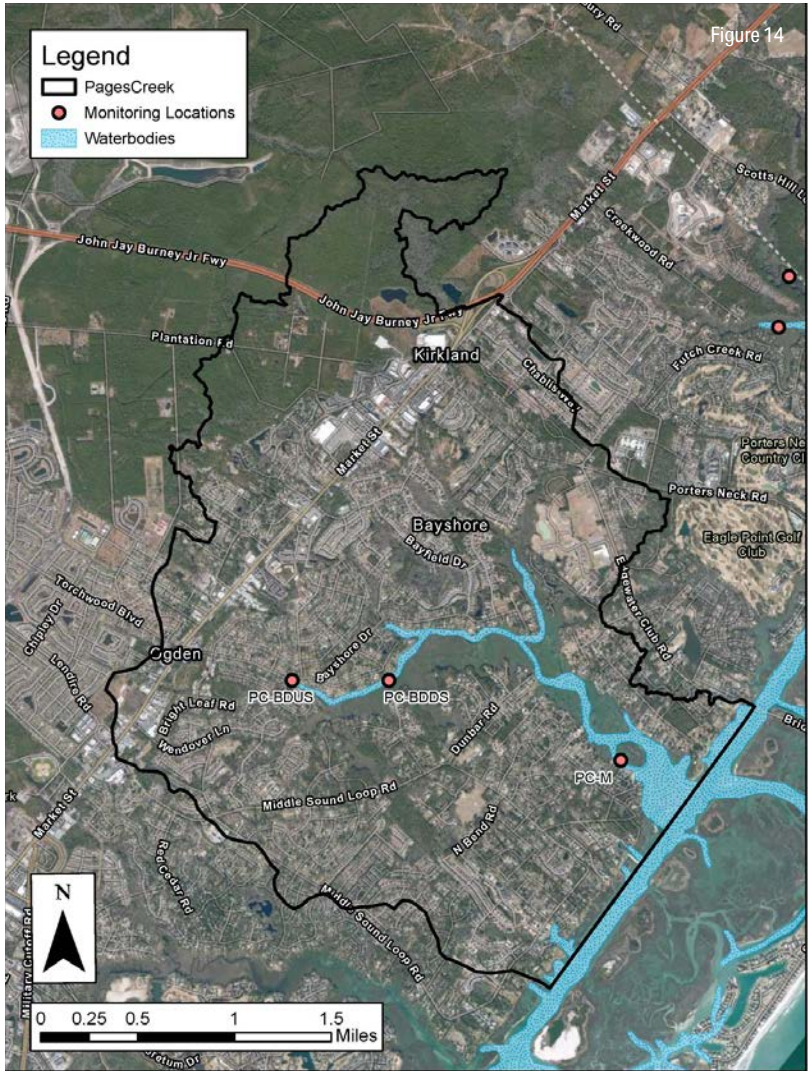
Study Period	Barnards Creek	Futch Creek	Lords Creek	Mott Creek	Pages Creek	Prince George Creek	Smith Creek
2008-2009	POOR	GOOD	FAIR	POOR	POOR	FAIR	POOR
2009-2010	POOR	GOOD	POOR	POOR	POOR	POOR	POOR
2010-2011	POOR	GOOD	GOOD	POOR	FAIR	POOR	POOR
2011-2012	POOR	GOOD	GOOD	POOR	POOR	POOR	POOR
2012-2013	POOR	GOOD	FAIR	POOR	POOR	POOR	POOR
2013-2014	GOOD	GOOD	GOOD	POOR	POOR	POOR	FAIR
2014-2015	GOOD	GOOD	GOOD	POOR	POOR	POOR	FAIR
2015-2016	POOR	FAIR	FAIR	POOR	POOR	POOR	FAIR
2016-2017	GOOD	GOOD	GOOD	FAIR	POOR	GOOD	FAIR
2017-2018	FAIR	FAIR	POOR	FAIR	POOR	POOR	POOR
2018-2019	FAIR	GOOD	FAIR	FAIR	FAIR	GOOD	GOOD
2019-2020	GOOD	GOOD	GOOD	FAIR	FAIR	GOOD	GOOD
2020-2021	GOOD	GOOD	GOOD	FAIR	POOR	FAIR	GOOD

rating for Pages Creek watershed based on all water samples across all three sites.

The two monitoring sites found in the proximity of the Bayshore Community Pages Creek Up-Stream Site (PC-BDUS) and Pages Creek Down-Stream Site (PC-BDDS) have consistently reported relatively high levels of enterococci bacteria over time since 2008. Specifically, since the start of the Water Quality Monitoring Program enterococci sampling data reporting in 2008, these sites have exceeded the State standard for enterococci 37% of the time. The upstream site, PC-BDUS, has displayed the most elevated level occurrences, followed by the downstream site, PC-BDDS.

Although enterococci data has been reported in New Hanover County since 2008, annual water quality reports have been published for the tidal creeks in the County since 1993. Since the start of these reports, chlorophyll-a, which is seen as a response to nutrient loading, has often surpassed the State standard of 40 parts per billion at both the PC-BDUS and PC-BDDS sites. These incidents most often occurred in summer months and near the creek's headwaters; this can be due to the proximity to nutrient

FIGURE 14: (FAR RIGHT) EXISTING WATER QUALITY MONITORING STATIONS, NEW HANOVER COUNTY WATER QUALITY MONITORING PROGRAM



sources and/or slower-moving waters upstream. Both monitoring stations receive drainage from established residential areas, which has been the case since prior to 1993 when this data was reported.

Additionally, incidents of hypoxia were reported from at least one of either of these two sites, and in some cases, both sites every

In Pages Creek, urban developments and utilities located upstream are all potential nonpoint sources of pollution, particularly the three lift stations and the public boat ramp

year since 1993. Looking at long-term trends from 1993 to 2001, as noted in the 2006-2007 report, overall water quality saw a decline as fecal coliform bacteria levels were increasing year over year and dissolved oxygen levels had decreased. Additionally, in the most recent 2021–2022 annual report, it was reported that enterococci levels are generally decreasing without human intervention.

3.2 SOURCE ASSESSMENT

The primary source being addressed through this Plan will be stormwater runoff, which is typically associated with water quality impairment.

3.2.1 NONPOINT SOURCE ASSESSMENT

New Hanover County reports that due to the flushing activity of the Atlantic Intracoastal Waterway and the fact that upstream areas of Pages Creek are closer to anthropogenic pollution sources and are, therefore, less well flushed, water quality upstream is often considerably poorer than in downstream areas. In Pages Creek, urban developments and utilities located upstream are all potential nonpoint sources of pollution, particularly the three lift stations and the public boat ramp (Figure 20). Due to rapid urban development and alteration of natural hydrology within the watershed, bacterial pollutants have been found to be the primary issue of poor water quality, as reported in water quality assessments and shellfish sanitation reports. Stormwater control measures began to be implemented within the watershed in 2001.However, areas such as Bayshore and the surrounding residential areas of Ogden/Middle Sound Loop Road were predominantly constructed prior to the implementation of state stormwater regulations. Consequently, these areas lack the modern controls found in more recent developments. Difficulty in preventing violations of bacteria standards for coastal waters caused by stormwater runoff is compounded by the unique challenges related to coastal hydrology and bacteria pollution. These are:

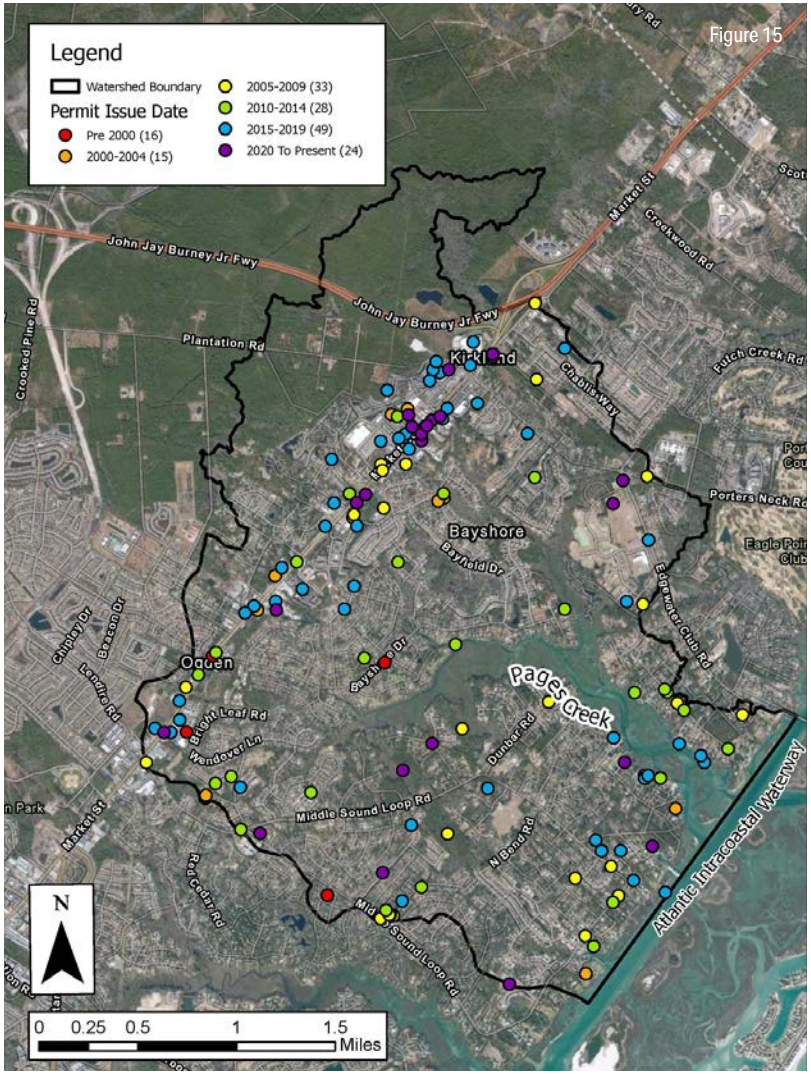
1. The two bacteria used as indicators of water quality—fecal coliform and enterococcus—naturally occur across the terrestrial landscape. These bacteria are found in the feces of warm-blooded animals such as birds, deer, raccoons, and domestic pets. Although measures should be taken to reduce the sources of bacteria, these efforts alone will not result in satisfactory improvements in coastal water quality due to elevated levels of stormwater being discharged.
2. Treating stormwater runoff to remove bacteria pollution before it flows into shellfishing and swimming waters can be difficult
3. Treated runoff can easily be recontaminated. Due to the ubiquitous nature of bacteria, treated runoff can simply pick up more bacteria once discharged back onto the landscape.

A more practical approach can be to reduce the amount of stormwater running off and entering waterways. Stormwater runoff can convey a variety of pollutants due to a variety of causes. Potential nonpoint sources range from animal sources to connected conveyance systems.

3.2.2 POINT SOURCES

Point sources of pollution, unlike nonpoint sources, can be any individual, identifiable source where pollutants are discharged. The input of pollutants from point sources into water bodies causes direct and obvious impairments to water quality—both at the direct site of input and in water downstream from it. Similar to nonpoint sources, impacts from point sources can often be lessened or mitigated through management strategies, but with the advantage of being more easily identifiable. Their identifiable nature can also

FIGURE 15: STATE-ISSUED STORMWATER PERMITS IN PAGES CREEK WATERSHED



make measuring the success of management strategies easier or more efficient.

As of 2022, NCDEQ has issued 165 state stormwater permits within Pages Creek Watershed since 1988, the start of stormwater permit records in the area (Figure 15). Many of these permits were issued for developments that overlap. Examining stormwater permits can help to understand development trends in an area, given that a new development requires the issuance of a permit. An analysis of stormwater permits issued over time at 5-year intervals in the Pages Creek Watershed results in an increasing trend observed from the early 2000s to present day, indicating an increasing trend in land development in the area. There are no permitted wastewater discharges or National Pollutant Discharge Elimination System (NPDES) Permits within the watershed.


NEW HANOVER COUNTY • NORTH CAROLINA
• ESTABLISHED 1729 •
PAGES CREEK
PRESERVE
PARK HOURS
8 AM - SUNSET
No Smoking

4 RUNOFF VOLUME REDUCTION

Stormwater runoff passes over the landscape and can collect nutrients and bacteria before discharging to open waters throughout the watershed.

Stormwater runoff behavior throughout a watershed is a factor of land use, impervious percentage, soil type, and conveyance patterns. Land use and soil types that allow for ample infiltration cause rainwater to be absorbed and pollutants to be filtered into the ground, while land use types with a higher percentage of impervious area and soil types that do not have high infiltration capacities cause more water to be transported over the ground and through conveyance systems. This excess water that does not infiltrate following a storm event is referred to as stormwater runoff. Stormwater runoff passes over the landscape and can collect nutrients and bacteria before discharging to open waters throughout the watershed. Reducing stormwater runoff volumes can be an effective method of reducing pollutant loads.

Watershed hydrologic conditions can be quantified based on land use and soils data. Hydrologic conditions were evaluated for two scenarios: baseline conditions and current conditions. The baseline condition was two-fold, comprised of 2 years during which healthier watershed conditions were present and, as a result, Pages Creek was not included in the 303(d) Listed and Impaired Waters Program. Selected baseline years are 2001 and 2006; in 2001, Pages Creek was not listed as an impaired waterway and in 2006 Pages Creek began to be listed as an impaired waterway and was closed to shellfish harvesting. Existing (2023) watershed conditions can be compared to conditions in 2001 and 2006 to estimate the magnitude of runoff volume reduction needed to return the Pages Creek Watershed to pre-impairment runoff conditions.

Utilizing aerial imagery and the New Hanover County Comprehensive Plan, the watershed was delineated into one of the following land use classifications (Table 6) for both baseline conditions and current conditions.

Soil and land use data from 2001, 2006, and 2019 (the latest available year) was used to generate runoff curve numbers that help characterize stormwater runoff behavior. The curve numbers in Table 7 were used in the analysis.

