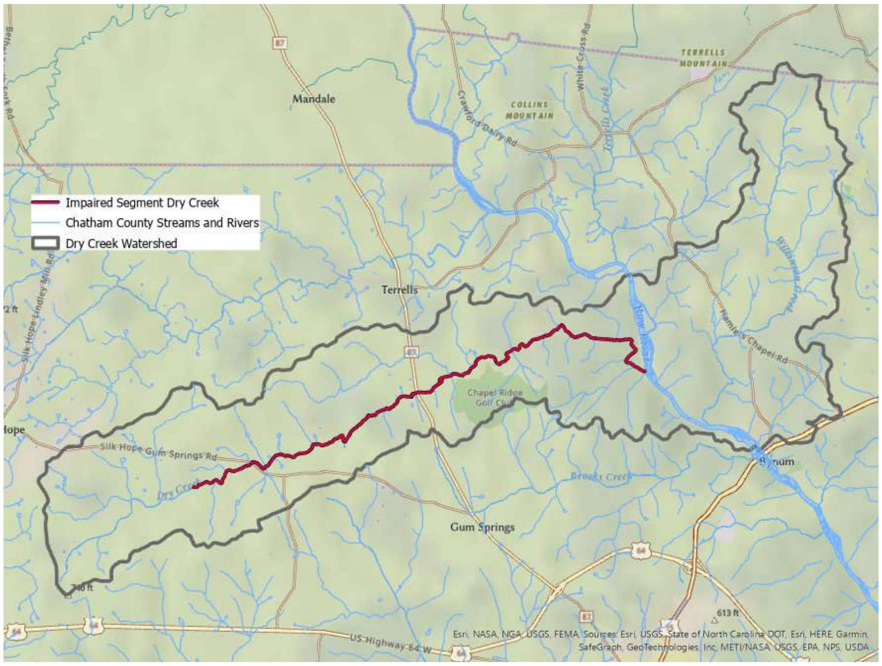
Dry Creek Watershed Plan
USGS HUC 030300020701



Dry Creek Watershed Action Plan (8.29.2022)
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Triangle J Council of Governments

Last Updated August 2022

Contributing Partners

Chatham County Watershed Protection and GIS Departments
Chatham County Soil and Water Conservation District
Chatham County Environmental Health Department
North Carolina Division of Water Resources
Haw River Assembly
Chapel Ridge HOA
Biocenosis, LLC

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Acronyms and Abbreviations

303(d)	List of Impaired Waterbodies
AU	Stream assessment unit used for 303(d) list
Biocenosis	Biocenosis, LLC
CFS	Cubic feet per second
CWEP	Clean Water Education Partnership
DMS	North Carolina Division of Mitigation Services
DOT	North Carolina Department of Transportation
EHD	Chatham County Environmental Health Department
EPT	Pollutant-sensitive insects that live in streams
HRA	Haw River Assembly
HSG	hydrologic soil group
HUC	hydrologic unit code
LF	Linear feet (ie, of streambank restored)
mg/L	milligrams per liter
mL	milliliters
NCDEQ	North Carolina Department of Environmental Quality
NCDWR	NC Division of Water Resources
NCLWF	NC Land and Water Fund
NCNHP	North Carolina Natural Heritage Program
NCWRC	North Carolina Wildlife Resources Commission
NRCS	National Resource Conservation Service
NSW	Nutrient Sensitive Water
Plan	Dry Creek Watershed Action Plan
Plan Chatham	Chatham County Comprehensive Plan
SCM	Stormwater Control Measure
SR	State Route

SWCD	Chatham Soil and Water Conservation District
TJCOG	Triangle J Council of Governments
TLC	Triangle Land Conservancy
USEPA	US Environmental Protection Agency
USGS	United States Geological Survey
Watershed Group	To-be-formed group of staff/volunteers who lead the implementation of this plan
Watershed Protection	Chatham County Watershed Protection

Guide to Nine Minimum Elements

This table serves as a quick reference guide to where the Environmental Protection Agency (EPA) Nine Minimum Elements 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.	**CTRL + click on section numbers to jump to them in text:** • Impaired waterbodies identified: Section 1 • Goals defined: Section 4 • Stressors and sources of impairment mapped, causes identified: Section 2.2. • Existing water quality data review: Section 2.1 • Loads from sources and load reduction goals identified: Section 3 • More granular watershed analysis: Section 2.2.1.3.1, section 2.2.2, and section 3.3 • Initial field assessment at areas of greatest concern: Photos, notes throughout Section 2.2. • Data sources, estimates and assumptions cited throughout • Data gaps: Section 2.1.1
2	An estimate of the load reductions expected from management measures.	Indicate the quantitative load reduction targets, and how target will ensure water quality criteria or other goals will be achieved: Section 3 Load reductions linked to causes/sources: Section 3 Section 5.1 Prioritize proposed activities/projects and identify critical areas that need management: Section 5 Basis of load reduction estimates associated with management measures explained and cited for different BMP types: Section 5.3.2.1 Section 5.3.3.1 Section 5.3.4.1

		Data to extrapolate practice types to load reductions and cost - EMCs by SCM practice type: Section 5.3.3.1 - Agricultural BMP load reductions and costs: Section 5.3.2.1 - Septic replacement reference calculations: Section 5.3.4.1 Describe potential management measures within the watershed: Section 5 Document relevant authorities that may have a role in management plan: Second table from top of Section 4 Management activities should address the indicators: Table in Section 3.1 Table in Section 5
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.	Management measures: Section 5 Critical source areas: Section 2.2.2 Objectives table in Section 4
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 6.9
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 5.5
6	Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.	Schedule: Section 6.1 and 6.2

7	A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.	Milestones: Sections 6.3 through 6.6
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.	Criteria and indicators: 6.7
9	A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the established criteria.	Monitoring of plan goals: 6.7 Monitoring/evaluation of plan: Sections 6.8

Executive Summary

The Dry Creek watershed is an important resource for species and habitats and protection of downstream water quality, but a broad range of nonpoint source pollutants are degrading its water quality and ecosystems. Development and land use impacts since approximately the year 2000 have degraded the benthic macroinvertebrate community at the bottom of the food chain, and data and stakeholder input indicate that this relates to increased inputs of sediment, nutrients, and fecal coliform bacteria to the creek.

Without intervention, increasing development in this watershed region will further these trends over time. This Watershed Action 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 will be essential to meaningfully improve water quality and ecosystem health here.

Introduction

The purpose of this watershed plan is to guide restoration efforts and improve water quality in the Dry Creek watershed of Chatham County, North Carolina. A major driver for the development of this plan was the designation of Dry Creek as “impaired” by the North Carolina Department of Environmental Quality (NCDEQ) due to benthic macroinvertebrate community being rated as “Fair”. Additionally, project partners completed a study in 2009 of baseline watershed condition and restoration needs in this watershed, which provided a foundation for this plan to build upon. The overall goal of this document is to identify pollution sources which have degraded water quality and watershed habitat resulting in benthic community declines and provide a roadmap for project partners and other stakeholders to improve conditions, with the ultimate result of "impaired" stream segments removal from the impaired water list.

Per the United States Environmental Protection Agency (USEPA)’s Nine Minimum Elements of a Watershed Restoration Plan, this document outlines current watershed conditions, priorities for future conservation and restoration projects, benchmarks for measuring success, and recommendations for ongoing improvement. This plan is intended to be updateable as further information becomes available, so that it will continue to be useful to future stakeholders as the watershed changes over time.

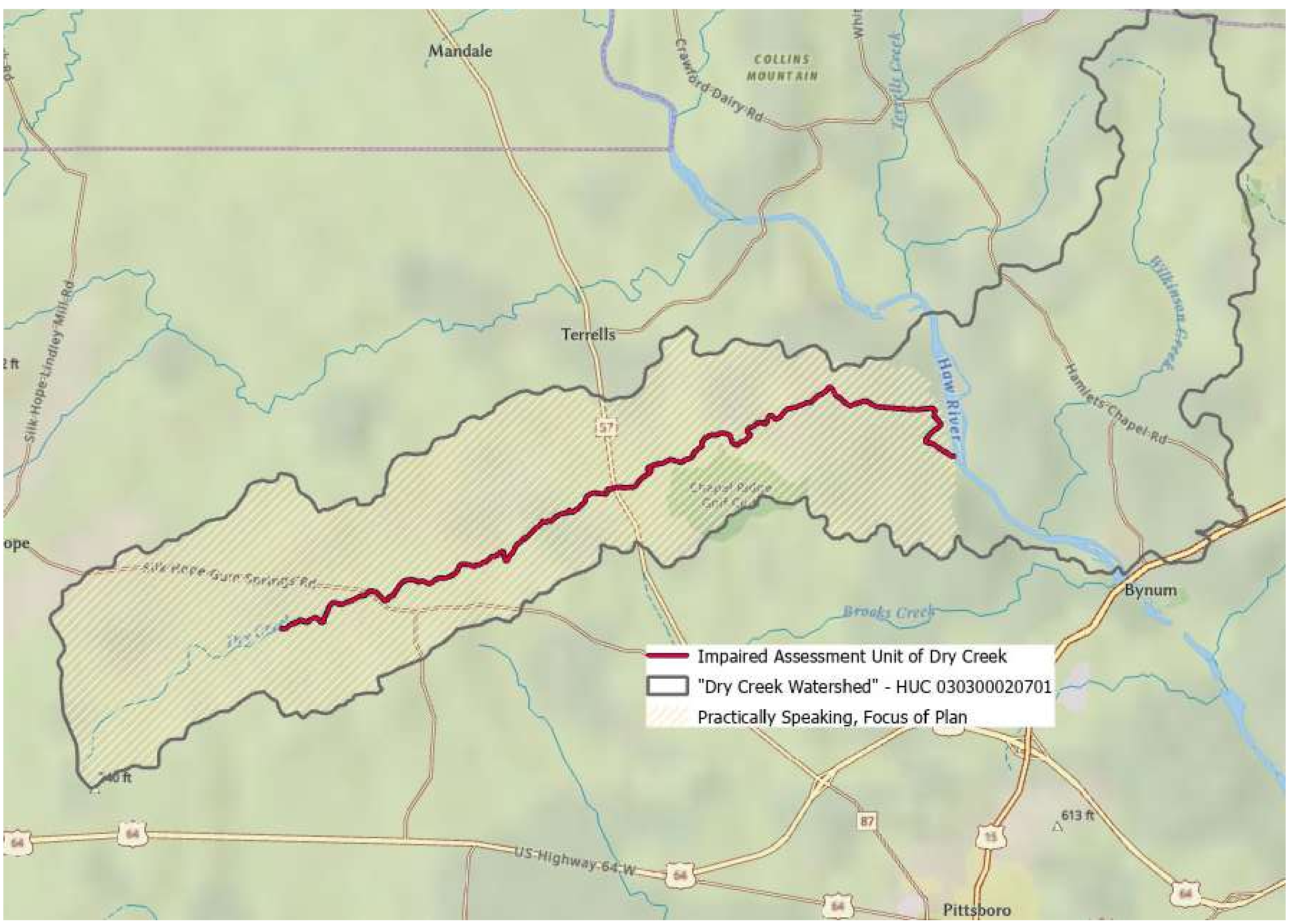
1 Watershed Description

The Dry Creek watershed, USGS 12-digit HUC 030300020701, flows into the Haw River in northern Chatham County. It is composed of farmland, forestland, and several subdivisions, with more in development. Dry Creek has been impaired since 2004 due to "fair" benthic aquatic invertebrate life.

To the north of Dry Creek lies the Terrells Creek watershed; to the south, the Brooks Creek watershed. The 12-digit HUC that NCDEQ now calls the Dry Creek watershed is made up of two component subwatersheds: Dry Creek is west of the Haw River, and Wilkinson Creek is east of the Haw River.

Due to data availability and the interests of project partners, this watershed plan focuses primarily on applying EPA's 9 elements to the 15,360 acre (24 square mile) subwatershed west of the Haw. When USGS and DEQ still used 14-digit HUCs, the "Dry Creek watershed" HUC 14 consisted of the area in hatched tan in the map below, from the origins of Dry Creek to the Haw River. This is the portion of the 12-digit HUC where DEQ monitors water quality, and that is designated as "impaired" based on benthic macroinvertebrate data. Past planning work completed as part of a 319 grant-funded project focused on collecting additional data in this HUC 14. This watershed restoration plan builds on that data. No DEQ data is collected in the Wilkinson Creek watershed, so it is considered unimpaired.

Figure 1: Map of HUC 030300020701, and Dry Creek Watershed Plan Focus Area



Throughout this document, the term "Dry Creek watershed" is used to refer to Dry Creek west of the Haw, the focus area of the plan. Where available, maps and data also include Wilkinson Creek for future reference for assessment for protection and restoration priorities as well. A complete analysis of Wilkinson Creek's needs was largely outside the scope of this planning project and less of a priority for nonpoint source pollution management since it is currently considered unimpaired. However, it will be important to prevent degradation of the whole HUC 12 and in the wider region as development form the Triangle continues to expand into Chatham County. Should DEQ begin to collect data in the Wilkinson Creek watershed that deems it impaired, data created for Wilkinson Creek as part of this watershed plan can be used to start a restoration plan specifically for this subwatershed.

1.1 Physical and Natural Features

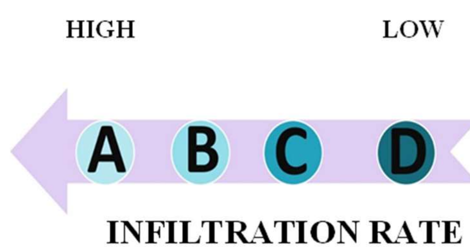
1.1.1 Hydrology

Dry Creek lies in the Jordan Lake Watershed, which is part of the Cape Fear River Basin. As its name suggests, Dry Creek experiences periodic low flows, especially in summer. This is because of its Carolina Terrane geology (formerly called the Carolina Slate Belt.) Implications of low flows are described in section 2.2.1.5.

1.1.2 Soils

The U.S. Department of Agriculture Natural Resource Conservation Service's (NRCS) Web Soil Survey has designated four hydrologic soil groups (HSGs). Groups A, B, C, D exist with progressively decreased infiltration potential characteristics; 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 lowest runoff potential.

Figure 2: Hydrologic Soil Groups' Infiltration Potential

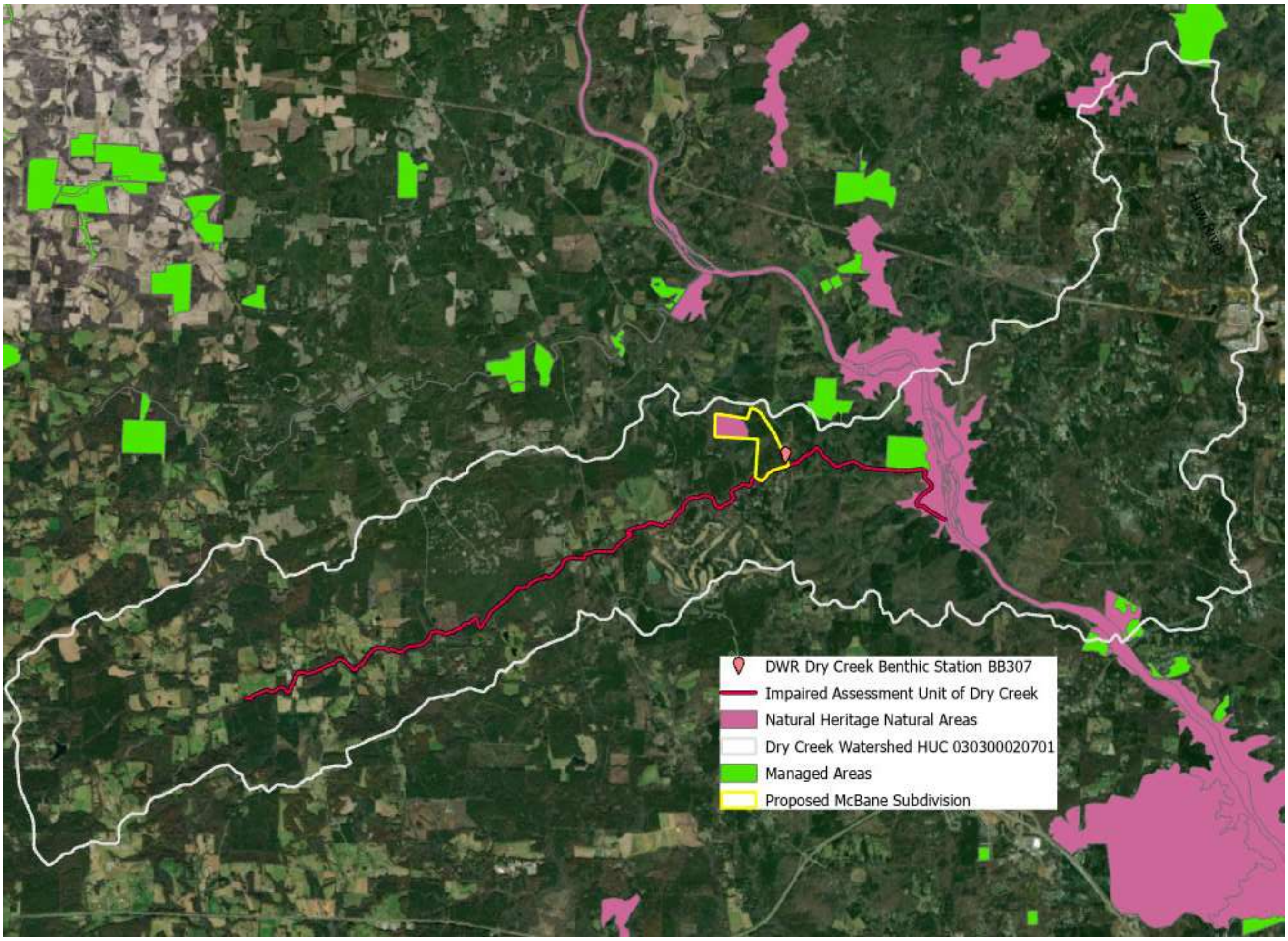


Per NRCS Web Soil Survey data, the primary HSG in the Dry Creek watershed is HSG B at 60%, followed by HSG C at 35%, meaning that soils are relatively well drained.

1.1.3 Important Natural Areas

The North Carolina Natural Heritage Program (NCNHP) has identified several important natural communities in the areas shown in the map below.

Figure 3: NCNHP-Identified Natural and Managed Areas In/Adjacent to Dry Creek Watershed



In February/March 2020, North Carolina Natural Heritage Program (NCNHP) staff conducted a "customized environmental review for the McBane project near the intersection of White Cross Road and Rock Rest Road near Bynum, NC to look for natural communities, rare plants and aquatic animals."

As part of their review, they surveyed forest community types, fish species, and provided management recommendations. The fish survey was conducted to assess the presence of *Etheostoma collis*, or the Carolina Darter, a species of State Special Concern, because this species was collected by NC Wildlife Resources Commission staff in electrofishing surveys in 2004 in the same vicinity of Dry Creek. NCNHP staff did not find the Carolina Darter during this survey but noted that the "species is believed to be extant in Dry Creek regardless of our failure to detect in current survey," (Ratcliffe 2020, retrieved from Withers and Ravenel EIA.) Staff also noted that Dry Creek confluences with the Haw River 2.4 miles downstream, and the Haw provides habitat for the Federal Endangered Cape Fear Shiner or *Notropis mekistocholas* and the USFWS At-Risk Septima's Clubtail dragonfly or *Gomphurus septimal*. However, staff found no federally or state-designated threatened or endangered species during their surveys.

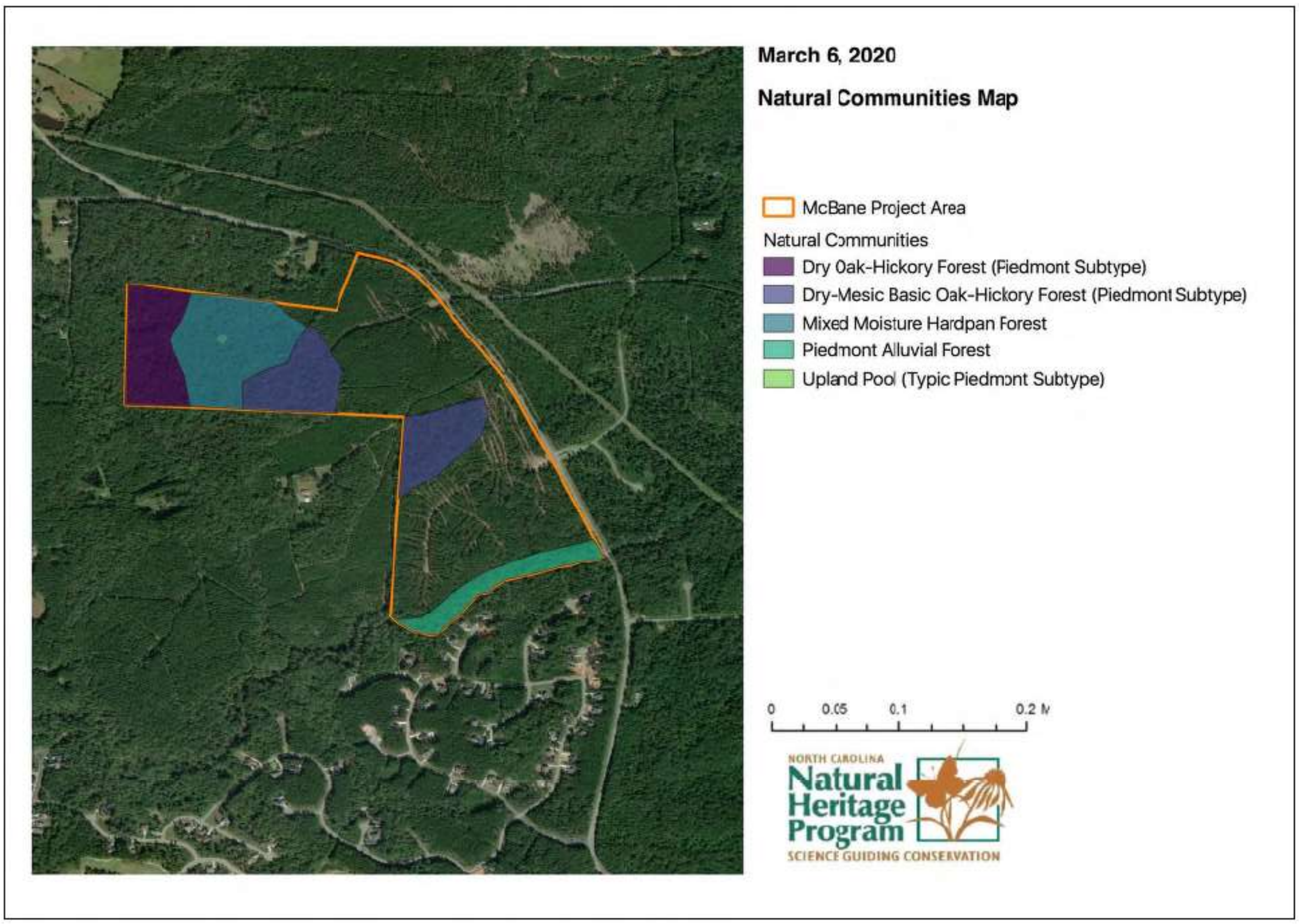
NCNHP staff conservation recommendations included the following:

If possible, it is recommended that the two rare to uncommon natural communities found within this project area (Upland Pool and Mixed Moisture Hardpan Forest) be conserved and periodically monitored for changes. Although no rare plants were observed in this survey, soils found in the project area are associated with rare plants and salamanders in adjacent counties. In other areas with these uncommon soils, a regime of prescribed fire has resulted in appearances of previously unobserved rare plants.

As rare natural communities disappear across the landscape due to land use changes, tracts like this one become ever more important as a buffer and refuge in a changing landscape. Areas of high ecological quality or areas with high restoration potential should be considered for open space or conservation planning.

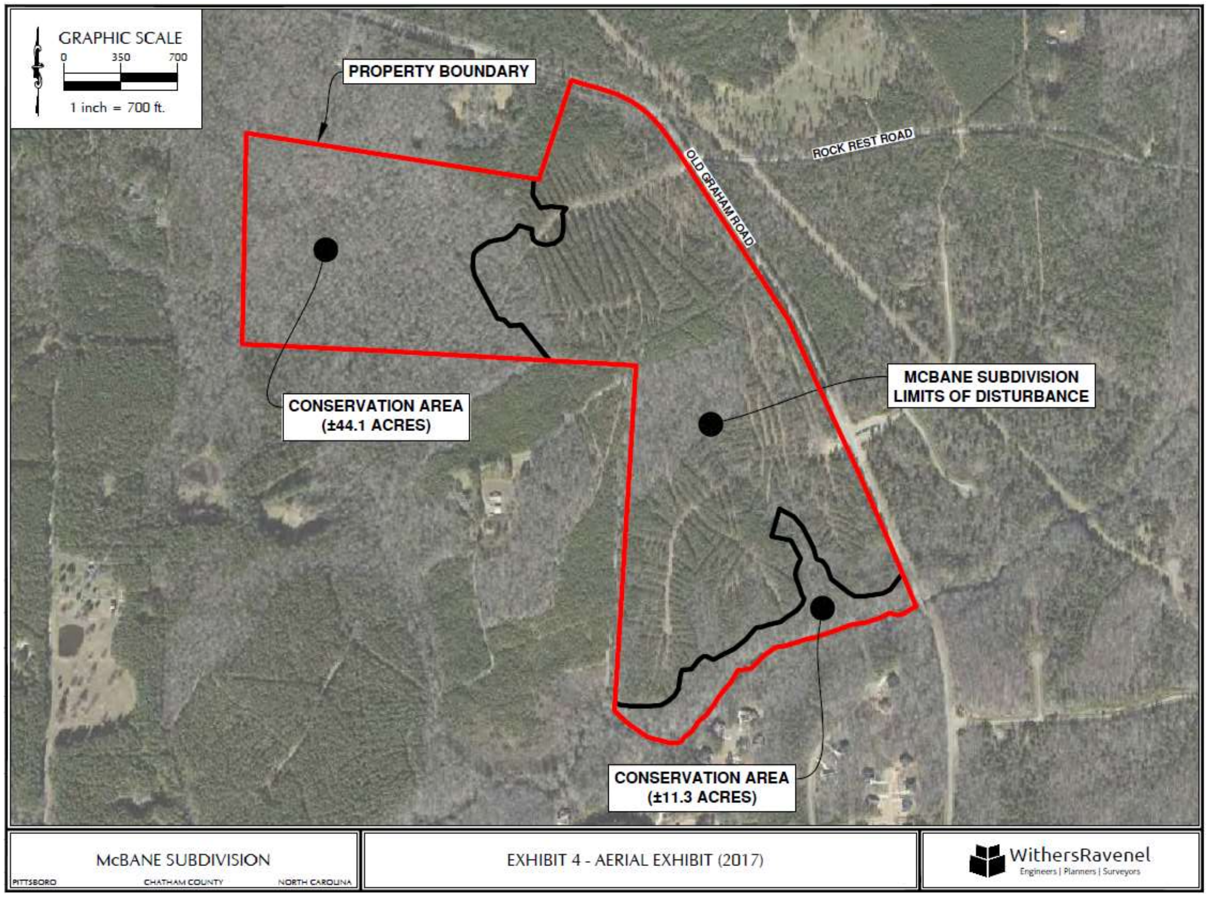
NC Natural Heritage Program recommends setting aside a 200 ft riparian buffer zone along Dry Creek to support the aquatic community and habitat condition of Dry Creek and the Haw River downstream.

Figure 4: NCNHP-Identified Natural Communities per McBane EIA



WithersRavenel's Environmental Impact Assessment conducted as part of the McBane subdivision planning noted that "the Mixed Moisture Hardpan Forest and Upland Pool communities identified within the project site were deemed by the NCNHP to be “rare to uncommon” communities and recommended for conservation. The Mixed Moisture Hardpan community is located in the northwestern portion of the site. The Upland Pool community is located adjacent to Dry Creek in the southern portion of the site. Both communities are located within the proposed conservation areas and will be conserved for the life of the project.”

Figure 5: McBane Conservation and Development Areas per EIA



1.2 Development Patterns

1.2.1 Land Use

The Dry Creek watershed does not contain any incorporated municipalities. Land use is primarily low-density residential (subdivisions or single homes), forest/silviculture, and farmland. Chatham County is the primary relevant jurisdictional authority over land use, development, zoning, and stormwater management, except where superseded by DEQ.

Land is more highly developed on the eastern side of the watershed nearer to the Haw River/Orange County border and more agricultural on the western side of the watershed. SWCD staff and a longtime farmer in the watershed shared regarding the history of the watershed that in the early 1900s, there was cotton grown throughout, and cotton mills on Dry Creek. Then land transitioned to dairy farms. Now, it is being subdivided into smaller farms or horse pastures, or large houses on large lots.

Haw River Assembly staff conducted stream walks as part of the 319 grant-funded study they completed in the mid-2000s, and found that “deeply incised stream channels, divergent channels coupled with the numerous rock walls along the stream banks indicate that Dry Creek has a long history of being affected by rural living. Besides old rock walls we found what appeared to be the remains of old grist mills. The location of some of these remains corresponds to the location of Clarks Mill on Captain Ramsey’s 1870 Map of Chatham. This old mill site and other stone crossings over Dry Creek have created drops greater than foot deep that could be impeding fish movement along Dry Creek. The stream channel also invariably falls apart into braided channel or shows signs of significant erosion after flowing past these old rock walls which act as levees forcing the stormwater to flood on only one side of the creek or to severely erode the stream channel.”

1.3 Regulatory Landscape

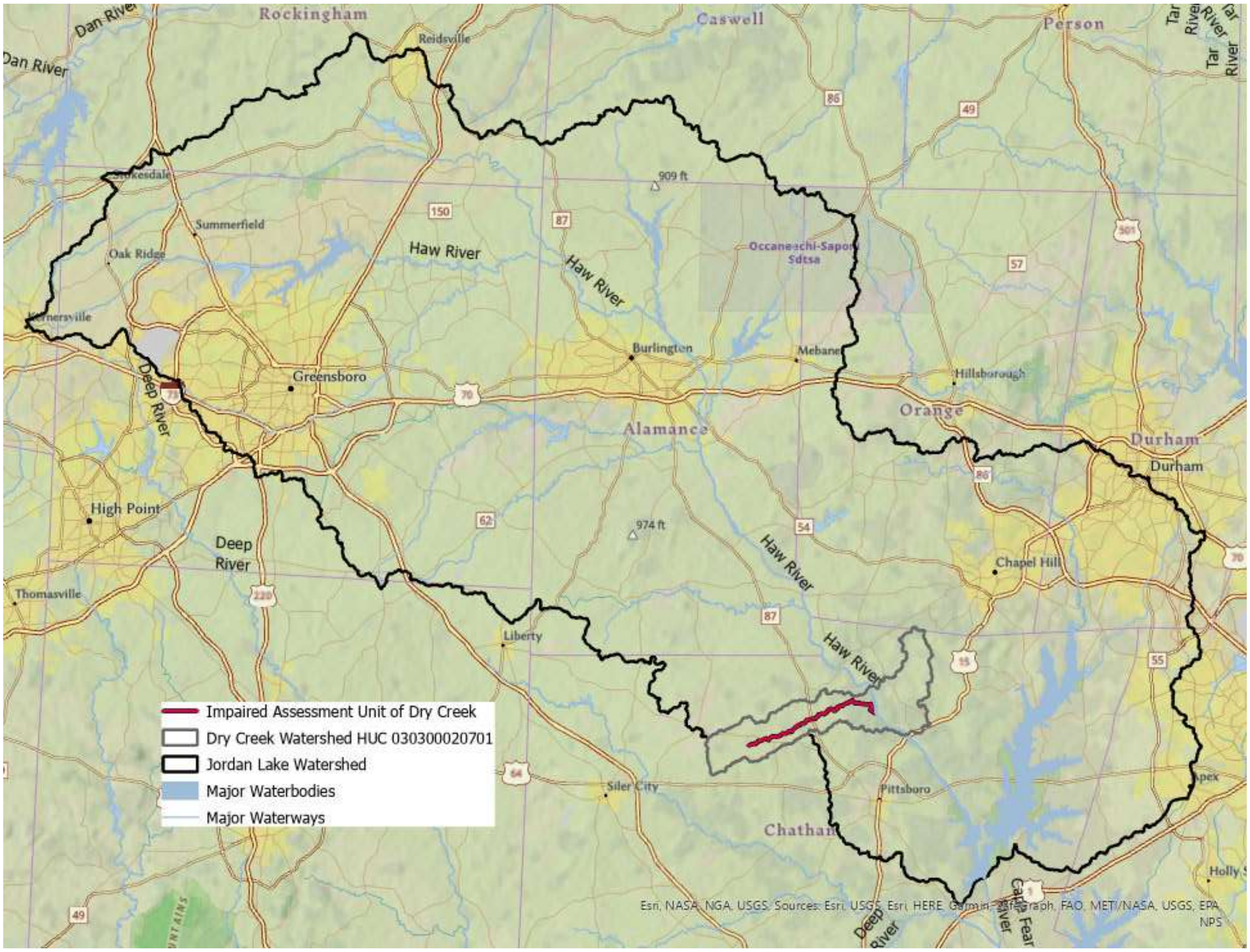
1.3.1 Federal and State

Congress enacted the federal Clean Water Act (CWA) (33 U.S.C. §1251 et seq. (1972)) to establish regulations on water quality standards for waters with a purpose of protecting surface waters for drinking, fishing, and recreation. The EPA set water quality standards for many contaminants in surface waters and established pollution control programs. North Carolina, the state Department of Environmental Quality’s Division of Water Resources is responsible for delegating water quality designations. When they do not meet their designation, waters are listed on the 303(d) list. Dry Creek’s impairment, or 303d listing, is the primary driver for the development of this plan.

All surface water segments within the Dry Creek watershed described in this section are classified as WS-IV; Nutrient Sensitive Waters (NSW). WS-IV waters are defined by NCDEQ as “waters used as sources of water supply for drinking, culinary, or food processing purposes where a WS-I, II or III classification is not feasible. These waters are also protected for Class C uses, or secondary recreation, which includes fishing, wildlife, fish consumption, aquatic life including propagation, survival and maintenance of biological integrity, and agriculture (NCDEQ Classifications, n.d.)

NSW is a “supplemental classification intended for waters needing additional nutrient management due to being subject to excessive growth of microscopic or macroscopic vegetation.” Due to nutrient-related pollution, the Jordan Lake Rules laid out a “nutrient strategy” which seeks to reduce nutrient levels delivered to Jordan Lake, a reservoir which allocates drinking water to residents of Cary, Apex, Durham, and others across the Triangle region. Thus, protection of water quality in Dry Creek is important for broader water quality in the region.

Figure 6: Watershed Context: Dry Creek's Location in the Jordan Lake Watershed



1.3.2 Local Regulations

Chatham County passed a Watershed Protection Ordinance in 2008 that regulates aspects of stormwater management and riparian buffers on some land uses in Chatham County. These are outlined more fully in section 2.2.1.3.2 and 2.2.1.3.3. Any subdivisions that received construction approval prior to this ordinance were allowed to complete development without stormwater and riparian buffer protections outlined in the ordinance. Agricultural land uses existing prior to this ordinance are exempt.

