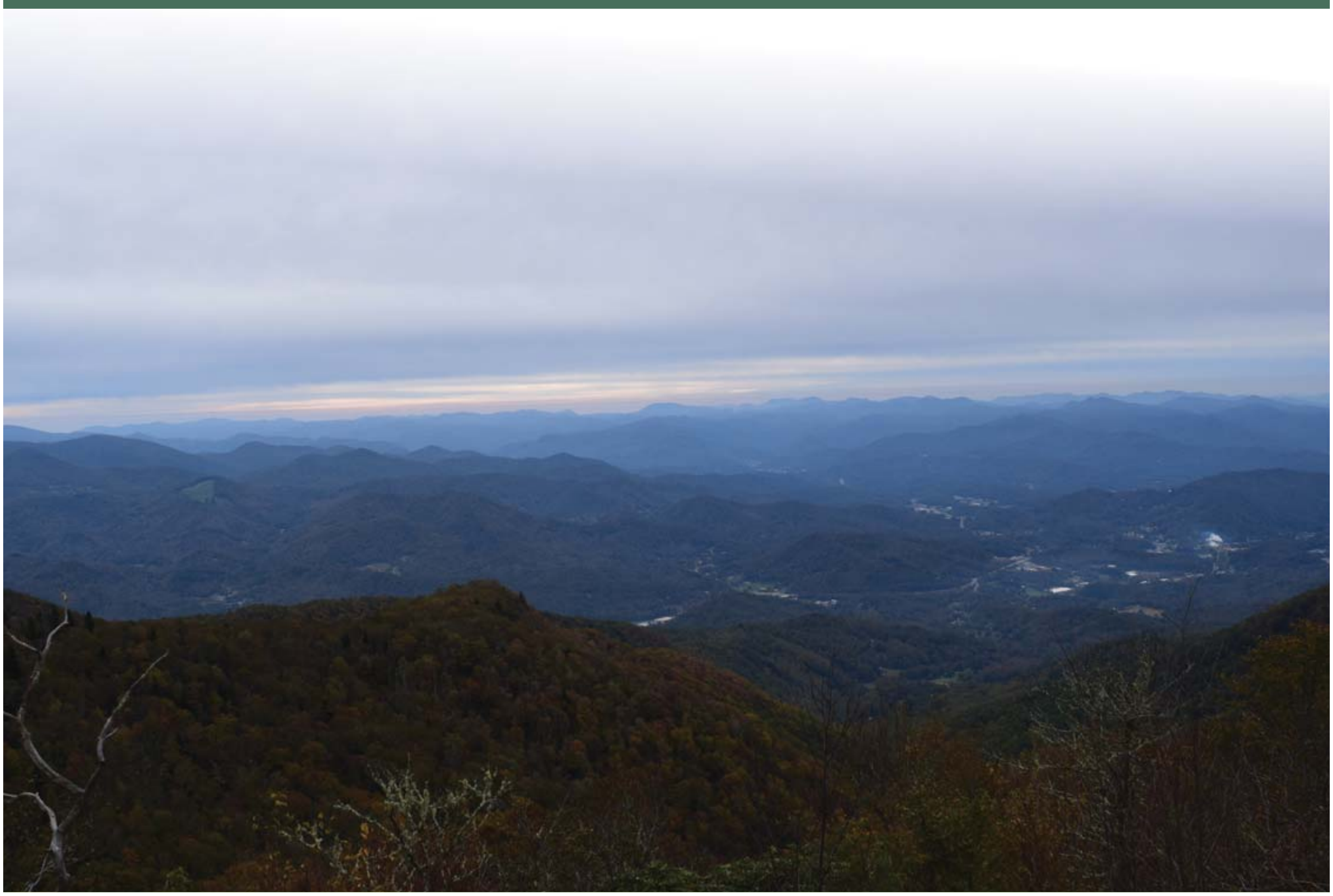
Scotts Creek

Watershed Action Plan



Jackson County

November 2018

Prepared By:

EQUINOX

balance through proper planning

Executive Summary

The purpose of the Scotts Creek Watershed Action Plan (WAP) is to guide restoration efforts and implementation of stormwater control measures (SCMs) to improve surface water quality in the Scotts Creek Watershed of Jackson County, North Carolina. Although there are a few permitted point sources of discharge within the watershed, this WAP focuses primarily on nonpoint source pollution. The WAP was created by Equinox for the Town of Sylva, NC. It is the result of stakeholder collaboration to address water quality issues within the Scotts Creek Watershed. Project stakeholders have expertise and/or interest in addressing water quality issues and will continue to work to together to revise the WAP as additional information and opportunities become available.

The Scotts Creek Watershed has a drainage area of 59.1 square miles with headwaters near the Blue Ridge Parkway and outlet at the confluence with the Tuckasegee River. The watershed is predominantly forested, but includes a 14 mile stretch of the Great Smoky Mountain Expressway and large portions of the towns of Sylva and Dillsboro.

Scotts Creek is a hatchery-supported trout waters from its confluence with Dark Ridge Creek to its confluence with the Tuckasegee River and is stocked with brook, rainbow, and brown trout. Four other streams in the watershed are designated wild trout waters. Sylva and Dillsboro are both participants in the NC Mountain Heritage Trout Waters program. There are also sections of Scotts Creek used for whitewater paddling. Despite its high potential for recreational use, in 2008 Scotts Creek was placed on the NC list of impaired waterways for exceeding the state's fecal coliform standards. Since that time, efforts have been made to identify and eliminate failing septic systems and eliminate straight piping of household septic waste. Recently collected data indicate these efforts have been successful in reducing fecal coliform concentrations in Scotts Creek.

To restore and preserve the streams of the watershed for their best uses, it is important to identify and eliminate nonpoint source pollution impacts such as stormwater runoff, inadequate riparian buffer, and poor agricultural practices, in addition to failing septic and straight piping. Data collection and monitoring by project partners aids in identifying the most significant issues, prioritizing restoration efforts, justifying grant applications, and demonstrating measureable improvements from projects implemented within the watershed.

Stormwater control measures are a means of limiting and treating pollutants and reducing the harmful effects of stormwater runoff discharge. Stormwater management including Low-Impact Development (LID) as part of green infrastructure could significantly improve water quality in the watershed. Seventeen sites within Scotts Creek where SCMs could be implemented have been identified and designed at a conceptual level of detail. We have attached the list of sites and conceptual designs for stormwater management as a potentially stand-alone document for ease of distribution.

No Total Maximum Daily Load (TMDL) was developed to accompany this Watershed Action Plan.

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Section 1. Overview

1.1 Purpose

The purpose of this Watershed Action Plan (WAP) is to both identify the sources of impairment to Scotts Creek and guide improvement and protection efforts in the Scotts Creek Watershed of Jackson County, North Carolina. Its focus is on nonpoint source pollution within the watershed, specifically on sources contributing to high fecal coliform concentrations and stormwater pollution. The plan is intended to be a "living document" allowing for the incorporation of new information and technology as well as modifications based upon its impact on water quality. Continuous evaluation of the success of any watershed management plan is crucial to keeping a plan relevant (Jones, 2016).

1.2 Watershed Description

The Scotts Creek Watershed considered for this plan consists of the entirety of the Headwaters Scott Creek subwatershed (Hydrologic Unit Code (HUC12) = 061002030302) and a small portion of the Scott Creek -Tuckasegee River subwatershed (HUC12 = 060102030303) which is the drainage area of Cope Creek (Figure 1). The Cope Creek drainage was considered because it is a first order tributary of Scotts Creek and is partially within Town of Sylva municipal limits. Primary tributaries to Scotts Creek include Dark Ridge Creek, Sugarloaf Creek, Ochre Hill Creek, North Fork Scott Creek, Buff Creek, Blanton Branch, Fisher Creek, Monteith Branch, Kitchen Branch, Allens Branch, Cope Creek, and Dills Branch. Scotts Creek originates near the Blue Ridge Parkway, the Balsam community, and the Haywood and Jackson county line, then runs parallel to US 23/74 and Old US 19/23 for most of its 15.3- mile length. The stream passes through many residential areas before entering the urban environment in Sylva and Dillsboro.

Scotts Creek Watershed is located in the Southern Crystalline Ridges and Mountains, Southern Metasedimentary Mountains, and High Mountains Level IV ecoregions of the Blue Ridge Level III ecoregion. Elevations range from 1960 to 6290 feet. Streams are generally high gradient, often with boulder and bedrock substrates. The watershed contains 37,824 acres (59.1 mi^2); the watershed is primarily forested, but other land uses include residential, commercial, cropland, and pasture (Figure 2; Table 1).

Scotts Creek is designated as a Class C, Trout Water stream by the Division of Water Resources (DWR). As defined by DWR, Class C waters are those 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. A "Trout water" designation is a 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. The watershed is identified as a Targeted Local Watershed which receives priority for NC Division of Mitigation Services (NC DMS) planning and restoration project funds.

Figure 1. Location of Scotts Creek Watershed in Jackson County, NC.

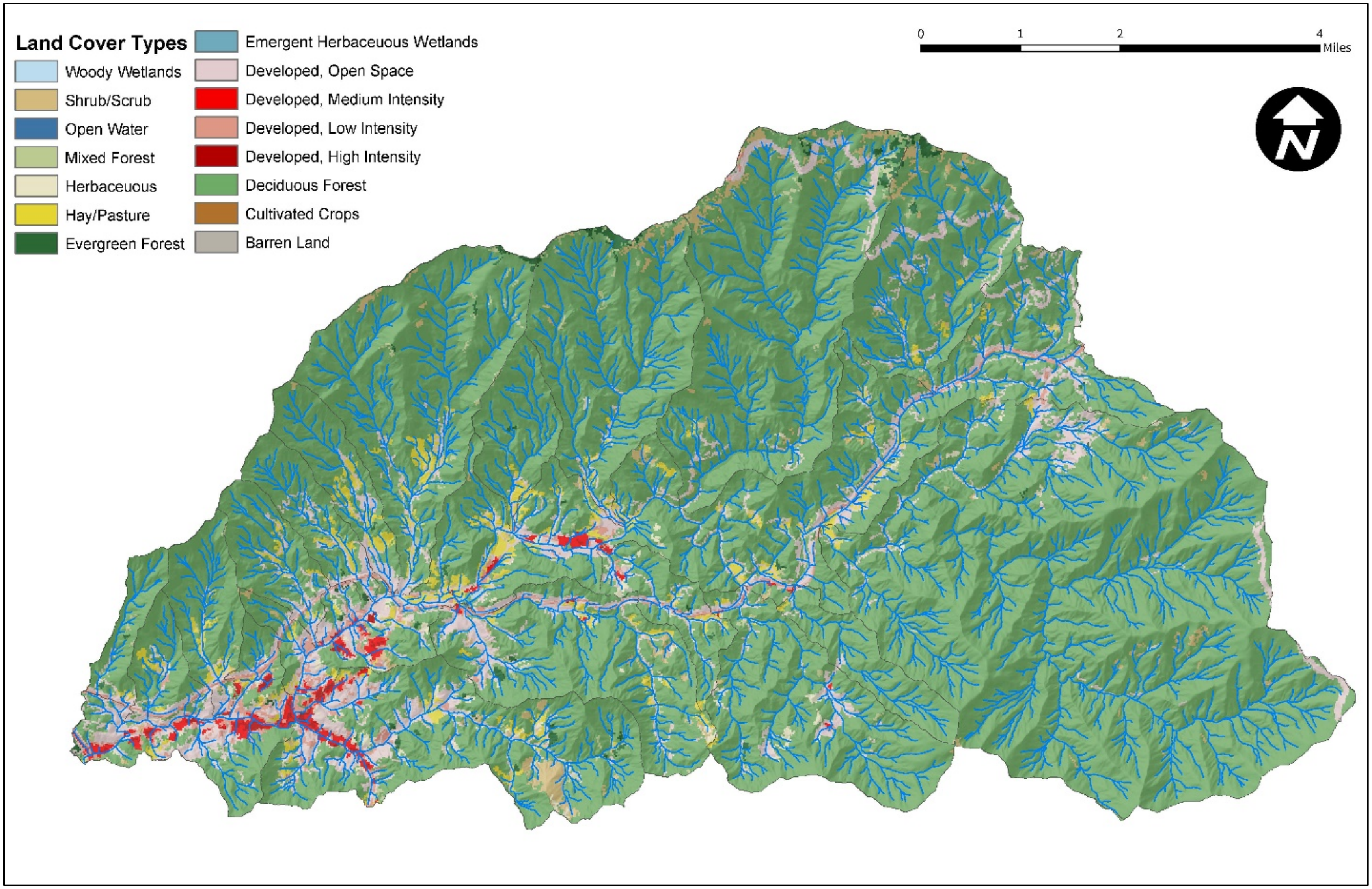

Figure 2. Land Cover types in Scotts Creek Watershed

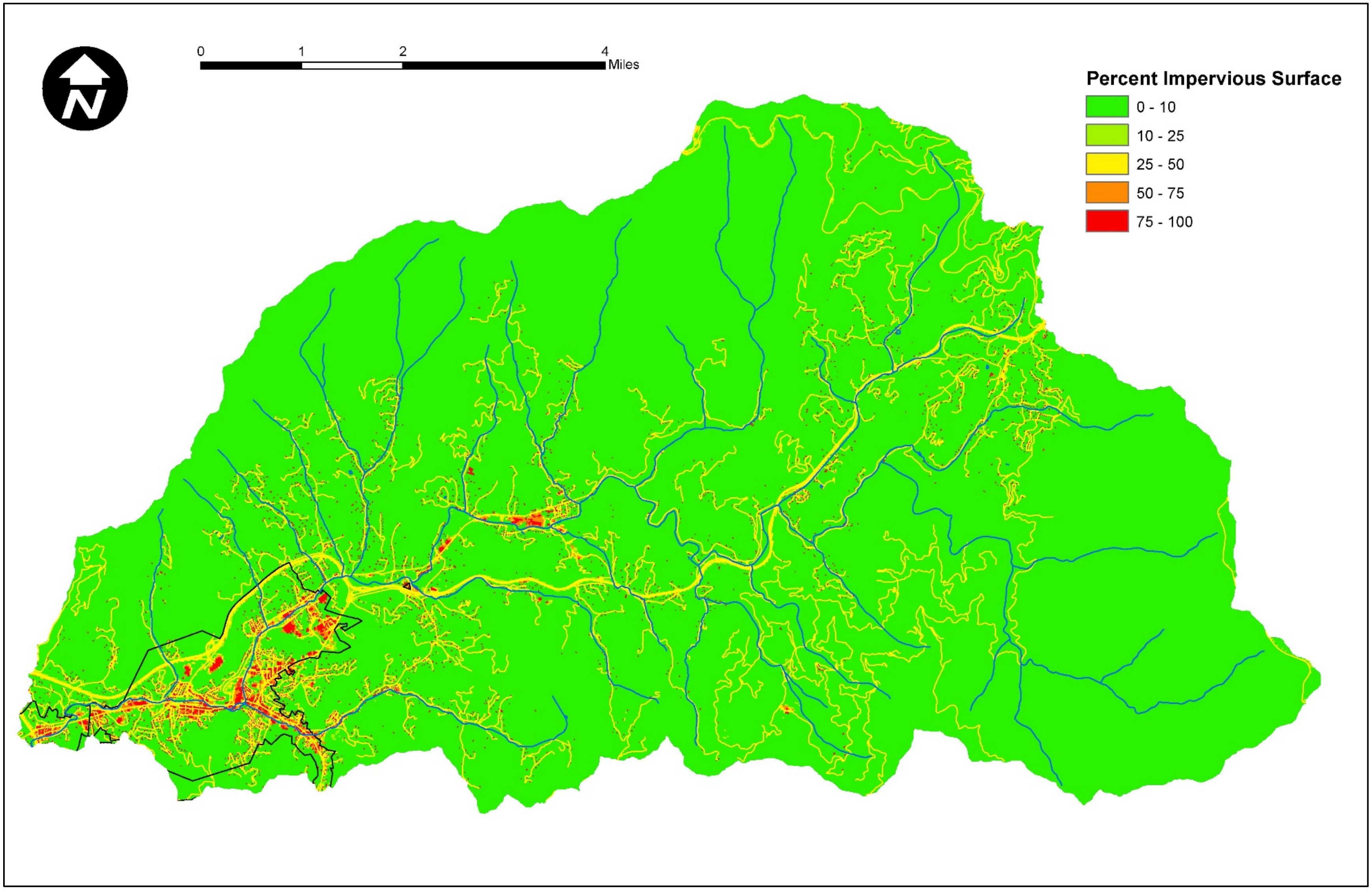

Figure 3. Percent impervious area in Scotts Creek Watershed

Table 1. Land Cover Types and Percentages

Land Cover Type	Percent of Watershed	Percent of Riparian Area
Forested	84.8%	69.1%
Developed, Open Space	8.0%	17.6%
Developed, Low Intensity	1.5%	4.5%
Developed, Medium Intensity	0.7%	2.1%
Developed, High Intensity	0.2%	0.3%
Hay/Pasture	2.5%	4.9%

1.3 Extent of Impairment

Although most of the watershed is forested, Sylva and Dillsboro are becoming increasingly urbanized. The watershed has been affected by a number of long-term nonpoint source pollution impacts related to failing septic systems, stormwater runoff, residential mountain development (home sites, paved and unpaved roads), stream modifications, removal of riparian vegetation, and agricultural (crop and livestock) activity. The stressors impacting the watershed are reducing its recreational and aesthetic quality, degrading fish and wildlife habitat, causing erosion of stream banks, and degrading water quality for users downstream. These stressors have resulted in the 15.3 miles of Scotts Creek being placed on the DWR list of impaired waterways due to exceeding the standard criteria for fecal coliform for its designated uses (Category 5, 2016 list).

Many water quality impairment issues can be attributed to impervious surfaces and stormwater. The average percentage of impervious area for Scotts Creek Watershed is 1.5% according to the NLCD 2011 impervious dataset; this is equivalent to approximately 567 acres of Total Impervious Area (TIA) (Figure 3). The average impervious area within the towns of Sylva and Dillsboro is approximately 17 percent. This is equivalent to a TIA of 337 acres; nearly 60% of the TIA within the entire Scotts Creek Watershed. The percentage of developed area within the riparian zone is higher relative to the percentage of developed area within the watershed as a whole.

Subwatersheds of the Scotts Creek Watershed were delineated and evaluated for their existing condition, quality, and potential for uplift in terms of restoring water quality. Data required for assessment included:

- Land Use/Land Cover (LULC) using the National Land Cover Database 2011 (NCLD2011)
- Soils using Soil Survey Geographic Database (SSURGO)
- A digital elevation model derived from LIDAR data (Light Detection and Ranging)
- Hydrologic lines based on the National Hydrologic Dataset (NHD).

Indicators used in prioritizing riparian buffer improvement at the subwatershed scale included:

- Percent riparian lands
- Percent Nonpoint Source Pollution (NPS) contributing LULC
- Percent NPS contributing LULC in riparian areas
- Average annual estimated erosion calculated using the Revised Universal Soil Loss Equation (RUSLE)

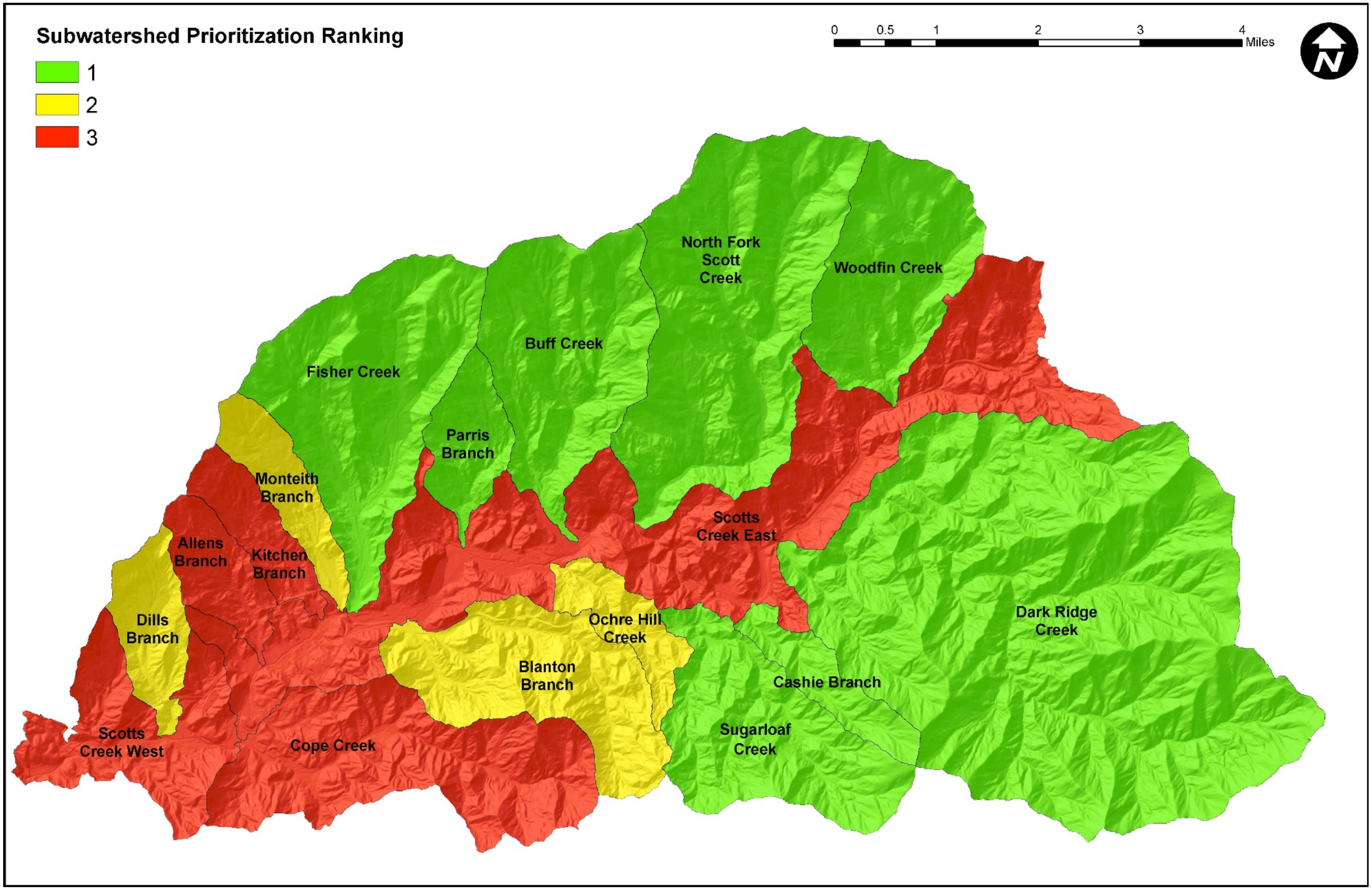

Figure 4. Subwatershed riparian prioritization ranking. Three tiers of priority were created based on the final prioritization score of the subwatershed. Tier 1 is lowest priority and Tier 3 is highest.

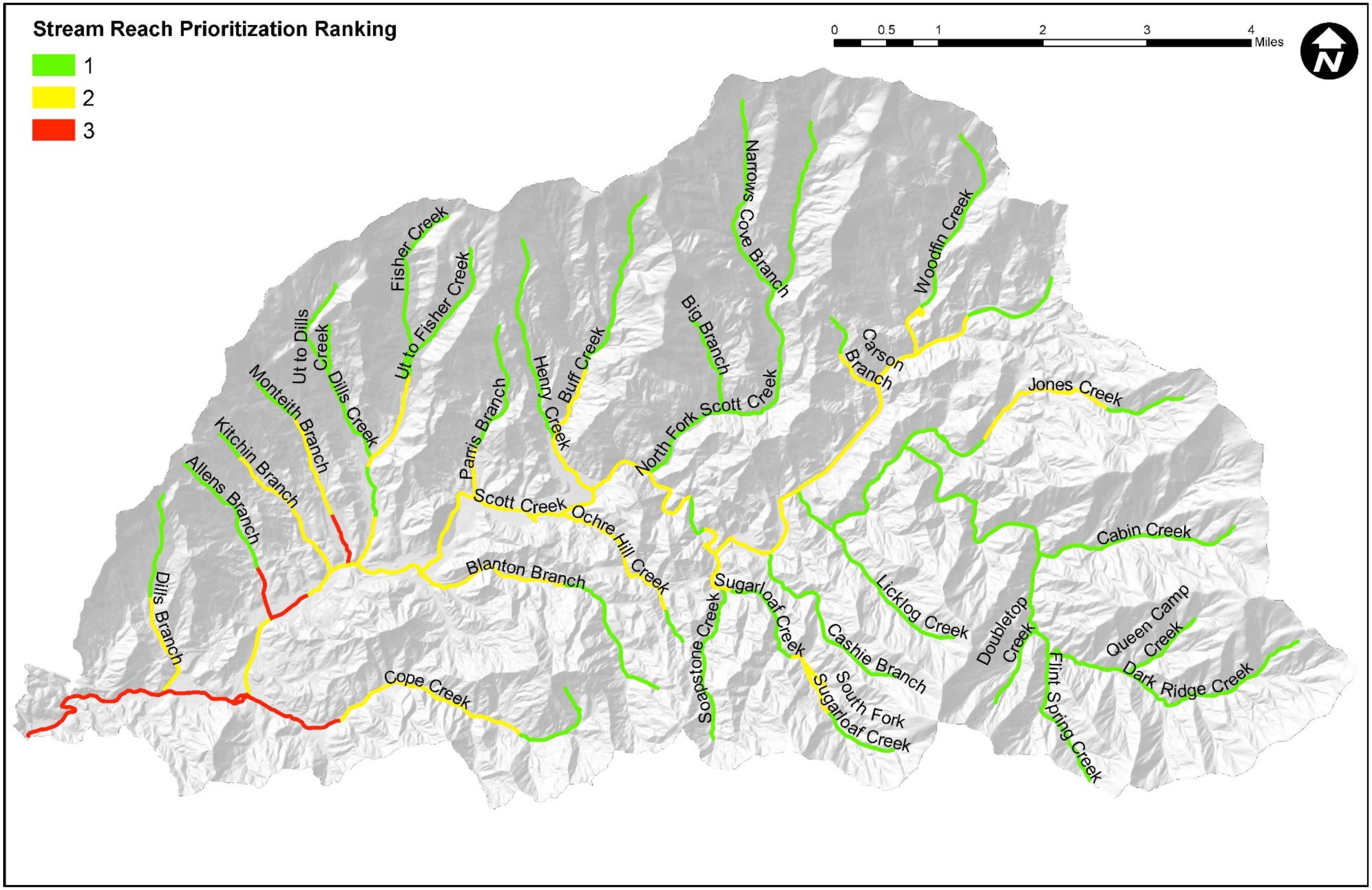

Figure 5. Stream reach buffer prioritization. Green reaches have the most intact riparian buffers and stable stream bank conditions, while red reaches have little to no riparian buffer and areas of active stream bank erosion.

Scores were then given for the percent of subwatershed area with a contributing Land Use/Landcover (LULC), percent of the subwatershed riparian area with a contributing LULC, percentage of the subwatershed which is riparian area, and annual soil loss (tons/acre/year). A "Final Score" was calculated by adding the scores of these indicators (Figure 4; Table 2). Higher final scores indicate higher need for restoration. One subwatershed which has a low "Final Score" but a high score for erosion is Woodfin Creek. Road density in the Woodfin Creek subwatershed is 7 miles of road per square mile. Most of the roads are also unpaved. This relatively high road density and unpaved road surface imperils the hydrology of the watershed due to the increased opportunities for the road to transport sediment and other pollutants to streams.

