DURHAM
1869
CITY OF MEDICINE

CITY OF DURHAM

Memorandum

February 24, 2009

To: Heather Saunders, Upper Neuse River Basin Association

Through: John Cox, Water Quality Manager

From: Michelle Woolfolk

RE: Interim summary of water quality data for the Lick Creek watershed

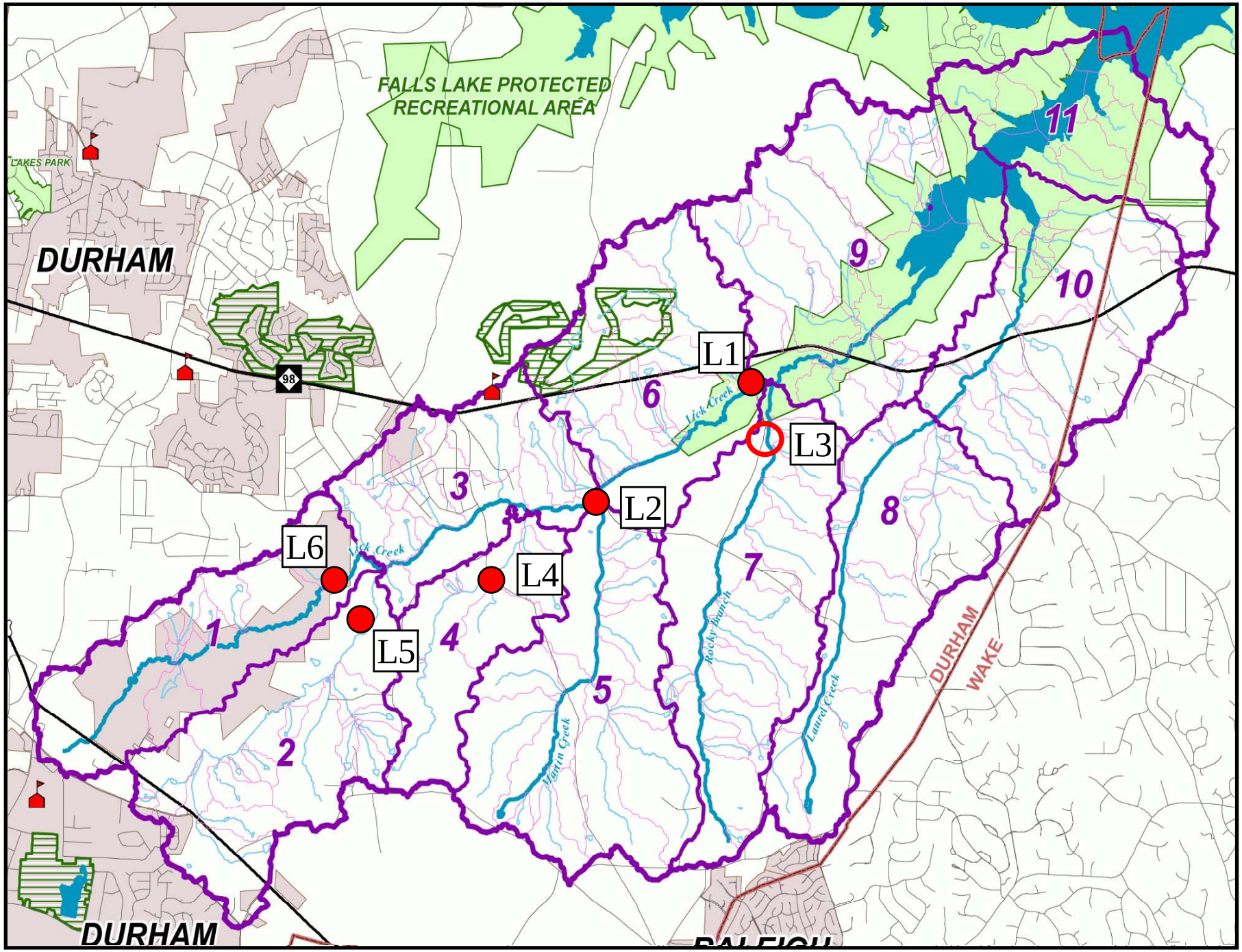
As discussed, this memorandum describes the interim data analysis Durham Stormwater Services agreed to provide to the Upper Neuse River Basin Association (UNRBA) regarding water quality monitoring data collected for the Lick Creek watershed in Durham County. The City of Durham participated in a stakeholder process, coordinated by UNRBA, to develop a local watershed plan for the Lick Creek watershed. This process is nearing completion and this summary will assist in the overall interpretation of information collected in the watershed. Stormwater Services assumes a final report describing and interpreting monitoring data from Lick Creek will be provided at a later date.