2 Watershed Conditions

2.1 Water Quality

2.1.1 Water Quality and Benthic Macroinvertebrate Data Availability

Available water quality data collected in the Dry Creek watershed is described below and in following sections. Locations where surface or groundwater has been collected are shown on the map on the following page. Available data may not fully represent the impact of nonpoint source pollutants in this watershed, but takeaways have been summarized.

The following summarizes current and historic (>10 years old) data available:

NCDEQ-DWR scientists collect benthic macroinvertebrate community data at station BB307 where Dry Creek intersects Old Graham Road. DWR collects benthic species and habitat data at this station every 4-6 years as part of routine benthic monitoring. The last sample was collected here in 2018. This data is used to generate a "biotic index" that provides an overall snapshot of water quality and ecosystem health. This biotic index is used to generate a rating from Excellent to Poor, and the current benthic community health rating at this station is Poor (shown as a red pin on the map.)

During the summer of 2021, Haw River Assembly (HRA) staff and trained interns collected benthic data at six sites on Dry Creek and its tributaries. All these sites are 0.5 to 10 miles upstream of the DEQ benthic monitoring site. HRA uses the Izaak Walton League method (approved by DEQ for citizen science data collection) to generate a different kind of rating than the biotic indexes that DWR develops from benthic species data, which also ranks benthic health into categories from Excellent to Poor. Data collected at the range of Dry Creek and tributary sites during the single summer of 2021 generated ratings from Fair to Excellent (represented as green dots on the map above.)

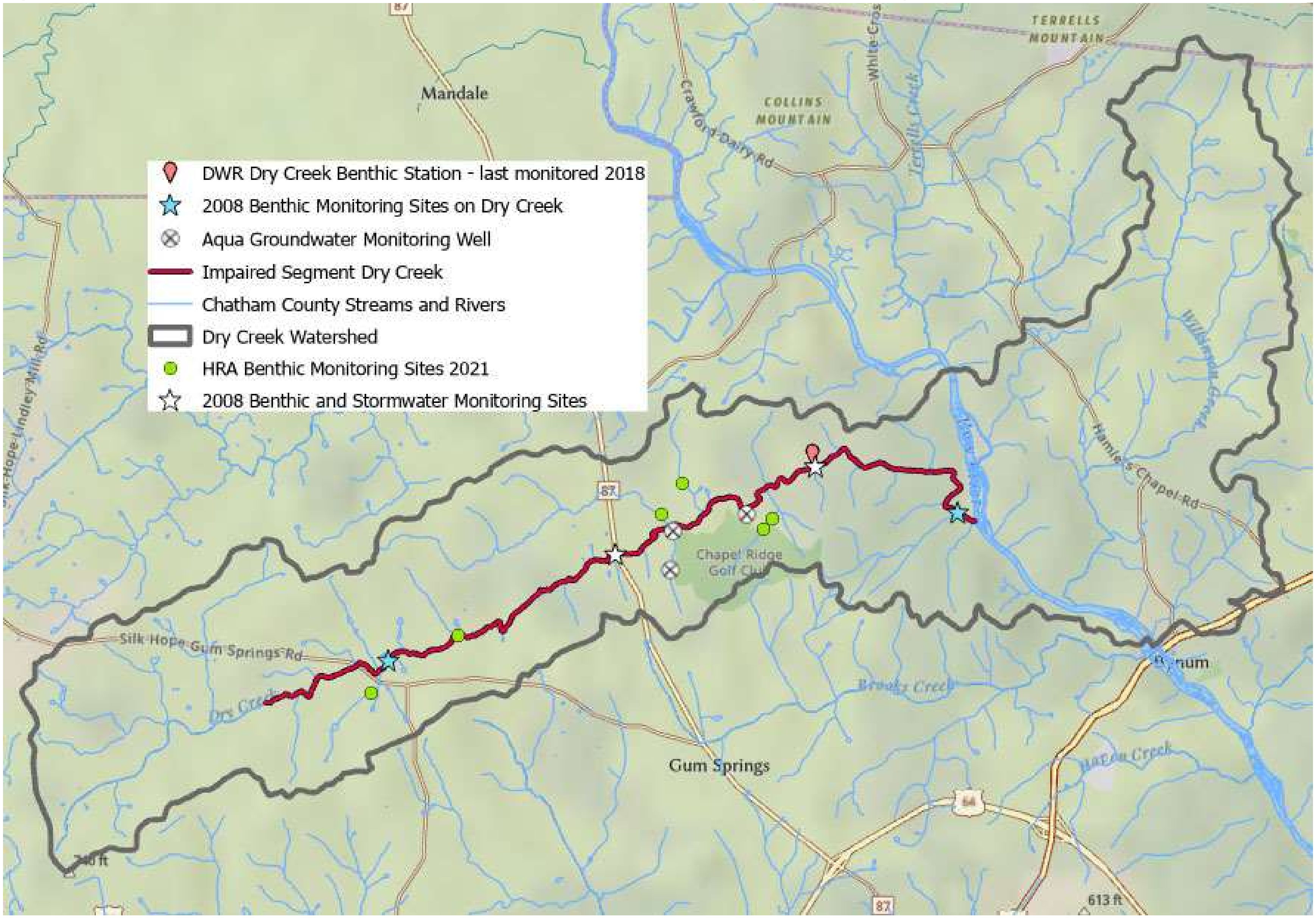
In 2007-2008, HRA staff also collected water quality and benthic data as part of a time-bound, grant funded study. The benthic data was used to generate biotic indexes with a similar method as DEQ's. Data collection sites are noted as blue stars on the map below. Water quality and stormflow data were also collected by the NCSU water quality group from 2007-2008. This data provides a baseline on Dry Creek watershed health beyond the single DWR benthic station. There has not been funding to conduct this level of detailed data since then.

Under their "non-discharge permit" with NCDEQ, private wastewater company Aqua North Carolina uses treated wastewater from the wastewater treatment facility that they manage for the Chapel Ridge subdivision to irrigate the private golf course within the subdivision. Every three months, Aqua is required to monitor a range of groundwater constituents at three monitoring wells on the Chapel Ridge golf course. Groundwater parameters monitored include pH, ammonia nitrogen, total nitrate, total phosphorus, total organic carbon, chloride, total coliform and total dissolved solids.

Data availability challenges include that surface water quality and streamflow data are not consistently collected in this watershed outside of the 2007-2009 study and occasional citizen science monitoring. There are no DWR ambient monitoring, water quality monitoring coalition or USGS stations in the watershed. The lack of consistent data collection in space and time makes it hard to compare change/trends over time or upstream/downstream in the watershed.

Additionally, benthic data does not answer the question of why the benthic macroinvertebrate community is impaired; it just shows that it is.

Figure 8: Past and Present Benthic, Stormwater and Groundwater Monitoring Sites in the Dry Creek Watershed, 1986 - 2021



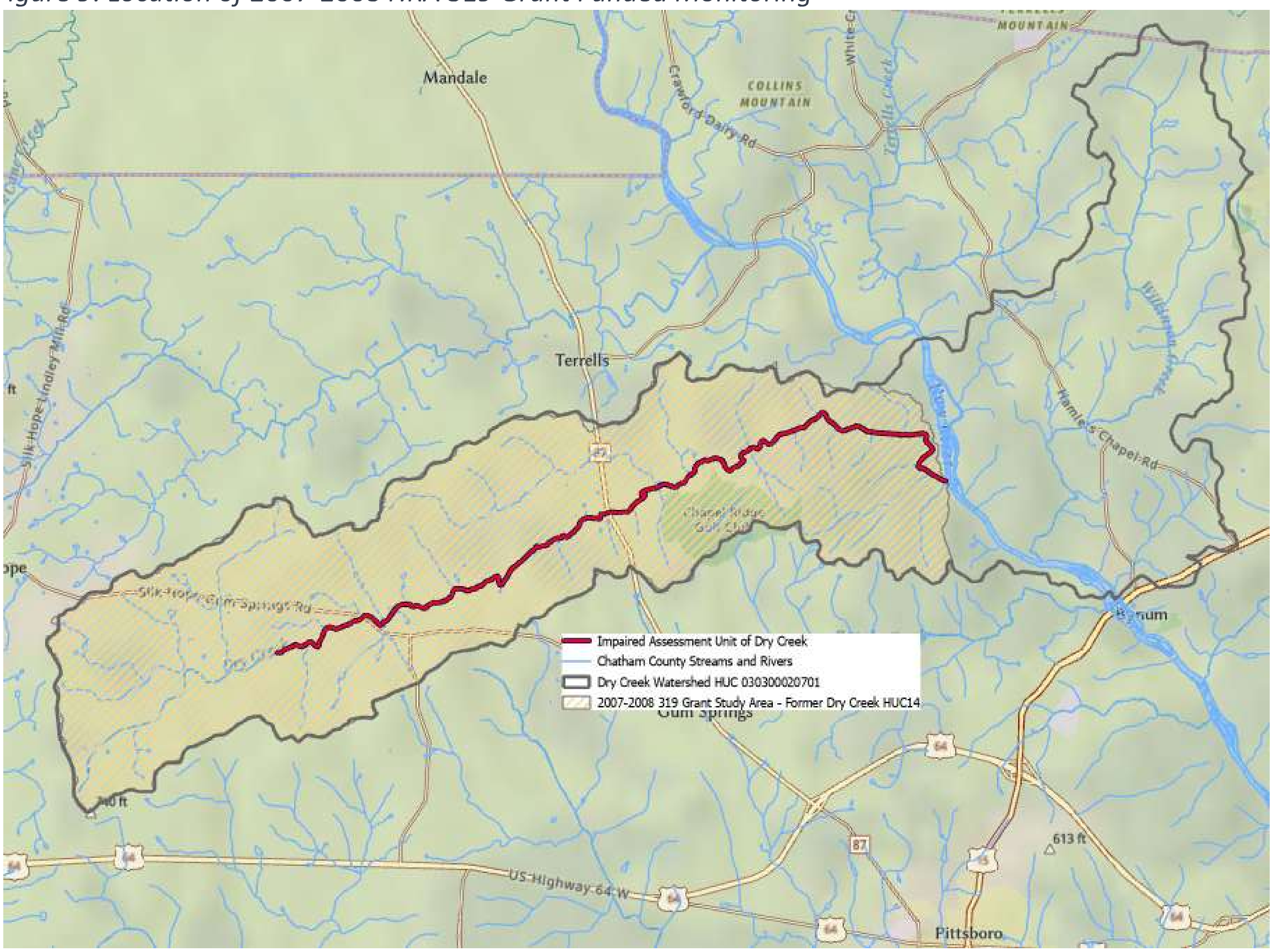
2.1.2 Water Quality Data Overview

2.1.2.1 Historic Data (2007-2009)

2.1.2.1.1 Historic Water Quality and Stormwater Data

As part of the 319-grant funded monitoring effort described above, from 2007-2008 the Haw River Assembly worked with the NCSU Water Quality Monitoring group to assess water quality upstream and downstream of recently completed or under-construction residential developments. This work was completed in the former Dry Creek USGS HUC14 west of the Haw River, shown on the map below.

Figure 9: Location of 2007-2008 HRA 319 Grant Funded Monitoring



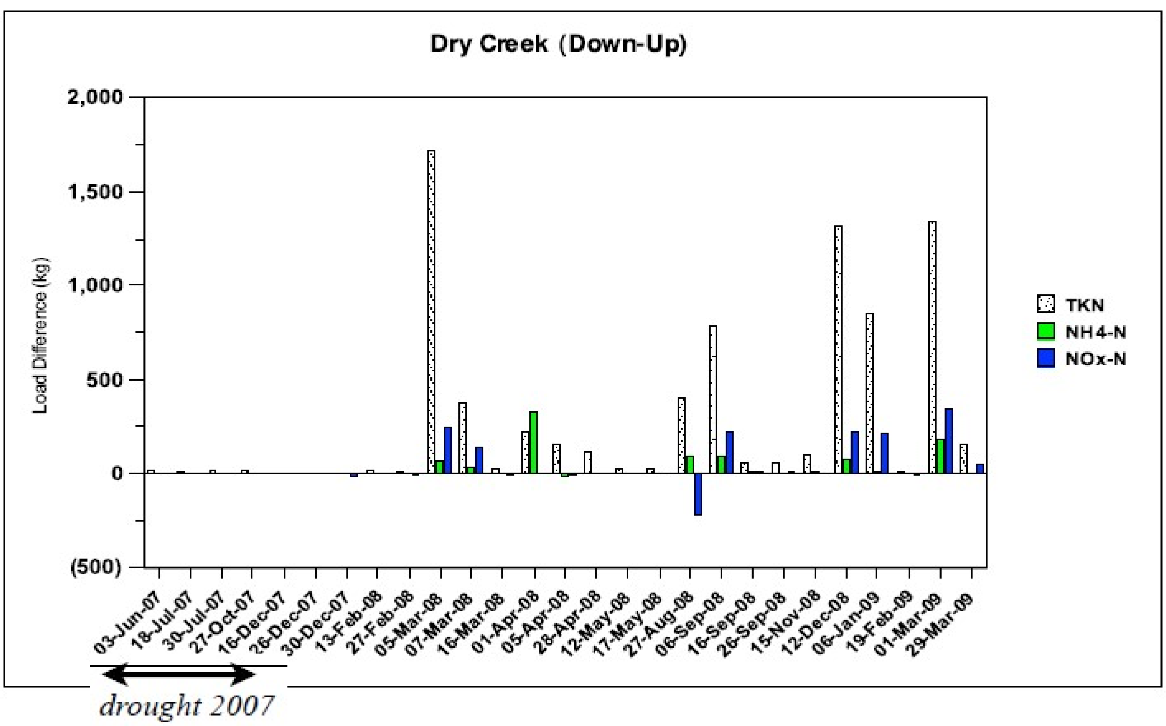
Rainfall, streamflow, TKN, NH3, NO3, TP, TSS and turbidity were monitored at these sites between December 2007 and March 2009 (delayed at the beginning due to the 2007 drought.) The primary purpose of the project was to assess differences between upstream and downstream water quality. The upstream water quality monitoring station was located just downstream of the NC 87 bridge while the downstream station was located about 3.1 miles downstream under the old NC 87 bridge. The drought of

2007 and the fact that not every storm event during the period was monitored limit the comparability of the results with other studies. Storm sample data and comparison of upstream to downstream loads are summarized below.

Table 1: Summary of storm sample data for Dry Creek, 2007-2008

	Discharge	**Turb**	**TKN**	**NH_4-N**	**NO_x-N**	**TN**	**TP**	**TSS**
	(gal)	(ntu)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Dry Creek-upstream (at Dry 2)								
mean	34,081,804	78	1.24	0.11	0.54	1.78	0.24	126
median	7,831,621	49	1.11	0.10	0.60	1.71	0.20	49
count	27	22	23	23	23	23	23	23
Dry Creek-downstream (at Dry 3)								
mean	91,578,496	112	1.09	0.17	0.27	1.36	0.24	105
median	16,801,000	72	1.02	0.08	0.26	1.28	0.19	53
count	27	23	25	25	25	25	25	25

Figure 10: Differences between upstream and downstream storm loads on Dry Creek, 2007-2009



319 project lead Catherine Deininger summarized water quality monitoring results and implications in her final grant report, quoted/slightly edited below for length and clarity (Deininger 2009):

Comparing upstream and downstream data:

- *During the 2 years of monitoring (2007 and 2008), 81% and 74% of the total discharge at the upstream and downstream monitoring sites (respectively) was attributed to storm event discharge. The extended drought of 2007 likely skewed this number higher than normal; nevertheless, it is clear that discharge and pollutant movement in Dry Creek are storm event driven.*
- *Mean concentrations of TKN, NO_x-N, TN, and TSS were greater in upstream than downstream samples.*
- *Turbidity was higher downstream than upstream; this could be due to random variability, a source other than sediment (TSS), or possibly was associated with development.*
- *Approximately half of the mean turbidity levels were greater than the state standard for most receiving waters (50 NTU).*
- *Mean ammonium nitrogen concentration was greater at the downstream site, which could indicate organic waste sources between the two monitoring sites.*
- *Mean phosphorus concentrations was the same between sites.*

Comparing concentration data to a background or recommended level:

- *The mean concentration of TKN at both Dry Creek sites (1.24 mg/L and 1.09 mg/L) was much greater than the level of organic nitrogen found in unpolluted streams of western NC ((0.11 mg/L per USGS, 1982), and the level generally considered adequate for accelerated algal growth in receiving waters (0.30 mg/L per US EPA, 1976). These data indicated that levels of organic nitrogen in discharge from the watershed could have moderately impacted downstream water resources.*
- *The mean concentrations of NO_x-N at both sites were slightly more than three times the level found in unpolluted streams of western NC (0.08 mg/L per USGS 1982). Mean concentrations at both sites were less than the national background level for NO_3-N of 0.6 mg/L (USGS 1999) and near the range associated with non-point source impacts (0.3 to 0.5 mg/L per Omernik, 1977). This indicates that NO_3-N levels were comparable to most areas of the US, and were likely not impacted by significantly by human activities.*
- *The mean TP concentrations (0.24 mg/L) were much greater than the mean reported for unpolluted streams of western NC (0.01 mg/L per USGS, 1982), and greater than the range reported for streams impacted by non-point sources (0.03 to 0.05 mg/L per Omernik, 1977). They were also greater than the national background level (0.1 mg/L), or the level generally desired to prevent nuisance algal growth in streams not discharging directly into lakes (0.1 mg/L per USGS 1999). These data indicate that TP concentrations are likely a focus of concern for the watershed. Because TP is often associated with TSS, focusing watershed restoration efforts on reducing TSS in the watershed may also help reduce TP concentrations in discharge.*

2.1.2.1.2 Historic Benthic Data

Deininger (2009) also discussed benthic macroinvertebrate data and implications, summarized in the table and text below:

Table 2: Benthic Macroinvertebrate Scores 2007-2008

		Total Taxa			EPT		
Site	Season	BI Score	Abundance	Richness	BI Score	Abundance	Richness
Dry 1	Apr-07	3.9	126	17	1.7	73	4
	Nov-07	monitoring site dry					
	Apr-08	6.1	555	24	2.0	167	8
	Nov-08	7.0	746	23	2.7	31	5
Dry 2	Apr-07	4.2	135	21	2.0	66	5
	Nov-07	6.3	468	24		4	2
	Apr-08	3.5	252	22	2.1	189	9
	Nov-08	6.6	346	28	2.7	80	11
Dry 3	Apr-07	4.3	163	22	2.2	80	7
	Nov-07	6.0	363	23		1	1
	Apr-08	4.6	129	21	2.4	65	6
	Nov-08	5.2	272	24	2.2	58	8
Dry 4	Apr-07	4.2	310	19	3.2	175	11
	Sept-08	4.0	92	12	2.9	64	2
	Nov-07	4.7	93	15	3.2	46	3
	Apr-08	3.5	276	18	2.6	210	7
	Nov-08	4.2	179	16	2.8	116	7

The abundance, richness, and Biotic Index scores were calculated for each sample for both the Ephemeroptera, Plecoptera, and Tricoptera (EPT) families and for all the benthic macroinvertebrate families collected (Total Taxa, below.) Biotic index scores are linearly proportional to the tolerance value of each organism. The more tolerant the organism is to pollution the higher the tolerance value. Thus, the lower the Biotic Index score the higher the water quality at that monitoring site. The two downstream sites tended to have higher Biotic Index scores each season compared to the two upstream sites.

In other words, Biotic Index scores indicated that upstream sites tended to have better water quality than downstream ones (at least as far as factors that affect benthic macroinvertebrates.) Presumably this is because benthic macroinvertebrates at downstream sites experience greater cumulative nonpoint source pollution impacts.

2.1.2.2 Recent Data

2.1.2.2.1 Biological Assessment Ratings

Every 4-7 years since 1986, DWR biologists have monitored benthic macroinvertebrates at station BB307, where Dry Creek intersects Old Graham Road. These monitoring events provide detailed information about the benthic community health at the specific times when they were monitored. Benthic ratings and associated bioclassifications are shown below (see data sheets in full in Appendix.)

Table 3: Benthic Community at NCDWR Station BB307, 1986 - 2018

Collection date	12/9/1986	2/8/1993	2/2/1998	7/15/2003	11/21/2003	3/19/2009	6/4/2013	5/1/2018
Criteria	Winter/ Piedmont	Winter/ Piedmont	Winter/ Piedmont	Summer/ Piedmont	Fall/ Piedmont	Spring/ Piedmont	Summer/ Piedmont	Spring/ Piedmont
EPT Biotic Index	6.00	4.65	4.33	5.72	5.25	4.18	4.83	3.25
Bioclass-ification	Poor	Excellent	Good	Fair	Fair	Fair	Fair	Poor

These data seem to indicate a worsening trend in Dry Creek's benthic macroinvertebrate community health over time. Identifying causes of a benthic impairments is difficult because their health can be affected by many factors, including sedimentation, habitat loss and chemical pollutants. Pollution-sensitive benthic macroinvertebrates also require high dissolved oxygen, neutral pH, and cold water. Much of the near-stream environment of the impaired stretch of Dry Creek is forested, though buffer is lacking in some places. Where buffer is intact, it provides shade to help keep stream temperatures cool and oxygenated and provides adequate organic matter inputs to support aquatic food webs.

Data collected at Dry Creek benthic macroinvertebrate station BB307 reflects the impacts of all nonpoint source pollutants upstream of this point on Dry Creek, making it impossible to point to one cause alone. Additionally, one must be careful when interpreting such data due to their infrequent collection. They are unlikely to capture impacts of changes to either water quality or quantity on the benthic community in the intervening years between monitoring (ie, impacts of sediment or other spills associated with construction, drought, stormflow loading, etc.)

A stream's benthic macroinvertebrate community reflects the effects, rather than the causes, of water pollution. Monitoring benthic macroinvertebrates alone cannot conclusively indicate why benthic macroinvertebrate community health may be declining. Benthic monitoring staff note that "forest cover … has slowly decreased from 73% in 1992 to 53% in 2006…continued benthic sampling at this site is recommended to further assess water quality impacts associated with changes in Dry Creek's land use." Monitoring staff surmised that "increased development and limited riparian buffers leading to increases in nonpoint source pollution" as well as "low flow fluctuations, nonpoint source runoff from recent large residential construction projects, and beaver dams leading to reduced flow and low dissolved oxygen values downstream" affected benthic metrics at this location. The potential impact of natural low flow fluctuations is explored further in the Source Assessment section.

Additionally, Haw River Assembly staff and a trained intern collected semi-quantitative benthic data at several sites upstream of BB307 during the summer of 2021. This data collected using the Izaak Walton League method was used to rank benthic health into categories from Excellent to Poor. This method is not directly comparable to DWR benthic data but has been approved for planning use by DWR's Modeling and Assessment Branch (in Planning section.) This data is shown in the map, tables and text below (tables are included in upstream to downstream order.)

Figure 11: Recent Benthic Data Collection Sites on Dry Creek and Tributaries

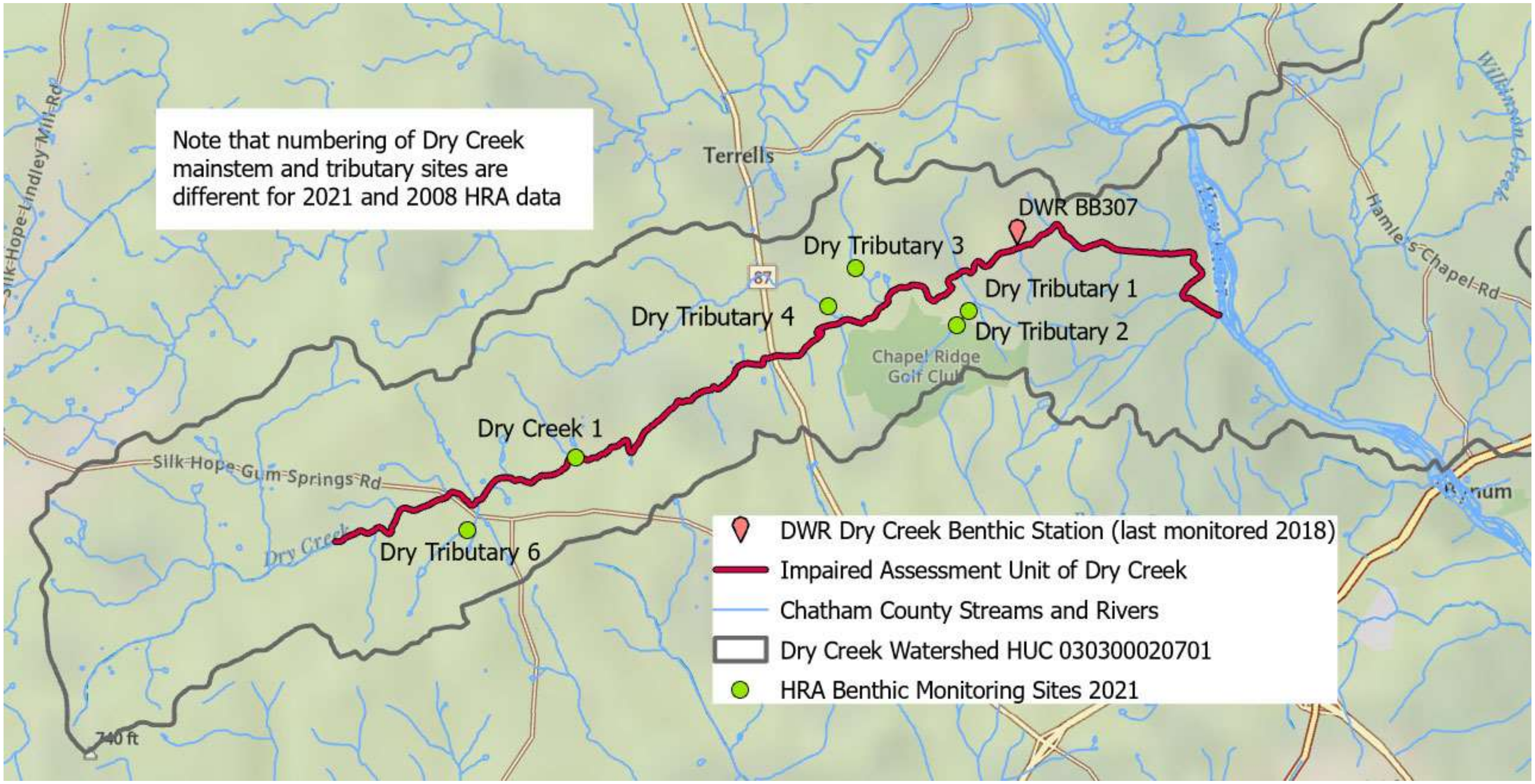


Table 4: Dry Trib 6 Summary of 2021 HRA Data

Site Name	Date	Flow	Water Temp	pH	DO (%)	Conductivity (uS/cm)	Turbidity (NTU)	Benthic Total Score	Izaak Walton Rating	Notes
Dry Trib 6	3/30/21	Baseline	13.9	7.06	68.4	115.2	35.7	21	Good	Eroding banks (~15%); diatomaceous algae
Dry Trib 6	4/20/21	Baseline/ Low	16.1					14	Fair	Eroding banks (~15%); diatomaceous algae

Table 5: Dry Creek 1 Summary of 2021 HRA Data

Site Name	Date	Flow	Water Temp	pH	DO (%)	Conductivity (uS/cm)	Turbidity (NTU)	Benthic Total Score	Izaak Walton Rating	Notes
Dry Creek 1	3/25/21	Baseline/ Low	13.3	7.12	60.3	110.6	41.01	25	Excellent	Eroding banks (~35%), periphyton, diatomaceous algae
Dry Creek 1	4/17/21	Baseline/ Low	14.4					28	Excellent	Eroding banks (~40%); periphyton, diatomaceous algae
Dry Creek 1	6/15/2021	Baseline/ Low	23	6.88	30.5	128.1	12.95	26	Excellent	Eroding banks (~45%); periphyton, diatomaceous algae

Table 6: Dry Trib 4 Summary of 2021 HRA Data

Site Name	Date	Flow	Water Temp	pH	DO (%)	Conductivity (uS/cm)	Turbidity (NTU)	Benthic Total Score	Izaak Walton Rating	Notes
Dry Trib 4	3/30/21	Baseline	14.5	7.5	64.2	112.5	32.1	17	Good	Eroding banks (~10%); filamentous and diatomaceous algae
Dry Trib 4	4/20/21	Baseline/ Low	16.1					15	Fair	Eroding banks (~15%); periphyton, filamentous and diatomaceous algae
Dry Trib 4	6/8/2021	Low	21.1	6.33	43.2	120.3	10.96	15	Fair	Eroding banks (~10%); periphyton, filamentous and diatomaceous algae

Table 7: Dry Trib 3 Summary of 2021 HRA Data

Site Name	**Date**	**Flow**	**Water Temp**	**pH**	**DO (%)**	**Conductivity (uS/cm)**	**Turbidity (NTU)**	**Benthic Total Score**	**Izaak Walton Rating**	**Notes**
Dry Trib 3	3/30/21	Baseline	14.9	7.13	70.4	109.4	33.23	23	Excellent	Eroding banks (~55%); diatomaceous algae
Dry Trib 3	4/20/21	Low	15.6					17	Good	Eroding banks (~55%); diatomaceous algae

Table 8: Dry Trib 2 Summary of 2021 HRA Data

Site Name	**Date**	**Flow**	**Water Temp**	**pH**	**DO (%)**	**Conductivity (uS/cm)**	**Turbidity (NTU)**	**Benthic Total Score**	**Rating**	**Notes**
Dry Trib 2	3/23/21	Baseline/ Low	10.6	7.14	68	113.5	30.3	19	Good	Eroding banks (~45%); periphyton and diatomaceous algae
Dry Trib 2	4/17/21	Low	15.1					18	Good	Eroding banks (~45%); diatomaceous algae
Dry Trib 2	6/8/2021	Low	20.9	6.79	59.3	165.8	6.91	19	Good	Eroding banks (~30%); periphyton and diatomaceous algae

Table 9: Dry Creek Trib 1 Summary of 2021 HRA Data

Site Name	**Date**	**Flow**	**Water Temp**	**pH**	**DO (%)**	**Conductivity (uS/cm)**	**Turbidity (NTU)**	**Total Score**	**Rating**	**Notes**
Dry Trib 1	3/23/21	Baseline	11.1	7.06	71.2	112.3	34.87	17	Good	Eroding banks (10%); diatomaceous algae
Dry Trib 1	4/17/21	Baseline	15.6					16	Fair	Eroding banks (10%); diatomaceous algae
Dry Trib 1	6/10/2021	Low	22.1	7	81.1	171.1	32.09	16	Fair	Eroding banks (10%); periphyton and diatomaceous algae

These data showed there to be “fair” benthic health on several tributaries at sites, not necessarily correlated with low flows, where there was varying degrees of streambank erosion and algae growth. Algae growth can be an indicator of nonpoint source nutrient enrichment. Per TJCOG’s riparian buffer analysis, riparian buffers were impacted to degraded upstream of sites where HRA found fair benthic community in 2021. Combined with other data described above, and sources described in the following section, these data point to the importance of riparian buffer restoration along with ongoing management of nonpoint nutrient sources.

pH, turbidity and temperature data did not exceed DEQ standards below, indicating that none were likely to be stressing pollution-intolerant benthic macroinvertebrates at the times monitored. Of course, grab samples are not representative of other times or seasons, high-flow conditions, any ‘pulse’ pollutants, etc.

Temperature: <=29-32 degrees C (per NCAC 02B .0208, .0211, and .0220)
DEQ pH standard (protective range for benthic health): 6 – 9
DEQ DO standard for aquatic life: >=5mg/L

2.1.2.2.2 Groundwater Data

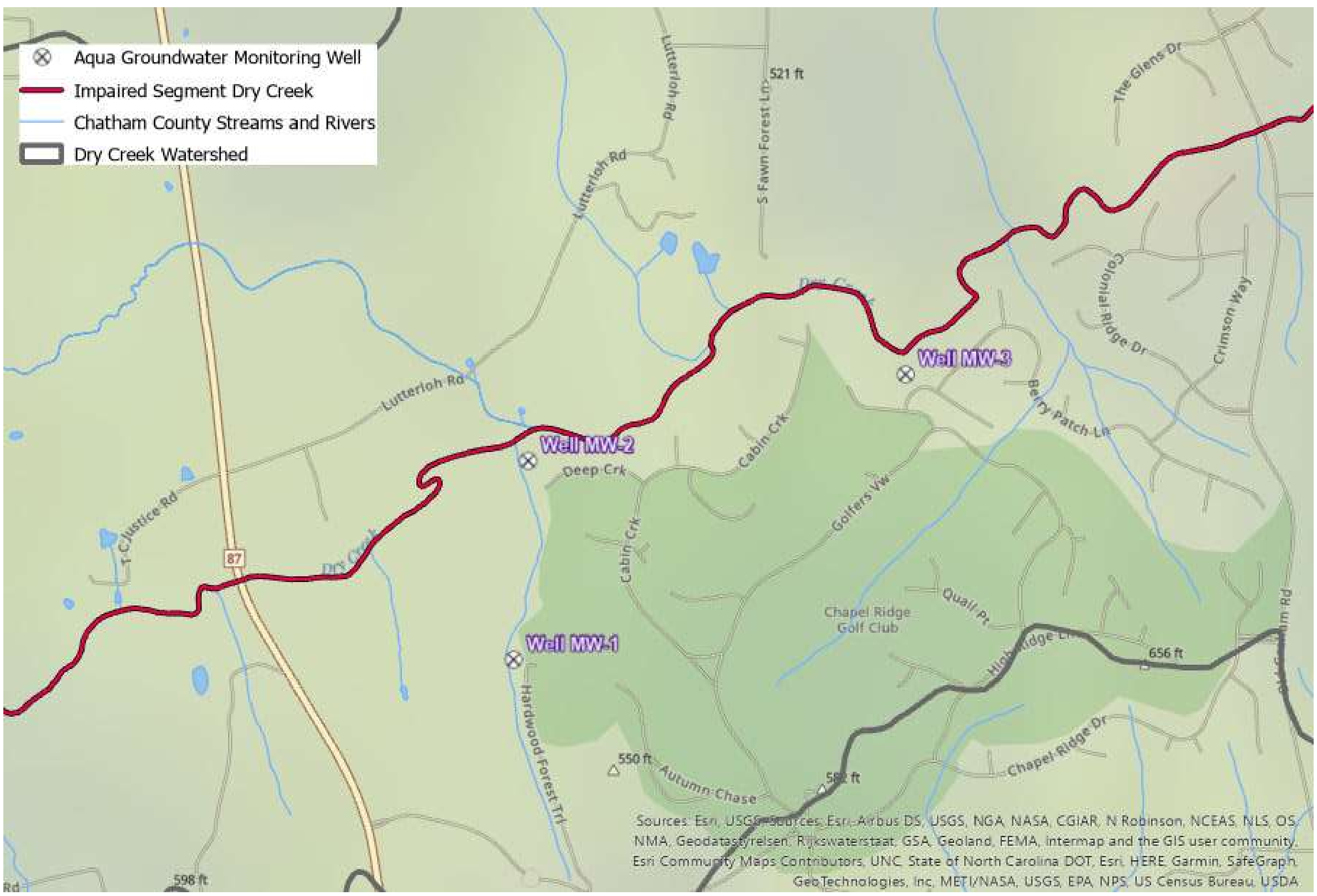
Aqua is required to collect quarterly grab samples for a range of constituents at three monitoring wells on the Chapel Ridge golf course where wastewater from surrounding subdivisions is spray irrigated. Included below are the monitoring wells' distance to Dry Creek and an unnamed tributary to Dry Creek adjacent to spray irrigation fields.

