Evaluation of Pollution Sources to Lake Glenville
Quarterly Report – March 2019

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Summary

Chemical and microbial analysis of water samples collected at Lake Glenville area sites helps to characterize water quality in relation to potential sources of water pollution. Overall water quality, as evidenced by data collected on March 19, 2019, is acceptable but there is evidence to suggest the influence of soil erosion and runoff events on nutrient concentrations. Water quality was comparable to that observed in December 2018 with the exception of orthophosphate and nitrate concentrations. Specifically, orthophosphate concentrations increased while nitrate concentrations decreased from December 2018 to March 2019. The next quarterly monitoring event will take place in June 2019. Results from that monitoring event will be evaluated individually and in relation to the results presented in this report to evaluate temporal changes in water quality and evaluate sources of pollution.

Methodology

Lake Glenville area samples were collected on Tuesday, March 19, 2019. At each sampling location, the following data were collected: creek name, time of sample collection, pH, dissolved oxygen, conductivity, air temperature, and water temperature. Weather conditions during the time of sample collection were also recorded. Samples were collected in triplicate at each site in labeled 2L Nalgene™ bottles and transported to Western Carolina University's Environmental Health lab on ice. Upon arrival to the Environmental Health lab, samples were analyzed for the following parameters within 6 hours: alkalinity, ammonia ($NH_3$), nitrates ($NO_3$), orthophosphates (as $PO_4$), total suspended solids (TSS), turbidity, and *E. coli*. Detailed explanations of laboratory analyses are available upon request.

Results

**Acidity and Alkalinity:** pH is used to measure acidity. The ambient water quality standard for pH is between 6.0 and 9.0, although natural pH in area streams generally ranges from 6.5-7.2. Values below 6.5 may indicate the effects of acid precipitation or other acidic inputs, and values above 7.5 may indicate industrial discharge. Pine Creek exhibited pH readings above 7.5 while the pH readings of the remaining creeks were comparable to area streams. All March 2019 pH measurements were comparable to those observed in December 2018 and all pH observations are within the North Carolina water quality standard for freshwater aquatic life (Figure 1).

Alkalinity is the measure of the pH buffering capacity of a water or soil. High alkalinity waters are generally better protected against acid inputs from sources such as acid rain, organic matter, and industrial effluent. Waters with an alkalinity below 30mg/L are considered to have low alkalinity. The observed mean alkalinity concentrations demonstrate low alkalinity in all monitored creeks (Figure 2). Historically low alkalinity concentrations in these creeks may account for the observed fluctuations in pH as the waters have little buffering capacity and are therefore more susceptible to changes in pH. All creeks displayed an increase in average alkalinity concentrations compared to December 2018 with the exception of Mills Creek.

