Upper Neuse River Basin Association

Draft Memorandum

To: Kimberly Nimmer, NC Division of Water Quality

From: Chris Dreps, Upper Neuse River Basin Association

Date: March 19, 2007

Re: Lick Creek Watershed —Initial watershed characterization, existing water quality data, and stakeholder process.

This memorandum provides a characterization of the Lick Creek Watershed (Hydrologic Unit 03020201050030). The Upper Neuse River Basin Association (UNRBA) will provide the NC Division of Water Quality (NC DWQ) with regular memoranda in order to (1) report progress made by the various partners on project tasks and (2) provide NC DWQ with a format for feedback to the UNRBA.

This memorandum details the results of the following subtasks completed under Task 1, Baseline Watershed Assessment:
Subtask 1.1, Compile and review existing watershed data;
Subtask 1.2, Perform an initial scoping-level analysis (subwatershed delineation, water quality interpretation, and monitoring plan only); and
Subtask 1.4, Convene Technical Team (Stakeholders).

This memorandum was originally meant to include a summary of subtask 1.3, which includes an analysis of current and future land uses and watershed programs in Lick Creek. Due to the timing of other tasks (fieldwork task, February 26-March 2), and in order to simplify this technical memorandum, the UNRBA will present the land use analysis findings and watershed programs review in a separate memorandum.

1. Background

The North Carolina Division of Water Quality has provided the Upper Neuse River Basin Association with a Section 319 grant to perform a Watershed Restoration Plan in the Lick Creek Watershed (Hydrologic Unit Code 03020201050030) in eastern Durham, North Carolina.

Figure 1 shows the Lick Creek watershed's location in the Falls Lake Basin. The Lick Creek Hydrologic Unit is a 22.9 square-mile watershed located on the borders of Durham and Wake County. Lick Creek flows directly into Falls Lake upstream of where NC Highway 50 crosses the Reservoir. The NC Division of Water Quality (NC DWQ) classifies Lick Creek as "impaired" because it does not adequately support aquatic life (NC DWQ 2006). Lick Creek is classified as a water supply watershed with nutrient sensitive waters (WS IV NSW) because it is in the Falls of the Neuse Reservoir Basin. NC DWQ currently is conducting a detailed study of the Falls of the Neuse Reservoir to determine if water quality in the reservoir is sufficient to meet its intended uses.

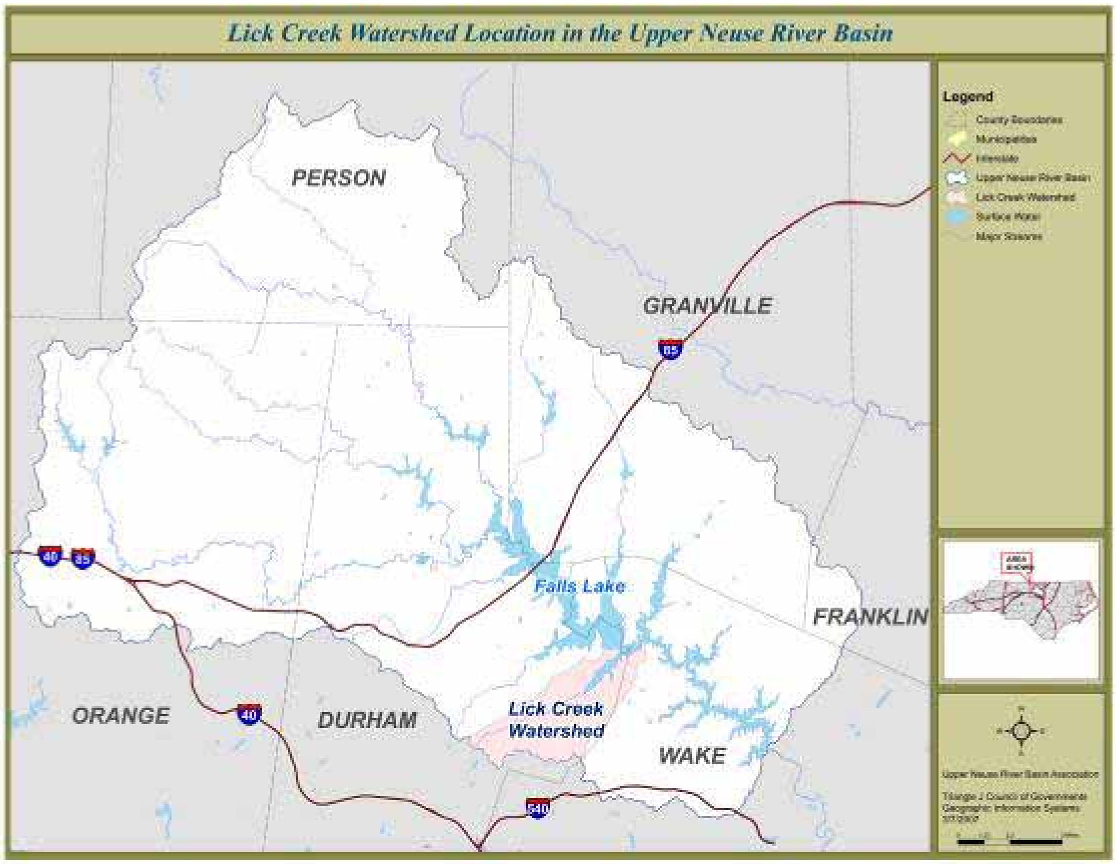

Figure 1: Lick Creek Watershed Location in Upper Neuse Basin

This Technical Memorandum presents five sections:

1. Background
2. A watershed characterization for the Lick Creek watershed, including a detailed subwatershed delineation of the watershed;
3. A summary of findings from the NC State University Water Quality Group's stream data analysis and monitoring recommendations for Lick Creek;
4. An analysis of current land use in the watershed; and
5. A brief description of the Lick Creek planning process.

2. Natural Features of the Watershed

The Technical Memorandum first presents a general characterization of the Lick Creek Watershed. This characterization describes the natural features of the watershed, including geography, geology, soils, topography, surface hydrology, floodplains and wetlands, and habitat and species.

2.1 Geography

The Lick Creek hydrologic unit is a 22.9 square mile area that includes the Lick Creek Watershed and several small streams that flow directly into Falls Lake. For this study, we will focus only on the Lick Creek Watershed, which has an area of 22 square miles. Figure 2 is a map of the Lick Creek Watershed study area.

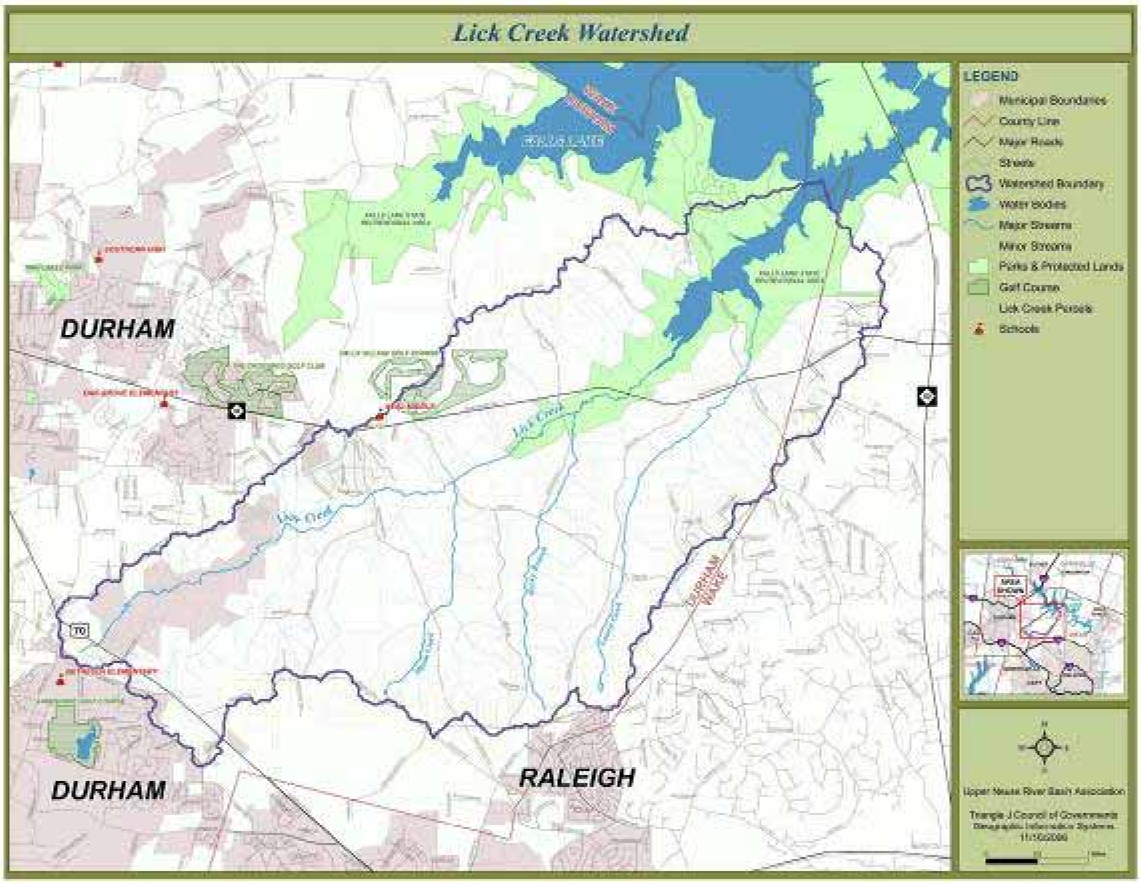

Figure 2. Lick Creek Watershed study area

The Lick Creek watershed is located the extreme eastern portion of Durham County. A short drive east from NC Highway 70 on Leesville Road and then north onto Carpenter Pond Road past NC Highway 98 and into Wake County is a tour of the southern and eastern divide of the watershed. From its headwaters, Lick Creek flows to the north-east under NC Highway 98, the main artery between Durham and Wake Forest. The creek flows several miles through newly developing suburbs, forest, and a few farms before flowing into the federally protected land that forms Falls Lake State Recreation Area. Just past this junction, creek slowly flows into Falls Lake near Rollingview State Recreational Area.