Table 2. Subwatershed Ranking and Scores

Subwatershed	%Subwshd LULC	Score	%Riparian LULC	Score	%Riparian Land	Score	Erosion	Score	Final Score
North Fork Scotts Creek	4.65	1	1.73	1	5.18	1	3.66	1	4
Dark Ridge Creek	3.61	1	8.38	1	4.83	1	2.74	1	4
Buff Creek	2.68	1	20.07	1	6.85	2	2.89	1	5
Parris Branch	5.65	1	18.41	1	8.54	2	2.39	1	5
Fisher Creek	6.60	1	19.95	1	7.37	2	2.92	1	5
Sugarloaf creek	7.21	1	24.05	1	6.84	2	3.01	1	5
Cashie Branch	3.37	1	3.23	1	10.75	3	3.07	1	6
Woodfin Creek	10.59	1	12.22	1	4.19	1	7.32	3	6
Blanton Branch	17.20	2	41.67	2	4.56	1	3.68	1	6
Dills Branch	14.30	1	42.34	2	9.23	3	2.99	1	7
Allens Branch	18.18	2	37.63	2	10.62	3	3.94	1	8
Monteith Branch	23.53	2	42.92	2	9.61	3	2.97	1	8
Ochre Hill Creek	22.43	2	44.50	2	10.42	3	3.39	1	8
Kitchen Branch	21.17	2	50.52	2	9.32	3	3.59	1	8
Cope Creek	24.36	2	63.95	3	4.74	1	4.68	2	8
Scotts Creek East	27.24	2	62.40	3	8.25	2	4.66	2	9
Scotts Creek West	43.51	3	89.23	3	5.42	1	6.90	3	10

Identifying stream reaches that are most disturbed can aid in determining where stressors have the highest negative impact on water quality. Individual stream reaches (approximately 0.5 mile in length) within the Scotts Creek Watershed were prioritized for riparian buffer enhancement and improvement.

Indicators used in prioritizing riparian buffer improvement at the stream reach (0.5 mi) scale include:

- Percent NPS contributing in each stream reach
- Average annual estimated erosion

Reaches of Scotts Creek and Cope Creek through the towns of Sylva and Dillsboro demonstrate the highest need for riparian improvement (Figure 5). However, both creeks are heavily constrained through this area by businesses, parking, roads, and the railway, making stream restoration and riparian buffer enhancement more difficult. For several of these stream reaches, the minimal vegetated cover that exists close to the stream is composed of non-native invasive species. These plants do little to prevent erosion and ultimately degrade water quality.

1.4 Responsible Parties and Stakeholders

A number of groups have been working together to protect and improve the health of Scotts Creek Watershed. The Town of Sylva, Jackson County Commissioners, and the Southwestern Regional Commission took the lead in developing this WAP, but much of their efforts are based on the work of the many of the partners in the stakeholder group. The goal of these groups and this WAP is to have Scotts Creek removed from the state list of impaired waterways. A great deal of resources exist among this group; professional and technical support from regional, state, and federal agencies and organizations are all represented. It will take close coordination of these stakeholders and involvement at the local level to accomplish this goal.

Table 3. Scotts Creek Partners and Roles

Partner	Role
American Rivers	Stakeholder, technical assistance
Jackson County Commissioners	Stakeholder
Jackson County Cooperative Extension Service	Education, technical assistance
Jackson County Environmental Health Department	Wastewater treatment
Jackson County Soil and Water Conservation District	Technical assistance, grant writing
Mainspring Conservation Trust	Stakeholder, technical assistance
Landowners	Stakeholder, matching funds
NC Department of Transportation	Technical assistance
NC DEQ, Division of Water Resources	Monitoring, technical assistance
North Carolina Wildlife Resources Commission	Monitoring, technical assistance
Southwestern NC RC&D	Stakeholder, grant writing
Town of Sylva	Stakeholder
Tuckaseigee Water and Sewer Authority	Stakeholder
Tuckaseigee Chapter of Trout Unlimited	Education, outreach
United States Fish and Wildlife Service	Monitoring , technical assistance
US Environmental Protection Agency	Technical assistance, funding agent
USDA Natural Resources Conservation Service	Technical assistance, funding agent
Watershed Association of the Tuckasegee River	Education, outreach, monitoring
Western Carolina University	Monitoring, technical assistance
Western North Carolina Stormwater Partnership	Education, technical assistance

Section 2. Stressor and Source Identification

As part of the Little Tennessee River Basinwide Water Quality Plan (2007, 2012), Scotts Creek was identified as needing additional protection and restoration plans. Stressors included:

- Fecal coliform
- Sediment

Potential sources were identified as:

- Non-point source runoff
- Failing septic systems

Collecting and using data to identify stressors and their sources is a key component of developing management measures and projects to improve the health of the watershed.

2.1 Fecal Coliform

Fecal coliforms, a subset of total coliform bacteria, are more fecal-specific in origin than total coliform bacteria. However, even this group contains a genus, Klebsiella, with species that are not necessarily fecal in origin. Klebsiella are commonly associated with textile and pulp and paper mill wastes. Other types of bacteria associated with decaying vegetative matter (including grass clippings) have been shown to be nonfecal origins of fecal coliform (Tomasko et al., 2017). For recreational waters, this group was the primary bacteria indicator until relatively recently, when the US Environmental Protection Agency (US EPA) began recommending E. coli and enterococci as better indicators of health risk from water contact. Fecal coliforms are still being used in many states, including North Carolina, as the indicator bacteria.

As part of the effort to identify stressors of water quality in the Scotts Creek Watershed, Equinox conducted water quality sampling for fecal coliform on October 17, 24, and 31 and November 8 and 11 of 2017. This sampling was conducted in accordance with the Division of Water Resources sampling plan which dictates that no fewer than five samples be collected at each site within a period of no longer than 30 days. Samples were collected at the same 19 sites on each of the dates listed above (Figure 6).

The majority of the sample sites were located at the confluence of major tributaries with Scotts Creek and samples were taken just downstream of those confluences. One site (SC17) is located on Scotts Creek just upstream of its confluence with the Tuckasegee River, and another site (CC1) is located on Cope Creek near the intersection of Cope Creek Rd with East Cope Creek Rd. Samples were collected in dry weather conditions from freely flowing portions of the stream, stored on ice, and delivered to Environmental Quality Institute laboratories in Black Mountain, NC within 6 hours of collection. Precipitation amounts for the previous 24 hours were recorded for each round of sampling and are included on Figure 7.

The geometric mean (GM) for the five samples exceeded 200 CFU/100 mL at one site (CC1) on Cope Creek (Figure 8; Table 3). Cope Creek is a small tributary with a baseflow discharge of approximately 1-10 cubic feet per second (cfs) while Scotts Creek baseflow discharge is more on the order of 50 to 100 cfs. Fecal coliform levels were highest on sampling days when there had been rainfall in the previous 24 hours, indicating that stormwater runoff and disturbed sediments within the stream channel are likely causes.

The NC Department of Water Quality and the Watershed Association of the Tuckasegee River have also been monitoring fecal coliform in Scotts Creek. The maximum fecal concentration for their April 2018 was 31 CFU/100 mL, the maximum sampled in May 2018 was 170 CFU/100 mL, and the maximum sampled in June 2018 was 360 CFU/100 mL. Fecal coliform concentrations in runoff are typically higher in summer than winter, which is troublesome as most recreation within streams is likely to take place during warmer weather.

Straight piping of sewage directly into streams was once a common practice in Western North Carolina. Efforts of the North Carolina Wastewater Discharge Elimination Program (WaDE), the Jackson County Environmental Health Department (JCEH), and the Watershed Association of the Tuckasegee River (WATR) have greatly reduced the number of these types of illicit discharges and had a great effect on reducing fecal coliform concentrations in general. According to data provided by the NC Division of Water Quality, fecal coliform concentrations in Scotts Creek Watershed were reduced from an average of 2,150 CFU/100 mL in 2005 to an average concentration of 100 CFU/100 mL in 2009.

Although they are not large scale, livestock operations in the watershed are a source for fecal coliform in the watershed, particularly in pastures where there is no fencing and inadequate riparian buffer. Largest among these are an approximately 20 acre site on Cope Creek near the intersection of East Cope Creek Road and Laramie Drive, an approx. 50 acre site on Fisher Creek near the intersection of Fisher Creek Road and Hayfield Drive, an approx. 25 acre site on Monteith Branch near the intersection of Monteith Branch Road and Monteith Drive, and finally an approx. 10 acre site on Monteith Branch near the intersection of Monteith Branch Road and Going South Lane. This last site is of particular note due to the density of animals on the property and the high level of animal access to the streams. All of these sites would be good candidates for stream restoration and rehabilitation, which would reduce fecal pollution loading.

Dr. Kim Hall, a professor at Western Carolina University, is conducting research on determining sources of fecal coliform using multivariate statistics coupled with a targeted water quality monitoring program. The results of Dr. Hall's efforts have yet to be published, but it is anticipated her study will contribute greatly to identifying sources of fecal pollution in Scotts Creek Watershed.

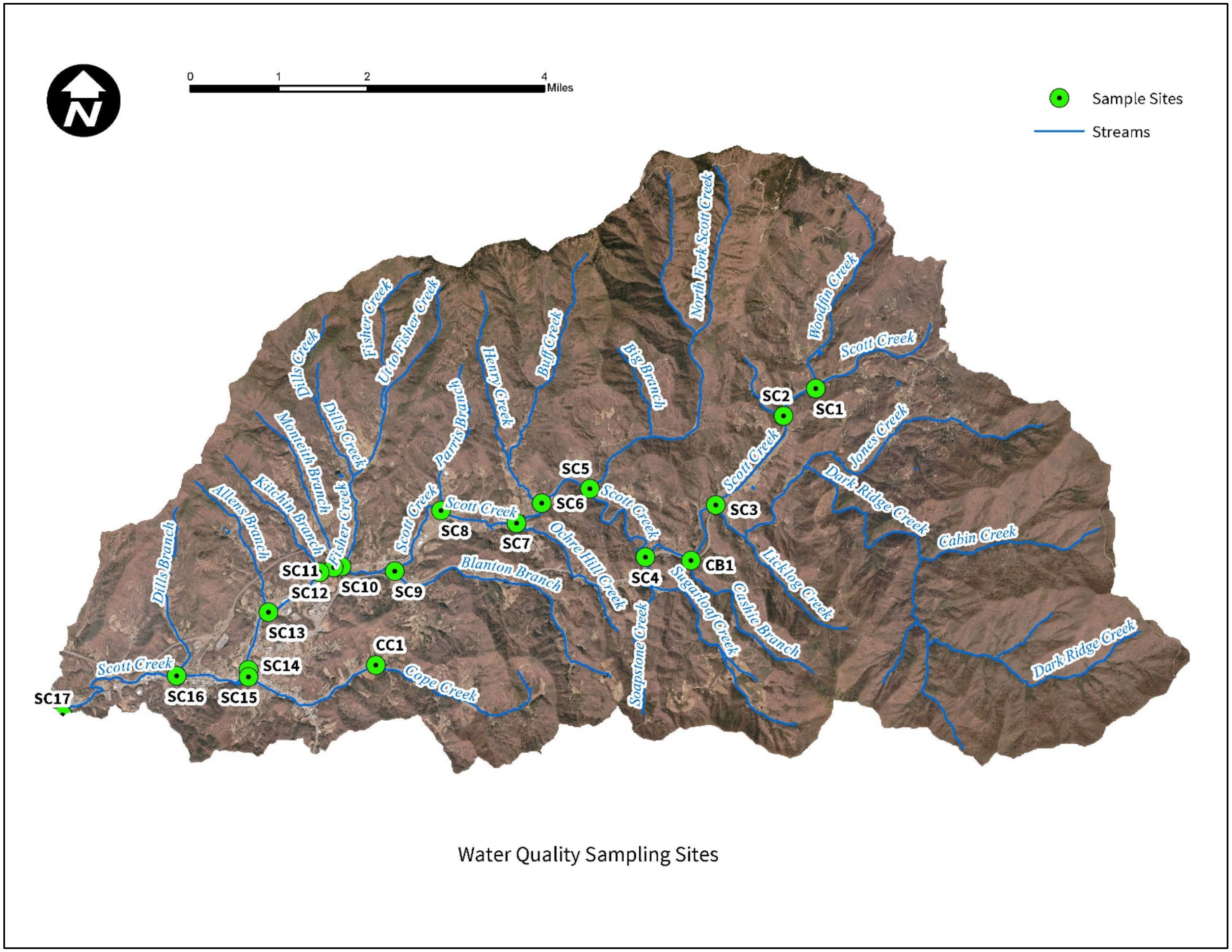

Figure 6. Sample Sites

Table 3. Fecal Coliform Concentrations (CFU/100mL)

	10/17/2017	10/24/2017	10/31/2017	11/8/2017	11/14/2017	Geometric Mean
SC1	54	74	26	62	38	48
SC2	45	86	27	56	33	45
SC3	53	86	24	84	46	53
CB1	49	114	17	72	39	48
SC4	64	106	40	58	42	58
SC5	55	64	14	46	20	34
SC6	40	84	27	64	32	45
SC7	53	64	26	128	32	51
SC8	123	119	36	100	44	75
SC9	210	118	48	104	54	92
SC10	270	240	85	130	88	145
SC11	155	330	68	165	38	117
SC12	170	189	46	140	34	93
SC13	127	250	52	124	31	91
SC14	209	210	112	111	35	114
SC15	191	175	98	125	40	110
SC16	78	250	62	252	36	102
SC17	191	290	86	168	39	126
CC1	100	587	290	302	338	281

Both wildlife and pets are a source of fecal coliform within the watershed. The heaviest density of the wildlife population is within the forested portion of the watershed where good riparian buffer is in place and the likelihood of streams being polluted by runoff from these sources is significantly lower. Depending on the size of the population, feral swine have the potential to be a significant source of fecal contamination within the forested areas. Feral swine herds concentrate, wallow, and feed near streams contributing to fecal contamination of the water. In developed and urbanized areas pet waste is a source of contamination, particularly within the narrow valleys of the watershed where many homes and yards are adjacent to streams.

Failing septic systems are a source of fecal coliform in Scotts Creek. A failing septic system near a waterway can contribute up to 360 gallons of untreated wastewater into the stream every day. Septic systems with a drain field that is on inadequate or inappropriate soils, excessive slopes, or high ground water tables are those most likely to fail. Failure to perform the routine maintenance of pumping a septic tank every three to five years can lead to a clogged system. Jackson County Environmental Health (JCEH) officials are concerned that certain areas of the watershed where there is a high groundwater table may become more susceptible to failure during increasingly frequent and heavy precipitation events. JCEH officials also conveyed that lack of public awareness about what should not be flushed into a septic system is another cause of septic failure, citing a range of past incidents where cat litter, baby wipes, and feminine hygiene products have clogged septic systems.

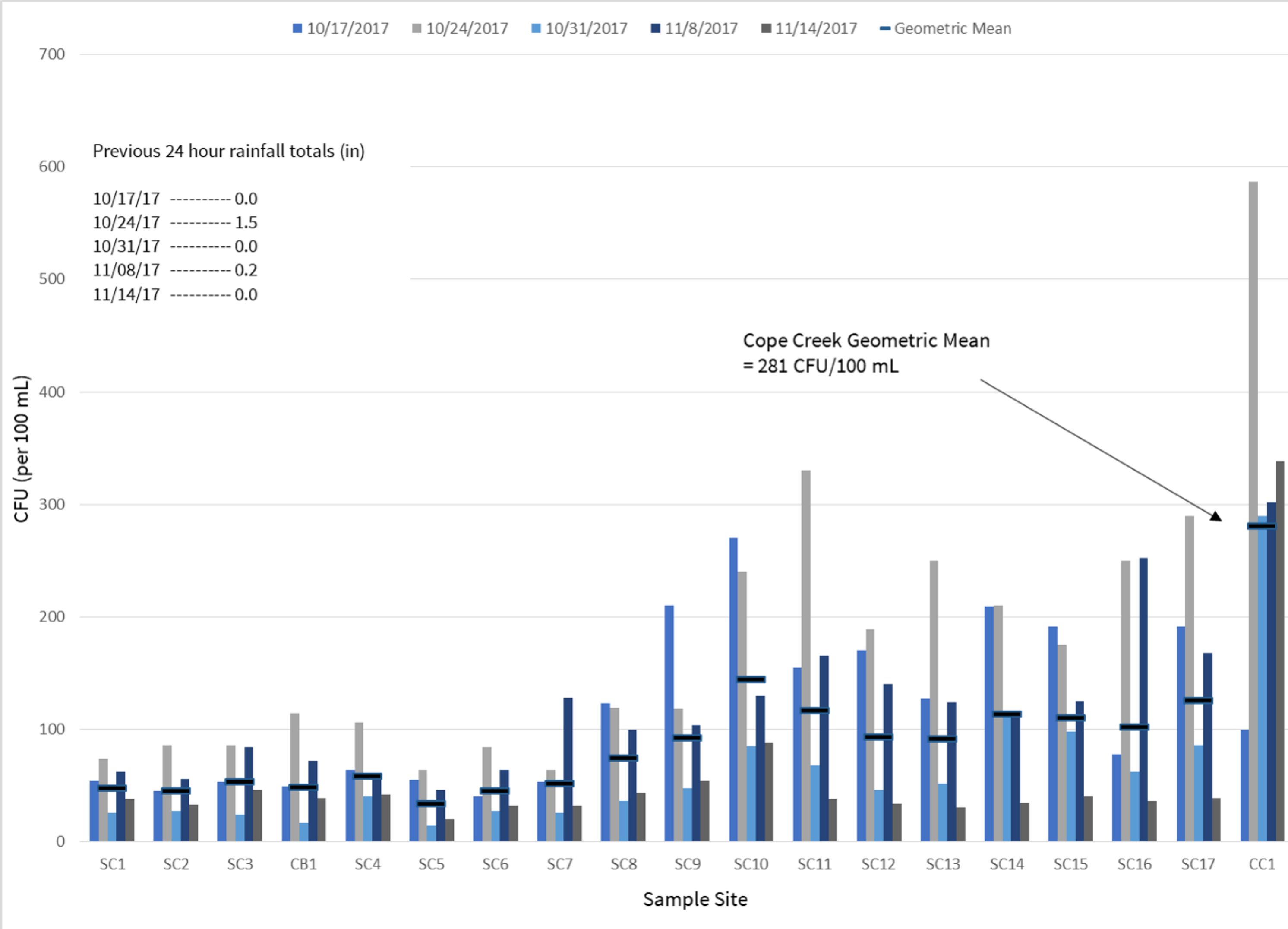

Figure 7. Fecal coliform concentrations.

Sewer systems provide a very significant asset to the economy, health, and well-being of urban communities. It is commonly acknowledged, however, that receiving waters should be protected against sewer discharges in order to maintain water quality. Additionally, the structural integrity and water tightness of the sewer system must be maintained. According to Tuckaseigee Water and Sewer Authority (TWSA) GIS data acquired by Equinox in August of 2017, there are nearly 37 miles of sewer line within Scotts Creek Watershed. Sanitary sewer exfiltration and infiltration in damaged pipes is a potential source for introducing harmful bacteria into soil, groundwater, and surface water. Exposed sanitary assets in areas where sewer lines run across streams, or where sewer lines and manholes have been uncovered by stream incision and bank erosion, are also potential sources of bacteria entering waterways. TWSA also has issues related to poor public awareness of what should not be flushed into the sewer system. In 2015, it was reported that motel guests at the Economy Inn on West Main Street had been flushing baby diapers into the motel's system, causing blockages that triggered overflows, and necessitated the replacement of the sewer line. It should be noted that TWSA has closely collaborated with WATR to identify leaking sewer pipes, and has made significant investments in sewer line repair and replacement.

Urban streams are greatly affected by nonpoint source pollutants in runoff, especially during storms. Studies have shown that urban streams tend to have fecal coliform counts that are higher than most rural and forested streams (Young & Thackston 1999; Schoonover 2005). In addition, research has shown that fecal bacteria levels are related to density of housing, population, development, impervious surfaces, and domestic animal density (Young & Thackston 1999; Mallin et al. 2000). Mallin et al. (2000) observed that the most significant factor influencing fecal bacteria loads was the percentage of impervious surfaces around the stream site. Therefore, the more impervious surfaces there are, the higher the fecal counts.

Escherichia coli (E. coli) is a species of fecal coliform commonly found in the intestines of animals and humans. E. coli has been shown to survive much longer in sediment than in the water column. The length of E. coli survival is related to a multitude of other factors (Fig. 9). Depending on the conditions E. coli can have a half-life of about 30 days in sediment, which is higher than the survival rate of E. coli in the water column. Disturbances of sediment within the stream caused by stormwater resuspend the bacteria laden sediment back into the water column.

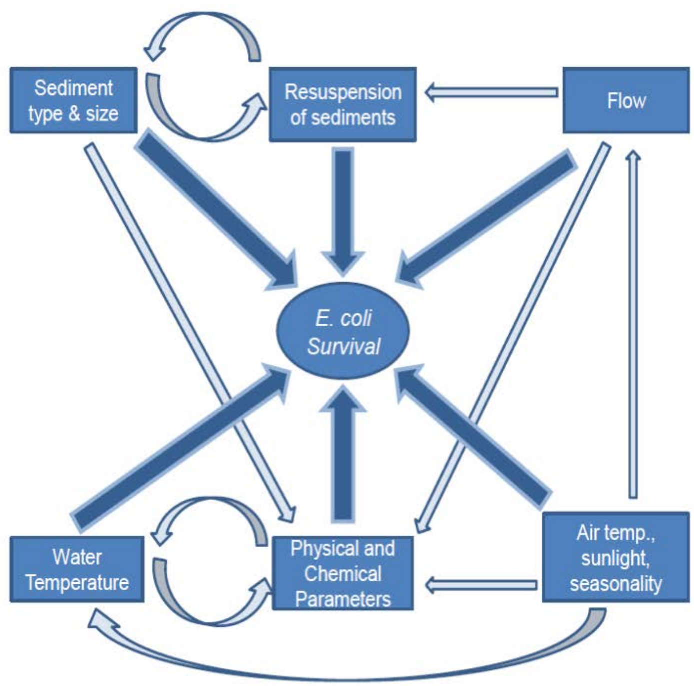

Figure 8. Interaction of factors involved in E. coli survival (Figure from McCulloch, 2015).

2.2 Soil Loss and Erosion

Soil loss for Scotts Creek Watershed was estimated using available rainfall, soil, elevation, and land cover data. The Revised Universal Soil Loss Equation (RUSLE) was used to calculate the soil loss for both subwatersheds and the entire Scotts Creek Watershed. Subwatershed soil loss is presented in Table 2 in the Soil Erosion column. The overall watershed soil loss rate was estimated to be 3.7 tons/acre/year. A soil loss map is presented in Figure 9.

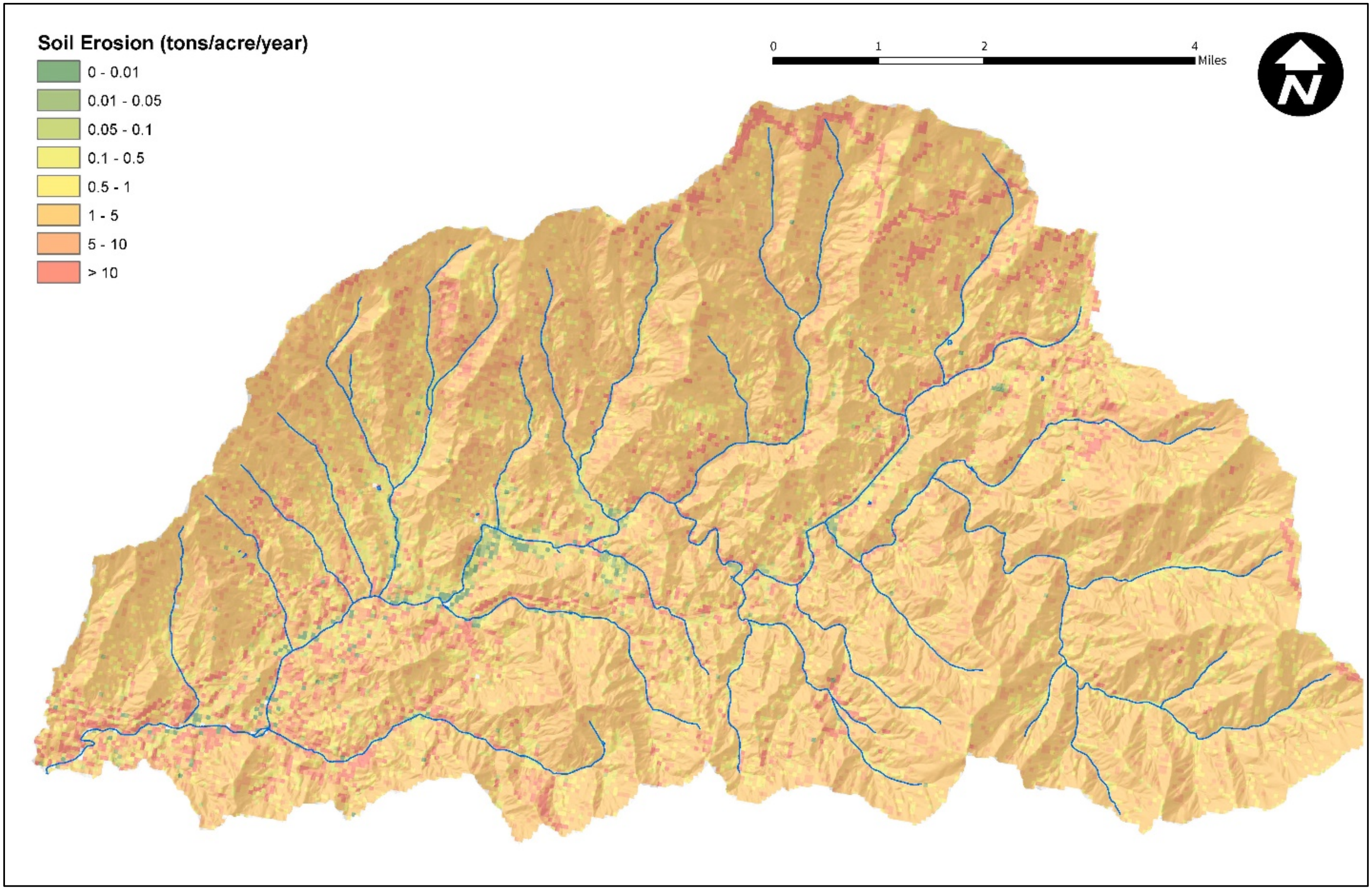

Figure 9. Soil erosion within Scotts Creek Watershed.

2.3 Pollutant Load Estimates (Nutrients, TSS, Fecal Coliform)

Pollutant loads were estimated for nutrients, Total Suspended Solids (TSS), and fecal coliform using the Watershed Treatment Model (WTM) 2013 provided by the Center for Watershed Protection through the Online Watershed Library (OWL). An estimated 135,190 lb of nitrogen, 14,650 lb of phosphorous, and 10,285,130 lb of suspended solids are flushed into the Scotts Creek Watershed each year (Table 4). Fecal coliform loading into the watershed is estimated to be 2,640,620 billion counts per year. Roads and urban areas in the watershed contribute the highest loads of nitrogen, phosphorous, and fecal coliform. Bank erosion within the stream channel is the largest contributor of TSS.