The standardized Watershed EZ Form developed by the North Carolina Coastal Federation and WithersRavenel was used to calculate the stormwater runoff volume reduction. A 1.5-inch precipitation depth was used to generate a runoff hydrograph that describes runoff flows in the watershed over the course of the "first

TABLE 6: LAND USE CLASSIFICATIONS FOR BOTH BASELINE AND CURRENT CONDITIONS

Land Use Classification	Description
Barren Land	Areas of bedrock desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits, and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of cover
Cultivated Crops	Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled
Deciduous Forest	Areas dominated by trees generally greater than 5 meters tall and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change
Developed, High Intensity	Highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses, and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover
Developed, Low Intensity	Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units
Developed, Medium Intensity	Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units
Developed, Open Space	Areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes
Emergent Herbaceous Wetlands	Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water
Evergreen Forest	Areas dominated by trees generally greater than 5 meters tall and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage
Grassland/Herbaceous	Areas dominated by gramanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling but can be utilized for grazing
Mixed Forest	Areas dominated by trees generally greater than 5 meters tall and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover
Open Water	Areas of open water, generally with less than 25% cover of vegetation or soil
Pasture/Hay	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation
Shrub/Scrub	Areas dominated by shrubs less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage, or trees stunted from environmental conditions
Woody Wetlands	Areas where forest or shrubland vegetation account for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water with high water table or standing water. See classification 50 for dry conditions

flush" water quality event. Research shows the "first flush" volume is the most contaminated volume of stormwater runoff during storm events. Within coastal counties, permitted stormwater systems are designed to handle the "first flush" water quality event. Therefore, these systems release off site only what is permitted and are not accounted for in the below calculations. The total precipitation

TABLE 7: CURVE NUMBERS USED TO ANALYZE STORMWATER RUNOFF BEHAVIOR

Land Use Classification	Soil Characteristics			
	A	B	C	D
Barren Land	70	81	N/A	92
Cultivated Crops	62	74	N/A	86
Deciduous Forest	30	N/A	N/A	77
Developed, High Intensity	88	92	N/A	94
Developed, Low Intensity	81	88	N/A	93
Developed, Medium Intensity	84	89	N/A	94
Developed, Open Space	52	68	N/A	84
Emergent Herbaceous Wetlands	80	80	N/A	80
Evergreen Forest	30	55	N/A	77
Grassland/Herbaceous	39	63	N/A	85
Mixed Forest	30	55	N/A	77
Open Water	98	98	N/A	98
Pasture/Hay	40	61	N/A	79
Shrub/Scrub	30	42	N/A	62
Woody Wetlands	86	86	N/A	86

depth and Pages Creek Watershed area can also be used to calculate the total stormwater runoff volume anticipated during the storm event. The volume differences between baseline (2001 and 2006) and current (2023) conditions can be calculated to determine the amount of stormwater runoff that must be eliminated in order to mimic baseline runoff conditions.

4.1 RUNOFF CALCULATIONS

A summary of the curve numbers used for the 2001 baseline, 2006 baseline, and current conditions is presented below in Tables 8-10.

Figure 16 shows stormwater runoff hydrographs for baseline (2001) and current (2023) conditions based on the 1.5-inch rainfall event.

TABLE 8: CURVE NUMBERS USED FOR 2001 BASELINE CONDITIONS

HSG	Land Use	CN	Area (acres)	%
User Defined Land Uses				
A	Barren Land	70.00	5.74	0%
B	Barren Land	81.00	0.42	0%
D	Barren Land	92.00	1.75	0%
A	Cultivated Crops	62.00	91.34	2%
B	Cultivated Crops	74.00	10.87	0%
D	Cultivated Crops	86.00	36.31	1%
A	Deciduous Forest	30.00	0.10	0%
D	Deciduous Forest	77.00	0.50	0%
A	Developed, High Intensity	88.00	6.05	0%
D	Developed, High Intensity	94.00	20.58	0%
A	Developed, Low Intensity	81.00	358.16	7%
B	Developed, Low Intensity	88.00	110.33	2%
D	Developed, Low Intensity	93.00	386.67	8%
A	Developed, Medium Intensity	84.00	58.84	1%
B	Developed, Medium Intensity	89.00	3.25	0%
D	Developed, Medium Intensity	94.00	113.49	2%
A	Developed, Open Space	52.00	397.11	8%
B	Developed, Open Space	68.00	117.99	2%
D	Developed, Open Space	84.00	446.36	9%
A	Emergent Herbaceous Wetlands	80.00	17.72	0%
B	Emergent Herbaceous Wetlands	80.00	2.82	0%
D	Emergent Herbaceous Wetlands	80.00	197.25	4%

Figure 17 shows runoff hydrographs for baseline (2006) and current (2023) conditions based on the 1.5-inch rainfall event. Table 11 compares runoff flows and volumes between baseline and current conditions.

HSG	Land Use	CN	Area (acres)	%
A	Evergreen Forest	30.00	395.89	8%
B	Evergreen Forest	55.00	101.08	2%
D	Evergreen Forest	77.00	596.70	12%
A	Grassland/Herbaceous	39.00	7.52	0%
B	Grassland/Herbaceous	63.00	2.65	0%
D	Grassland/Herbaceous	85.00	19.95	0%
A	Mixed Forest	30.00	9.84	0%
B	Mixed Forest	55.00	1.46	0%
D	Mixed Forest	77.00	2.27	0%
A	Open Water	98.00	7.15	0%
B	Open Water	98.00	0.15	0%
D	Open Water	98.00	268.93	5%
A	Pasture/Hay	40.00	2.29	0%
B	Pasture/Hay	61.00	0.20	0%
D	Pasture/Hay	79.00	5.06	0%
A	Shrub/Scrub	30.00	139.38	3%
B	Shrub/Scrub	42.00	22.99	0%
D	Shrub/Scrub	62.00	120.02	2%
A	Woody Wetlands	86.00	60.85	1%
B	Woody Wetlands	86.00	15.16	0%
D	Woody Wetlands	86.00	860.68	17%
Total Drainage Area (ac):				**5023.9**

TABLE 9: CURVE NUMBERS USED FOR 2006 BASELINE CONDITIONS

HSG	Land Use	CN	Area (acres)	%
User Defined Land Uses				
A	Barren Land	70.00	4.41	0%
B	Barren Land	92.00	0.20	0%
D	Barren Land	62.00	1.90	0%
A	Cultivated Crops	74.00	48.32	1%
B	Cultivated Crops	86.00	3.03	0%
D	Cultivated Crops	30.00	25.87	1%
A	Developed, High Intensity	88.00	9.51	0%
B	Developed, High Intensity	92.00	0.32	0%
D	Developed, High Intensity	94.00	30.36	1%
A	Developed, Low Intensity	81.00	440.02	9%
B	Developed, Low Intensity	88.00	124.97	2%
D	Developed, Low Intensity	93.00	453.97	9%
A	Developed, Medium Intensity	84.00	123.42	2%
B	Developed, Medium Intensity	89.00	10.06	0%
D	Developed, Medium Intensity	94.00	167.82	3%
A	Developed, Open Space	52.00	525.18	10%
B	Developed, Open Space	68.00	137.08	3%
D	Developed, Open Space	84.00	572.55	11%
A	Emergent Herbaceous Wetlands	80.00	20.48	0%
B	Emergent Herbaceous Wetlands	80.00	3.93	0%
D	Emergent Herbaceous Wetlands	80.00	221.67	4%
A	Evergreen Forest	30.00	227.10	5%
B	Evergreen Forest	55.00	73.84	1%
D	Evergreen Forest	77.00	445.67	9%
A	Grassland/Herbaceous	39.00	24.23	0%
B	Grassland/Herbaceous	63.00	8.83	0%
D	Grassland/Herbaceous	85.00	31.46	1%
A	Mixed Forest	30.00	0.72	0%
D	Mixed Forest	55.00	0.61	0%
A	Open Water	98.00	5.09	0%
B	Open Water	98.00	0.30	0%
D	Open Water	98.00	271.18	5%

HSG	Land Use	CN	Area (acres)	%
A	Pasture/Hay	40.00	1.98	0%
B	Pasture/Hay	61.00	0.20	0%
D	Pasture/Hay	79.00	6.31	0%
A	Shrub/Scrub	30.00	79.99	2%
B	Shrub/Scrub	42.00	14.32	0%
D	Shrub/Scrub	62.00	86.12	2%
A	Woody Wetlands	86.00	46.84	1%
B	Woody Wetlands	86.00	13.36	0%
D	Woody Wetlands	86.00	762.17	15%
Total Drainage Area (ac):				**5025.4**

TABLE 10: CURVE NUMBERS USED FOR 2019 CURRENT CONDITIONS

HSG	Land Use	CN	Area (acres)	%
User Defined Land Uses				
A	Barren Land	70.00	5.28	0%
D	Barren Land	92.00	4.72	0%
A	Cultivated Crops	62.00	41.63	1%
B	Cultivated Crops	74.00	2.28	0%
D	Cultivated Crops	86.00	19.11	0%
A	Deciduous Forest	30.00	0.22	0%
A	Developed, High Intensity	88.00	31.44	1%
B	Developed, High Intensity	92.00	2.65	0%
D	Developed, High Intensity	94.00	50.40	1%
A	Developed, Low Intensity	81.00	470.04	9%
B	Developed, Low Intensity	88.00	135.31	3%
D	Developed, Low Intensity	93.00	506.21	10%
A	Developed, Medium Intensity	84.00	191.94	4%
B	Developed, Medium Intensity	89.00	31.29	1%
D	Developed, Medium Intensity	94.00	245.44	5%
A	Developed, Open Space	52.00	480.54	10%
B	Developed, Open Space	68.00	132.21	3%
D	Developed, Open Space	84.00	562.80	11%
A	Emergent Herbaceous Wetlands	80.00	19.49	0%
B	Emergent Herbaceous Wetlands	80.00	3.12	0%
D	Emergent Herbaceous Wetlands	80.00	191.04	4%
A	Evergreen Forest	30.00	211.35	4%
B	Evergreen Forest	55.00	55.71	1%
D	Evergreen Forest	77.00	382.91	8%
A	Grassland/Herbaceous	39.00	6.20	0%
B	Grassland/Herbaceous	63.00	4.37	0%
D	Grassland/Herbaceous	85.00	16.79	0%
A	Mixed Forest	30.00	0.92	0%
B	Mixed Forest	55.00	0.34	0%
A	Open Water	98.00	4.40	0%
B	Open Water	98.00	0.30	0%
D	Open Water	98.00	270.93	5%
A	Pasture/Hay	40.00	3.32	0%
B	Pasture/Hay	61.00	0.20	0%
D	Pasture/Hay	79.00	5.84	0%
A	Shrub/Scrub	30.00	46.88	1%
B	Shrub/Scrub	42.00	9.54	0%
D	Shrub/Scrub	62.00	50.00	1%
A	Woody Wetlands	86.00	43.64	1%
B	Woody Wetlands	86.00	13.12	0%
D	Woody Wetlands	86.00	771.49	15%
Total Drainage Area (ac):				**5025.4**

FIGURE 16: BASELINE (2001) AND CURRENT CONDITIONS RUNOFF HYDROGRAPH PLOTS

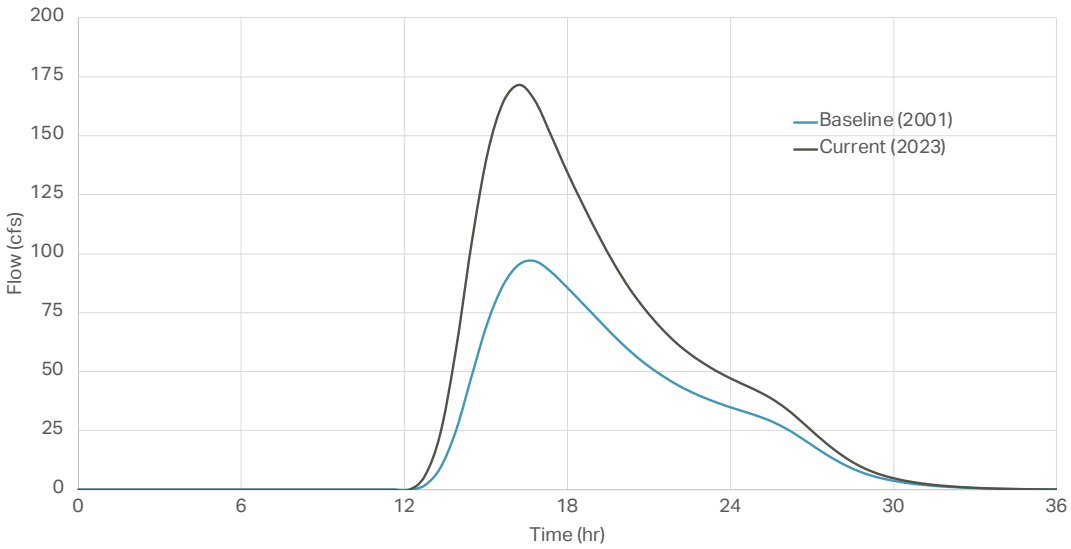


FIGURE 17: BASELINE (2006) AND CURRENT CONDITIONS RUNOFF HYDROGRAPH PLOTS

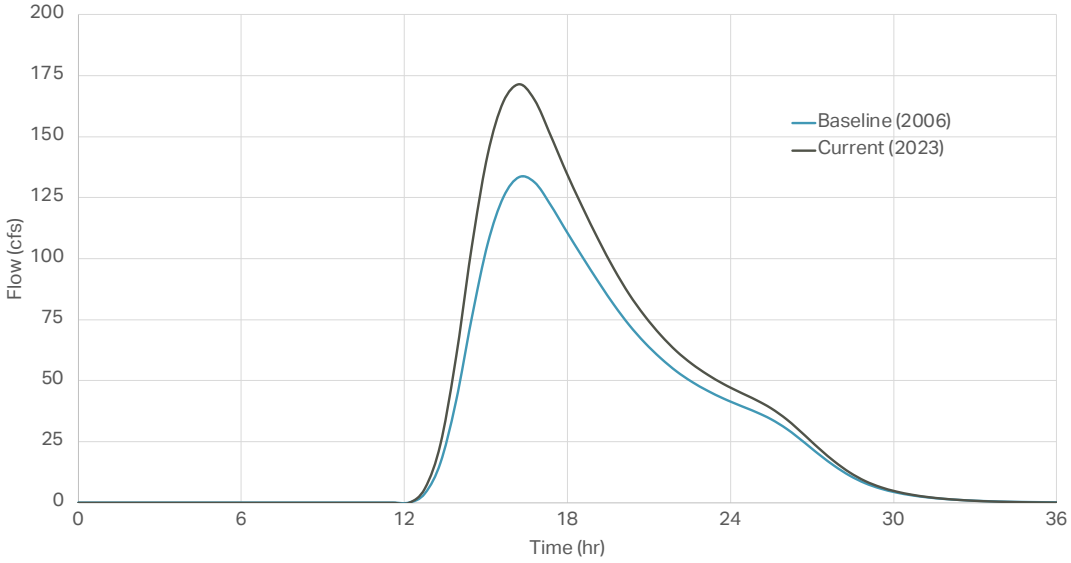


TABLE 11: PAGES CREEK RUNOFF REDUCTION GOAL CALCULATIONS

Condition	Peak Flow (cfs)	Runoff Volume (ac-ft)	Target Volume Reduction – Current to Baseline (2001, 2006) (ac-ft)	Target Volume Reduction – Current to Baseline (2001, 2006) (gal/ft2)
Baseline (2001)	97	64.8	--	--
Baseline (2006)	134	84.6	--	--
Current (2023)	172	104.0	39.2, 19.4	0.10, 0.03


unto us a Child is born

5 GOALS

Mimicking natural drainage processes protects life and properties from flooding, improves the aesthetics of urban areas, and maintains the water quantity and quality requirements of receiving water bodies.