Figure 1. pH levels at each monitoring site, March 2019

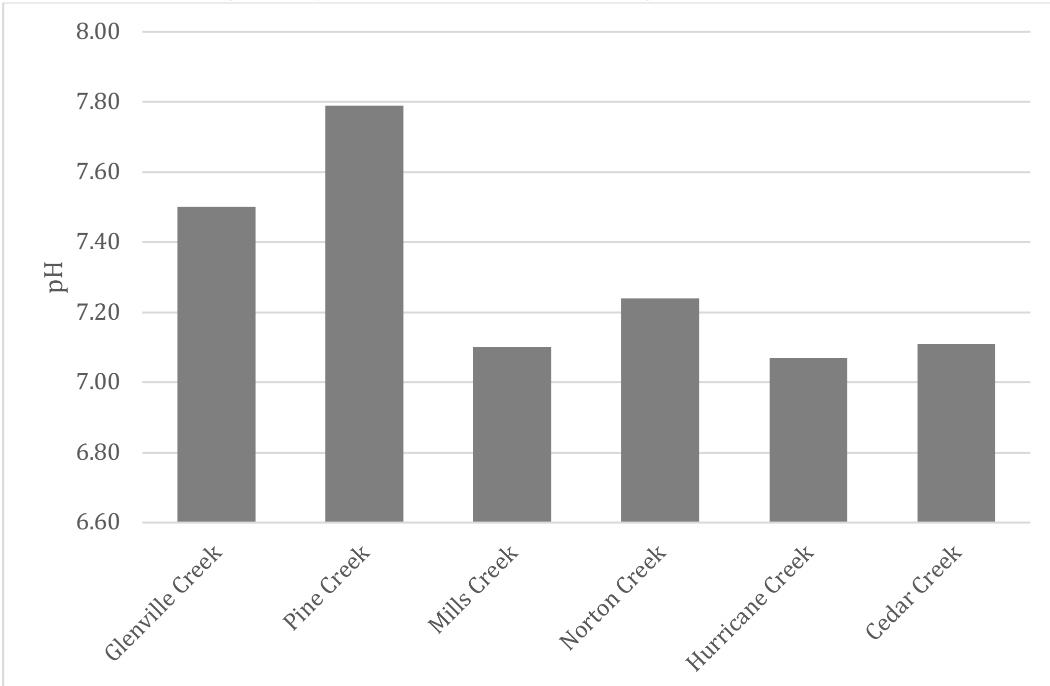
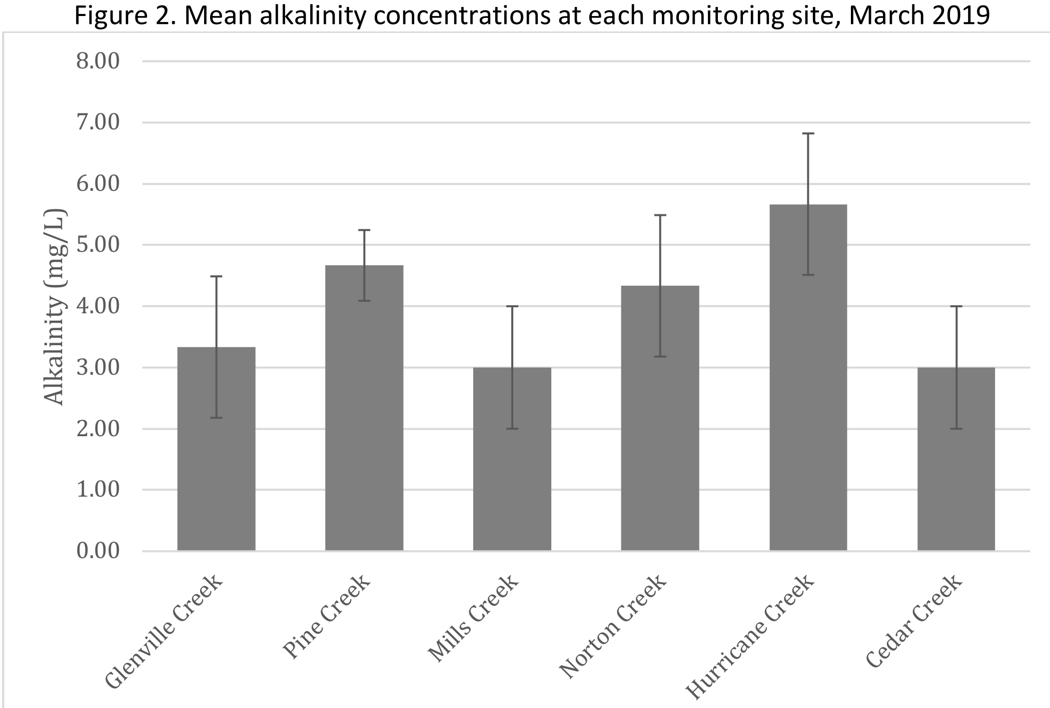



Figure 2. Mean alkalinity concentrations at each monitoring site, March 2019




**Turbidity and Total Suspended Solids (TSS):** Turbidity is a measure of visual water clarity and of the presence of suspended particulate matter. The standard for trout-designated waters is 10 NTU and the standard to protect other aquatic life is 50 NTU. Turbidity measurements in all creeks are below the 10 NTU trout-designated water standard (Figure 3). TSS quantifies solids by weight and is heavily influenced by a combination of stream flow and land disturbances. Although there is no legal standard for TSS, concentrations below 30mg/L are generally considered low. All monitoring sites exhibited low TSS concentrations (Figure 4). While moderately heavy precipitation events and land disturbance can increase turbidity and TSS concentrations, the undisturbed forested areas and presence of riparian zones in the Lake Glenville area likely help prevent significant increases in turbidity and TSS particulates during rainfall and runoff events.