Monitoring data were obtained from the NC State University (NCSU) Water Quality Group, with whom UNRBA contracted to conduct monitoring of the watershed. Data were provided in an MS Excel ® spreadsheet and included relevant information as follows:

Site number and description	Date sampled
Gage height	Discharge (calculated)

Concentrations of various pollutants, including turbidity, *Echerichia coli (E. coli)*, nutrients, metals, dissolved oxygen (DO), pH, turbidity, total suspended solids (TSS) and conductivity. Water temperature was also measured instream and rainfall was recorded as measured at the Falls Lake dam.

The short-term monitoring (approximately 2 years), which is occurring concurrently with the development of the Lick Creek Watershed Restoration Plan, has consisted of collecting monthly grab samples at five sites (Figure 1). Flow-proportional samples from at least two storm events per site were also collected during this period. Although monitoring sites were visited monthly over a period of 21 months, drought conditions persisted through most of 2007 and into early 2008. As indicated in the NCSU spreadsheet, many streams were dry or not flowing when field teams visited monitoring sites. When streams were dry or not flowing, water quality samples were not collected. Even when water was present and flowing, samples may not be representative of typical conditions in Lick Creek because of the drought. Although Stormwater Services has monitored this watershed for several years, additional comparisons of NCSU data to Stormwater Services data were not performed for this interim summary.


FALLS LAKE PROTECTED
RECREATIONAL AREA
LAKES PARK
DURHAM
98
L1
L2
L3
L4
L5
L6
1
2
3
4
5
6
7
8
9
10
11
Lick Creek
Lick Creek
Marin Creek
Rocky Branch
Laurel Creek
DURHAM
WAKE
DURHAM
RALEIGH

Methods

- All data provided by NCSU were used. This includes data collected and analyzed by NCSU and the Durham Stormwater Services at LC3. Data at LC3 did not extend beyond June 2007.
- All qualifying information was reviewed to determine if sufficient quality concerns existed to warrant discarding any individual observation. Quality information provided describes samples outside of hold times, duplicate or split sample variation, laboratory blanks contaminated, and laboratory spikes out of range. Ultimately, all data were retained for the summaries.
- Values indicated as non-detected in the sample were included in statistics as the detection limit.
- All statistics were generated using JMP7®.
- The NC Division of Water Quality (NCDWQ) water quality standards (15A NCAC 02B .0211) and the US Environmental Protection Agency (EPA) Ambient Water Quality Criteria (AWQC) were used to provide benchmarks values to assist with interpretation of the numeric data.
    - NCDWQ water quality standards were preferentially used over EPA AWQC values when both were available. NCDWQ standards were available for temperature, DO, pH, and turbidity. EPA AWQC values were available for ammonia, total phosphorus, total nitrogen, and *E. coli*.
    - Where insufficient information for a criterion existed to provide practical comparisons, alternate or additional methods were used to highlight potential problem areas. This generally applied to nutrients and is noted where applicable.

Results

The interim results of water quality monitoring are provided in Tables 1 and 2. Table 1 provides a detailed summary of water quality data including the number of samples, the arithmetic or geometric mean of the parameter, the range of the parameter, and two columns used to compare the results to accepted levels. The column labeled "% > WQS" or "% > EPA criteria" indicates the number of samples that were greater than, or less than, the accepted levels. Where a state water quality standard exists, the NCDWQ evaluates the percent of samples that violate the standard in order to deem a water "Impaired" and justify placement on the state impaired waters list. Generally, this decision is based upon 10% of the samples indicating a violation of the standard. There is no such evaluation of the EPA criteria to deem a water impaired, although samples may violate the criteria.