As seen in Table 1, the runoff volume increased over 20% from 2001 baseline conditions (prior to the 303(d) listing in 2002) to today's current conditions. Therefore, New Hanover County seeks to utilize multiple water volume reduction techniques to reduce the volume of stormwater runoff by 20% to achieve baseline conditions. This will be achieved through targeted stormwater retrofits that infiltrate stormwater before it reaches the creek's surface waters. Mimicking natural drainage processes protects life and properties from flooding, improves the aesthetics of urban areas, and maintains the water quantity and quality requirements of receiving water bodies. By addressing stormwater, this Plan will directly mitigate pathogenic pollution. The Plan relies on community involvement from partners and the community (please see Appendix B for Stakeholder Meeting Summary). Community outreach and education opportunities will demonstrate how surface runoff pollutes the waterways and how volume reduction will work to restore water quality.

5.1 PRIMARY GOALS

The primary goal of the Plan is to restore water quality, reduce flooding, and enhance resiliency within the Pages Creek Watershed. The goal will be accomplished by combining cost-effective, high-yield strategies such as stormwater control measures and nature-based strategies, as well as lot level and streetwide retrofit projects, that reduce the impact of an impervious surface by mimicking natural hydrology to reduce flooding, protect water quality, and provide the community with recreationally accessible waters.

Over time, reductions in the volume of stormwater runoff will be achieved through implementation of this Plan and will result in measurable water quality improvements. This Plan uses an innovative approach of reducing runoff volumes within the Pages Creek Watershed to reduce existing water quality impairments and restore water quality, as shown in Table 12.

TABLE 12: WATERSHED MANAGEMENT PLAN APPROACH

Objective 1: Stormwater volume is reduced through strategic conservation and restoration efforts	
1-1	Identify locations for Low Impact Development (LID) to filter runoff into Pages Creek (i.e., bioretention/vegetated swales, infiltration basin)
1-2	Stabilize eroding creek and tributary banks and reconnect floodplain where feasible
	Conduct a feasibility study to assess the potential for implementing green infrastructure practices in the watershed, including retrofitting existing
1-3	Increase the use of green infrastructure such as rain gardens, bioswales, and permeable pavements to capture and treat stormwater runoff
1-4	Develop a beautification program to encourage the use of native plants in landscapes to help absorb water and reduce erosion
1-5	Implement stream restoration and stabilization projects to reduce erosion and improve water quality
1-6	Promote the use of rain barrels and for collecting rainwater and reducing stormwater runoff
Objective 2: Water quality improves through infrastructure improvements and installation of stormwater control measures	
2-1	Inventory stormwater pipe and culvert conditions throughout the watershed
2-2	Conduct regular maintenance of stormwater infrastructure, such as storm drains and detention ponds, to ensure they are functioning properly
2-3	Conduct a barrier assessment using the appropriate Southeast Aquatic Resource Partnership methodology
2-4	Gather existing hazard data and identify data gaps required to identify at-risk properties and infrastructure in the watershed under a variety of sea level rise and flooding scenarios
2-5	Evaluate existing stormwater mitigation projects within the watershed for potential volume reduction enhancements
2-6	Conduct a sedimentation assessment through the collection of soil samples within the watershed
Objective 3: The community is educated about stormwater pollution and volume reduction needs and engaged in accomplishing the plan objectives.	
3-1	Include educational signage regarding any installed stormwater retrofits
3-2	Develop and distribute educational materials on stormwater management and conservation practices to residents, businesses, and schools in the watershed
3-3	Hold quarterly stakeholder meetings in communities affected by flooding and water quality issues
3-4	Hold tours for residents and businesses explaining flooding and water quality issues and solutions
3-5	Host workshops and training sessions for residents, landscapers, and developers on the benefits and implementation of green infrastructure practices
3-6	Develop a watershed-wide volunteer program to engage community members in monitoring and restoration activities
3-7	Provide a workshop to discuss the importance of soils within the watershed
3-8	Partner with local media outlets to raise public awareness of watershed issues and the importance of conservation and restoration efforts
3-9	Conduct community outreach events such as stream cleanups and tree planting to engage and educate the public
Objective 4: Conduct periodic monitoring to ensure the plan's goal and objectives are being met and identify new opportunities to address water quality impairments in the watershed	
4-1	Increase water quality monitoring sites and frequency of water samples supplied to the County
4-2	Conduct a 1-month stormwater monitoring pilot program that measures the water quality, particularly fecal coliform, immediately after rainfall events to capture the "first flush"
4-3	Investigate preservation planning strategies utilized by other coastal communities
4-4	Seek funds to develop and implement a citizen water quality and flood monitoring program
4-5	Collaborate with academic institutions and other research organizations to identify new opportunities for research and innovation in watershed restoration
4-6	NHSWCD secure funds to provide private property owners incentives to minimize stormwater runoff from their property

Objective 5: Form and maintain partnerships to carry out the watershed restoration plan	
5-1	Form a watershed steering committee to guide the restoration plan's development and implementation
5-2	Collaborate with academic institutions and other research organizations to identify new opportunities for research and innovation in watershed restoration
5-3	Form relationships with homeowner associations (HOA) and other citizen groups in areas affected by flooding and water quality issues. Provide training opportunities for residents on techniques to reduce stormwater volume
5-4	Develop a communication plan to facilitate regular updates and coordination among partners involved in the restoration plan, which includes City of Wilmington, North Carolina Department of Transportation, New Hanover County, HOAs, private businesses, etc.
5-5	Develop a relationship with NRCS and additional agencies within the State of North Carolina


EXIT
PRICES CREEK

6 MANAGEMENT STRATEGIES

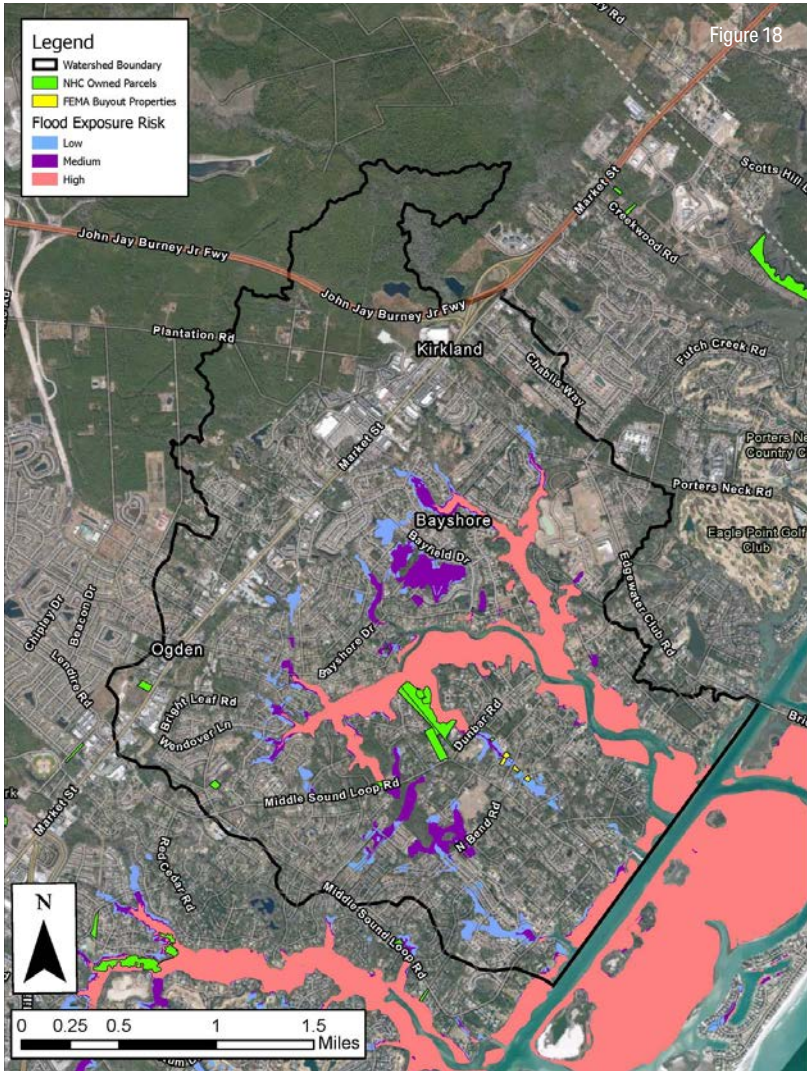
TABLE 13: POTENTIAL RESTORATION PROJECTS

Install Living shoreline along Mason's Marina and Bayshore Drive Boat Ramp
Install a stormwater wetland, replace parking lots with permeable pavement, and install downspout retrofits to provide stormwater education at Porters Neck Elementary School and Ogden Elementary School
Install stormwater educational story time / walking trail highlighting local stormwater control measures and best management practices through Pages Creek Park Preserve
Analyze existing stream banks along Bay Shore Drive and conclude if stream restoration / enhancement is necessary. Install native plants along stream banks to absorb pollutants and mitigate erosion
Install pet waste stations and educational signage regarding pet and horse waste and fecal matter within the Pages Creek Park Preserve
Plant native trees along Business Highway 17
Investigate potential inflow and infiltration (I&I) into and out of the wet well of lift stations within the Pages Creek Watershed; if found, rehabilitate lift stations to mitigate I&I
Conduct a 1-month stormwater monitoring pilot program that measures the water quality, particularly fecal coliform, immediately after rainfall events to capture the "first flush"

Stormwater management typically targets peak flow conveyance and volume storage in order to reduce flooding, transporting runoff through the conveyance network to receiving water as quickly and efficiently as possible. These methods are effective at mitigating flooding due to stormwater quantity issues, but often fail to provide sufficient treatment to reduce pollutant loads, leading to water quality issues in receiving waterways.

Stormwater management strategies aimed at improving water quality can be implemented through a number of avenues, focusing on existing drainage or flooding issues, new development and redevelopment, illicit discharges from point and non-point sources, and public education and outreach. The following sections discuss potential management strategies that can be employed in the Pages Creek Watershed to reduce overall pollutant loads and improve water quality in Pages Creek. The strategies presented are not comprehensive—additional strategies may be considered throughout the Plan's implementation, as necessary. Table 13 and Figures 18 and 19 present a range of potential projects that can be pursued as funding becomes available. These items make up a

FIGURE 18: POTENTIAL SITES FOR NATURE-BASED SOLUTIONS AND GREEN INFRASTRUCTURE PROJECTS



comprehensive list that can be used as the basis for future projects, while allowing for growth of new ideas and potential solutions. The proposed solutions, strategies, and techniques are based on information collected during the restoration plan's development and are not actual planned projects. Before implementing any projects further consideration and research is recommended on the feasibility of the proposed project.

6.1 STORMWATER CONTROL MEASURES

Various stormwater control measures (SCM)—both new and retrofits—can be installed throughout the watershed to provide stormwater storage, retention, infiltration, and treatment. Measures include, but are not limited to, stormwater wetlands, bioretention, infiltration swales and basins, permeable pavement, rain gardens, and green roofs. Each SCM has a different potential for stormwater retention and treatment based on soil health in the area. For example, most SCMs have a high potential for performance where soils infiltrate well and have a relatively high percentage of organic matter. Certain SCMs, such as stormwater wetlands, may be more preferable than other SCMs in areas where soils are lower in organic matter and do not infiltrate as readily. The potential performance of some SCMs, including green roofs, are largely irrespective of soil conditions.

6.2 NATURE-BASED SOLUTIONS

Potential nature-based solutions to be considered for implementation in the Pages Creek Watershed include living shorelines, increased tree canopy and vegetative coverage (particularly with native plant species), stream restoration and stabilization, and soil amendments to increase organic matter. These practices utilize natural features to help filter pollutants and reduce stormwater runoff.

6.3 ORDINANCES AND POLICIES

Existing and future ordinances and policies that affect the Pages Creek Watershed can be evaluated for potential detriments to water quality. Ordinances and policies to be considered may cover new

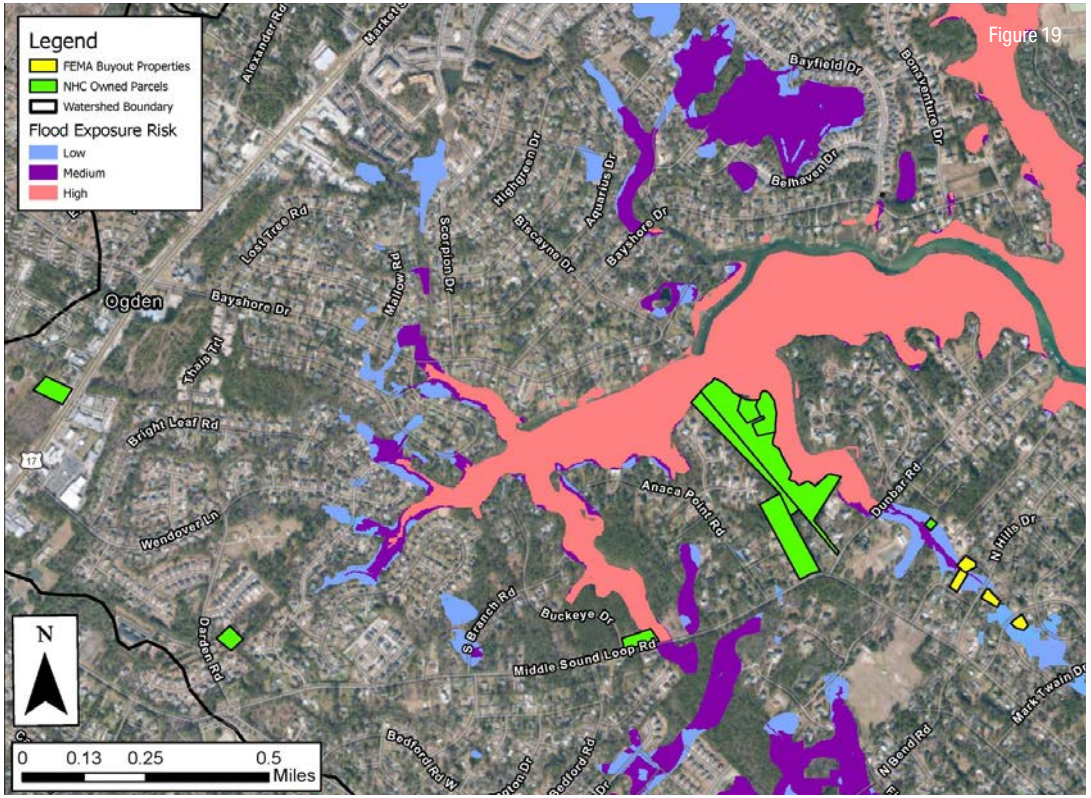


FIGURE 19: SITES WITHIN WATERSHED THAT HAVE BEEN IDENTIFIED AS POTENTIAL SITES FOR NATURE-BASED SOLUTIONS AND GREEN INFRASTRUCTURE PROJECTS WITH FOCUS ON THE MIDDLE SOUND LOOP ROAD AREA TECHNICAL AND FINANCIAL ASSISTANCE RESOURCES

development and redevelopment, erosion and sediment control, stormwater management, illicit discharges, and more.