Table 10: Groundwater Monitoring Well Distance to Waterways on Spray Irrigation Site

Monitoring Well	Approximate Proximity to Dry Creek	Approximate Proximity to UT to Dry Creek
MW-1	725 meters	15 meters
MW-2	80 meters	N/A
MW-3	65 meters	N/A

Because of these wells' proximity to the stream, there may not be much attenuation between well locations and Dry Creek or its tributaries shown below.

Figure 12: Location of Groundwater Monitoring Wells Near Impaired Dry Creek

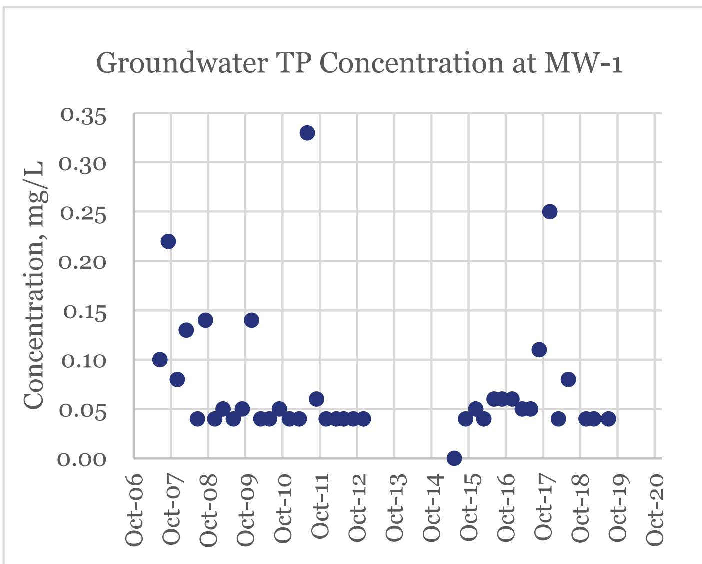


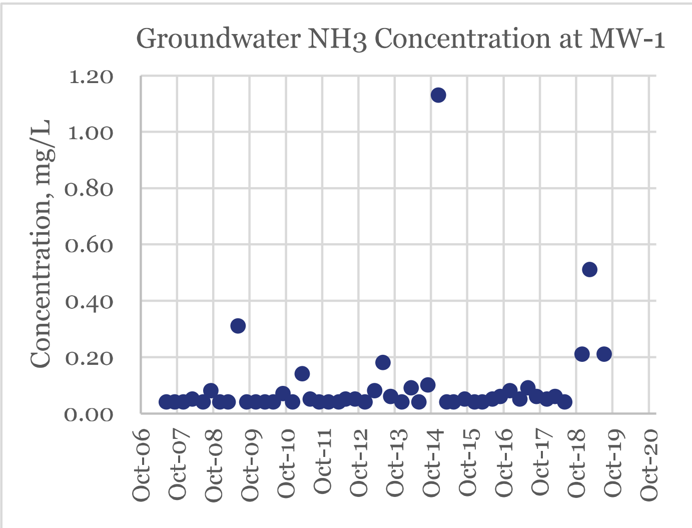
East Carolina University researcher Guy Iverson noted that without additional data, it is difficult to identify water quality impact from land application sites. Additional information is needed to better understand groundwater flow direction, soil characteristics, depth to groundwater at land application sites, volume and application rate of wastewater, and/or geophysics to assess potential nutrient treatment. Water quality from existing groundwater wells did not exceed surface water quality standards.

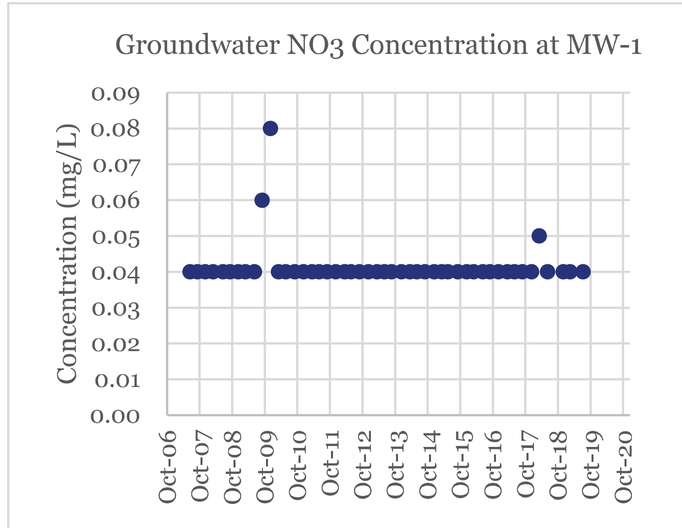
Iverson noted that concentrations of all groundwater constituents appeared relatively low, except for a couple of sampling events when ammonia and total phosphorus spiked. Those spikes in phosphorus and ammonia are shown in the graphs below, along with nitrate because Iverson notes that "nitrogen generally converts from ammonium to nitrate [in the vadose zone under wastewater disposal sites] and can leach from the site" (personal communication, 2021.) If the depth to water table is too shallow, this can inhibit nitrification, which can result in leaching of ammonium.

In the graphs below, all values shown as 0.04 are at or below the detection limit of 0.04 mg/L. Raw data for all sampled parameters for the three monitoring wells is included in the Appendix.

Figure 13: Groundwater Grab Sample N and P Data for Aqua Monitoring Well #1

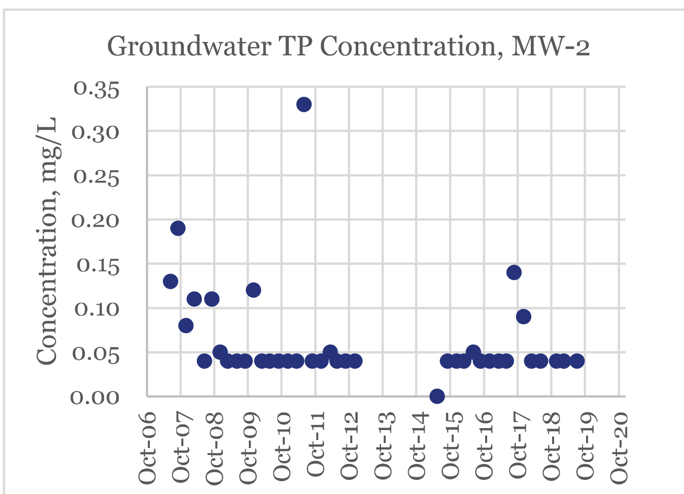


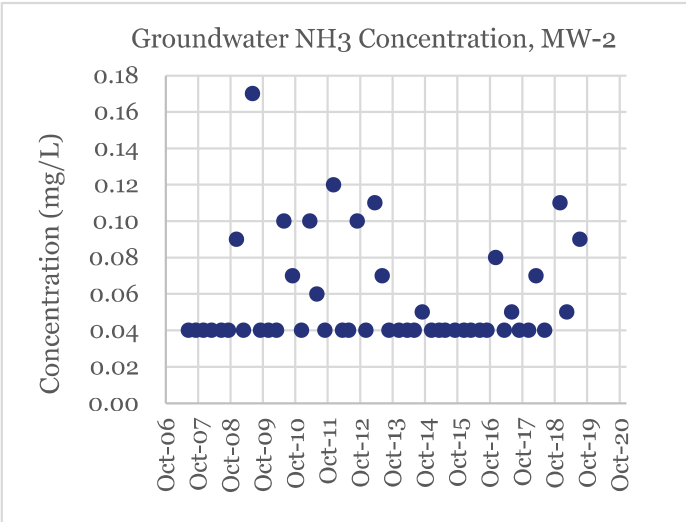


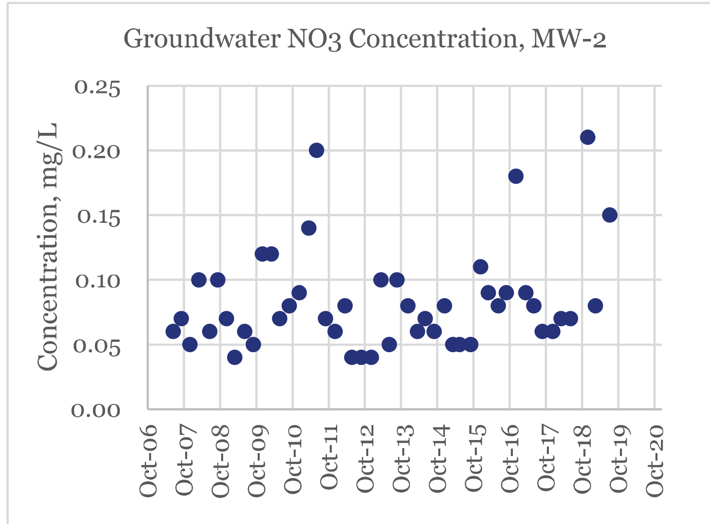


Iverson also mentioned that coupling routine grab sampling with high-frequency data collection (e.g., autonomous logging at the minute or hourly scale) can improve the likelihood of capturing water quality differences at finer temporal scales. Elevated concentrations of pollutants may "pulse" through the shallow groundwater system after spray events, which can be challenging to capture with lower frequency grab sampling, especially if/when spikes occur outside of typical sampling hours (i.e., overnight)" (personal communication, 2021.)

Figure 14: Groundwater Grab Sample N and P Data for Aqua Monitoring Well #2



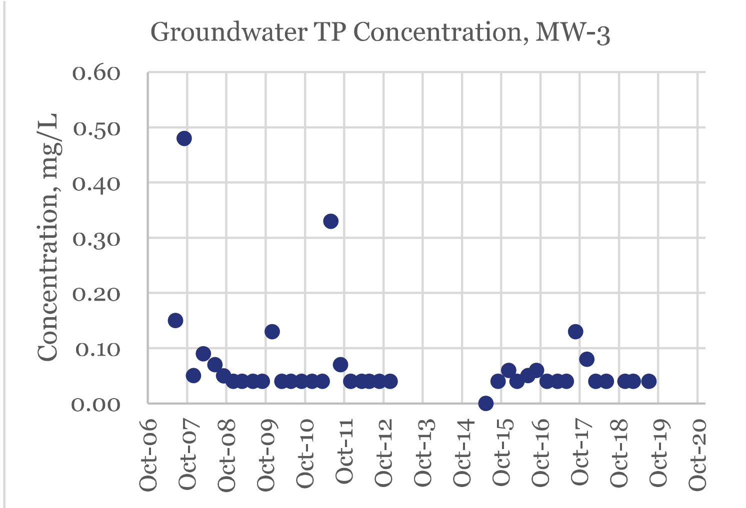


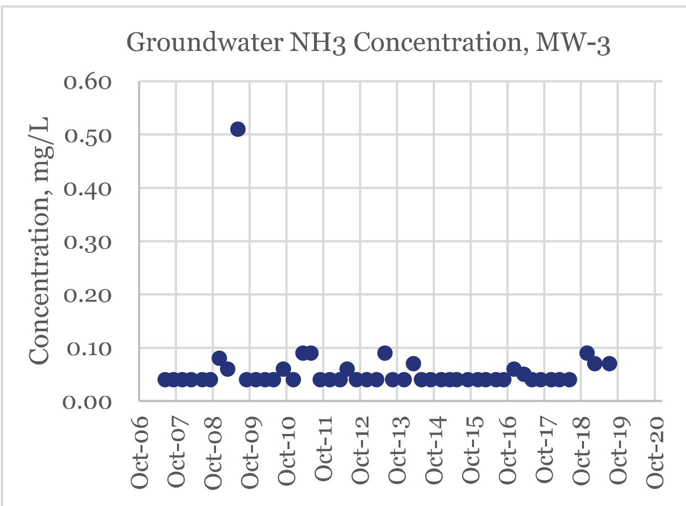


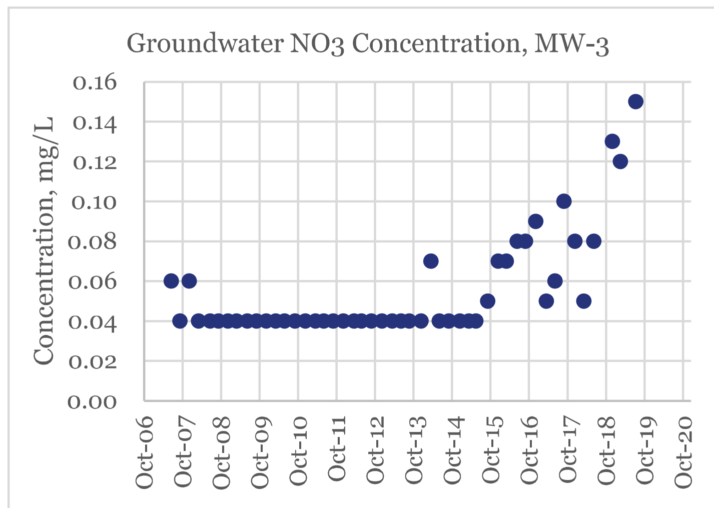
Spray irrigated wastewater could also migrate to Dry Creek via overland flow, which may inhibit nutrient removal processes that typically occur in the vadose zone. Iverson notes that “typically, we see high reductions of phosphorus in the vadose zone beneath sites of wastewater disposal, as phosphorus tends to adsorb to the soil surface” (personal communication, 2021.)

He notes that riparian buffers can provide substantial treatment of nutrients because they can facilitate nutrient transformations that ultimately result in removal of plant available nutrients. Some studies have suggested that eutrophication may begin when surface waters exceed 1 mg/L TN and 0.04 mg/L TP. If surface waters greatly exceed these "soft thresholds", it's possible that other negative effects may occur (e.g., algal blooms, fish kills, etc.). However, available data do not provide a thorough, direct ability to evaluate the effectiveness of riparian buffers. Organic nitrogen is a component of TN that may be the dominant nitrogen species in TN exports from vegetated areas and this is not data collected as part of Chapel Ridge’s required routine monitoring (Iverson, personal communication, 2021.)

Figure 15: Groundwater Grab Sample N and P Data for Aqua Monitoring Well #3







In summary, more frequent groundwater monitoring (such as after large storms), TN data and additional data collected regarding groundwater flow direction would all be helpful to assess any potential impacts of wastewater spray irrigation on Dry Creek. More frequent grab sampling or use of high-frequency loggers to monitor water quality year-around would also be helpful. Data about wastewater impacts in the Carolina Terrane geology would also help translate research findings to this watershed.

2.2 Source Assessment

This section outlines causes and sources of nonpoint source pollution based on geospatial data, prior and current watershed studies, field observation, project partners' and other subject matter experts' experience monitoring benthic macroinvertebrates and water quality, permitting subdivisions, SCMs and septic systems, and working with farmers across the watershed to implement agricultural BMPs. Following elaboration on pollution sources, in section 2.2.2 a basic critical source area analysis outlines locations in the watershed likely to be contributing outsize nonpoint source pollution impacts to Dry Creek and tributaries.

Given the broad range of land uses and pollution sources and limited data, it is not possible to point to a single pollution source that is causing the benthic impairment. Rather, all the identified pollution sources should be managed concurrently to help achieve the ultimate goal of restoring the benthic macroinvertebrate community to good-fair or better rating. This is the case for most benthic impairments, but especially true here. As the impaired assessment unit has largely been rated as "fair" over the years and the watershed is not completely built out, there is much potential for pollution prevention, restoration and conservation to improve benthic health in the Dry Creek watershed.

HRA data from 2007-2009 summarized in the previous section suggested that turbidity and nutrients were elevated at the time, especially downstream in the watershed. High nutrient levels are correlated with algae growth, organic matter, high suspended solids, and other conditions that worsen habitat for pollution-intolerant macroinvertebrates (EPA, n.d.) High algal biomass can also harm pollution-sensitive macroinvertebrates by physically blocking sunlight, using up oxygen when they die and decompose, compromising stratification in the water column, and potentially releasing cyanotoxins, depending on the species. Thus, nutrients, sediment and other suspended solids should be managed to protect and improve benthic community health.

Synthesizing the various information sources in prior and below sections, a summary of priority pollutants (and likely sources) in the Dry Creek watershed includes the following:

- Sediment (source: residential subdivision development and streambank erosion hastened by degraded riparian buffers)
- Nutrients (source: lawns, golf courses, livestock, and possibly wastewater sources)
- Fecal coliform (source: livestock in streams and potentially wastewater and aging septic systems)

Additionally, flashy stormwater runoff (due to increasing development) will likely grow as a driver of benthic community degradation as the watershed continues to develop. At present, low flows in times of drought appear to be having greater negative impacts on benthic macroinvertebrates than high flows.

2.2.1 Nonpoint Pollution Sources

As mentioned previously, the watershed lies in Chatham County outside municipal boundaries. There are no NPDES-permitted stormwater or wastewater dischargers, CAFOs, or WWTPs in the watershed, aside from the Chapel Ridge WWTP serving a set of subdivisions mentioned below. Thus, Dry Creek suffers almost exclusively from nonpoint source pollution. This section summarizes known and potential pollution sources outlined above, organized into the following broad categories of stressors on benthic macroinvertebrate health:

- Land use change and associated stormwater runoff contributing additional sediment, nutrients, and potentially other wastewater-derived pollutants to Dry Creek and tributaries
- Riparian buffer degradation on both residential and agricultural properties impacting aquatic/benthic habitat and decreasing interception/filtration of runoff to creeks
- Agricultural nonpoint source pollution, primarily stemming from livestock access to creeks, contributing to streambank erosion and degradation of benthic habitat
- Potential impacts of natural low flow regimes on benthic macroinvertebrates

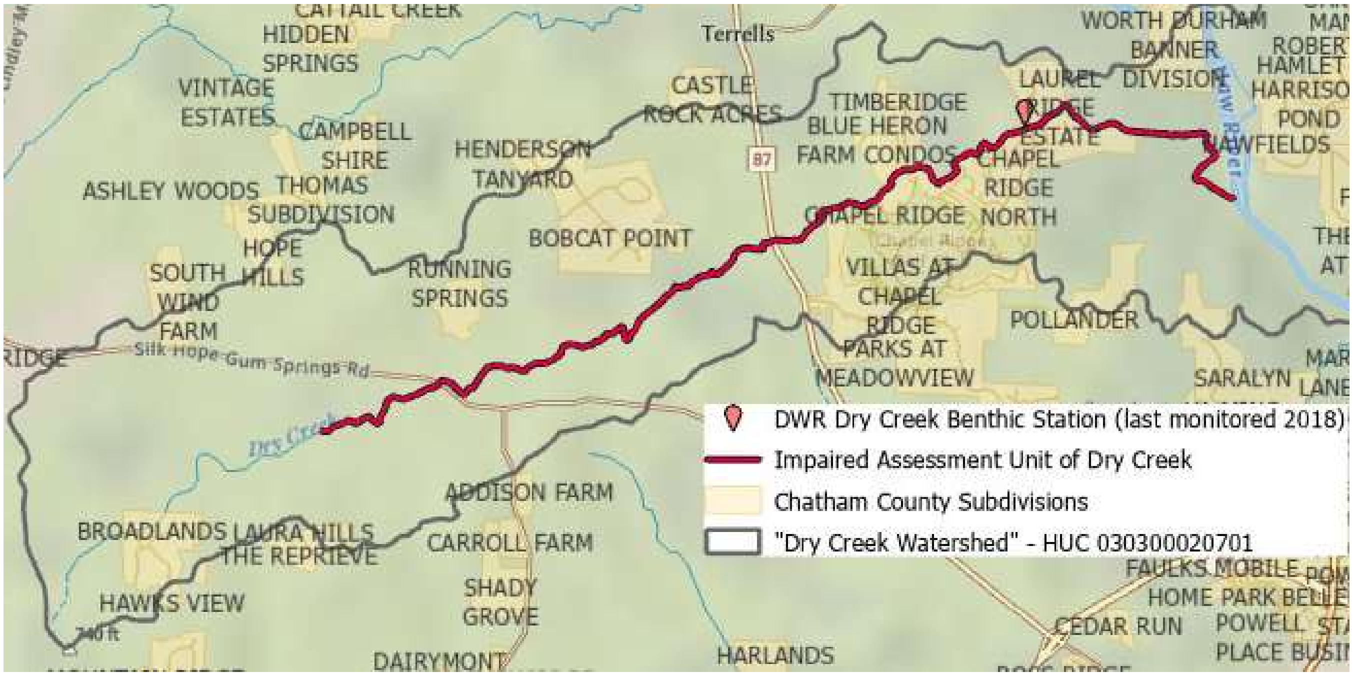
As additional information about pollution sources come to light in future, they should be added to this section.

2.2.1.1 Land Use Change Impacts

Dry Creek was unimpaired as of 2000, and has been impaired for aquatic habitat since 2006, with listed stressors of turbidity and habitat degradation due to land clearing. There has been an ongoing trend of forested and agricultural land in the Dry Creek watershed transitioning to low-density subdivisions. This land use change creates a range of pollution sources both during and after the construction process.

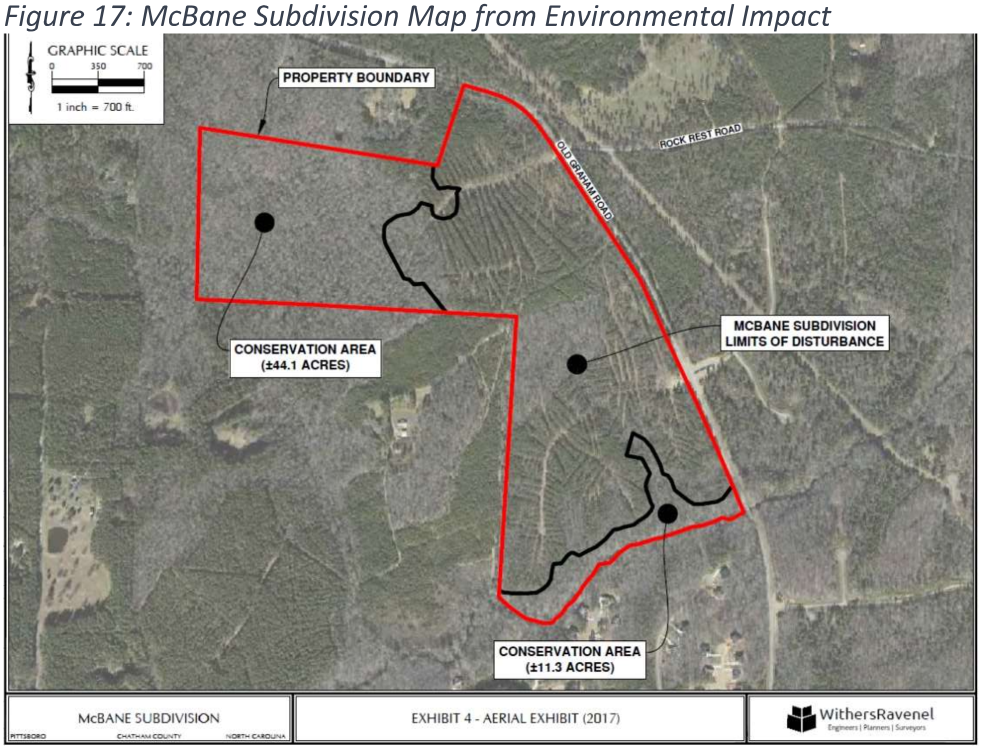
Chatham SWCD staff noted in 2021 that over time, they have seen larger tracts of timber transitioning to residential development and family farms being split into smaller pieces as generational owners change. Older generations were likelier to farm conventionally; younger generations are likelier to sell land as relatively large residential lots, smaller farms and hobby/homestead farms for personal use. Agriculture trends over time have changed as well, with more cropland and dairies historically cropping land for silages (which produced more soil loss). Historical crop fields have been converted to producing more beef and poultry, or hay or pasture for the beef/poultry sector. That cropland conversion can produce less soil loss, as perennial grasses are better than cultivated crops to hold soil (and nutrients) in place, depending on individual management.

Figure 16: Current Subdivisions in Plan Focus Area, Dry Creek Watershed West of the Haw River



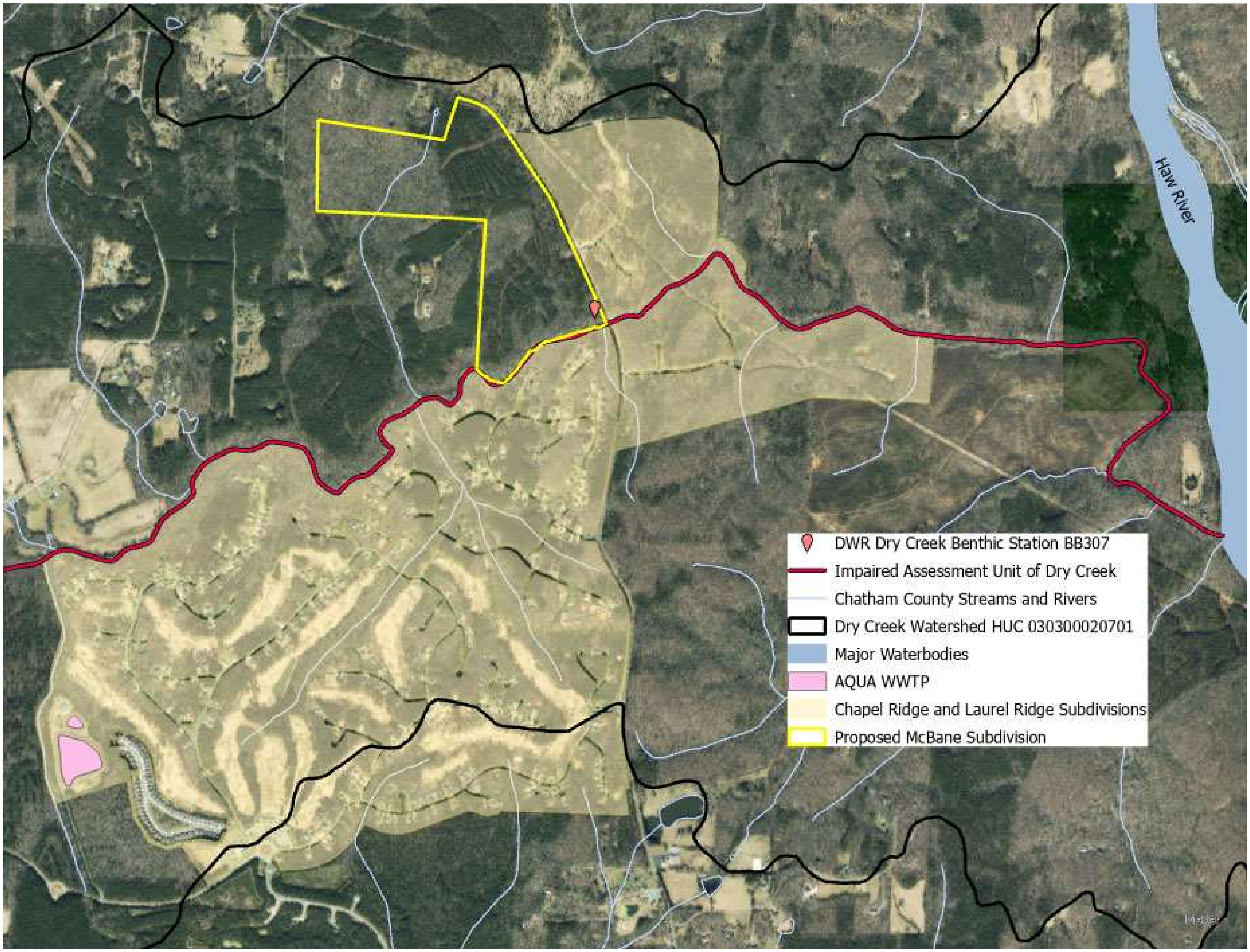
The Chapel Ridge subdivision was constructed between 2004 and 2008. At the time of writing, a subdivision called McBane was planned adjacent to/west of Laurel Ridge, downstream of DWR benthic monitoring site BB307.) (Proposed subdivisions can also be seen here on Chatham County's GIS page.) Laurel Ridge and McBane will have their wastewater sent across Dry Creek to be treated at Chapel Ridge wastewater plant. At a public meeting about the McBane subdivision, citizens expressed concerns about the potential for wastewater spills into Dry Creek, the developer's record of erosion/ sediment control violations, and the ultimate buildout density given proximity to impaired Dry Creek.

Figure 17: McBane Subdivision Map from Environmental Impact



Concessions granted included a 200-foot buffer and protection of ecosystems identified as valuable by the North Carolina Natural Heritage Program. Construction of this subdivision will be regulated by NC DEMLR, while site erosion control and 2 stormwater ponds will be regulated by Chatham County.

Figure 18: Location of New Proposed McBane Subdivision Relative to AQUA-Sewered Subdivisions



2.2.1.1.1 Stormwater-Related Impacts of Development

Pollutants in stormwater associated with development can affect benthic community health during and after the construction process. Project partners reported observing a large release of sediment into Dry Creek several years ago when Chapel Ridge was under construction, and the developer who will construct the planned McBane subdivision has received notices of violation and citations in inspection reports for sediment and erosion issues.

HRA's 2009 319 grant report cites increase in pollution loads between upstream and downstream monitoring sites as well as turbidity and bank instability on Dry Creek and its tributaries (Deininger 2009.) These impacts are likely to increase as the watershed continues to develop and more stormwater runoff yields greater pollution load delivery to surface waters.

Increased impervious surfaces yield higher, flashier stormwater volumes that may impact stream biota through a range of pathways. Sedimentation and/or scour of microhabitat or directly clogging gills of the benthic macroinvertebrate are some ways that stormwater may diminish benthic community health (Deininger, personal communication, 2021.)

Figure 19: Degraded Buffer and Sediment Excavation (?) on Dry Creek's Long Branch Tributary

Reducing the stormwater-related impacts of development is essential to prevent further degradation of Dry Creek and its tributaries. This includes ensuring developers follow recommended sediment and erosion control practices during development.

On existing subdivisions, relying on required stormwater management alone will not protect the Dry Creek watershed. Stormwater runoff and associated pollutant impacts are unregulated and unlikely to be regulated on or adjacent to small tributaries on private property. Educating HOAs and golf courses and encouraging them to voluntarily manage their runoff or preserve buffers will be necessary.

The photo at right was taken near the origins of the Long Branch tributary of Dry Creek, in the Bobcat Point subdivision. This is one place where knowing someone with an HOA could help to educate residents about the benefits of protecting riparian buffers.

The photo below (from Deininger's 2021 report for Chapel Ridge HOA landscape committee chair) shows unregulated impacts of nutrients from the Chapel Ridge golf course on a channel downslope created by stormwater runoff piped off the golf course. This runoff feeds into an unregulated stormwater device between residential lots on HOA property. As of 2021, the Chapel Ridge landscaping committee chair had not had success reaching the golf course about this issue.

Figure 20: Algae Growth Downslope of Chapel Ridge Golf Course

Ideas and resources for public education to help inform residents and alleviate these impacts are discussed further in section 5.5.

2.2.1.1.1.1 Recommendations and Next Steps

Below are steps that Dry Creek project partners could continue to work together on:

- Advocate for incentives for voluntary forest and farmland preservation
- Ensure sediment and erosion control best practices are followed during development, especially by developers with a history of violations
- Encourage Chapel Ridge golf course to manage its runoff since residential properties and SCMs downslope are being impacted by runoff and erosion
- Work with landscaping committee chairs to educate HOAs/residents about how to reduce their impacts to nonpoint source pollution

- If subdivision residents express interest in voluntary residential SCMs, consider seeking funding to install

2.2.1.2 Potential Wastewater-Related Nonpoint Source Pollution

Residential development requires wastewater services. Incorporated municipalities typically have sewer systems that collect and treat wastewater which they discharge to local streams. Residents of decentralized rural areas without municipal sewer systems typically rely on individual septic systems (at the lowest housing density) and small wastewater treatment package plants (in higher density rural subdivision) where the wastewater is spray irrigated across land rather than being discharged to streams. When properly functioning, these wastewater treatment and disposal methods can enable development in rural areas while alleviating most nitrogen, phosphorus and fecal coliform bacteria pollution to surface- and groundwater. When not properly functioning, they may become sources of nonpoint source pollution.

Proper management of wastewater is essential as nitrogen, phosphorus and fecal coliform bacteria affect ecosystem health in ecologically impaired Dry Creek as well as downstream drinking water users in the nutrient-impaired Jordan Lake watershed. NC Policy Collaboratory researchers recommend focusing on wastewater infrastructure upgrades and maintenance as well as on stormwater-derived sources when that that to reduce the impacts of nutrient pollution.

The Dry Creek watershed sits outside municipal boundaries, and most homes are on septic systems. The only piped wastewater in the watershed is operated by Aqua North Carolina, a private company that since 2007 has operated a 50,000 gallon per day wastewater treatment plant, the treated wastewater from which is distributed across the Chapel Ridge Golf Course by spray irrigation. The Chapel Ridge golf course is privately owned but surrounded by the Chapel Ridge, Meadowview, Woodlands, Bluffs, and Creekside subdivisions, all served by Aqua wastewater. The Aqua plant will also serve the Laurel Ridge subdivision, where construction is in progress, as well as the proposed McBane subdivision. Wastewater from these two subdivisions will be piped across Dry Creek and spray irrigated on the golf course.

The new McBane subdivision proposed to be built across Dry Creek from Chapel Ridge has raised stakeholder concerns about the capacity of the near-stream environment to assimilate additional treated wastewater that this subdivision would produce. At a 2021 public meeting, citizens raised concerns about possible spills of wastewater from the McBane subdivision into Dry Creek, as wastewater from this new proposed subdivision will be piped across the creek to be treated at Aqua's existing wastewater treatment plant. Delesantro et al's 2019 technical report for the NC Policy Collaboratory observed when speaking of sewer lines generally that "even minor leaks may have a direct nexus to streams" (Delesantro 2019.)