Problem parameters for Lick Creek monitoring sites were identified using the NCDWQ water quality standards and the EPA AWQCs. Total nitrogen and total phosphorus (or nutrients) do not have water quality standards, therefore they were compared to the recommended ambient water quality criteria published by EPA (EPA 2000). However, EPA did not provide guidelines for implementing the recommended criteria. For example, should the criteria never be exceeded, or the average concentration not exceed the criteria, or another method of evaluation be used. As such, the interpretation of total nitrogen and total phosphorous data in this interim memorandum should be considered best professional judgment until EPA or the State of North Carolina provide additional guidance.

Overall, water quality appeared to be the best at monitoring sites describing Subwatersheds 4 and 5. The worst water quality was observed in Subwatersheds 1 and 7. Subwatersheds 1 and 7 had water quality data indicating high nutrient levels (phosphorus and nitrogen) and violations of either state water quality standards or EPA recommended criteria for turbidity and *E. coli*.

Table 1. Lick Creek Water Quality Data Summary (a)

			Pollutant Summary (b)													
			Temperature, C					Conductivity, uS/cm					DO, mg/L				
Site No.	Sub-watershed	Description	n	Mean	Range	%>WQS (c)	Compliance status	n	Mean	Range	%>WQS (d)	Compliance status	n	Mean	Range	%<WQS (e)	Compliance status
LC6	1	Lick Creek at Sherr	7	16.3	3.41 - 25.61	0%	NA	7	143	68 - 204	NA	NA	7	5.21	2.01 - 13.5	43%	(e)
LC5	2	UT on Randsell Pro	8	15.7	3.83 - 30.19	0%	NA	8	218	67 - 800	NA	NA	8	5.46	2.39 - 12.93	50%	(e)
None	3																
LC4	4	UT at Olive Branch	7	13.9	2.1 - 21.33	0%	NA	7	117	50 - 189	NA	NA	7	5.28	1.98 - 12.67	43%	(e)
LC2	5	Martin Creek at Ke	8	16.1	6.28 - 25.47	0%	NA	8	94	51 - 151	NA	NA	8	5.4	2.29 - 12.53	38%	(e)
LC1	6	Lick Creek at South	8	17.7	5.49 - 25.41	0%	NA	8	135	82 - 189	NA	NA	8	3.95	1.65 - 7.66	50%	(e)
LC3	7	Rocky Branch at Ke	2	11.5	5.7 - 17.34	0%	NA	2	121	73 - 169	NA	NA	2	7.41	2.37 - 12.46	50%	(e)

			Pollutant Summary													
			Total Kjeldahl nitrogen, mg/L					Nitrate+Nitrite Nitrogen, mg/L					Ammonia, mg/L				
Site No.	Sub-watershed	Description	n	Mean	Range	%>WQS (d)	Compliance status	n	Mean	Range	%>WQS (d)	Compliance status	n	Mean	Range	%> EPA criteria (g)	Compliance status
LC6	1	Lick Creek at Sherr	12	0.678	0.39 - 0.901	NA	NA	12	0.048	0.003 - 0.131	NA	NA	12	0.082	0.016 - 0.513	0%	Compliant
LC5	2	UT on Randsell Pro	13	0.411	0.249 - 0.700	NA	NA	13	0.057	0.001 - 0.156	NA	NA	13	0.048	0.016 - 0.129	0%	Compliant
None	3																
LC4	4	UT at Olive Branch	11	0.548	0.298 - 1.167	NA	NA	11	0.041	0.007 - 0.214	NA	NA	11	0.057	0.022 - 0.22	0%	Compliant
LC2	5	Martin Creek at Ke	12	0.0465	0.252 - 0.688	NA	NA	12	0.101	0.014 - 0.335	NA	NA	12	0.041	0.015 - 0.072	0%	Compliant
LC1	6	Lick Creek at South	16	0.529	0.351 - 0.779	NA	NA	16	0.058	0.007 - 0.161	NA	NA	16	0.081	0.015 - 0.227	0%	Compliant
LC3	7	Rocky Branch at Ke	6	1.59	0.07 - 2.8	NA	NA	6	0.127	0.05 - 0.20	NA	NA	6	0.39	0.025 - 1.42	0%	Compliant