6.4 CONTINUED WATER QUALITY MONITORING

It is recommended that New Hanover County continue, if not increase, water quality monitoring throughout the watershed to identify point and non-point sources of various pollutants of interest. Regular collection and evaluation of water quality monitoring data will be valuable in detecting key areas of water quality concern and identifying potential sites for improvement efforts.

6.5 POTENTIAL SITES FOR NATURE BASED SOLUTIONS

The identification and selection of potential sites for stormwater management strategies will depend on 1) the desired strategy to be implemented, and 2) the availability of parcels on which to implement strategies. Figure 18 and Figure 19 show parcels currently owned by New Hanover County that were purchased using clean water funds or are under conservation status, indicating availability for nature-based projects. These figures also display the Federal Emergency Management Agency (FEMA) buyout properties that are now also owned by the County and available for use for nature-based projects. These parcels can be considered for potential stormwater management activities to reduce water volume inputs and improve water quality. Additional parcels may become available for utilization but may require easements or property acquisition. Figure 18 and Figure 19 also display the flood exposure within Pages Creek Watershed (Shivers et al., 2022) to better understand the risks faced by the areas surrounding these sites. Flood exposure risk can be an important factor to consider when evaluating the need for management strategies.

Like many local governments, New Hanover County, along with existing non-profit organizations, has limited staff capacity and resources available. In order to implement elements of the Pages Creek Watershed Restoration Plan, they will likely need to rely on an established network of local and regional partners (many of which were actively involved in the watershed planning process). Table 14 provides a list of organizations that could provide financial resources that are available to support green infrastructure, coastal resilience, restoration projects, conservation, and educational programs.

TABLE 14: SOURCES OF FINANCIAL ASSISTANCE

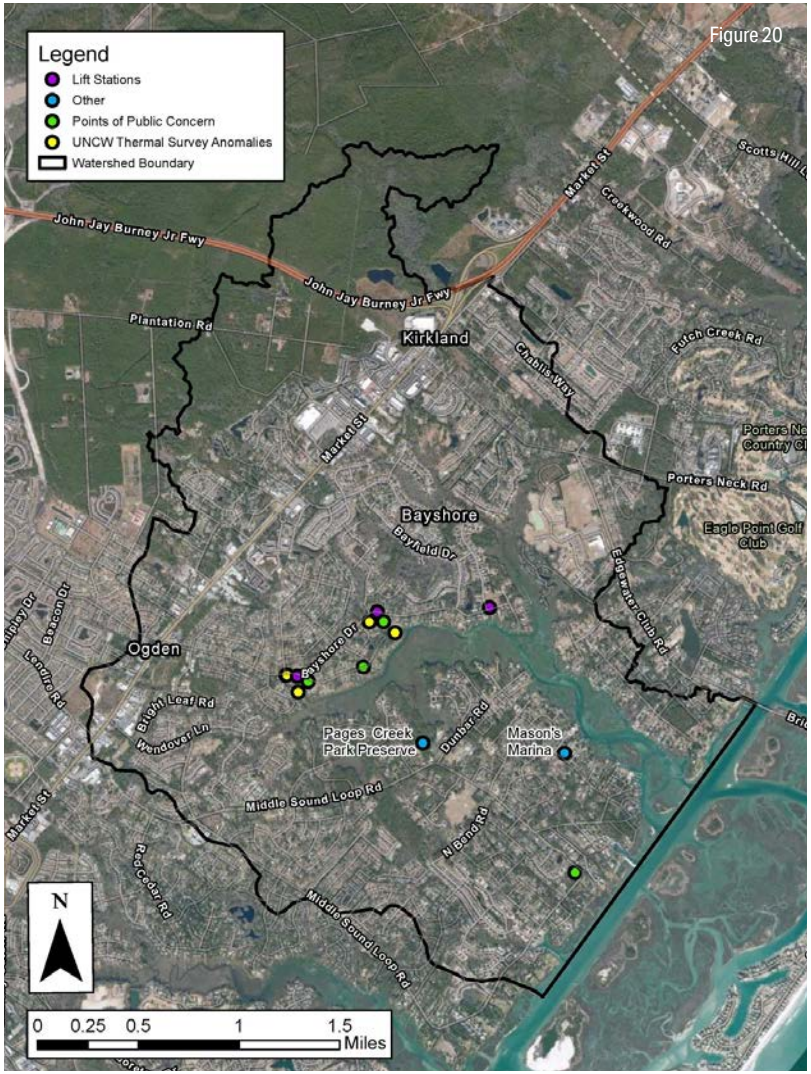
Funding Source	Activities Funded	Match Required	Eligibility
319 Grant Program (EPA and NCDWR)	Implementation of approved nine element watershed restoration plan(s) with approved checklist	40% of total award	State and Local Governments, Nonprofits, Educational Institutions
NC Land and Water (NCDNCR) (Clean Water Mgt Trust)	Protect, improve, and/or restore surface water, acquire lands with ecological, cultural, and/or historical significance (including riparian buffers)	Varies	State Agencies, Local Governments, Nonprofits
NC DEQ Water Resources Development Grant	Provide cost-share grants and technical assistance to local governments throughout the state. Grant funding for water management, stream restoration, feasibility/engineering	50% Non-federal Match	Units of Local Government
205(i) Planning Grant (EPA and NCDWR)	Water quality management and planning	Optional Match	Regional Councils of Governments
Z. Smith Reynolds Foundation	Improves, restores, and protects water quality, and ensure access to all waters		501(c) 3 Organizations
Clean Water State Revolving Fund (EPA and NCDWI)	Provides low interest loans to fund wastewater collection and treatment facilities, as well as estuary and non-point source program projects	N/A	Local Governments
Five Star and Urban Waters Restoration Grant Program (NFWF)	Provides support for innovative job opportunities that expose young people, particularly urban and underserved youth, to natural world and career opportunities in conservation	1:1	Non-profit 501(c) organizations, state and local government agencies, Indian tribes, and educational institutions
Flood Mitigation Assistance Grant Program	Helps communities fund projects and planning that reduce or eliminate long-term risk to flood damage to structures insured under the National Flood Insurance Program	Varies	Most state and local governmental entities, nonprofits, federally recognized tribes, academic institutions
Parks and Recreation Trust Fund (NCDPR)	State Park land acquisition and capital improvements, local government park and recreation purposes, and beach access	1:1	
North Carolina Attorney General's Office Environmental Enhancement Grant Program	Immediate or long-term environmental enhancement projects that improve North Carolina's air, water, and/or land quality	Varies	Federal or state agencies, local governments, nonprofits
Community Conservation Assistance Program (CCAP, NCDSWC)	Funds non-agricultural management measures	Up to 75%	Citizens
Duke Energy Foundation Powerful Communities	Provides funding for a variety of focus areas, including K-12 (engineering and environmental education), nature, local impact, community initiative	Varies	Nonprofit 501(c) organizations, state and local government agencies, Indian tribes, and educational institutions

Notes: NCDWR = North Carolina Department of Environmental Quality, Department of Water Resources; NCDNCR = Department of Natural and Cultural Resources; NCDWI = North Carolina Department of Water Infrastructure; NFWF = National Fish and Wildlife Foundation; NCDPR = North Carolina Division of Parks and Recreation; CCAP = Community Conservation Assistance Program; NCDSWC = North Carolina Division of Soil & Water Conservation

6.6 EDUCATION AND OUTREACH

The targeted audience of education and outreach for the community includes residents of Bayshore, Ogden, and Porters Neck, business owners, and K-12 students. Partnerships with public schools are an effective means of engaging the community and implementing education and outreach objectives. Educating the public is one of the best strategies for the long-term benefit of water quality as it helps build community participation, giving citizens an interest in the health of their waterways. Education and outreach to the community can encourage the use of residential

FIGURE 20: AREAS OF INTEREST DISCUSSED IN COMMUNITY OUTREACH AND STAKEHOLDER MEETING



stormwater retrofits such as disconnecting downspouts, planting native plants, installing rain barrels, and other techniques. Residents, whether renting or homeowners, can be encouraged to understand how their homes and properties contribute to the water quality of the watersheds. The following strategies will engage and involve the local community:

- **Public meetings**: The County could hold regular public meetings to update the community on the Plan's progress and to solicit feedback and input from local residents.
- **Workshops**: The County could host workshops to educate the community on topics related to wetland restoration. These workshops will be designed to be interactive and engaging, with opportunities for hands-on learning.
- **Educational outreach**: The County could work with local schools and community organizations to provide educational outreach programs. These programs will be tailored to different age groups and will include activities such as creek cleanups, Pages Creek Preserve Nature Walks, and native tree planting.
- **Volunteer opportunities**: The County could work with community groups and individual citizens to organize volunteer opportunities for creek cleanups and other restoration activities and create a water quality monitoring program. These opportunities will be promoted through the County's website and social media channels.

Education and outreach projects can include:

- Distribution of the Smart Yards informational booklet developed by the North Carolina Coastal Federation. The Smart Yards booklet can be mailed directly to all residents or can be made available at the New Hanover County government building.
- Collaborate with Odgen Elementary to develop contests in which the students can participate.
- Conduct presentations on current events related to stormwater enhancements and water quality monitoring for community members.

TABLE 15: AREAS OF INTEREST DISCUSSED IN COMMUNITY OUTREACH MEETING AND STAKEHOLDER MEETING

Point	Classification on Map	Notes
Pages Creek Park Preserve	Other	Visited during site visit to investigate protected areas
Mason's Marina	Other	Area of interest due to potential of being a point source of pollution into Pages Creek
Lift Station #1	Lift Stations	Noted in community outreach meeting for possible leakage
Lift Station #2	Lift Stations	Noted in UNCW study for possible effluents, as well as in community outreach meeting for leakage and smell of sewage; history of spilling twice in past 3 years
Lift Station #3	Lift Stations	Noted in community outreach meeting for possible leakage
366 Shorepoint Drive	UNCW Thermal Survey Anomalies	Noted in UNCW study for possible effluents
540 Baycove Lane	UNCW Thermal Survey Anomalies	Noted in UNCW study for possible effluents
324 Bayshore Drive	UNCW Thermal Survey Anomalies	Noted in UNCW study for tidal inlet vegetation anomalies
522 Scenic Circle	UNCW Thermal Survey Anomalies	Noted in UNCW study for temperature distinction from vegetation to water; potential seepage from unknown source
466 Biscayne Drive	Points of Public Concern	Noted in community outreach meeting for culvert needing repair, previous sinkholes from severe flooding
406 Biscayne Drive	Points of Public Concern	Noted in community outreach meeting for flooding and excessive silt in creek; poor health of live oak trees due to flooding
Boat Ramp	Points of Public Concern	Noted in community outreach meeting for sediment deposition from runoff
1824 Middle Sound Loop Road	Points of Public Concern	Noted in community outreach meeting for flooding along the roadway between 1824-1828 Middle Sound Loop Road

- Encourage residents to attend or participate in project demonstrations and installation at public buildings to learn how to install retrofits.
- Install educational signs about stormwater runoff in public areas.
- Outreach to HOAs to encourage stormwater and water quality education and training opportunities to reduce stormwater volumes. An example can be found in Appendix C. Maintain the Pages Creek Watershed Restoration plan website: https://www.nhcgov.com/2489/Pages-Creek-Watershed-Preservation-Proje

6.6.1 PARTNERSHIPS

The Pages Creek Restoration Plan involves many key participants. NHSWCD will be in charge of carrying out this Plan. Cape Fear Resource and Conservation Development will support in identifying grant opportunities and providing financial assistance. Potential partners range from engagement of government agencies, nonprofit organizations, volunteer groups, local clubs and organizations, educational and scientific institutes, and businesses. A list of potential partnerships has been developed and will be maintained by the county as a list to refer to when collaborative projects present themselves. Developing partnerships with schools can be an effective means of engaging the community and addressing education and outreach implementation. UNCW is a valuable partner to assist with research and monitoring.

6.6.2 COMMUNITY OUTREACH MEETING

New Hanover Soil and Water Conservation District held a community outreach meeting on June 29, 2022, to allow members to share their input on water quality and flooding issues experienced within the Pages Creek Watershed (see Appendix D).

Poor water quality, stormwater runoff, and sedimentation within the creek were the top citizen concerns.

Sixty-six community members joined the meeting to discuss personal experience with the poor water quality conditions and provide input on feasible solutions. Poor water quality, stormwater runoff, and sedimentation within the creek were the top citizen concerns. Citizens in attendance also provided specific areas of concern, which have been mapped in Figure 20, and notes regarding specific concerns can be found in Table 15.

Additionally, as part of the preliminary research into Pages Creek watershed to understand community concerns, NHSWCD held a stakeholder meeting on November 8, 2022. Following this meeting, Moffatt & Nichol, New Hanover County, Cape Fear Resource Conservation & Development, and other stakeholders conducted a site visit to areas of interest, including lift stations and areas identified as displaying a thermal anomaly. These areas were identified through a thermal imaging study by UNCW staff to examine where there may be anomalies or warmer spots, indicating potential pollutant input into the water body (Pricope and Scopa, 2021). These points are noted in Table 15.


Highways and Roads
in Pages Creek Watershed
TRADITIONALLY BREWED
1991
OCRACOKE
LIGHT
TYPICALLY CONSUMED

7 IMPLEMENTATION SCHEDULE

Before implementing any management solution presented here, the county should research its cost and feasibility and consult with engineers and other relevant professionals.

New Hanover Soil and Water Conservation District and Cape Fear Resource Conservation and Development will work with partners to implement the goals, objectives, actions, and management strategies identified in the Plan. The solutions presented here are not actual planned projects. Before implementing any management solution presented here, the county should research its cost and feasibility and consult with engineers and other relevant professionals. Table 16 provides an overview of the general implementation schedule describing actions that can potentially be taken over the course of the next 10 years (2024–2034).

7.1 OVERVIEW OF IMPLEMENTATION SCHEDULE

Year 1–2:

- Strengthen existing partnerships within New Hanover County departments to leverage resources.
- Form a watershed steering committee to guide the restoration plan's development and implementation.
- Conduct feasibility study to assess potential for implementing green infrastructure practices in the watershed.
- Inventory stormwater pipe and culvert conditions throughout the watershed.
- Conduct regular maintenance of stormwater infrastructure.
- Gather existing hazard data and identify data gaps required to identify at-risk properties and infrastructure.
- Develop and distribute educational materials on stormwater management and conservation practices to residents, businesses, and schools in the watershed.
- Hold quarterly stakeholder meetings in communities affected by flooding and water quality issues.
- Conduct community outreach events such as stream cleanups and tree planting to engage and educate the public.
- Develop relationships with groups in coastal North Carolina to support implementation of actions.
- Form relationships with HOAs and other citizen groups in areas affected by flooding and water quality issues.

Year 3–4:

- Increase water quality monitoring sites and frequency of water samples.
- Identify locations for LID and potential nature-based solutions.

The timeline for these projects may vary depending on various factors such as funding, permits, and community involvement.

- Increase use of green infrastructure such as rain gardens, bioswales, and permeable pavements to capture and treat stormwater runoff.
- Identify vegetated buffer gaps to reduce sediment transport into surface waters.
- Implement stream restoration and stabilization projects to reduce erosion and improve water quality.
- Hold tours for residents and businesses explaining flooding and water quality issues and solutions.
- Host workshops and training sessions for residents, landscapers, and developers on the benefits and implementation of green infrastructure practices.