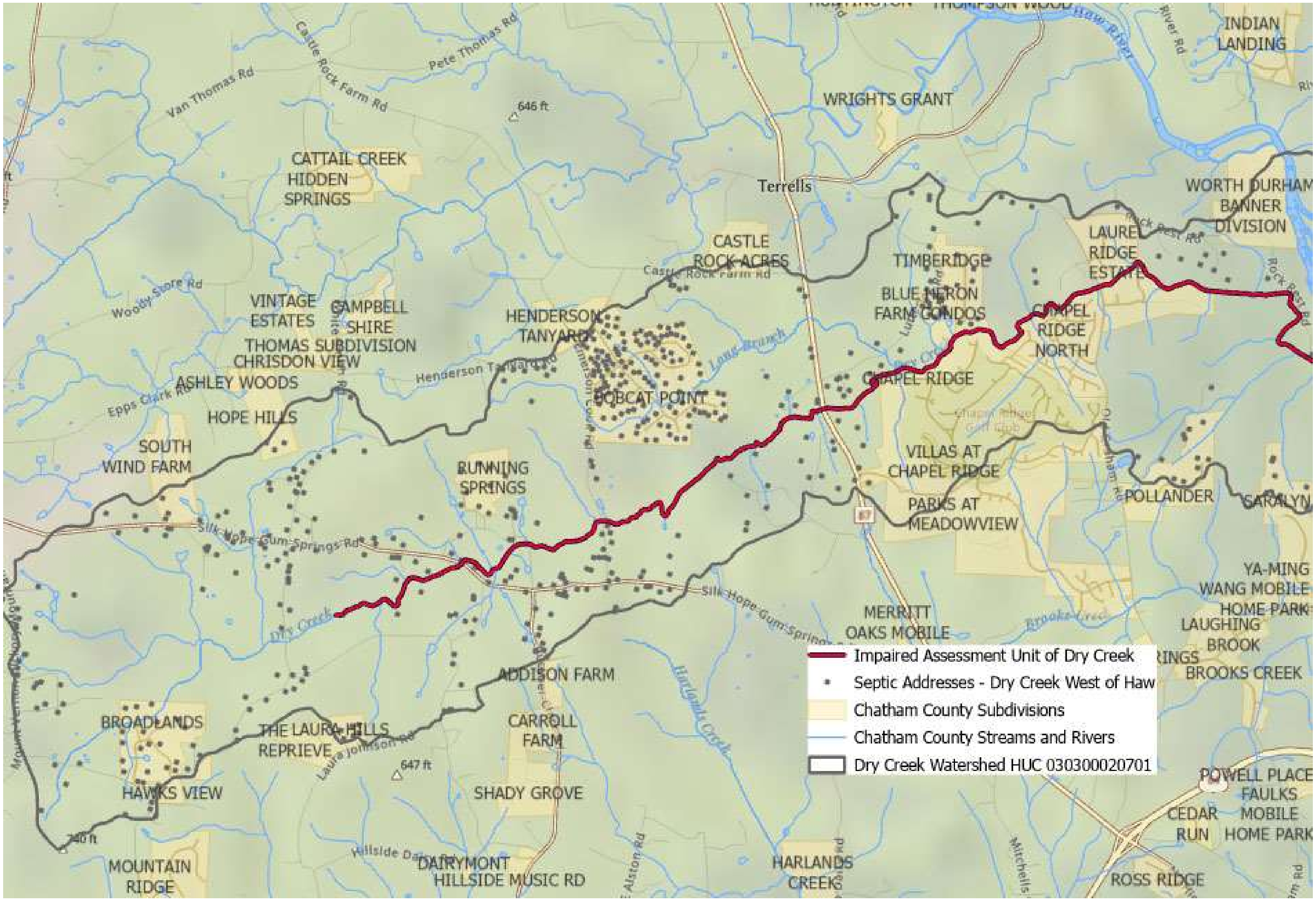
NC Policy Collaboratory-funded efforts to understand nutrient pollution sources in the Jordan Lake Watershed have included studies of wastewater impacts on nutrient pollution in both surface and groundwater. Research teams led by Drs. Guy Iverson and Joseph Delesantro have studied wastewater impacts in nearby sub-watersheds, but not specifically in the Dry Creek watershed. Their studies have focused on the impacts of septic and sewer systems on surface- and groundwater across a range of geographies and soil types. Some of their broader recommendations for preventing wastewater-derived pollution loading apply to the Dry Creek watershed and are summarized below in the following sections.

If Collaboratory researchers' findings did translate from other watersheds, wastewater-derived pollutant loading could play a role on Dry Creek watershed health and benthic macroinvertebrate decline. At the time of writing in 2022, sufficient data do not exist to show a causal link between a wastewater-derived pollutant sources and in-stream benthic health in the Dry Creek watershed. Any data from future Collaboratory studies or other research should be reviewed and included in this plan if it becomes available.

2.2.1.2.1 Malfunctioning Septic Systems

Residential areas outside of the Chapel Ridge complex of subdivisions rely on septic systems to dispose of their wastewater. Due to the obstacle of gathering data from myriad private residential landowners, and the uncomfortable nature of septic system failures, septic system contributions to surface and groundwater pollution are not well quantified locally. Chatham County Environmental Health Department permits individual home septic systems and offer an annual homeowner education session about septic system maintenance; they do not have staff capacity to also track the location of failing septic systems. Specifically, they only hear about septic failure when individuals apply for repair permits or register a complaint. Staff do not track the location of calls but do not recall receiving complaints in the Dry Creek watershed recently.

Figure 21: Septic System Location and Density in the Dry Creek Watershed, Estimated as Residential Addresses Not Served by Sewer



According to the EPA Onsite Wastewater Treatment Manual, septic system failure rates in North Carolina are estimated to be between 15-20% (EPA 2002). There are approximately 500 septic systems in the Dry Creek watershed, so if the statewide failure rate translates to Dry Creek, approximately 75-100 could be failing.

In the absence of data about failure rates in this watershed and given that Dry Creek appears to be suffering from the cumulative effect of many times of nonpoint source pollution, following best practices to reduce the potential impact of septic failures seems like a reasonable precaution. (Proactively managing septic systems as a potential pollution source also improves public health.)

Additionally, Iverson et al's 2021 research in the Falls Lake watershed suggests that septic systems can contribute nutrients and fecal coliform bacteria at higher rates than watersheds with sewer systems even when septic systems are functioning well. When septic systems are malfunctioning, or in particularly large storm events, local water quality impacts can be significantly greater.

Guy Iverson's Collaboratory research findings on septic system and water quality in the Falls Lake watershed suggest that >0.5 septic systems/hectare may be a threshold for water quality. This finding may not translate to the Dry Creek watershed given its position in the Carolina Terrane geology with different soil types (soil also affects how densely septic systems can be permitted.) If Iverson's conclusions from the Falls Lake watershed did hold here, the Dry Creek watershed would be unlikely to exceed his threshold of 0.5 septic systems/hectare except potentially at the Bobcat Point subdivision on the Long Branch tributary of Dry Creek. This older subdivision also is likely to have older septic systems.

Iverson's team is hoping to obtain funds to study septic system performance in the Carolina Terrane geology of the Dry Creek watershed. Research to date has been focused on the Triassic Basin, per personal communication in 2021. Since research conclusions from other geologies may not translate to the Dry Creek watershed, any further research on septic systems in similar geology and soil types should be assessed and included in future updates to this watershed plan.

Delesantro et al's 2019 study for the NC Policy Collaboratory on watersheds neighboring Dry Creek notes that "natural soil processes remove the majority remaining nutrients, but during wetter periods and storms, nutrients are transported faster, reducing treatment in the soil and resulting in greater N-loading." Delesantro's study found large ranges of nutrient loading in watersheds served by septic systems. He and research colleagues concluded that both septic system performance, and septic system location relative to streams and groundwater flow paths, may be important to whether septic system-derived pollutants reach streams.

In summary, at present, insufficient data exist to show a causal link between a spatially specific wastewater-derived pollutant source and in-stream benthic health. However, given that onsite septic contributes a largely unquantified amount of nutrients to surface and groundwater, it should be managed as a pollutant by ensuring residents have the information and resources they need to maintain their septic systems, prevent malfunctions, and prevent potential impacts to water quality.

2.2.1.2.1.1 Next Steps and Recommendations

Research community:

- Study septic system performance and surface and groundwater quality in septic-served watersheds in the Carolina Terrane geology in/near Dry Creek watershed

TJCOG:

- Keep up on the state of research on septic performance and potential pollution impacts in the Carolina Terrane and in areas with older, denser septic systems.
- Keep up with Chatham EHD and if anyone there reaches out to Chatham Environmental Health staff that is unable to afford septic repair or replacement, offer to connect residents with TJCOG programs to apply for loan or grant funding.
- If Chatham EHD is able to track location of calls in future and identified any 'hotspots' for septic maintenance issues, prioritize these areas for septic system repair grants/homeowner education.

Chatham EHD:

- Take advantage of any opportunities to provide education/outreach about upkeep of septic systems to new homeowners or renters
- If possible, increase staffing or find an automated way (ie, something like SeeClickFix) to be able to track the locations of septic malfunctions to assess any patterns/ help residents get resources; prioritize tracking whether any complaints of failing septic systems are registered at Bobcat Point subdivision

2.2.1.2.2 Spray Irrigation in the Dry Creek Watershed

NCDEQ-DWR's Nondischarge Branch permits wastewater spray irrigation in lieu of direct discharge to surface waters. As part of Aqua North Carolina's nondischarge permit, they are required to monitor groundwater quality in the fields where they spray irrigate treated wastewater. Data from their three monitoring wells adjacent to the impaired stretch of Dry Creek is reviewed in section 2.1.2.2.2, on groundwater quality data.

East Carolina University Assistant Professor and scholar Guy Iverson reviewed groundwater well data, noting that concentrations appeared relatively low, except for a couple of sampling events when ammonia and total phosphorus spiked. He thought that more data about the direction of groundwater flowpaths would be needed to know whether groundwater infiltrated by spray irrigation could be reaching Dry Creek. If groundwater was flowing toward Dry Creek, he noted that groundwater data has not exceeded surface water standards for any constituent.

However, Aqua North Carolina was issued a Notice of Violation (NOV) in September 2019 because of wastewater odor at their plant and failure to report data from some wastewater spray irrigation fields as required by their non-discharge permit. Documentation of Aqua's response to this NOV suggests that miscommunication between Aqua and the Chapel Ridge Golf Course may have caused the data reporting failure. This highlights how continued oversight is important where multiple parties are responsible for compliance.

2.2.1.2.2.1 Next Steps and Recommendations:

Aqua/Chapel Ridge WWTP:

- Report all data collected as part of permit requirements
- Use caution when spray irrigating wastewater on hilly terrain near streams

McBane developer: Distance sewer infrastructure from impaired Dry Creek

Research community (NC Policy Collaboratory, others)

- Study impacts of spray irrigation on surface or groundwater quality in the Jordan Lake watershed, specifically in the Carolina Terrane geology
- Assess groundwater and surface water interactions

2.2.1.2.3 Biosolids Application

Wastewater treatment plants in urban centers may offer biosolids from treated wastewater to farmers in rural areas as a free or low-cost alternative to fertilizer. The USGS notes that “biosolids have characteristics that may be beneficial to soil and plants. Land application can take advantage of these beneficial qualities, whereas disposal in landfills or incineration poses no beneficial use of the waste,” (2014).

However, municipal wastewater treatment plants treat residential, commercial, and industrial wastewaters together, and while industrial wastewater dischargers must pre-treat their wastewater before sending it to a municipal WWTP, industrial wastewater has become a source of emerging contaminants such as perfluorinated compounds, nationally as well as specifically in the Cape Fear river basin.

A USGS paired watershed study in 2011-2013 assessed the effects of biosolids application on surface and groundwater quality in adjacent Orange County, NC. They undertook the study because of prior research suggesting that “land-applied biosolids can pose a threat to human health and surface-water and groundwater quality. The effect of municipal biosolids applied to agriculture fields is largely unknown in relation to the delivery of nutrients, bacteria, metals, and contaminants of emerging concern to surface-water and groundwater resources” (USGS 2014).

In the Collins Creek watershed where OWASA biosolids were applied, USGS sampled shallow groundwater wells at the edges of biosolids-applied fields as well as surface water on Collins Creek. They found higher nitrate concentrations on Collins Creek and in shallow groundwater wells downgradient of biosolids applied fields. Their report noted that “the largest differences in concentrations between sites were measured at baseflow conditions, which indicate that the main cause of these differences…is related to nitrate contribution from the shallow groundwater,” (USGS 2014).

USGS Orange County data may or may not translate to the Dry Creek watershed. In 2016, HRA report entitled “Sludge in Our Waters” detailed their monitoring of surface waters upstream and downstream of biosolids application sites in several locations including the Dry Creek watershed. They found high levels of perflorinated compounds downstream of application sites, some exceeding the EPA provisional health advisory of 200 ng/L at the time. Encouragingly, HRA’s Executive Director Elaine Chiosso notes that there has been no biosolids application in last 2 years in this watershed.

2.2.1.2.3.1 Next Steps and Recommendations

Project partners should work together to:

- Keep up on the state of research on impacts of biosolids on nutrients, perflorinated compounds and other contaminants on ground- and surface water quality in the Dry Creek watershed.

2.2.1.3 Degradation of Riparian Buffers

2.2.1.3.1 Riparian Buffer Quality GIS Assessment

A riparian buffer is a vegetated area along a stream or other waterbody that shades streams and helps protect them from impacts of nearby land uses. They can filter nutrients and other pollutants, lower water temperature, improve aquatic habitat, reduce flooding, stabilize streambanks, and enhance areas for recreation and wildlife. When riparian buffer vegetation matures, they are an efficient way to improve water quality.

Riparian buffer conditions in the Dry Creek watershed were evaluated using 2021 Chatham County aerial imagery. Stream segments were classified as Pristine, Impacted, Managed, Degraded or Absent based on the level of vegetation present at each section. The riparian buffer assessment found 33% of streams and tributaries in the watershed to retain pristine riparian buffers, while 20% have degraded or absent buffers. As the photos below show, Dry Creek has excellent buffers in some locations, and no buffer in others.

Figure 22, on left: Good Buffer Downstream in Watershed at DEQ Monitoring Location BB307

Figure 23, on right: No Buffer Present on UT at Horse Farm in Headwaters

The following sections outlines impacts to riparian buffers, the policy context for protecting or restoring them, and recommendations for next steps to restore and protect riparian buffers to improve benthic community health.

2.2.1.3.2 Residential Development Impacts to Riparian Buffers

Per Chatham County Watershed Protection department, "existing development in the watershed is subject to Jordan buffer rules as defined in Section 304 (J) of the Chatham County Watershed Protection Ordinance:

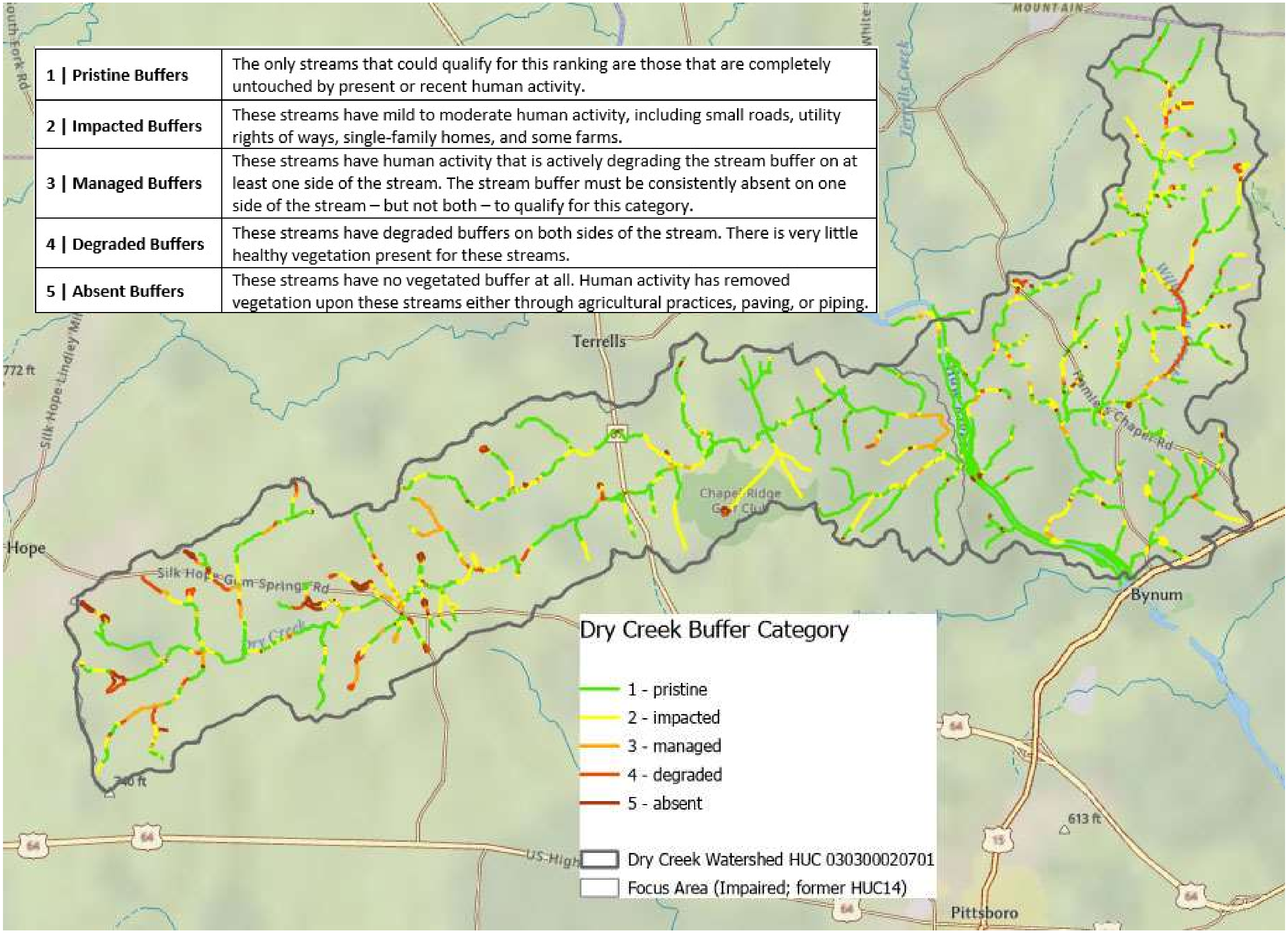
- Intermittent Streams – the riparian buffer is 50-ft from the top of bank
- Perennial Streams, Lakes, Ponds (within natural drainage features), and Reservoirs – the riparian buffer is 50-ft from the top of bank
- There are no buffers on wetlands or ephemeral streams"

Any subdivisions permitted prior to Chatham County passing these buffer rules (ie, Chapel Ridge and Bobcat Point) are not subject. Additionally, subdivisions that were permitted and started construction before 2008 were grandfathered in under old buffer rules and completed construction under these rules.

New subdivisons are subject to "Chatham County buffers as defined in Section 304 (D) of the Chatham County Watershed Protection Ordinance. The buffers below also apply to those properties within the Jordan Lake Watershed that are going through the subdivision process or have an onsite buffer confirmation completed by county staff.

- Ephemeral Streams – the riparian buffer is 30-ft from the top of bank
- Intermittent Streams – the riparian buffer is 50-ft from the top of bank
- Perennial Streams – the riparian buffer is 100-ft from the top of bank
- Wetlands – the riparian buffer is 50-ft from the delineated boundary
- Ponds – the riparian buffer is 50-ft only if the pond is fed by or discharges into a stream that scores 19 points or higher within 50-ft of the pond" (Chatham County Watershed Protection website, n.d.)

Figure 24: Results of Dry Creek Riparian Buffer Assessment (2021)



1 | Pristine Buffers	The only streams that could qualify for this ranking are those that are completely untouched by present or recent human activity.
2 | Impacted Buffers	These streams have mild to moderate human activity, including small roads, utility rights of ways, single-family homes, and some farms.
3 | Managed Buffers	These streams have human activity that is actively degrading the stream buffer on at least one side of the stream. The stream buffer must be consistently absent on one side of the stream – but not both – to qualify for this category.
4 | Degraded Buffers	These streams have degraded buffers on both sides of the stream. There is very little healthy vegetation present for these streams.
5 | Absent Buffers	These streams have no vegetated buffer at all. Human activity has removed vegetation upon these streams either through agricultural practices, paving, or piping.

2.2.1.3.3 Agricultural Impacts to Riparian Buffers

Livestock access to Dry Creek and its tributaries can circumvent the filtration benefits of riparian buffers. Trampling of banks can also cause erosion and sedimentation in the creek, which as noted above can diminish benthic macroinvertebrate habitat quality and directly affect their health.

Additionally, in some places, buffers are absent or inadequate in width to protect stream health. According to Sweeney and Newbold's 2014 literature review, a minimum of 30-foot riparian buffers are necessary to protect stream water quality.

The Chatham County Watershed Protection Ordinance notes that per the Food Security Act of 1985 and the Food, Agricultural, Conservation and Trade Act of 1990, agricultural uses are exempt from buffer requirements.

Instead, the ordinance specifies that agricultural uses "shall maintain a minimum ten foot vegetative buffer, or equivalent control as determined by the Soil and Water Conservation Commission, along all perennial waters indicated on the most recent versions of U.S.G.S. 18 1:24,000 (7.5 minute) scale topographic maps or as determined by local government studies" (Chatham County NC Watershed Protection Ordinance Section 302, last revised 2016.)

Figure 25: Example of Buffer Width Inadequate to Reduce Bank Erosion

Additional agricultural exemptions to the Jordan Buffer rules are outlined in 15A NCAC 02B .0267 of which directs all agricultural activities to go through DEQ.

Because most agricultural properties comply with the 10-foot buffer width requirements, Dry Creek may benefit from focusing on voluntary buffer widening as part of establishing conservation easements or stream, wetland or nutrient mitigation sites. The photo below shows where HRA staff recruited local Boy Scouts to plant a buffer on an interested landowner's property in 2009.

Figure 26: Boy Scouts Planting Stream Buffer

2.2.1.3.4 Buffer Recommendations and Next Steps

Developers of new subdivisions:

- Ensure riparian buffer best practices are followed when constructing McBane, other subdivisions.

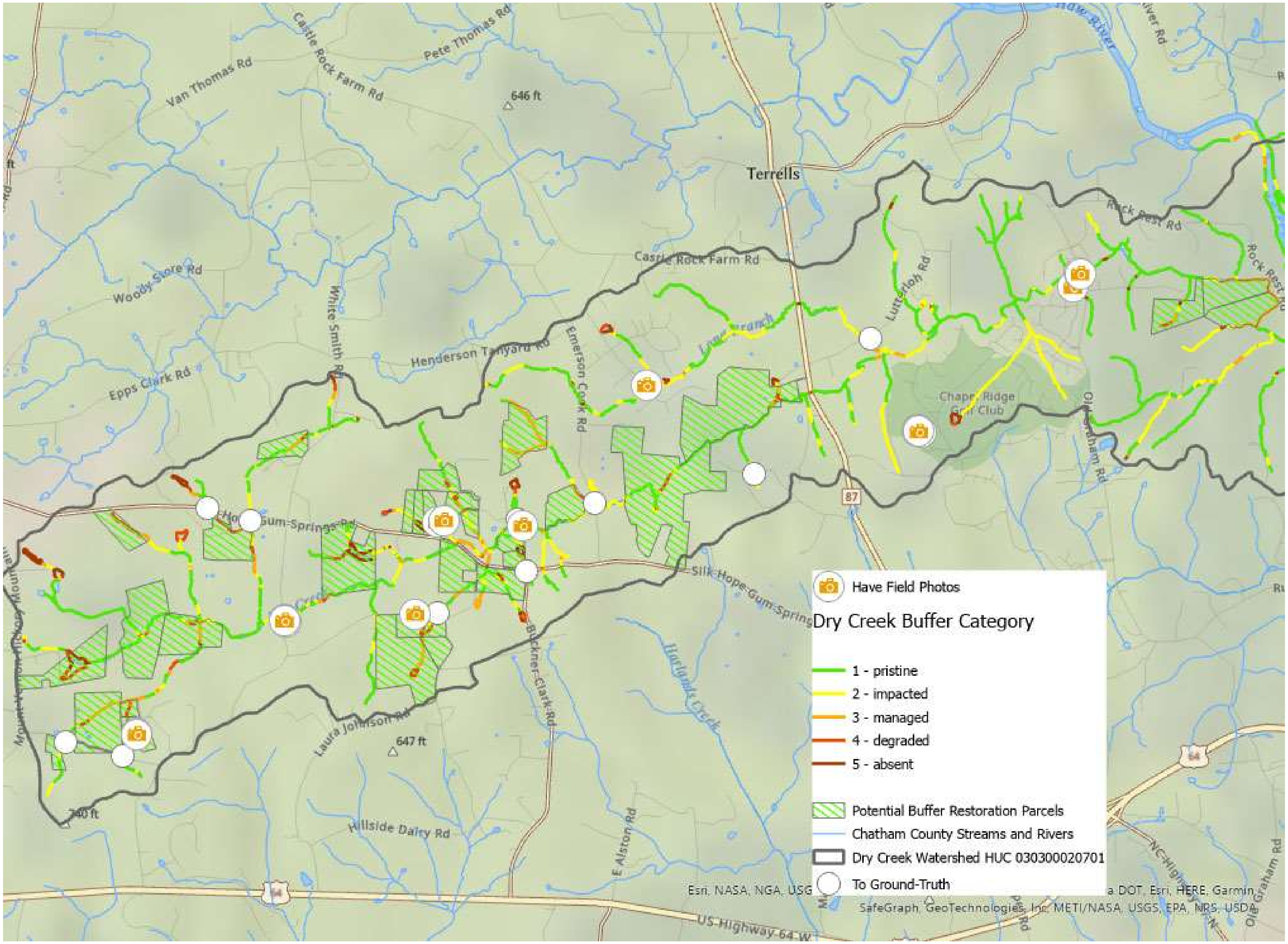
TJCOG/Project partners:

- Ground truth the riparian buffer analysis at the points with white dots in the map below (areas adjacent to public roads in the watershed where riparian buffer is degraded or absent)
- Explore opportunities to share educational materials about benefits of (voluntary, wider) riparian buffers with SWCD networks

Chatham SWCD:

- Consider using ground-truthed riparian buffer analysis data as part of process to allocate funding assistance if interested landowners reach out in Dry Creek watershed
- Coordinate with TJCOG if grant assistance is needed to restore riparian buffers

Figure 27: Riparian Buffer Areas to Ground-Truth



2.2.1.4 Agricultural Nonpoint Source Pollution

2.2.1.4.1 Livestock Impacts

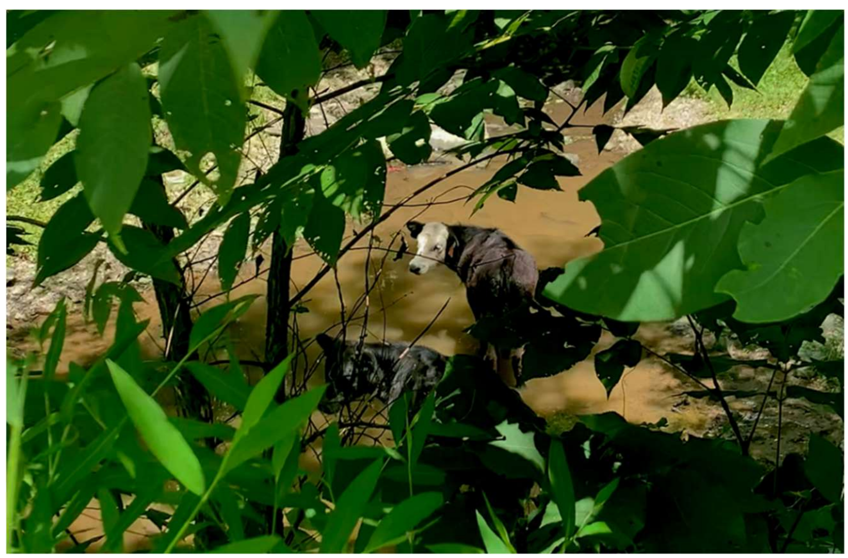
As mentioned above, when livestock have access to streams, they trample the banks and cause erosion which delivers sediment to waterways. Stream channel erosion was noted repeatedly during 2009 assessments, indicating a potential need for stream restoration once livestock are not impacting the stream channel.

Figure 28: Cattle Access to Dry Creek, Winter 2008

In addition, waste from livestock such as cattle, horses and poultry can increase nutrient levels in and contribute fecal coliform bacteria to Dry Creek and tributaries. This ultimately results in lower dissolved oxygen levels, which is detrimental to most pollution-sensitive aquatic life.

Stream visual assessments completed as part of HRA's 2009 study identified manure presence and bank stability as stressors to Dry Creek. Impacts of cattle on Dry Creek could be addressed by fencing livestock farther from streams (the report noted that in some locations, livestock exclusion fences exist but are ~10 feet from the stream, so don't prevent manure from running off into streams in large rain events.)

Figure 29: Cow in Dry Creek, Summer 2021



As of 2021, cattle still had unobstructed access to Dry Creek at several locations, such as those pictured at right. SWCD staff mentioned that cattle in the streams is not uncommon in the county and this watershed could benefit from some livestock exclusion practices. Additionally, they noted that horses moving into the area on larger residential lots and can result in over-grazing issues.

2.2.1.4.2 Pesticide and Fertilizer Impacts

Chatham SWCD staff report that farmers typically get herbicide, pesticide and fertilizer application training from NCSU and test their soil and buy bulk fertilizer at appropriate nutrient ratios. Most farms in the watershed are low- or no-till; the downside of this is that they must do more spraying at the end of season. At least one farm practices silvopasture, which may increase plant nutrient uptake efficiency:

Figure 30: Silvopasture in Dry Creek Watershed, 2021

2.2.1.5 Extreme Low Flow Fluctuations (Natural)

The impact of natural low flows present in Slate Belt streams like Dry Creek was assessed as a potential driver of the benthic impairment. NCDEQ Benthos site details for monitoring site BB307 in the watershed noted that natural stream fluctuations and beaver dams could be detracting from benthic community health. Fred Tarver (NCDEQ environmental flows expert) noted that "factors that affect benthic species ability to withstand drought include the tolerance value of the organism; the ability of the organism to seek out a wetted refuge in the channel; temperature; the ability to recolonize," (personal communication, 2021.) HRA Executive Director Elaine Chiosso, also a longtime resident of the Dry Creek watershed, noted that "Dry Creek is typical of Carolina Slate Belt creeks in its riffle and pool formation. It is not unusual to see riffles dry up in long dry spells. There are typically pools right downstream that still have water that aquatic life migrates to, or some water remains hidden under the rocky surface of riffles. Even during droughts these pools usually contain water and sustain aquatic life."

Eric Fleek (NCDEQ Biological Assessment expert) noted that "taxa are diminished by both no flow and low flow events; the former causing (generally) total mortality, the latter more chronic effects (i.e., reduced abundances and diversities). Hydropsychid caddisflies and Heptageniid mayflies are typically reduced or absent after no-flow events. In addition, due to lowered water levels due to no/low flows, we see edge taxa (things that live on root mats) also reduced/excluded (i.e., the caddisflies Triaenodes, Nectopsyche, Oecetis) since in low/no flow situations, root mats are often out of the water and thus these taxa cannot exist in those habitats any longer," (personal communication, 2021.)

The Two Threatened Streams study reported that "During the drought all the monitoring sites on Dry Creek except for the most downstream site went dry. For the collection in November 2007, the sites on Dry Creek were wet but they were more a series of pools than a flowing stream except for the most the most upstream site on Dry Creek which was still completely dry. We were amazed though at the abundance of benthic macroinvertebrates we found in those pools. The macroinvertebrates found for this sampling period were dominated by facultative species such as dragonflies and aquatic beetles that can survive low oxygen situations," (HRA 2009.)

In 2009, DWR benthic monitors at BB307 observed two species of hetagenid mayflies as "common" at station BB307, as well as one species of hydropsychid caddisflies, considered "rare" but present. (See data sheets in appendix.) As noted above, hetagenid mayflies and hydropsychid caddisflies suffer in low-flow situations, and the 2008 drought was extreme. The observation of these flow-dependent species after major drought suggests that seasonal low flows are not the primary cause of the benthic community impairment. (Of course, low flows could contribute to the impact of other stressors.)

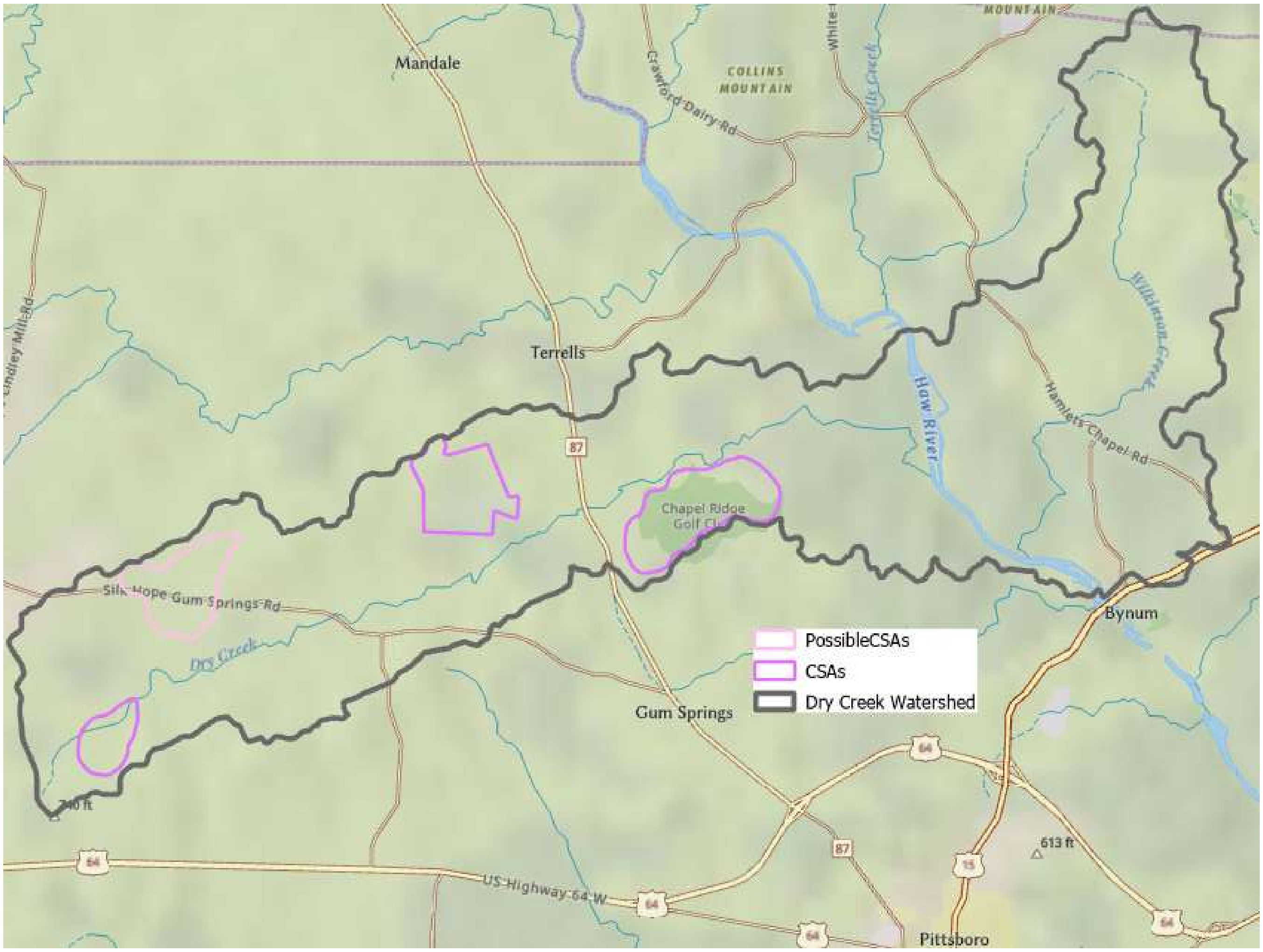
2.2.1.6 Additional Potential Pollution Sources

Data do not exist on all pollution sources; therefore, other sources may exist that are contributing to the benthic impairment. Any "invisible" or "pulse" pollutants are unlikely to have been detected given there has been no regular water quality monitoring outside of the 2007-2009 study and intermittent citizen science monitoring. If funding were available, future research could investigate the presence in watershed of any other pollution sources of concern.