Figure 3. Mean turbidity levels at each monitoring site, March 2019

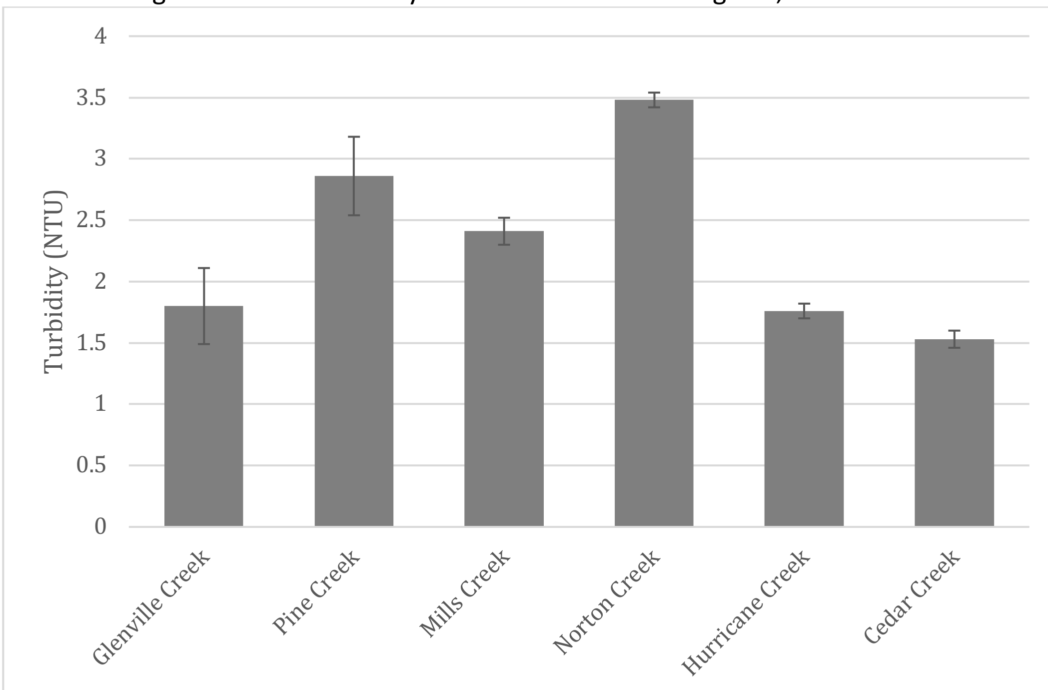
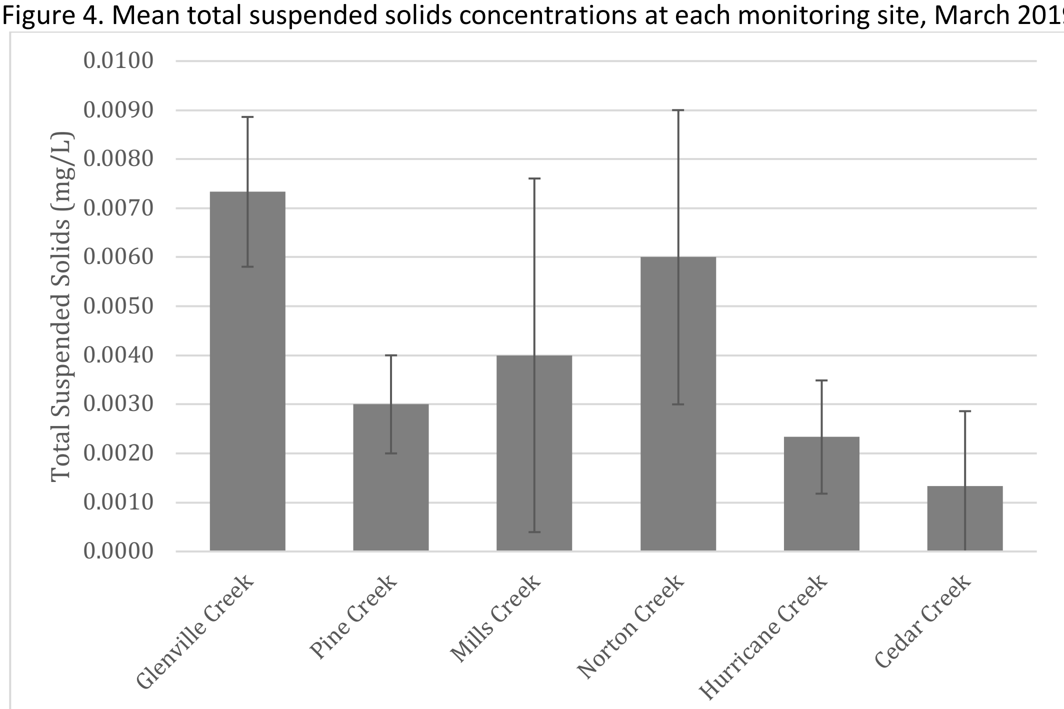