Year 5–6:

- Conduct a barrier assessment using appropriate methodologies.
- Evaluate existing stormwater mitigation projects within the watershed for potential volume reduction enhancements.
- Conduct a sedimentation assessment through the collection of soil samples within the watershed.
- Develop a community leadership team within the watershed.
- Develop a watershed-wide volunteer program to engage community members in monitoring and restoration activities.
- Provide a workshop to discuss the importance of soils within the watershed.

Year 7–8:

- Increase water quality monitoring sites and frequency of water samples.
- Conduct a 1-month stormwater monitoring pilot program that measures the water quality immediately after rainfall events to capture the "first flush."
- Investigate preservation planning strategies utilized by other coastal communities.
- Seek funds to develop and implement a citizen water quality and flood monitoring program.
- Collaborate with academic institutions and other research organizations to identify new opportunities for research and innovation in watershed restoration.

Year 9–10:

- Work with partners to secure grants to install lot-level, low-cost retrofits that disconnect impervious surfaces and enhance stormwater infiltration.
- Develop a communication plan to facilitate regular updates and coordination among partners involved in the restoration plan, including City of Wilmington, North Carolina Department of Transportation, New Hanover County, HOAs, private businesses, etc.
- Develop a relationship with NRCS and additional agencies within the State of North Carolina.

It is important to note that the above schedule is just a general outline, and the timing of each action item may depend on various factors such as funding availability, community engagement, and regulatory approvals. The schedule should be adjusted based on the actual progress made over time.

7.2 PROJECT IMPLEMENTATION SCHEDULE AND MILESTONES

Table 16 is the suggested stormwater runoff reduction techniques previously introduced in Section 6 with an implementation schedule. The list represents potential projects and will likely evolve to suit the condition and needs of the watersheds. The timeline for these projects may vary depending on various factors such as funding,

TABLE 16: POTENTIAL PROJECT IDEAS IMPLEMENTATION SCHEDULE

Project Ideas	Milestones	Maintenance Schedule	Completed By
Living shoreline installation	Secure funding Obtain permits Complete shoreline design Install shoreline	Monthly monitoring for shoreline erosion	Year 5
Stormwater management at Porters Neck and Ogden Elementary	Secure funding Obtain permits Design stormwater management techniques (stormwater wetland, permeable pavement, downspout retrofits) Construct and install stormwater management techniques (stormwater wetland, permeable pavement, downspout retrofits) Implement stormwater education program	Maintenance of stormwater features per design requirements	Year 10
Stream restoration/enhancement along Bay Shore Drive	Secure funding Complete stream bank analysis Complete restoration design Complete native plant installation	Regular stream bank monitoring Annual plant maintenance	Year 10
Stormwater educational trail at Pages Creek Park Preserve	Secure funding Complete trail design Install signage and educational material	Annual signage update Regular maintenance of trail and signage	Year 2
Pet waste stations and signage at Pages Creek Park Preserve	Secure funding Install pet waste stations Install educational signage	Monthly waste station maintenance	Year 1
Lift station rehabilitation	Secure Funding Complete I&I investigation If I&I found, design and construct solution	Annual inspection Regular tree pruning and maintenance	Year 10
Stormwater monitoring pilot program	Secure funding Install monitoring equipment Complete data collection and analysis	Annual data analysis	Year 3

permits, and community involvement. The indicators listed are examples and may need to be further refined based on the specific goals and objectives of each project. The proposed management solutions, strategies, and techniques are based on the information compiled during the restoration plan's development. These projects are not actual planned projects but illustrate potential opportunities.

8 MONITORING

TABLE 17: PRIMARY WATERSHED MANAGEMENT PLAN GOAL INDICATORS AND HOW TO MEASURE THE INDICATORS

Indicator	Measured by	Collected by	Collection Cycle
Fecal Coliform	Comparing numerical historical data and modern measurements of fecal coliform for changes in impairment and quantity of bacteria per sample	New Hanover County	Yearly, annual reports released
Stormwater Runoff Volume	Applying the Runoff Reduction Scenario Tool to stormwater reduction techniques to determine how much stormwater is reduced by the techniques; these measures should attempt to reduce current stormwater runoff volume to the levels of the baseline year	New Hanover Soil and Water Conservation District	Upon completion of a project

TABLE 18: EVALUATION OF THE WATERSHED MANAGEMENT PLAN

Evaluation	Indicator	Timeframe
Load reduction calculation for installed stormwater runoff projects	Utilize the Watershed EZ Tool and Runoff Reduction Scenario Tool	Pre-/post-implementation of projects
Scheduled assessment	Conduct yearly scheduled assessment of water quality data and discuss future projects with project team, board members, and county commissioners	Yearly
Publicize successes	Update the community on successes; publish report on watershed health and past, current, and future projects for the year	As necessary
Update the Plan	Update the Plan every 5 years based on findings from water quality and project implementation	Years 5, 10, 15
Final evaluation	Determine whether to extend the Plan	Year 20

Monitoring is a critical strategy to maintain a comprehensive understanding of current conditions, changing watershed conditions, restoration needs, and measurable results from the watershed improvement projects. Monitoring will be conducted using indicators listed in Table 17.

8.1 EVALUATION AND PROGRESS CRITERIA

To ensure that the Pages Creek Watershed Restoration Plan is meeting the needs of the watershed and community, the Plan should be evaluated on a regular basis to determine effectiveness (see Table 18).

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APPENDICES

APPENDIX A: GIS DATA SOURCES

Figure	Layer	Data Source
1. Watershed Description	Pages Creek Watershed Boundary	New Hanover County (provided via email)
	Roads	NCDOT https://connect.ncdot.gov/resources/gis/pages/gis-data-layers.aspx
	Waterbodies	NC One Map https://www.nconemap.gov/search?collection=Dataset
	Census Designated Places	U.S. Census Bureau
2. Topography	Pages Creek Watershed Boundary	New Hanover County (provided via email)
	Topography	USGS https://apps.nationalmap.gov/downloader/
3. Flood Zones	Pages Creek Watershed Boundary	New Hanover County (provided via email)
	Flood Zones	North Carolina Flood Risk Information System https://fris.nc.gov/fris/download.aspx?FIPS=129&ST=NC &user=General%20Public#
4. NCNHP Managed and Natural Areas	Pages Creek Watershed Boundary	New Hanover County (provided via email)
	NCNHP-Managed Areas	NC One Map https://www.nconemap.gov/search?collection=Dataset
	NCNHP Natural Areas	NC One Map https://www.nconemap.gov/search?collection=Dataset
5. Soils	Pages Creek Watershed Boundary	New Hanover County (provided via email)
	Soil Groups	USDA https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx
6. Trends in Vegetation Health	Pages Creek Watershed Boundary	New Hanover County (provided via email)
	Vegetation Health	Greer Shivers and Dr. Narcisa Pricope, 2022. UNCW Department of Environmental Sciences
7. Wetland Vulnerability	Pages Creek Watershed Boundary	New Hanover County (provided via email)
	Wetland Vulnerability	Greer Shivers and Dr. Narcisa Pricope, 2022. UNCW Department of Environmental Sciences

8. Land Use Classifications	Pages Creek Watershed Boundary	New Hanover County (provided via email)
	New Hanover County Land Use	New Hanover County (provided via email)
9. Changes in Land Use	Pages Creek Watershed Boundary	New Hanover County (provided via email)
	Changes in Land Use	National Land Cover Database (NLCD), USGS. https://www.usgs.gov/search?keywords=Land%20Use/Land%20Cover
10. Designated Uses Water Quality Classification	Pages Creek Watershed Boundary	New Hanover County (provided via email)
	Water Quality Classification	NCDEQ https://data-ncdenr.opendata.arcgis.com/
	Outstanding Resource Waters	NCDEQ https://data-ncdenr.opendata.arcgis.com/
11. 303(d) Impaired Waters	Pages Creek Watershed Boundary	New Hanover County (provided via email)
	303(d) Impaired Waters	NCDEQ https://data-ncdenr.opendata.arcgis.com/
12. Shellfish Harvest Classifications	Pages Creek Watershed Boundary	New Hanover County (provided via email)
	Classification Status	NCDCM (NCDEQ) https://data-ncdenr.opendata.arcgis.com/
14. Water Quality Monitoring Stations	Pages Creek Watershed Boundary	New Hanover County (provided via email)
	Water Quality Monitoring Stations	New Hanover County (provided via email)
	Water Bodies	NC One Map https://www.nconemap.gov/search?collection=Dataset
15. Stormwater Permits Issued Over Time	Pages Creek Watershed Boundary	New Hanover County (provided via email)
	Permits by Issue Year	NCDEQ https://data-ncdenr.opendata.arcgis.com/
18/19. Potential NBS project sites	Pages Creek Watershed Boundary	New Hanover County (provided via email)
	FEMA Buyout Properties	New Hanover County (provided via email)
	New Hanover County Government-Owned Parcels	New Hanover County (provided via email)
	Flood Exposure	Greer Shivers and Dr. Narcisa Pricope, 2022. UNCW Department of Environmental Sciences.
20. Areas of Interest	Pages Creek Watershed Boundary	New Hanover County (provided via email)
	Lift Stations	New Hanover County (provided via email)
	UNCW Thermal Survey Anomalies	Created by Rachel Baker based on data from Pricope and Scopa, 2021
	Points of Public Concern	Created by Rachel Baker based on community feedback
	Other	Created by Rachel Baker

APPENDIX B: STAKEHOLDER MEETING SUMMARY

Pages Creek Watershed Restoration Plan

To: **Pages Creek Stakeholders**

From: **New Hanover Soil and Water Conservation District / Cape Fear Resource Conservation & Development / Moffatt & Nichol**

Date: **November 8, 2022 (Stakeholder Meeting 9 AM – 11:30 AM) / Site Visit (1 PM – 4 PM Transportation Provided)**

Location: **NHC Government Building – Harrell Conference Room/ Microsoft Teams (link provided below)**

Subject: **Pages Creek Watershed Restoration Plan – Stakeholder Meeting and Site Visit**

1. Welcome and Introductions (NHSWCD/CFRC&D)
2. Nature Based Solutions for Flood Mitigation (Dr. Narcisa Pricope, UNCW)
3. Overview of Watershed Plan Goals and Project Timeline (Moffatt & Nichol)
4. Overview of Water Quality Trends in Pages Creek (New Hanover County Planning)
5. Community Outreach Findings (NHSWCD)
6. Working Session to Identify Priority Areas (Moffatt & Nichol)
7. Site Visit Overview (NHSWCD/Moffatt & Nichol)

**Lunch will be made available starting at 11:30 AM

***Virtual Option to Join Meeting

Click here to join the meeting (https://teams.microsoft.com/l/meetup-join/19%3ameeting_OTU3YjhlOGItZGE4Ni00NWFhLWJiMmQtYmIwMjJmZDQ2ZmZi%40thread.v2/0?context=%7b%22Tid%22%3a%22862dbdf2-91c9-4fca-a8a0-ba27ae7ab190%22%2c%22Oid%22%3a%222961e831-a4dd-42a5-b209-09864dc4c6ee%22%7d)

Meeting ID: 272 650 033 332
Passcode: AFoMwr

4700 Falls of Neuse Road, Suite 300
Raleigh, NC 27609

(919) 781-4626 Fax: (919) 781-4626
www.moffattnichol.com

MEMORANDUM

To: Pages Creek Watershed Restoration Plan Stakeholders

From: Moffatt & Nichol

Date 11/08/2022

Subject: Pages Creek Watershed Restoration Plan - Stakeholder Meeting and Site Visit Summary

Meeting and Site Visit Attendees:

Name	Organization	Email
Danielle Darkangelo	CFRC&D	Danielle.darkangelo@gmail.com
Jim Iannucci	NHC Engineering	jiannucci@nhcgov.com
Robert Daughtry	CFPUA	Robert.daughtry@cfpua.org
Samantha Marchisin	Moffatt & Nichol	smarchisin@moffattnichol.com
Dawn York	Moffatt & Nichol	dyork@moffattnichol.com
Rachel Baker	Moffatt & Nichol	rbaker@moffattnichol.com
Allison Bryan	Moffatt & Nichol	abryan@moffattnichol.com
Matt Collogan	NCCES/ NHSWCD	mcollogan@nhcgov.com
Sue Hayes	NHSWCD	suehayes1@ec.rr.com
Dru Harrison	NHSWCD	drharrison@nhcgov.com
John Riggs	Resident	riggs@riggsyachtsales.com
Kat Pohlman	CFPUA	Kathryn.pohlman@cfpua.com
Dr. Narcisa Pricope	UNCW	pricopen@uncw.edu
Tim Lowe	NHC Engineering	tlowe@nhcgov.com
Robin Hoffman	NCDEQ White Oak River Basin Planner	Robin.hoffman@ncdenr.gov
Rebecca Roth	NHC Planning	rroth@nhcgov.com
Dylan McDonnell	NHC Planning	dmcdonnell@nhcgov.com
Charles Robbin	Resident	charlesvrobbins@mnc.com
Bobby Brown	Resident	23seacraft@att.net
Andres Boena	NHC – CAMA LPO	aboena@nhcgov.com
Wendell Biddle	NHC – CAMA LPO	wbiddle@nhcgov.com

Jennifer Butler	City of Wilmington Stormwater/Pages Creek resident	Jennifer.Butler@wilmingtonnc.gov

Meeting began at 9:00 am

- Presentations associated with the meeting discussion are provided as attachments to these meeting minutes.
- Dru Harrison (NHSWCD) discussed why Pages Creek was chosen as a critical targeted watershed for the NHC Soil and Water Conservation District's 2018-2022 Strategic Plan.
- Danielle Darkangelo, lead for the NC Land and Water Fund grant associated with the development of the Pages Creek Watershed Restoration Plan discussed the mission and objectives of the Cape Fear Resource Conservation & Development (CFRC&D).
    - Dr. Narcisa Pricope (UNCW) asked what is the size threshold considered for a project for CFRC&D?
    - Danielle responded that CFRC&D tries to conquer projects which will positively impact numerous residents.
- It was stated by Dru and confirmed by Sue Hayes (NHSWCD) that it is the intent of NHSWCD to maintain the Pages Creek Watershed Restoration Plan and it will be updated every 5 years, with the goal of having this plan serve as a living document.
- The grant contract between NC Land and Water and CFRC&D is through the end of 2023, all deliverables will be completed by fall 2023.
- Dawn York (M&N) asked NHC how grants are developed and managed.
    - The County is evaluating the need for a technical grant writer to help manage ongoing and new grants.
- It was stated that the NC Coastal Federation is updating the Bradley and Hewlett's Creek watershed restoration plan. It is anticipated that the NC Coastal Federation will be asked to participate with the Pages Creek Watershed plan to ensure guidelines are followed accurately.
- UNCW created a 319-watershed plan for Greenfield Lake. The City of Wilmington is moving forward with a stormwater wetland retrofit to support water quality improvements in Greenfield Lake.
- Dawn (M&N) asked CFPUA to discuss recent efforts to identify sources of point and non-point sources.
    - Robert (CFPUA) stated CFPUA is using recently completed thermal imaging and surveying sewage system to identify point sources and there have been no sources identified thus far.
    - CFPUA indicated they conduct priority maintenance on all pipes adjacent to all tidal creeks within the county.
- Report of groundwater testing will be released in January 2023.
    - Tim (NHC) stated that 50-60% of Pages creek which includes open ditches, streams, and pipes have been mapped, any SCMS will have to factor in, lots of short runs and tributaries feeding into the creek, lots of wetlands feeding into the creek.