2.2.2 Critical Source Areas

The maps on the following pages show potential Critical Source Areas (CSAs) for the range of observed pollutants present in the Dry Creek watershed as assessed using publicly available geospatial data (land slope, locations of subdivisions, wastewater spray irrigation and biosolids application, estimated septic system locations/density, and riparian buffer condition). This series of maps can be considered a 'first pass' approach to identifying Critical Source Areas. As project partners continue to ground truth areas with degraded buffers and identify potential restoration projects, additional pollution sources may be discovered. When this happens, this information should be used to update and further target locations to implement restoration projects.

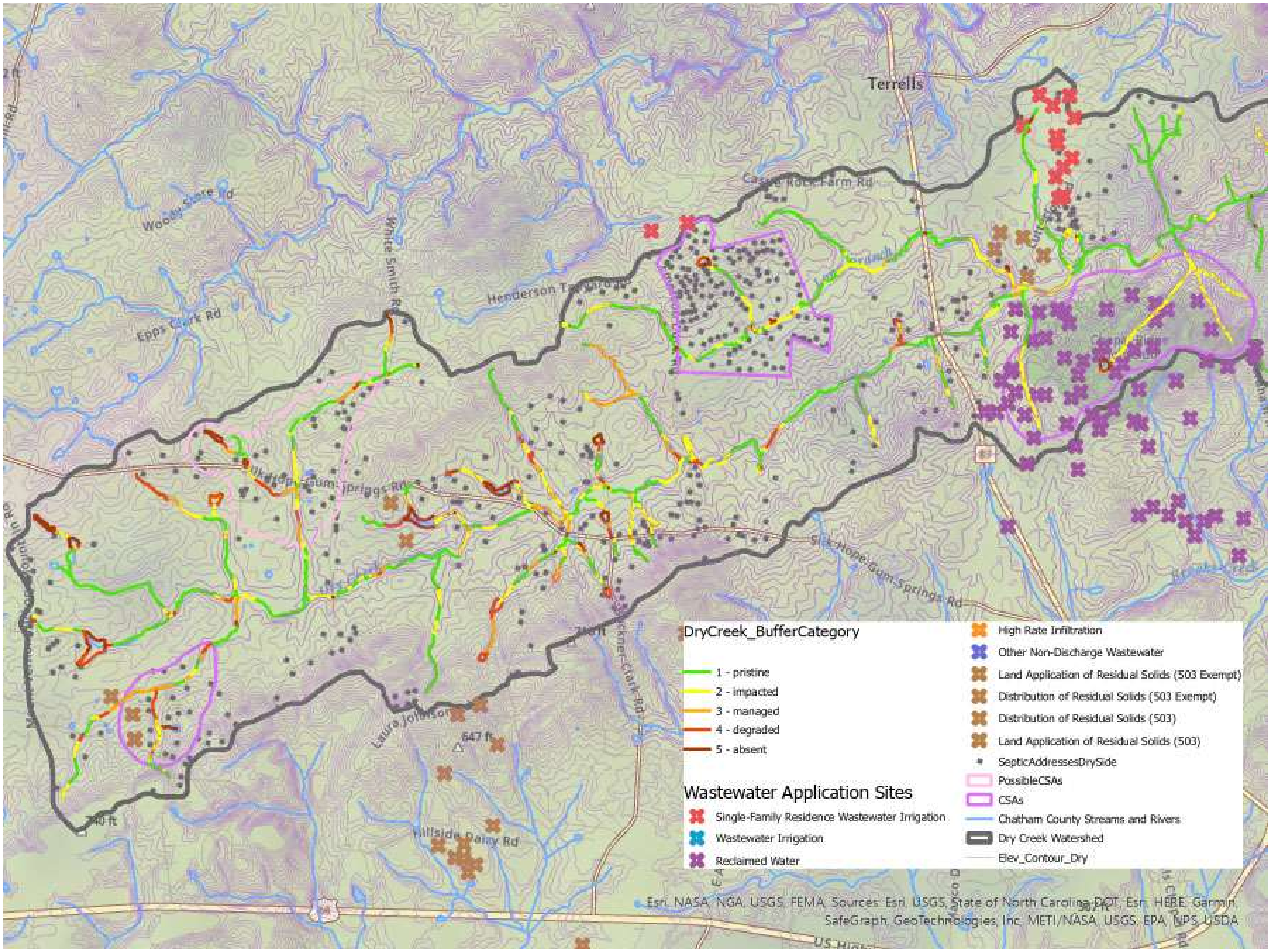
Figure 31: Contextual Map for Potential Critical Source Areas in HUC 030300020701



The CSAs outlined in purple and pink above were identified for the following reasons. All CSAs identified above should be ground truthed before prioritizing specific restoration projects.

- In headwaters: Potential sediment source area (possibly also nutrients, fecal): Steep-ish, headwaters contribute disproportionately, no buffer, horses overgrazing up to the tiny origins of the creek. Also, homes are on septic, and fields they back up to have biosolids applied.
- At Bobcat Point - Potential sediment source area (possibly also nutrients, fecal): Steep-ish, we saw significant degradation of tributary here, buffers intermittently impacted, higher-density septic systems here (for this watershed.)
- At Chapel Ridge - Potential sediment and nutrient source area: Steep, all buffers impacted, we saw erosion and algae coming from golf course to small BMP, spray irrigation throughout.
- Along Silk Hope Gum Springs Road (possible CSA in pink above): Steep-ish, lacking buffer, poultry farms, low density septic systems here

Figure 32: Potential CSAs As Suggested by Spray Irrigation, Biosolids Application, Buffer Quality, Steep Slopes and Septic Systems



3 Load Reductions

3.1 Existing Pollution Load Estimates

Watershed-wide baseline pollutant loads for sediment and nutrients (priority pollutants) were estimated below using EPA's STEPL tool. This tool relies on the simple method of estimating pollution loads via annual runoff x pollutant concentrations. STEPL was used to separately assess the Dry Creek watershed west of the Haw and Wilkinson Creek watershed east of the Haw.

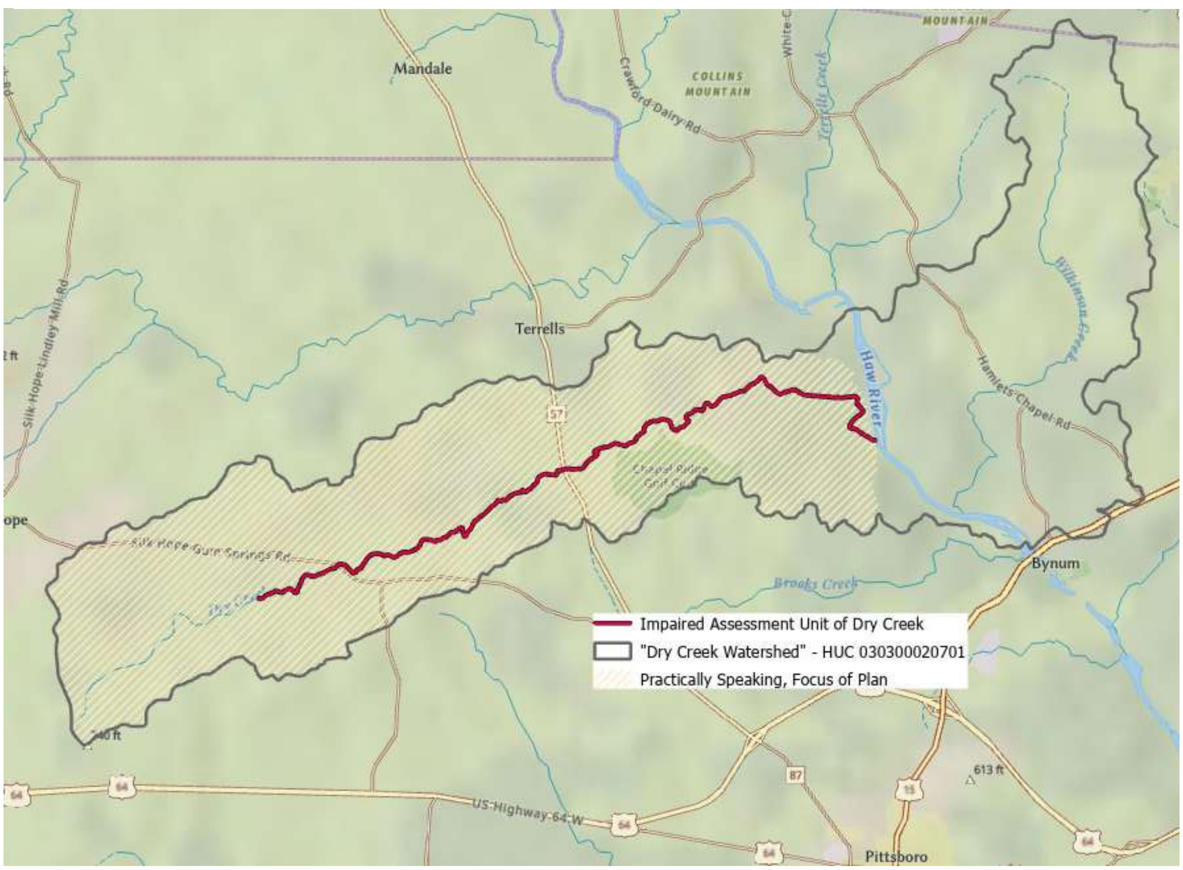
Table 11: Estimated Baseline Pollutant Loads for Impaired Dry Creek Watershed Plan Focus Area

N Load (lbs/year)	P Load (lbs/year)	Sediment Load (tons/year)
36,381.20	8,390.54	3,079.95

Table 12: Estimated Baseline Pollutant Load for Unimpaired Wilkinson Creek Watershed

N Load (lbs/year)	P Load (lbs/year)	Sediment Load (tons/year)
14,395.5	3,995.1	1,121.5

Figure 33: Dry Creek Watershed 12-Digit HUC vs. Plan Focus Area West of Haw River



The EPA's *Critical Source Area Identification and BMP Selection Supplement to the Watershed Planning Handbook* notes that "while watershed models have been commonly used to estimate pollutant loads from alternative BMP treatment scenarios, they should not be used to estimate load reductions for direct comparison with pollutant load reduction targets. Nor should inadequate water quality monitoring (e.g., monthly grab samples and instantaneous flow measurements) be used to calculate measured pollutant loads. In cases where pollutant loads cannot be estimated with suitable confidence, projects should focus their monitoring efforts on BMP implementation…by tracking implementation against interim milestones, project managers will know if the plan is being executed properly even if they don't know the resulting pollutant load reductions. Biological monitoring or tracking of other indicators related to the pollutant load reduction targets may be helpful in demonstrating whether there is an impact on water quality," (EPA 2018).

This guidance has been followed in the consideration of load reduction targets in this and the following sections, as well as their correlation with load reductions associated with management measures outlined in section 5.3.

3.2 Load Reduction Targets

As previously explained in section 2.1.2.2.1, a stream's benthic macroinvertebrate community reflects the effects, rather than the causes, of water pollution. Benthic community health is typically affected by many factors, including sedimentation, habitat loss and chemical pollutants. A full range of land uses and pollution sources are present in the Dry Creek watershed and nearly all of them can affect benthic health. Collectively they appear to have been degrading benthic community health over the last two decades.

Priority pollutants that affect benthic health include nutrients and sediment. Sediment plays a role in impacting benthic macroinvertebrate community health through reducing water clarity and smothering microhabitat. Nitrogen and phosphorus may impact benthic species by causing excess algae growth that blocks light and uptakes oxygen when it decomposes.

In 2000 the US EPA published a report that used extensive in-stream monitoring data to make nutrient criteria recommendations for reference streams in the southeast region, including targets for specific sub-regions. The targets for the Carolina Slate Belt for turbidity, TN and TP are included below for future monitoring staff to use as restoration benchmarks. Achieving these benchmarks (along with temperature, DO and pH standards) will indicate that watershed conditions are supportive of sensitive benthic macroinvertebrate communities:

Turbidity: 5.713 NTU
TN: 0.411 - 0.615 mg/L
TP: 0.03 mg/L

Developing more locally specific, quantitative targets for nitrogen, phosphorus and/or TSS load reductions that would 'restore' the benthic community would require current data quantifying N, P and TSS pollutant source magnitude and location, as well as the impacts of these pollutants on dissolved oxygen, light availability, sediment, and any other factors affecting benthic health, as well as quantifying the benthic community response to these stressors, while controlling for any other stressors to benthic community. That level of analysis is outside the scope of this project. However, achieving the turbidity and nutrient concentration benchmarks above should be protective of water quality for benthic communities in Dry Creek.

Additionally, pollution-sensitive benthic macroinvertebrates require clear, cool water with high dissolved oxygen and neutral pH to survive. State temperature, DO and pH standards for Class C waters in the Piedmont (also supportive of a healthy benthic macroinvertebrate community) are included below as minimum targets to maintain in this watershed. HRA's routine monitoring of Dry Creek can assess over time to ensure that Dry Creek and tributaries remain protective of benthic health for the below.

Temperature: Not to exceed 29-32 degrees C (per NCAC 02B .0208, .0211, and .0220)
DEQ DO standard for aquatic life: >=5mg/L
DEQ pH standard (protective range for benthic health): 6 – 9

Finally, the table below outlines ways that various land uses and pollution sources are impacting benthic community health, and how those impacts can be monitored over time.

Table 13: Identifying and linking concerns, causes and indicators

Issue	Source of Issue	Quantify Issue (Indicators)
Benthic community not meeting standards	Fair or poor benthic macroinvertebrate community health as the cumulative effect of many nonpoint sources Priority pollutants identified include sediment, nutrients, fecal coliform (see below)	Medium-term: HRA citizen scientists' benthic data collected via semi-quantitative Izaak Walton League method/benthic app piloted with DWR Long term: DEQ special benthic study in 20 years to verify if restoration/protection efforts have improved benthic community
Instances of elevated instream sedimentation	Stormwater runoff from construction sites, impervious surfaces, and managed pervious like golf courses and agricultural fields Clearing of buffers where buffers not required (ie, ephemeral streams) and buffers <30 feet in width where only required to be 10 ft Livestock access to streams trampling banks	Turbidity ≤ 50 NTU per state standard observed as part of routine HRA monitoring Redo riparian buffer analysis in 5-10 years and compare % in each buffer quality category to assess change over time
Instances of elevated nutrient levels	Golf course runoff causing algae growth (observed)	Visible algae growth downslope of golf course runoff

	Cows in stream (observed) Lawn fertilization Wastewater sources (potential)	Livestock exclusion fences >30 ft from stream Visible algae growth in Dry Creek and tributaries observed as part of routine monitoring
Potential fecal coliform pollution sources	Livestock sources Wastewater sources (potential)	Livestock exclusion fences >=30 ft from stream State standard is ≤ 200 cfu/100 mL. Since no fecal coliform data is currently collected in this watershed, if partners prioritize could propose a potential future 5 in 30 study done by DEQ to get a baseline and redo after implementing projects to reduce impacts of fecal (nutrient, BOD) sources. If partners prioritize expense could do microbial source tracking to differentiate human and animal waste

3.3 USGS Modelled Nutrient and TSS Loads

The USGS developed the "SPARROW (SPAtially Referenced Regressions on Watershed attributes) modeling framework to relate water-quality monitoring data to upstream sources and watershed characteristics," in part to help NCDEQ assess basin-wide nutrient management needs (USGS 2018.) Input data consisted of national-level data on nitrogen, phosphorus and sediment sources.

The data used to generate these model results may not be granular enough to accurately predict loads in this watershed. The EPA's "Critical Source Area Identification" reference guide notes that "watershed simulation models have limitations in delineating CSAs and selecting BMPs because of the disconnection between watershed modeling scales and the…scale at which BMPs are selected and implemented," (EPA 2018.)

As you can see in the maps below, in the Dry Creek watershed, USGS SPARROW modelling indicated nitrogen yields to be highest upstream in the watershed west of Buckner Clark Road. TSS modeled loads were highest in the corridor being developed adjacent to Chapel Ridge. Modeled phosphorus loads appeared relatively consistent throughout. Note that this roughly aligns with estimated critical source areas (pink polygons on the maps below.)

Figure 34: USGS SPARROW Model-Predicted TSS Yields for NHD+ Catchments in the Dry Creek Watershed

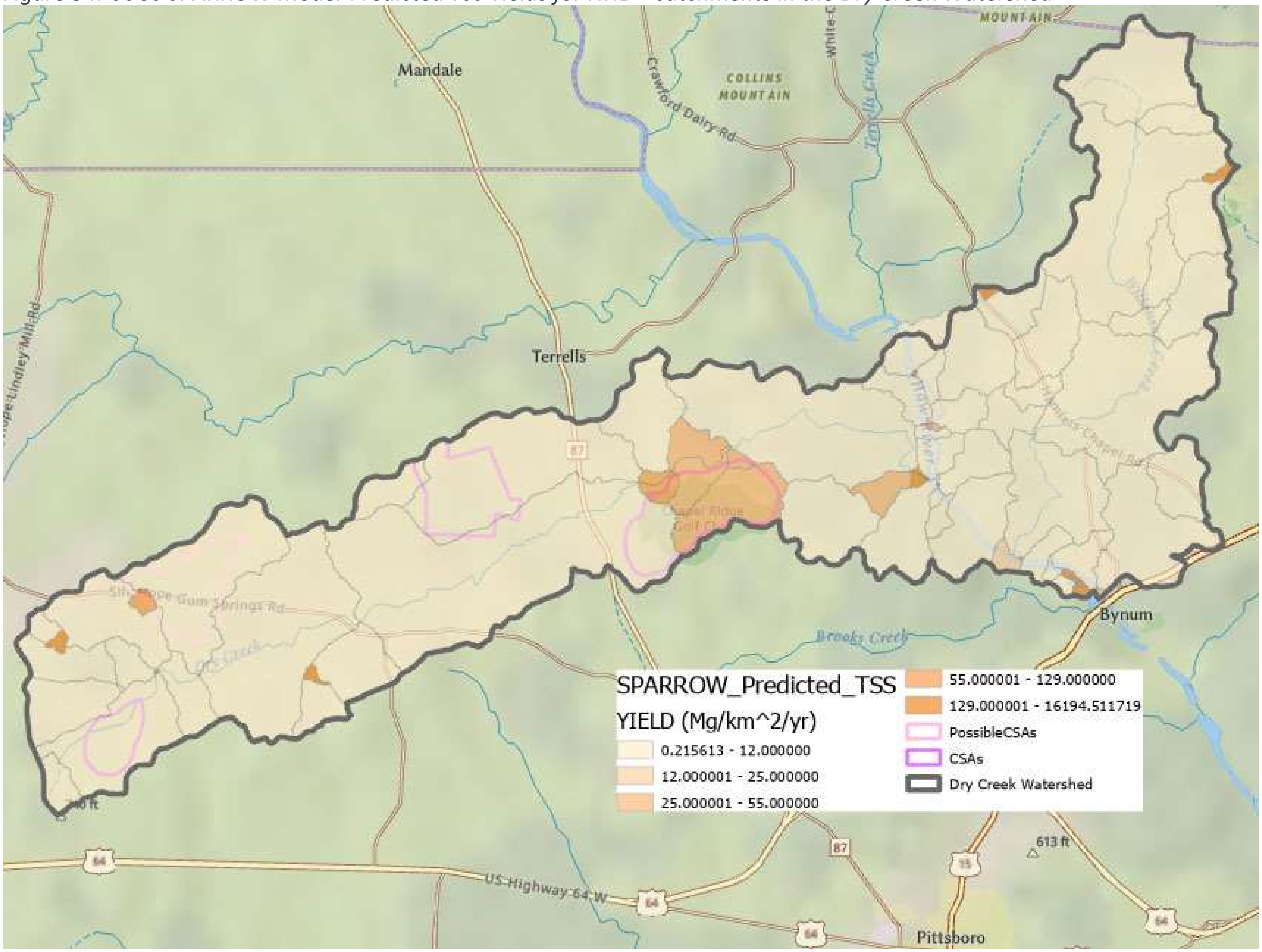


Figure 35: USGS SPARROW Model-Predicted TN Yields for NHD+ Catchments in the Dry Creek Watershed

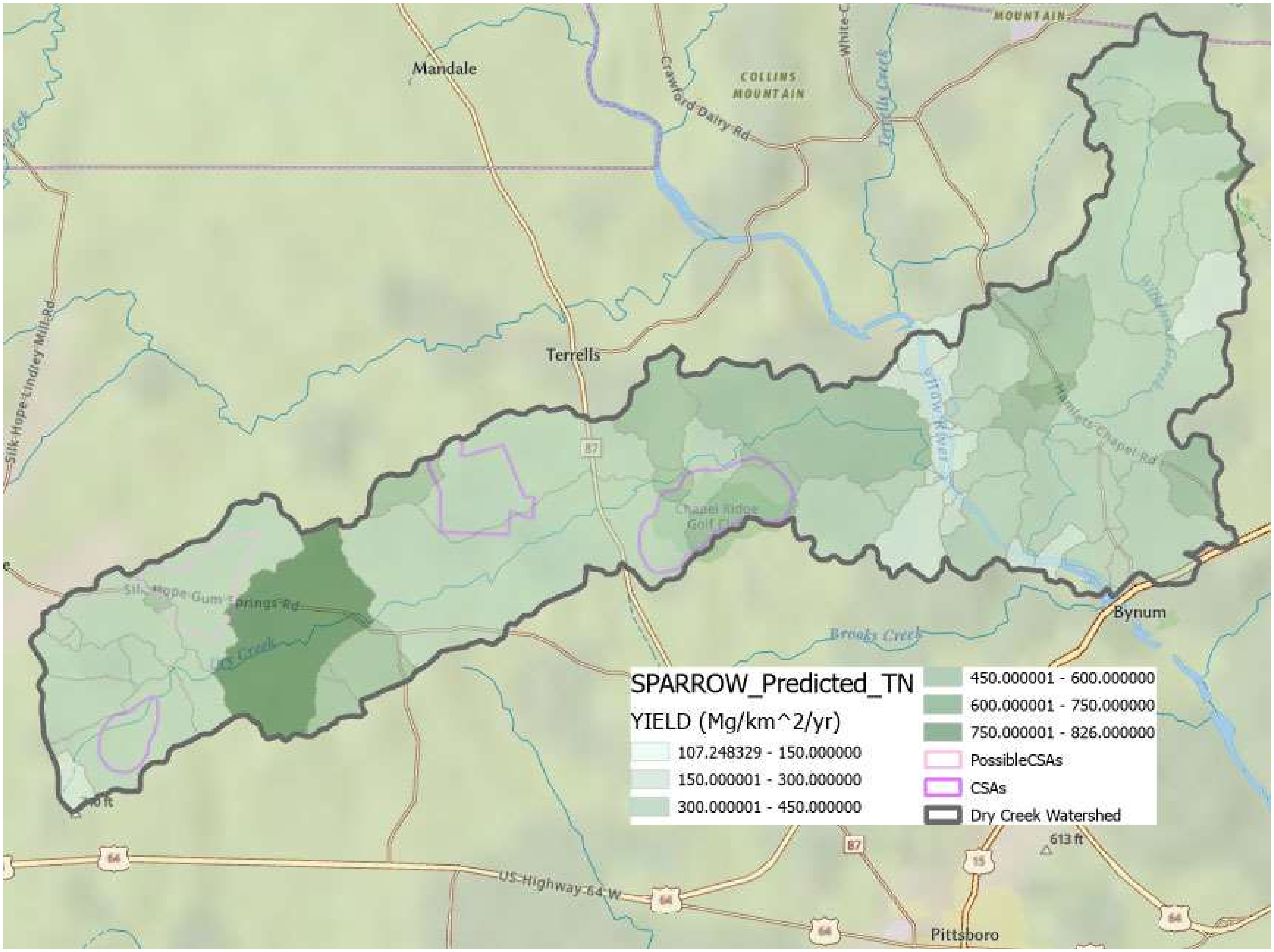
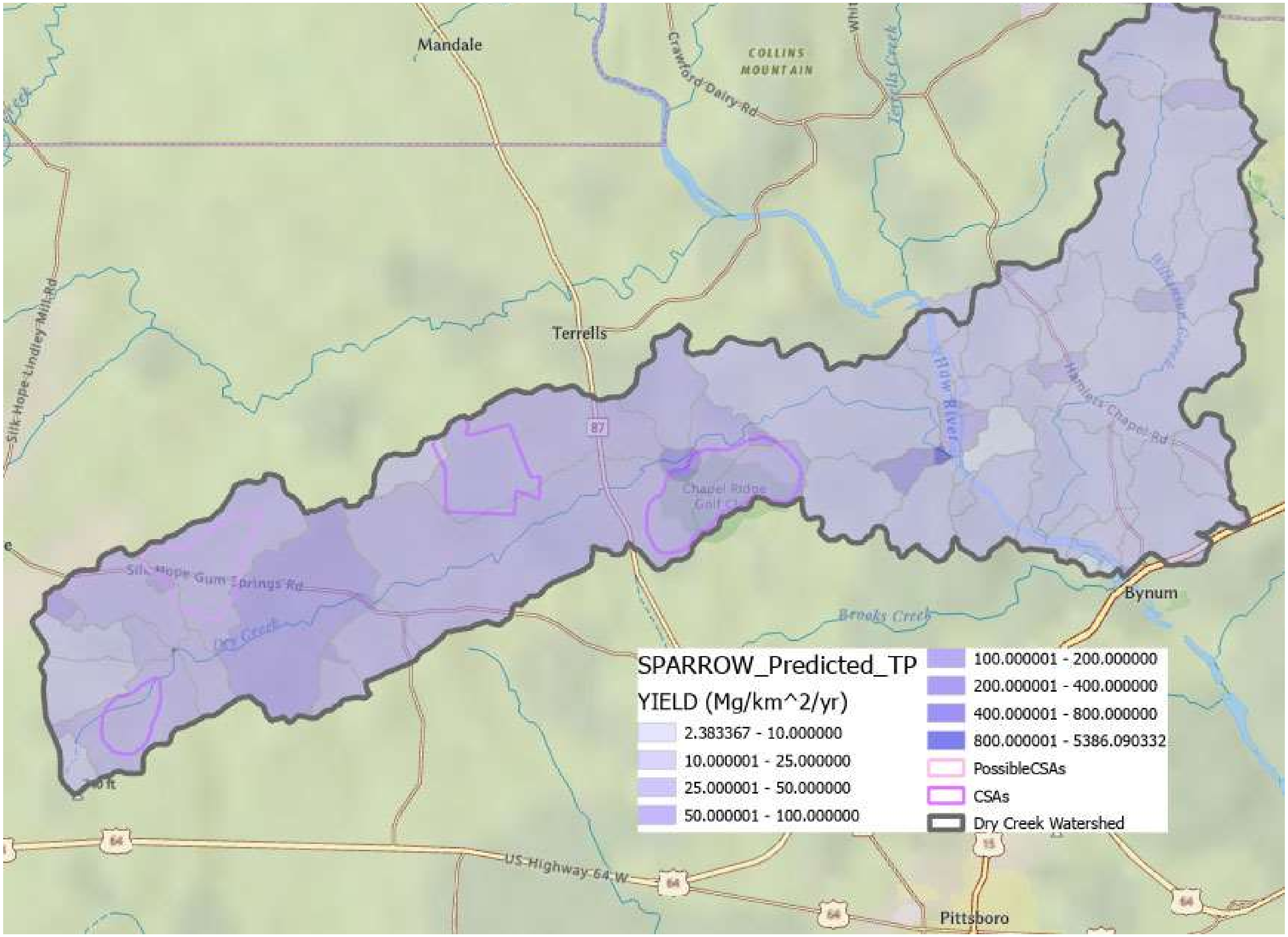


Figure 36: USGS SPARROW Model-Predicted TP Yields for NHD+ Catchments in the Dry Creek Watershed



4 Goals and Objectives

Watershed restoration work is recognized as a long- term undertaking that will take many years. The ultimate goal of a water resource restoration plan is to meet water quality standards. The objectives and actions under this goal can serve as interim measures of success that will set the stage for work to protect and restore aquatic habitat and ultimately the ecological integrity of the Dry Creek Watershed.

The goal of the Plan is to help improve the benthic community rating to good-fair or better, indicating a diverse benthic macroinvertebrate community. This will be assessed in the near term by Haw River Assembly citizen scientists and in the long term by DEQ monitoring of benthic macroinvertebrates.

Figure 37: Reproduced with permission from Haskett Creek Watershed Action Plan

Considering the priority pollutants, pollution sources and data outlined in prior sections, the following section outlines objectives and actions to take to improve benthic ratings. Recommended actions will help improve aquatic habitat and reduce the impacts of pollution sources on benthic macroinvertebrates in Dry Creek.

Expected timeframe, partners, resources, and evaluation criteria needed to accomplish each action and ensure the plan's success are outlined in successive tables associated with each objective and its action steps. These tables should be updated as the needs of the watershed change and action items are completed.

Table 4-1. The primary goal of the watershed management plan and the objectives.

Primary Goal **Improve benthic community rating to good-fair or better to meet biological water quality standards.**
OBJECTIVES
1. Preserve existing land uses (farmland, forestland, open space) to maintain water quality and reduce impacts of land use change as the watershed develops.
2. Protect and restore riparian buffers along creeks and tributaries to filter stormwater runoff and shade the stream, improving benthic macroinvertebrate habitat.
3. Encourage implementation of stormwater, wastewater and agricultural best management practices to reduce sediment, nutrients and fecal coliform bacteria impacts to Dry Creek and its benthic macroinvertebrate community.
4. Continue public outreach/education and involvement to promote stewardship and appreciation of water quality and ecosystem health in the Dry Creek watershed's human community.

5. Facilitate partnerships to implement plan, evaluate outcomes and modify based on results of implementation

The objectives above and actions below were identified by local and regional stakeholders who will work with TJCOG staff to be responsible for implementing this plan. Stakeholders, abbreviations and roles are shown in the table below.

Table 14: Project Partner Roles and Responsibilities

Organization	Role in Project
Triangle J Council of Governments	Maya Cough-Schulze was the project manager and plan writer. Implementation responsibilities: - Lead communication between partners and convene partners annually to update plan on progress toward meeting implementation goals, objectives and actions - Ground-truth potential riparian buffer restoration sites - Seek 319 funding to implement any prioritized projects - Via TJCOG CWEP program staff, create educational materials and/or technical communications for public as needed - Coordinate with DEQ to train interested stakeholders on community science tools
Chatham County Watershed Protection and GIS departments	Watershed Protection staff Rachael Thorn and Drew Blake manage stormwater permitting, watershed management and riparian buffers in county. They have extensive knowledge of sediment and erosion control, stormwater and watershed management, and riparian buffer regulations. Chatham County GIS staff Lucian and Austin also provided data and technical assistance. Chatham County Planning staff were unable to donate time to this effort but are aware of recommendations below. Implementation responsibilities: - Watershed Protection: Provide SCM and stream restoration recommendations as needed, and lead project implementation - Planning: Consider implementing the conservation recommendations below; update team accordingly - Both: Provide updates on any programmatic changes that enable more widespread restoration and conservation implementation
Chatham Soil and Water Conservation District	Works with farmers to provide technical assistance and cost share on voluntary agricultural watershed management practices; they have extensive knowledge of agricultural practices for water quality, landowners and land conversion in county. Susannah Goldston currently serves as the Chatham Soil and Water Conservation District director and works to

	implement agricultural best management practices in the county; when ranking ACSP cost share applications, they prioritize 303d streams. Implementation responsibilities: - Lead communication with agricultural community about 319 funding opportunities for BMPs - As needed, provide agricultural BMP recommendations and lead implementation
Haw River Assembly	Staff and trained volunteers conduct water quality and benthic monitoring in watershed. They have extensive local knowledge of watershed (past and present.) Catherine Deininger previously worked for HRA in 2007-2009 and led the 319 grant-funded study referenced in this Plan; current staff Elaine Chiosso and Emily Sutton advised and provided data for this plan. Implementation responsibilities: - Continue to monitor Dry Creek every 1-2 years - Provide updates on any programmatic changes that enable more widespread restoration and conservation implementation
Chapel Ridge subdivision HOA landscaping committee	Landscaping committee chair Linda DiFrancesco wants to mitigate impacts of sediment/erosion, lawn fertilizer on the tributaries of Dry Creek on Chapel Ridge property. The committee had Biocenosis assess 1) How to mitigate erosion and algae on private property stemming from golf course runoff and 2) How to manage a stormwater treatment device in a tributary that accepts this runoff (via road culvert). Linda has made efforts to connect with the Chapel Ridge golf course about fertilizer use and runoff but they were not responsive at the time of plan writing. Implementation responsibilities: - Provide updates about status of golf course runoff impacts/communication with golf course, HOA residents' interest in managing stormwater device on tributary or implementing small-scale residential green stormwater infrastructure
North Carolina Division of Water Resources	Project funders and technical experts on various water quality / nutrient management issues. Kelsey Rowland advised on 9-element planning, Eric Fleek on benthic data, Nora Deamer on basin-scale nutrient issues. Implementation responsibilities: - Provide updates about any 9-element planning or 319 grant implementation requirements to project team
Biocenosis, LLC	Co-owner Catherine Deininger of small consultancy focused on watershed restoration in Chatham County and surrounding areas conducted the 2009

	study when working for HRA and has extensive local knowledge of watershed (past and present.) Implementation responsibilities: - Serve as technical advisor on any riparian buffer or green stormwater infrastructure projects' siting and implementation
Chatham County Environmental Health	Inspects and permits septic systems in Chatham County. James Tiger was primary contact during the plan writing process. Implementation responsibilities: - Try to identify and track location of septic system failures as reported by residents
Whole team	- Propose updates to goals, objectives and actions in plan, as necessary, as implementation progresses - Communicate updates to TJCOG project manager, other team members as they occur - Participate in annual meeting to update plan, assess progress toward meeting goals - Technical assistance and funding for prioritized projects within jurisdictions - Education and outreach within jurisdictions - Monitor effectiveness of implemented projects
Watershed Group (TBD)	- Engage stakeholders (local residents, schools, parks, etc) - Participate in annual team meetings

The implementation charts in the following sections are organized as follows:

Timeframe – The period of time in which each task is to be completed. Actions' timeframes are classified using best available information about local priorities and feasibility. Although this plan is meant to be a living document, a 20-year planning horizon was assumed for the purposes of implementation.

Partners – The organizations that are responsible for implementing each task. Organizations in **bold** have been assigned to lead this particular initiative.