Table 4. Pollutant Load Estimates

	Total Nitrogen		Total Phosphorous		TSS		Fecal Coliform	
	(lb/yr)	(lb/ac/yr)	(lb/yr)	(lb/ac/yr)	(lb/yr)	(lb/ac/yr)	(billion/yr)	(billion/ac/yr)
Surface Water Load	135190	3.57	14560	0.38	10285130	271.92	2640620	69.81
Storm Related Load	84550	2.24	11500	0.30	9912740	262.08	1927760	50.97
Nonstorm Related Load	50640	1.34	3070	0.08	372390	9.85	712860	18.85

2.4 Basic Water Quality Parameters

In November 2017, a synoptic water quality sampling of 21 sites within the watershed (including the 19 sites sampled for fecal coliform) was conducted. Parameters measured included temperature, specific conductivity, pH, alkalinity, dissolved oxygen, and turbidity (Table 5). Basic water quality parameters (specific conductivity, pH, Dissolved Oxygen (DO), turbidity, and temperature) are frequently used to assess overall watershed health.

Temperature

Temperature is another important water quality parameter. Temperature affects water chemistry and influences the amount of oxygen that can be dissolved in water, photosynthesis by algae and other aquatic organisms, and the suitability of habitat for certain fish communities. Temperatures in Scotts Creek are affected by runoff from paved roads and parking areas. Pavements that are 100°F can elevate initial rainwater temperature from roughly 70°F to over 95°F. This heated stormwater generally becomes runoff, which drains into storm sewers and raises water temperatures as it is released into streams, rivers, ponds, and lakes. Studies over the last decade have been conclusive that the impacts on downstream ecosystems have been devastating to fish populations and their abilities to reproduce. Lack of riparian vegetation that shades and cools the stream is also a factor contributing to high stream temperatures.

Specific Conductivity

Specific conductivity is a measure of the ability of water to conduct an electrical current. High specific conductivity could be an indicator of certain cations and anions in the water, which in turn can be an indicator of pollution. High electrical conductivity can also be an indicator of sewage and septic leaks due to an increase in chloride, phosphate, and nitrate. Studies indicate inland fresh waters of the region that support healthy ecological function have electrical conductivity values ranging from 50 - 150 µS/cm.

pH

Another water quality parameter measured was pH, which indicates the alkalinity or acidity of the water. The largest variety of aquatic animals prefer a range of 6.5-8.5. Outside this range pH reduces the diversity in the stream because it stresses the physiological systems of most organisms and can reduce reproduction. Low pH can also allow toxic elements and compounds to become mobile and "available" for uptake by aquatic plants and animals. This can produce conditions that are toxic to aquatic life, particularly to sensitive species like rainbow trout.

Turbidity

Turbidity is a measurement of water clarity and the amount of suspended particles in water. Algae, suspended sediment, and organic matter can contribute to high turbidity. Higher turbidity increases water temperatures because suspended particles absorb more heat. This, in turn, reduces the concentration of dissolved oxygen (DO) because warm water holds less DO than cold. Higher turbidity also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of DO. Suspended materials can clog fish gills, reducing resistance to disease in fish, lowering growth rates, and affecting egg and larval development. As the particles settle, they can blanket the stream bottom, especially in slower waters, and smother fish eggs and benthic macroinvertebrates. Turbidity often increases sharply during a rainfall, especially in developed watersheds, which typically have relatively high proportions of impervious surfaces. The flow of stormwater runoff from impervious surfaces rapidly increases stream velocity, which increases the erosion rates of streambanks and channels. Turbidity can also rise sharply during dry weather if earth-disturbing activities are occurring in or near a stream without erosion control practices in place. The North Carolina turbidity standards for all fresh waters which support aquatic life and secondary recreation is ≤ 50 NTU for streams and ≤ 25 NTU for lakes and reservoirs.

Dissolved Oxygen

Dissolved oxygen is the amount of oxygen dissolved in water and is important for ecological health as most aquatic organisms need oxygen to survive and grow. Some species, such as trout and stoneflies, require high DO levels while others, such as catfish and worms, do not require high DO. Dissolved oxygen concentrations for fresh water are temperature dependent but typically between 6-9 mg/L during summer months.

Table 5. Basic Water Quality Parameters

	Temperature (°F)	Specific Conductivity (µS/cm)	pH	DO Concentration (mg/L)	Turbidity (NTU)
SC1	47.28	32.98	7.45	11.58	2.07
SC2	45.17	35.34	6.71	10.94	5.01
SC3	43.30	21.42	5.91	11.26	2.04
SC4	43.94	6.99	6.09	11.19	2.00
SC5	44.09	20.90	6.68	11.23	2.11
SC6	44.29	23.37	6.69	11.45	1.16
SC7	44.51	41.91	6.98	11.22	1.07
SC8	46.02	26.65	6.50	11.24	1.19
SC9	45.75	28.27	7.02	11.25	1.26
SC10	48.26	21.38	6.94	10.85	2.46
SC11	48.94	27.91	7.15	10.62	1.48
SC12	48.62	29.26	7.16	10.87	1.28
SC13	48.89	28.98	7.23	10.91	1.08
SC14	48.38	30.11	7.25	11.19	1.41
SC15	48.70	30.72	7.34	11.07	1.24
SC16	48.90	32.11	7.23	11.04	1.11
SC17	49.31	33.13	7.41	11.05	1.05
CC1	51.89	41.92	7.23	9.88	4.50

2.5 Benthic Macroinvertebrates

Penrose Environmental was subcontracted by Equinox to help with the baseline determination of water quality conditions and stormwater impacts in the Scotts Creek watershed. Benthic invertebrates, or aquatic insects, comprise a heterogeneous assemblage of taxa that inhabit the sediment or live on or in other bottom substrates in the aquatic environment (Klemm et. al., 1990). They vary in size from forms small and difficult to see without magnification to other individuals large enough to see without difficulty. Benthic invertebrates are large enough to be seen without magnification and can be retained by a U.S. Standard No. 30 sieve and live at least part of their life cycles within or on the substrate. These organisms are effective assessment tools for many reasons (Plafkin et.al., 1989). This community of aquatic organisms is found in all aquatic habitats including very small perennial stream systems (1st and 2nd order), which normally support a very limited fish fauna. Benthic macroinvertebrates are easily and inexpensively collected. These communities integrate the effects of short-term environmental perturbations. Sensitive species respond quickly to stress, while community shifts are generally more long-term. In addition, benthic macroinvertebrate communities respond to the various types of water pollution in predictable fashions (Hocutt, 1975) and are important in the diets of most fish species.

Benthic insects were collected from five locations in the Scotts Creek Watershed (SC3, SC4, SC5, SC11, and Monteith Farmstead Park). The sites were chosen based on the availability of riffle, bank, and sweep habitat within the reach. High precipitation prior to the benthic survey limited available habitat and access to several locations. Stage data were monitored prior to the survey to reduce the effects of recent high flows on benthic communities. Several intolerant EPT taxa (Ephemeroptera, Plecoptera, Trichoptera) were found at each of the five Scott's Creek locations. Biotic Index values range from 2.18 to 3.55, indicating "Good" to "Excellent" scores at all sampled locations. These results indicate the Scotts Creek Watershed is reference quality and only minor sources of perturbation are evident based on the observed biological assemblages (Table 6).

Table 6. Benthic Macroinvertebrate Biotic Index and EPT Richness

Site	NC Biotic Index	EPT Taxa Richness
SC5	2.18	30
SC3	2.65	29
SC11	3.55	32
SC4	2.68	33
FP1	3.29	21

Bioclassification Criteria for Small Mountain Streams		
Bioclass	**NC Biotic Index**	**EPT Taxa Richness**
Excellent	< 3.30	>35
Good	3.30 – 4.73	28-35
Good/Fair	4.74 – 5.62	19-27
Fair	5.63 – 6.52	11-18
Poor	>6.52	0-10

Five of six benthic macroinvertebrates sampling stations in the watershed were most recently classified as "Good", while the station on Sugarloaf Creek rated as "Fair" in 2007. Sugarloaf Creek was placed on the 303(d) list of impaired waters as a result.

2.6 Invasive Non-Native Plants

Non–native invasive plants (NNIP) alter the type and abundance of organisms, relative abundance of species, and function of ecosystem processes, usually with undesirable outcomes (Olson 1999). NNIP hinder the establishment of woody vegetation within riparian zones. This leads to areas of easily eroded, bare soil near streams, streambank erosion, and high stream temperatures due to a lack of canopy, among other negative effects on water quality. Large patches of Kudzu (*Pueraria montana var.lobate)* are found within Scotts Creek Watershed. Despite being planted for soil erosion control in the 1930s and 1940s, Kudzu has been proven to lead to increased, rather than decreased, erosion. Infestations of Japanese knotweed (*Reynoutria japonica*) were also observed on streambanks within the watershed. Ground beneath knotweed thickets is often bare, with little other growth, and it is very susceptible to erosion. Scouring of the ground is the main mode of transport and distribution of knotweed.

2.7 Litter

The majority of litter found in creeks is washed from gutters and parking lots into streams and rivers by storm events. The primary sources of litter are: pedestrians, motorists, trucks with uncovered loads, illegal dumping, incorrect household handling and its placement at the curb or in overflowing bins. Chemicals found in litter can leach into the water, degrading water quality. Plastic six-pack rings, plastic bags, and rope are among the various forms of litter that can get wrapped around the fins and limbs of animals in the water. Litter blocks sunlight from bottom dwelling plants and animals. Litter is also an unsightly blemish that prevents people from identifying streams as a valuable resource for the community.

Section 3. Management Measures and Evaluation Criteria

Strategies and action steps to address watershed stressors are provided in this section. Tables 7 and 8 summarize stressors, sources, management measures, restoration indicators, and target goals. By implementing these measures, it is expected that Scotts Creek could become a candidate for removal from the state list of impaired waterways within five to ten years. Furthermore, long term protection of water quality within the watershed can be achieved.

Stormwater runoff is the primary source of pollution in Scotts Creek. Intermittently, the Great Smokey Mountains Expressway, Skyland Drive, West Main Street, and Blue Ridge Southern Railroad parallel Scotts Creek throughout much of the watershed. The proximity of these roads to Scotts Creek allows stormwater from impervious and poorly vegetated surfaces to flow with increased velocity, pick up sediment, nutrients, bacteria, and chemicals, and deliver those pollutants directly into streams. Stormwater also causes increased peak flows within streams which leads to excess streambed scour and bank erosion; stormwater attenuation will reduce this erosion. A variety of stormwater control measures have been proposed as a primary strategy for addressing water quality issues within Scotts Creek Watershed.

Scotts Creek is on the impaired waterways list due to high concentrations of fecal coliform. Fecal coliform bacteria in aquatic environments indicate that water may have been contaminated with fecal material from humans or other animals, but decaying vegetation may also be a nonfecal source of fecal coliform (Tomasko et. al, 2017). In a study conducted on urban stormwater runoff fecal coliform concentrations were between 400 and 50,000 cfu/100 mL (Bastian, 1997). Not all sources of fecal coliform pose the same level of risk to human health. Failing septic and sewer along with any potential straight piping would be sources of bacteria and viruses which pose the highest risk to human health.

Erosion and sedimentation in the watershed are closely related to stormwater runoff, land development, and agricultural practices. Streambank erosion and erosion of unpaved roads (particularly roads on steep terrain) are major sources of sediment in the streams. Inadequate riparian buffers, livestock access to streams, poor pasture conditions, and row crops which are susceptible to erosion are also contributing sediment to streams. Proper erosion control practices should always be a part of any construction and development.

Few data are available on nutrient pollution in Scotts Creek other than the load estimates modeled for the purpose of this WAP. Monitoring for nutrients is recommended due to nitrate and phosphate being important indicators of the overall health of the watershed.

Table 7. Stressors, Sources, and Target Indicators to Achieve Management Goals

Stressor	Sources	Restoration Indicator and Target	Five-year Target
Bacteria	Stormwater Animal waste Failing sewage and septic Decaying vegetation	Fecal coliform concentrations GM < 200 cfu/ 100 mL, nor exceed 400/100 mL in more than 20 percent of the samples. E. coli concentrations GM < 126 cfu/100 mL	Fecal coliform concentrations GM < 200 cfu/ 100 mL, nor exceed 400/100 mL in more than 20 percent of the samples. E. coli concentrations GM < 126 cfu/100 mL
Sediment	Stormwater Streambank erosion Livestock access Soil erosion Row crops	TSS < 30 mg/L non-stormwater TSS < 100 mg/L stormwater Turbidity <10 NTU	TSS does not exceed 100mg/l for 90% of storm events less than one inch. Median turbidity of < 6 NTU (VWIN regional median).
Nutrients	Insufficent riparian buffer Stormwater Animal waste Fertilizers Failing sewage and septic	Orthophosphorous < 0.05 mg/L	Fewer than 10% of samples with Orthophosphorus > 0.1 mg /L
Temperature	Stormwater Insufficent riparian buffer Lack of deep pools in stream	Temperature < 68° F most days during the summer	Temperature < 68° F most days during the summer

Basis for targets:

- Fecal coliform: NC DWR freshwater recreational standards
- E. coli: EPA freshwater recreational standards
- Total Suspended Solids (TSS): no legal standard
    - Non-stormwater <30mg/L
    - Stormwater <100mg/L
- Turbidity: NC DWR standards (trout waters)
- Temperature: NC DWR standards (trout waters)

Table 8. Management Measures, Load Reduction Parameters, and Evaluation Measures

Management Measure	Target Stressor	Parameter Targeted for Load Reduction	Evaluation Measures
Stormwater Control Measures	Attenuated peak flows	Discharge: ft^3/s	Discharge measurement
	Streambank erosion	Sediment: tons/yr	Streambed composition; SSC
	High stream temperature	Temperature: °F	Temperature
	Excess nutrients	Nutrients: lb/yr	Nitrogen and Phosphorous
	Bacteria	Fecal coliform and E. coli: cfu/100 ml	Fecal coliform and E. coli
Stream Restoration	Attenuated peak flows	Discharge: ft^3/s	Discharge measurement Streambed composition; SSC
	Streambank erosion	Sediment: tons/yr	Fish community assessment Macrobenthic invertebrate assessment
Riparian Buffer Enhancement	Attenuated peak flows	Discharge: ft^3/s	Discharge measurement
	Streambank erosion	Sediment: tons/yr	Streambed composition; SSC
	High stream temperature	Temperature: °F	Temperature
	Excess nutrients	Nutrients: lb/yr	Nitrogen and Phosphorous
	Bacteria	Fecal coliform and E. coli: cfu/100 ml	Fecal coliform and E. coli
Agricultural Practice Improvement	Soil erosion	Sediment: tons/yr	Streambed composition; SSC
	Excess nutrients	Nutrients: lb/yr	Nitrogen and Phosphorous
	Bacteria	Fecal coliform and E. coli: cfu/100 ml	Fecal coliform and E. coli
Wastewater Treatment	Excess nutrients	Nutrients: lb/yr	Nitrogen and Phosphorous
	Bacteria	Fecal coliform and E. coli: cfu/100 ml	Fecal coliform and E. coli

- *Stormwater Control Measures (SCMs) include anything that detains, captures, or treats stormwater runoff. SCMs include constructed wetlands, bioretention, regenerative stormwater conveyance, bioswales, rain gardens, downspout disconnection, green roofs, rain barrels, cisterns, and pervious pavements.*
- *Stream restoration treatments include restoring pattern, profile, and dimension where appropriate. Bedform features including pools, riffles, runs, and glides are restored and spaced according to reference reach geometry. In stream-structures are used when necessary. Structures could include cross vanes, j-hook vanes, boulders, log sills, and brush and boulder toe revetments. Streambank stabilization involves lowering the slope of over-steep banks and restoring floodplain.*
- *Riparian buffer enhancement includes replanting riparian buffer with native vegetation, live staking, and invasive plant removal.*
- *Agricultural practice improvements include rotational grazing, planting of seasonal grasses, installation of heavy use area protection, installation of wells and watering tanks, and fencing livestock out of streams.*
- *Wastewater treatment improvements include locating and eliminating illicit discharges, straight piping, and failing septic systems.*

3.1 Continue and Improve Water Quality Monitoring

Monitoring is one of the primary strategies in this WAP. It is essential to establish and maintain a comprehensive monitoring program to characterize current conditions, changing watershed conditions, identify restoration needs, justify grant applications and demonstrate measurable results from watershed improvement projects. A few specific monitoring recommendations are made in this WAP. Monitoring should include the collection of water and sediment samples to be analyzed for E. coli in addition to fecal coliform. The US EPA has recommended that E. coli be used as the Fecal Indicator Bacteria (FIB) in fresh water streams used for recreation.

Optical Brightener Agents (OBAs) are primarily added to laundry soaps, detergents, and cleaning agents for the purpose of brightening fabrics and/or surfaces. Laundry wastewater is the largest contributor of OBAs to wastewater systems because it retains a large portion of dissolved OBAs. Water municipalities and researchers are evaluating OBA concentrations in lakes, rivers, and coastal ocean to determine the efficiency of wastewater treatment protocols and wastewater systems. When wastewater systems fail, human waste leaks into natural aquatic systems and might cause an increase in fecal coliform bacteria, which may impact ecosystems. In an effort to determine source contaminations, researchers are correlating fluorescence of OBAs to bacterial levels. These studies may help decrease this type of anthropogenic input. Acquisition and frequent use of a handheld fluorometer and turbidimeter configured to detect OBAs would greatly assist in detecting failing septic and sewage leaks. A handheld fluorometer costs approximately $2500 per unit.

If FIB concentrations continue to increase and the sources cannot be determined, Microbial Source Tracking (MST) should be seriously considered to discern the source fecal pollution. MST is a highly effective means for accurately determining the fecal source and allows for appropriate preventative and remediation measures. Source Molecular is a company which specializes in MST and also provides information on developing a customized sampling strategy.

Action Steps:

- Continue project partners monitoring programs for fecal indicator bacteria, temperature, turbidity, substrate composition, nutrients, and biological communities.
- Use a comprehensive monitoring plan to document water quality improvements as management measures are implemented, as well as continue monitoring after project completion.
- Expand water quality monitoring in Scotts Creek. Acquisition of multiparameter sondes which can be used for spot checks or long term monitoring is recommended. (In Situ Aqua TROLL 600).
- Expand stormwater suspended sediment monitoring in Scotts Creek. Acquisition of automatic samplers designed for automatic sampling are recommended. (Teledyne ISCO 3700).
- Develop a discharge rating curve for gauge at Scotts Creek near Beta.
- Make the data available to public officials and agencies and organizations working on water quality improvement projects.
- Periodically review monitoring parameters, locations and frequency; modify as needed to ensure they represent the highest priority needs.
- Generate new pollutant source identification data sets every 5 years.
- Share information about changing conditions and threats with stakeholders.
- Include monitoring funds in grant requests.
- Work with WATR and other organizations to continue offering volunteer monitoring opportunities.
- Develop an open, regularly updated database of all monitoring data relevant to watershed health.

Table 9. Management Measures and Potential Load Reduction

Management Measure	Parameter Targeted for Load Reduction	Potential Load Reduction
Stormwater Control Measures	Discharge: ft^3/s	30% Annual Runoff Volume
	Sediment: tons/yr, Total Suspended Solids (TSS)	10% Total Suspended Sediment
	Temperature: °F	N/A
	Nutrients: lb/yr	20% Total Nitrogen/30% Total Phosporous
	Fecal coliform and E. coli: cfu/100 ml	30% Fecal Coliform (billion/year)
Stream Restoration	Discharge: ft^3/s	N/A
	Sediment: tons/yr, TSS, Turbidity	10% Total Suspended Sediment
Riparian Buffer Enhancement	Discharge: ft^3/s	30% Annual Runoff Volume
	Sediment: tons/yr, Total Suspended Solids (TSS)	10% Total Suspended Sediment
	Temperature: °F	N/A
	Nutrients: lb/yr	20% Total Nitrogen/30% Total Phosporous
	Fecal coliform and E. coli: cfu/100 ml	40% Fecal Coliform (billion/year)
Residential and Agricultural Practice Improvement	Sediment: tons/yr, Total Suspended Solids (TSS)	10% Total Suspended Sediment
	Nutrients: lb/yr	10% Total Nitrogen/10% Total Phosporous
	Fecal coliform and E. coli: cfu/100 ml	10% Fecal Coliform (billion/year)

3.2 Continue and Expand Education and Awareness Campaigns

Educating the public is one of the best strategies for the long-term benefit of water quality. It helps build community participation, giving citizens a vested interest in the health of their waterways. Youth education and awareness campaigns should be the focus of the watershed partnership group.

Environmental education at an early age has been demonstrably effective in building enduring environmental values. Public presentations should focus on the management measures and recommendations found in this section of the Watershed Action Plan, in part to recruit landowners to implement management measures. The key project partners working on education include Watershed Association of the Tuckasegee River (WATR), Jackson Soil & Water Conservation District (JSWCD), Jackson Cooperative Extension Service, Wildlife Resources Commission, US Fish & Wildlife Service, and National Park Service, but there are many others that assist these organizations.

One important education program should be erosion control training, not only for developers and general contractors but also for the equipment operators and staff working on the ground. Staff involved with actual construction are ultimately responsible for implementing the sedimentation and erosion control plans as well as troubleshooting. They should be able to identify issues in the field and relay that information to developers, engineers, and others responsible for site planning. Jackson County erosion and sediment control inspectors would likely need to coordinate this kind of training.

Education of municipal employees is very important. Grounds crews need to understand the importance of not mowing areas where riparian vegetation should be left. Maintenance crews should be educated about pollution prevention and good housekeeping for municipal operation. Here is a link to more information on pollution prevention for municipalities: http://www.wncstormwater.org/pdf/GHPP.pdf.

Storm drain stenciling and marking is a cost effective and easy way to convey to educate the public that everything that goes down a storm drain flows, untreated, into a nearby stream. Stenciling can bring together community organizations and civic groups to give them a vested interest in improving water quality. Storm drain murals are also becoming increasingly popular. These can be quite visually striking and educational (Figure 10).

Figure 10. Examples of storm drain marking in the Chesapeake Bay (left) and Vancouver, BC (right).

Education for the public on what can be disposed of into septic systems is essential. For example, studies have shown that most "flushable wipes" are, in fact, detrimental to the proper function of septic systems. Landowners should be educated about the frequency with which a septic system should be pumped and the fact that pumping a septic system will not repair a clogged or failed drainfield.

Shade Your Stream initiatives are another important public education and outreach tool to improve watershed health (Figure 11). In the words of Dr. Bill McLarney, Senior Scientist and Aquatic specialist for Mainspring Conservation Trust (MCT): "The single most positive thing we can do for our streams is to maintain full streamside vegetation zones along all of them, from a river to the tiniest spring branch". Efforts must be made to inform landowners why riparian zones have such an impact on water quality and what they can do to preserve and restore them.

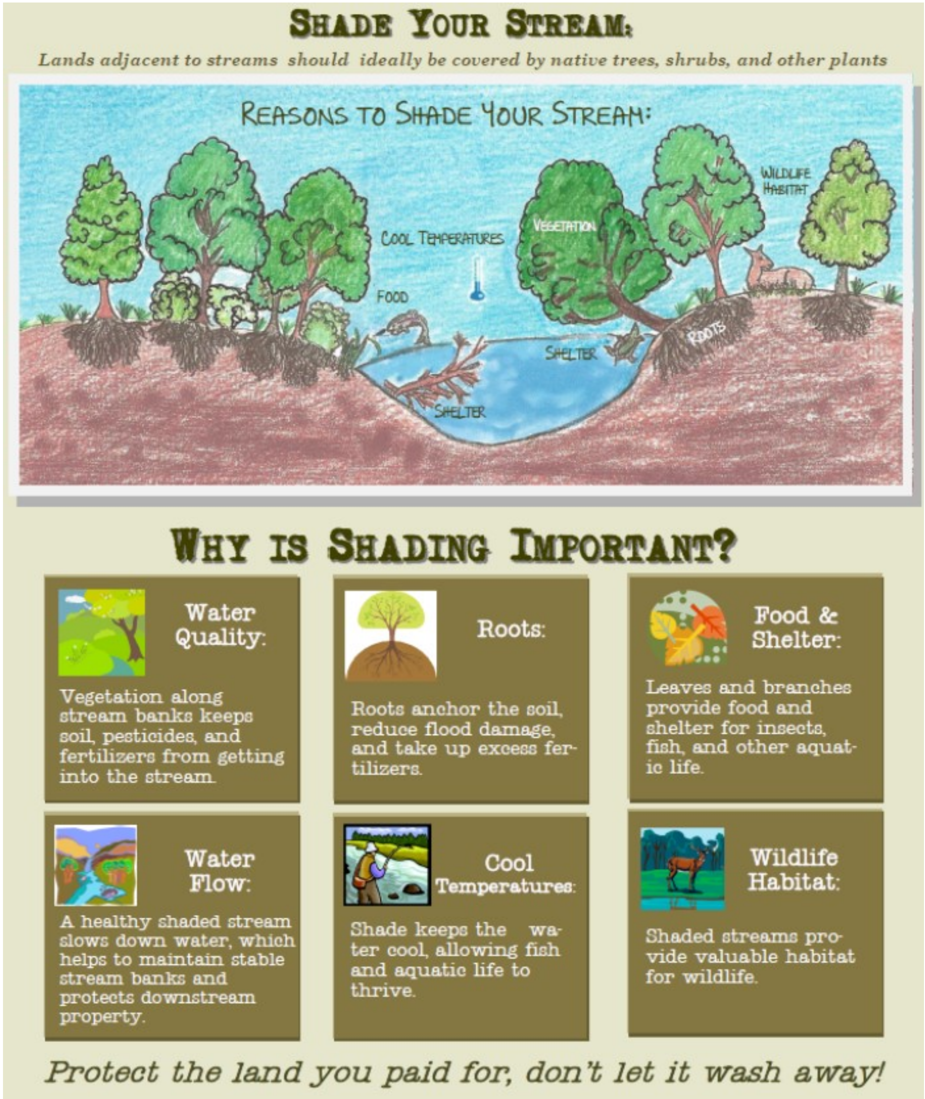

Figure 11. Excerpt from Mainspring's Shade Your Stream brochure.

It has been demonstrated that education goes only so far in its effectiveness. Behavioral changes may be a desired outcome from education, but its primary purpose is to enhance a person's intellect about a certain subject matter with the hope that once a person understands, they will respond in the way that is desired. Marketing, on the other hand, is designed with the express intention to motivate certain actions among a target population. Like education, a marketing approach may appeal to intellect, but it also appeals to emotion. It rests upon an assumption that most people will be more motivated to participate in a stream improvement project or change behaviors to enhance stream health when they feel an urge to do so. The scientific and technical information located throughout this planning document provides us with a great deal of useful intellectual data and information. But messages that are crafted to appeal to peoples' core values are also a means of facilitating the changes that are desired.