2.2 Geology

The Lick Creek watershed lies over Durham Triassic Basin, a geologic formation within the larger Deep River Basin Triassic formation. It is believed that the Durham Triassic Basin formed from rifting of the Super continent Pangaea during the Mesozoic period

200 million years ago. The land masses that are now Africa and North America separated, and the separation left rift valleys many miles wide and thousands of feet deep. These rifts filled over time with sediment deposited by the huge Appalachian Mountains. These compacted sediments now form the parent material of the Triassic Basin (Clark et al 2001).

The geology underlying Lick Creek is mainly unconsolidated Triassic Basin-formed sedimentary rock. The sedimentary parent material is a mix of various other parent materials, and thus its characteristics vary greatly within the basin. The alluvium underlying the stream valleys is made of eroded Triassic material. The soils created by the weathering and eroding of this parent material are generally clay and are often considered poor quality soils with low nutrient levels (USDA 1971).

Figure 4 shows the general geology underlying the Lick Creek Watershed. Triassic Basin geology covers most of the watershed. In the eastern portion of the watershed, Laurel Creek flows over less erosive metamorphic material of the Carolina Slate Belt.

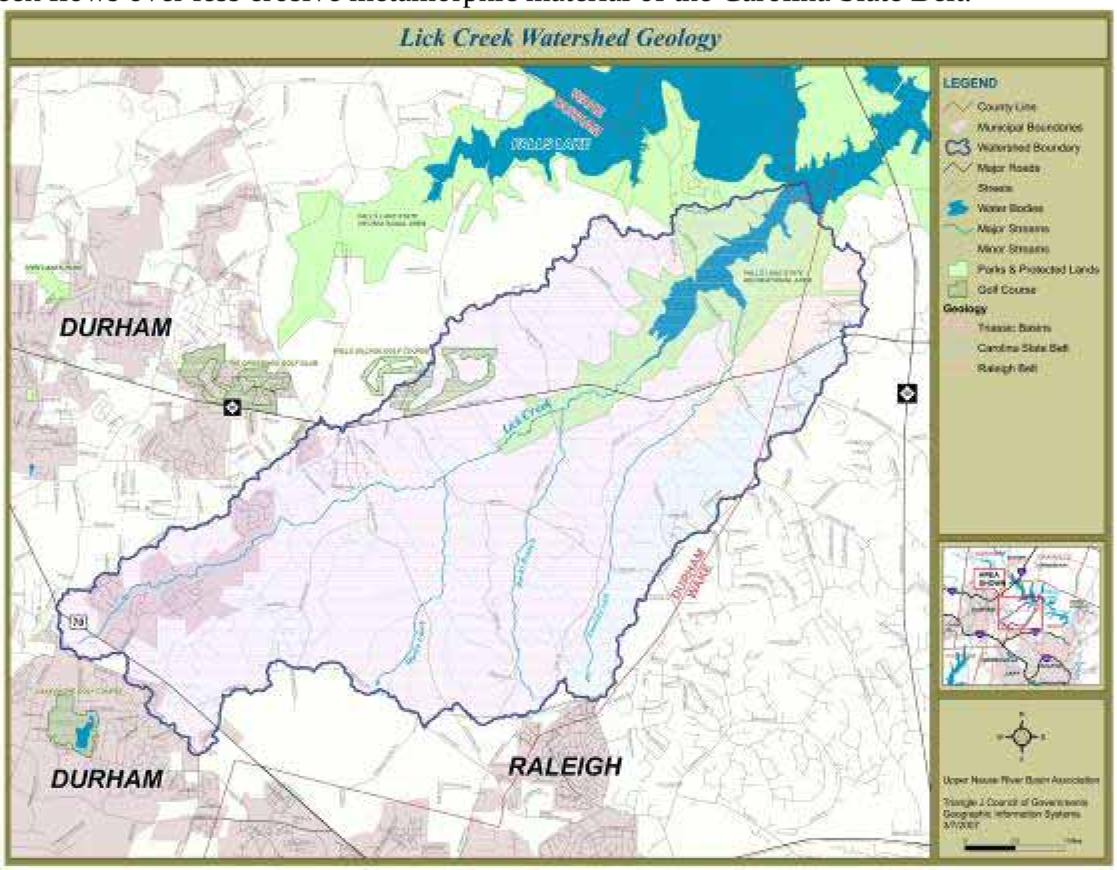

Figure 4. Lick Creek Watershed Geology

Because Laurel Creek and its tributaries flow through metamorphic formations with greater resistance to erosive forces such as increased stormwater discharges, the stream bed is shallower and much rockier than other Lick Creek tributaries of similar size and land use (see Figure 3). Because of its geology and soils, Laurel Creek is likely to support a greater abundance and diversity of aquatic life.

Figure 3: Carolina Slate Belt in Laurel Creek (left) and Triassic Basin in Upper Lick Creek (right)

Although maps do not indicate it, there may be outcroppings of harder, less erosive metamorphic diabase material under Triassic Basin streams. These diabase sills were formed during the creation of the Triassic rift valleys, when magma escaped to the surface. In nearby Little Lick Creek, outcrops of diabase sills have resisted the erosion affecting the surrounding Triassic sandy-clay soils. These areas support relatively abundant and healthy aquatic life. In addition, Diabase areas likely provide streams with a relatively rocky substrate compared with the surrounding Triassic material. For these reasons, it may be valuable to explore whether diabase sills exist in the Lick Creek Watershed. If so, these areas may offer potential land protection sites.

2.3 Soils

The Durham County Soil Survey identifies over 30 soils series in the Lick Creek watershed (USDA 1971). The soil types are primarily determined by their parent geologies. White Store and other upland soils in the Triassic Basin portion of the watershed formed under forest cover in material weathered from Triassic Mudstone. These soils are highly erosive. Cecil and Wilkes are the predominant upland soils over metamorphic Raleigh Belt and Carolina Slate Belt in the eastern part of the watershed. Table 1 demonstrates the soils in Lick Creek.

Series	Description
Altavista	Consists of nearly level and gently sloping, moderately well-drained soils on low stream terraces. Formed under forest vegetation in alluvial deposits. Located just upland and adjacent to Chewacla soils. Flooded infrequently for brief periods. 2.5 feet to seasonal water table. Acidic.
Cartecay	Consists of nearly level, somewhat poorly-drained soils on flood plains. Formed in coarse loamy material washed from soils on uplands. Flooded very frequently for only brief periods. Permeability moderately rapid. Acidic.
Cecil	Occurs at transition between Triassic Basin and Slate/Carolina Belt geologies. Consists of gently-sloping to steep, well-drained, deep soils. Medium to strongly acid.
Chewacla	Chewacla is the floodplain soil of Lick Creek. Consists of nearly level, somewhat poorly-drained soils on flood plains. Formed in fine loamy material washed from upland soils. Flooded very frequently for very brief periods. Depth to seasonal high water table in winter and early in spring. Acidic.
Creedmoor	Consists of gently sloping and sloping, moderately well-drained soils on uplands, esp. rounded divides. Formed under forest vegetation in residuum from Triassic Mudstone. Permeability very slow. Depth to seasonal water table 1.5 feet. Strongly acidic.
Granville	Gently sloping and sloping, well-drained soils on uplands/rounded divides. Formed under forest vegetation in residuum from Triassic Sandstone. Permeability moderate. Strongly acidic.
Iredell	Consists of nearly level to sloping, moderately well-drained soils on uplands. On broad flat areas and rounded divides. Formed under forest vegetation in residuum from basic diorite rock. Permeability slow.
Mayodan	Consists of nearly level to moderately steep, well-drained soils on uplands. Rounded divides. Formed under forest vegetation in residuum from Triassic Mudstone. Permeability is moderate. Acidic. Primarily found in the headwaters of Lick Creek's watershed.
Pinkston	Consists of gently-sloping to moderately steep, well-drained or excessively-drained soils on uplands. Formed under forest vegetation in residuum from Triassic Sandstone. In Lick Creek, these soils are located along upland streams. Permeability moderately rapid. Erosion hazard from runoff.
White Store	The predominant soil series in Lick Creek's watershed. Consists of gently sloping to moderately steep, moderately well-drained soils on uplands. These soils are found on the upland divides between drainage features. White store soils formed under forest vegetation, in material weathered from Triassic Mudstone. Water capacity medium. Permeability very slow. Erosion hazard with runoff. Strongly acidic.
Wilkes	Consists of gently sloping to steep, very shallow to moderately deep, well drained soils. Shrink-swell is moderate. Moderately acidic.