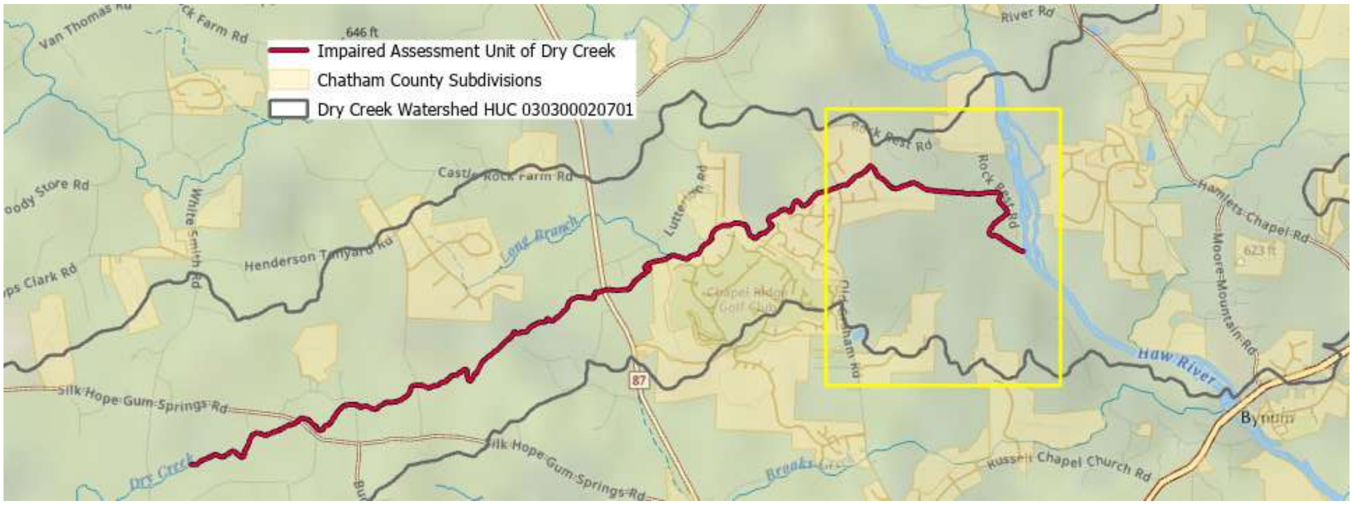
Resources Needed – Assets that will need to be secured in order to complete each task. Resources are grouped into six main categories: Funding, Staff Capacity, Technical Assistance, Training, Public or Elected Official Support, and Educational Materials.

Evaluation Criteria – Specific indicators that will be used to track the progress and success of each action. It is recommended that local stakeholders regularly maintain this information using spreadsheets or other resources discussed in this plan.

4.1 Objective 1: Conserve Land to Maintain Water Quality

Land conservation can help protect Dry Creek from impacts associated with development. Conservation (particularly of forests and open space) can protect water quality by capturing stormwater and associated pollutants, decreasing erosion and flooding, and recharging groundwater. Specifically, Plan Chatham prioritizes protection of the Haw River corridor, between Old Graham Road and the Haw River:

Figure 38: Haw River Corridor Area Prioritized by Plan Chatham in the Dry Creek Watershed



As the watershed continues to develop, Plan Chatham's Comprehensive Conservation Plan "envisions a future where a network of agricultural fields, pasture, timberlands, rural homesteads, and natural areas still dominate the County. The Haw, Rocky, and Deep Rivers and their tributaries provide good water quality and aquatic habitat. Agriculture is thriving. The form and function of rural character is preserved. Tourism contributes significantly to the economy and is buoyed by a connected network of trails, conservation lands and open spaces--many publicly owned and accessible, others are privately owned and are sensitively integrated into new development through innovative design that achieves environmental goals while protecting private property rights," (Chatham County, 2017).

The Comprehensive Plan also aims to "promote a compact growth pattern by developing in and near existing towns, communities, and in designated, well planned, walkable, mixed use centers." Growth in this manner would also benefit the Dry Creek watershed and should be encouraged.

Conservation efforts are often most effective when coordinated with other local priorities, such as farmland preservation, outdoor recreation, wildlife habitat, or flood prevention. Project partners should work with Chatham County Soil and Water, Cooperative Extension, and others listed below to identify specific properties for conservation that align with agricultural and environmental goals. Local land trusts like the Triangle Land Conservancy can provide technical assistance when specific parcels or projects are identified.

The tables below outline actions that can be taken to achieve conservation objectives.

Objective 1: Conserve land to maintain water quality as the watershed develops.

Action #	Specific Action	Timeline	Partners	Resources Needed	Evaluation Criteria
1-1	Work with partners to explore conservation opportunities in the watershed. Prioritize land in critical areas that provides multiple benefits (ie, Haw River corridor, NCNHP-identified priority areas.) Aim for ≤10% impervious cover in each NHD+ subcatchment.	Within first 5 years	**Chatham SWCD, Chatham County Cooperative Extension,** TJCOG, Triangle Land Conservancy, potentially residents of Rock Rest and Blue Heron Farm communities	Technical assistance, staff time, interested landowners	Grant funds acquired for land conservation, acres of new conservation easements or fee-simple properties protected, water quality data, value added ($/ft/year)
1-2	Encourage land use practices such as cluster development, open space requirements, and/or maximum built upon area limits for new development in the watershed	Ongoing	**Chatham County Planning**, TJCOG	Technical assistance, staff time, & elected official buy-in	Acres of land conserved, stormwater reduced, water quality data, value added ($/ft/year)
1-3	Use tools such as the Center for Watershed Protection Code & Ordinance Worksheet and the NC Wildlife Resources Commission (WRC) Green Growth Toolbox to identify other opportunities to improve open space protections in County ordinances	Within first five years	**Chatham County Planning, TJCOG**, NC WRC	Staff time	# of strengthened policies

1-4	Explore and pursue incentives to encourage land conservation/open space preservation (ie, conservation tax credit)	Within 15-20 years	**Chatham County Planning**, Triangle Land Conservancy, TJCOG, American Rivers	Funding, technical assistance, & staff time	Acres of land conserved, new policies/incentives adopted
1-5	If Plan Chatham's land conservation goals are achieved, track long-term benefits of land conservation on benthic community via HRA citizen scientists using NCDEQ community science apps	In 15-20 years	**NCDEQ-DWR Modeling and Assessment Branch, HRA**	Staff time, technical assistance	Benthic community uplift

4.2 Objective 2: Protect and Restore Riparian Buffers Along Creeks and Tributaries

Riparian buffers along streams shade and help protect them from nonpoint source pollution, lower water temperature, improve aquatic habitat, reduce flooding, stabilize streambanks, and enhance areas for recreation and wildlife. A mature riparian buffer (ie, when vegetation has grown in) is an efficient way to improve water quality. TJCOG's riparian buffer GIS analysis described in previous sections can be used to help inform future riparian buffer protection and restoration steps below.

Objective 2. Protect and restore riparian buffers along creeks and tributaries

Action #	Specific Action	Timeline	Partners	Resources Needed	Evaluation Criteria
2-1	Ground-truth potential riparian buffer restoration sites	Year 1	**TJCOG**, project partners	Staff time & technical assistance	# of identified projects
2-2	Work with partners to help find funding, provide education for landowners considering protecting wider than 30-foot riparian buffers	Ongoing, annually	**TJCOG, Chatham County Watershed Protection, Chatham SWCD,** Extension, grant sources including 319, NCLWF	Funding, technical assistance, stakeholder buy-in, & staff time	# of identified interested landowners, funding amounts
2-3	Work with partners and any interested landowners to implement voluntary wider stream buffers	[Based upon project schedules]	TJCOG, **Chatham SWCD, Chatham Extension**, landscaping companies, nurseries	Funding, technical assistance, stakeholder buy-in, & staff time	Linear feet of buffers, stormwater reduced, water quality data, value added ($/ft/yr)
2-4	Connect any interested landowners with NC DMS, Triangle Land Conservancy if mitigation or conservation easement is of interest	[Based upon project schedules]	**TJCOG**, Chatham SWCD, NC DMS, TLC	Technical assistance, stakeholder buy-in, & staff time	# of new easement projects
2-5	Identify maintaining and increasing riparian buffers as a priority in other ordinances and plans	Ongoing	**Chatham County Watershed Protection and Planning**	Staff time	N/A

4.3 Objective 3: Encourage Implementation of Stormwater, Wastewater and Agricultural Best Management Practices

Reducing runoff from developed and agricultural areas and encouraging wastewater best practices will help prevent pollution transport to impaired Dry Creek. This will help maintain natural stream channel functions and habitat which support benthic macroinvertebrate health. Addressing impacts of nonpoint source stormwater, wastewater and agricultural runoff also requires programmatic coordination between public and private entities and the public. The table below outlines actions in this arena that will help maintain and improve the health of the Dry Creek watershed.

Objective 3. Promote Best Management Practices to Reduce Development Impacts					
Action #	**Specific Action**	**Timeline**	**Partners**	**Resources Needed**	**Evaluation Criteria**
3-1	Work with Chatham County to share educational materials on sediment and erosion control requirements for new subdivision construction sites	Ongoing	Chatham County Watershed Protection	Technical assistance & staff time	# of sites posted with sediment and erosion control requirements, number of violations
3-2	Work with Chatham SWCD to share educational materials, help find funding for agricultural landowners interested in implementing agricultural best management practices	Ongoing	**TJCOG**, Chatham SWCD, Extension	Funding, technical assistance, & staff time	# of agricultural BMPs implemented
3-3	Encourage voluntary implementation of green stormwater infrastructure on residential or subdivision property that can serve as amenities as well as alleviating some stormwater impacts. Prioritize visible sites to promote education.	Ongoing	TJCOG, **HOA landscaping committee chairs (starting with Chapel Ridge)**	Funding, technical assistance, & staff time	# of SCMs installed, stormwater reduced, water quality data, value added ($/ft/yr)

3-4	Work with partners to identify and track location of reported septic system failures in the Dry Creek watershed. Offer assistance to any homeowners with failing septic systems to find grants/loans to repair	Ongoing	TJCOG, **Chatham EHD,** NCDHHS	Funding, technical assistance, & staff time	# of homeowners educated, # of septic systems repaired/replaced
3-5	Evaluate existing stormwater wet and dry detention ponds for potential enhancements, and if feasible, find funding to retrofit them to improve ecosystem service and nutrient reduction benefits	1-2 years	**TJCOG, Chatham Watershed Protection and GIS,** grants like 319 and NCLWF, NCSU BAE staff if retrofit designs are needed	Technical assistance & staff time	# of potential retrofits, # of retrofits implemented
3-6	Work with partners to encourage Chapel Ridge golf course to manage runoff, reduce impacts to downslope residential properties and waterways	Ongoing	**Chapel Ridge HOA,** Chapel Ridge golf course (separate entities)	Technical assistance & staff time	Estimated # gallons of stormwater reduced, visible reduction in erosion and algae
3-7	Keep up on research on impacts of septic failure, spray irrigation and biosolids application on surface and groundwater in Dry Creek watershed or nearby watershed in Carolina Terrane geology	Ongoing	**TJCOG**	Staff time	N/A
3-8	Incorporate watershed plan recommendations into Plan Chatham and other County plans, regulations and	As plans are updated	Chatham County – all departments including Planning	Technical assistance & staff time	N/A

	management strategies as applicable				

4.4 Objective 4: Continue Public Outreach, Education and Engagement to Promote Stewardship of the Dry Creek Watershed

It will only be possible to obtain significant reduction in the volume of stormwater runoff if strategic decisions are made about how to achieve the most benefit for the staff and resources used.

Objective 4. Continue Public Outreach, Education and Engagement to Promote Stewardship of the Dry Creek Watershed

Action #	Specific Action	Timeline	Partners	Resources Needed	Evaluation Criteria
4-1	Work with Chatham County to incorporate education and engagement on Dry Creek watershed into Chatham County's Clean Water Education Partnership programming (ie, social media watershed spotlight, Creek Week focus, Stream Watch & Adopt a Stream volunteer groups)	Year 1 + Ongoing	**Chatham County Watershed Protection** and other departments, **TJCOG – CWEP program,** NCDWR education staff, afterschool programs, scouts	Technical assistance, staff time, & willing volunteers	# of programs/events, # of people reached, public buy-in, # of volunteers, level of interest, citizen science data
4-2	Coordinate with partners to consider establishing Keep Chatham Beautiful chapter to increase community buy-in	Ongoing	**TJCOG**, Chatham County Watershed Protection, Chatham SWCD, HRA, Biocenosis	Technical assistance & staff time	# of programs/events, # of people reached, public buy-in
4-3	Work with project team to establish Watershed Group to implement and update plan. Determine organizational	Years 1-5	**TJCOG,** Biocenosis, HRA, Chatham County Watershed Protection	Staff time & stakeholder buy-in	# of milestones met

	responsibilities and meeting frequency				

4.5 Objective 5: Facilitate Partnerships to Implement Plan, Evaluate Outcomes and Modify Based on Results

Accomplishing the actions called for in this plan require partnerships with state and local government agencies, non-profit organizations, universities, landowners and residents. Progress made in achieving water quality improvements will be measured and this plan will be adapted as necessary based upon the results of this monitoring.

Objective 5. Facilitate Partnerships to Implement Plan, Evaluate Outcomes and Modify Based on Results					
Action #	**Specific Action**	**Timeline**	**Partners**	**Resources Needed**	**Evaluation Criteria**
5-1	Conduct annual and five-year assessment of plan's progress toward implementing the actions in these tables. Document and track progress toward watershed goals. Evaluate success to date and modify plan as needed.	Annually in years 1 – 5	**TJCOG**, with input from all project partners	Staff time	# of actions taken, milestones achieved
5-2	Monitor Dry Creek and tributaries every 1-2 years to assess any changes to benthic health, water quality between DEQ monitoring at BB307	Every 1-2 years	**HRA**	Staff time	Benthic rating, water quality data
5-3	Work with DEQ and partners to explore increasing frequency of water quality, benthic monitoring	Within 5 years	**TJCOG, NC DWR, HRA**	Technical assistance & staff time	Frequency of new data collected
5-4	Identify which management measures are most effective at reducing impacts to benthic	Years 5-15	**TJCOG, NC DWR,** HRA	Technical assistance & staff time	# of priority projects implemented

	macroinvertebrates based on best available science, practical feasibility, cost effectiveness, and other factors				
	Evaluate intermediate benthic recovery metrics via citizen scientist data using NCDEQ apps	Years 15-20	**TJCOG, NC DWR,** HRA	Technical assistance, willing citizen scientists & staff time	# of recovery metrics achieved

5 Management Strategies

5.1 Management Strategies to Achieve Load Reductions for Priority Pollution Sources

This section outlines management measures that address the priority pollutants and their sources identified in section 2.2.

The mix of land uses and watershed impacts would benefit from broader implementation of practices to address the priority pollutants and sources below:

- Sediment from residential subdivision development and streambank erosion, hastened by degraded buffers
- Nutrients from livestock waste, lawn and golf course fertilizer, and possibly wastewater sources
- Fecal coliform from livestock in streams and potentially wastewater and aging septic systems

Note that low flows in times of drought are a 'force multiplier' for these other stressors, though they are not the primary cause of the benthic impairment. Ironically, as the watershed continues to develop, stormwater runoff will likely become flashier and thus high flows may also grow as a driver of benthic community degradation.

A major challenge for implementing management strategies in this watershed is that most of the land is privately-owned residential development or working farmland or forestland. Due to the pace of growth, many farmers and forestland owners have a strong incentive to subdivide and sell their land to developers. Thus, as outlined in section 4 above, restoration in this watershed will require working with residents who may already have an interest in championing restoration project implementation (or conservation to prevent further degradation) as well as educating and encouraging residents throughout the watershed to consider going above and beyond buffer, stormwater, agricultural BMP, and wastewater management requirements.

Section 5.1 below outlines existing plans, policies and projects which are already being implemented to reduce the impacts of nonpoint source pollution. Section 5.3 outlines the management measures (and their load reduction estimates) which local government staff prioritized to help alleviate nonpoint source impacts on water quality.

5.2 Existing Management Measures

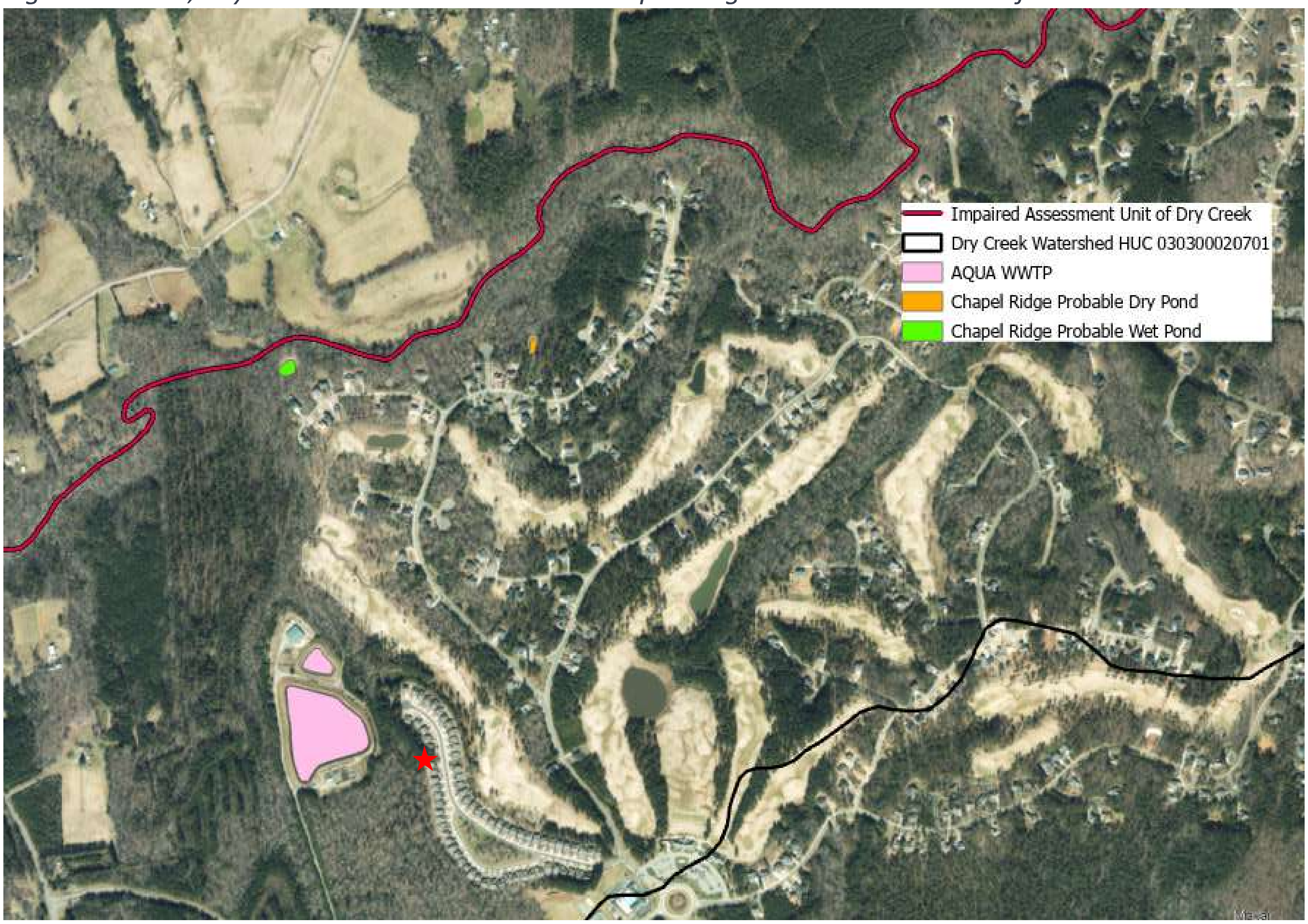
5.2.1 Current Stormwater Control Measures

Because the watershed is comprised of older subdivisions that were proposed and construction had begun prior to the Chatham County stormwater program existing, they had no stormwater requirements. Thus, Chatham County regulates no post-construction SCMs in the Dry Creek HUC east of the Haw and only one in a subdivision on the easternmost edge of the Wilkinson Creek watershed. New subdivisions

Laurel Ridge and McBane will have SCMs. Chatham County Erosion Control handles construction stormwater.

That said, Chatham County GIS staff identified what appear to be at least one dry pond and one wet pond on Chapel Ridge. These should be ground-truthed to confirm and assessed for current functionality and retrofit potential if needed. The AQUA WWTP location is provided below for context. Additional ponds on the golf course (not included as polygons or in legend) may just be decorative but could also serve as stormwater amenities – unknown at time of writing.

Figure 39: Wet, Dry and Wastewater Ponds on Chapel Ridge Subdivision as Identified via GIS



In addition, there is at Chapel Ridge an unregulated small stormwater treatment device below, which Biocenosis assessed for Chapel Ridge's Landscaping Committee, and Chatham County staff think that could have just been a byproduct of the installation of the road culvert. Flow from the culvert comes from behind the willows in the picture on left. This SCM (?) is at the location of the red star on the map above. Other small-scale SCMs (or devices functioning as SCMs) like this may also exist at other locations in the watershed, but have not been inventoried or mapped.

Figure 40: Unregulated Stormwater Treatment Pocket Wetland (?) on Chapel Ridge From Two Angles, in Winter and Summer (photos: Catherine Deininger and Karli Meckler)

5.2.2 Current Agricultural BMPs

Chatham SWCD offers technical advice and conservation planning as well as assistance through federal and state programs (EQIP, CSP and ACSP) that can provide cost share to eligible farm operations to implement agricultural BMPs. Assistance in the Dry Creek watershed would be provided if a producer reached out to the SWCD.

Chatham SWCD tracks assistance requests county-wide. They can typically offer cost share assistance to between 7 to 10 cooperators via state funded programs. In the past 5 years, to address water quality concerns on agricultural operations county-wide, there were 10 projects for livestock waste management systems, 10 projects for livestock exclusion systems, 5 projects for pasture renovation, and three cropland practice (strip crop, grassed waterways, cover crop.) Locations are protected by state statute.

Chatham SWCD recommends the following types of BMPs countywide to address priority sediment, nutrient and fecal coliform sources. These will continue to be applied in the Dry Creek watershed as interested producers reach out:

- Livestock Exclusion Systems including fencing, stream crossings, and watering systems can reduce the impact of sedimentation from livestock (including horses) impacting streambanks. Overgrazing is an issue that can increase soil loss and can be remedied by prescribed grazing.

Figure 41: Overgrazed Horse Farm in Headwaters

- Conventional crop fields in the watershed are typically under no-till or reduced-tillage systems. There are management changes that could further reduce nutrient or sediment loss including diversifying crop rotation, diverse or multi-species cover crops, and field borders. Farms working with federal programs are required to manage cropland for conservation soil loss under 2T or T which is a soil loss factor relating to specific soil types. There are cost share incentives to further improve these numbers.

- Poultry operations with dry litter systems and third party haulers/land applicators of poultry litter are required to follow state statutes. To assist with these requirements, Chatham SWCD recommends nutrient management plans, dry stacks and composters or incinerators for waste management.

- Soil Sampling is also a common recommendation and a cheap/free service provided by the state.

5.3 Types of Management Measures and Specific Prioritized Projects

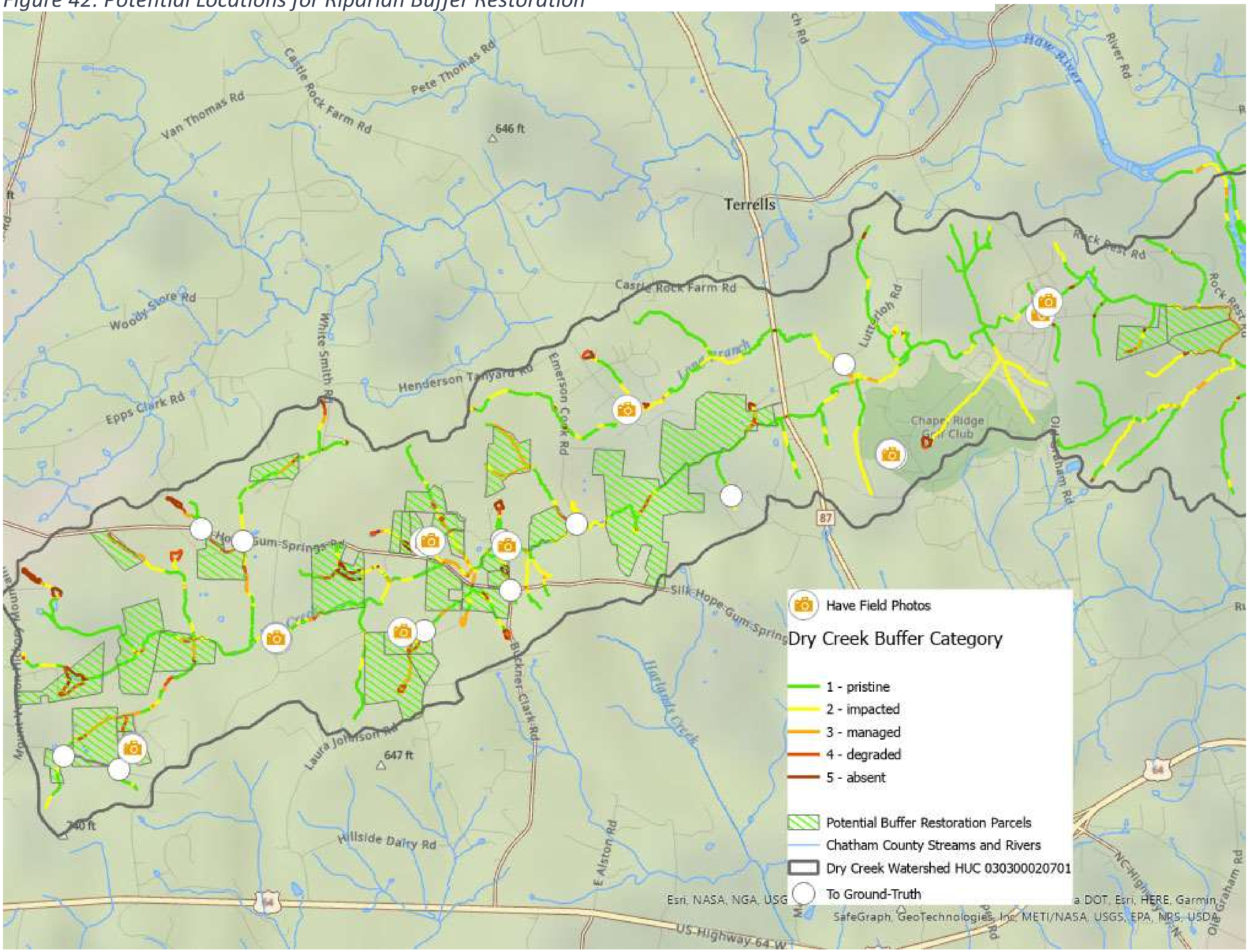
The following sections outline management measures to help meet the goals and objectives outlined in section 4 to restore the watershed. Any management measures' effectiveness depends on landowners and developers understanding their importance to the watershed and their willingness or ability to pay for projects to reduce nonpoint source pollution. Additional funding assistance would likely be required for widespread application of management measures necessary to restore the watershed.

Unfortunately, it was not possible as part of the planning process to identify many specific locations for restoration projects. Although extensive fieldwork and engagement was done between 2007-2009 as part of the 319 grant funded planning work on which this plan builds, current project partners did not have a critical mass of recent, warm contacts with landowners in the watershed. The level of stakeholder engagement that would be necessary to potentially yield interest from new landowners was outside of the scope of this plan, because building relationships takes time and deliberation. Future updates to this plan should include identifying more specific project sites via taking the action steps identified in section 4. Recommended next steps to identify, prioritize and move forward with implementation on restoration projects are outlined in the action tables in the prior section as well as in the sections below.

5.3.1 Riparian Buffer Restoration

Potential properties that could benefit from buffer restoration were identified via desktop GIS analysis (see section 2.2.1.3.) Mapped below are locations TJCOG and Chatham County staff 1) have visited and 2) will visit to assess buffer degradation, erosion, pollution sources, and potential project locations.

Figure 42: Potential Locations for Riparian Buffer Restoration



5.3.1.1 Recommendations and Next Steps

TJCOG/Project partners:

- Ground truth the riparian buffer analysis at the points with white dots in the map below (areas adjacent to public roads in the watershed where riparian buffer is degraded or absent)
- Explore opportunities to share educational materials about benefits of (voluntary, wider) riparian buffers with SWCD networks
- Keep up with stormwater/nutrient quantification of agricultural riparian buffer credit; share any relevant takeaways with Chatham SWCD

Chatham SWCD:

- Consider using ground-truthed riparian buffer analysis data as part of process to allocate funding assistance if interested landowners reach out in Dry Creek watershed
- Share riparian buffer education resources with networks, possibly by mailing to landowners whose properties were identified from ground-truthing riparian buffer analysis
- Coordinate with TJCOG if grant assistance is needed to restore riparian buffers, as landowner interest allows

Developers of new subdivisions (though we don’t really have control over this)

- Encourage protection of NHP-identified species/ecosystems, widest buffers and mature trees when constructing McBane, other subdivisions.

Section 5.5 includes further detail on education and engagement strategies which can be used to identify additional specific restoration project sites in addition to the ones currently identified.

5.3.2 Agricultural Best Management Practices

As mentioned previously in this plan, Dry Creek could benefit from more livestock exclusion fencing at a distance appropriate to protect streams, as well as other agricultural BMPs. The 319-funded project that concluded in 2009 included identifying the following agricultural BMPs at four sites. These sites are in agriculture or forestland use at the time of plan writing in 2022 and landowner interest in pursuing these projects should be further evaluated. (Chatham SWCD staff funds projects with landowners who reach out to them and HRA implementation of these projects was contingent on grant funding that was not awarded.)

Because Chatham SWCD has limited funds, the agricultural BMPs below would likely need to be funded via 319 or other grants if landowners still have interest in pursuing them. SWCD staff can currently complete only the high priority projects identified by the landowners that reach out to them. SWCD would be responsible for landowner outreach and TJCOG would be responsible for grant writing.

The sites below, along Dry Creek, were identified based on assessments conducted on Dry Creek during the HRA Two Threatened Streams project. Staff at the Chatham SWCD in 2010 (no longer on staff) made cost estimates for the four agricultural BMP sites. Discussions of potential BMP installations were held with the first landowner listed in the table below and they were willing to participate, but HRA was not awarded 319 grant funding to complete the project.

*Table 15: Potential Agricultural BMPs (Recommended in 2010)**

BMP Site	Quantities	Units	BMP1	BMP1 Unit Cost	BMP1 Total Cost	BMP2	BMP2 Unit Cost	BMP2 Total Cost
Ag. BMP 1	2200 ft buffer	5.1 acres	Site prep	$40/ac	$204.00	Hardwood buffer	$175/ac	$892.50
	400 ft stabilization	400 ft	Stream stabilization	$85/ft	$34,000.00			
	2600 ft fencing	2600 ft	Fencing	$1.20 ft	$3,120.00			
Ag. BMP 2	2200 ft fencing	2200 ft	Fencing	$1.20 ft	$2,640.00			
	Waterers	4	Troughs, line, etc					
	500 ft stabilization	500 ft	Stream stabilization	$85/ft	$42,500.00			
	2200 ft buffer	5.1 acres	Site prep	$40/ac	$204.00	Hardwood buffer	$175/ac	$892.50
Ag. BMP 3	850 ft buffer	1.0 acre	Site prep	$40/ac	$40.00	Hardwood buffer	$175/ac	$175.00
	22,000 fencing	22,000 feet	Fencing	$1.20/ft	$26,400.00			
	Waterers	4	Troughs, line, etc					
	Stream crossings	2						
	Heavy use areas	2						
Ag. BMP 4	2200 ft buffer	5.1 acres	Site prep	$40/ac	$204.00	Hardwood buffer	$175/ac	$892.50
	2200 ft fencing	2200 ft	Fencing	$1.20 ft	$2,640.00			

*2010 costs included where available

All livestock exclusion fencing projects are recommended to be >30 ft from the stream channel. The 2009 319 grant report noted that "All but a few of the cattle and horse farms along Dry Creek have fenced their animals away from the creek. Unfortunately, a number of these fences are within 10 feet of the stream channel so when the creek floods much of the animal waste is washed into creek."

5.3.2.1 *Agricultural BMP Load Reductions*

If all of these projects were completed, 50,000 linear feet of livestock exclusion, 10 acres of buffer plantings, 8 waterers, 2 stream crossings, and 2 heavy use areas would result in the following estimated load reductions:

Table 16: Estimated Load Reductions for Prioritized Projects per Chatham SWCD staff, 2010

8000 lbs N saved from project implementation per NCANAT*
120 lbs P saved from project implementation per NCANAT
300 lbs tons of soil saved from project implementation per NCANAT and actual volume calculations

*Consisting of the Phosphorus Loss Assessment Tool (PLAT) whose methods are described here and the Nitrogen Loss Estimation Worksheet whose methods are described here

Figure 43: Site #2 Identified as Cattle Exclusion Fencing Priority in 2010

EPA's BMP Selection guidance (2018) notes the challenge of "transferring the information acquired from a complex watershed scale model into a simplified form suitable for interpretation by conservation specialists, extension personnel, landowners, and others closely involved with practical aspects of NPS pollution control. Also challenging is the fact that evaluations of CSAs and the impacts of mitigating BMPs are commonly performed using watershed-scale models based on hydrologic boundaries, whereas BMPs are generally selected and maintained at the farm level and are ultimately applied within the field and farm boundaries. In addition, management changes recommended from a watershed or landscape perspective may not be feasible for some farms because each farm experiences unique challenges in balancing various factors of farm production with environmentally-driven management changes," (EPA 2018).

5.3.2.2 *Recommendations and Next Steps*

TJCOG and Chatham SWCD work together to:

- Send mailings to landowners identified in 2010 priorities above offering to apply for funding to complete projects
- To solicit new potential interested landowners, share information about eligible types of agricultural BMPs and the potential for grants to complete them (via newspaper and speaking with extension agents and at agricultural group meetings – methods SWCD typically uses)
- Apply for 319 grant funding for practices to supplement SWCD funding if interested landowners

5.3.3 Stormwater Control Measures

SCM implementation and maintenance can help reduce sediment and nutrients in the watershed while also providing other ecosystem service benefits. Voluntary SCM implementation should be prioritized based on estimated water quality benefits, cost, site suitability, and low operation and maintenance needs.

5.3.3.1 Potential Volume Reductions and Effluent Concentrations (EMCs)

Retrofitting low-functioning SCMs with outdated designs (such as dry detention basins) is one way to cost-effectively retain and treat more runoff. Based on NCSU research there are many dry ponds across the state, and they were constructed primarily for volume retention, rather than water quality, so retrofitting them has great potential for water quality uplift at low cost.

As the table below shows, dry ponds neither infiltrate nor treat stormwater as well as wet ponds, stormwater wetlands or bioretention. Current dry ponds in the watershed may be good candidates for retrofitting as wet ponds or infiltration basins, and current wet ponds may be good candidates for retrofitting with floating wetland islands to increase nutrient removal and other ecosystem service benefits. (Recent NCSU pre- and post-retrofit monitoring at a Morrisville dry pond retrofitted into a wetland found 89% TSS load reduction, 60% TP reduction and 71% TN reduction (Ellis and Hunt, unpublished, 2021.))

Dry ponds are not currently mapped at the county level. Chatham County GIS staff attempted to identify them from geospatial data but did not have a high degree of confidence in these methods.