			Pollutant Summary													
			Total phosphorus, mg/L					Total nitrogen, mg/L					Total suspended solids, mg/L				
Site No.	Sub-watershed	Description	n	Mean	Range	%> EPA criteria (i)	Compliance status	n	Mean	Range	%> EPA criteria (h)	Compliance status	n	Mean	Range	%>WQS (d)	Compliance status
LC6	1	Lick Creek at Sherr	12	0.726	0.405 - 0.947	100%	(i #)	12	0.726	0.405 - 0.947	75%	(h #)	12	34.1	6.0 - 97.0	NA	NA
LC5	2	UT on Randsell Pro	13	0.08	0.051 - 0.159	100%	NA	13	0.467	0.250 - 0.816	23%	NA	13	7.21	1.0 - 22.0	NA	NA
None	3																
LC4	4	UT at Olive Branch	11	0.057	0.038 - 0.096	100%	NA	11	0.588	0.322 - 1.202	36%	NA	11	7.55	4.8 - 12.0	NA	NA
LC2	5	Martin Creek at Ke	12	0.052	0.031 - 0.084	100%	NA	12	0.567	0.295 - 0.876	25%	NA	12	13.6	1.0 - 45.0	NA	NA
LC1	6	Lick Creek at South	16	0.089	0.047 - 0.168	100%	NA	16	0.587	0.374 - 0.866	25%	NA	16	12.6	1.5 - 45.0	NA	NA
LC3	7	Rocky Branch at Ke	6	0.11	0.05 - 0.334	100%	(i #)	6	1.72	0.27 - 2.9	66%	(h #)	6	30.6	14.0 - 68.0	NA	NA

			pH					Turbidity					E. coli, mpn/100mL				
Site No.	Sub-watershed	Description	n	Mean	Range	%<WQS (k)	Compliance status	n	Mean	Range	%>WQS (f)	Compliance status	n	Geometric mean	Range	%> EPA criteria (j)	Compliance status
LC6	1	Lick Creek at Sherr	7	NA	4.84 - 7.53	43%	(k*)	13	74.7	30.0 - 119.0	76%	Non-compliant	13	215	9 - 2400	NA	Non-compliant
LC5	2	UT on Randsell Pro	8	NA	5.07 - 7.58	13%	(k*)	14	25.6	2.0 - 79.0	14%	Non-compliant	13	93	15 - 2400	NA	Compliant
None	3																
LC4	4	UT at Olive Branch	7	NA	3.5 - 7.98	14%	(k*)	12	21.2	7.4 - 39.0	0%	Compliant	12	72	3 - 460	NA	Compliant
LC2	5	Martin Creek at Ke	8	NA	5.86 - 7.93	13%	(k*)	13	19.2	7.4 - 30.0	0%	Compliant	13	84	1.5 - 1100	NA	Compliant
LC1	6	Lick Creek at South	8	NA	5.18 - 7.15	13%	(k*)	15	36.7	4 - 97	27%	Non-compliant	18	178	15 - 2400	NA	Non-compliant
LC3	7	Rocky Branch at Ke	2	NA	6.02 - 7.68	0%	NA	2	33.7	29 - 38.5	0%	NA	6	777	71 - 25000	NA	Non-compliant

n = Number of samples analyzed
mean = arithmetic mean concentration except as noted.
Range = Minimum to maximum of reported levels. Where the minimum was not detected at a specified quantitation limit, the quantitation limit is shown.
Compliance state = evaluate of the concentrations and/or percent of criteria exceeded to determine complaince with criteria. For simplicity, a result of Compliant or Non-complaint is reported.
WQS = NC Water Quality Standard, 15A NCAC 02B .0211
* = Generally indicates minimum sample sizes are not met. See specific letter footnote.
# = Generally associated with nutrients for which EPA has not provided sufficient guidance on applying recommended criteria. See specific letter footnote.