- Tim (NHC) mentioned stream bank erosion can contribute to the boat ramp erosion and recommended the watershed plan includes stream bank erosion and solutions to the watershed.
- Dylan (NHC) stated old neighborhoods were built before stormwater control and will have potential FEMA buyout areas. FEMA buyout areas serve as an opportunity to do larger retrofits on properties.
- Dylan (NHC) asked what does the stormwater fee cover in Wilmington?
    - Stormwater fee is primarily for maintenance
- Dylan (NHC) asked if the restoration plan helps with the timeline to received approval for grant funding.
- Kat (CFPUA) said the approved 319 watershed plan will help receive grants, however there is only grant per year per watershed.
- Watershed Restoration Plan must be reviewed and approved by the county commissioners prior to being sent to DEQ for review. Dru will work with county commissioners to review and support the plan.
- Matt (NHCSWCD) suggested to working with property owners to apply for grants.
- Dru (NHCSWCD) anticipates producing a newsletter to inform and update residents on the restoration plan. She plans on working with school system at Ogden Elementary and creating a contest with the kids for community outreach.
- Residents discussed stormwater runoff and the sedimentation resulting from the development upstream of Pages Creek.
    - Jim (NHC) suggested multi-use paths for community members.
    - Sue (NHCSWCD) commented if the problem is coming from development, education needs to be brought to developers.
    - John (resident) mentioned there was no follow up or clean ups for developers for sediment runoff.

  Tim (NHC) mentioned that is going to be hard to transition from plan to development. There will be some steps unless there are shovel ready projects. Dawn (M&N) mentioned next steps could include development of concept designs and what types of features will be used.
- Bobby (resident) asked if soil samples are being taken for the sedimentation.
    - Dylan (NHC) stated turbidity is the indicator and turbidity samples are taken monthly.
- Tim (NHC) asked if high bacteria levels could be due to inability to fluish the system due to the sedimentation buildup.
- Sue (NHSWCD) asked if plan would review County ordinances? If there are no consequences for development, nothing will change. Dawn (M&N) indicated a review of ordinances could be one of the recommendations of the plan.
- Discussion took place on whether aging septic infrastructure is still being used or just old ones that are leaking? It was confirmed that old ones are in place. Originally a USDA project, part of early sewer system of NHC. Septic tanks were supposed to be pumped out once connected to sewer system, not sure if that took place.
    - Bobby (Resident) stated he doesn't think that happened. Abandoned septic tanks sitting in the clay.

- CFPUA-Where line comes into sewer system, capped off, but still leaches out, going into nearby leach field on Bayshore Dr. Well over 20 years that septic tanks abandoned, don't see that as much of an issue because of how much time has passed.

- Dylan stated fecal count has naturally decreased over time, not sure if because people have tied on to CFPUA system.

Meeting adjured: 11:30 am

Site Visit began at 1:00 pm

1. 701 Scorpion Drive
   - Sediment builds up is located at the conveyance.
   - The creek behind the property receives run off from Aquarius Drive and Scorpion Drive.
   - Any future projects would receive a 401/404 permit.
   - Suggested to present a bank stabilization project within the plan.
2. Lift Station at Boat Ramp (#2)
   - Since 2008, New Hanover County have worked with CFPUA to identify sources of bacteria and contamination surrounding the lift station.
   - Contamination is confirmed to come from human signature, but it is not sure where the source is coming from.
   - Water quality is tested at the life station once a month and tests after a rainfall event.
   - The trends have shown bacteria levels have naturally decreased but this site consistently sees the most elevated levels.
   - Shellfish closure and 303d listing is due to the high fecal bacteria.
   - Residents recommend testing the soil within Pages Creek near the lift station.
3. Pages Creek Park Preserve with Jennifer Butler
   - 319 watershed plans will transfer to 5R watershed action plan to allow public review with NCDEQ. 5R plans will allow the information public friendly with story maps.
   - A small project suggested is to remove the cinderblocks within the Preserve for tidal flushing
   - Horses are a major issue within the Preserve as pet owners don't want to pick up waste.
   - Suggested to put up signs near the kayak access to inform residents not to swim in the water.
   - The Preserve was purchased for $430,000 which is a heavily used area now.
   - Discussion of other properties for sale and County priorities for conservation.
4. FEMA Buyout Property
   - Culverts are under North Hills Drive, a county property. These culverts were replaced 1-2 years ago.
   - Houses were bought out due to flooding multiple times during previous heavy rainfall events.
   - Areas are between 0.34 to 0.5 acres.

SLIDES FROM STAKEHOLDER MEETING PRESENTATION

Meeting Agenda:

- Welcome and Introductions (NHSWCD/CFRC&D)
- Nature Based Solutions for Flood Mitigation (Dr. Narcisa Pricope, UNCW)
- Overview of Watershed Plan Goals and Project Timeline (Moffatt & Nichol)
- Overview of Water Quality Trends in Pages Creek (New Hanover County Planning)
- Community Outreach Findings (NHSWCD)
- Working Session to Identify Priority Areas (Moffatt & Nichol)
- Site Visit Overview (NHSWCD/Moffatt & Nichol)

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NHC Soil and Water Conservation District: 2018-2022 Strategic Plan

	Stormwater Management		Education and Outreach			Land Conservation & Resource Managmeent		
Strategic Objective	Improve water quality	Reduce stormwater volume	Improve resident's understanding of being an environmental steward	Improve student's understand of being an environmental steward	Improve awareness of Soil and Water's mission and actions	Increase tree canopy	Aquire property in critical watersheds (Pages Creek, Hewitts Creek)	Protect Eagles Island's natural and cultral resources
Desired Outcome	Fewer incidents of flooding during rain events	Reduce miles/acres of impaired water in target watersheds	Increase recycling	Increase Env Edu programs in schools across grade levels	Increase the number of LCFSDC project applications	Increase amount of tree cover in NHC	Improve water quality monitoring results in critical watersheds	Conserve Eagles Island from development
	Decrease in peaks of cubic/second on hydrograph in watershed restoration plan	Fewer temporary waterway closures	Reduce non-point source pollution	Sponsor RCW study scholarship				
				Enviro-thon Teams				
				Outdoor learning centers at schools				
Target	1) TBD	1) TBD	1) 25% of NHC residents recycle	1) Increase programs by 10%	Maintain LCFSDC projects submitted (?)		Increase shellfish open areas	Acquire 40 acres on East Bank of Eagles Island to be placed in conservation
				2) 1 Student per year receive scholarship				
	2) 25 new BMPS per year that address quantity	2) Reduce waterway closures by 50%	2) Increase LID by 50%	3) Enviro-thon teams for 1 Middle School and all High Schools			Positive trends in water quality	
				Add 5 outdoor learning centers				
Technical Support								
Provide conservation-based technical support to resource agencies, units of local government, the agricultural community and the general public.								
	Support local businesses first	Technical staff to implement soil, water, and conservation management		Integrated data bases	Partnerships for programs and funding		Engage in continuous learning for board and staff	

3

Project Goals

Goals:

- Identification and prioritization of targeted retrofit projects for implementation
- Engage stakeholders within the Pages Creek watershed through community outreach initiatives and implementation of retrofit projects
- Approval by NCDEQ of the Pages Creek Watershed Restoration Plan to enable New Hanover County and Partners to qualify for 319 grant funding opportunities

- **EPA 319 grant program was added under the Clean Water Act in 1987 to establish a national program to address nonpoint sources of water pollution**
- **Grant funded projects must restore waterbodies currently impaired by nonpoint source pollution in areas with approved watershed restoration plans.**

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New Hanover Soil and Water Conservation District Goals and Outcomes

Desired outcomes include:

- Improve Water Quality in Target Watersheds
- Reduce Flooding through installation of Stormwater Control Measures
- Reduce Stormwater Volume through strategic conservation/restoration efforts
- Identify and prioritize projects for future implementation
- Develop a Watershed Restoration Plan to ensure eligibility for future funding through the NCDEQ 319 Program

Project Timeline

- Award granted to CFRC&D: December 2021
- Grant Contract Executed: June 2022
- Community Meeting #1: June 2022
- Project Team Kickoff: July 2022
- NHSWCD Website Project Update: July 2022
- Existing data and studies compilation: August - Present
- Stakeholder Meeting and Reconnaissance Site Visit: November 2022
- Source Identification Analysis / Develop Baseline Conditions: December 2022
- Evaluate Stormwater Control Measure Opportunities: January 2023
- Develop Watershed EZ Tool and Runoff Reduction Tool: February 2023
- Draft Watershed Restoration Plan prepared for review: March 2023

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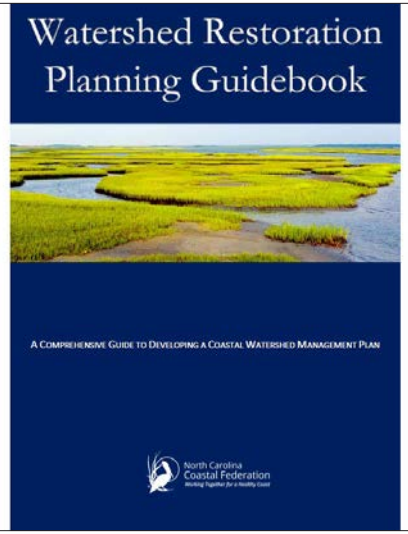
319 Grant Overview

- Section 319 addresses the need for greater federal leadership to help focus state and local nonpoint source efforts.
- Section 319 grant money can support a wide variety of activities including: technical assistance, financial assistance, education, training, technology transfer, demonstration projects and monitoring to assess the success of specific nonpoint source implementation projects.
- The EPA has identified nine minimum elements to be included in a watershed plan for impaired waters funded using incremental Section 319 funds. If existing watershed plans developed by local groups contain the nine key elements, they can be used to support section 319 work plans that contain projects extracted from the plan.

7



Elements of a Watershed Plan

1) Identify causes and sources of pollution
2) Estimate load reductions from practices
3) Describe management practices needed to achieve load reductions
4) Estimate technical and financial resources needed
5) Information and education component
6) Implement schedule
7) Interim milestones
8) Criteria: determine load reduction/progress
9) Monitoring: evaluate effectiveness

8

1) Identify Causes and Sources of Pollution

- **New Hanover Water Quality Monitoring Report, 2007-2022**
- **Pages Creek Thermal Survey Report, UNCW**
- **Watershed Restoration Planning Guidebook, NC Coastal Federation**
- **State and Federal Sources**
  - DEQ NC surface water classifications
  - NC DEQ Shellfish Sanitation
  - EPA
- **Publications**
  - Effect of Human Development on Bacterial Water Quality

2) Estimate Load Reductions

- The process of calculating stormwater runoff volume reduction goal has been standardized through the development of the *Watershed EZ Tool*, developed by the North Carolina Coastal Federation.
- The *Watershed EZ Tool* uses watershed characteristics (land use, impervious surface, soil characteristics, etc.) to evaluate watershed hydrologic behavior and evaluate potential stormwater load reductions provided by different stormwater control measures (SCMs).
- Stormwater volume reduction can lead to reduction in pollutant loads.

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3) Describe management practices needed to achieve load reductions

- The watershed plan seeks to utilize various stormwater reduction techniques to reduce stormwater runoff.
- For already developed areas where low-impact development cannot be used, stormwater reduction techniques can reduce the amount of stormwater entering waterways so that less bacteria and pollutants are transported off the land and into water systems.
- Load reductions refer to both the quality (bacteria and other pollutants) and quantity (areas of localized flooding) of runoff.
- This can include:
  - Applying stormwater reduction techniques on public properties
  - Reducing the volume of stormwater runoff from existing private land uses

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4) Estimate technical and financial resources needed

- A grant matrix will be developed for the plan
- Need commitment from New Hanover County to maintain technical and financial resources
- Future Implementation Funding Opportunities:
  - NCDEQ 319 grant program
  - NC Land and Water Fund – Restoration/Innovative Stormwater Fund (?)
  - New Hanover County – Stormwater Fee

5) Information and education component

- To achieve success in the overall watershed goals,, it is imperative that the community is educated about stormwater pollution and volume reduction needs and engaged in accomplishing the plan objectives.
- This could include actions such as:
  - Installing educational signage at select retrofits to highlighting the County's commitment to reducing stormwater.
  - Facilitating technical training opportunities for planners, engineers, developers, landscapers and local government staff on techniques to reduce volume of stormwater within the County.
  - Collaborating with partners to educate and engage property owners, businesses, and K-12 students and their families on stormwater management.

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6) Implementation schedule

- Tasks and activities related to implementation and monitoring are identified
- Timeline presents projected dates for the development and implementation of the actions needed to meet the goals of the plan (short, medium, and long-term)
- Includes information on how implementation will be tracked
- Implementation of point source and regulatory activities are coordinated with nonpoint source actions and other watershed implementation activities

7) Interim milestones

- Milestones are measurable accomplishments utilized to track positive changes and success of the plan.
- The short-term milestones for restoring water quality through volume reduction of surface runoff are:
  - Reducing stormwater runoff by 25%
  - Source funding for stormwater reduction projects
  - Hold quarterly education and outreach event

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8) Criteria: determine load reduction/progress

- To ensure that the Pages Creek Watershed Restoration Plan is meeting the needs of the watershed and community, the restoration plan should be evaluated on a regular basis to determine effectiveness
- Progress will be monitored through:
  - Calculated approximate volumes which are reduced by stormwater retrofits that are installed
  - A full assessment of plan with suggestions on ways to enhance or redirect the plan
  - Published report on watershed health

9) Monitoring: evaluate effectiveness

- Monitoring will be conducted by using several indicators:
  - Bacteria will be measured by comparing numerical historical data and modern measurements of fecal coliform
  - A simple inventory of retrofits will be kept and performance of stormwater reduction retrofits that have been installed within the watershed will be monitored
  - The volume of stormwater reduced by each retrofit will be documented by utilizing the runoff reduction scenario
  - Opportunities to utilize community members to conduct citizen science-based monitoring of stormwater reduction retrofits and inventory already installed retrofits can be explored

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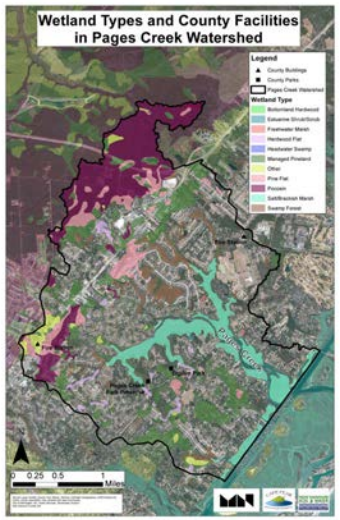

Current Watershed Issues

- Flooding incidents
- Water quantity and water quality
- Aging septic infrastructure
- High fecal counts (303d listed)

Sediment in Pages Creek adjacent to failing culvert, 2021

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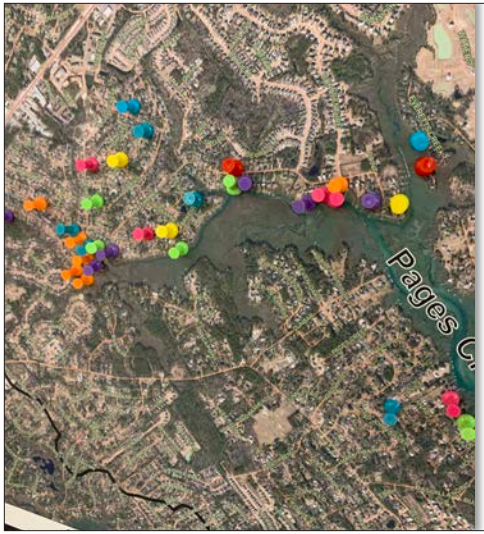

Public Outreach

- First community meeting held June 29, 2022
- Provided an opportunity for community members to voice concerns
- 66 community members attended
- Several community members are affiliated with commercial businesses, NCDOT, retired UNCW, and retired State agencies
- Community members have been observing water quality and quantity issues for many years

Residential community member locations that attended the public meeting are shown on the map.