Table 10. Environmental Education Opportunities

Program/Activity	Organization
Adopt-A-Stream	WATR
Conservation Field Days	JSWCD
Envirothon Program	JSWCD, Jackson County Schools
Erosion & Sediment Control training	All
Informational brochures	All
Monteith Farmstead Education	WATR, Jackson County Schools
Newsletters	All
Newspaper columns and articles	All
Presentations to public	All
Presentations in schools	All
Public displays	All
Public meetings	All
Shade Your Stream	Mainspring Conservation Trust
Signs – stream and watershed	All
Social media – Facebook, Twitter	All
Surveys	WATR
Project tours	All
Websites	All

3.3 Implement Stormwater Treatment and Control Measures

Stormwater is the number one cause of nonpoint source pollution to waterways. The primary concerns with stormwater are high stream flows and the transport of pollutants off the landscape into steams. To reduce risks associated with high flows, stormwater should be collected and retained on or near the point of origin. By keeping stormwater on-site, downstream peak flows are reduced, resulting in lower bank shear stress, and decreased stream bank erosion. Groundwater recharge is also facilitated by stormwater retention. Any collection methods should also provide some measure of treatment to filter pollutants, including sediment, nutrients, and thermal pollution. Bioretention and wetland basins have been shown to effectively reduce fecal coliform and E. coli concentrations (International Stormwater BMP Database, 2016).

It is also possible and recommended to retrofit existing sites, though it may take additional planning to accommodate utilities, infrastructure, and other challenges. Disconnecting gutters and downspouts from existing standpipes and letting water flow over landscaped areas or lawns is an affordable, low-maintenance option to retain stormwater on residential and sites. Rainspout disconnection and bioretention is an effective stormwater control measure which should be considered for commercial and industrial sites.

When it comes to capturing stormwater runoff, communities can capture more volume over time by encouraging the use of multiple stormwater management practices with smaller capacity as opposed to one stormwater management practice with large capacity. This is because most storms only generate a small amount of runoff, while big storms that fully utilize large capacity are rare. A sequence of multiple stormwater treatments, known as a treatment train, can be used to maximize effectiveness.

Based on available performance data (International Stormwater BMP Database, 2011), some general recommendations for SCM implementation are made. General recommendations include implementing normally-dry vegetated SCMs. Normally-dry vegetated SCMs (filter strips, vegetated swales, bioretention, and grass lined detention basins) appear to have substantial potential for volume reduction on a long-term basis, on the order of 30 percent for filter strips and grass-lined detention basins, 40 percent for grass swales, and greater than 50 percent for bioretention with underdrains. Therefore, these SCMs can be an important part of an overall strategy to manage site hydrology and control pollutant loading via volume reduction. Normally-dry vegetated SCMs also tend to provide better volume reduction for smaller storms, which tend to occur more frequently than larger storms; this can lead to reduced frequency of discharges or much smaller discharge volumes. Both of these would tend to reduce the frequency of water quality impairments.

Rain gardens are aesthetically pleasing, cost effective stormwater control measures which almost any landowner can implement on their own. The backyard rain garden program of the North Carolina Cooperative Extension includes useful guidance on the appropriate soil drainage, sizing, construction, planting, and maintenance of a rain garden. A link to a document on rain gardens is included here: https://forsyth.ces.ncsu.edu/wp-content/uploads/2016/03/RGmanual2015.pdf?fwd=no

The Environmental Stewardship Grant Program in Knox County, TN provides financial and technical assistance to private landowners wishing to build rain gardens and other SCMs. The program has completed over 200 projects since the year 2000 and could possibly be a model for developing a similar program in Jackson County.

Rain water collected in rain barrels and cisterns can be used for a variety of purposes. The Town of Sylva and Jackson County governments should consider installing rain barrels and cisterns and using this rain water for watering landscaping and washing vehicles.

Low Impact Development (LID) is a way of creating new residential, commercial and industrial spaces that simultaneously protect trees and green space, use less pavement, and make extensive use of the types of stormwater SCMs discussed previously. LID treats stormwater as a resource rather than a waste product. Its goal is to maintain the pre-development hydrology of a property. Perhaps most intriguing from a developer's point of view is that LID often costs less to develop than traditional approaches, especially when considering life-cycle costs.

The following techniques should be considered for controlling and treating stormwater runoff:

- Stormwater collection devices, including rooftop retention (green and blue roofs), constructed wetlands, bioretention, rain gardens, retention ponds, and storage tanks (rain barrels, cisterns, and vaults).
- Stormwater drainage controls including permeable surfaces, bioswales, berms, drop boxes, diversion ditches to vegetated strips, appropriate culvert spacing and sizing, and minimizing direct discharge from bridges.
- Streambank modifications including riparian buffers and live staking with native species.
- Revegetating exposed ground.

Action Steps:

- Municipalities should consider implementing stormwater fees and using them as a dedicated revenue stream for stormwater programs.
- Develop environmental stewardship grant program dedicated to assisting landowners address stormwater issues on private property.
- The Town of Sylva is encouraged to align with the Western North Carolina Stormwater Partnership and adopt regulations in line with Phase II stormwater requirements.
- Identify and prioritize properties in need of treatment. See the attached stormwater management section of this watershed plan.
- Encourage developers, municipalities, and others to install stormwater treatment and control measures in all new construction. Limit any variances for groundwater recharge ordinance.
- Encourage property owners and public officials to retrofit existing sites.
- Work with technical resource agencies to identify appropriate stormwater treatment and control devices for new construction or to retrofit existing sites.
- Apply for financial resources to assist landowners.
- Implement stormwater management measures.
- Map storm drains throughout watershed to help identify illicit dischargers.

3.4 Eliminate Sources of Fecal Contamination

Livestock access and direct runoff from agricultural fields to streams within Scotts Creek Watershed are a source of bacterial pollution. Fencing out the livestock from the streams and restoring appropriate riparian buffer would aid in preventing harmful bacteria from entering the streams. Often watering tanks and wells need to be installed for livestock once they have been fenced out of the stream. Programs are available to help pay for installation of fencing, wells, and watering tanks.

Elimination of any remaining or new straight piping within the watershed must be a priority.

Monitoring of fecal coliform and E. coli, supplemented by the use of a handheld fluorometer to detect optical brighteners associated with human wastewater sources can aid in eliminating the sources of fecal contamination most harmful to human health. Securing funding for the repair of failing septic systems is an important component of a successful effort to eliminate sources of fecal contamination and harmful bacteria. Failing septic systems is often associated with older homes and in rural mountain areas, homeowners may not have the financial resources to address the issue on their own.

Continuing to improve and extend TWSA's sewer network will eliminate sources of bacteria in the watershed. Making efforts to protect exposed sanitary assets near streams will prevent future failures which would result in sewage spills.

Pet waste from lawns and parks should be collected and disposed of properly. Education campaigns, signage, and providing pet waste bags and receptacles can aid in achieving this goal.

Actions Steps:

- Implement stream restoration projects which restore riparian buffer, fence livestock out of creeks, and protect the stream system with a conservations easement.
- Implement Stormwater Control Measures to treat urban stormwater runoff.
- Continue identification of problems areas by improved monitoring methods.
- Continue developing GIS database of septic systems.
- Apply for financial assistance to provide landowners an affordable means to repair failing septic systems.
- Increase public awareness of what should not be disposed of in septic systems and how often they should be pumped.
- Encourage public to pick up and properly dispose of pet waste.
- Protect exposed sanitary sewer assets in and near streams.
- Encourage public officials to re-fund the WaDE Program and support the program if it returns.

3.5 Treat and Eliminate Sources of Soil Loss and Erosion

Streambank erosion is a major contributor of sediment to the streams in Scotts Creek Watershed. Erosion of unpaved roads and runoff from paved roads are also contributors of sediment. Pastures with poor ground cover and row crops (particularly those on steep slopes) are also a source of soil loss in the watershed. Monitoring suspended sediment concentration and turbidity can help identify sources and magnitude of sediment pollution. Recommended techniques for preventing erosion include:

- Streambank stabilization and enhancement. Restoring riparian buffers, reducing bank slope steepness, and installation of rootwads.

- Restoration of stream profile to include appropriate riffle-pool sequences. This can be achieved by installing in stream structures such as cross-vanes, j-hook vanes, and boulder and wood toe revetments.
- Agricultural practice changes like fencing livestock out of streams, installing wells and watering tanks for livestock, designating stream crossings, rotating pasture grazing, protecting heavy use areas, and seeding with no till drills can help reduce erosion.
- Minimize concentration of stormwater along unpaved and paved roads. Minimize development of road networks on steep slopes.

Live staking and re-establishing vegetation in riparian zones is a very simple, cost effective technique for preventing erosion. Where this management measure can be applied, the cost is very low and the work can be done by volunteers. A mix of grasses on the outer edges of the buffer, with shrubs and trees composing the forested inner portion of the buffer nearest the stream, is advised.

Equally as important as putting plants in the ground is refraining from mowing or burning existing creekside vegetation. Through education and outreach efforts like the previously mentioned Shade Your Stream initiative, landowners can learn the value of riparian vegetation and change their practices of actively mowing and weed eating vegetation in the riparian zone (Figure 12).

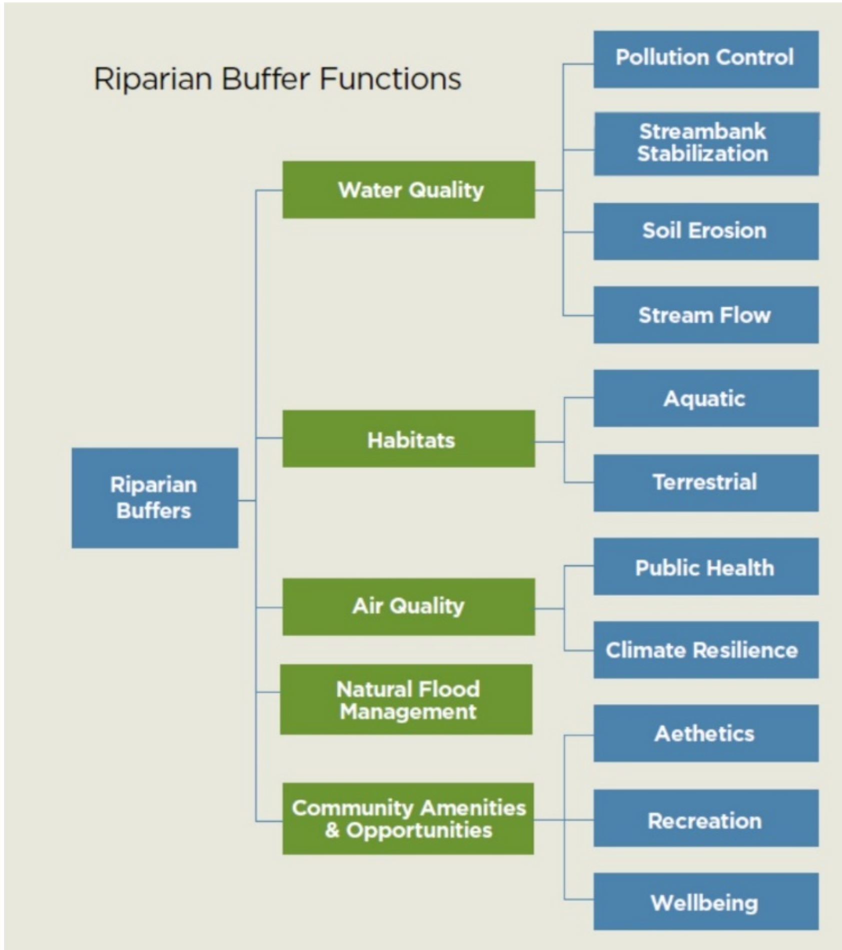

Figure 12. Riparian buffer functions and benefits. (From American Rivers' "Economic Value of Riparian Buffers")

3.6 Promote Low Impact Development

Low Impact Development (LID) was discussed earlier in this chapter as a means of managing stormwater better. Because protecting green space is a principle of LID, we have included it as a land protection tool as well. Some landowners may have property that is conducive to development and they wish to use their land in that manner. We encourage them and developers to consider LID or even more protective conservation development principles to help protect sensitive portions of their properties that are identified as important to the objectives of this plan. Sometimes, developments such as these can be combined with a conservation easement to ensure protection even if ownership changes. Significant land planning and design assistance is required for LID. The Jackson County Planning Department and other permit issuing agencies should direct landowners to the appropriate technical resources.

Actions Steps:

- LID should be incentivized through expedited permitting, decreased fees, zoning upgrades, and reduced stormwater permitting requirements for developers using LID practices.

- Make grant funding available to private landowners and community groups to encourage green infrastructure and LID.
- Offer rebates and installation financing including funding, tax credits, and reimbursements to property owners who install green infrastructure. These programs typically offer a list of specific practices, such as installation of cisterns, rain gardens, or green roofs.
- Develop an awards and recognition program which rewards innovation and increases awareness of green infrastructure projects by the public and decision-makers.
- Offer stormwater fee discounts to programs implementing LID practices.

3.7 Promote Conservation Easements

Conservation easements protect water quality by reducing the density of development in the watershed. They also improve wildlife habitat and provide recreational and educational opportunities. A conservation easement is a legally binding agreement between a property owner and a qualified easement holder in which the owner voluntarily agrees to give up certain rights to the use of the property. Those rights have a financial value, but at a level that is less than fair market value. Conservation easements can be donated or sold. A donation often results in significant federal and state tax advantages for the landowners whereas a sale will provide some income. Sometimes conservation easements can be structured to where they can provide the property owner with both income and tax benefits.

The upper portions of the Scotts Creek Watershed contain many parcels which would likely qualify for a conservation easement because of the water quality, scenic, habitat or recreational benefits they provide the public. Headwater areas of streams are particularly sensitive to development and benefit most from protection by a conservation easement. Conservation of an approximately 5000 acre parcel in the eastern portion of the watershed would protect the headwaters of Jones Creek, Cabin Creek, and Dark Ridge Creek. Large parcels of land at the headwaters of Cope Creek, Dills Branch, Allens Branch, Kitchin Branch are also excellent prospects for conservation.

The State of North Carolina is required by its General Statutes to acquire a conservation easement on all sites qualifying for a North Carolina Division of Mitigation Services (NC DMS) project to permanently protect the site. This means that stream and wetland restoration projects implemented through NC DMS also contribute to increasing the amount of conserved land within the watershed.

Actions Steps:

- Continue to identify and prioritize properties for easements.
- Educate landowners about what conservation easements are and how they can be financially beneficial for the landowner, while simultaneously benefitting the health of the watershed.
- Support efforts by town, state, federals and grant funding agencies to acquire easements.
- Incentivize conservation by including a low, present use value for land in a conservation easement.
- Establish conservation easements.

3.8 Support Watershed Protection Ordinances

Jackson County has a number of ordinances designed to protect its ample natural resources. Maintaining and enforcing these ordinances are important to restore the health of Scotts Creek Watershed. Among these ordinances are watershed protection, erosion and sedimentation control, floodplain development, groundwater recharge protection, mountain and hillside development, mountain ridge protection, and Scotts Creek water quality protection. It is recommended that a stormwater control ordinance be added to this list. It should be recognized that these ordinances have been developed for important reasons, but are only effective if properly enforced. Sufficient funding and staffing are required to ensure enforcement.

Action Steps:

- Understand and stay up to date with watershed protection ordinances.
- Encourage a consistent set of watershed protection ordinances for the county and municipality; this will make enforcement easier and may enable hiring additional staff.
- Evaluate what state-wide ordinances don't work in the mountains and what holes exist in the current local ordinances.
- Participate in the development of ordinances to protect water quality.
- Determine if there are barriers to enforcement and implement strategies to remove those barriers.
- Track local and state legislation, rule-making, and planning processes that have implications for water quality; submit comments and recommendations as needed.
- Develop relationships with local, state, and federal officials whose decisions affect water quality.
- Assist local governments with obtaining funds and skills to address nonpoint source pollution abatement opportunities.
- Recognize and support initiatives by all levels of government that help keep our waters clean.
- Support a new ordinance requiring implementation of stormwater control measures and administering stormwater fees.

3.9 Promote Land Use Planning Efforts

One of the best ways to predict the future of the Scotts Creek Watershed is to plan for it. As the populations of Sylva and Dillsboro grow, the pressure of development on the watershed will increase. The resources and guidance of the Southwest Regional Commission will be vital in ensuring the towns and surrounding areas grow in a sustainable manner. Thought and care must be given to developing new roads along with new residential and commercial/industrial areas. Construction on steep slopes which are prone to erosion should be avoided whenever possible. Sufficient riparian buffer must be maintained and stormwater control measures should be considered and implemented in every development.

We reiterate the action steps of Jackson County's Land Use Plan 2040:

Action Steps:

- Continue administration and enforcement of Watershed, Water Recharge, and Floodplain Development Ordinances to protect water sources.
- Continue to identify changes in technology and best management practices related to storm water control to ensure that the ordinances encourage environmentally sound development practices.
- Update stormwater control measure guidance.
- Educate and promote stormwater control measure guidance to the public.
- Continued enforcement of trout water riparian buffer rules.
- Continue to identify and modify policies and procedures to protect trout waters.
- Continue to administer and update the Mountain Ridge Protection Ordinance and the Mountain and Hillside Development Ordinance as necessary.
- Continue and expand GIS based inventories of septic systems and sewer lines.

3.10 Support Local Water Quality Initiatives

Having a well-supported and active watershed association is an important component of restoring and maintaining water quality in Scotts Creek Watershed. WATR has been working to educate, monitor, and coordinate volunteer cleanup efforts in the watershed for nearly twenty years. Recently, longtime WATR executive director Roger Clapp stepped down from his position and Ken Brown has been named as his replacement. Still, this is only a part time position. Securing funding for creation of a full time paid director position should be a priority for WATR. One recommendation for securing long-term, sustained funding is to seek donors for creation of an endowment fund. Jackson Paper could potentially be a good donor prospect. Jackson Paper is one of the largest private employers in Jackson County and has been named by industry experts as on one of the top five most environmentally friendly paper mills in the nation. Filling vacant board positions and increasing membership are also important steps in WATR fulfilling its mission.

American Rivers is another organization whose work is important to recognize and support. American Rivers is a nationwide organization with tremendous resources. The mission of American Rivers is to protect wild rivers, restore damaged rivers, and conserve clean water for people and nature. Currently, American Rivers is working on a Blue Trails project on the Tuckasegee River. Blue Trails are voluntary, locally led efforts that improve community quality of life and focus on helping communities enjoy their rivers through recreation. American Rivers recognizes that protecting the water quality of tributaries to the Tuckasegee Rivers is vital to their efforts.

Mainspring Conservation Trust works primarily to conserve land throughout the southwestern portion of North Carolina. As discussed earlier, conservation is a valuable tool in protecting watershed health. Mainspring also does important work in stream restoration and education. The Kids in the Creek program gets 8th and 9th grade kids in waders and into the creek to learn more about stream health.

Mountain True has been working to protect land and water in the area around Asheville for several years, and is now opening an office in the Sylva area. Mountain True has experience and resources for water quality monitoring which will be an asset in improving and protecting Scotts Creek Watershed.

The Tuckaseigee Chapter of Trout Unlimited works to conserve coldwater fisheries in the region. Education about trout and their importance is a large part of their efforts. They also conduct trach cleanups in streams around the area. These trash cleanups not only improve water quality and beautify the stream, they give people an opportunity to get in the creek and feel connected to it with a sense of ownership.

Action Steps:

- Support local water quality initiatives.
- Develop and promote new water quality initiatives as needed.

3.11 Provide Financial and Technical Incentives

Many forms of financial assistance are available to landowners and community groups wishing to implement measures which would increase the health of the watershed. A list of some of these measures is provided in Table 10, along with estimates of the costs for various management measures (LPWRG, 2017). Sources of financial assistance are presented in Table 11.

In many instances, homeowners who need repairs are low-income and unable to afford them; they may also live on sites that are inaccessible to a backhoe, further complicating the repair work. In these cases, landowners who will have difficulty paying for repairs are reluctant to report they are having an issue. Major repairs or replacement of septic systems can be costly, but there are sources of financial assistance for homeowners who need it. In neighboring Haywood County, Haywood Waterways Association has partnered with the Haywood County Environmental Health Department to help homeowners determine if they qualify for funding to repair septic systems. The program pays for 75 to 100 percent of the cost of the septic repair and is partially funded through the NC DEQ Section 319 Grant Program. Similar programs offering septic tank pump-out rebates, grants, and low-interest loans have been established with Clean Water Management Trust Fund grants. Low interest loans are also available through the USDA Single Family Housing Repair loans program.

National Resource Conservation Services-Environmental Quality Incentives Program (NRCS-EQIP) funding by the USDA and NC DWR is available for approved stream restoration projects. Projects approved for this program are funded at 65% Federal cost and 35% non-Federal cost. Projects in North Carolina, which have been approved by the NRCS for federal funding, are eligible for up to 100% funding by the state of the 35% non-federal cost. The NC Division of Mitigation Services (NC DMS) provides funding for purchase of conservation easements where stream and wetland restoration projects are implemented as a part of the compensatory mitigation program. Landowners who agree to these projects receive cash payment for donating their land to the conservation easement, while retaining ownership.

The State of North Carolina provides significant income tax credits for donation of a conservation easement. Additional tax deductions for a conservation easement donation may be available through the federal government.

Creation of a county conservation tax rate would also be a great financial incentive. Often, landowners are reluctant to agree to a conservation easement if it will significantly increase their property taxes.

Technical resources can be provided by agencies like the Jackson Soil and Conservation District, the NRCS, the NC Cooperative Extension, and others.

Action Steps:

- Establish a financial assistance program for septic repair.
- Create a low conservation easement use tax rate.
- Maintain a current database of existing technical and financial programs, responsible agencies and local contacts, federal or state oversight and appropriation committees, funding history, and an estimate of qualifying projects.
- Annually identify and focus efforts on those programs that have the greatest potential to substantially contribute to nonpoint pollution source reduction.
- Annually contact elected officials to inform them of the opportunities to assist Jackson County in addressing nonpoint pollution issues.

Table 11. Management Measure Cost Estimates and Technical Resources

Management Measure	Cost	Technical Assistance
Monitoring	Depends on parameter	JSWCD, JCE, WRC, DWR, WATR
Education	Depends on type	JSWCD, JCE, WRC, WATR
Conservation easement	State appraisal	JSWCD, MCT
Storage tank	\$50 - \$100/rain barrel \$1/gallon cistern	JSWCD, NRCS
Bioretention	\$12/ft2	JSWCD, JCE
Bank stabilization	\$15 - 75/lf	JSWCD, NRCS
Riparian Enhancement	\$1 - 2/lf	WATR, JSWCD, NRCS
Boulders	\$77/ton	JSWCD
Tree revetments	\$30/linear ft	JSWCD
Silt fence	\$1.50/linear ft	JSWCD
Root wads	\$80	JSWCD
Pasture renovation	\$300/acre	JSWCD, NRCS
Revegetating exposed ground	\$700/acre	JSWCD, NRCS
Livestock fencing	\$3.25/linear ft	JSWCD, NRCS
Well	\$13/linear ft	JSWCD, NRCS
Watering tank	\$1,000	JSWCD, NRCS
Stream crossing	\$1,100	JSWCD, NRCS
Septic system repair	\$4,600 Average	JEHD

JSCWD: Jackson Soil & Water Conservation District
JCE: Jackson Cooperative Extension
WRC: NC Wildlife Resources Commision
DWR: NC Division of Water Resources
WATR: Watershed Association of the Tuckasegee River
MCT: Mainspring Conservation Trust
JEHD: Jackson Environmental Health Department

Table 12. Sources of Financial Assistance

Source	Application	Website
Duke Energy Foundation Water Resources Fund	May, November	https://www.duke-energy.com/community/duke-energy-foundation/water-resources-fund
DWR 319 Program	May	www.deq.nc.gov/about/divisions/water-resources/planning/nonpoint-source-management/319- grant-program
Jackson County Community Fund	September	https://www.nccommunityfoundation.org/communities/western/jackson-county
National Fish & Wildlife Foundation, Five Star and Urban Waters Restoration Grant Program	February	www.nfwf.org/Pages/default.aspx
NC Agricultural Cost-Share Programs	Variable	www.ncagr.gov/SWC/costshareprograms/ACSP/index.html
NC Clean Water Management Trust	February	www.cwmtf.net/
NC Division of Mitigation Services	Variable	www.deq.nc.gov/about/divisions/mitigation-services
NRCS Financial Assistance Programs	Variable	www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/
USDA Single Family Housing Repair Loans	Year Round	https://www.rd.usda.gov/programs-services/single-family-housing-repair-loans-grants/nc
Z Smith Reynolds Foundation	January	www.zsr.org/

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Stormwater Management
Site Identification & Conceptual Designs

Scotts Creek Watershed

Prepared By:

EQUINOX

balance through proper planning

Stormwater Control Measures

What is Stormwater Runoff?

Stormwater runoff is water that flows over land from rain or snow melt. The water runs off of streets, parking lots, lawns, and other sites and accumulates in larger quantities due to development of impervious surfaces. Stormwater can soak into pervious surfaces, such as soil by infiltration, or can be held on the surface and evaporate. Stormwater in large quantities can contribute to sedimentation, erosion, turbidity, increased contamination of streams, and flooding.

One inch of precipitation falling on 1,200 square feet of roof produces approximately 750 gallons of runoff.

The term "first flush" is a common term used in the stormwater management field. The theory behind this term is that pollutants that have collected on impervious surfaces will wash off during the first portion of a rainfall event. Essentially, the first portion of a given rain event will "flush" the impervious surface of its pollutants, resulting in stormwater runoff that contains more pollutants than runoff produced later in the event. It is important then for stormwater treatment measures to be designed to capture and treat the first half inch of rainfall.

What are Stormwater Control Measures (SCMs)?

Stormwater management limits the negative effects of stormwater runoff by addressing water quantity and/or quality by reducing its peak flow, velocity, and removing pollutants. Designed measures can be taken to act preventatively to reduce the impact of stormwater runoff. There are two types of SCMs:

Non-structural Control Measures

Non-structural SCMs include small, low cost measures that cumulatively can add up to significantly reduce stormwater runoff impacts. Homeowners and small businesses can easily implement simple SCMs on their properties and usually at low cost. Done properly these simple practices will beautify a property, protect basements and foundations from water seepage, and for structural SCMs- reduce water consumption and money that property owners spend on water utilities. Each property is unique; prior to implementing any of these solutions, property owners should assess their site to ensure that their runoff will not cause or worsen storm runoff problems for neighbors or create or add to erosion and flooding conditions on their properties. Even though these solutions are referred to as 'simple', professional assistance with design and construction may be needed. Landowners will be encouraged to install these features through the education and outreach program.

Structural Stormwater Control Measures

Structural SCMs typically treat larger areas of imperviousness. They are designed to reduce downstream effects, such as pollution, erosion, and flooding. The use of design professionals and precise installation parameters are most often needed when implementing structural SCMs. They vary greatly in size, complexity, and function, often incorporating specialized plant material, soil mixes, and proprietary structures that filter pollutants by natural processes. Common examples of structural SCMs include bioretention, constructed wetlands (also known as stormwater wetlands), wet ponds, and sand filters. Less common and often more expensive solutions include permeable paving, regenerative stormwater conveyances, underground storage chambers, and green roofs.