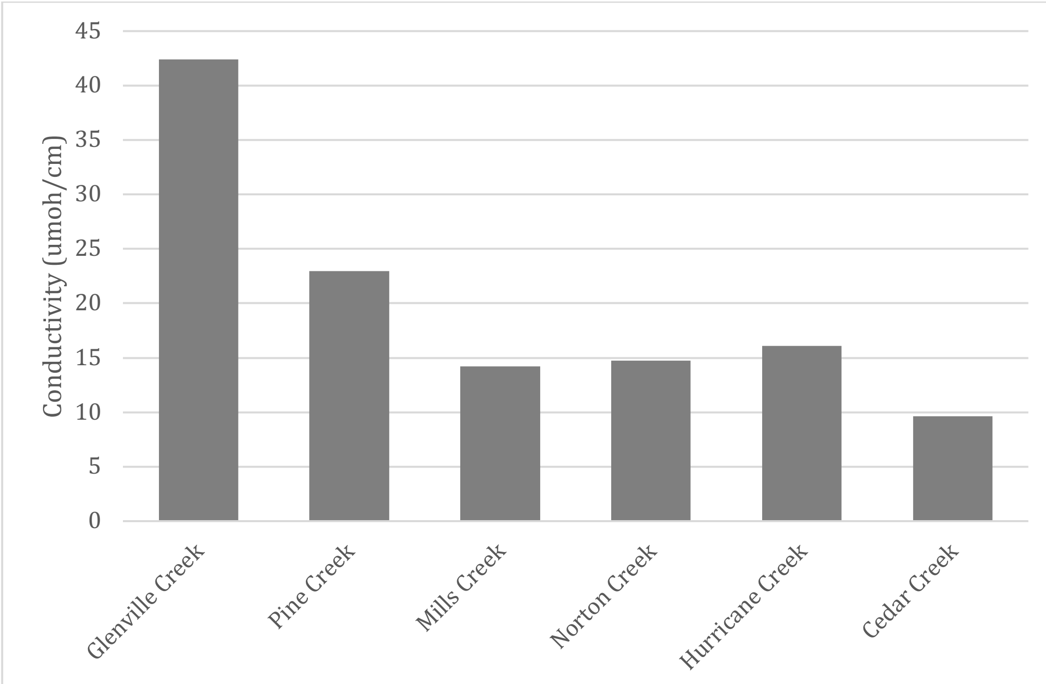

Figure 4. Mean total suspended solids concentrations at each monitoring site, March 2019




**Conductivity:** Conductivity is used to measure the ability of water to conduct an electrical current. Samples containing dissolved solids and salts will form ions that will conduct an electrical current and the concentration of dissolved ions in a sample determines conductivity. Inorganic dissolved solids such as chloride, nitrate, phosphate, calcium, sulfate, iron, sodium, and aluminum will affect conductivity levels and local geologic conditions will influence the types and extent of dissolved ions. Elevated levels of conductivity are most often seen in streams receiving wastewater discharge, urban runoff, or eroded soils.

The observed conductivity levels in all creeks are low (Figure 5) yet are comparable to the conductivity measurements observed in December 2018. It is likely that these temporal similarities are the due to the continued influence of colder water temperatures compared to those in the spring and fall months.