Table 1: Lick Creek Soils

White Store is the primary upland soil series occurring in the Triassic Basin portion of the watershed, covering 54% of the total surface of the watershed. White Store is hydrologic soils group D, with a high potential for runoff. Creedmoor and Pinkston soils are also prevalent in the Triassic Basin portion of the watershed. These soils are low in natural fertility and organic matter content. Permeability is very slow, and the available water capacity is medium. According to the Durham Soil Survey, "the major limitations are the erosion hazard resulting from runoff, the very slow permeability, the steep slopes, the high shrink-swell potential, and a perched water table."

Lick Creek's large, broad flood zone is predominated by Chewacla Soils. These soils formed as upland soils weathered over time and washed to low-lying areas. These soils support lowland hardwood forests. They have also been used for farming row crops.

Initial field observations of Lick Creek and its tributaries confirm that the stream substrate in the Triassic Basin portion of the watershed is primarily sand. These Triassic streams are greatly impacted by the increased flows accompanying urban development because the sand and clay substrate material erodes easily. This response is likely magnified on steeper slopes. Data from the in-stream fieldwork will help project partners to verify this assertion. These findings will help to inform several recommendations, including restoration, stormwater management, and steep slopes protection.

2.4 Topography

Light Detection and Ranging (LIDAR) data created for the NC Division of Emergency Management's Floodplain Mapping Program provide a very detailed representation of Lick Creek's surface topography. LIDAR's primary use for use in NC Flood Insurance Rate Maps; however, the USGS has developed a detailed digital elevation model for use in the Upper Neuse (Terziotti 2004). This digital elevation model is a 20-foot precision, the best data currently available for watershed modeling in the Upper Neuse.

The digital elevation model data show that the watershed's general grade from the headwaters to Falls Lake is low. The highest area of the watershed is at the headwaters along the southern divide separating Lick Creek from the Cape Fear Basin and along the eastern divide that separates it from Barton Creek Watershed. These ridges range from 480 to 509 feet above sea level in elevation. The divide between Lick and Little Lick Creek, along Sherron and Baptist Roads, is relatively low (330 to 390 feet above sea level) and gently sloping. The lowest elevations are around the creek where it meets the Falls Lake Reservoir. This area is about 250 feet above sea level. A straight-line measurement between the highest and lowest areas (about 32,000 feet) yields a watershed-wide gradient of less than 1%.

A map of areas of steep slopes tells a very different story. Figure 5 divides the Lick Creek watershed into slopes of less than 15%, 15%-25%, and greater than 25%. This figure shows that there are significant areas of slopes greater than 15%, particularly to the south and east of the main stem of Lick Creek. Subwatersheds 2, 4, 5, 6, 7, 8, 9, and 10 exhibit slopes much steeper than those in subwatersheds 1, 3, and 6, which are similar to the slopes of neighboring Little Lick Creek. This area is a transition from Triassic Basin to Carolina Slate Belt and Raleigh Belt geography.

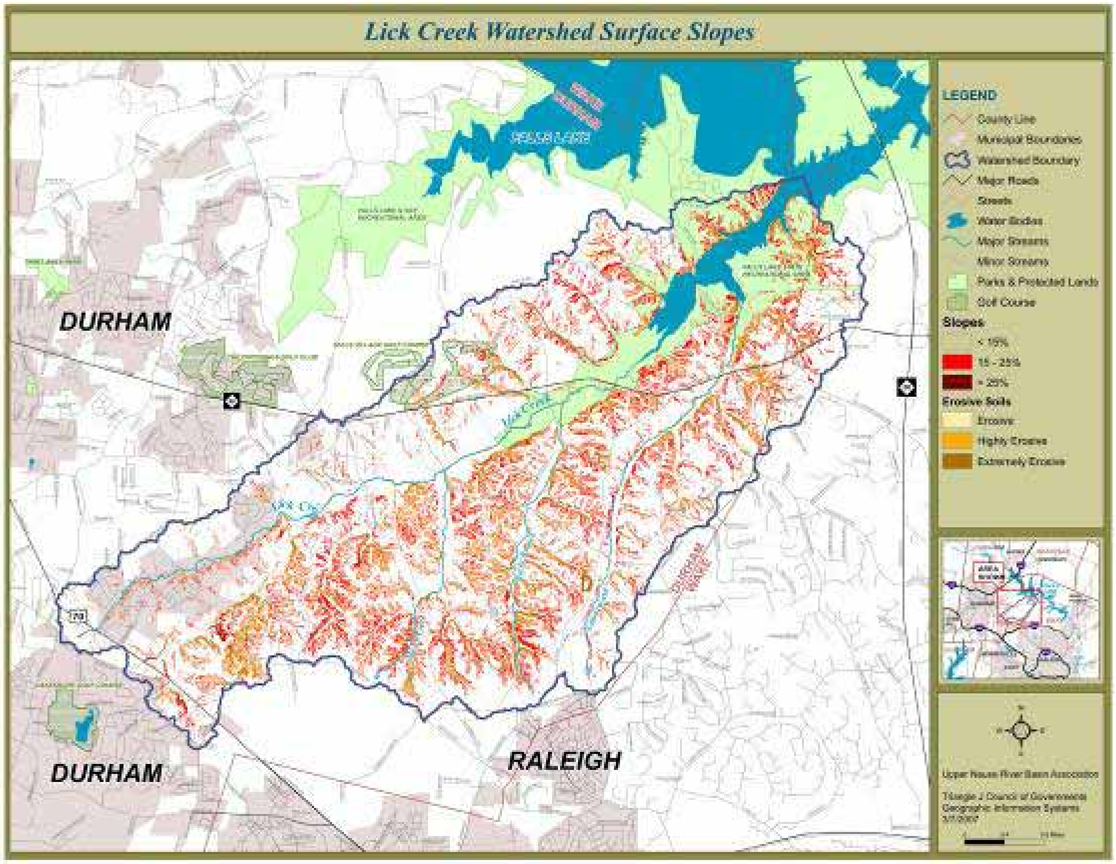

Figure 5: Lick Creek Surface Slopes

Figure 5 also shows highly erosive soils in Lick Creek. Based on fieldwork observations in neighboring Little Lick Creek, many Triassic Basin soils erode severely on slopes of greater than 15%, particularly in areas of channelized stream flow. Soils with high erosion potential (as the Universal Soil Loss Equation expresses generally with the soil's k value[1]) on slopes greater than 15% may be areas of high erosion potential. These areas should be closely examined throughout the Lick Creek planning process.

[1] Erosive soils are identified using GIS and a modified version of the Universal Soil Loss Equation to estimate average soil loss based on soil type and slope: A = KS Where: A = soil loss average over the slope length. K = Soil erodibility factor S = 65.4s2 + 4.56s + 0.065 where s= sin(Theta); Theta = slope angle = arctan (slope) K is found in the SSURGO Soils in the Upper Neuse River Basin data set S is calculated from 20-ft Resolution LIDAR-derived slopes of the Upper Neuse River Basin

2.5 Surface Hydrology

Average annual rainfall at the National Weather Service's RDU Airport site is just over 43 inches per year. A study from nearby Duke Forest has shown that, under forested conditions, over 70% of this water would be evaporated or transpired. Only about 5% of water in Duke Forest would become surface runoff, and over 20% would infiltrate to groundwater (Schafer et al 2002). These results may vary somewhat based on soil type differences, but the findings of the Schafer study offer a general understanding of the forested hydrologic cycle in Durham County.

Figure 6 is a map of surface water hydrology features in the watershed. The TJCOG used the LIDAR-derived Upper Neuse digital elevation model created by the USGS to delineate the watershed and subwatersheds. Lick Creek is a fifth-order stream draining an area of 22 square miles. The watershed has a minimum of 120 miles of streams[2]. The watershed therefore has a minimum drainage density of 5.45 miles/square mile.