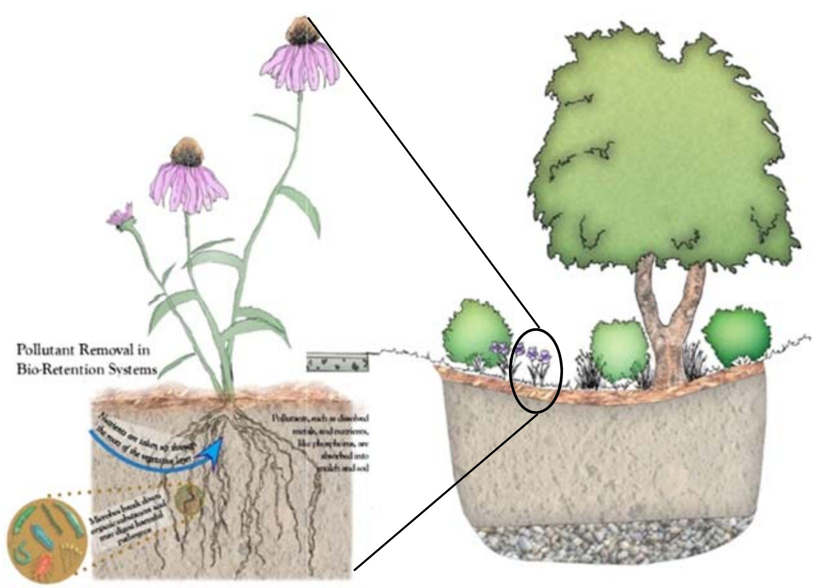
Stormwater Control Measures used in the Scott's Creek Watershed Plan

Bioretention Cells

Bioretention features are depressions that rely on soils and plants to treat storm runoff, using many of the water storage and pollutant-removal mechanisms that operate in healthy forests. During storms, water temporarily ponds on the surface of a sand/soil bed and then infiltrates slowly through the bed. Nutrients are taken up by plants while microbes break down organic substances (Figure 1). Bioretention cells are intended to "draw down" or empty within 24-48 hours following a rain event, alleviating stagnant water and mosquito breeding concerns. Cells can be designed to infiltrate water directly into native soils, if these soils are sufficiently permeable. If not, special soil media and underdrain systems may be necessary or a system of sand layers to encourage infiltration. To reduce the sizing requirements of bioretention features, a structure can be installed to limit the amount of water the bioretention receives to the first inch of rain. Larger storm volumes bypass the bioretention cells protecting them from receiving amounts of water beyond what they are capable of treating. Overflow structures are typically installed within the bioretention cell, especially when a bypass structure, such as a curb cut in a parking lot, is not feasible. Bioretention can be used in a variety of topographic conditions, and can generally treat runoff from areas of one acre or less.

Figure 1: Plant Uptake and Pollutant Removal Process in Bioretention Cells

Drawing created by Equinox



Raingardens

Raingardens are often simply excavated areas located in low points of a property where stormwater accumulates (Figure 2). They are intended to slow, treat, percolate, and promote evapotranspiration of stormwater. Therefore, they rely primarily on the permeability of existing soils. They usually do not include underdrains or inlet structures.

Because they lack drainage structures, soils in raingardens need to be highly permeable to function correctly. It is important to test the composition of existing soil to ensure the raingarden is able to "draw down" between rain events. Native plants that can tolerate fluctuating water levels and drought should be planted to further aid in water uptake while also adding pollinator and wildlife benefits.

Figure 2: Rain Garden at Drovers Road Preserve

Project by Equinox, photo by Equinox

Stormwater Wetlands

Constructed wetlands are shallow depressions constructed to mimic the functions of natural wetlands (Figure 3). They are intended to increase the flow paths of stormwater and temporarily store water in pools of varying depths that contain diverse wetland vegetation. The wetland uses physical, chemical, and biological processes to filter pollutants. They can also be designed to provide stormwater volume control (Figure 4). However, because they are shallow, stormwater wetlands require more surface area than similar wet detention ponds, but provide much greater habitat due to the undulations in topography.

Sediments that accumulate in the forebay of a constructed wetland need to be removed every 5 years or when the depth of the forebay diminishes by 50%. Wetlands should also be monitored for the invasion of exotic plant species, which should be removed promptly when found. Other maintenance requirements include periodic inspection of the flow delivery mechanisms upstream of the wetland to ensure that stormwater is able to get to the wetland as designed. Otherwise, the wetland plant species may die. Trash and other debris removal may also be needed periodically.

Figure 3: Stormwater Wetland

Photo by Equinox

Figure 4: Stormwater Wetland Cell

Photo by Equinox

Riparian Buffers

Riparian buffers are vegetated areas directly adjacent to streams and rivers (Figure 5). The re-establishment of buffers is becoming more common as a response to the negative effects of historic agricultural and industrial land uses developing right to the water's edge. A vegetated buffer helps intercept sediment, nutrient, and pollutant runoff from adjacent land uses. Riparian buffers, often forested, help shade and cool the water in the stream or river, improving water quality and creating micro-climates. The vegetation acts to stabilize the banks of the waterbodies reducing erosion and further sedimentation downstream as well as acting as habitat.

Figure 5: Early establishment of a Riparian Buffer

Photo by Equinox

Rain Barrels/Cisterns

Rain barrels and cisterns provide a storage device to capture rooftop drainage for later use on the site. Many people capture and reuse this water for their gardens and landscape plantings. Rain barrels come in a variety of sizes, shapes, and colors. It has become fairly commonplace to find 50 to 75-gallon barrels that make attractive additions to the landscape (Figure 6), while cisterns tend to be much larger and may even be designed to be used for non-potable indoor plumbing. A simple, 50-gallon plastic rain barrel will typically cost $100 or less. Users of this practice will need to make sure that they have screens over openings to keep mosquitoes from using the reservoir as a breeding ground. They will also need to direct overflow to a suitable location to keep it from seeping into foundations and basements. Cisterns can be located below ground (Figure 7) to store water in tight spots or above ground (Figure 8) and used for educational purposes.

Figure 6: Rain Barrel

Photo sourced from Wikimedia (2018)

Figure 7: Buried Cistern

Photo sourced from Wikimedia (2018)

Figure 8: Above Ground Cistern

Photo by usepagov, sourced from Flickr (2018)

Maintenance

Maintenance of SCMs is critical, not only for them to function effectively, but to maintain aesthetically pleasing landscapes. Due to existing physical constraints often associated with retrofits, maintenance access should be given special consideration during the design phase. The level of maintenace that the owner is able to provide is best understood early on in the design phase so the proposed SCM solution is appropriate.

Inspections of the SCM should occur yearly, at minimum. It’s recommended that SCMs are inspected on a more frequent basis to ensure that it’s functioning as intended. Inspections are recommended after large storm events and in the autumn after leaf fall has occurred. Typically leaf litter and other debris during this time needs to be cleared or removed to prevent clogged inlets and other structures, if applicable. SCMs should be inspected by certified professionals that have a sound understanding of the intended functions of the design and the complexities of the infrastructure involved. Certification programs such as those conducted by North Carolina State University require individuals to satisifactorily complete a training workshop and pass a written examination. Once certified, inspectors are required to attend continuing education workshops.

Potential Stormwater Control Measures in Scotts Creek Watershed

Equinox staff conducted a preliminary desktop review of the Scotts Creek Watershed, using GIS data and the most recent aerial imagery, to identify potential SCM sites. These sites were then ground-truthed and spatially analyzed to determine both feasibility and need. Overall, sixteen sites were identified as potential retrofit sites (Table 2).

Stormwater Control Measure Criteria Selection

Surface area was estimated for each treatement based on the contributing drainage area as observed on site and via analysis from the desktop review.

A holistic approach was taken to determine the appropriate SCM to implement for each individual site. Factors considered included existing slopes, contributing hydrology, depth to bedrock, targeted pollutants, public visibility, and available space. It is important to recognize that the siting and design of SCMs is as much of an art as it is a science (NCDWQ 2007). Appropriately fitting treatments into a landscape can not only help reduce impacts to water qaulity, but can also address community concerns, safety issues, community acceptance, and habitat uplift (Table 1).

Conceptual Studies

Conceptual studies of the sixteen sites are included to aid in communicating with landowners, and to convey intent with more detailed design (Figs 9-26). Due to the cursory nature of the concepts, they are not intended to be used for direct implementation, and should not be construed as detailed drawings. Factors such as site features, utility conflicts, land uses, and topography may vary from what is shown.

Precedent Project—*Bridge Park*

The Bridge Park site was selected as the precedent project due to its visibility, location in downtown Sylva and the potential for implementation of a stream restoration. A detailed conceptual design (Fig 27), example imagery, a cost estimate and potential schedule for this design are provided.

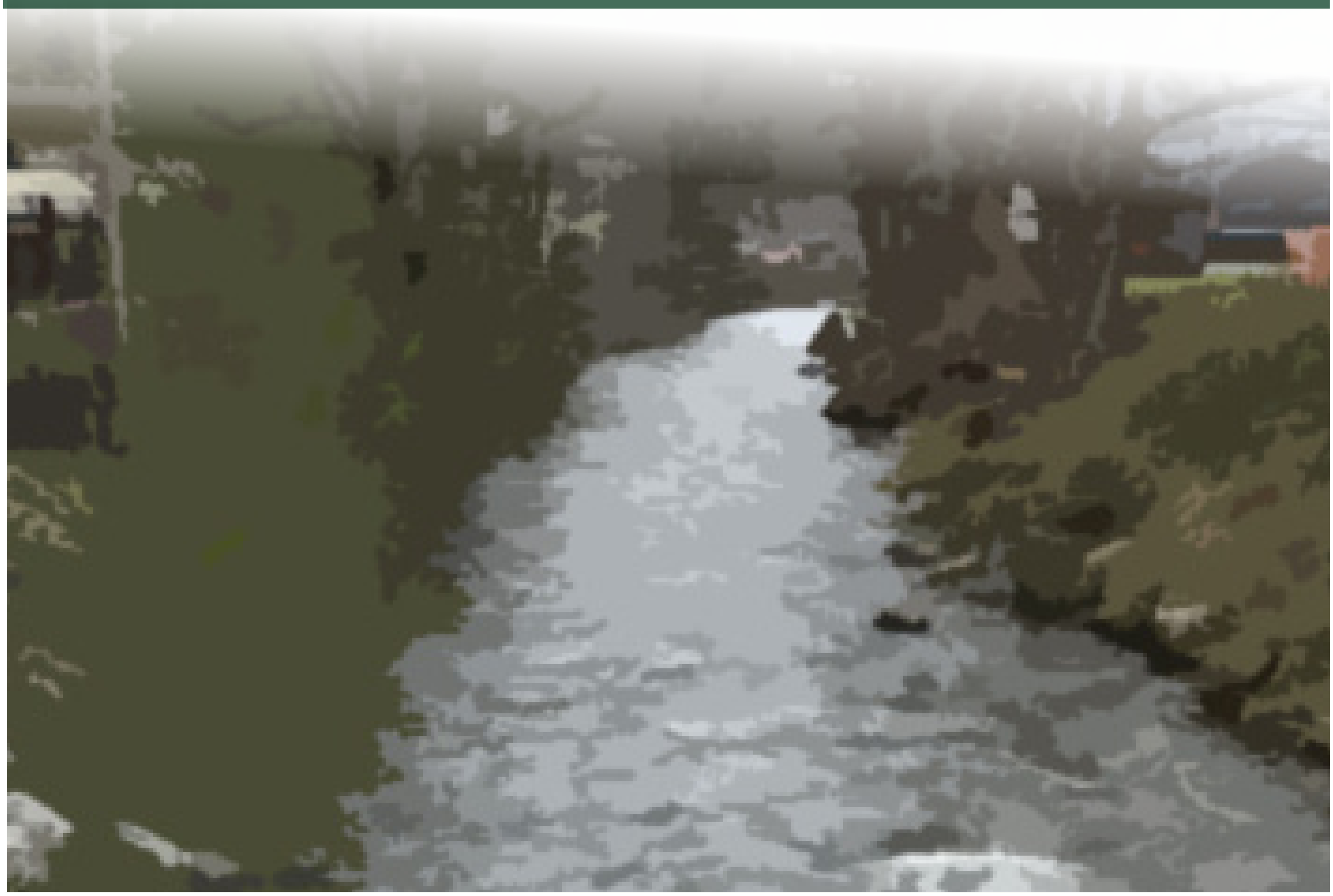
Table 1: Stormwater Control Measure Characteristics*

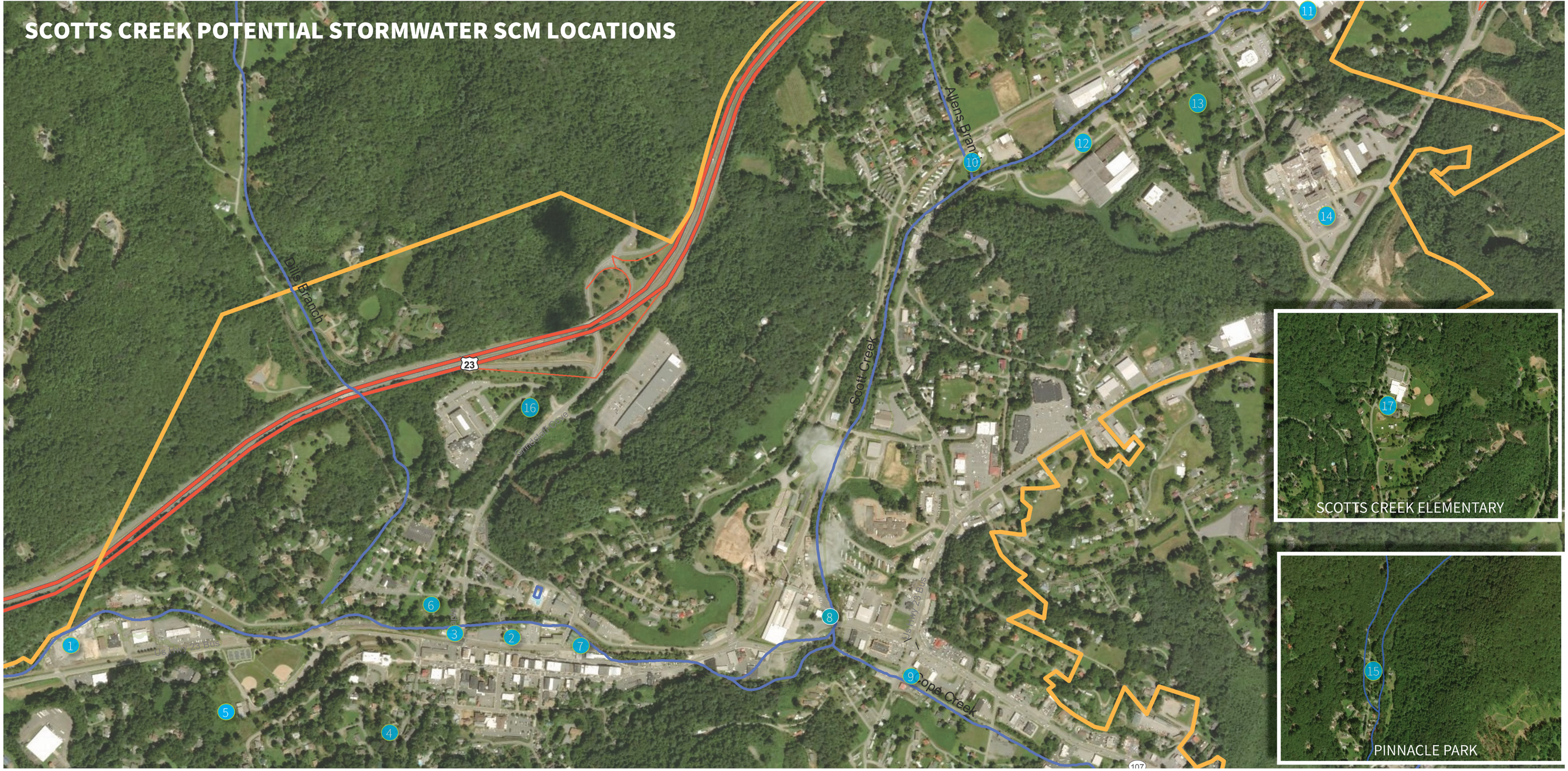
SCM Type	Construction Cost	Maintenance Level	Safety Concerns	Community Acceptance	Wildlife Habitat
Bioretention	Medium-High	Medium-High	No	Medium-High	Medium
Wetlands	Medium	Medium	Yes	Medium	High
Wet Detention Basin	Medium	Medium	Yes	Medium	Medium
Sand Filter	High	High	No	Medium	Low
Filter Strip	Low	Low	No	High	Medium
Grassed Swale	Low	Low	No	High	Low
Restored Riparian Buffer	Medium	Low	No	High	Medium-High
Infiltration Devices	Medium-High	Medium	No	Medium-High	Low
Dry Extended Detention Basin	Low	Low-Medium	Yes	Medium	Low
Permeable Pavement System	Medium-High	High	No	Medium	None
Rooftop Runoff Management	Medium	Medium	No	High	Low

*Source: NCDWQ Stormwater BMP Manual (NCDWQ 2007)

Site	Property Name	Type of SCM	Was The Site Observed?	Public Land	Land Use	Drainage Area* (acres)	Impervious Area (acres)	Percent Impervious (%)	Surface Area REQUIRED for SCM(s) (square feet)	Surface Area IDENTIFIED for SCM(s) (square feet)
1	Southern Concrete Materials	Riparian Buffer	Yes	No	Industrial	N/A	N/A	N/A	N/A	N/A
2	Bridge Park	Bioswale, Bioretention, Riparian Buffer, In-stream Structures	Yes	Yes	Public	6.5	5	85	32,000	4,000
3	Nantahala Brewery	Raingarden, Riparian Buffer	Yes	No	Commercial	0.12	0.12	100	540	540
4	Bicentennial Park	Bioswale, Bioretention	Yes	Yes	Public	0.85	0.37	43	3700	2500
5	Mark Watson Park	Wetland Enhancement	Yes	Yes	Public	N/A	N/A	N/A	N/A	N/A
6	Community Garden	Raingarden	Yes	No	Institutional	0.4	0.14	35	1700	1200
7	Motion Makers Bike Shop	Bioretention, Riparian Buffer	Yes	No	Commercial	1.5	0.83	55	6700	3000
8	Jackson Paper	Riparian Buffer	Yes	No	Industrial	N/A	N/A	N/A	N/A	N/A
9	Kel-Save	Riparian Buffer	Yes	No	Commercial	N/A	N/A	N/A	N/A	N/A
10	Herron Branch Road	Riparian Buffer	Yes	No	Residential	N/A	N/A	N/A	N/A	N/A
11	Parking Lot	Raingarden	Yes	No	Commercial	5.6	4.9	90	24,300	1,600
12	Agricultural Field	Riparian Buffer	Yes	No	Farmland	N/A	N/A	N/A	N/A	N/A
13	Jackson County Services Building	Raingarden, Bioretention	Yes	Yes	Government	1.29	1.17	91	5600	3100
14	Hospital Parking	Bioretention	Yes	No	Institutional	0.69	0.69	100	3000	1200
15	Pinnacle Park	Bioswale, Bioretention	Yes	Yes	Public	2.5	0	0	10,840	1000
16	Jackson County Justice Center	Bioretention	Yes	Yes	Government	1.1	1	90	4700	4700
17	Scotts Creek Elementary School	Bioswale, Cisterns	Yes	Yes	Public	0.14	0.14	100	N/A	N/A

Watershed SCM Concepts





WATERSHED SITE LEGEND

1. SOUTHERN CONCRETE MATERIAL
2. BRIDGE PARK
3. NANTAHALA BREWERY
4. BICENTENNIAL PARK
5. MARK WATSON PARK
6. COMMUNITY GARDEN
7. MOTION MAKERS BIKE SHOP
8. JACKSON PAPER
9. KEL-SAVE
10. HERRON BRANCH ROAD
11. PARKING LOT
12. AGRICULTURAL FIELD
13. JACKSON COUNTY SERVICES BUILDING
14. HOSPITAL PARKING
15. PINNACLE PARK
16. JACKSON COUNTY JUSTICE CENTER SOUTHERN CONCRETE MATERIAL
17. SCOTTS CREEK ELEMENTARY

Legend

Streams

Town of Sylva Boundary

Feet

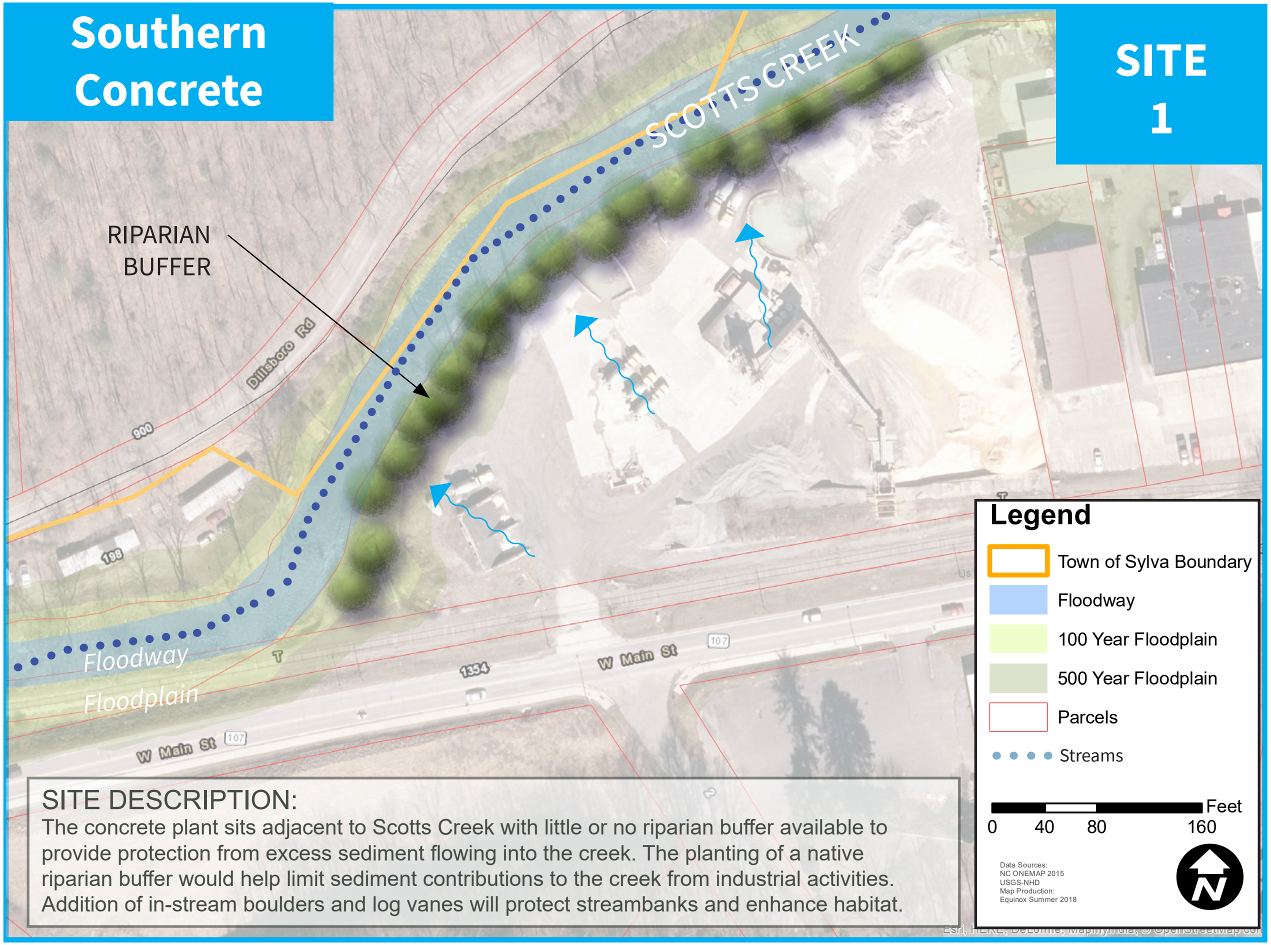
0 375 750 1,500

Data Sources:
NC ONEMAP 2015
USGS-NHD
Map Production:
Equinox Summer 2018

SCOTT'S CREEK WATERSHED SITE LOCATION MAP

Southern Concrete

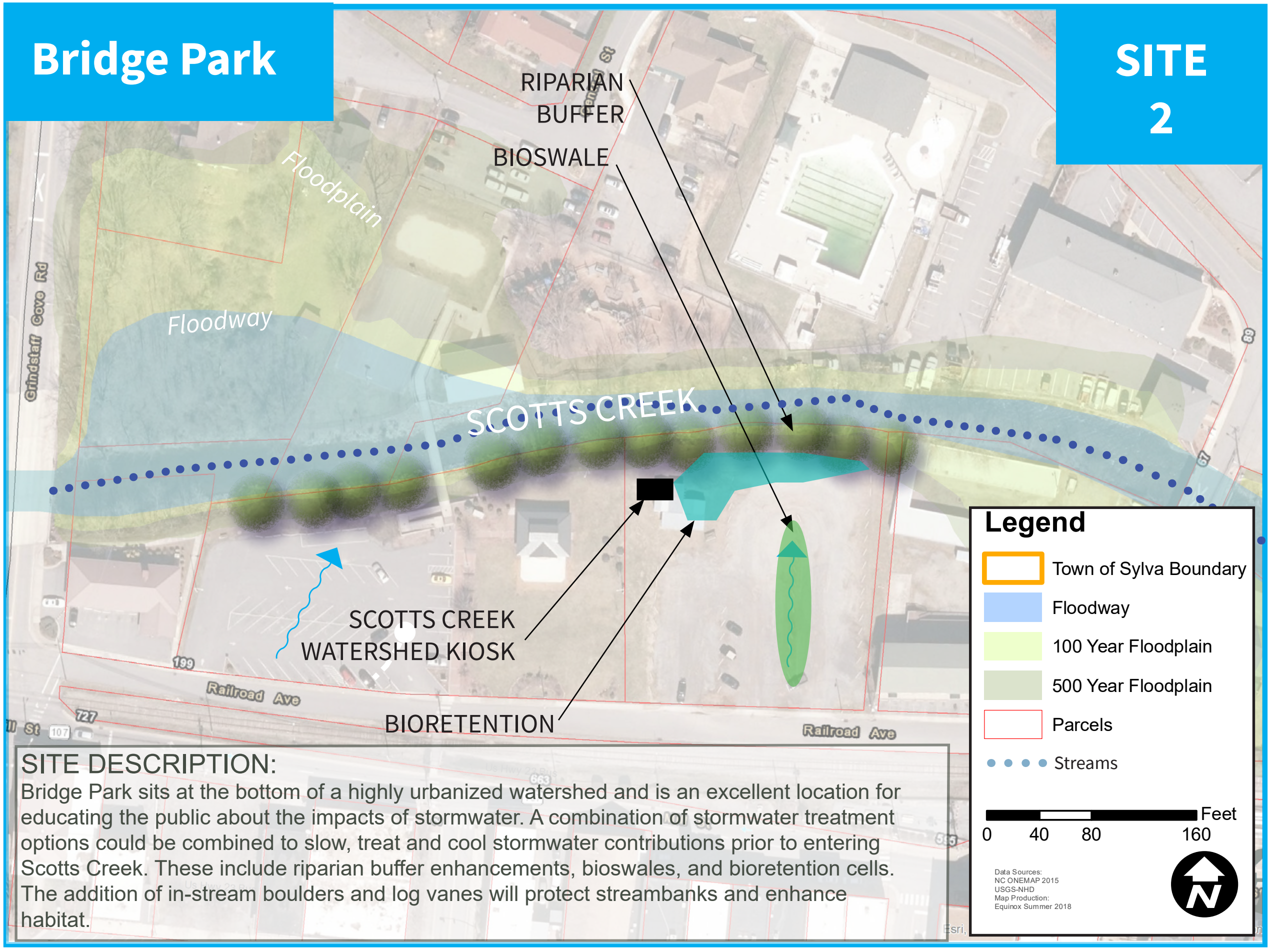
SITE 1



SITE DESCRIPTION:
The concrete plant sits adjacent to Scotts Creek with little or no riparian buffer available to provide protection from excess sediment flowing into the creek. The planting of a native riparian buffer would help limit sediment contributions to the creek from industrial activities. Addition of in-stream boulders and log vanes will protect streambanks and enhance habitat.