Table 17: Current Potential SCMs' Stormwater and Nutrient Removal Efficiencies

SCM	Role	% Annual Runoff Volume Eliminated via ET&I	TN EMC of Effluent in mg/L	TP EMC of Effluent in mg/L
Dry Pond	Secondary	4%	1.65	0.66
Wet Pond per MDC	Primary	17%	1.22	0.15
Wet Pond per MDC with > 5% covered by floating wetland islands	Primary	17%	0.85	0.09
Stormwater Wetland per MDC	Primary	29%	1.12	0.15
Bioretention per MDC	Primary	67%	0.58	0.12
Infiltration per MDC	Primary	84%	0	0

*Calculated from references in DEMLR SCM Credit Document for predominant HSG B per communication with Rich Gannon, 2021

5.3.3.2 Recommendations and Next Steps

TJCOG with Chatham County Watershed Protection and GIS departments:

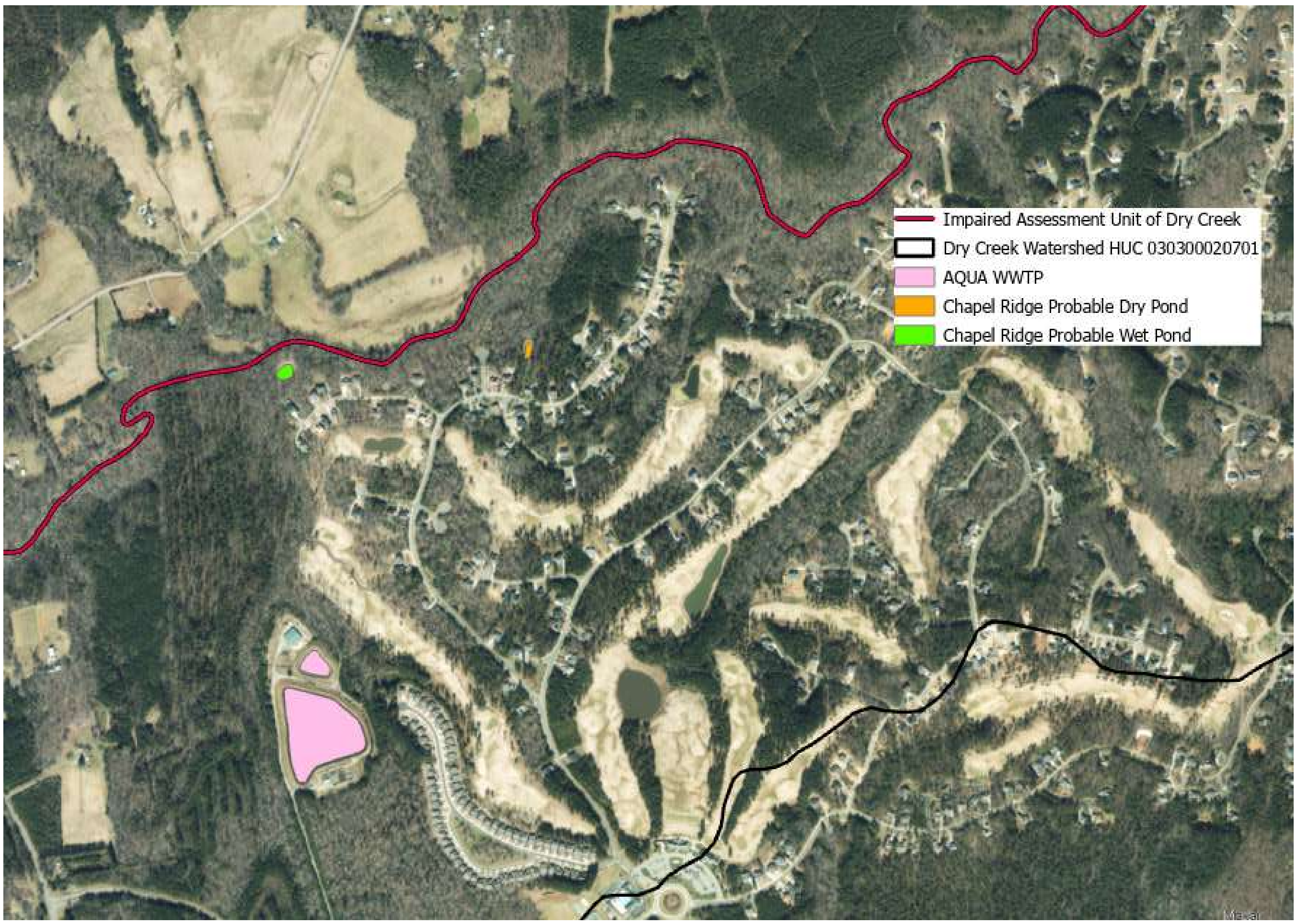
- Identify candidate dry ponds for retrofit based on local government and other watershed stakeholders' knowledge of their on-the-ground locations.
    - Assess the feasibility of upfitting these dry ponds for better ecosystem services and nutrient reduction.
- Explore any incentives (nutrient credit banking?) for HOAs to upfit dry ponds as stormwater wetlands or infiltration basins (depending on soil drainage characteristics)
    - If yes: Coordinate with NCSU on funding, engineering designs
- Coordinate with Chatham County staff to assess performance of wet ponds on Chapel Ridge HOA property; consider retrofitting with floating wetland islands for better ecosystem services and nutrient reduction
- Try to work with other HOA landscaping committees to identify other potential retrofit opportunities
- Help make the case for increased Chatham County stormwater staffing needs to help support this kind of work

TJCOG with Chapel Ridge HOA, NCSU Extension:

- Continue to try to get in touch with golf course staff and encourage them to manage stormwater runoff (since no regulations to require them to and neighboring properties and SCMs downslope on residential property are being impacted)

- Work with landscaping committee chairs to share NCSU resources with HOAs/residents about benefits of residential rain gardens and how to construct them, residential streambank repair, and how to reduce personal impacts to nonpoint source pollution
  - If subdivision residents express interest in voluntary residential SCMs, seek funding to install
  - Coordinate with NCSU to offer streambank repair workshop if interest

Figure 44: Wet, Dry and Wastewater Ponds at Chapel Ridge



5.3.4 Wastewater-Related Management Measures

As previously mentioned, the locations of failing septic systems are not tracked in the Dry Creek watershed. However, as septic system failure rates in North Carolina are estimated to be between 15-20% (EPA 2002), approximately 75-100 systems could be failing in the Dry Creek watershed.

5.3.4.1 Potential Septic Replacement Load Reductions

Bearing in mind all assumptions below, if it were possible to identify all approximately 100 potentially failing septic systems in the Dry Creek watershed and fix them, the potential load reductions as calculated from references could yield approximately 948 lbs of N and 307 lbs of P reductions in the Dry Creek watershed.

Assume typical properly functioning septic effluent is 40mg/L N (Cantor & Knox, 1985) and assuming average household waste of 200 gallons per day (Swann 2013) = 24.37 lbs/year N per house. Assuming typical properly functioning septic N reduction is 28% (USEPA 1993), untreated can be as high as 33.85 lbs/year N per house. Assuming total failure of septic system, the maximum N reduced is 9.48 lbs/house/year. Assuming 100 houses' failing septic systems were fixed, a maximum of 948 lbs of N could be reduced.

Assume typical properly functioning septic effluent is 15 mg/L P (Cantor & Knox, 1985) and assuming average household waste of 200 gallons per day (Swann 2013) = 9.14 lbs/year P per house. Assuming typical properly functioning septic P reduction is between 25% (S. Pradhan 2018 estimate) and untreated can be 12.18 (Pradhan 2018) lbs/year P per house. Assuming total failure of septic systems repaired in this project and using the estimate by Sushama Pradhan, P reduced would be 3.04 lbs/house/year. Assuming 100 houses' failing septic systems were fixed, a maximum of 307 lbs of P could be reduced.

5.3.4.2 Next Steps and Recommendations

TJCOG:

- Keep up with research on malfunctioning septic system impacts to surface and groundwater, failure rates associated with septic system age and maintenance frequency, and impacts to surface waters of aging high density septic systems in the Carolina Terrane geology
- Keep up with Chatham EHD and if anyone there reaches out to Chatham Environmental Health staff that is unable to afford septic repair or replacement, offer to connect residents with TJCOG programs to apply for loan or grant funding.
- As needed, help make the case for Chatham EHD to increase staff capacity or technology (ie, something like SeeClickFix) to track location of calls about septic system issues. Prioritize any 'hotspots' for septic system repair/homeowner education.

Chatham EHD:

- In the near term, prioritize tracking whether any complaints of failing septic systems are registered at Bobcat Point subdivision
- Take advantage of any opportunities to provide education/outreach about upkeep of septic systems to new homeowners or renters
- If possible, increase staffing or find an automated way (ie, something like SeeClickFix) to be able to track the locations of septic malfunctions to assess any patterns/ help residents get resources they need

5.4 *Preventing Further Degradation*

5.4.1 Conservation

Refer to actions under Objective 1 described in section 4.1 for planning tools to prevent degradation. In addition to engineered management measures noted in this plan, land conservation is essential to protect water quality by infiltrating polluted runoff and decreasing erosion and flooding. Chatham County Watershed Protection staff cited the Chatham County Comprehensive Plan ("Plan Chatham") as a community vision for the next 30 years that includes land acquisition for conservation purposes.

Specifically, Plan Chatham prioritizes protection of the Haw River corridor, between Old Graham Road and the Haw River. Voluntary forest and farmland preservation should focus in this area to align with county-level goals. Because development is a strong incentive for forest and farmland owners to sell their property, project partners should continue to work together to identify potential incentives, funding sources and opportunities to keep forest and farmland as such and share these opportunities with landowners.

For instance, agricultural landowners in the watershed may be eligible for Chatham County's tax deferral program: https://www.chathamcountync.gov/government/departments-programs-i-z/tax-administration/present-use-value-tax-deferral-program. This program assesses land based on its present-use value rather than its market value.

Another incentive is Chatham County's Voluntary Agricultural Districts Program. This program encourages the "economic and financial health of agriculture, horticulture, and forestry through protection from non-farm development and other negative impacts on properly managed farms," and enrollees "may benefit from higher ranking in Chatham Soil & Water Conservation District cost share programs." More info can be found here: https://www.chathamcountync.gov/government/departments-programs-i-z/soil-water-conservation-district/our-services/farmland-preservation/voluntary-agricultural-district-program.

5.5 *Education and Outreach*

Project partners have played critical roles in the planning process and have consensus about the importance of public education. Their areas of knowledge should be drawn on and combined to pursue education and outreach goals over the life of the plan:

Table 18: Project Partners and Their Area of Expertise

Organization	Subject Matter Expertise
Chatham County Watershed Protection	Watershed Protection staff Rachael Thorn and Drew Blake manage stormwater permitting, watershed management and riparian buffers in county. They have extensive knowledge of sediment and erosion control, stormwater and watershed management, and riparian buffer regulations.

Chatham Soil and Water Conservation District	Works with farmers to provide technical assistance and cost share on voluntary agricultural watershed management practices; they have extensive knowledge of agricultural practices for water quality, landowners and land conversion in county. Susannah Goldston currently serves as the Chatham Soil and Water Conservation District director and works to implement agricultural best management practices in the county; when ranking ACSP cost share applications, they prioritize 303d streams.
Haw River Assembly	Staff and trained volunteers conduct water quality and benthic monitoring in watershed. They have extensive local knowledge of watershed (past and present.) Catherine Deininger previously worked for HRA in 2007-2009 and led the 319 grant-funded study referenced in this Plan.
Triangle J Council of Governments	Maya Cough-Schulze was the project PI, plan writer, grant manager for the Dry Creek Watershed Plan.
Chapel Ridge subdivision HOA landscaping committee	Landscaping committee chair Linda DiFrancesco had Biocenosis assess 1) How to mitigate erosion and algae on private property stemming from golf course runoff and 2) How to manage a stormwater treatment wetland in a tributary that accepts this runoff (via road culvert). Linda wants to mitigate impacts of sediment/erosion, lawn fertilizer on the creek. She has made efforts to connect with the Chapel Ridge golf course about fertilizer use and runoff but they have not been responsive at the time of plan writing.
North Carolina Division of Water Resources	Project funders and technical experts on various water quality / nutrient management issues. Kelsey Rowland advised on 9-element planning, Eric Fleek on benthic data, Nora Deamer on basin-scale nutrient issues.
Biocenosis, LLC	Co-owner Catherine Deininger of small consultancy focused on watershed restoration in Chatham County and surrounding areas conducted the 2009 study when working for HRA and has extensive local knowledge of watershed (past and present.)
Chatham County Environmental Health	Inspects and permits septic systems in Chatham County.

Effective education, outreach and public involvement is important to increase the public's understanding of how their actions impact watersheds, and how watersheds impact them, to promote behaviors that protect water quality, and to solicit input on potential restoration projects. As outlined in previous sections, education and outreach efforts should first involve offering resources and information to agricultural and subdivision landowners. Project partners report that most people living in the watershed are homeowners rather than renters. Many families have lived in this watershed for generations, and have an interest in using their property in specific ways. At the same time, the watershed is seeing development from the Triangle spreading into it. With that comes higher land values, large properties being subdivided and/or landowners selling outright.

Asking for peoples' time (ie, for public meetings) can too easily be done in a way that seems extractive, and preemptively asking for commitments to take actions on peoples' private land can be seen as proscriptive. It is possible to do well/at the right time - many resources exist regarding best practices for public involvement and education. Care should be taken to create and share educational materials that are relevant to the specific watershed stakeholder's needs and interests as well as the goal of the watershed plan. Project partners should first offer something, and action will come where different parties' interests align. (Engagement is a process that will take time.)

Sharing educational resources about watershed restoration with HOA landscaping chairs and subdivision homeowners and information about financial resources to implement agricultural BMPs should yield some interested residents. Relevant project partners can work with these residents either one-on-one or through in-person or virtual meetings, which may yield the watershed champions that start a Watershed Group.

Those with the financial capacity to at least match a grant may have an interest in constructing residential agricultural or stormwater BMPs. At this point, Chatham County SWCD and Chatham/NCSU extension agents can offer trainings and technical assistance (eg, a rain garden construction workshop.) Some of these interested landowners will likely form a Watershed Group and then may have interest in sharing educational resources with their networks about how individual and collective behaviors can improve water quality.

Project partners have interacted with individuals in the watershed who are interested in learning about specific pollutants and ways to alleviate them through behavior change, green infrastructure and other BMPs. Before this planning process began, Catherine Deininger had met with Chapel Ridge residents about their concerns about algae and erosion. One landowner had just cleared vegetation up to the stormwater detention area but was open to learning what might be more sustainable to be doing/planting. Speaking from her perspective as a Dry Creek resident, Elaine Chiosso mentioned in an early planning team meeting that she thought that many people who live in the watershed could benefit from learning about what is wrong with the creek and how they can help.

TJCOG's Clean Water Education Partnership (CWEP) program, Chatham County and NCSU extension, NC Water Resources Research Institute and NCDEQ can all offer physical and digital resources for all ages. Additionally, CWEP's Education and Outreach Coordinator offers in-depth education at schools, libraries, and festivals, as well as via social media and a dedicated website. Municipal staff from Chatham County have taught school-aged children about stormwater alongside CWEP's Education and Outreach Coordinator, whose lessons are also made available to teachers and the public to use on their own and tailor for their needs.

Education and outreach pertain not just to individuals but groups of stakeholders, institutions and companies. Project partners can explore whether any of their or their networks' contacts live in or work with the various HOAs, Chapel Ridge Golf Course, development companies, etc. and whether they can work with the leadership of these groups, institutions and companies to suggest implementing plan goals and participating in the Watershed Group to be formed. In addition, CWEP has resources about fertilizers, pesticides and stormwater, and will likely create new resources about how homeowners can stem erosion and sediment runoff from their property, and potentially also about sediment and erosion control requirements at construction sites. These could be printed and shared with relevant organizations/at relevant sites via CWEP partner Chatham County.

At the point in the implementation of this plan where project partners are exploring stakeholder interest in implementing restoration projects, they recommended sharing information via the following networks**:**

- Chatham SWCD typically does outreach to landowner via advertising in the paper and by speaking at agricultural events and with extension agents.
- Chapel Ridge HOA landscaping committee chair Linda DiFrancesco can share education materials via community's quarterly newsletter and/or NextDoor website. She noted that information can be shared with neighboring communities as well. She is a master gardener and may have an opportunity to educate the public about rain gardens.
- Catherine Deininger recommended the Chatham Chat list which goes to the whole county. Additionally, she offered to connect project partners with someone at the Chatham Conservation Partnership to present at one of their meetings.

6 Implementation Schedules

This plan is being developed for the next 20 years. It will be re-evaluated and updated every 5 years based on project partner input.

6.1 General Implementation Schedule

Table 19: General Implementation Schedule

Action	Partner	Time
Seek and budget funds for watershed restoration projects.	Chatham County with TJCOG assistance on grant applications (local governments to provide match)	Years 1-10
Meet with partners to support outreach and education already in place and determine best methods to incorporate additional information about nonpoint source pollution, sediment and erosion control requirements for subdivision construction sites, benefits of implementing voluntary green stormwater infrastructure projects, potential availability of funds for agricultural BMPs and septic system repair, and/or how these align with Dry Creek watershed restoration plan goals.	TJCOG project manager to work with Chatham County departments, SWCD (with CWEP educator if needed)	Annually
Catalyze development of watershed group and/or champion by doing at least one of the following (based on partner input): 1) Develop citizen/stakeholder capacity to lead watershed efforts a) Hold meeting for stakeholders to learn about the watershed plan, give input, and survey them on their values and priorities b) Based on interest, host follow-up meeting for interested residents of watershed to coalesce into watershed group, with TJCOG staff input and local government staff support c) Consider integrating dedicated volunteer-led watershed group with County planning efforts following the model of the Loves Creek Watershed	TJCOG to facilitate, local governments to support, residents of watershed to attend	Within 5 years

Stewards' work with Siler City Planning Department 2) Develop local government staff capacity to lead watershed efforts. a) Present to County/SWCD Boards about benefits of implementing this watershed restoration plan, and the need for more funded staff time to lead implementation b) If it is possible to create a funded position(s) they could serve as watershed coordinator/ champion to help implement this plan	TJCOG with local government support	Within 5 years
Assess how current County planning, zoning, new development and land management strategies and regulations to maximize watershed restoration benefits (ie, using Center for Watershed Protection Codes and Ordinances worksheet). Coordinate with Plan Chatham goals.	Local government staff lead or TJCOG could lead if funded time to complete	Within 5 years
Mid-course Evaluation. Update the Watershed Management Plan with Addendums (see Evaluation section)	TJCOG	Year 10
Explore Education and Outreach opportunities, resource needs (such as for HOAs)	TJCOG with local government partners via CWEP	Year 1-5
Promote stormwater reduction retrofits within private developments once HOAs have information they need to maintain them	Local government partners to lead within jurisdictions	Year 10
Annual review of Milestones and Evaluation to determine whether plan remains on track. Implement further evaluation to get back on track if needed	TJCOG and/or local government watershed coordinator	Year 15
Renew plan. Update and write updated Watershed Management Plan. Additional funding should be sought during this time to support additional 10 years.	TJCOG and/or local government watershed coordinator	Year 17
Final Assessment. Review entire plan and implementation successes and failures, lessons learned and how future plans can improve	TJCOG and/or local government watershed coordinator	Year 20

6.2 Project Implementation Schedule

The estimated cost does not incorporate staff time of partners involved and strictly considers cost of materials and professional labor to install projects. Estimated Cost reflects total cost to install or execute all components of the Action and Indicator (it does not reflect each individual installation but the Action as a whole).

Action	Partner Responsible	Time	Maintenance Schedule	Estimated Cost	Indicator
Printing and distribution of materials to residents about watershed restoration grant funds, other topics outlined in table above	TJCOG with Chatham SWCD	Year 1-5	Annually provide additional prints to public buildings	$100/year for physical printing	500 residents receive educational materials annually
Pending interested landowners reaching out, install agricultural BMPs (including riparian buffer restoration) prioritized in the Dry Creek Watershed	Chatham SWCD with TJCOG if funded by 319 or other grant(s)	Year 1-10	Contract between landowner and SWCD stipulates permanence for 10 years (SWCD conducts annual spot checks of 5% of open contracts)	$114,804.50 (construction cost of BMPs prioritized in 2010, if all are implemented)	Agricultural BMPs on 4 properties (multiple BMPs per property)
Evaluate dry detention basin at Chapel Ridge for retrofit potential; design retrofit if appropriate.	Pending funding by 319 or other grant(s), engineering contractor or NCSU BAE to design, TJCOG to manage grant project, Chapel Ridge and Chatham Watershed Protection to partner	Year 1-10	Annually, incorporate with regular landscape maintenance schedule	TBD based on type of retrofit needed	# of retrofits, measured water quality data or modeled effluent concentration

Evaluate potential of wet ponds in watershed (starting with Chapel Ridge) for retrofit with floating wetland islands to increase nutrient removal and other ecosystem service benefits	Pending funding by 319 or other grant(s), engineering contractor or NCSU BAE to design, TJCOG to manage grant project, Chapel Ridge and Chatham Watershed Protection to partner	Year 1-10	Annually, incorporate with regular landscape maintenance schedule	TBD based on type of FWIs needed	# of retrofits, measured water quality data or modeled effluent concentration
Share educational materials or hold live session about benefits of improving riparian buffers and constructing residential-scale green stormwater infrastructure at Chapel Ridge or other subdivision with interested residents where properties abut Creek/tributaries. Consider holding a Rain Garden workshop for interested residents. Construct demonstration rain garden on interested landowner's property.	TJCOG facilitate connecting interested subdivision lead (ie, Chapel Ridge Landscaping Chair) with NCSU Extension staff trainers	Year 1-5	Annually, incorporate with regular landscaping committee responsibilities	TBD based on type of rain garden needed	LF of riparian buffer revegetated, # of rain gardens constructed, downspouts disconnected, associated runoff reductions
Evaluate location of reported septic system failures in the Dry Creek watershed. Direct low-income homeowners with failing septic systems	Chatham EHD with TJCOG	Year 1-10	As EHD staff capacity or TJCOG grant-funded time allows; or if a technological solution can make process	N/A	# of failing systems identified for repair; estimated effluent reduction

toward grants/loans to repair.			more efficient somehow		
(Other projects to be added here after year 10)					

6.3 Milestones

Interim, measurable milestones that will be tracked include:

- Quantitative milestones like the number of agricultural BMP projects installed, linear feet/acres riparian area revegetated, acres of land conserved, number of septic systems repaired, amount of funding received to implement watershed restoration projects, the number of community members educated on stormwater pollution/reduction techniques, number of residential green stormwater infrastructure projects implemented, and ultimately, the number of stream miles no longer impaired
- Qualitative milestones like pre- and post-project photos, the existence of a watershed group, existence of contracts for implementation of agricultural BMPs prioritized in this plan and project permanence for 10 years per contract between landowner and Chatham Soil and Water Conservation District, and adoption of ordinance and programmatic changes that support, enforce, or enhance plan recommendations
- See also criteria/indicators section

6.4 Short Term (1-5 years)

- TJCOG, Chatham SWCD and/or Chatham County secure at least one 319 grant to implement projects that could include a combination of:
    - Installing agricultural BMPs on 1 of 4 properties prioritized in plan, or alternative properties vetted by SWCD who reach out (linear feet vary by project; see 5.3.2 for LF for specific projects)
    - Riparian buffer restoration in identified priority areas
    - Detention basin retrofit if deemed appropriate and partners prioritize
- Appropriate SME partner share educational materials with relevant residents about nonpoint source pollution, sediment and erosion control requirements for subdivision construction sites, benefits of implementing voluntary green stormwater infrastructure projects, potential availability of funds for agricultural BMPs and septic system repair, and/or how these align with Dry Creek watershed restoration plan goals.

- If requested by partners, TJCOG and/or local government staff present to appropriate boards to make the case for the importance of funding dedicated staff for watershed conservation and restoration
- TJCOG to compare how DEQ benthic data/rating and HRA benthic data trends up/down

6.5 Mid-Term (5-10 years)

- Chatham County departments/SWCD (with TJCOG support if needed) secure at least one NCLWF, 319 or other grant to install projects that could include:
    - Install agricultural BMPs on 2nd of 4 properties prioritized in plan or alternative properties vetted by SWCD who reach out if these projects no longer remain relevant
    - Additional retrofits of dry detention basins across the watershed to reduce stormwater volume and peak flows
    - Riparian buffer restoration in identified priority areas
    - Detention basin retrofit if deemed appropriate and partners prioritize
    - Septic system repairs if identified need in watershed
- Continue education efforts outlined above
- Project partners work to with Triangle Land Conservancy to conserve land to prevent degradation of water quality, benthic health and other habitats prioritized by NCNHP
- If requested by partners, at least one local government (or TJCOG) has hired a staff member with dedicated funding to focus on watershed protection and restoration planning, policies and projects (not primarily on regulatory compliance, development review, gray stormwater infrastructure inventory and maintenance, etc. as important as those may be.) This person could be the 'champion' of the plan and Dry Creek restoration.
- TJCOG to compare how DEQ benthic data/rating and HRA benthic data trends up/down

6.6 Long-Term (10-20 years)

- Chatham SWCD install agricultural BMPs on 3rd and 4th of 4 properties prioritized in plan or substitute appropriate deliverable if these projects no longer remain relevant
- Continue to prioritize and install other agricultural BMPs, SCMs (new or retrofit), and riparian buffer conservation and restoration projects as appropriately prioritized using methods outlined in this plan or by project partners using new data/information about watershed
- Continue education efforts outlined above
- TJCOG to compare how DEQ benthic data/rating and HRA benthic data trends up/down
- Benthic rating has improved to Good or above and Dry Creek is unimpaired

6.7 Monitoring and Evaluation of Meeting Plan Goals

Progress toward meeting the primary plan goal of benthic recovery will be monitored using the following evaluation criteria in the table below. These will be used to determine whether water quality issues impacting sensitive benthic macroinvertebrates are being improved over time, and therefore whether substantial progress is being made toward attaining water quality standards.

The definitions of short-, medium- and long-term below are the same as above:
Short term: 1-5 years; Medium-term: 5-10 years; Long-term: 10-20 years.

Table 20: The Primary Goal of the Watershed Plan, Indicators, and How to Measure Them

Primary Goal Indicators				
	Indicator	**Measured by**	**Collected by**	**Collection Cycle**
1	Benthic community health	Short term: HRA citizen scientists' benthic data collected via semi-quantitative Izaak Walton League method/benthic app piloted with DWR	HRA	Every 1-2 years
		Medium term: Compare routine DEQ benthic community ratings at BB307 in future assessments with past data until non-impaired levels are reached	NCDEQ	Every 3-4 years
		Long term: DEQ special benthic study in 20 years to verify if restoration/protection efforts have improved benthic community	NCDEQ	Single instance
2	Sedimentation issues	Short term: Turbidity ≤ 50 NTU per state standard assessed as part of routine HRA monitoring of Dry Creek and tributaries	HRA	Every 1-2 years
		Medium term: Presence/absence of developer sediment/erosion control violations	TJCOG with info from Chatham County Watershed Protection and HRA	Assessed yearly
		Long term: Redo riparian buffer analysis in 5-10 years and compare	TJCOG	Single instance

		% in each buffer quality category to assess change over time		
3	Nutrient enrichment (due to golf course, cows in stream and potentially wastewater)	Short term: Visible algae growth downslope of golf course runoff Short term: Presence/absence of visible algae growth observed as part of routine monitoring	Chapel Ridge HOA landscaping chair HRA	As needed/ observed Every 1-2 years
4	Fecal coliform issues (due to cows in stream, possible wastewater sources)	Medium term: New livestock exclusion fencing >=30 ft from stream Long term: Fecal coliform not to exceed state standard of ≤ 200 cfu/100 mL Since no fecal coliform data is currently collected in this watershed, partners could prioritize DEQ do a 5 in 30 study to get a baseline and redo after implementing projects to reduce impacts of nutrient sources If partners prioritize expense, could do microbial source tracking to differentiate human and animal waste	Chatham SWCD	After new project implementation (TBA) TBA depending on project partner priorities (likely will prioritize known pollution sources first)
5	Education to increase community stewardship	Short/medium term: Attendance at educational meetings Number of landowners implementing BMPs that received 319 RFP or other education about watershed protection, funding availability	TJCOG Chatham SWCD, Watershed Protection and EHD, HOAs	1-5 years 1-5 years
6	Facilitate partnerships to implement, update plan	Project partner attendance at yearly check-ins about status of watershed health, updates for plan	TJCOG (facilitate); all partners (active participants)	Annually

In addition, as the watershed develops, project partners should meet annually to review any new pollution sources associated with stormwater, wastewater, and agricultural runoff to identify any new drivers of benthic community degradation.

6.8 Evaluation of Plan Deliverables

To ensure that the Watershed Management Plan is meeting the needs of the watershed and the community, the watershed plan will be evaluated on a regular basis to determine its effectiveness. The table below outlines how this plan will be evaluated over its 20-year lifespan.

Note that the evaluation metrics below effectively will be evaluating the impacts of ongoing development as well as of implementing watershed restoration projects. Thus, the project team should re-evaluate metrics over the life of the plan and re-assess strategies to meet the plan goals, to ensure partners meet goals and that any failures to meet them do not reflect impacts to the watershed outside of partners' control.

Table 21: Evaluation of the Dry Creek Watershed Management Plan

Evaluation	Partner	Indicator	Timeframe
Progress toward implementing projects prioritized in plan	Chatham SWCD, Chapel Ridge or other HOAs with TJCOG assistance as needed	Interested landowners have responded to sharing 319 RFP; partners have applied for and been awarded funds to implement ag BMP projects, with SWCD matching.	Year 1-5
		OR partners have applied on behalf of interested HOA/subdivision landowners to implement voluntary riparian buffer restoration or residential GSI or SCM retrofit	Year 1-5
		Partners have evaluated detention basins at Chapel Ridge or other subdivisions for retrofit potential	Year 1-10

Progress towards meeting benthic standards	TJCOG to evaluate DEQ, HRA data	Fair benthic rating should increase to Good-Fair or above at station BB307 and/or all tributaries HRA monitors maintain or increase to Good Izaak Walton rating	Assess at years 10, 15, 20 based on data collected every 3-4 years
Mid-course evaluation	TJCOG with local government input	Conduct full assessment of plan with suggestions on ways to enhance or redirect the plan to meet goals	Year 10
Education and Outreach Evaluation	TJCOG CWEP program with local governments	Evaluation of Education and Outreach success: review input from project partners, Watershed Group or other stakeholder groups.	Year 10
Publicize and evaluate successes	Partner implementing projects or education efforts	During/after project implementation and during education and outreach events, update stakeholders on watershed successes	Throughout, as projects and education efforts are implemented

6.9 Cost and Technical Needs

Table 22: Sources of Technical Assistance to Implement Plan

Organization	Role in Project
Chatham County Watershed Protection	Watershed Protection staff Rachael Thorn and Drew Blake manage stormwater permitting, watershed management and riparian buffers in county. They have extensive knowledge of sediment and erosion control, stormwater and watershed management, and riparian buffer regulations.
Chatham Soil and Water Conservation District	Works with farmers to provide technical assistance and cost share on voluntary agricultural watershed management practices; they have extensive knowledge of agricultural practices for water quality, landowners and land conversion in county. Susannah Goldston currently serves as the Chatham

	Soil and Water Conservation District director and works to implement agricultural best management practices in the county; when ranking ACSP cost share applications, they prioritize 303d streams.
Haw River Assembly	Staff and trained volunteers conduct water quality and benthic monitoring in watershed. They have extensive local knowledge of watershed (past and present.) Catherine Deininger previously worked for HRA in 2007-2009 and led the 319 grant-funded study referenced in this Plan.
Triangle J Council of Governments	Maya Cough-Schulze was the project PI, plan writer, grant manager for the Dry Creek Watershed Plan.
Chapel Ridge subdivision HOA landscaping committee	Landscaping committee chair Linda DiFrancesco had Biocenosis assess 1) How to mitigate erosion and algae on private property stemming from golf course runoff and 2) How to manage a stormwater treatment wetland in a tributary that accepts this runoff (via road culvert). Linda wants to mitigate impacts of sediment/erosion, lawn fertilizer on the creek. She has made efforts to connect with the Chapel Ridge golf course about fertilizer use and runoff but they have not been responsive at the time of plan writing.
North Carolina Division of Water Resources	Project funders and technical experts on various water quality / nutrient management issues. Kelsey Rowland advised on 9-element planning, Eric Fleek on benthic data, Nora Deamer on basin-scale nutrient issues.
Biocenosis, LLC	Co-owner Catherine Deininger of small consultancy focused on watershed restoration in Chatham County and surrounding areas conducted the 2009 study when working for HRA and has extensive local knowledge of watershed (past and present.)
Chatham County Environmental Health	Inspects and permits septic systems in Chatham County.