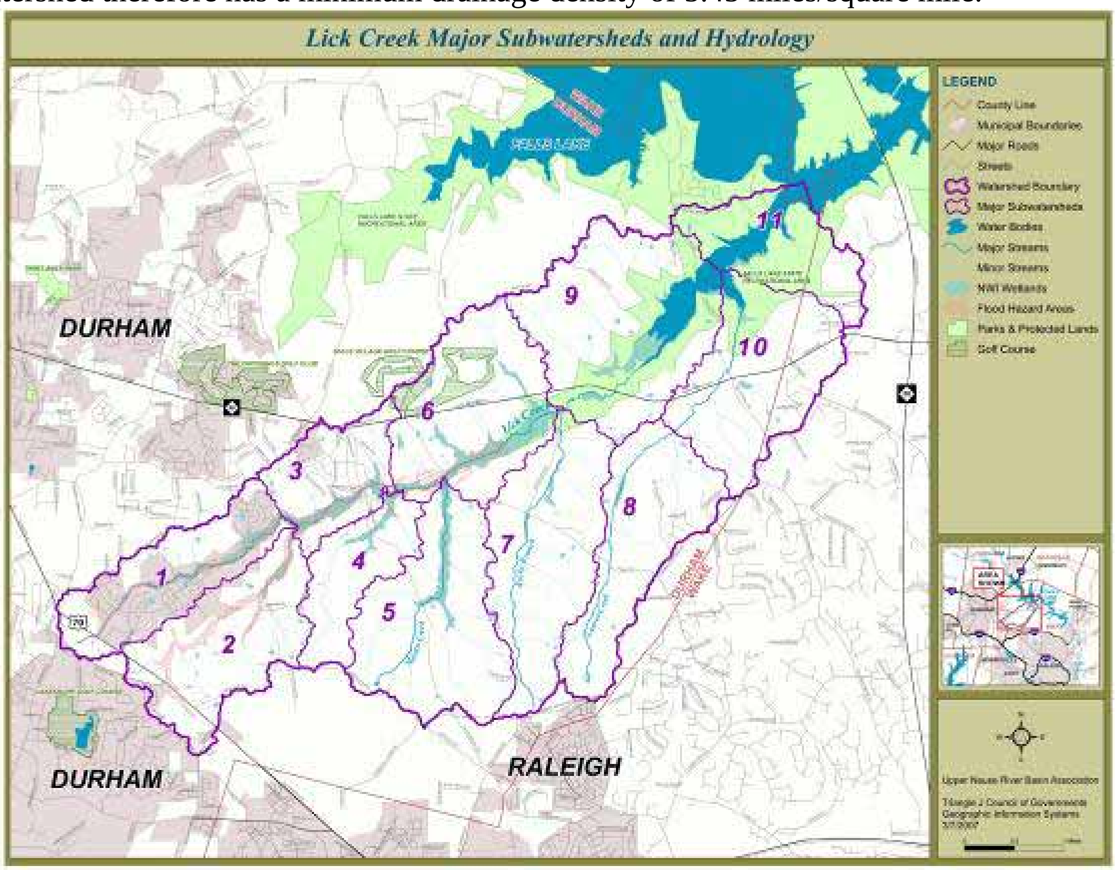

Figure 6: Lick Creek Hydrology and Subwatersheds

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[2]Total stream length is based on Durham's GIS coverage of streams for Lick Creek. This underestimates total stream length because it does not include the large streams and ponds. The US Geological Survey's mapped streams, used in many jurisdictions to enforce stream protection regulations, estimate only about 97 miles of streams in Lick Creek's watershed (Durham uses both of these two sources and non-digital NRCS soils maps, for regulation). Stream maps derived using the state's high-resolution LIDAR data estimate 161 miles of streams in the watershed.

Figure 6 divides the watershed into 11 subwatersheds, and Table 2 describes their total areas in acres and square miles. The Lick Creek Partners and Stakeholders will use these 11 subwatersheds as the “management units” for this project. The subwatersheds will be assessed for current land uses, impervious cover, soil types, and slopes. These factors, as well as data on existing point sources of pollution, potential contamination sites, active construction sites, and other suspected impacts guide the prioritization of subwatersheds and areas within subwatersheds. High-priority subwatersheds with the greatest number of potential impacts are targeted for fieldwork. Modeling of existing conditions and general pollutant loading is completed for each subwatershed.

As described in Section 3 of this memorandum, monthly water quality, bi-annual aquatic insect, and periodic storm flow samples will be collected and assessed for the main stem of Lick Creek and in subwatersheds 1-7, all upstream of Durham City and NC Division of Water Quality sampling sites. It is hoped that by combining sampling, GIS analysis, fieldwork, and modeling results of each of these subwatersheds, the project partners, technical team, and stakeholders will be able to identify subwatersheds with water quality degradation and hypothesize possible factors contributing to degradation.

In addition, all subwatersheds are assessed for future land uses. Expected build-out conditions and current watershed-related management practices (such as sediment and erosion control, stormwater, and buffer protection requirements) are modeled to predict general pollutant loading in each subwatershed.

Subwatershed Number	Total area	
	(acres)	(miles^2)
1	1501	2.34
2	757	1.18
3	1079	1.69
4	1310	2.05
5	698	1.09
6	1600	2.50
7	1551	2.42
8	1294	2.02
9	1959	3.06
10	1430	2.23
11	881	1.38
Total Area	14,059	22.0

Table 2: Lick Creek Subwatersheds

Lick Creek’s hydrology is strongly affected by the Falls Lake Reservoir. The entire Lick Creek system is a tributary of the Falls Lake Reservoir, created in the early 1980’s to provide flood storage and drinking water for Raleigh. The Lick Creek arm of the reservoir backs up into lower Lick Creek (subwatersheds 9, 10, and 11). This impoundment of water has changed the hydrology of this portion of the creek from what was a medium-sized, meandering piedmont stream into a shallow, lentic system subject to eutrophication (enrichment by nutrients). The reservoir also hydrologically separates Laurel Creek (subwatersheds 8 and 10) from the main stem of Lick Creek.

When Falls Lake was impounded, the new reservoir drowned over twenty-five stream miles of piedmont bottomland hardwood forest. In an attempt to mitigate for the loss of habitat in these ecologically valuable lands, the US Army Corps of Engineers constructed a series of "waterfowl impoundments" in streams tributary to the reservoir. Lick Creek has such an impoundment, shown in Figure 7, immediately upstream of where the creek intersection NC Highway 98.

Figure 7: Waterfowl Impoundment at NC Highway 98 in Lick Creek

2.6 Floodplains and Wetlands

Lick Creek's abundant wetlands are due to a combination of the underlying Triassic Basin geology, low relief, sedimentary soils, and wide 100-year floodplains. According to Flood Hazard Areas GIS data from the NC Floodmapping Program, there are 1,510 acres of floodplains in Lick Creek (see Figure 6). These floodplains are as wide as 3000 feet near Falls Lake, and in most areas along the main stem of the creek measure over 1000 feet wide. These floodplains harbor the watershed's wetlands and likely contain the predominance of its biodiversity.

The National Wetlands Inventory (NWI) data offer a general idea of the area, location, and type of wetlands in the Lick Creek watershed. The NWI data estimate 979 acres of wetlands in Little Lick Creek. The general categories are described in Table 3.

Wetland Type	Total area (acres)
(PUBH): Palustrine, unconsolidated bottom, permanently flooded, impounded includes all non-tidal wetlands dominated by trees, shrubs, and emergent vegetation, mosses or lichens or wetlands lacking such vegetation but that are less than 20 acres, do not have an active wave-formed or bedrock shoreline feature, and have at low water a depth less than 6.6 feet in the deepest part of the basin. Farm ponds comprise the majority of these wetlands in Lick Creek.	56
(L1UBHh) Lacustrine, Limnetic wetlands and deepwater habitats created by the Falls Lake Reservoir or other impoundment.	285
(PFO1A & PFO1C) Palustrine, forested, broad-leaved deciduous, temporarily flooded. These are the primary floodplain wetlands of Lick Creek.	481
PEM1Ah (PEM1Fh, PEM1Ch) Palustrine, emergent, temporarily (seasonally) flooded wetlands upstream of the Falls Lake Reservoir.	110
(PSS1) Palustrine, shrub-scrub wetlands in Lick Creek floodplains.	47
Total NWI Wetlands in Lick Creek	979

Table 3: Lick Creek Wetlands

With the exception of palustrine wetlands in farm ponds, Lick Creek's wetlands lie primarily in the floodplains. Initial observations in subwatersheds 1, 2, 4, and 7 confirm that these wetlands are, and may have historically been, closely related to impoundments created by beavers. The management of wetlands in the Lick Creek watershed may depend upon a thorough understanding and management of the beaver population. In Laurel Creek (subwatersheds 8 and 10), there are relatively few wetlands and few observed beaver impoundments.

Figure 8: Beaver impoundment in a palustrine wetland, Lick Creek

2.7 Habitat and Endangered Species

Lick Creek contains the Lick Creek Bottomlands Natural Heritage Areas, which encompass 1,652 acres of bottomland hardwoods forest recognized by the state for its high quality habitat. The Lick Creek Bottomlands are given a high protection status by the NC Natural Heritage Program because the Lick Creek stands of bottomland hardwood forest are "among the most mature and diverse in the entire area: and support fauna of forest interior and bottomland species among the "best remaining around the edge of Falls Lake" (Hall 1995).

Terrestrial Habitat

The Lower Lick Creek Bottomlands area is of regional significance for its fauna, which include over forty species of breeding birds indicative of high quality bottomland sites and four species that are permanent residents of large woodland tracts (Hall 1995). The area also supports two species of state Special Concern: four-toed salamanders (*Hemidactylium scuatatum*) and Carolina darters (*Etheostoma collis*). Plant species of note in the Lower Lick Creek Bottomlands include Sweet Shrub (*Calycanthus floridus*, a NC "Watch List" plant) and three species of Ground Cedar, *Lycopodium (flabellum, obscurum and lucidulum)*.