(a) All data summarized in this table were provided by the NCSU Water Quality Group in November 2008 and includes data collected and analyzed by NCSU and the City of Durham Stormwater Services. The period represented is from January 2007 through September 2008.
(b) All pollutants are included in this summary except metals (i.e., Copper, Lead and Zinc). Values reported as less than detected were used in calculations of means as the detection limit.
(c) Temperature levels were compared to the North Carolina water quality standard for Class C lower piedmont streams which states that temperature is "not to exceed 2.8 degrees C (5.04 degrees F) above the natural water temperature, and in no case to exceed 29 degrees C (84.2 degrees F) for mountain and upper piedmont waters and **32 degrees C (**89.6 degrees F) for lower piedmont and coastal plain waters". 15A NCAC 02B .0211 (3)(j)
(d) Conductivity, total Kjeldahl nitrogen, nitrate+nitrite nitrogen and total suspended solids do not have water quality standards or recommended criteria for Class C streams.
(e) Dissolved oxygen levels were compared to the instantaneous North Carolina water quality standard for Class C streams which states that dissolved oxygen shall be "not less than a daily average of 5.0 mg/L with a minimum instantaneous value of not less than **4.0 mg/L**". 15A NCAC 02B .0211 (3)(b). When a minimum of 10 samplies is available, the North Carolina Division of Water Quality methods for assessing stream use support allow a 10% exceedance of a standard before deeming the stream "Impaired". None of the monitored sites had a minimum of 10 samples, however all sites recorded non-compliant dissolved oxygen concentrations.
(f) Turbidity levels were compared to the North Carolina water quality standard for Class C streams, which states "the turbidity in the receiving water shall not exceed **50 Nephelometric Turbidity Units (NTU)** in streams not designated as trout waters". 15A NCAC 02B .0211 (3)(k). When a minimum of 10 samples is available, the NCDWQ methods for assessing stream use support allow a 10% exceedance of the standard before deeming the stream non-complaint or "Impaired".
(g) The EPA criteria for ammonia are both temperature and pH specific. For this comparison, the more strict Continuous Chronic Criterion (CCC) for fish early life stages present was used. (EPA 1999)
(h) Total nitrogen was determined as the sum of total Kjeldahl nitrogen and nitrate+nitrite nitrogen. North Carolina does not have water quality standards for total nitrogen, so the EPA AWQC recommendations for nutrients were used for comparison. For Region IX (which includes central North Carolina), Level III Ecoregion 45, the total nitrogen AWQC based on measured data is **0.615 mg/L** (EPA 2000). EPA has not provided guidance on the method for evaluating the AWQC, so the compliance status reflects those sites with an arithmetic mean concentration greater than 0.615 mg/L. These are noted with an (h #).
(i) North Carolina does not have water quality standards for total phosphorus. The EPA AWQC recommends the following total phosphorus criteria for Region IX, Level III, Ecoregion 45: **0.03 mg/L**. (EPA 2000). However, all of the data for the Lick Creek watershed exceed this recommended criteriona, possibly due to naturally elevated levels of phosphorus in soils. The Complaince status column highlights those sites with an arithmetic mean total phosphorus concentration greater than **0.10 mg/L** with an (i #).
(j) North Carolina does not have water quality standards for E. coli, so the EPA AWQC recommendations for E. coli were used to judge instream levels. For freshwaters, a geometric mean concentration of **126 cfu/100mL** is recommended (EPA 1986). EPA recommends applying this geometric mean to a minimum of 5 samples collected within a 30-day period. Since samples were collected monthly over a 21 month period, this cannot be regidly applied to the Lick Creek study. However, comparing the geometric mean of all the data collected to the 30-day criterion does provide an important indicator of sites that would most likely violate the citerion as written.
(k) pH levels were compared to the North Carolina water quality standard for Class C streams, which states that pH "shall be normal for the waters in the area, which generally shall range between **6.0 and 9.0**". 15A NCAC 02B .0211(3)(g) When a minimum of 10 samples is available, the North Carolina Division of Water Quality methods for assessing stream use support allow a 10% exceedance of the standard before deeming the stream as noncompliant or "Impaired". None of the monitored sites had a minimum of 10 samples, however all sites recorded non-compliant pH at levels lower than 6.0. These sites are noted with a (k *).