Bridge Park

SITE 2

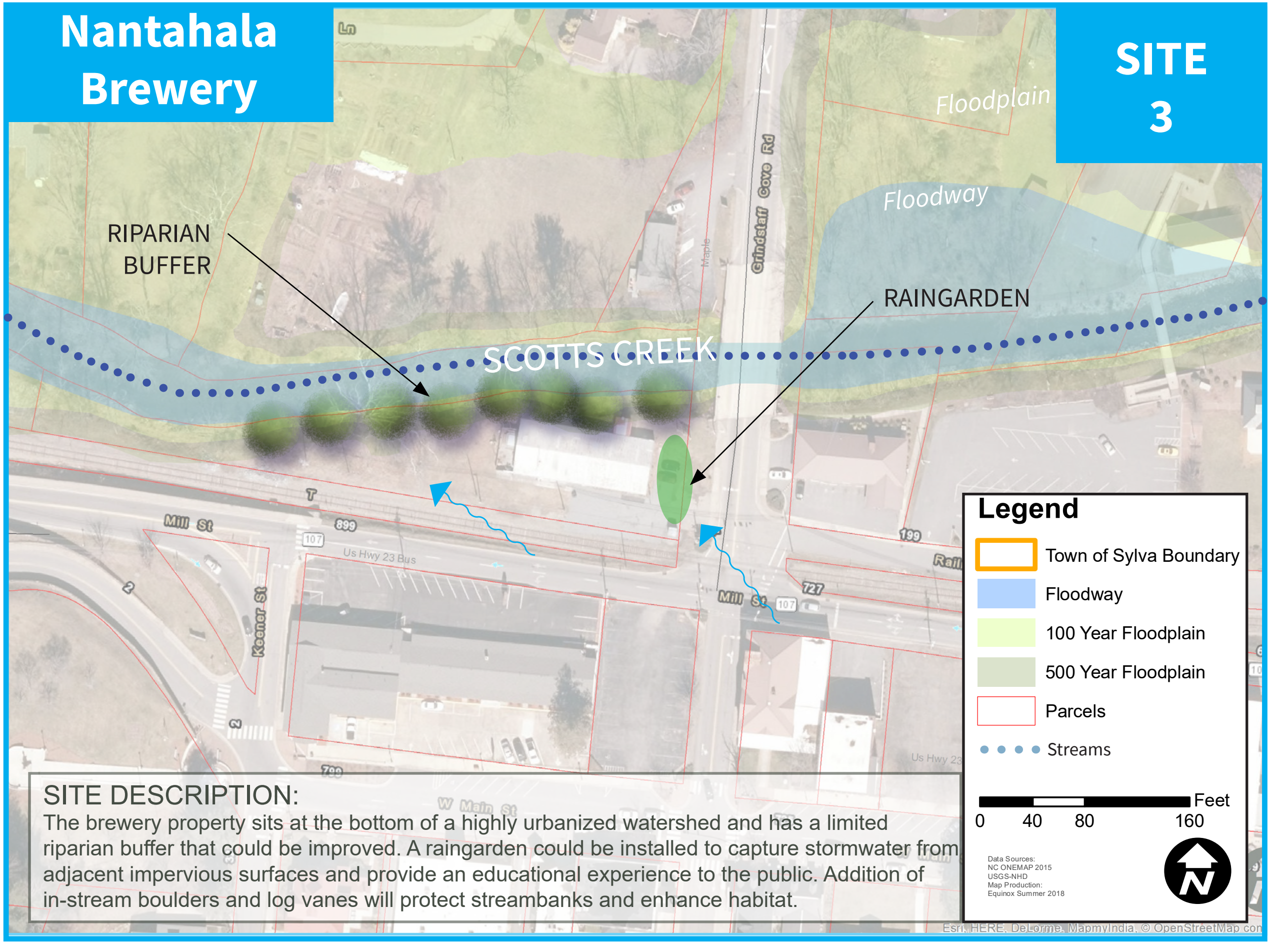


SITE DESCRIPTION:

Bridge Park sits at the bottom of a highly urbanized watershed and is an excellent location for educating the public about the impacts of stormwater. A combination of stormwater treatment options could be combined to slow, treat and cool stormwater contributions prior to entering Scotts Creek. These include riparian buffer enhancements, bioswales, and bioretention cells. The addition of in-stream boulders and log vanes will protect streambanks and enhance habitat.

Nantahala Brewery

SITE 3



SITE DESCRIPTION:

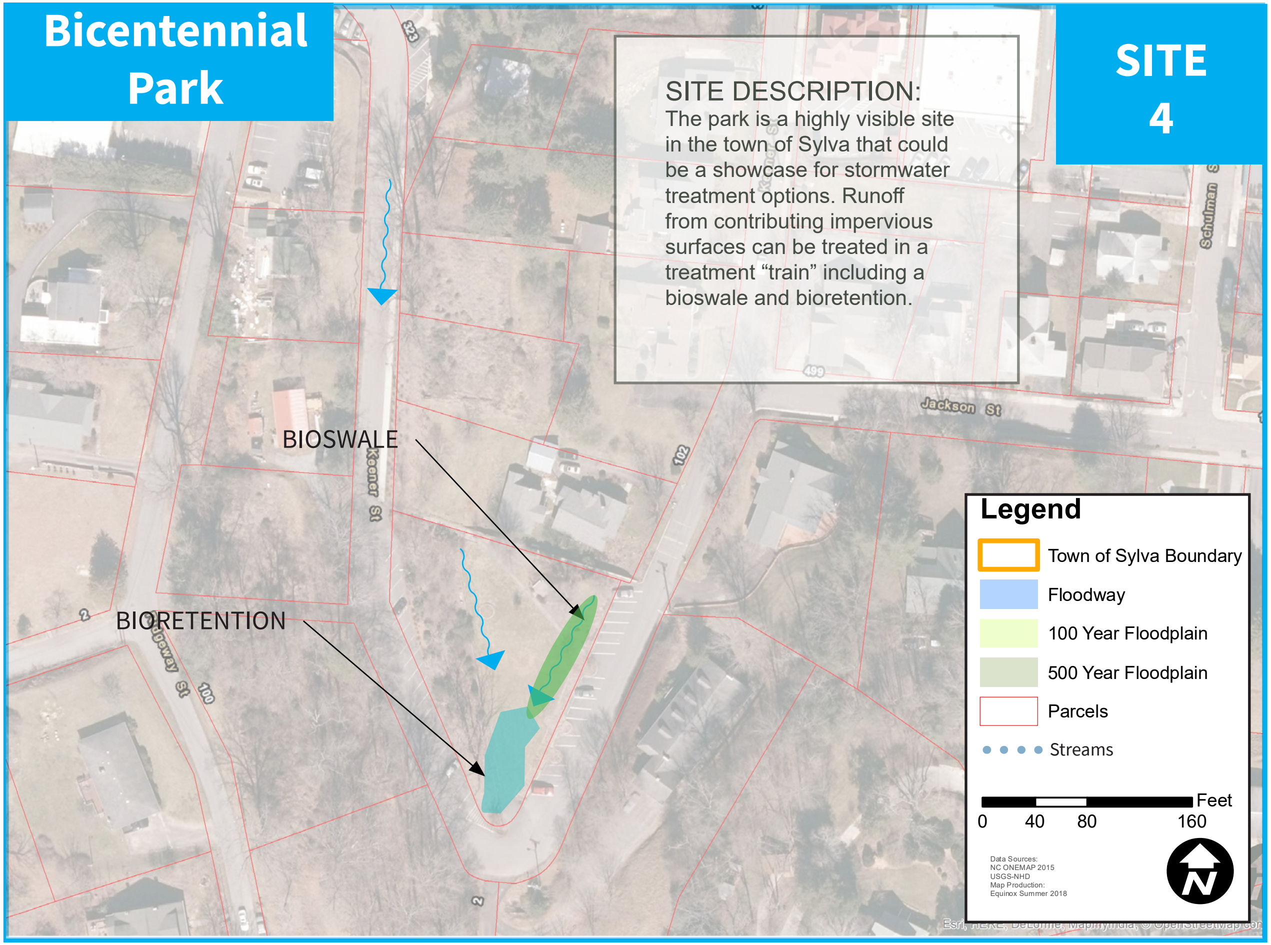
The brewery property sits at the bottom of a highly urbanized watershed and has a limited riparian buffer that could be improved. A raingarden could be installed to capture stormwater from adjacent impervious surfaces and provide an educational experience to the public. Addition of in-stream boulders and log vanes will protect streambanks and enhance habitat.

Bicentennial Park

SITE 4

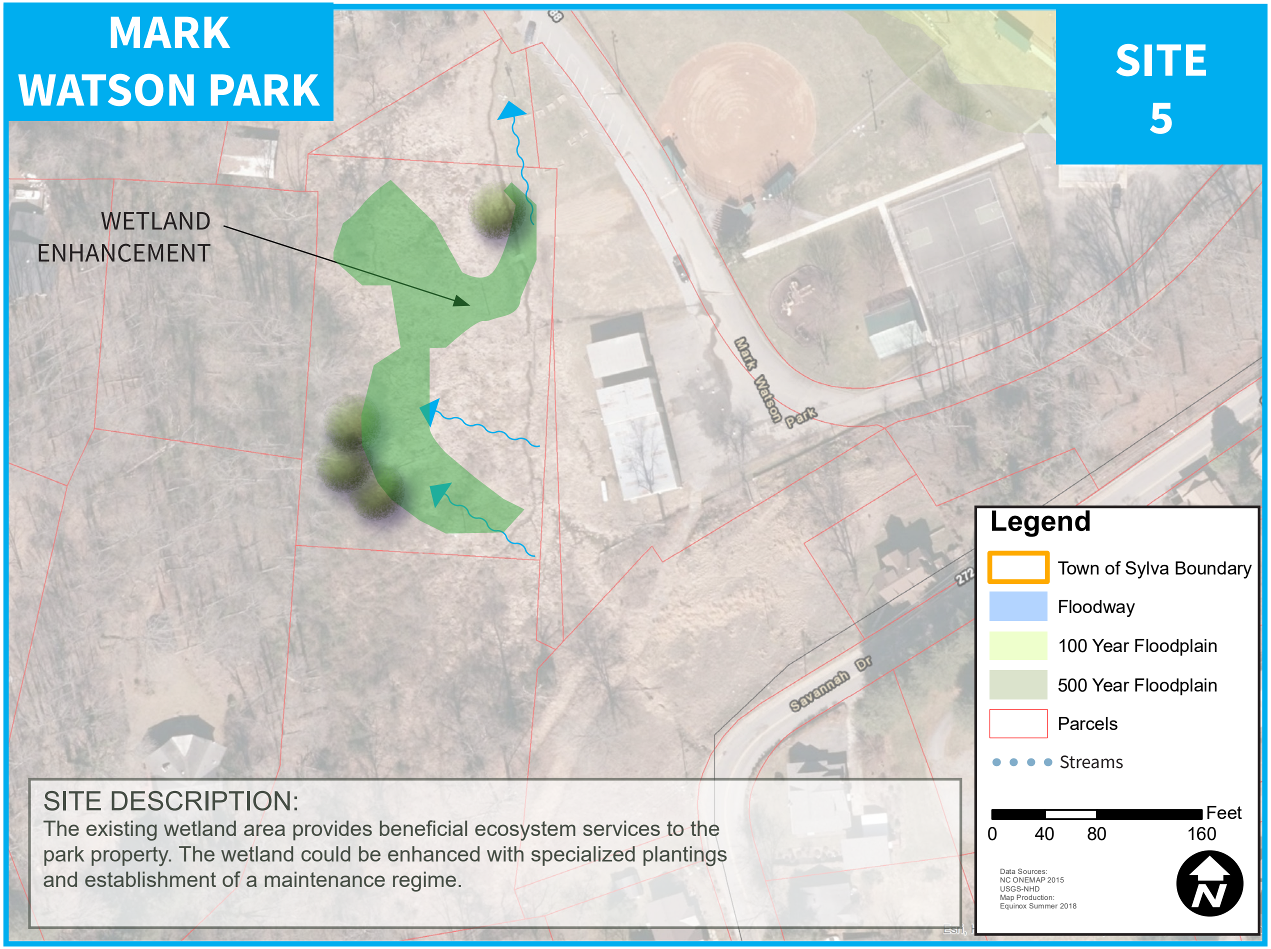
SITE DESCRIPTION:

The park is a highly visible site in the town of Sylva that could be a showcase for stormwater treatment options. Runoff from contributing impervious surfaces can be treated in a treatment “train” including a bioswale and bioretention.



MARK WATSON PARK

SITE 5

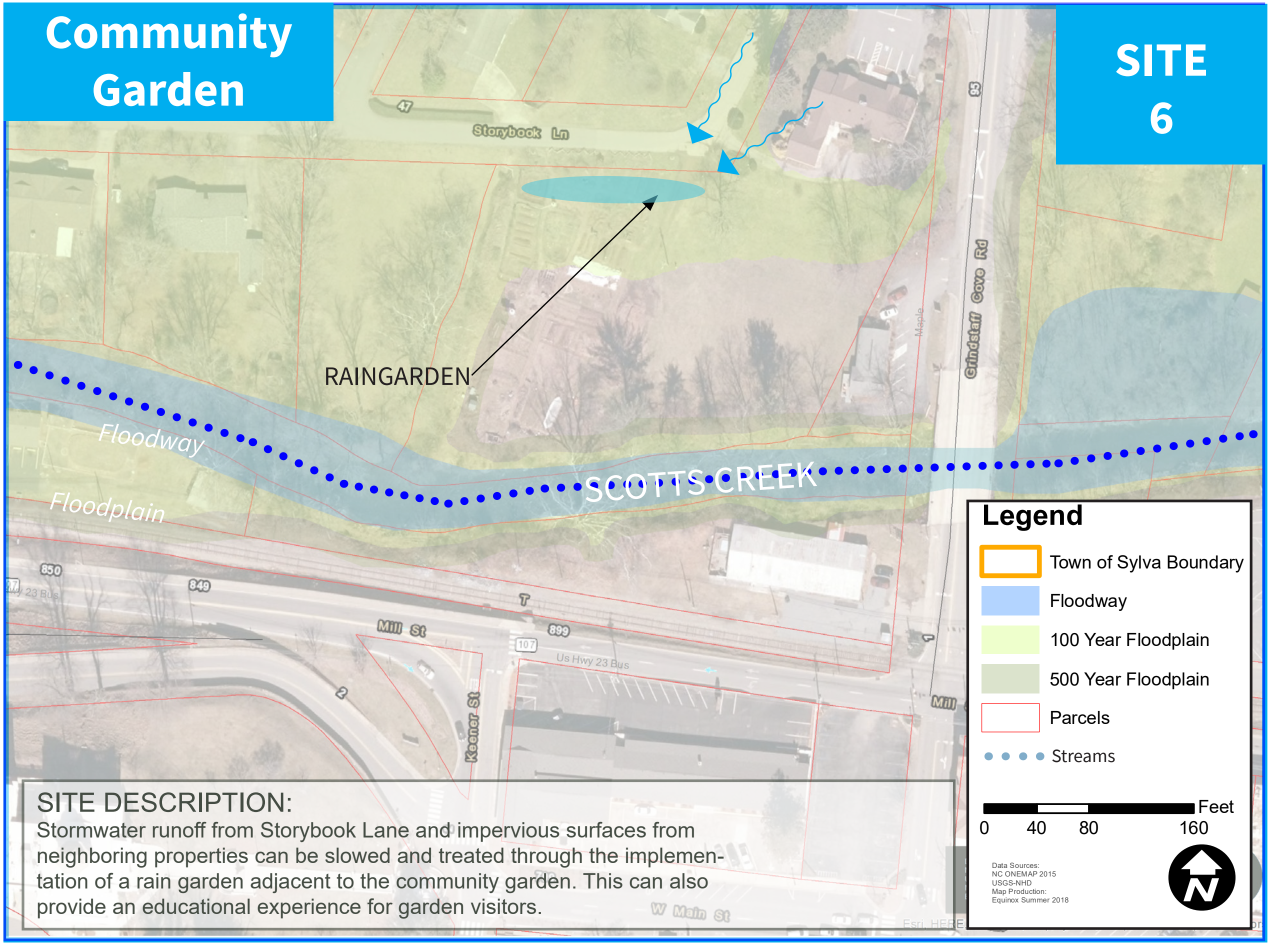


SITE DESCRIPTION:

The existing wetland area provides beneficial ecosystem services to the park property. The wetland could be enhanced with specialized plantings and establishment of a maintenance regime.

Community Garden

SITE 6

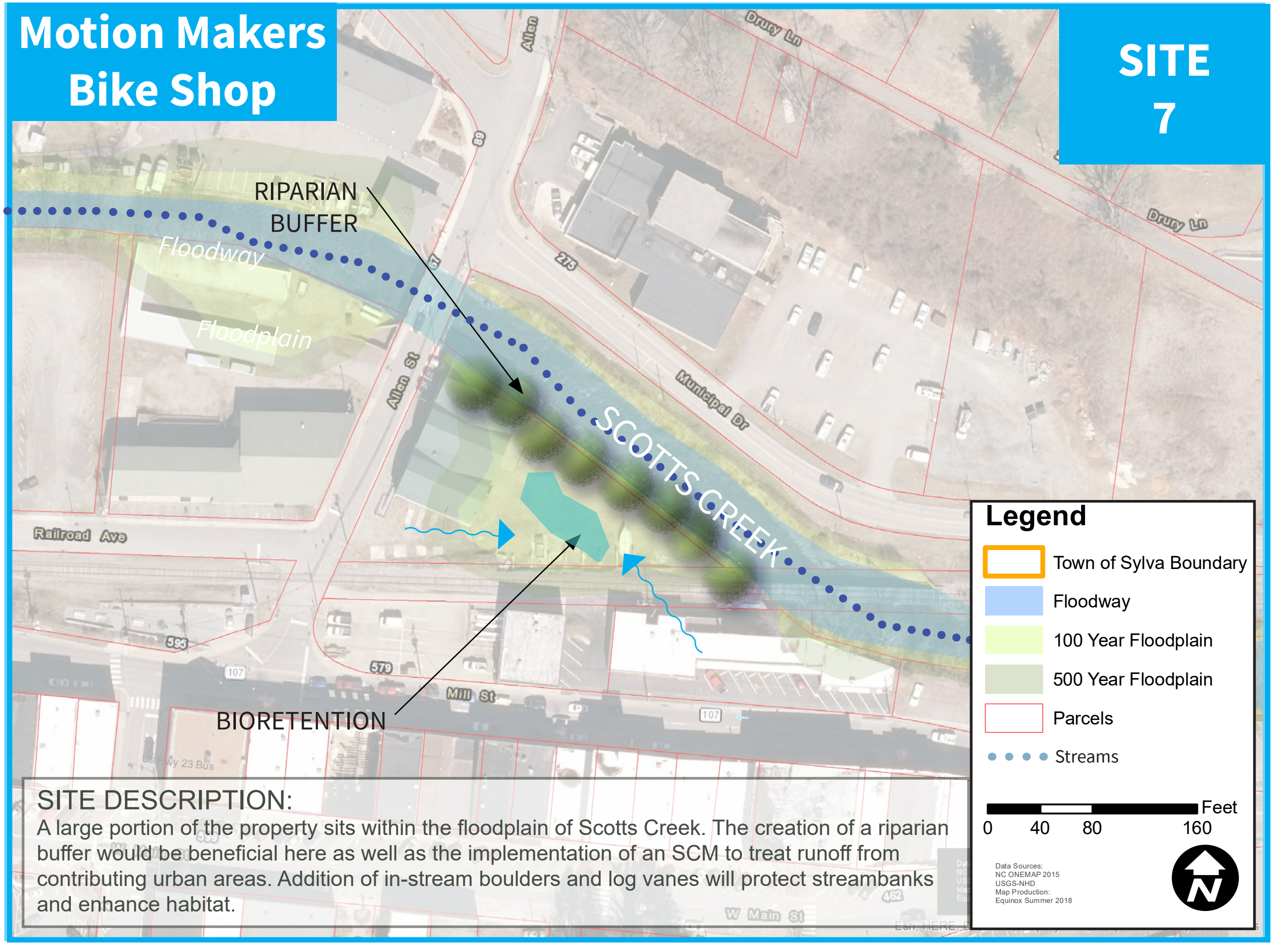


SITE DESCRIPTION:

Stormwater runoff from Storybook Lane and impervious surfaces from neighboring properties can be slowed and treated through the implementation of a rain garden adjacent to the community garden. This can also provide an educational experience for garden visitors.

Motion Makers Bike Shop

SITE 7

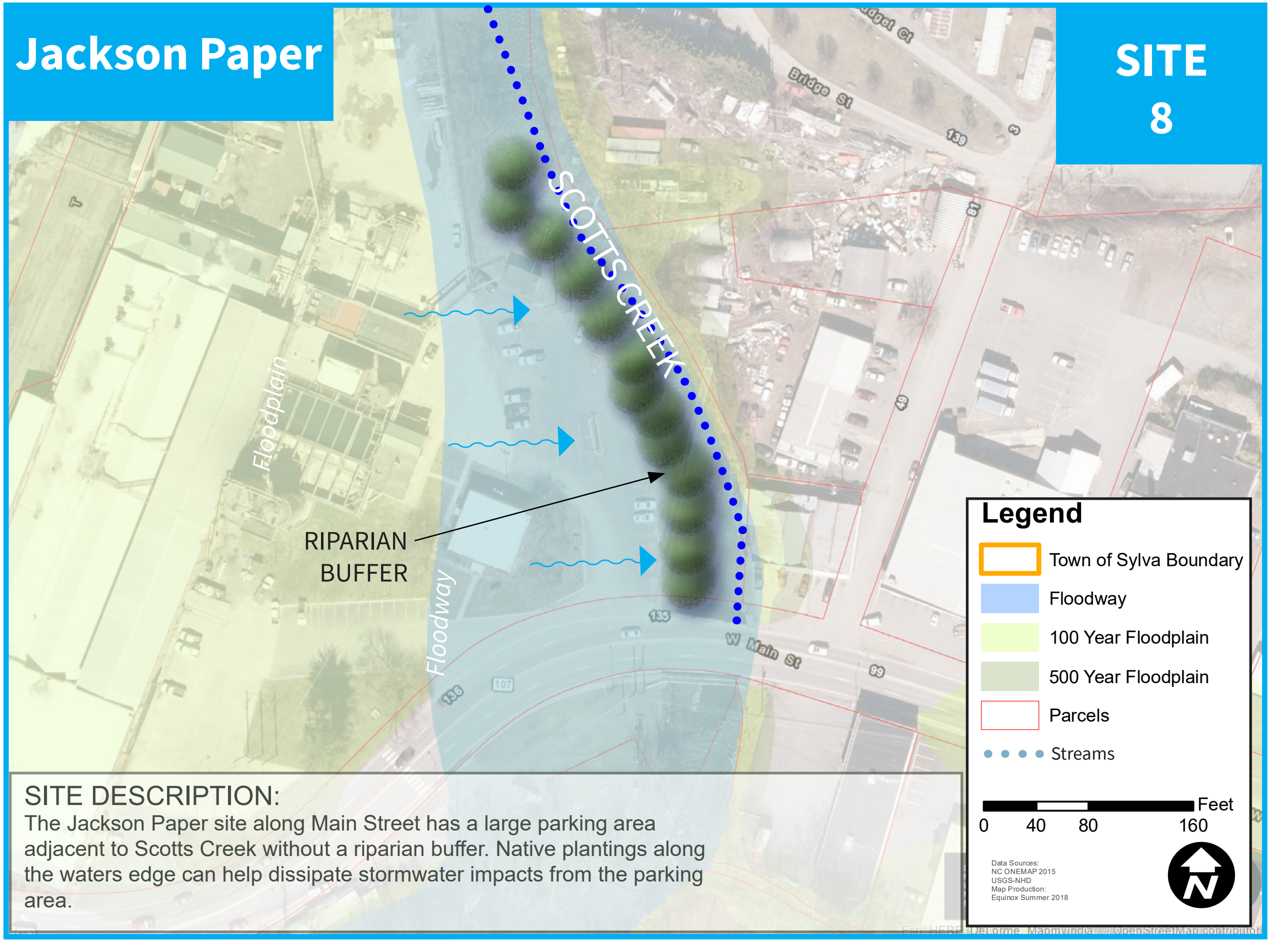


SITE DESCRIPTION:

A large portion of the property sits within the floodplain of Scotts Creek. The creation of a riparian buffer would be beneficial here as well as the implementation of an SCM to treat runoff from contributing urban areas. Addition of in-stream boulders and log vanes will protect streambanks and enhance habitat.

Jackson Paper

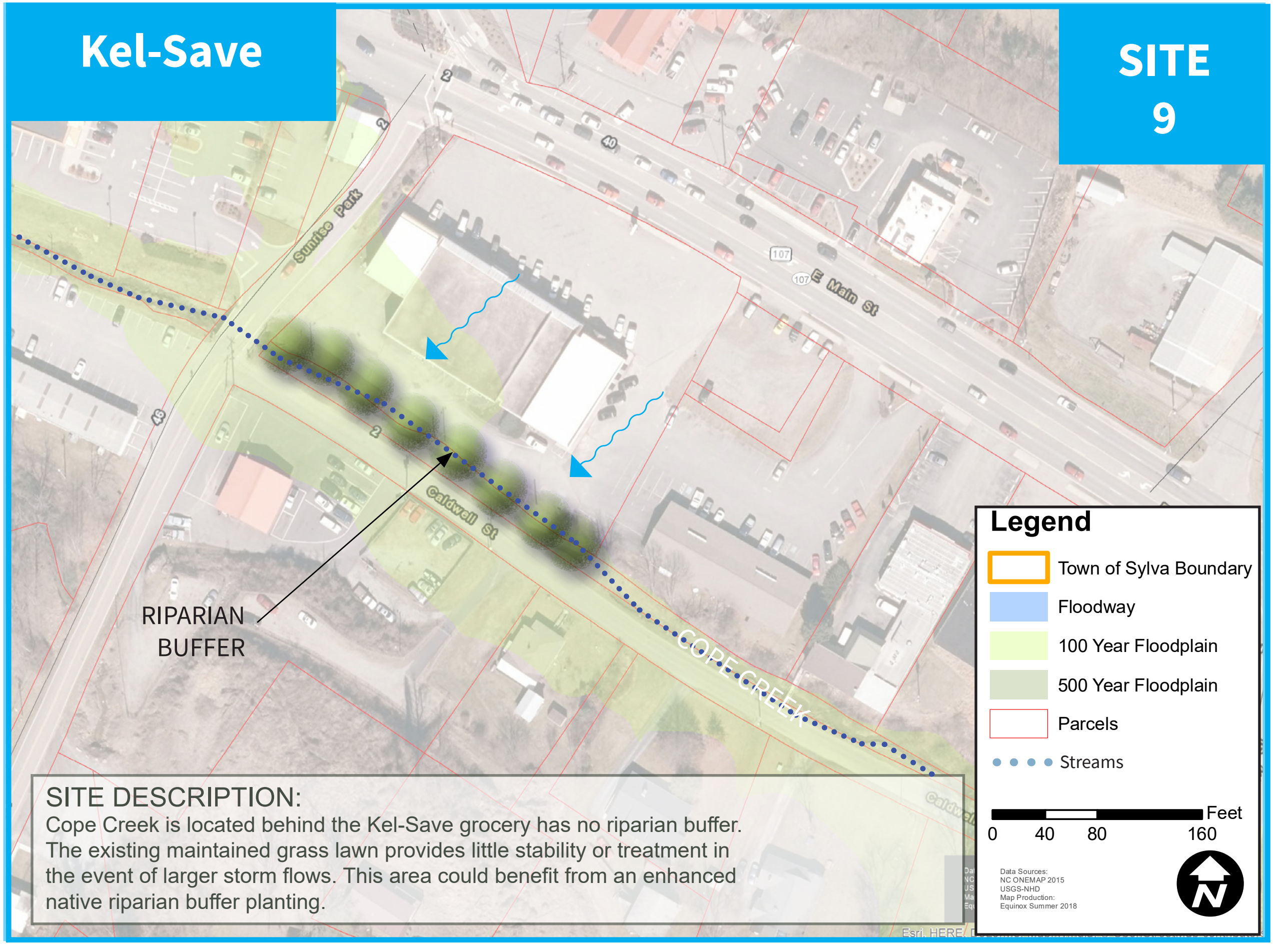
SITE 8



SITE DESCRIPTION:
The Jackson Paper site along Main Street has a large parking area adjacent to Scotts Creek without a riparian buffer. Native plantings along the waters edge can help dissipate stormwater impacts from the parking area.