The Middle Lick Creek Bottomlands contains young to middle-aged forest with lower diversity of tree species. Middle Lick Creek has colonies of Dissected Cress (*Cardmine dissecta*), significantly rare in NC, and the regionally rare plant species Doll's Eyes (*Actea pachypoda*).

On the east side of Laurel Creek, in subwatersheds 8 and 10 is found a natural area referred to as Leatherwood Cove (Durham City-County Planning 2006). The cove gets its name from the Leatherwood plant (*Dirca palustris*)**,** a woody, deciduous shrub found in very rich forests, on slopes or bottomlands (Weakley 2004). *D. palustris* has a ½-inch long, tube-like, greenish-yellow flower. *D. palustris* is on the NC Watch List. The plant's curiously flexible twigs and tan-brown bark are extraordinarily tough. Native Americans used the twigs for cordage, hence its common name.

Leatherwood cove also contains several other plant species of note, including Douglass' Bittercress, Doll's Eyes, Yellow Lady's Slipper, five species of hickory. This extensive undisturbed area of 140 acres is on private property. Both Leatherwood Cove and the Laurel Creek Wildlife Habitat Area downstream are high priority wildlife habitat areas in the East Durham Open Space Plan (Durham City-County Planning 2006).

Aquatic Habitat

Aquatic habitats were especially hard hit by impoundment. Species that once freely migrated up and down river and between tributaries are now isolated by the reservoir. Lake species such as crappie and large-mouth bass prey on both smaller native species in the streams and amphibians in formerly isolated vernal pools. The Natural Heritage Inventory lists one aquatic species of state concern, the Carolina darter (*Etheostoma collis*) and several water-quality sensitive aquatic species: mountain redbelly dace

(*Phoxinus oreas*); white shiner (*Luxilus albeolus*); satinfin shiner (*Cyprinella analostana*); and swallowtail shiner (*Notropis procne*). Hall (1995) notes that the fish records in this inventory were probably made prior to the impoundment of Falls Lake.

The aquatic, amphibian and reptile species that the Inventory documented in the Lick Creek Watershed are shown in Table 4.

Common Name	Scientific Name	Comment
Mountain redbelly dace	*Phoxinus oreas*	Water-quality tolerant species
White shiner	*Luxilus albeolus*	Water-quality tolerant species
Satinfin shiner	*Cyprinella analostana*	Water-quality tolerant species
Swallowtail shiner	*Notropis procne*	Water-quality tolerant species
American eel	*Anguilla rostrata*	Water-quality tolerant species
Yellow bullhead catfish	*Ameiurus natalis*	Water-quality tolerant species
Green sunfish	*Lepomis cyanellus*	Invasive, water-quality tolerant species
Black crappie	*Pomoxis nigromaculatus*	
Green sunfish	*Lepomis cyanellus*	
North American bullfrog	*Rana catesbeiana*	
Snapping turtle	*Chelydra serpentina*	
Speckled killifish	*Fundulus rathbuni*	
Grass pickerel	*Esox americanus*	
Creek chub	*Semotilus atromaculatus*	
Bluehead chub	*Nocomis leptocephalus*	
Creek chubsucker fish	*Erimyzon oblongus*	
Greenside darter	*Etheostoma nigrum*	
Carolina darter	*Etheostoma collis*	Species of state concern

Table 4: Potential aquatic species in the Lick Creek Watershed (Hall 1995). (Common names confirmed using http://animaldiversity.ummz.umich.edu/)

3. Water Quality and Aquatic Habitat

The NC Division of Water Quality (NC DWQ) classifies Lick Creek as "impaired" because it does not adequately support aquatic life (NC DWQ 2006). Two segments totaling 7.2 miles from the headwaters of the main stem to the Falls Lake Reservoir are impaired. NC DWQ considers Urban Runoff/Storm Sewers as a potential source of impairment.

Lick Creek is classified as a water supply watershed with nutrient sensitive waters (WS IV NSW) because it is in the Falls of the Neuse Reservoir Basin. NC DWQ currently is conducting a detailed study of the Falls of the Neuse Reservoir, known more commonly as Falls Lake, to determine if water quality in the reservoir is sufficient to meet its intended uses of supplying drinking water, supporting aquatic life, and supporting recreation. Earlier water quality data and studies such as the Upper Neuse Watershed Management Plan (UNRBA 2003) indicate that the upper portion of the lake, including the Lick Creek arm of the reservoir, may be impaired. The detailed study and modeling conducted by NC DWQ will result in a Nutrient Management Strategy for Falls Lake.

Any assessment of water quality and aquatic habitat and any subsequent management strategies must consider Lick Creek's impaired status and the Falls Lake Nutrient Management Strategy as driving factors behind watershed management. The Lick Creek Watershed Restoration Plan will use these driving forces to guide the establishment of restoration goals and objectives.

3.1. Review of Existing Monitoring Data

The NC State University Water Quality Group (NCSU WQG) is conducting watershed-wide water quality and aquatic biota monitoring as part of the development of the Lick Creek Watershed Restoration Plan. This first step in assessing water quality and aquatic biota is a review of the existing monitoring data and the development of a short-term monitoring plan. This section summarizes the NCSU WQG memo, "Analysis of Existing Data and Short-Term Monitoring Plan for Lick Creek" (Line and Penrose 2007). The NCSU report is provided in Appendix 1.

Since 2004, Durham Stormwater Services has conducted benthic macroinvertebrate and physical-chemical monitoring at a sampling site on the main stem of Lick Creek on Southview Road and physical-chemical monitoring at a site on Kemp Road in Rocky Branch. Figure 9 shows the location of these two sites in red. The Southview Road site is located at the outlet of subwatershed 6 and therefore samples the stream at a point where its contributing watershed is 6,945 acres (10.85 square miles). The Kemp Road site is located in Rocky Branch, a 1,551-acre (4.42 square-miles) tributary of Lick Creek.

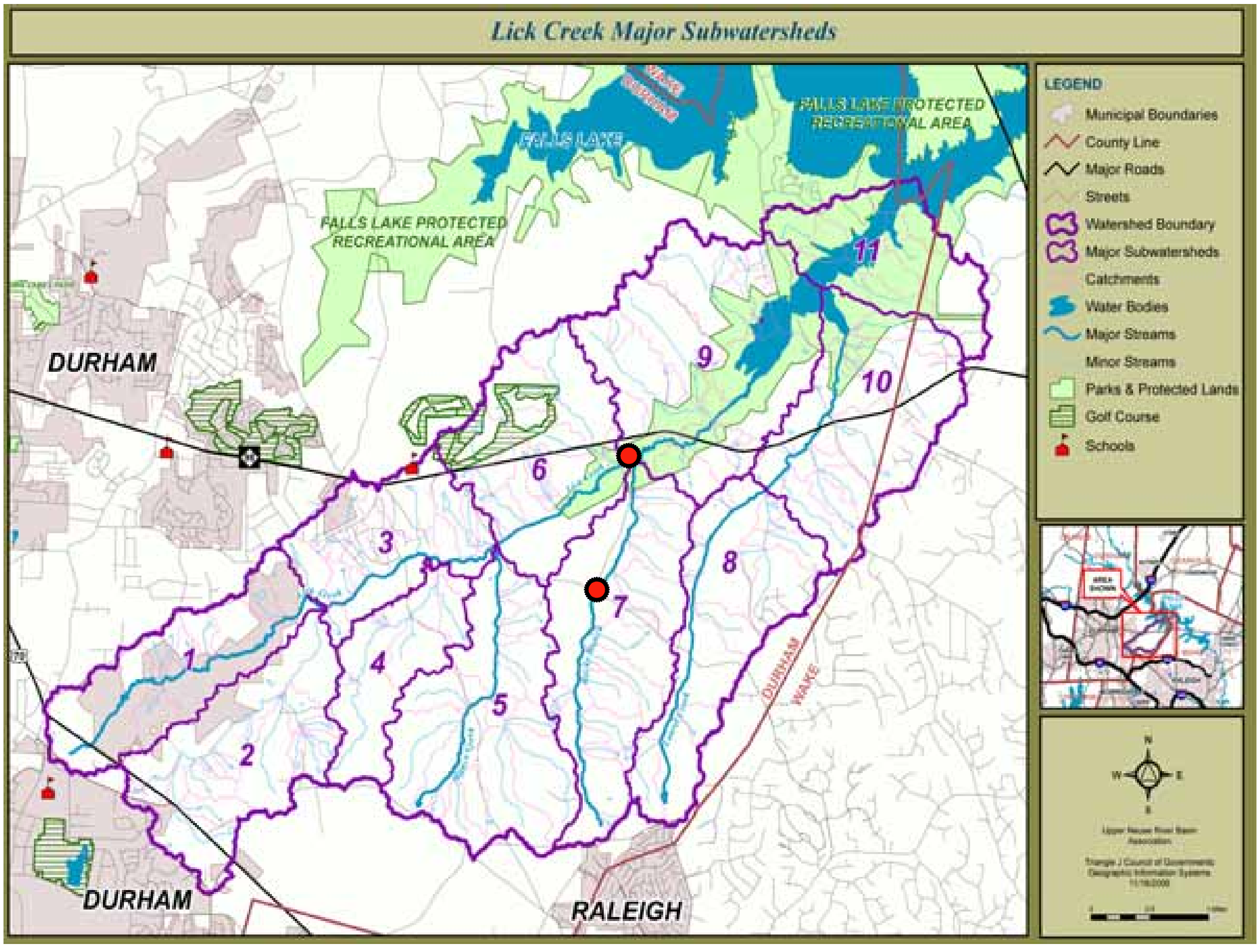

Figure 9: Durham Stormwater Services Monitoring Sites in the Lick Creek Watershed

Table 6 summarizes the data collected by Durham Stormwater Services at these two sites.