Subwatershed 5 also had violations of standards or criteria for turbidity and *E. coli,* while Subwatershed 2 had violations of the water quality standard for turbidity. An overall summary of problem parameters is presented in Table 2. A check mark indicates a parameter that exceeded state or federal standards. In cases where a state or EPA standard was not available, best professional judgment was used to indicate problem parameters. Data were not collected in Subwatershed 3; this row appears shaded grey in Table 2.

Table 2. Lick Creek watershed water quality problem indicators, by subwatershed

Sub-watershed	Dissolved oxygen	*E. coli*	pH	Total nitrogen	Total phosphorus	Turbidity
1	✓	✓	✓	✓	✓	✓
2	✓	-	✓	-	-	✓
3						
4	✓	-	✓	-	-	-
5	✓		✓	-	-	
6	✓	✓	✓	-	-	✓
7	✓	✓	-	✓	✓	-

DO levels were depressed below the NC instantaneous water quality standard at all monitoring locations during summer months. It is difficult to determine the cause of low DO during the period monitored due to drought conditions. DO may have worsened during the drought due to stagnant or pooled water. Other potential causes, for example continuous sources of ammonia and other oxygen consuming wastes, may have become more pronounced during this period and may have contributed to the low DO values. Given the number of monitoring location visits where stagnant and/or dry conditions were recorded, drought conditions most certainly contributed to low DO, but this could not be separated from other sources of pollution.

E. coli were evaluated using the EPA criteria for bacteria (EPA 1986). Using this criteria, subwatersheds 1, 6 and 7 each had a geometric mean concentration of *E. coli* greater than the EPA criteria. Subwatershed 7 had a geometric mean concentration more than five times worse than the EPA criteria, far worse than any other Lick Creek monitoring locations.

It appears that a one-time low pH event occurred in February and March 2007 throughout the Lick Creek watershed, causing this parameter to be highlighted as a problem. What event or condition may have caused these widespread low pH levels is unknown. In general, all other samples indicated a pH within the range specified by the NC DWQ water quality standards. (see Table1, footnote (k)). Although pH is presented as a problem parameter in Table 2, it may not be of significance to current water quality management goals because it appears to be a one-time event.

Total nitrogen and total phosphorus were evaluated based on arithmetic mean concentrations. The arithmetic mean total nitrogen concentration was compared to the EPA AQWC to determine those sites that might be out of compliance. However, total phosphorus concentrations were worse than the EPA AWQC at all monitoring locations. In order to highlight those subwatersheds with significantly worse levels of total phosphorus, best professional judgment was used, as described in Table 1, footnote (i).

Turbidity concentrations may be elevated whenever there is a significant amount of soil exposed on land or when stream flows are such that erosion of the stream banks occurs. Using the NC water quality standard as a benchmark, turbidity violations occurred at a high frequency in three subwatersheds, as noted in Table 1.

References:

15A North Carolina Administrative Code (NCAC) 2B .0200. Procedures for Assignment of Water Quality Standards

US Environmental Protection Agency (EPA). 1986. Quality Criteria for Water 1986. EPA 440/5-86-001. Office of Water Regulations and Standards, Washington DC. May

US Environmental Protection Agency (EPA). 1999. 1999 Update of Ambient Water Quality Criteria for Ammonia. EPA-822-R-99-014. Office of Water 4304. December

US Environmental Protection Agency (EPA). 2000. Ambient Water Quality Criteria Recommendations. Information Supporting the Development of State and Tribal Nutrient Criteria. Rivers and Streams in Nutrient Ecoregion IX. EPA 822-B-00-019. Office of Water. December