6.10 Funding

Table 23: Sources of Funding to Implement Plan

Funding Source	Deadline	Funding Purpose	Website
NCDWR 319 Program	May	Projects to restore watersheds impaired by nonpoint source pollution	www.deq.nc.gov/about/divisions/water-resources/planning/nonpoint-source-management/319-grant-program
Chatham County Agricultural Cost Share Program	Not on website; last advertised March 2022	Improve water quality on agricultural lands by helping interested participants install, and in some cases help fund, Best Management Practices	https://www.chathamcountync.gov/government/departments-programs-i-z/soil-water-conservation-district/our-services/agriculture-cost-share-program
NCDWR Water Resources Development Grant	June, December	Stream restoration, land acquisition	https://deq.nc.gov/about/divisions/water-resources/water-resources-grants/financial-assistance
National Fish and Wildlife Foundation Five Star and Urban Waters Restoration Grant Program	January	Restoration, education and training to support stewardship and restoration of coastal, wetland and riparian ecosystems across the country	https://www.nfwf.org/programs/five-star-and-urban-waters-restoration-grant-program?activeTab=tab-2
NC Land and Water Fund	February	Stream restoration, land acquisition, innovative stormwater projects	www.NCLWF.net
USEPA Environmental Education Grants	Variable	Promote environmental awareness and stewardship and help provide people with the skills to take responsible actions to protect the environment	www.epa.gov/education/environmental-education-ee-grant-solicitation-notice

NC Division of Soil and Water Community Conservation Assistance Program (CCAP)	Variable	Installation of various best management practices on urban, suburban and rural lands not directly involved with agriculture production	http://www.ncagr.gov/SWC/costshareprograms/CCAP/index.html
USDA NRCS Environmental Quality Incentives Program (EQIP)	March	Financial and technical assistance to implement structural and management conservation practices that optimize environmental benefits on working agricultural land	https://www.nrcs.usda.gov/wps/portal/nrcs/main/nc/programs/financial/eqip/
Stormwater utility fees	N/A	If Chatham County developed a stormwater utility in future, could use fees collected by this utility to fund green infrastructure projects	See model of Person County, Granville County, and several towns within that formed a joint stormwater utility due to being subject to nutrient strategy requirements: https://www.raftelis.com/work/granville-person-cooperative-stormwater-services/

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8 Appendix A: Benthic and Water Quality Data

Table 24: NCDWR Benthic Metrics at Station BB307

Benthic Community Table

Stream	DRY CR	DRY CR	DRY CR	DRY CR	DRY CR	DRY CR	DRY CR	DRY CR
Site Location	SR 1520	SR 1520	SR 1520	SR 1520	SR 1520	SR 1520	SR 1520	SR 1520
County	Chatham	Chatham	Chatham	Chatham	Chatham	Chatham	Chatham	Chatham
Site ID	BB307	BB307	BB307	BB307	BB307	BB307	BB307	BB307
Collection date	12/9/1986	2/8/1993	2/2/1998	7/15/2003	11/21/2003	3/19/2009	6/4/2013	5/1/2018
BAU sample nu	3967	6072	7478	9199	9314	10606	11583	12357
Sample methoc	EPT	EPT	EPT	EPT	EPT	EPT	EPT	EPT
Criteria	Winter/ Piedmont	Winter/ Piedmont	Winter/ Piedmont	Summer/ Piedmont	Fall/ Piedmont	Spring/ Piedmont	Summer/ Piedmont	Spring/ Piedmont

Richness								
Ephemeroptera	4	13	9	5	6	7	5	2
Plecoptera	1	9	7	1	3	7	1	1
Trichoptera	0	9	5	3	4	3	1	2
Odonata								
Megaloptera								
Coleoptera								
Chironomidae								
non-Chironomidae Diptera								
Oligochaeta								
Mollusca								
Other taxa								
Total taxa richness								

Other biological metrics								
Total EPT	5	31	21	9	13	17	7	5
Seasonal EPT	*0*	*0*	*0*		*0*	*6*		*0*
Corrected EPT	*5*	*31*	*21*		*13*	*11*		*5*
EPT abundance	13	177	62	33	86	79	20	34
EPT Biotic Index	6.00	4.65	4.33	5.72	5.25	4.18	4.83	3.25
NCBI	---	---	---	---	---	---	---	---
Seasonal Correction								
Corrected NCBI								
Bioclassification	Poor	Excellent	Good	Fair	Fair	Fair	Fair	Poor

** denotes a tentative classification that should not be used for use support decisions*

Table 25: Dry Creek Benthic Taxa at Station BB307

		DRY CR SR 1520 Chatham COUN 09 Dec 1986	DRY CR SR 1520 Chatham COUN 08 Feb 1993	DRY CR SR 1520 Chatham COUN 02 Feb 1998	DRY CR SR 1520 Chatham COUN 15 Jul 2003	DRY CR SR 1520 Chatham COUN 21 Nov 2003	DRY CR SR 1520 Chatham COUN 19 Mar 2009	DRY CR SR 1520 Chatham COUN 04 Jun 2013	DRY CR SR 1520 Chatham COUN 01 May 2018
Ephemeroptera									
Ameletidae	Ameletus lineatus		R	C					
Baetidae	Baetis flavistriga				R			R	
	Baetis intercalaris				R				
	Baetis pluto					R			
	Callibaetis spp							R	
	Heterocloeon amplum		A	R			A		
	Plauditus dubius gr						A		A
	Pseudocloeon spp (dubious)		R						
Caenidae	Caenis spp	C	C	R	R	A	R	R	R
Ephemerellidae	Ephemerella catawba/dorothea		A						
	Eurylophella coxalis (dubious)		C						
	Eurylophella doris			R					
	Eurylophella spp		A				R		
	Eurylophella temporalis gr	C							
	Eurylophella verisimilis			R		C			
Heptageniidae	Leucrocuta aphrodite		A						
	Leucrocuta spp			R					
	Maccaffertium modestum		C		A	A	C	R	
	Stenacron interpunctatum	C	A	R		C	C	C	
	Stenacron pallidum			R					
	Stenonema femoratum		A	R					
Isonychiidae	Isonychia spp		R		C	A			
Leptophlebiidae	Leptophlebia spp	R	A				R		
Plecoptera									
Capniidae	Allocapnia spp		A	A					
Nemouridae	Amphinemura spp		R				R		
	Prostoia spp						R		
Perlidae	Eccoptura xanthenes					C			
	Perlesta placida (dubious)		R						
	Perlesta spp			R	R		A	A	A
Perlodidae	Clioperla clio		A	C		A	C		
	Isoperla burksi		C	C			C		
	Isoperla kirchneri complex		C				A		
	Isoperla poffi/n sp-Collins Cr		C	C			A		
Taeniopterygidae	Strophopteryx spp		A	A					
	Taeniopteryx spp	C	C	A		A			
Trichoptera									
Hydropsychidae	Cheumatopsyche spp		C	C	A	A	R	C	
	Hydropsyche (H.) betteni/depravata		A		C	C			
Hydroptilidae	Hydroptila spp		R						
	Ochrotrichia spp								A
Lepidostomatidae	Lepidostoma spp			C					
Leptoceridae	Ceraclea ancylus		R						
	Ceraclea transversa		A						
Limnephilidae	Ironoquia punctatissima		A				A		C
	Pycnopsyche spp					C			
Philopotamidae	Chimarra spp		A		C	A			
Phryganeidae	Ptilostomis spp			C					
Polycentropodidae	Nyctiophylax moestus			R					
	Nyctiophylax spp		C						
Rhyacophilidae	Rhyacophila fenestra/ledra		C	R			R		

9 Appendix B: Relevant Figures from 2009 319 Study

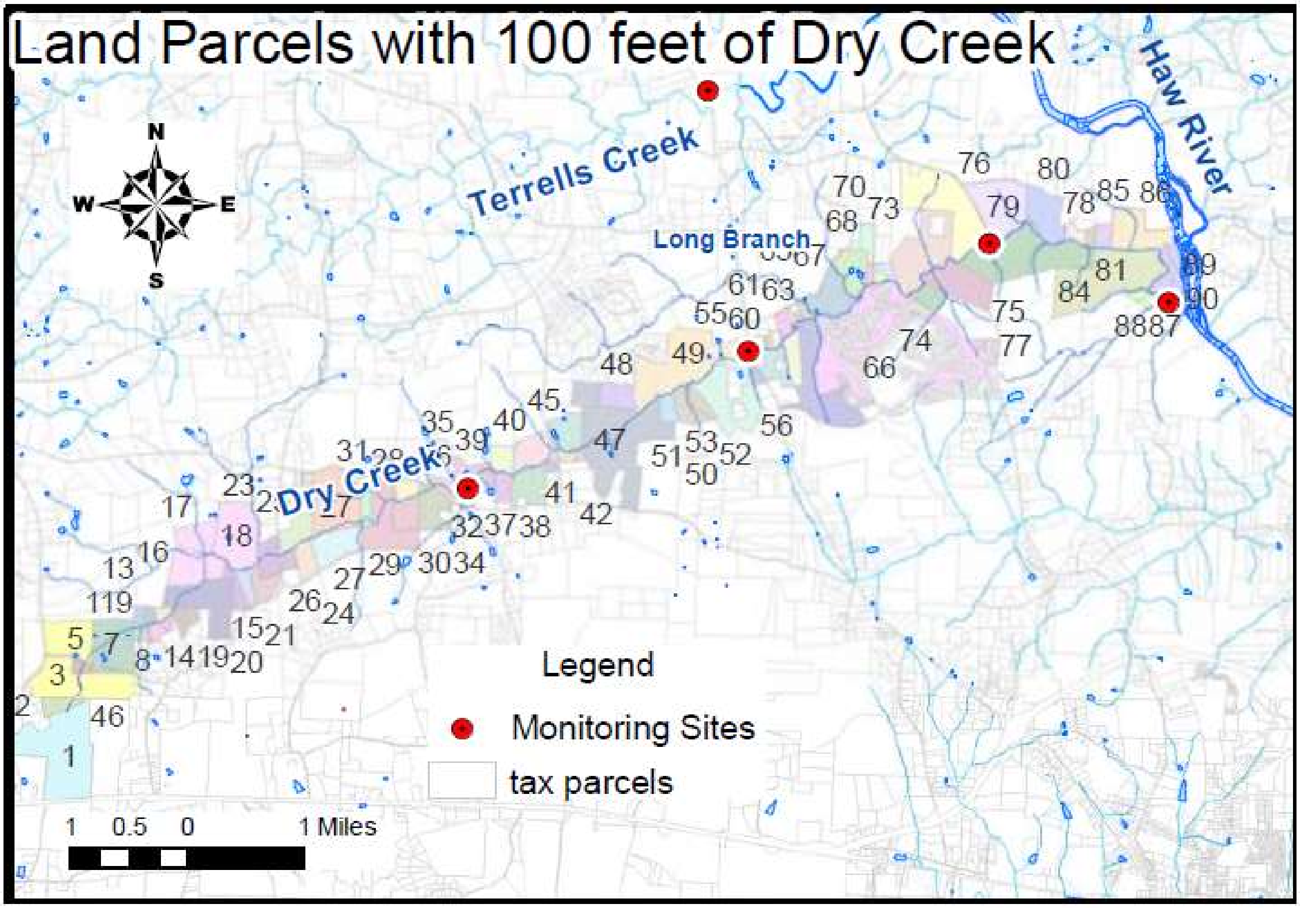
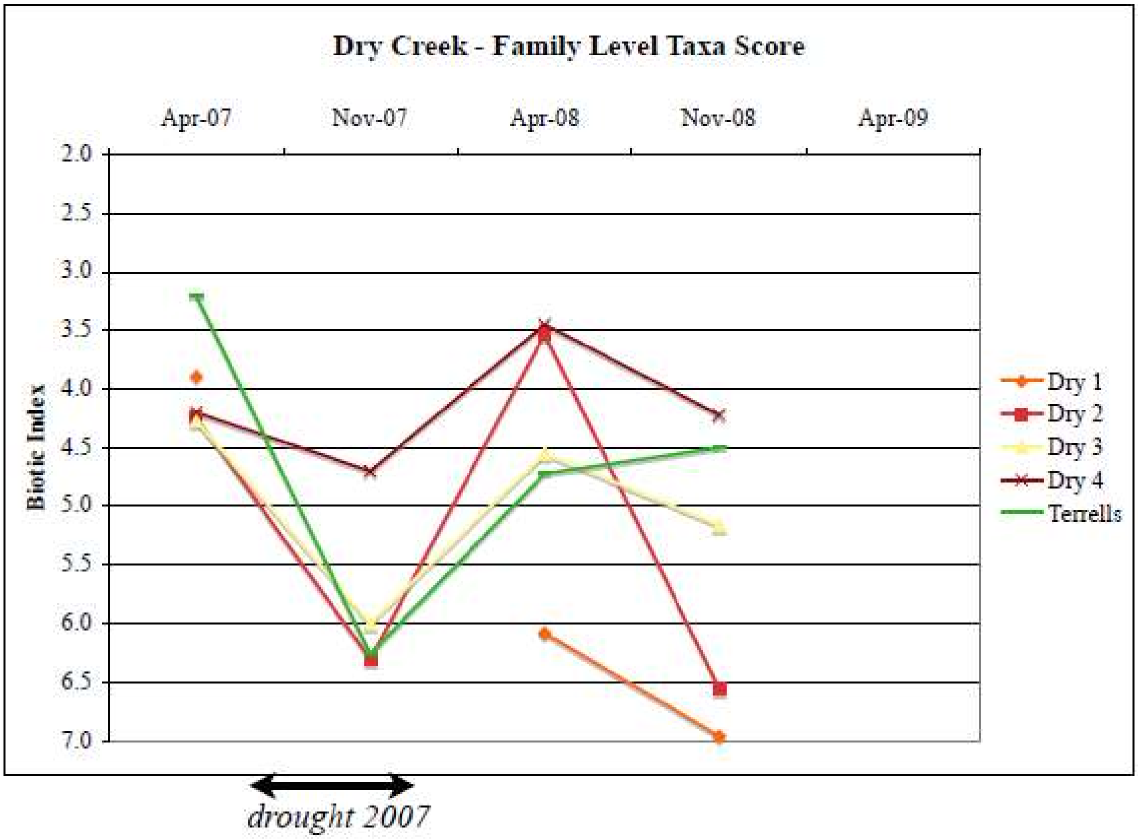


Figure 5. Monitoring Sites and Parcels within 100 feet of Dry Creek

Land parcels are colored so that adjacent parcels with the same landowner are the same color.

		Total Taxa			EPT		
Site	**Season**	**BI Score**	**Abundance**	**Richness**	**BI Score**	**Abundance**	**Richness**
Dry 1	Apr-07	3.9	126	17	1.7	73	4
	Nov-07	monitoring site dry					
	Apr-08	6.1	555	24	2.0	167	8
	Nov-08	7.0	746	23	2.7	31	5
Dry 2	Apr-07	4.2	135	21	2.0	66	5
	Nov-07	6.3	468	24		4	2
	Apr-08	3.5	252	22	2.1	189	9
	Nov-08	6.6	346	28	2.7	80	11
Dry 3	Apr-07	4.3	163	22	2.2	80	7
	Nov-07	6.0	363	23		1	1
	Apr-08	4.6	129	21	2.4	65	6
	Nov-08	5.2	272	24	2.2	58	8
Dry 4	Apr-07	4.2	310	19	3.2	175	11
	Sept-08	4.0	92	12	2.9	64	2
	Nov-07	4.7	93	15	3.2	46	3
	Apr-08	3.5	276	18	2.6	210	7
	Nov-08	4.2	179	16	2.8	116	7


Dry Creek - Family Level Taxa Score
Apr-07
Nov-07
Apr-08
Nov-08
Apr-09
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
Biotic Index
Dry 1
Dry 2
Dry 3
Dry 4
Terrells
drought 2007

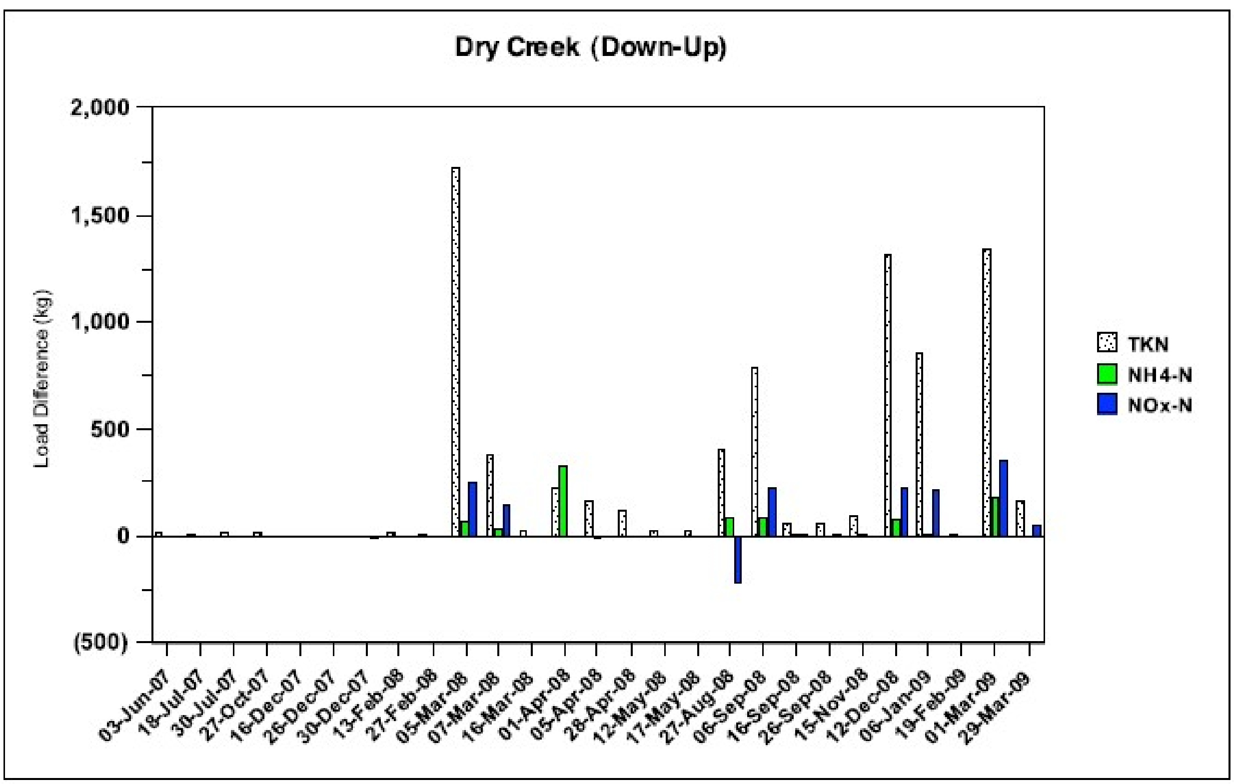

Dry Creek (Down-Up)
2,000
1,500
1,000
500
0
(500)
Load Diference (kg)
TKN
NH4-N
NOx-N
03-Jun-07
18-Jul-07
30-Jul-07
27-Oct-07
16-Dec-07
26-Dec-07
30-Dec-07
13-Feb-08
27-Feb-08
05-Mar-08
07-Mar-08
16-Mar-08
01-Apr-08
05-Apr-08
28-Apr-08
12-May-08
17-May-08
27-Aug-08
06-Sep-08
16-Sep-08
26-Sep-08
15-Nov-08
12-Dec-08
06-Jan-09
19-Feb-09
01-Mar-09
29-Mar-09

Table 4. Dry Creek Visual Stream Assessments

The scores are highlighted to indicate *Poor*, *Fair*, *Good*, *and* *Excellent*.

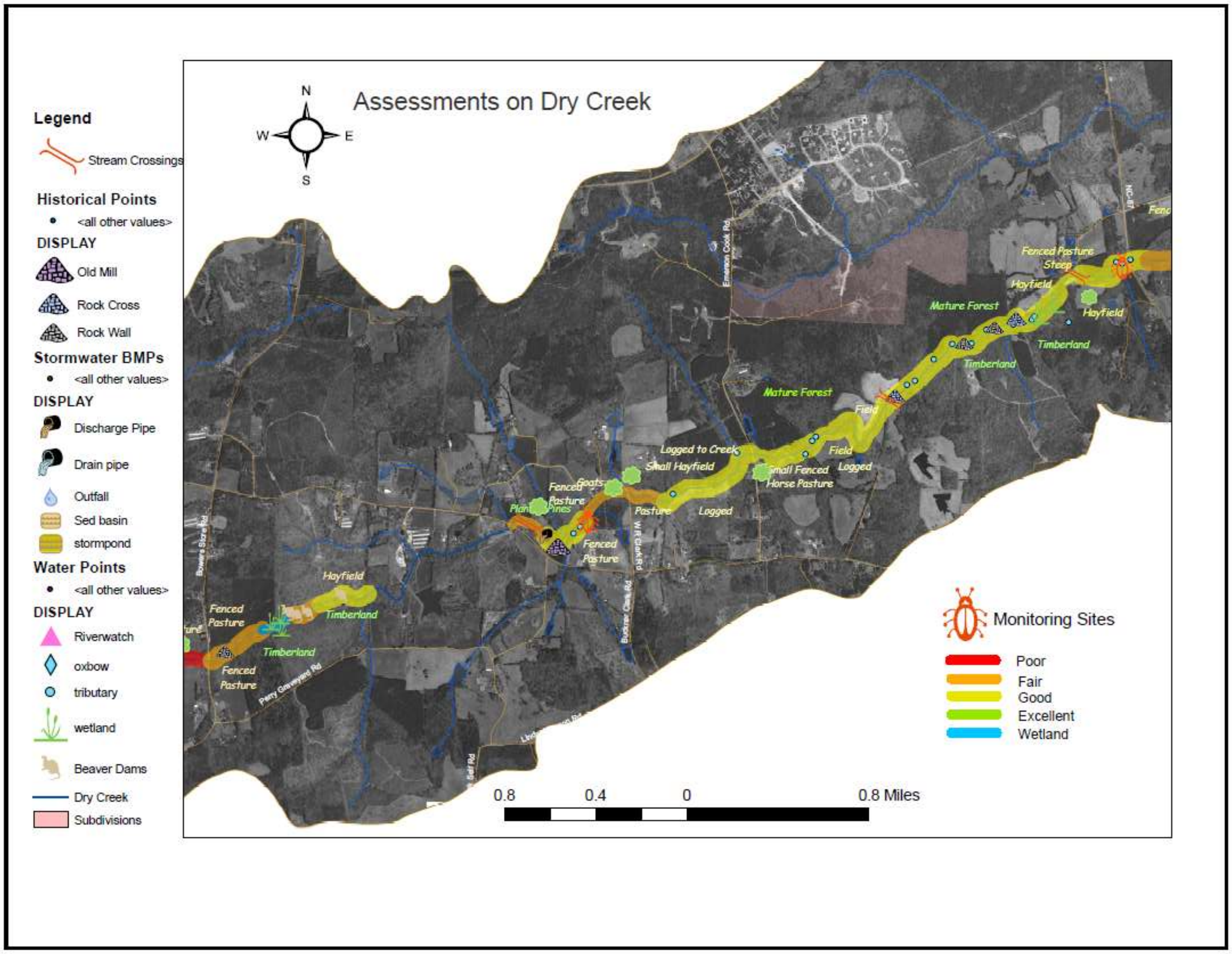
Number	Parcel #	Channel Condition	Hydrologic alteration	Riparian Zone	Bank Stability	Water Appearance	Nutrient Enrichment	Barriers to Fish	Fish Cover	Pools	Macroinvertebrate Habitat	Canopy Cover	Manure Presence	Riffle Embeddedness	Macroinvertebrates Observed	Overall Score	Recommendations
1	14, 15	7	10	2	7	8	10	10	5	3	7			3	15	7.3	Riparian enhancement
2	15	3	7	1	5	10	10	5	5	3	10	10	3	10	15	6.9	Riparian enhancement, farm crossing
3	15	10	10	10	3	7	10	10	10	10	10	10		8	15	9.5	Farm crossing
4	16	10	10	5	1	5	10	10	10	10	10	10			15	8.8	
5	16	7	10	3	4	7	7	10	10	10	10	10		15		8.6	Riparian enhancement
6	17	7	10	3	5	5	7	10	10	10	10	10		10	15	8.6	Riparian enhancement
7	18	10	10	10	5	3	7	10	10	10	10	10		3		8.2	Farm crossing
8	18, 20, 22	10	10	10	1	3	7	10	10	10	10	10		10		8.4	Farm Crossing
9	22,23,	3	10	5	1	3	3	10	8	10	10	10	1	5		6.1	Fence, stream restoration
10	25, 24	3	10	7	3	3	7	10	5	8	7	10	5	1		6.1	Fence
11	25, 26	7	10	5	2	3	7	10	5	8	7	10	5	1		6.2	Fence, riparian enhancement
12	25, 24	7	10	7	3	3	7	10	5	8	7	10	5	1		6.4	
13	27, 25, 26	wetland not scored															
14	27	10	10	7	3	3	7	10	10	8	10	10		1		7.4	
15	27	10	10	8	3	3	8	10	10	8	10	10		1		7.6	
16	27	10	10	7	4	3	4	10	10	10	10	10		10	15	8.7	Discharge pipe, historical assessment
17	35, 33	4	10	1	3	5	5	1	10	10	10			10	15	7.0	Riparian enhancement
18	35, 33	10	7	10	2	6	4	3	10	10	10	10		10	15	8.2	
19	33, 36	10	10	10	1	6	7	3	10	10	10	10		8	15	8.5	
20	36, 37	10	10	10	1	5	5	3	10	10	10	10		5	15	8.0	
21	27, 36	10	10	1	1	5	5	3	10	10	10	10	5	5	15	7.1	Riparian enhancement
22	39, 38	10	10	3	1	3	4	3	10	10	10	10		8	10	7.1	Riparian enhancement

Table 4. Dry Creek Assessments (continued)

Number	Parcel #	Channel Condition	Hydrologic alteration	Riparian Zone	Bank Stability	Water Appearance	Nutrient Enrichment	Barriers to Fish	Fish Cover	Pools	Macroinvertebrate Habitat	Canopy Cover	Manure Presence	Riffle Embeddedness	Macroinvertebrates Observed	Overall Score	Recommendations
23	41, 40	10	10	10	2	3	4	3	10	10	10	10		10		7.7	
24	40, 41	10	10	10	2	3	4	3	10	10	10	10		10	15	8.2	
25	45, 43	10	10	1	3	5	9	10	10	10	10	10	5		15	8.3	Riparian enhancement
26	44, 46, 45	10	10	9	1	5	9	10	10	10	10	10				8.5	
27	47	10	10	5	3	5	9	10	10	10	10	10				8.4	
28	47	10	10	10	2	5	9	10	10	10	10	10				8.7	
29	47	10	10	5	3	5	9	10	10	10	10	10				8.4	Riparian enhancement
30	47	7	10	10	2	5	9	1	10	10	10	10			15	8.3	
31	47, 49, 50	7	10	10	2	5	9	3	10	10	10	10				7.8	
32	53, 49	5	10	10	7	7	9	3	10	10	10	10			15	8.8	
33	53, 49	5	10	5	7	7	9	3	10	10	10	10			15	8.4	Riparian enhancement
34	53,49	10	10	10	2	7	9	3	10	10	10	10		10	15	8.9	Farm crossing
35	53,49	9	10	1	7	7	9	3	10	10	10	10		10	15	8.5	Riparian enhancement
36	49, 54, 55	10	10	10	5	5	9	3	10	10	10	10		10	10	8.6	
37	55, 56	7	10	10	7	5	5	3	10	10	10	10		10	15	8.6	
38	58, 56, 59	10	10	10	5	5	7	3	10	10	10	10				8.2	
39	60, 61	10	10	3		5	7	3	10	10	10	10				7.8	Riparian enhancement
40	61, 60	10	10	10	5	7	7	3	10	10	10	10		10	15	9.0	Potential River Watch site
41	62	10	10	8	6	7	7	3	10	10	10	10		10		8.4	
42	63, 64, 65	10	10	9	3	7	7	3	10	10	10	10		10	15	8.8	
43	67, 86	10	10	3	3	7	7	3	10	10	10	10	5	10	15	8.1	Riparian education, stormwater BMPs
44	67, 66, 68	10	10	10	5	7	7	3	10	10	10	10		10	15	9.0	
45	66, 69	10	1	5	7	7	3	10	10	10	10			10		7.5	Riparian enhancement

Table 4. Dry Creek Assessments (continued)

Number	Parcel #	Channel Condition	Hydrologic alteration	Riparian Zone	Bank Stability	Water Appearance	Nutrient Enrichment	Barriers to Fish	Fish Cover	Pools	Macroinvertebrate Habitat	Canopy Cover	Manure Presence	Riffle Embededness	Macroinvertebrates Observed	Overall Score	Recommendations
46	66, 73, 74	10	7	10	3	3	7	10	10	10	10	10		10	15	8.8	Potential River Watch site
47	74, 73, 75	10	10	10	2	5	7	10	10	10	10	10		10	15	9.2	Stormwater BMPs
48	75, 73	10	10	10	3	5	7	10	10	10	10	10				8.6	
49	76, 77	10	10	10	7	5	7	10	10	10	10	10		10	5	8.8	
50	79, 78	7	10	10	5	5	7	10	10	10	10	10		10	15	9.2	
51	79, 78	7	7	10	3	5	7	10	10	10	10	10				8.1	
52	79, 78	6	10	10	5	5	7	10	10	10	10	10		10	15	9.1	Stream crossing
53	79	10	10	1	7	5	7	10	5	10	10	1		10		7.2	Riparian enhancement
54	79	5	10	10	3	5	7	10	10	10	10	10		10	15	8.8	Conservation easement
55	78, 89, 82	3	10	10	3	5	7	10	10	10	10	10		10		8.2	Conservation easement
56	82, 83, 81	10	10	10	10	5	7	10	10	10	10	10		10		9.3	Conservation easement
57	85, 84	3	10	10	3	5	7	10	10	10	10	10		10		8.2	Conservation easement
58	84, 86, 89	3	10	10	3	5	7	10	10	10	10	10		10		8.2	Conservation easement
59	84, 90	7	10	10	4	5	7	10	10	10	10	10		10		8.6	Conservation easement
60	84,90	3	10	10	3	5	7	10	10	10	10	10		10		8.2	Conservation easement
61	89	10	10	10	7	5	7	10	10	10	10	10		10	15	9.5	Conservation easement
62	4	7	5	1	3			10			7	10	3	5		5.7	Riparian enhancement, pasture fence
63	5	7	10	10	10	10	7	10	10	8	10	10		10		9.3	Conservation easement
Average Score		**8**	**10**	**7**	**4**	**5**	**7**	**7**	**9**	**9**	**10**	**9**	**4**	**6**	**15**	**8**	


Assessments on Dry Creek
Legend
Stream Crossings
Historical Points
<all other values>
DISPLAY
Old Mill
Rock Cross
Rock Wall
Stormwater BMPs
<all other values>
DISPLAY
Discharge Pipe
Drain pipe
Outfall
Sed basin
stormpond
Water Points
<all other values>
DISPLAY
Riverwatch
oxbow
tributary
wetland
Beaver Dams
Dry Creek
Subdivisions
Monitoring Sites
Poor
Fair
Good
Excellent
Wetland
0.8 0.4 0 0.8 Miles
Fenced Pasture
Steep
Hayfield
Mature Forest
Timberland
Field
Logged to Creek
Small Hayfield
Small Fenced Horse Pasture
Logged
Pasture
Goats
Fenced Pasture
Pines
Timberland
Perry Graveyard Rd
Emerson Cook Rd

11 Appendix C: Water Quality Standards

Further information regarding 303(d) List and its reporting categories[1]:

> *"The term "303(d) list" or "list" is short for a state's list of impaired and threatened waters (e.g. stream/river segments, lakes). States are required to submit their list for EPA approval every two years. For each water on the list, the state identifies the pollutant causing the impairment, when known. In addition, the state assigns a priority for development of Total Maximum Daily Loads (TMDL) based on the severity of the pollution and the sensitivity of the uses to be made of the waters, among other factors (40 C.F.R. §130.7(b)(4)).*
> *In general, once a water body has been added to a state's list of impaired waters it stays there until the state develops a TMDL and EPA approves it. EPA reporting guidance provides a way to keep track of a state's water bodies, from listing as impaired to meeting water quality standards. This tracking system contains a running account of all the state's water bodies and categorizes each based on the attainment status. For example, once a TMDL is developed, a water body is no longer on the 303(d) list, but it is still tracked until the water is fully restored."*

Table 1. EPA 303(d) List Integrated Report Categories

Category/Subcategory	Description
Category 1	**Meets tested standards for clean waters.** 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 make a use support 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 the 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 WQI 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.

DWR PRIMARY SURFACE WATER CLASSIFICATIONS

All surface waters in North Carolina are assigned a primary classification by the NC Division of Water Resources (DWR). All waters must at least meet the standards for Class C (fishable / swimmable) waters. The other primary classifications provide additional levels of protection for primary water contact recreation (Class B) and drinking water (Water Supply Classes I through V). To find the classification of a water body you can either use the BIMS database or contact Adriene Weaver of the Classifications & Standards/Rules Review Branch.

Class C

[1] Environmental Protection Agency. Retrieved from https://www.epa.gov/tmdl/program-overview-303d-listing

Waters protected for uses such as secondary recreation, fishing, wildlife, fish consumption, aquatic life including propagation, survival and maintenance of biological integrity, and agriculture. Secondary recreation includes wading, boating, and other uses involving human body contact with water where such activities take place in an infrequent, unorganized, or incidental manner.

Class B
Waters protected for all Class C uses in addition to primary recreation. Primary recreational activities include swimming, skin diving, water skiing, and similar uses involving human body contact with water where such activities take place in an organized manner or on a frequent basis.

Water Supply I (WS-I)
Waters protected for all Class C uses plus waters used as sources of water supply for drinking, culinary, or food processing purposes for those users desiring maximum protection for their water supplies. WS-I waters are those within natural and undeveloped watersheds in public ownership. All WS-I waters are HQW by supplemental classification. More information: Water Supply Watershed Protection Program Homepage

Water Supply II (WS-II)
Waters used as sources of water supply for drinking, culinary, or food processing purposes where a WS-I classification is not feasible. These waters are also protected for Class C uses. WS-II waters are generally in predominantly undeveloped watersheds. All WS-II waters are HQW by supplemental classification. More information: Water Supply Watershed Protection Program Homepage

Water Supply III (WS-III)
Waters used as sources of water supply for drinking, culinary, or food processing purposes where a more protective WS-I or II classification is not feasible. These waters are also protected for Class C uses. WS-III waters are generally in low to moderately developed watersheds. More information: Water Supply Watershed Protection Program Homepage

Water Supply IV (WS-IV)
Waters used as sources of water supply for drinking, culinary, or food processing purposes where a WS-I, II or III classification is not feasible. These waters are also protected for Class C uses. WS-IV waters are generally in moderately to highly developed watersheds or Protected Areas. More nformation: Water Supply Watershed Protection Program Homepage

Water Supply V (WS-V)
Waters protected as water supplies which are generally upstream and draining to Class WS-IV waters or waters used by industry to supply their employees with drinking water or as waters formerly used as water supply. These waters are also protected for Class C uses. More information: Water Supply Watershed Protection Program Homepage

Class WL
Freshwater Wetlands are a subset of all wetlands, which in turn are waters that support vegetation that is adapted to life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. These waters are protected for storm and flood water storage, aquatic life, wildlife, hydrologic functions, filtration and shoreline protection.

Class SC
All tidal salt waters protected for secondary recreation such as fishing, boating, and other activities involving minimal skin contact; fish and noncommercial shellfish consumption; aquatic life propagation and survival; and wildlife.

Class SB
Tidal salt waters protected for all SC uses in addition to primary recreation. Primary recreational activities include swimming, skin diving, water skiing, and similar uses involving human body contact with water where such activities take place in an organized manner or on a frequent basis.

Class SA
Tidal salt waters that are used for commercial shellfishing or marketing purposes and are also protected for all Class SC and Class SB uses. All SA waters are also HQW by supplemental classification.

Class SWL
These are saltwaters that meet the definition of coastal wetlands as defined by the Division of Coastal Management and which are located landward of the mean high water line or wetlands contiguous to estuarine waters as defined by the Division of Coastal Management.

DWR SUPPLEMENTAL CLASSIFICATIONS
Supplemental classifications are sometimes added by DWR to the primary classifications to provide additional protection to waters with special uses or values.

Future Water Supply (FWS)
Supplemental classification for waters intended as a future source of drinking, culinary, or food processing purposes. FWS would be applied to one of the primary water supply classifications (WS-I, WS-II, WS-III, or WS-IV). Currently no water bodies in the state carry this designation.

High Quality Waters (HQW)
Supplemental classification intended to protect waters which are rated excellent based on biological and physical/chemical characteristics through Division monitoring or special studies, primary nursery areas designated by the Marine Fisheries Commission, and other functional nursery areas designated by the Marine Fisheries Commission.

The following waters are HQW by definition:

- WS-I,
- WS-II,
- SA (commercial shellfishing),
- ORW,

Primary nursery areas (PNA) or other functional nursery areas designated by the Marine Fisheries Commission, or

Waters for which DWR has received a petition for reclassification to either WS-I or WS-II.

Outstanding Resource Waters (ORW)
All outstanding resource waters are a subset of High Quality Waters. This supplemental classification is intended to protect unique and special waters having excellent water quality and being of exceptional state or national ecological or recreational significance. To qualify, waters must be rated Excellent by DWR and have one of the following outstanding resource values:

- Outstanding fish habitat and fisheries,
- Unusually high level of water based recreation or potential for such kind of recreation,
- Some special designation such as North Carolina Natural and Scenic River or National Wildlife Refuge,
- Important component of state or national park or forest, or
- Special ecological or scientific significance (rare or endangered species habitat, research or educational areas).

For more details, refer to the Biological Assessment Branch homepage.

Nutrient Sensitive Waters (NSW)
Supplemental classification intended for waters needing additional nutrient management due to being subject to excessive growth of microscopic or macroscopic vegetation.

Swamp Waters (SW)
Supplemental classification intended to recognize those waters which have low velocities and other natural characteristics which are different from adjacent streams.

Trout Waters (Tr)
Supplemental classification intended to protect freshwaters which have conditions which shall sustain and allow for trout propagation and survival of stocked trout on a year-round basis. This classification is not the same as the NC Wildlife Resources Commission's Designated Public Mountain Trout Waters designation.

Unique Wetland (UWL)
Supplemental classification for wetlands of exceptional state or national ecological significance. These wetlands may include wetlands that have been documented to the satisfaction of the Environmental Management Commission as habitat essential for the conservation of state or federally listed threatened or endangered species.