Agency	Monitoring type	Sites	# of samples	Years sampled
City of Durham Stormwater Svcs.	Benthic macroinvertebrate	LC1.0LC Southview Rd. SR 1809	2	2004 to present
City of Durham Stormwater Svcs	Physical and chemical	Lick Creek Southview Rd. SR 1809	16 samples (monthly)	2004 to present
City of Durham Stormwater Svcs	Physical and chemical	Rocky Branch Kemp Rd. SR 1902	16 samples (monthly)	2004 to present

Table 6: Durham Stormwater Services Monitoring Sites in the Lick Creek Watershed

Biological Data Summary

Collection and analysis of bottom-dwelling aquatic insects (benthic macroinvertebrates) provide important information about water quality and aquatic habitat conditions in a stream. A robust, diverse community of insects typically indicates good water quality and aquatic habitat conditions. The presence of a variety of insects that are intolerant of pollution, such as mayflies (*ephemeroptera*), stoneflies (*plecoptera*), and caddisflies (*tricoptera*), indicates a lack of pollution. The City of Durham's Stormwater Services Division analyzes and rates these conditions and more, such as total number of Taxa, total number ephemeroptera, plecoptera, and tricoptera (EPT), EPT diversity, biotic index, biotic rating, and bioclassification score. These indicators can be compared with those from other watersheds, including relatively undisturbed (reference) watersheds to provide a relative understanding of conditions. They can also be assessed over time or before and after an event (such as watershed disturbance) or intervention (for example, a stream restoration) to detect long-term changes.

In general, Triassic Basin aquatic habitat is poorly understood. Durham Stormwater Services biological monitoring in Lick Creek and other Triassic Basin sites is providing important information for the NC Division of Water Quality and others as we attempt to better understand this unique habitat. Durham's aquatic insect monitoring at the Southview Rd. site (LC1.0LC) resulted in Fair (borderline Poor) bioclassifications. In addition, total numbers of EPT were also very low. However, it is important to note that these samples were taken in summertime, when Triassic Basin streams have very low flow conditions. As part of the Lick Creek Watershed Restoration Plan, NCSU WQG will conduct fall and winter monitoring of several sites in the watershed. For more detail on existing monitoring data, see Appendix 1.

Physical and Chemical Data Summary

Physical and chemical data provide important information about the ambient conditions in the stream. Physical data such as pH (measure of acidity), turbidity or total suspended solids (indicators of suspended sediments), and conductivity (indirect measure of elements in the water) are physical indicators of stream conditions. Chemical data include indicators such as nutrients (forms of nitrogen or phosphorous), dissolved metals, dissolved oxygen, or fecal coliform bacteria (indicator of waste contamination).

Physical and chemical data can be compared across multiple subwatersheds to provide information about relative water quality conditions. They can also be assessed over time to indicate water quality changes. Most physical and chemical data are measured in concentrations (such as milligrams/Liter) and can be combined with water flow data to reveal the levels of a potential pollutant. The water quality scientist or engineer can then determine if these levels are normal by comparing the information with data from relatively undisturbed watersheds.

Durham's physical and chemical sampling at the Lick Creek site on Southview Rd. site (LC1.0LC) reveal relatively good water quality for most parameters; however, there are some concerns. Low dissolved oxygen during summer months are likely due to high water temperatures and low flow, the second of which is typical of the Triassic Basin. High turbidity and total suspended solids following rainfalls indicate that storm events may be moving heavy quantities of sediment. Sampling also reveals median concentrations of nitrogen forms sufficient to produce excessive algae growth. Finally, median fecal coliform levels at the Lick Creek site tend to meet the NC standards; however, these levels are occasionally high and can be very high during storms.

Durham's Rocky Branch Creek site generally exhibits better water quality than the Lick Creek main stem site with the exception of dissolved oxygen and biological oxygen demand, which are worse in Rocky Branch. This may indicate low flows (not measured by Durham) or algae growth. Fecal coliform levels were generally low, but there were also several high concentrations exceeding the state standards, particularly on rainy days. Sampling indicates that metals such as copper and zinc may also be of concern. Sampling also indicates that turbidity values, which can indicate sediment and erosion in streams, are among the highest in the entire Durham Stormwater Services monitoring network. The project's storm flow sampling should verify these results, and fieldwork will focus on identifying potential upstream sources. For more detail on existing monitoring data, see Appendix 1.

3.2. Point Sources Discharges

There are no major permitted point sources discharging facilities in the Lick Creek watershed. A review of the NC Department of Environment and Natural Resources Source Water Assessment Program's review of potential contamination sources in the Lick Creek watershed reveals only a handful of NPDES sites, all of which are single family wastewater treatment systems.

The Durham County Health Department has more detailed information about the overall number of on-site wastewater treatment systems in Lick Creek, shown in Table 8.

Sub-watershed	Area (Acres)	Total Buildings*	With Sewer**	With On-Site WW**	Sand Filter Systems**
1	**1501**	74	24	50	4 (1)
2	**757**	88	13	75	2 (0)
3	**1079**	240	118	122	24 (0)
4	**1310**	23	0	23	2 (0)
5	**698**	61	0	61	11 (0)
6	**1600**	63	4	59	1 (0)
7	**1551**	51	0	51	6 (0)
8	**1294**	134	0	134	5 (0)
9	**1959**	57	0	57	12 (0)
10	**1430**	155	0	155	12 (12)
11	**881**	30	0	30	(0)
Total Area	**14,059**	**976**	**159**	**817**	**79 (13)**

Table 8: Summary of wastewater treatment type by subwatershed

*Parcels with building values were assumed to have buildings with wastewater disposal needs

**Parcels in City are assumed to have municipal sewer service; those outside city are assumed to treat wastewater with on-site wastewater systems

**Durham Environmental Health and Stormwater Services data. Number in parentheses indicates the number of systems for which City or County public sewer system is available.

Table 8 estimates the number of buildings in the Lick Creek Watershed on public sewer and on-site wastewater systems. A GIS analysis of Durham parcels and public sewer system data indicate that of the 976 total buildings currently in the watershed, about 159 are served by public sewer. The remaining 817 buildings are all being served by on-site wastewater treatment systems. The great majority of these are septic systems. The number of parcels without sewer is most likely an underestimate of the number of on-site wastewater treatment systems in the watershed. Durham City requires connection where a system owner has access, but according to City employees, this rule not regularly enforced. The sewer system extends only into subwatersheds 1-3, although it will be allowed throughout the City's urban growth area.

Of the total 817 on-site systems, an estimated 79 are discharging sand filter systems. The County allowed the installation of sand filter systems during the 1960's and 1970's in areas where soils would not permit standard septic systems. This treatment type was abandoned when it became clear that the systems were difficult to manage and often allowed untreated wastewater to pass into surface waters. The remaining filters are required to hold general NPDES discharge permits, and City, County and State officials hope to replace sand filters with cleaner methods over time. It is clear from experience in Little Lick Creek that these systems frequently fail, and even fully functioning systems are sources of nutrient pollution.

The data presented in Table 8 are preliminary, and Lick Creek Project Partners will conduct data searches and fieldwork to improve the estimation of the number and location of systems. The Center for Watershed Protection will use the final wastewater system estimates in estimating current levels of nutrient pollution by subwatershed.

ANY INFORMATION ON THE OLD LANDFILL SITE ON COLEY ROAD?

3.3. Lick Creek Short-Term Monitoring Plan

The NCSU Water Quality Group will conduct monitoring at 6 sites from January, 2007 to September, 2008. NCSU WQG will measure and analyze discharge (all sites), physical and chemical parameters (4 sites), aquatic insects (5 sites), and storm flow samples (4 sites). The purposes of this monitoring effort are to identify water quality conditions on various tributaries and the main stem of Lick Creek and to support watershed management efforts.

Figure 10 shows the short-term monitoring sites proposed for the Lick Creek Watershed Restoration Plan project.