Figure 5. Conductivity levels at each monitoring site, March 2019




**Nutrients (Orthophosphate [$PO_4^{3-}$], Ammonia [$NH_3$], and Nitrate [$NO_3^-$]):** Phosphorus is an essential nutrient for aquatic plants and algae, and is typically the limiting nutrient in most aquatic systems thereby restricting plant growth in an ecosystem. Phosphorus is introduced into water systems from soil, wastewater treatment systems, failing septic systems, and runoff from fertilized land. Excessive phosphorus stimulates excessive plant growth and results in eutrophication, a condition that can result in dissolved oxygen depletion in an aquatic ecosystem. Orthophosphate is the amount of phosphorus that is immediately available to plants or algae for biological assimilation. Generally, orthophosphate levels below 0.05 mg/L are sufficient to prevent eutrophication.

There is no legal water quality standard for orthophosphate, but the Environmental Protection Agency (EPA) nutrient criteria for total phosphorus in rivers and streams in this ecoregion is 0.01 mg/L. Although orthophosphate is only one component of total phosphorous, observed concentrations at all monitored sites exceed the EPA nutrient criteria for total phosphorous but are sufficient to prevent eutrophication (Figure 6). Glenville Creek exhibited a decrease in orthophosphate concentrations while all other creeks exhibited an increase in orthophosphate concentrations compared to those observed in December 2018. Orthophosphate concentrations are slightly correlated with conductivity suggesting the influence of soil erosion and runoff on orthophosphate concentrations.

Ammonia is contained in decaying plant and animal remains and microbial decomposition of these organic wastes can release ammonia. The most likely sources of ammonia are agricultural runoff, livestock farming, septic drainage, and sewage treatment plants. The ambient concentration of ammonia in water is approximately 0.10 mg/L but concentrations are heavily influenced by water temperature and pH, with higher temperatures and pH leading to more nitrogen being present in the form of ammonia. No creek exceeded the ambient concentration “norm” (Figure 7). The low water temperatures and neutral pH values likely contributed to the decreased ammonia concentrations in Pine, Mills, Norton, and Hurricane Creeks compared to those observed in December 2018. The elevated ammonia concentrations observed in Glenville Creek may be associated with observed total suspended solids concentrations.

Like phosphorus, nitrate serves as an algal nutrient and can contribute to excessive plant growth and eutrophication. Common sources of nitrate include septic drainage and fertilizer runoff from agricultural land and domestic lawns. The ability of nitrate to more readily dissolve in water contributes to its increased likelihood of traveling in surface waters. As a result, nitrate is a good indicator of sewage or animal waste input. There is no legal water quality standard for nitrate, but the EPA nutrient criteria for total nitrogen in rivers and streams in this ecoregion is 0.31 mg/L. Although nitrate is only one component of total nitrogen, observed concentrations in all creeks exceeded the EPA nutrient criteria for total nitrogen (Figure 8). Observed nitrate concentrations are lower than those observed in December 2018 for all creeks. Observed nitrate concentrations are strongly correlated with total suspended solids (Figure 9), suggesting that soil erosion and runoff may be contributing nitrate to these creeks.