Kel-Save

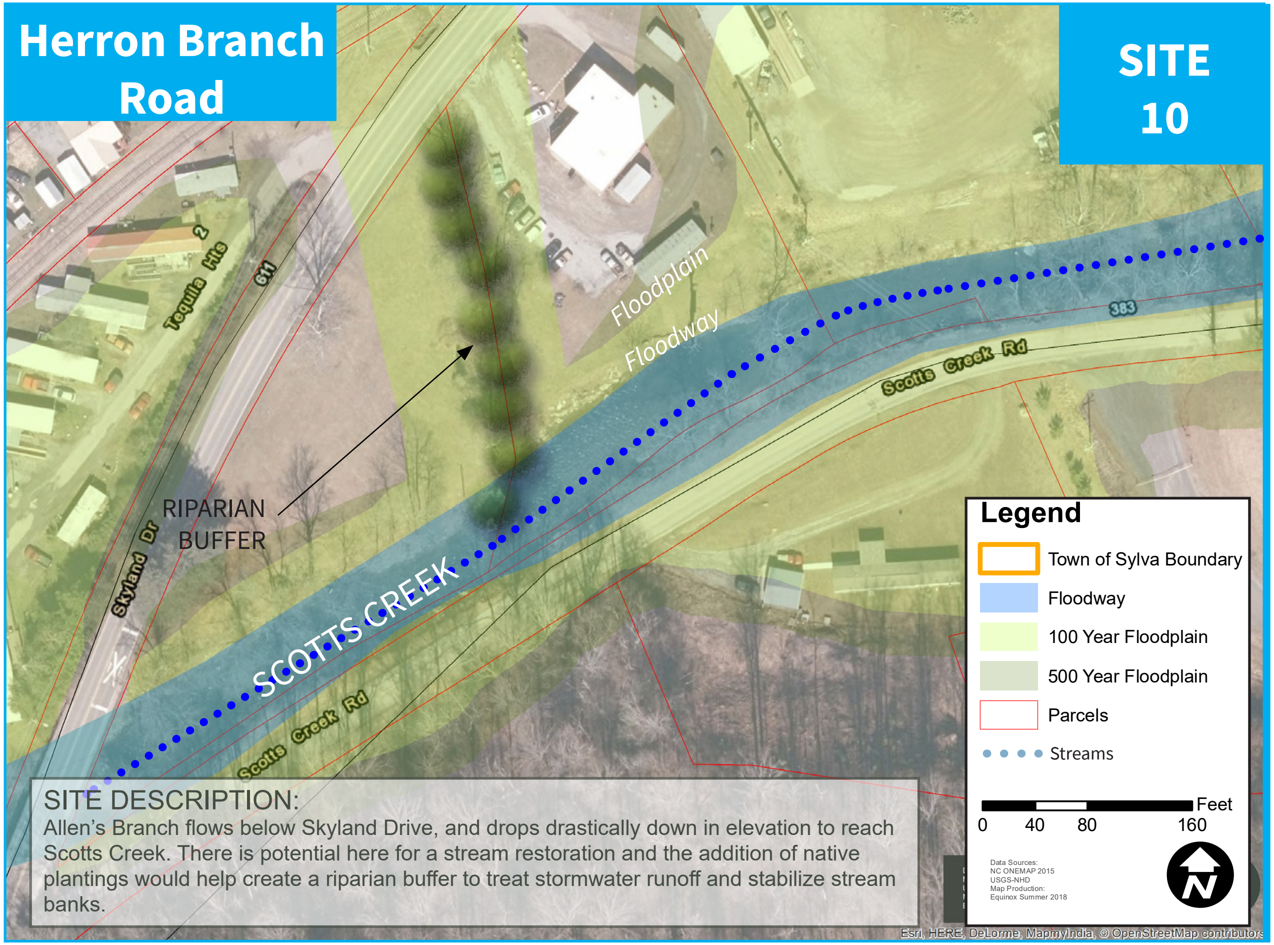
SITE 9



SITE DESCRIPTION:
Cope Creek is located behind the Kel-Save grocery has no riparian buffer. The existing maintained grass lawn provides little stability or treatment in the event of larger storm flows. This area could benefit from an enhanced native riparian buffer planting.

Herron Branch Road

SITE 10

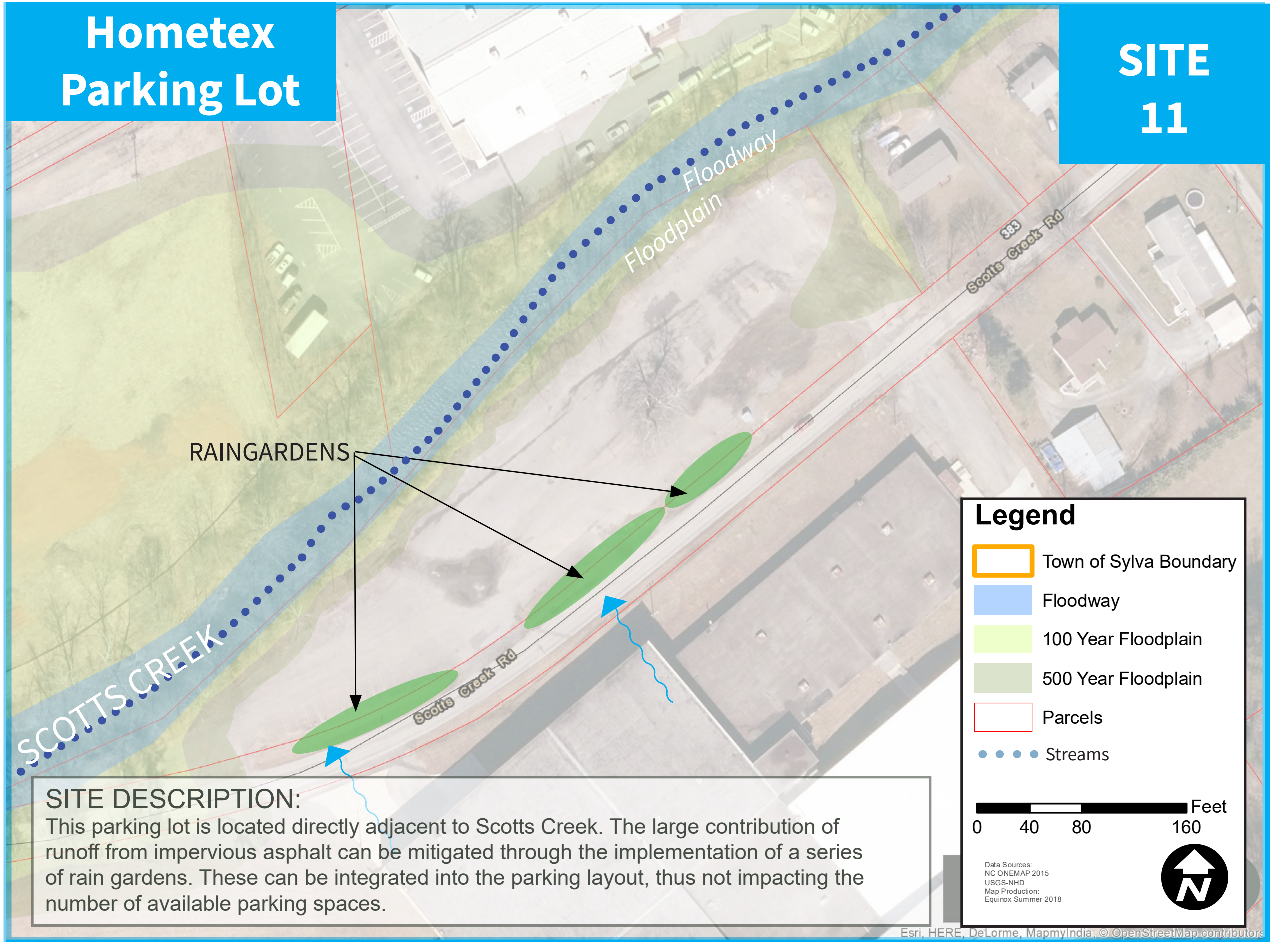


SITE DESCRIPTION:

Allen's Branch flows below Skyland Drive, and drops drastically down in elevation to reach Scotts Creek. There is potential here for a stream restoration and the addition of native plantings would help create a riparian buffer to treat stormwater runoff and stabilize stream banks.

Hometex Parking Lot

SITE 11



SITE DESCRIPTION:

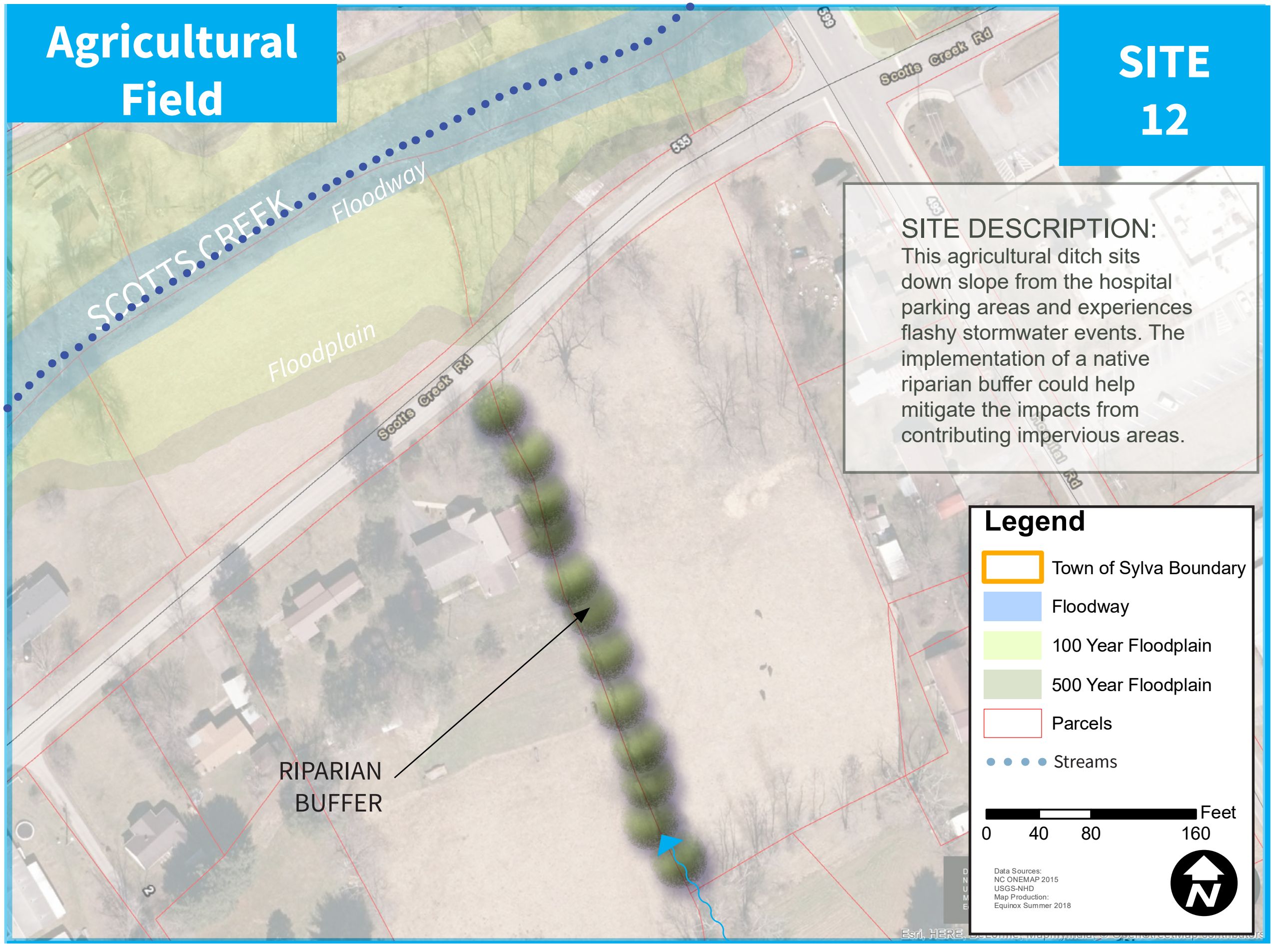
This parking lot is located directly adjacent to Scotts Creek. The large contribution of runoff from impervious asphalt can be mitigated through the implementation of a series of rain gardens. These can be integrated into the parking layout, thus not impacting the number of available parking spaces.

Agricultural Field

SITE 12

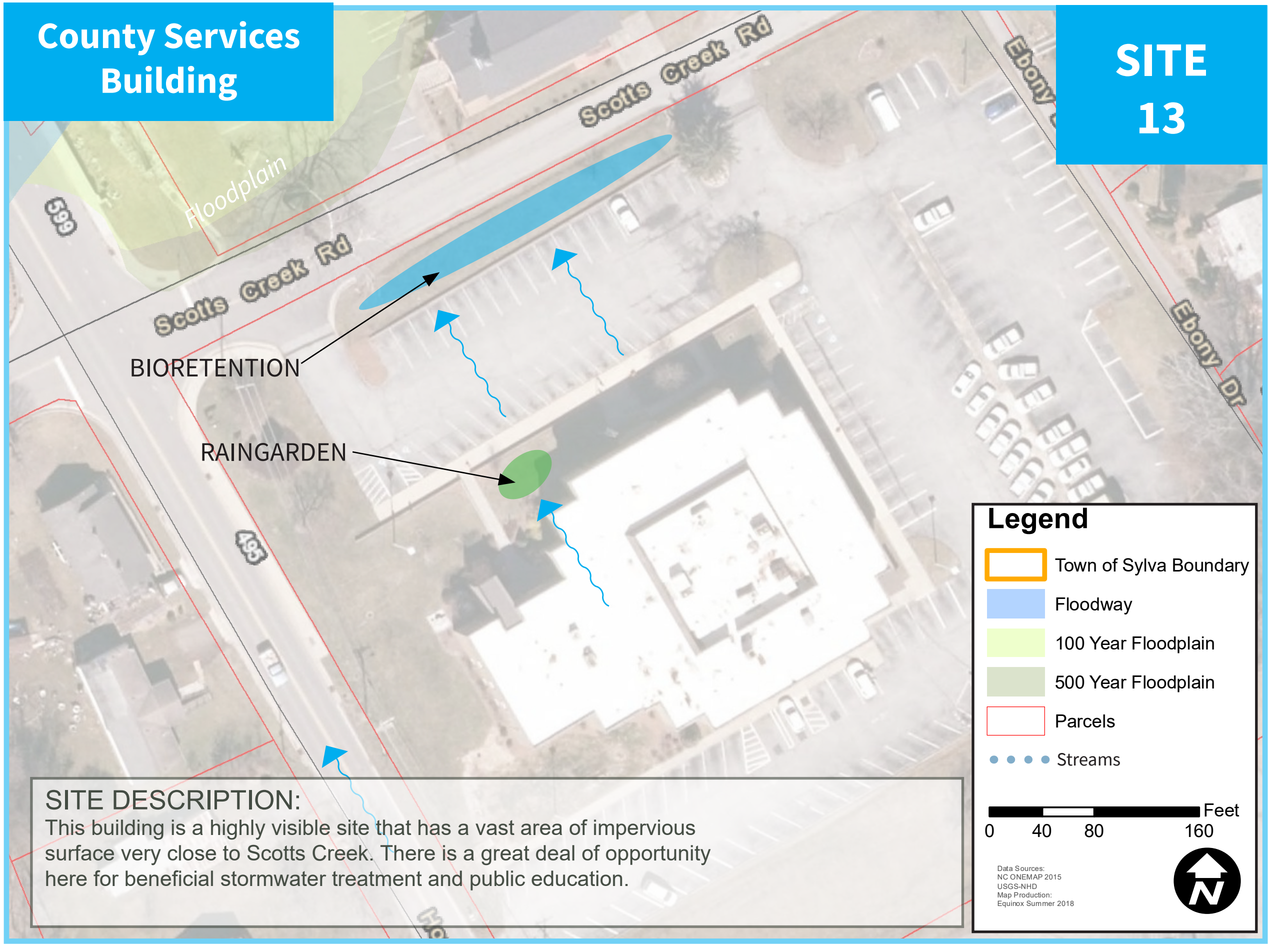
SITE DESCRIPTION:

This agricultural ditch sits down slope from the hospital parking areas and experiences flashy stormwater events. The implementation of a native riparian buffer could help mitigate the impacts from contributing impervious areas.

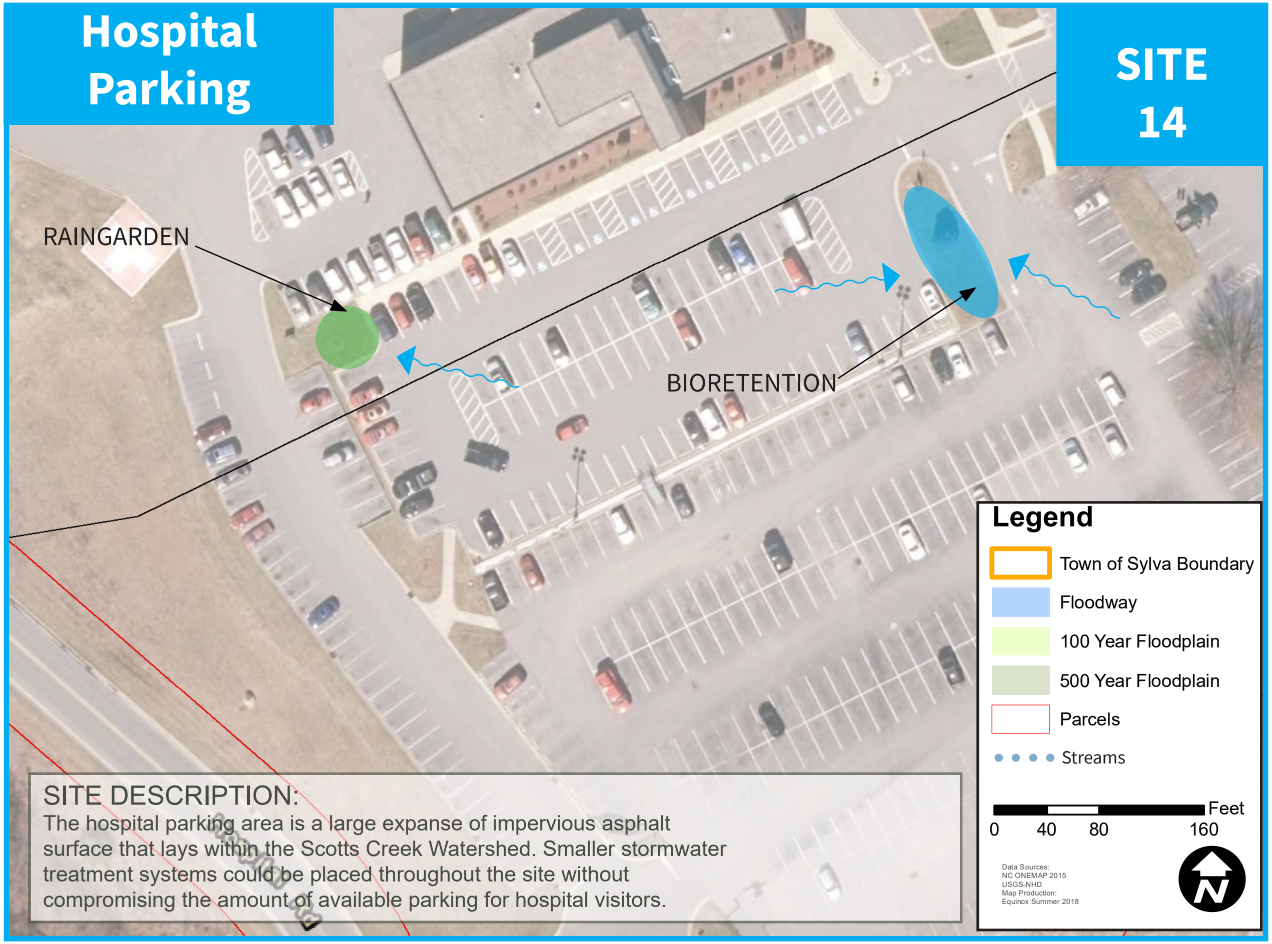


County Services Building

SITE 13



SITE DESCRIPTION:
This building is a highly visible site that has a vast area of impervious surface very close to Scotts Creek. There is a great deal of opportunity here for beneficial stormwater treatment and public education.

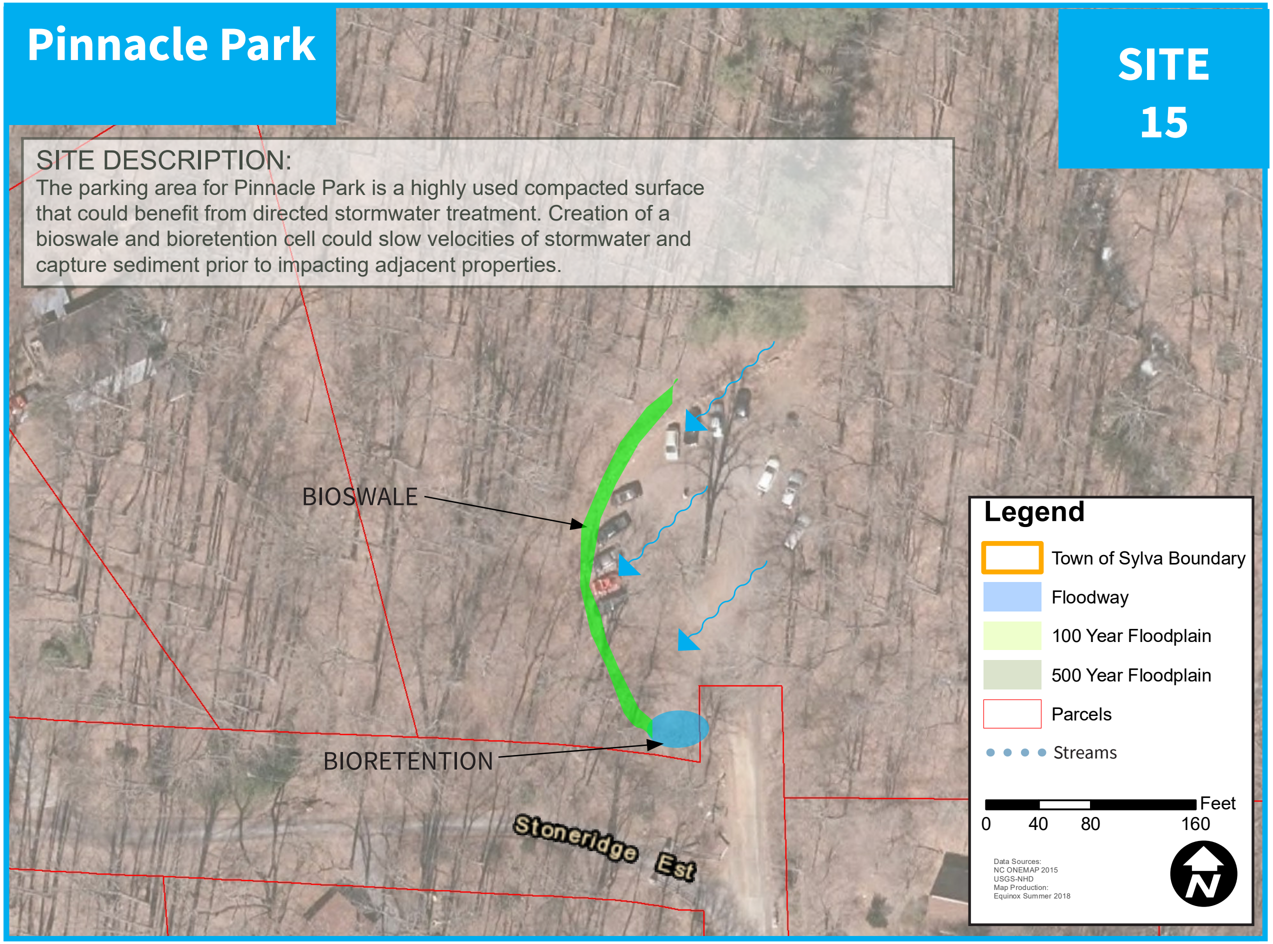


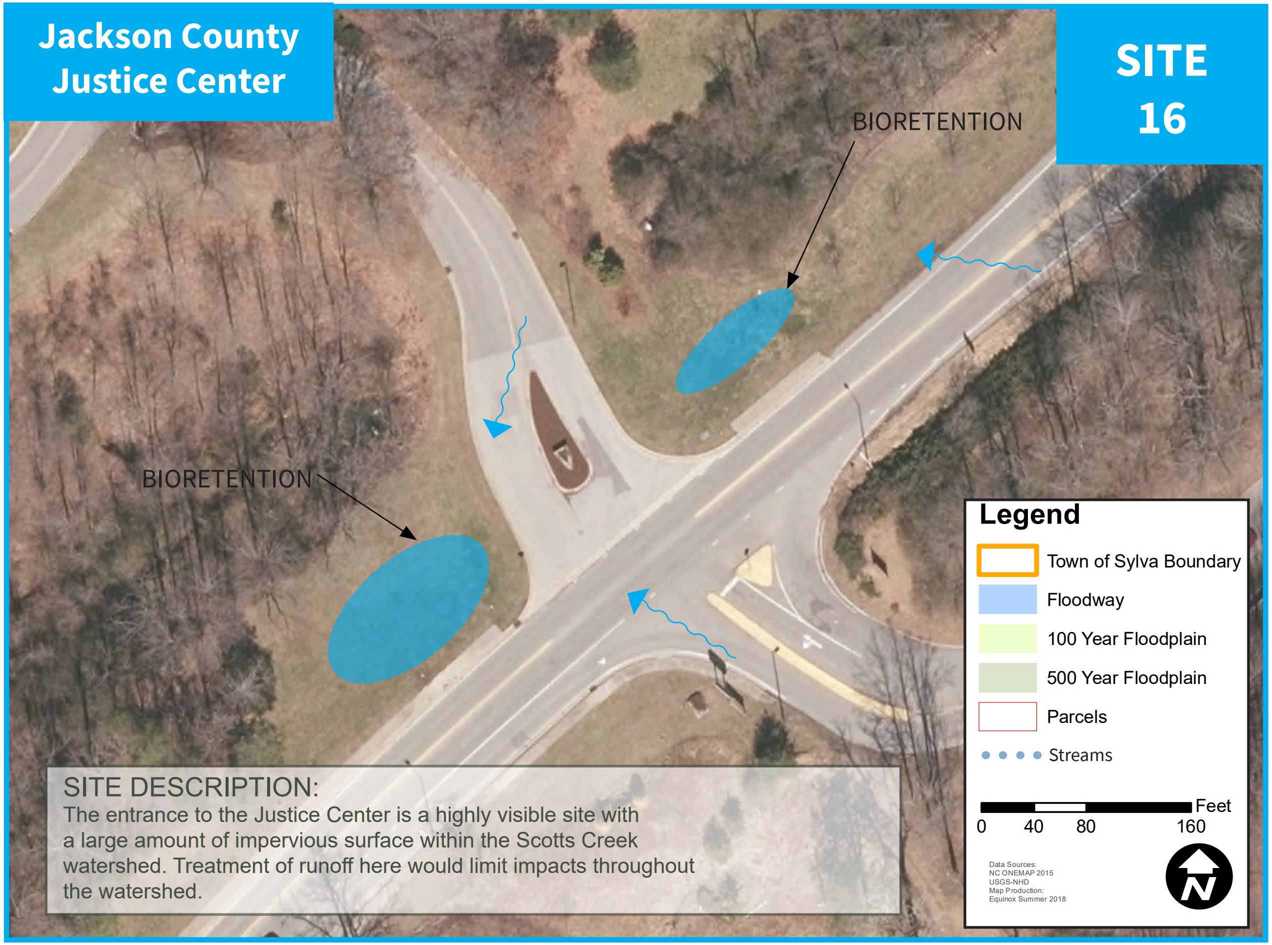
SITE DESCRIPTION:
The hospital parking area is a large expanse of impervious asphalt surface that lays within the Scotts Creek Watershed. Smaller stormwater treatment systems could be placed throughout the site without compromising the amount of available parking for hospital visitors.