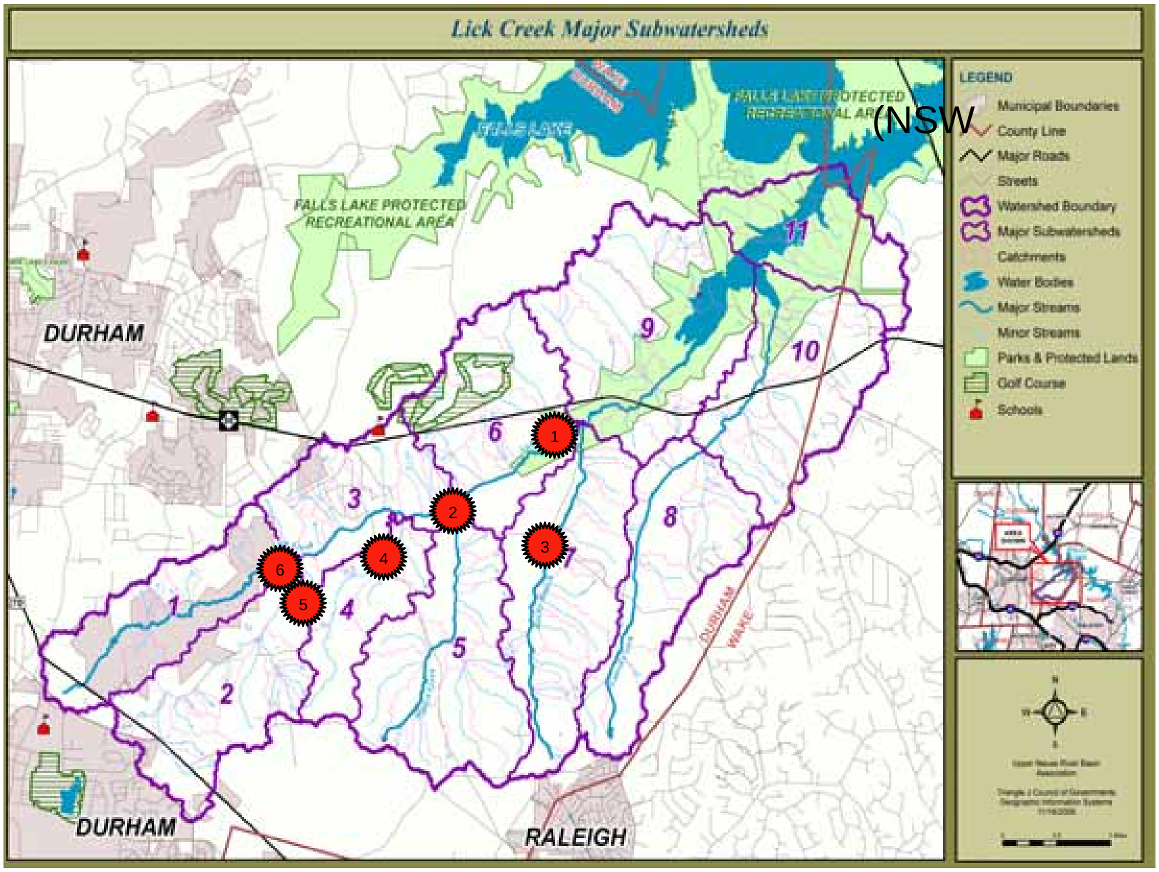

Figure 10: Short-Term Monitoring Sites for the Lick Creek Watershed Restoration Plan

NCSU WQG will monitor physical and chemical parameters such as dissolved oxygen, conductivity, temperature, turbidity, total suspended solids, various forms of nitrogen, total phosphorous, fecal coliform, lead, and zinc at four sites:

- Site 2, Martin Creek near SR 1902, subwatershed 5;
- Site 4, an unnamed tributary at SR1905, subwatershed 4;
- Site 5, Lick Creek, subwatershed 2;
- Site 6, a tributary of Lick Creek, subwatershed 1.

NCSU WQG will monitor benthic macroinvertebrates at 5 sites:

- Site 1 (Southview Road, subwatershed 6);
- Site 3 (Rocky Branch near Southview Road, subwatershed 7);
- Site 5 (Lick Creek, subwatershed 2); and
- Two additional sites along Lick Creek upstream and downstream of a planned stream restoration at Olive Branch Road (sites in subwatersheds 3 and 6).

NCSU WQG will also collect and analyze storm samples during two storms at sites 2, 4, 5, and 6. These samples will be analyzed for all physical and chemical parameters, with the possible exception of fecal coliform.

For more information on the short-term monitoring plan, see Appendix 1. Appendix 2, the Lick Creek Quality Assurance Plan, also provides more detail about the analytical methods to be used in this monitoring and assessment effort.

4. Lick Creek Watershed Land Use

4.1. Watershed Population

Population in Lick Creek is currently undergoing rapid growth. The City of Durham's Urban Growth Area fully encompasses subwatersheds 1-5 and much of subwatersheds 6-8. However, Lick Creek remains the last rural area in eastern Durham County. A Triangle J Council of Governments study based on US Census data from 2000 showed the watershed population to be 2,276 people, or 996 households (TJCOG 2000). A geographic information systems (GIS) assessment of year 2002 traffic analysis zones data conducted for this project estimates that the watershed population at that time was just over 3,400 people[3].

4.3 Watershed Land Uses

The TJCOG is conducting an analysis of both current and future land use specific to the Lick Creek Watershed. The product of this analysis will be a memorandum summarizing current and future land uses and impervious cover estimates for each of the 11 subwatersheds in Lick Creek. This analysis will be completed in March 2007. The following section summarizes the preliminary findings of the current land use analysis.

The current land use analysis shows that land use has not likely changed much since the 2000 Census data. The watershed is still a relatively rural, undeveloped area surrounded by urban growth to the west (Durham), south (Raleigh), and east (Wake County). Figure 11 and Table 9 summarize watershed land uses in Lick Creek based on recent available parcels data from Durham City and County Planning Department and Wake County Planning Department.

[3] UNRBA staff analyzed the 2002 Traffic Analysis Zones data using Lick Creek subwatershed boundaries and 2005 aerial photography. Houses outside the watershed but within TA zones partially inside the watershed were removed from the total household number of that TAZ. The final number of Lick Creek households within each TAZ was multiplied by the TAZ-reported average household size for that TAZ. The result is an estimate of the Lick Creek population for each TAZ.

Land Use Category	Acres	Square Miles	Pecent Total Land Use
Protected Natural Area (US ACE Land, Common Open Space in subdivisions)	1,425	2.23	10.1
Urban Green Space (Cemetaries, City Parks, Golf, Undeveloped lots <2 acres)	396	0.62	2.8
Forestry Lands	2,994	4.68	21.3
Agricultural Row Crop and Pasture	900	1.41	6.4
Medium Density Residential	36	0.06	0.3
Low-Medium Density Residential (0.125-0.25 acre)	22	0.03	0.2
Low-Density Residential (0.25-0.5 Acre)	47	0.07	0.3
Very Low Density Residential (0.5-2 Acre)	454	0.71	3.2
Semi-Rural Residential (2-3 Acres)	193	0.30	1.4
Rural Residential (3-10 Acres)	673	1.05	4.8
Unmanaged Rural Lands (Vacant, Undeveloped, or Residential Parcels >10 Acres)	5,153	8.05	36.7
Undeveloped Land (Vacant Land < 10 Acres)	623	0.97	4.4
Institutional	45	0.07	0.3
Industrial	30	0.05	0.2
Commercial Retail and Office	169	0.26	1.2
Falls Lake Water Surface	363	0.57	2.6
Special Use: Marina	71	0.11	0.5
Special Use: Well Sites	10	0.02	0.1
Road Right-of-Way (Local roads, US 70 and NC 98)	454	0.71	3.2
Total Land Use Area Excluding Road Rights-of-Way	13,605	21.26	96.8
Total Watershed Area	14,059	21.97	100.0

Table 9: Land Uses by Parcel in the Lick Creek Watershed
(Source: GIS coverage of August 2006 Durham City/Co. and Sep. 2006 Wake Co. parcels)

Lick Creek Watershed is a rural area. Protected natural area, urban green space, forestry, agriculture, unmanaged rural lands, and undeveloped land make up over eighty percent (80%) of the watershed's land. At the same time, over half of the rural land (or 37% of the total watershed area) is not being actively managed (unmanaged rural lands and undeveloped lands). This indicates that the watershed is in a state of change from rural management to non-management to suburban.

Twenty-one percent (21%) of the lands in the watershed are under forestry use tax valuation, and over 6% of the lands are under agricultural use tax valuation. So, despite the changes, the over 25% of the watershed is still managed for production of agricultural and forestry products.