Figure 6. Mean orthophosphate concentrations at each monitored site, March 2019

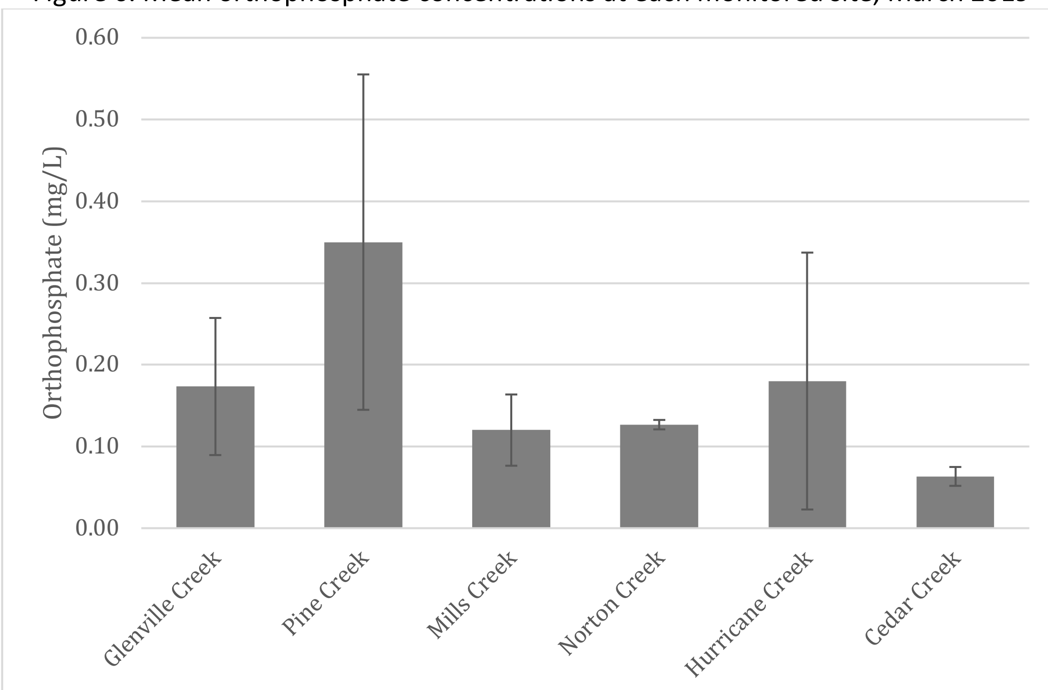



Figure 7. Mean ammonia concentrations at each monitored site, March 2019