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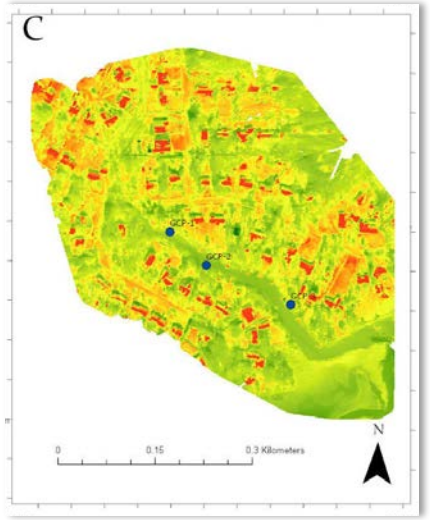

Future Implementation Opportunities

- Community Capacity Building and Planning
- Expand Innovative Research with Partners (i.e., thermal imagery, water quality monitoring)
- Community Education and Individual Property Owner Involvement
- Identify a Suite of Potential Flood-Mitigating Nature-Based Solutions

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moffatt & nichol

Thank you!

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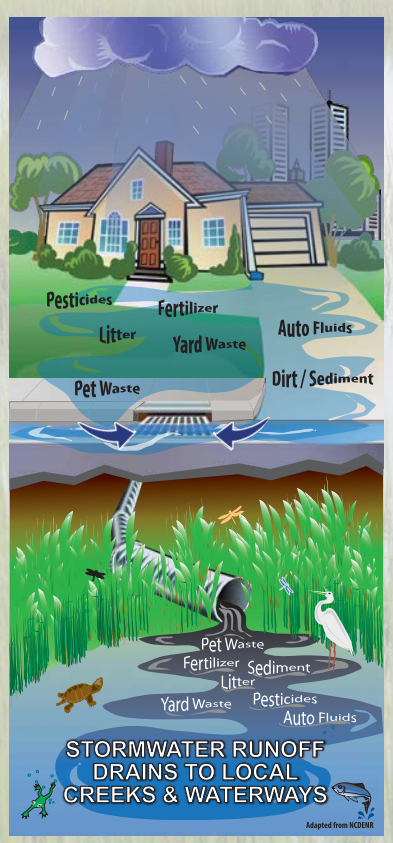
APPENDIX C: STORMWATER OUTREACH MATERIALS

CITY OF WILMINGTON STORMWATER SERVICES LEAFLET

STORMWATER is NOT treated!



Polluted stormwater runoff flows directly into where we fish, where we swim, and what we drink!

STORMWATER is a DIRTY word!

What goes in here ...

Stormwater runoff is rainwater that flows over land and ultimately into waterways. Hard surfaces like driveways, roofs, streets, and parking lots prevent stormwater from naturally soaking into the ground.

... ends up here!

Pollution like pet waste, fertilizers, pesticides, grass clippings, litter and motor oil are carried by stormwater runoff into local waterways — ***untreated!***

Polluted stormwater runoff is the biggest source of water pollution, but you can make a difference!

Connect the drops...YOU are the solution to stormwater pollution!

STORMWATER POLLUTION SIMPLE SOLUTIONS

STORMWATER POLLUTION is caused by human activities that occur on land and wash into our waterways when it rains. Polluted runoff harms fish, plants, wildlife, and humans. Fortunately, we can adopt simple solutions that will protect our waterways, our health, and our environment.

PET WASTE contains bacteria that can make humans sick and close waterways to swimming, fishing, and shellfishing, as well as nutrients that cause algae blooms.

- Always clean up after your pet on any public property, have the means to do so at all times, and dispose of pet waste in a closed trash can. It's the LAW! *($250 fine)*
- Don't forget to clean up pet waste in your own yard to prevent bacteria and nutrients from harming waterways and public health
- Use a covered litterbox for outdoor cats
- Don't flush pet waste down the toilet *(CFPUA Ordinance)*

VEHICLE & PRESSURE WASHING SOAPS destroy the natural oils on fish that protect them from harmful bacteria and help them move through water. Soaps and chemicals cause harmful algae to grow, which uses up oxygen that fish need to survive.

- Wash your car on the grass - the soapy, dirty water will be cleaned naturally by the soil. It won't harm the grass!
- Use a commercial car wash - dirty water goes to a wastewater treatment plant or is recycled on-site
- If you wash vehicles or boats or pressure wash on pavement, use plain water

VEHICLE/BOAT FLUIDS are toxic in water and harm fish, wildlife, and waterways.

- Recycle vehicle batteries, motor oil, and other fluids at an auto parts store or a suitable collection facility
- Keep vehicles and boats maintained
- Clean up any leaks or spills immediately

SEDIMENT also known as "dirt", creates muddy water, buries fish eggs, and harms aquatic life.

- Re-seed or add mulch to bare soil or landscape beds
- Install plants to hold down soil and prevent erosion
- Collect sediment off of paved surfaces; don't hose off
- Report construction site violations: *1.866.STOP.MUD*

FERTILIZERS contain nutrients that cause algae to grow in water, which uses up oxygen and kills fish and aquatic life. Nutrients cause "dead zones" in waterbodies.

- Grasscycle! Leave grass clippings on the lawn - they conserve soil moisture and are a natural fertilizer
- Save money! Learn the exact nutrients your lawn needs by getting a soil test from NHC Cooperative Extension, 910-798-7680, 6206 Oleander Drive
- Keep fertilizer off pavement; don't fertilize before rain

PESTICIDES are toxic chemicals that kill bugs, weeds, or fungus. However, pesticides are very harmful to humans, animals, and beneficial insects.

- Install native plants; they are adapted to the area and naturally resist pests and diseases
- Use natural methods to control pests or weeds (i.e., weed by hand, add mulch, use ladybugs, plant marigolds, etc.)
- Use pesticides as a last resort; never before it rains

YARD WASTE *(pinestraw, leaves, and grass clippings)* clogs storm drains, causes flooding, and pollutes our waterways with too many nutrients.

- Don't blow or leave yard waste in a street, storm drain, ditch, or waterway. It's the LAW! *($250 fine)*
- Grasscycle! Leave grass clippings on the lawn to conserve moisture and act as a natural fertilizer
- Compost yard waste; use in the landscape and garden
- Contain waste for City Yard Waste Collection Service

LITTER is ugly and clogs storm drains. Wildlife mistake litter for food and eat it or become entangled in it. Cigarette butts are litter too!

- Place litter, gum, and cigarette butts in the trash
- Reduce, reuse, recycle, and refuse

HOUSEHOLD HAZARDOUS WASTE (HHW) such as paint, cleaners, and electronics have toxins and heavy metals that shouldn't end up in our waterways.

- New Hanover County has HHW & Electronics Recycling locations. Visit: **https://recycling.nhcgov.com/services/household-hazardous-waste/**

THINGS YOU CAN DO IN YOUR OWN BACKYARD

The following "stormwater solutions" can be used on your property to clean and slow down polluted runoff and allow it to soak into the ground, as nature intended.

RAIN BARRELS & CISTERNS

are designed to capture and store rainwater from your roof to irrigate your yard, garden and house plants. Several rain barrels can be connected together to store additional water. A tight lid and screen will prevent mosquitoes from breeding. Cisterns store larger amounts of water and can be buried underground.

RAIN GARDENS

are shallow depressions designed to capture runoff and allow it to soak into the ground. Rain gardens are placed between sources of runoff *(i.e. roofs, driveways)* and runoff destinations *(i.e. storm drain, street, creek)*. They are planted with native trees, shrubs, and perennials which clean runoff, provide habitat, and beautify your yard.

Photo courtesy Maplewood, MN

BACKYARD WETLANDS

should be located in a naturally-occurring wet area on your property. Wetlands temporarily store, filter, and clean polluted runoff, replenish groundwater, provide wildlife habitat, and help prevent flooding. They should have plants that thrive in wet conditions and attract insects and wildlife that prey on mosquitoes and other pesky insects.

BUFFERS

are areas of native trees, shrubs, and grasses located next to a waterway. Buffers act as filters to clean polluted runoff before it reaches a waterway. They also stabilize shorelines, prevent erosion, and provide habitat and travel corridors for wildlife. Buffers can also provide privacy and increased property values for homeowners.

NATIVE PLANTS

are adapted to the region's weather and soil conditions. Native plants provide nectar, pollen, berries and seeds for birds and wildlife. These plants help filter runoff, prevent erosion, reduce flooding, provide habitat and beautify your yard. Native plants eliminate the need for toxic pesticides, fertilizers, and excess watering.

TREES

soak up and clean polluted runoff, improve air quality, provide food for wildlife, prevent erosion, increase property values, and help cool the climate. They save money by reducing heating and cooling costs in homes and buildings. Trees are also important for shading pavement to help cool runoff before it flows into waterways.

RE-ROUTE YOUR DOWNSPOUT

Downspouts on homes and buildings often drain rainwater directly onto pavement. This allows polluted runoff to flow straight to our waterways.

There is a solution! You can help our creeks out if you **re-route your downspout** and let water soak in, instead of running off! It's simple, here's what to do:

Redirect downspouts away from pavement to landscaped areas like lawns, flower beds, and rain gardens.

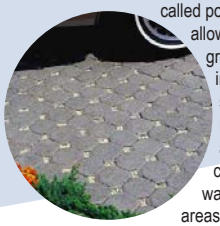
If a downspout can't be turned, attach a flexible gutter extension or a splash block underneath which can re-route rainwater to a landscaped area.

Redirect downspouts into rain barrels and collect free rainwater for your landscape, garden, and house plants.

HABITAT GARDENS

have plants that attract birds, butterflies, beneficial insects, and wildlife. Habitat gardens should have sunlight, shelter, food sources, and water. Habitat gardens are especially important for wildlife in urban areas where natural resources tend to be more limited. Plants in a habitat garden soak up polluted stormwater.

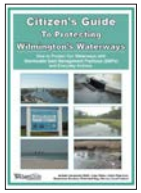
PERVIOUS SURFACES



also called porous or permeable surfaces, allow runoff to soak into the ground instead of running into waterways. Pervious surfaces reduce runoff, recharge groundwater, and lessen flooding. They can be used for driveways, walkways and low flow parking areas.

GET THE FREE GUIDE!

The Citizen's Guide to Protecting Wilmington's Waterways



Learn how to install these solutions in your own yard. The guide contains photos and native plant lists too!

To download, visit **www.wilmingtonnc.gov/stormwater** and click on "Publications & Videos".

MORE INFORMATION?

CITY OF WILMINGTON STORMWATER SERVICES

wilmingtonnc.gov/stormwater
910.343.4777

Report Stormwater Pollution

CALL 910.341.1020 **(Hotline)**
CLICK wilmingtonnc.gov/reportstormwaterpollution

APPENDIX D: COMMUNITY OUTREACH MATERIALS

PORTCITYDAILY
WILMINGTON, NC

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Pages Creek abundant with pollutants

County officials, local organizations collaborate to create watershed restoration plan

By **Amy Passaretti Willis** January 26, 2022

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Pages Creek watershed contains elevated levels of pollutants and local organizations are collaborating on a watershed restoration plan to mitigate the effects. (Courtesy photo)

PORT CITY DAILY ARTICLE, JANUARY 2022

Pages Creek abundant with pollutants: County officials, local organizations collaborate to create watershed restoration plan by Amy Passaretti Willis

NEW HANOVER COUNTY — Elevated levels of pollutants in Pages Creek watershed are leading to contaminated water, increased flooding and economic hardship for local shellfish industries, according to recent water quality reports

In violation of the U.S. Environmental Policy Agency's Clean Water Act, Pages Creek contains high levels of fecal coliform and nearby development has exponentially increased runoff, further polluting local water quality. New Hanover County and local organizations are working to mitigate these effects by establishing a plan for the 5,025-acre area.

The Cape Fear Resource Conservation and Development (CFRCD), New Hanover County Soil and Water Conservation District (NHCSWCD) and Moffatt & Nichol (a Raleigh-based civil engineering firm) signed a Memorandum of Understanding on Monday with New Hanover County Board of Commissioners to implement a watershed restoration program.

The intent is to obtain approval by N.C. Division of Water Resources, to allow the county to qualify for Federal EPA319 grant-funding opportunities. County SWCD director Dru Harrison explained at the meeting the plan will detail what can be done to improve water quality, and the EPA grant funding would help implement that strategy.

The state Land and Water Fund awarded the project $75,000 to begin the planning process, which Moffatt and Nichol senior coastal planner Dawn York said should be complete by spring 2023.

The memorandum also ensures all stakeholders involved in the planning process and the community are on the same page. Cape Fear RCD executive director Danielle Darkangelo explained that keeping the community abreast of the plan, sources and use of funding and roles of those involved is vital to the

project's success.

While eight organizations are involved in the planning, the workload will fall on the county's soil and water district, CFRCD and Moffatt & Nichol, the technical lead on development of the plan.

Out of New Hanover County's 12 watersheds, Pages Creek is considered to have the most severe problems and contains 17.8% impervious surface coverage. Located between Middle Sound Loop Road and Bay Shore, Pages ultimately flows into the Intracoastal Waterway, with its contaminants then draining into the ocean.

Based on scientific data from water-monitoring reports, Pages Creek has been designated as a target watershed in the soil and water district's strategic plan, along with Hewlett's Creek. The area is densely populated, with roughly 8,000 residents in its coverage area; it also contends with frequent flooding.