Pinnacle Park

SITE 15

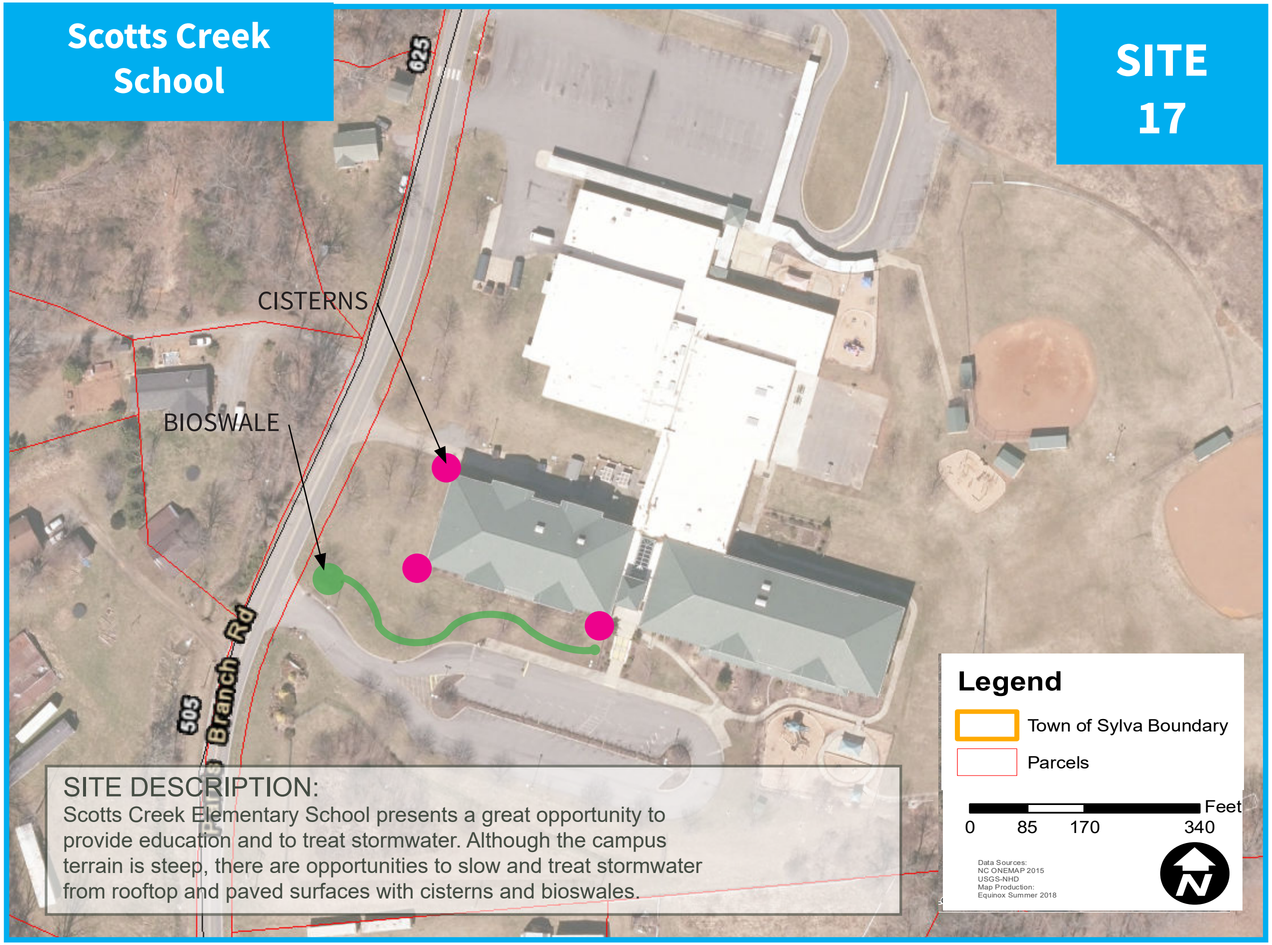
SITE DESCRIPTION:
The parking area for Pinnacle Park is a highly used compacted surface that could benefit from directed stormwater treatment. Creation of a bioswale and bioretention cell could slow velocities of stormwater and capture sediment prior to impacting adjacent properties.




Jackson County Justice Center
SITE 16
BIORETENTION
BIORETENTION
Legend
Town of Sylva Boundary
Floodway
100 Year Floodplain
500 Year Floodplain
Parcels
Streams
Feet
0 40 80 160
Data Sources:
NC ONEMAP 2015
USGS-NHD
Map Production:
Equinox Summer 2018
N
SITE DESCRIPTION:
The entrance to the Justice Center is a highly visible site with a large amount of impervious surface within the Scotts Creek watershed. Treatment of runoff here would limit impacts throughout the watershed.

Scotts Creek School

SITE 17



SITE DESCRIPTION:

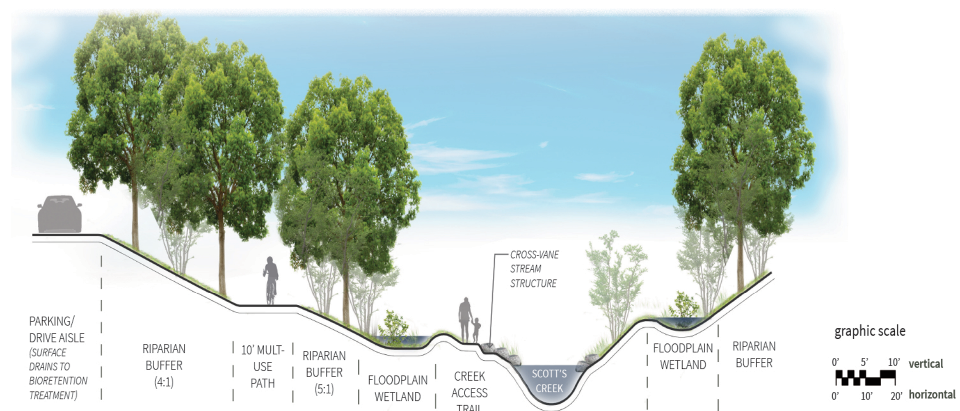
Scotts Creek Elementary School presents a great opportunity to provide education and to treat stormwater. Although the campus terrain is steep, there are opportunities to slow and treat stormwater from rooftop and paved surfaces with cisterns and bioswales.

Bridge Park Concept

CONCEPTUAL PLAN LEGEND

1. BIORETENTION CELL AT EXISTING PIPE OUTFALL
2. STORMWATER TREATMENT VIA BIORETENTION IN PARKING LOT ISLAND
3. RECONFIGURED PARKING LOT TO REDUCE IMPERVIOUS SURFACE (TOTAL 44 SPACES)
4. RIPARIAN BUFFER WITH MATURE TREES
5. MULTI-USE PATH (10')
6. SEATING AREA & CREEK OVERLOOK
7. FOOTPATH TO CREEK
8. FLOODPLAIN LINEAR WETLANDS
9. CROSS VANE (STRUCTURE) AT CREEK ACCESS
10. PROPOSED PICNIC SHELTER (DEMO EXISTING BUILDING)
11. PROPOSED SPLIT RAIL FENCE
12. MULTI-USE PATH CONNECTION TO BRIDGE AND POTEET PARK
13. RETROFIT EXISTING STAGE WITH RAINWATER COLLECTION SYSTEM (CISTERNS OR RAIN BARRELS
14. SIDEWALK AND GREENWAY CONNECTION
15. ENHANCED RIPARIAN BUFFER WITH MATURE TREES
16. STORMWATER RAINGARDEN/SWALE
17. RECONFIGURED BUS PARKING & PARKING LOT ENTRANCE TO REDUCE IMPERVIOUS SURFACE
18. LOG VANES (STRUCTURES) FOR STREAMBANK PROTECTION AND HABITAT ENHANCEMENT (SPACED 60'-80' APART)
19. POTENTIAL STAIR ACCESS & MULTI-USE PATH
20. *OPTIONAL STORMWATER TREATMENT-* IF STORAGE BUILDING IS DEMOLISHED, UTILIZE AREA FOR FOODPLAIN STORAGE VIA STORMWATER POND (DASHED BOUNDARY)

graphic scale 0 15' 30'



A TYPICAL CREEK CROSS-SECTION

BRIDGE PARK STORMWATER CONCEPTUAL PLAN

SCOTT'S CREEK WATERSHED PLAN

EQUINOX
balance through proper planning

Bridge Park Stormwater

Example Imagery

BIORETENTION

RIPARIAN BUFFER

FLOODPLAIN WETLAND

RAINWATER COLLECTION

Task	MONTH																
	2019												2020				
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
Bridge Park Stormwater Updates																	
Task 1: Design Development																	
1.1 Kick-off Meeting with Steering Committee (Meeting & Prep)	■																
1.2 Steering Committee Progress Meeting to Review Draft Plan					■												
Task 2: Construction Documents																	
2.1 Develop Base Maps (Survey, Natural & Built Environment)		■	■														
2.2 Construction Document Preparation				■	■	■	■	■									
Task 3: Permitting																	
3.1 401-404 Permit Application Process								■	■	■	■						
3.2 Stormwater & Erosion Control									■	■							
3.3 Trout Buffer Waiver									■	■							
3.3 Jackson County Planning & Development									■	■							
Task 4: Construction																	
4.1 Construction Bidding												■	■				
4.2 Stormwater & Park Construction														■	■	■	■
4.3 Stream Restoration Construction (Mar-Nov only)															■	■	■

BRIDGE PARK COST ESTIMATE

October 26, 2018

ITEM#	ITEM	UNIT	QUANTITY	ESTIMATED UNIT COST	ESTIMATE	TOTAL COST
	A	B	B		C	E
	Mobilization (3% of total)	LS	1	$ 7,124.10	$ 7,124.10	$ 7,124.10
	STORM					
	Flashboard Riser	EA	2	3,500.00	$7,000	$37,436
	HDPE pipe	LF	177	48.00	$8,496	
	Bioretention Media (2246 sf, 2' deep)	CY	166	60.00	$9,960	
	Concrete Drop Inlet	EA	2	1,500.00	$3,000	
	Cisterns	EA	2	1,200.00	$2,400	
	Gutters	LF	120	14.00	$1,680	
	Concrete Head Wall	EA	1	1,500.00	$1,500	
	Underdrains	LF	100	4.00	$400	
	Bioretention Grading	LS	1	3,000.00	$3,000	
				TOTAL	$37,436	
	SITE AMENITIES					
	Asphalt Paving	SY	1,687	$40.00	$67,480	$162,913
	Handicapped Parking Signage (including concrete footer)	EA	2	$1,000.00	$2,000	
	Wheel stops	EA	44	$77.00	$3,388	
	Shelter (900 SF)	EA	1	$50,000.00	$50,000	
	Picnic Tables	EA	2	$1,200.00	$2,400	
	Natural Surface Trail (3' Wide eath trail)	LF	80	$20.00	$1,600	
	Concrete Sidewalk	SY	559	$55.00	$30,745	
	Split Rail Fencing	LF	100	$53.00	$5,300	
				TOTAL	$162,913	
	EROSION CONTROL AND PLANTING					
	Shrubs (5 gal containers)	EA	15	$ 75.00	$ 1,125.00	$ 22,521.00
	Shrubs (3 Gal containers)	EA	15	$ 45.00	$ 675.00	
	Bioretention Plantings (6.7 c.u. plus or equal)	EA	2,594	$ 4.00	$ 10,376.00	
	Livestakes	EA	2000	$ 3.00	$ 6,000.00	
	Silt Fence	LF	560	$ 3.75	$ 2,100.00	
	Tree Protection Fence	LF	150	$ 3.20	$ 480.00	
	Inlet Protection	EA	3	$ 165.00	$ 495.00	
	Outlet Protection	EA	2	$ 635.00	$ 1,270.00	
				TOTAL	$ 22,521.00	
	PARK DESIGN, PERMITTING, AND MAINTENANCE					
	Design Fee	LS	1	$ 13,400.00	$ 13,400.00	$ 14,600.00
	Permitting (Erosion Control, NCDOT, Etc.)	LS	1	$ 1,200.00	$ 1,200.00	
				TOTAL	$ 14,600.00	
					Stormwater Sub-total	$244,594
	STREAM RESTORATION					
	Stream Restoration Excavation, boulder and log structures, bank stabilization (HIGHER COST)	LS	1	$200,000.00	$200,000	
	Stream Restoration Excavation, boulder and log structures, bank stabilization (LOWER COST)	LS	1	$120,000.00	$120,000	
	Floodplain wetland (HIGHER COST)	LS	1	$40,000.00	$40,000	
	Floodplain wetland (LOWER COST)	LS	1	$20,000.00	$20,000	
	Riparian Vegetation (HIGHER COST)	LS	1	$20,000.00	$20,000	
	Riparian Vegetation (LOWER COST)	LS	1	$10,000.00	$10,000	
	Engineering and Permitting (including Floodplain Permit Modeling) (HIGHER COST)	LS	1	$60,000.00	$60,000	
	Engineering and Permitting (including Floodplain Permit Modeling) (LOWER COST)	LS	1	$40,000.00	$40,000	
		COST RANGE:		TOTAL (HIGH)	$320,000	
				TOTAL (LOW)	$190,000	
					Sub-total (Low End)	$434,594
					Sub-total (High End)	$999,188
	TOTAL WITH 20% DESIGN CONTINGENCY (Low End)					**$521,513**
	TOTAL WITH 20% DESIGN CONTINGENCY (High End)					**$1,199,026**

Abbreviations:

EA	Each
LS	Lump Sum
SF	Square Foot
LF	Linear Foot
CF	Cubic Foot
CY	Cubic Yard
TN	Ton
SY	Square Yard

Note: All costs are approximate for 2018-2019 and should be revised to include fluctuations in market costs.

EQUINOX

NOTES:

1. All costs are approximate and include install.

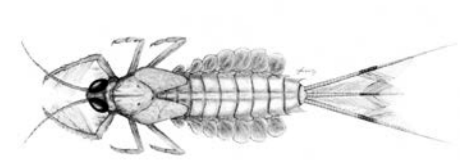
ATTACHMENT B: BENTHIC INSECT SUMMARY

Scotts Creek Project

Penrose Environmental

August, 2018

Background. Penrose Environmental was subcontracted by Equinox Environmental to help with the baseline determination of water quality conditions and storm water impacts in the Scotts Creek watershed. Our scope of work includes the collection and evaluation of benthic macroinvertebrate populations from five monitoring locations in the watershed. Benthic invertebrates, or aquatic insects, comprise a heterogeneous assemblage of taxa that inhabit the sediment or live on or in other bottom substrates in the aquatic environment **(**Klemm et. al. 1990). They vary in size from forms small and difficult to see without magnification to other individuals large enough to see without difficulty. Benthic invertebrates are large enough to be seen without magnification and can be retained by a U.S. Standard No. 30 sieve and live at least part of their life cycles within or on the substrate. These organisms are effective assessment tools for many reasons (Plafkin et.al. 1989). This community of aquatic organisms is found in all aquatic habitats including very small perennial stream systems (1st and 2nd order), which normally support a very limited fish fauna. Benthic macroinvertebrates are easily and inexpensively collected. These communities integrate the effects of short-term environmental perturbations. Sensitive species respond quickly to stress, while community shifts are generally more long-term. In addition, benthic macroinvertebrate communities respond to the various types of water pollution in predictable fashions (Hocutt 1975) and are important in the diets of most fish species. The Scotts Creek watershed is reference quality and only minor sources of perturbation are evident based on the observed biological assemblages.



Methods and metrics. The Scotts Creek watershed is a relatively small watershed which suggests the use of a modification of the full-scale collection protocol developed by the Division of Water Resources. This collection protocol is defined in the DWR Standard Operating Procedure (DWR 2016) and termed a "Qual 4". The "Qual-4" requires a kick net sample from a riffle habitat, a sweep net sample from a stream bank and a leaf pack sample. In addition, a visual inspection of the collection site is also conducted to look for more cryptic organisms. Organisms are picked roughly in proportion to their abundance, but no attempt is made to remove all organisms. If an organism can be reliably identified as a single taxon in the field, then no more than 10 individuals need to be collected. Some organisms are not picked, even if found in the samples, because abundance is difficult to quantify or because they are most often found on the water surface or on the banks and are not truly benthic. Organisms are classified as Abundant if 10 or more specimens are collected, Common if 3-9 specimens are collected, and Rare if 1-2 specimens are collected. This collection protocol will require approximately 1.5 to 2.0 hours at each location with a field team of at least two trained collectors. Samples are processed in the field and taken back to the Penrose Environmental lab in Asheville for identification and summary. Identification of each sample required approximately 2.0 hours.

The simplest method of data analysis is the tabulation of species richness (number of species), and species richness is the most direct measure of biological diversity. The association of good water quality with high species (or taxa) richness has been thoroughly documented. Increasing levels of pollution gradually eliminate the more sensitive species, leading to lower and lower species richness. EPT (Ephemeroptera, Plecoptera and Trichoptera) is the primary metric used to evaluate small mountain streams. However, the NC Division of Water Resources recommends the use of small stream classification criteria if the watershed is less than 3.0 square miles in size and relies exclusively on the calculated NCBI values. These criteria for mountain streams are summarized in Table 1. A seasonal correction factor may be required if the samples are collected out of the summer sampling season. Additional metrics include the total number of EPT taxa and EPT abundance, total taxa richness (Table 3), dominant and/or intolerant taxa and a biotic index value. Data were collected during a survey on July 19th, 2018 which documents “summer conditions,” and may require a

Table 1. Bioclassification Criteria for Small Mountain Streams

Bioclass	**NC Biotic Index**
Excellent	< 3.30
Good	3.30 – 4.73
Good/Fair	4.74 – 5.62
Fair	5.63 – 6.52
Poor	>6.52

seasonal adjustment to the NCBI value based on the NC DWR Standard Operating Procedures (NC DWR, 2016).

Station Locations. Benthic insects were collected from 5 locations in the Scotts Creek watershed. These sites and justifications are listed in Table 2. The sites were chosen based on the availability of riffle, bank, and sweep habitat within the chosen reach. High precipitation prior to the benthic survey limited available habitat and access to several locations. USGS water gauge data (waterdata@usgs.gov) and riverflows.net were monitored prior to the survey to reduce the effects of recent high-flows on benthic communities. At the time of the survey gauge levels in Scott's Creek read approximately 2.3ft.

Table 2. Benthic macroinvertebrate collection locations – 19 July, 2018

Station number	Location	Justification
SC #5	Un-named	Available habitat, pre-determined location
SC #3	Licklog and Scott's	Available habitat, pre-determined location
SC #11	Under Highway Bridge	Available habitat, pre-determined location
SC #4	Heirloom Dr.	Available habitat, pre-determined location
FP #1	Farmstead Park	Available habitat, pre-determined location

Results and Discussion. A summary of the species richness for all major groups of aquatic organisms is noted on Table 3 and a list of all taxa collected can be found on Appendix 1 of this report. Several intolerant EPT taxa (Ephemeroptera + Plecoptera + Trichoptera) and EPT abundance values were found at each of the five Scott's Creek locations. Biotic Index values range from 2.18 to 3.55, indicating "Good" to "Excellent" scores at all sampled locations. Bioclassification ratings for small streams in the mountain region based on Biotic Index values are listed in Table 1 (NC DWR., 2016).

Table 3. Summary of Benthic Macroinvertebrate Taxa. Scott's Creek, 19 July 2018					
Stream Name	SC #5	SC #3	SC #11	SC #4	FB #1
Total Taxa Richness	37	36	42	45	30
EPT Taxa Richness	30	29	32	33	21
Biotic Index	2.18	2.65	3.55	2.68	3.29

References

Hocutt, C. H. 1975. Assessment of a Stressed Macroinvertebrate Community. Water Resources Bulletin. 11(4):820-835.

Klemm, D. J., P. A. Lewis, F. Fulk and J. M. Lazorchak. 1990. Macroinvertebrate Field and Laboratory Methods For Evaluating The Biological Integrity Of Surface Waters. EPA/600/4-90-030.

North Carolina Division of Water Resources. Standard Operating Procedures for the Collection and Analysis of Benthic Maroinvertebrates. North Carolina Department of Environmental Quality. February, 2016

Plafkin, J. L., M. T. Barbour, K. D. Porter, S. K. Gross and R. M. Hughes. 1989. Rapid Bioassessment Protocols For Use In Streams And Rivers. EPA/444/4-89-001.

Appendix A, Species List

Scotts Creek, Jackson County, NC 7-9-18

Equinox Environmental

Jason York, Penrose Environmental

		Biotic Index Value	N. Fork Scotts Creek SC5	Licklog and Scotts SC3	SC#11 Under Bridge	SC #4 Heriloom Dr.	FP #1 Farmstead Park
Ephemeroptera							
	Acentrella parvula	4.8					
	Acentrella spp	2.5	R	R	C	C	C
	Baetis flavistriga	6.8	R				C
	Baetis pluto	3.4				C	
	Baetis tricaudatus	1.5	C	C	R	R	C
	Baetis sp.		C	C	C	C	
	Labiobaetis propinquus	5.8					R
	Drunella allegheniensis	0.3		R			
	Drunella walkeri	0.6	C	C		C	
	Serratella frisoni		R	C	R	C	
	Serratella serrata	1.4			C		R
	Teloganopsis deficiens	2.6		R	R		R
Heptageniidae	Cinygmula subaequalis	0		C			
	Epeorus dispar	1				R	
	Epeours subpallidus		R	R	R		C
	Epeorus vitreus	1.2			R	C	
	Heptagenia spp	1.9			R		
	Heptagenia pulla	2.2		C		C	
	Leucrocuta spp	2	C				
	Maccaffertium modestum	5.7	C	C		R	R
	Maccaffertium spp				R		
	Rhithrogena spp	0	R	R			
	Stenacron spp				R	R	
Isonychiidae	Isonychia spp	3.6		C			
	Isonychia serratta				C	R	
	Paraleptophlebia spp	1.2	R	R	R	R	
Capniidae	Allocapnia spp	3.3	C	C	R		C
Leuctridae	Leuctra spp	1.5	R				
Nemouridae	Amphinemura spp	3.8			R		

Peltoperlidae	Tallaperla spp	1.3	R	A	R	A	
Perlidae	Acroneuria abnormis	2.1	R	R		R	
	Agnetina flavescens		C	C	C	C	A
	Paragnetina immarginata	1.1	R		R	C	C
	Perlesta frisoni		R				
	Perlidae		R				
	Diploperla duplicata	2.8				R	
	Isoperla holochlora-light form	0.7		R	R	R	
	Malirekus hastatus	1	C	C	R	R	
	Pteronarcys spp	1.8	C	C	C	C	C
Brachycentridae	Brachycentrus appalachia	1	A	A		A	
	Glossosoma nigrior			C	R		
	Glossosoma spp	1.4	C	C		R	R
	Goera spp	0.7	R			R	
Helicopsychidae	Helicopsyche borealis	0					
Hydropsychidae	Arctopsyche irorata	0					
	Cheumatopsyche spp	6.6	R	C	A	C	R
	Diplectorn modestum						R
	Hydropsyche (H.) betteni/depravata			A	C	C	C
	Hydropsyche (C.) bronta	2.3			C	R	
	Hydropsyche (C.) morosa	2.3					R
	Hydropsyche (C.) sparna	2.5				C	C
Lepidostomatidae	Lepidostoma spp	1	C	C	C	C	R
	Oecetis spp	5.1			R		
	Pycnopsyche guttifer	2.2	R	R	C		
Odontoceridae	Psilotreta spp	0.5	R				
	Dolophilodes distincta	1	C	C	R	A	
	Polycentropus sensu lato spp	3.1					R
Psychomyiidae	Lype diversa	3.9			R		
	Rhyacophila fuscula	1.6	R			C	R
	Neophylax spp	1.6	C	R		R	R
Odonata							
Aeshnidae	Boyeria vinosa	5.8			R		R
Blephariceridae	Blepharicera spp	0	R	C			
	Simulium spp	4.9		C	C	C	A
Chironomidae	Parametriocnemus spp	3.9			R		R
Rhagionidae	Atherix	0.9				R	
Tipulidae	Tipula spp	7.5	R			R	
	Pseudolimnophila spp.	6.2				R	
Tabanidae	Chyrsops spp	6.7	R				
	Hexatoma	3.5			R		
	Antocha	4.4			C	R	C

Tanyderidae	Protoplasa fitchii	4		R		R	
Dixidae	Dixa	2.5	R				
Coleoptera	Helichus spp. (DRYOPIDAE)	4.1		R			
	Microcylloepus pusillus	3.3			C		
	Stenelmis spp	5.6	R		A	R	R
	Psephenis herricki	2.3				C	C
Gyrinidae	Gyrinus spp.	5.8		R			
Hydrophilidae	Tropisternus spp	9.3	C		R		
	Laccobius spp	6.5		R		R	
Ptilodactylidae	Anchytarsus bicolor	2.4					
	Dubiraphia spp	5.5				R	R
Dytiscidae	Hydroporous spp	7			R		
Gastropoda	Elimia	2.7				R	R
Crustacea	Cambarus spp	7.5					R
Gammaridae	Crangonyx spp	7.2			R		
	Corydalis	5.2	R				
	Lumbriculidae	9				C	###