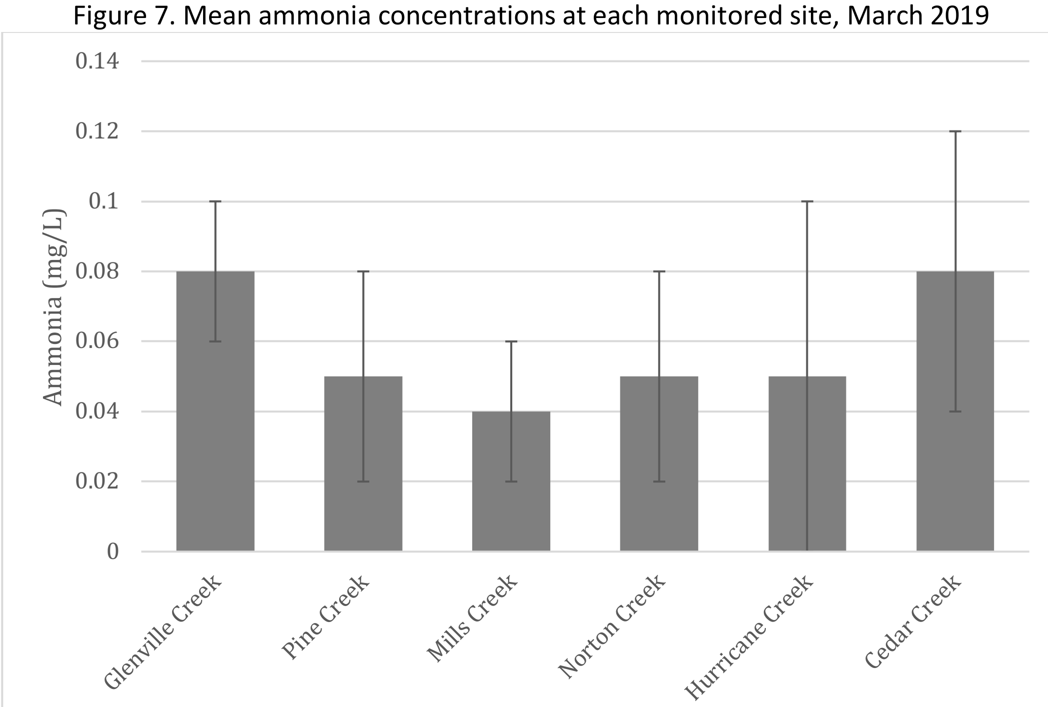


Figure 8. Mean nitrate concentrations at each monitored site, March 2019

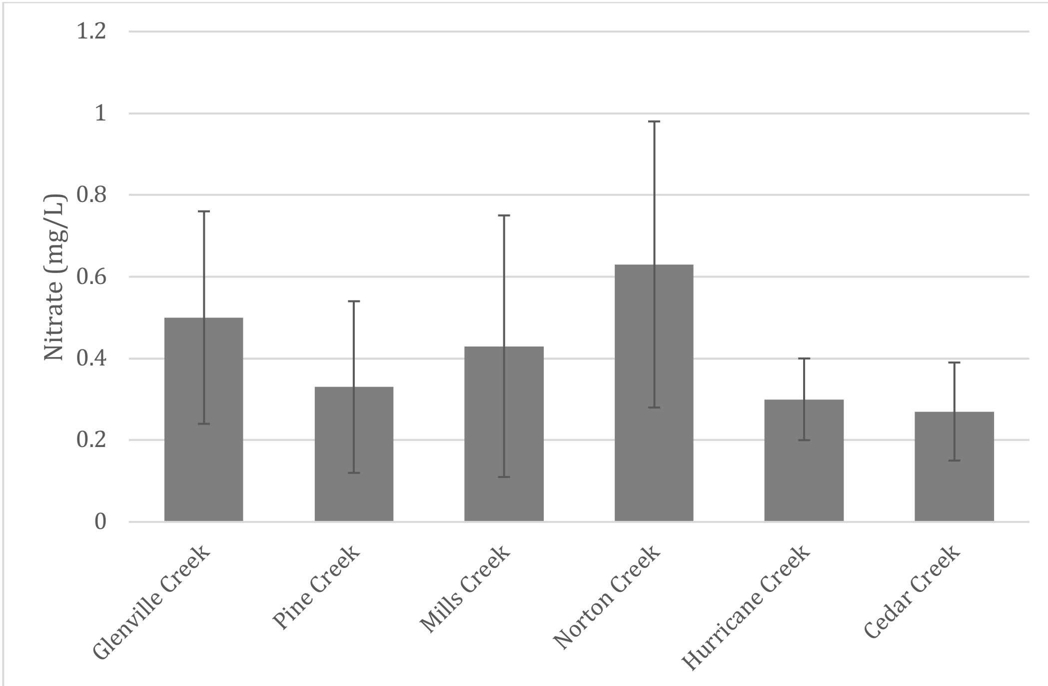
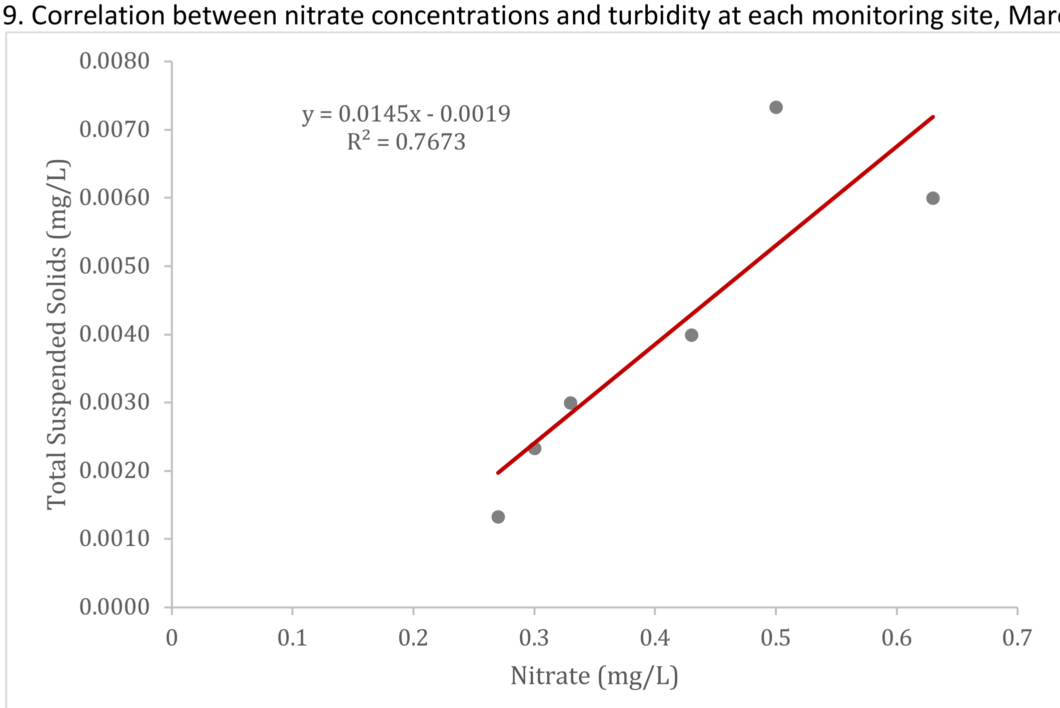