"Water quality and water quantity have become such big issues, and have gotten a lot of rhetoric, but there haven't been a great deal of active projects to address or find out what's going on," Darkangelo said.

The high levels of fecal coliform in the area are from human waste, but its destination point is still unclear, Harrison said. With 27,000 registered dogs in the county, there is also 12.5 tons of pet waste produced a day that run into local waterways.

Fecal bacteria is not the only pollutant creating issues. Statewide, sediment particles are abundant and when that gets stirred up in water beds, other pollutants cling to those particles.

"Imagine this: Say you're a fish that lives in this water," Harrison said. "When you have multiple pollutants in the water, it starts impacting wildlife greatly. Fish can't breathe. It's like us breathing in smog. So, they'll either leave or no longer reproduce."

The impact on shellfish in waterways is also extensive and growing statewide. Farmers can lease areas in North Carolina's watersheds to grow and harvest shellfish commercially. When pollutants are elevated, the N.C. Division of Marine Fisheries puts a temporary stop on harvesting or issues a closure of that location.

"The state is trying to encourage people to do more shellfish harvesting, specifically oyster farming, so we have a greater industry to contribute to more of our regional food source," Darkangelo said. "It's a very sustainable, economical and economic development supporting industry. So, for them to be shut down is quite an issue; it could impact the livelihood of growers and the surrounding community."

As such, oyster farming has been shut down in many areas, including Pages Creek. Oysters are filter-feeders, so when a person consumes an oyster harvested from a polluted watershed, he or she could get very sick from the pollutants seeping into the shellfish.

"[Nearly] every tidal creek in New Hanover County has a spot on it that's closed to shellfish harvesting," Harrison said.

The watershed restoration plan will dictate specific action to reduce the effects of polluted waters. Similar to Bradley and Hewletts creeks' watershed restoration plans, sponsored by the City of Wilmington and N.C. Coastal Federation, the Pages Creek plan will put in place "gray and green infrastructure" to help infiltrate more stormwater in the area to reduce flooding.

Gray infrastructure refers to manmade, traditional fixtures — such as seawalls, roads, pipes and water treatment plants — to slow the flow of water. Green infrastructure restores or mimics the natural water cycle and provides a way for water to absorb into the ground. Many factors, including space, soil type, money, all dictate the needed course of action. A combined approach is usually chosen to implement the most effective solution, Harrison explained.

Examples of projects done in other local watersheds range from backyard rain gardens to extensive projects, such as converting UNCW's parking lots to pervious surfaces.

"The goal is to reduce the hydrograph," Harrison said, "the measurement each year of how much water soaked into the ground and how much flowed into the creek."

Community Input Meeting: Pages Creek Watershed Restoration

June 17, 2022 by WWAY News

(Photo: MGN)

WILMINGTON, NC (WWAY) — New Hanover Soil & Water Conservation District (NHSWCD) is inviting people to share their input about water quality and flood protection in the Pages Creek Watershed.

NHSWCD and its partners, Cape Fear Resource Conservation & Development and Moffatt & Nichol, have been selected to receive a grant from the NC Land and Water Fund to conduct a study of the watershed to identify problem areas, causes, and potential solutions in a comprehensive Pages Creek Watershed Restoration Plan.

A news release from the district states:

WWAY NEWS ARTICLE, JUNE 2022

Community Input Meeting: Pages Creek Watershed Restoration

WILMINGTON, NC (WWAY) — New Hanover Soil & Water Conservation District (NHSWCD) is inviting people to share their input about water quality and flood protection in the Pages Creek Watershed.

NHSWCD and its partners, Cape Fear Resource Conservation & Development and Moffatt & Nichol, have been selected to receive a grant from the NC Land and Water Fund to conduct a study of the watershed to identify problem areas, causes, and potential solutions in a comprehensive Pages Creek Watershed Restoration Plan.

A news release from the district states:

"Now, in the early stages of the plan, we invite you to participate in the process by sharing your experiences and input on the quality of water in Pages Creek.

At the start of the meeting, general information about the restoration initiative will be provided. Following the presentation, participants will have an opportunity to interact with staff to share your insights.

We are seeking locations of localized flooding and water quality concerns, and areas where the community would like to see green infrastructure projects implemented such as rain gardens, bioswales, and conservation and enhancement of wetlands.

Your involvement is one of the first steps in a process of leveraging local resources to achieve the greatest water quality and flooding improvements with limited funding."

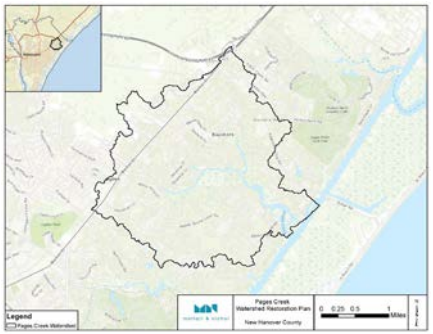
The meeting will take place June 29th, 2022 from 6:00 p.m. to 7:00 p.m. at the Lutheran Church of Reconciliation (7500 Market Street, Wilmington NC 28411).

All residents and business owners in the Pages Creek Watershed are welcome to attend.

In August, you will be able to contribute your input via online survey.

PAGES CREEK WATERSHED RESTORATION PLAN FACT SHEET

SUMMARY/DESCRIPTION



Pages Creek Watershed Boundary

The Cape Fear Resource Conservation & Development (CFRC&D), in partnership with the New Hanover County Soil and Water Conservation District (NHCSWCD) and Moffatt & Nichol (M&N), will support the development and completion of a Pages Creek Watershed Restoration Plan. A comprehensive watershed restoration plan for Pages Creek will provide a long-term management framework for northern New Hanover County (NHC) and its partners to address persistent water quality impacts.

The watershed restoration plan provides a voluntary management framework for NHC and its residents to address stormwater runoff and water quality issues in Pages Creek. The restoration strategies to be developed by partners, stakeholders, and residents will be aimed at mimicking the natural hydrology of the land pre-development before water quality impairment was an issue. Mimicking natural drainage processes can reduce runoff and nuisance flooding and help restore water quantity and quality requirements of receiving water bodies.

Building off previous plans developed in NHC (e.g., Bradley and Hewlett's Creek), the Pages Creek plan would be developed using many of the approaches presented in the Watershed Restoration Planning Guidebook developed by the North Carolina Coastal Federation. This guidance is designed to focus on how a community can replicate natural surface water hydrology to improve water quality by determining the stormwater runoff volume of a watershed in various land use scenarios and utilizing Stormwater Control Measures (SCMs) to reduce total runoff volume.

PAGES CREEK WATERSHED FACTS

- The Pages Creek watershed is in northern New Hanover County, and drains a 5,025-acre watershed into the Intracoastal Waterway and eventually the Atlantic Ocean.
- The population residing in the Pages Creek watershed is 8,000.
- Pages Creek has approximately 18% impervious surface coverage.
- The watershed is impaired under the Clean Water Act and its shellfish waters are closed due to high bacterial levels from runoff.
- Pages Creek has experienced an increase in flooding and a decrease in water quality over the past two decades.

FUNDING SOURCE & AMOUNT

North Carolina Land and Water Fund $75,000

TIMEFRAME

12 - 18 months (Anticipated Fall 2023)

GRANT ADMINISTRATOR

Cape Fear Resource Conservation & Development

PROJECT PARTNERS

Moffatt & Nichol

New Hanover County Soil and Water Conservation District

New Hanover County Planning

CAPE FEAR RESOURCE CONSERVATION & DEVELOPMENT

moffatt & nichol

NEW HANOVER SOIL & WATER CONSERVATION DISTRICT

NORTH CAROLINA LAND & WATER FUND

PROJECT GOAL(S)

- Completion and approval by NCDEQ of the Pages Creek Watershed Restoration Plan, which will enable NHC to qualify for federal 319 grant funding opportunities.
- Identification and prioritization of targeted retrofit projects for implementation aimed at reducing impact of impervious surface by mimicking natural hydrology to reduce flooding and improve water quality.
- Engage stakeholders within the Pages Creek watershed through community outreach initiatives and implementation of retrofit projects within five years.

Photo Credit: Jennifer Butler, local resident of Pages Creek watershed

WHAT ARE NATURE BASED SOLUTIONS?

Nature based solutions also known as green infrastructure, are sustainable planning, design, environmental management and engineering practices that work with nature to enhance the ecosystem services. Examples of nature-based solutions include living shorelines, rain gardens, wetland restoration, and riparian buffers.

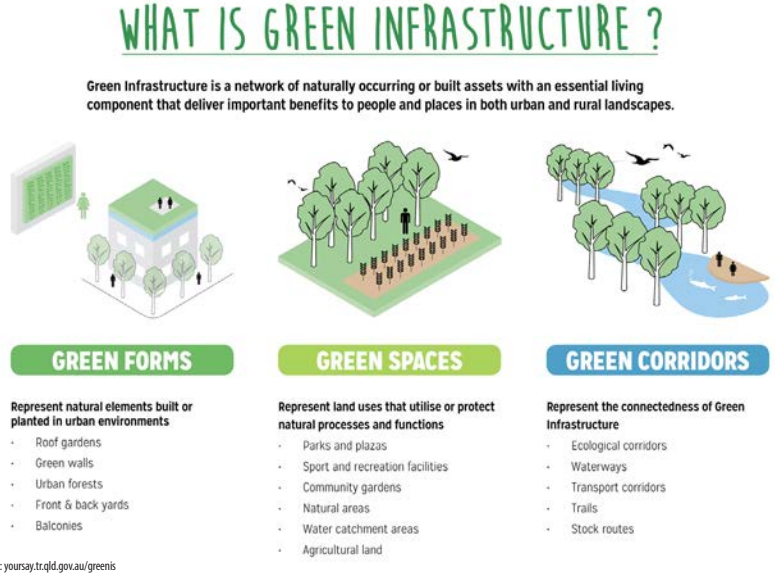


Image Credit: yoursay.tr.qld.gov.au/greenis

SLIDES FROM COMMUNITY MEETING PRESENTATION

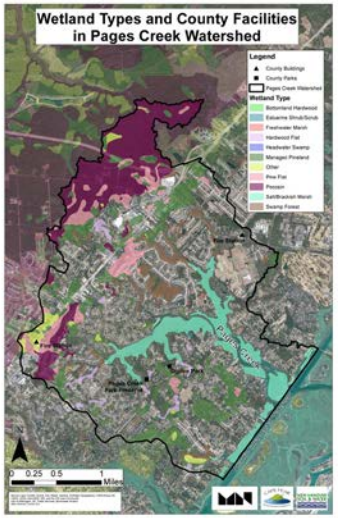
moffatt & nichol

CAPE FEAR RESOURCE CONSERVATION & DEVELOPMENT

NEW HANOVER SOIL & WATER CONSERVATION DISTRICT

Pages Creek Watershed Restoration Plan

June 29, 2022
Community Meeting



Current Watershed Issues

- Flooding incidents
- Water quantity and water quality
- Aging septic infrastructure
- High fecal counts (303d listed)

Sediment in Pages Creek adjacent to failing culvert, 2021

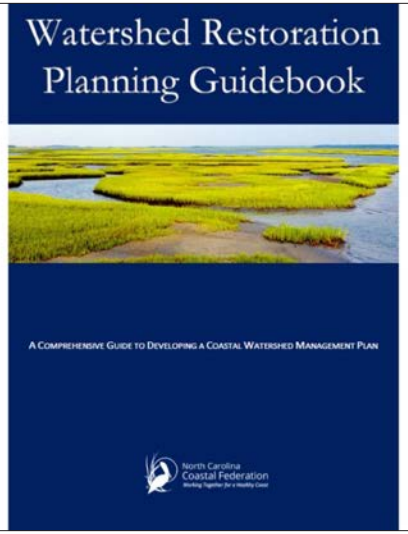
3

Goals of NHC Soil & Water Conservation District

NHC Soil and Water Conservation District: 2018-2022 Strategic Plan

	Stormwater Management		Education and Outreach		Land Conservation & Resource Management		
Strategic Objective	Improve water quality	Reduce stormwater volume	Improve resident's understanding of being an environmental steward	Improve student's understand of being an environmental steward	Improve awareness of Soil and Water's mission and actions	Increase tree canopy	Acquire property in critical watersheds (Pages Creek, Hewetts Creek)	Protect Eagles Island's natural and cultral resources
Desired Outcome	Fewer incidents of flooding during rain events	Reduce miles/acres of impaired water in target watersheds	Increase recycling	Increase Env Edu programs in schools across grade levels	Increase the number of LCFSDC project applications	Increase amount of tree cover in NHC	Improve water quality monitoring results in critical watersheds	Conserve Eagles Island from development
	Decrease in peaks of cubic/second on hydrograph in watershed restoration plan	Fewer temporary waterway closures	Reduce non-point source pollution	Sponsor RCW study scholarship				
				Enviro-thon Teams				
				Outdoor learning centers at schools				
Target	1) TBD	1) TBD	1) 25% of NHC residents recycle	1) Increase programs by 30%	Maintain LCFSDC projects submitted (?)		Increase shellfish open areas	Acquire 40 acres on East Bank of Eagles Island to be placed in conservation
				2) 1 Student per year receive scholarship				
	2) 25 new BMPS per year that address quantity	2) Reduce waterway closures by 50%	2) Increase LID by 30%	3) Enviro-thon teams for 1 Middle School and all High Schools			Positive trends in water quality	
				Add 5 outdoor learning centers				
Technical Support								
Provide conservation-based technical support to resource agencies, units of local government, the agricultural community and the general public.								
	Support local businesses first	Technical staff to implement soil, water, and conservation management		Integrated data bases	Partnerships for programs and funding		Engage in continuous learning for board and staff	

- Desired outcomes include:
- Improve Water Quality in Target Watersheds
- Reduce Flooding through installation of Stormwater Control Measures
- Reduce Stormwater Volume through strategic conservation/restoration efforts
- Identify and prioritize projects



Elements of a Watershed Plan

1) Identify causes and sources of pollution
2) Estimate load reductions from practices
3) Describe management practices needed to achieve load reductions
4) Estimate technical and financial resources needed
5) Information and education component
6) Implement schedule
7) Interim milestones
8) Criteria: determine load reduction/progress
9) Monitoring: evaluate effectiveness

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Project Goals and Future Implementation Opportunities

Goals:

- Approval by NCDEQ of the Pages Creek Watershed Restoration Plan to enable NHC to qualify for 319 grant funding opportunities
- Identification and prioritization of targeted retrofit projects for implementation
- Engage stakeholders within the Pages Creek watershed through community outreach initiatives and implementation of retrofit projects

Future Implementation Opportunities:

- NCDEQ 319 grant program
- NC Land and Water Fund – Restoration
- New Hanover County – Stormwater Fund

- **EPA 319 grant program was added under the Clean Water Act in 1987 to establish a national program to address nonpoint sources of water pollution**
- **Grant funded projects must restore waterbodies currently impaired by nonpoint source pollution in areas with approved watershed restoration plans.**

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moffatt & nichol

Thank you!

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