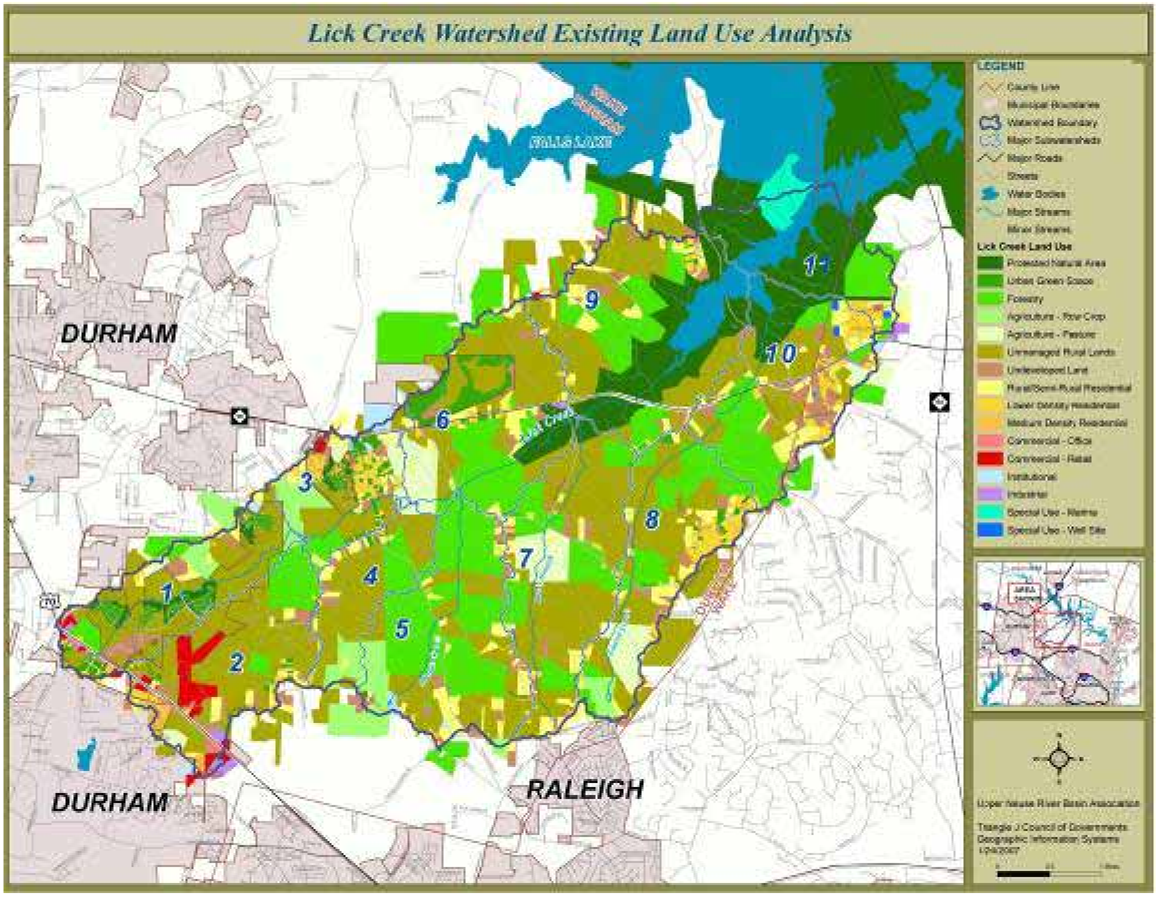

Figure 11: Current Land Use in the Lick Creek Watershed

Relative to surrounding watersheds, there is very little residential land use in the watershed. The majority of watershed residents live in single-family houses in very low-density to rural residential lots. Eleven percent (11%) of the watershed is divided into lots of 0.5 acres to 10 acres. Even in the most developed subwatersheds adjacent to Durham City, the total number of residential acres is low. In subwatershed 1, for example, the total number of residential parcels on lots smaller than 10 acres is 65 acres. In subwatershed 1, that is about the same amount of acreage devoted to row crops.

There are major land use changes underway, however. Durham's Urban Growth Area (UGA) encompasses most of the southern portion of the watershed, covering all or large portions of subwatersheds 1 through 8. These areas will be developed to suburban densities similar to those of neighboring Little Lick Creek, with a majority of new housing on lots less than 0.5 acres.

What will be the predominant land uses in Lick Creek once the watershed is "built out" to the level allowed under current regulations? In March 2007, the UNRBA and TJCOG will conduct an analysis of future land uses based on the zoning of parcels in the watershed. The analysis will predict the ultimate land use type for each parcel in the watershed based on current zoning and planned roads. The analysis will be consistent with the Durham Comprehensive Plan and Unified Development Ordinance (the UDO encodes the visions outlined in the Comprehensive Plan). The resulting "build out" land use analysis will provide a parcels-level land use change analysis that will be the basis for estimating changes in subwatershed-level impervious cover and relative pollutant loading.

The build out land use analysis will provide crucial information that will help the Lick Creek Partners and Stakeholders to predict the future of water quality and aquatic habitat in the watershed. Results from both the current and future land use analyses will be summarized by subwatershed. The Center for Watershed Protection will predict relative pollutant loading levels for pollutants such as nutrients (nitrogen and phosphorous) and sediments (total suspended solids)[4]

[4] The Center's Watershed Treatment Model (WTM) uses primary factors (such as land uses, impervious cover, and soil types) and secondary factors (such as sediment and erosion control practices, stormwater management practices, septic systems, and residential yard management practices, among other factors) to predict relative pollutant loadings for each subwatershed. The CWP and UNRBA will also use the WTM to predict the potential relative reductions expected from applying various management practices to the future land use scenario. The resulting predictions will allow the Lick Creek Partners and Stakeholders to assess the potential benefits of various management strategies. To learn more about the WTM, see the Little Lick Creek Watershed Treatment Model technical memorandum on the "Downloads" page of the Little Lick Creek project website www.unrba.org/littlelick.

5. Lick Creek Watershed Restoration Planning Process

The Upper Neuse River Basin Association has worked with partner organizations to recruit and convene watershed stakeholder groups to guide planning and facilitate other important project tasks. This section summarizes the process and stakeholder groups. Appendix 3 is the Lick Creek Local Watershed Plan Charter that the Technical Team adopted at its second meeting on March 7, 2007.

5.1 The Lick Creek Watershed Planning Group

The project will receive guidance from a Local Watershed Planning Group consisting of a Community Stakeholder Group, a Technical Team, and Project Partners. The primary purpose of the Watershed Planning Group is to develop watershed restoration and management recommendations for the Lick Creek watershed. A broad coalition of community groups will also help assure the ongoing support necessary for LWP implementation. Appendix 4, the Charter, defines the group objectives in detail.

The following sections describe the Community Stakeholder Group, the Technical Team, and Project Partners. Appendix 4 lists Partners, Stakeholders, and Technical Team members.

The Community Stakeholder Group

The main role of the Community Stakeholder Group is to provide input into the process and to ensure that the local watershed planning process considers a broad, diverse range of community interests. The Community Stakeholder Group also has the critical role of helping the Local Watershed Planning Group understand and account for local watershed conditions and problems. UNRBA has sought local community stakeholders from particular interest groups (by contacting farmers, developers, churches, homeowners' associations, etc.) as well as from the community at large (via newspaper announcements).

The Technical Team

The Technical Team comprises a group of resource professionals who contribute technical know-how to the project, conduct fieldwork, attend planning meetings, review staff findings, and make recommendations that guide the watershed plan. Members of the Technical Team represent various interests within the watershed (e.g., agriculture, forestry, wildlife / habitat protection, local government, economic development, etc.), and are expected to participate in all meetings or send alternates to represent their identified interests. The Technical Team directly participates in the process of developing recommendations that will create a viable Local Watershed Plan. In addition, the Technical Team may present relevant issues for consideration when investigating potential projects and potential sources of agency / program funding.

Project Partners

Project Partners are the governments and agencies working manage and financially support the project. Some partners, such as Durham City and County, hope to implement recommendations contained in the Local Watershed Plan. Project Partners include:

- Upper Neuse River Basin Association
- Triangle J Council of Governments
- Center for Watershed Protection
- NC State Water Quality Group
- Durham City Stormwater Services
- Durham County Stormwater and Erosion Control
- Durham City/County Planning Department

5.2 Potential Project Planning Process

The Lick Creek Watershed Planning process started in October 2006 with initial planning by the Lick Creek Project Partners. The UNRBA contacted stakeholders and held a project kickoff meeting (the meeting also presented the Little Lick Creek Local Watershed Plan recommendations). In November and December, Project Partners began collecting data and planning fieldwork. The first Lick Creek stakeholder meeting occurred in January 2007.

Major tasks of the Lick Creek Watershed Restoration Plan are listed below.

- Characterize the Lick Creek watershed through existing data (this Technical Memorandum).
- Determine watershed management goals based upon regulatory project drivers, such as Lick Creek's 303(d) impairment listing and the Falls Lake Nutrient Management Strategy, and other stakeholder goals.
- Assess current land use in the watershed, predict future land use, and discuss land use changes and watershed programs in place to guide new development.
- Conduct in-stream and upland fieldwork to identify impacts and stream reach conditions.
- Conduct water quality and biological monitoring. Monitoring will support management recommendations and long-term monitoring recommendations (to be carried out at Durham City Stormwater Service's two long-term monitoring sites).
- Assess subwatershed conditions through GIS analysis of subwatershed characteristics, current and future land uses, in stream conditions and impacts identified during fieldwork, regulatory circumstances, and watershed management practices. Use the Watershed Treatment Model to assess relative current and future pollutant loadings for each subwatershed.
- Conduct a critical lands protection analysis based on the Upper Neuse Clean Water Initiative and other local criteria.
- With Project Partners, Technical Team and Stakeholders, identify management strategies to address watershed management goals and subwatershed objectives.
- Write the Lick Creek Watershed Restoration Plan.

Subsequent technical memoranda will document findings from each task. Memorandum #2 will describe the land use analysis and the review of watershed protection-related programs in Durham City and County. The Lick Creek Watershed Restoration Plan will be a product of the project technical memoranda.

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Appendices

Appendix 1: Analysis of Existing Data and Short-Term Monitoring Plan for Lick Creek

Appendix 2: Lick Creek Monitoring Quality Assurance Plan

Appendix 3: Lick Creek Watershed Restoration Planning Group Charter