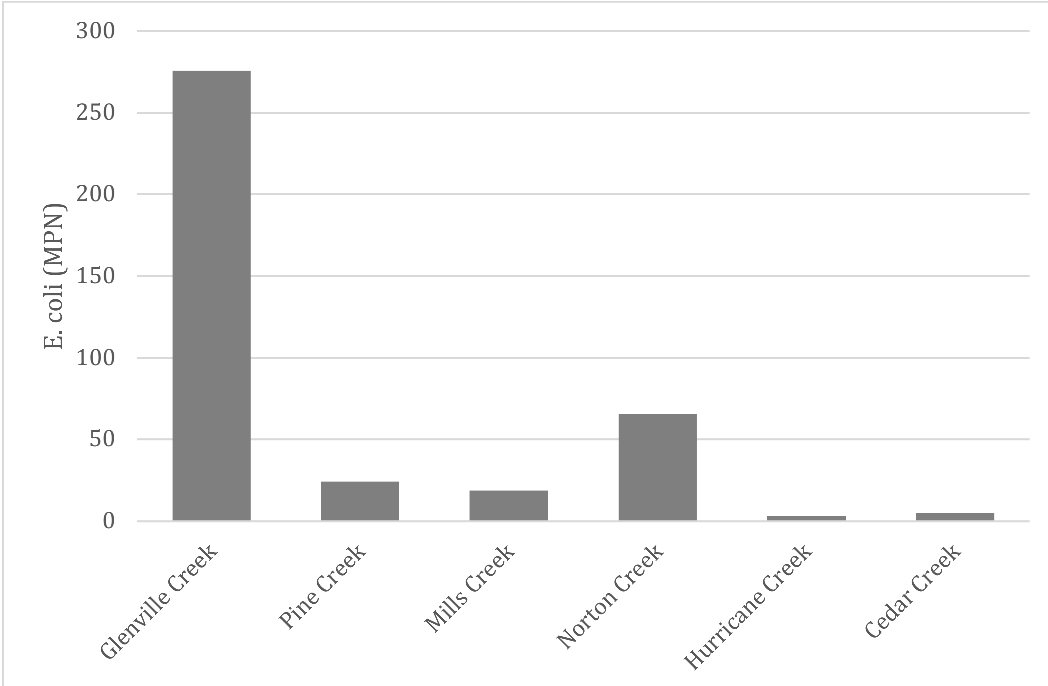

Figure 9. Correlation between nitrate concentrations and turbidity at each monitoring site, March 2019




***E. coli*:**

The potential presence of fecal pathogens in surface water is determined based on a surrogate measurement of fecal indicator organisms, including *E. coli*. The recreational standard for *E. coli* in the State of North Carolina is 200 CFU/100ml. Only Glenville Creek exhibited *E. coli* concentrations above this regulatory standard (Figure 10). *E. coli* concentrations in surface waters have been shown to be influenced in part by seasonality, and future sampling events will continue to monitor *E. coli* to identify possible influences of seasonality and agricultural activity on fecal pollution in the creeks discharging into Lake Glenville.

Figure 10. *E. coli* concentrations at each monitored site, March 2019




<u>Conclusions</u>

Chemical and microbial analysis of water samples collected at Lake Glenville area sites help to characterize water quality in relation to potential sources of water pollution. Overall water quality, as evidenced by data collected on March 19, 2019, is acceptable but there is evidence to suggest the influence of soil erosion and runoff events on water quality, particularly nutrient concentrations. The next quarterly monitoring event will take place in June 2019. Results from that monitoring event will be evaluated individually and in relation to the results presented in this report to evaluate temporal changes in water quality and evaluate sources of pollution.