Evaluation of Pollution Sources to Lake Glenville
Quarterly Report – December 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 December 5, 2019, is acceptable but there is evidence to suggest the influence of soil erosion on nutrient concentrations. Nitrate concentrations increased from September 2019 to December 2019, and orthophosphate and ammonia concentrations decreased in the same time period. Additionally, *E. coli* concentrations in Pine Creek were observed to be within regulatory standards. The next quarterly monitoring event will take place in February 2020. 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 Thursday, December 5, 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. pH measurements in all creeks were lower compared to those observed in September 2019 and were 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. Average alkalinity measurements in all creeks were comparable to those observed in September 2019 with the exception of Norton Creek, where the alkalinity concentration was half of that observed in September 2019.

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

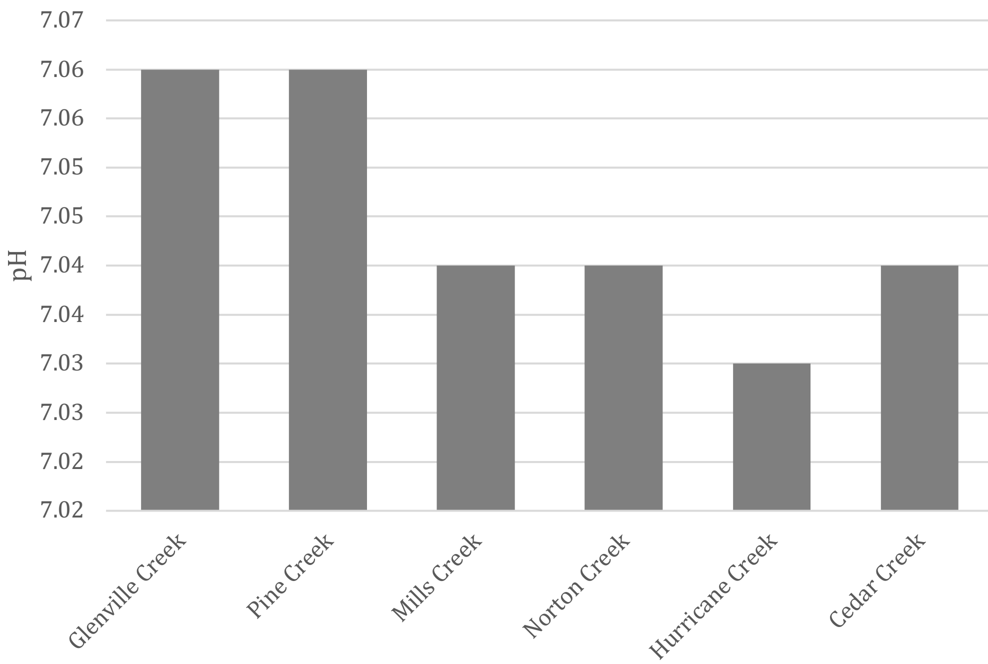
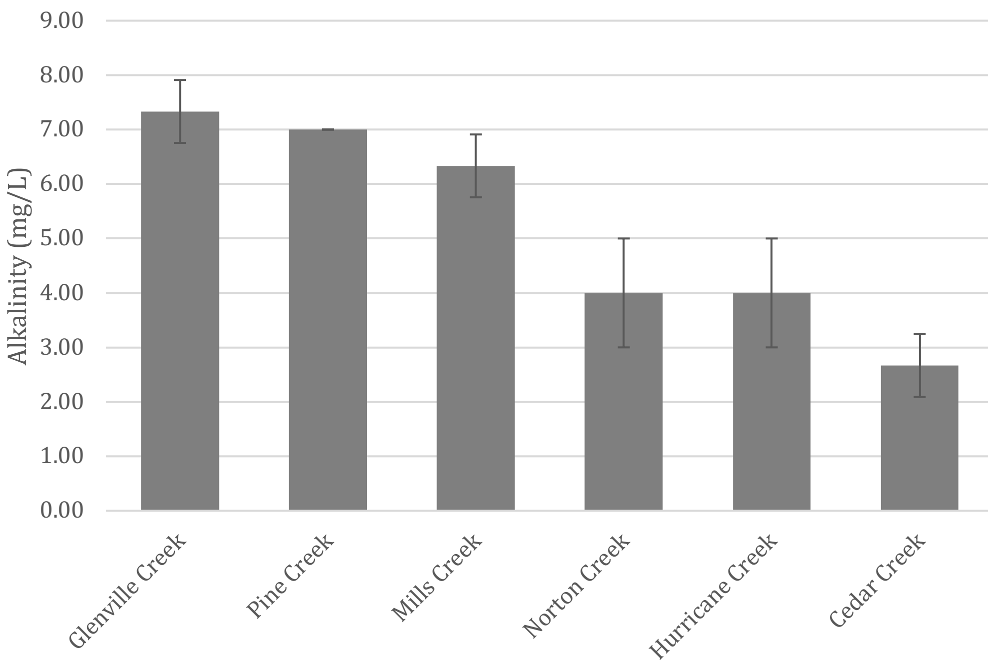


Figure 2. Mean alkalinity concentrations at each monitoring site, December 2019



Turbidity and Total Suspended Solids (TSS): Turbidity is a measure of visual water clarity and of the presence of suspended particulate matter and dissolved organic material. 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) and measurements were lower than those observed in September 2019.

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. TSS concentrations were higher that than those observed in September 2019 for Glenville and Pine Creeks, where increased creek water volume was observed at the time of sampling. Water elevations were above the established banks of these creeks but they were not considered to be flooded. The contact of the elevated water with exposed soil along the creek banks likely contributed to erosion resulting in increased TSS concentrations in these creeks compared to observed September 2019 TSS concentrations. TSS concentrations in the remaining creeks were comparable to those observed in September 2019.

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

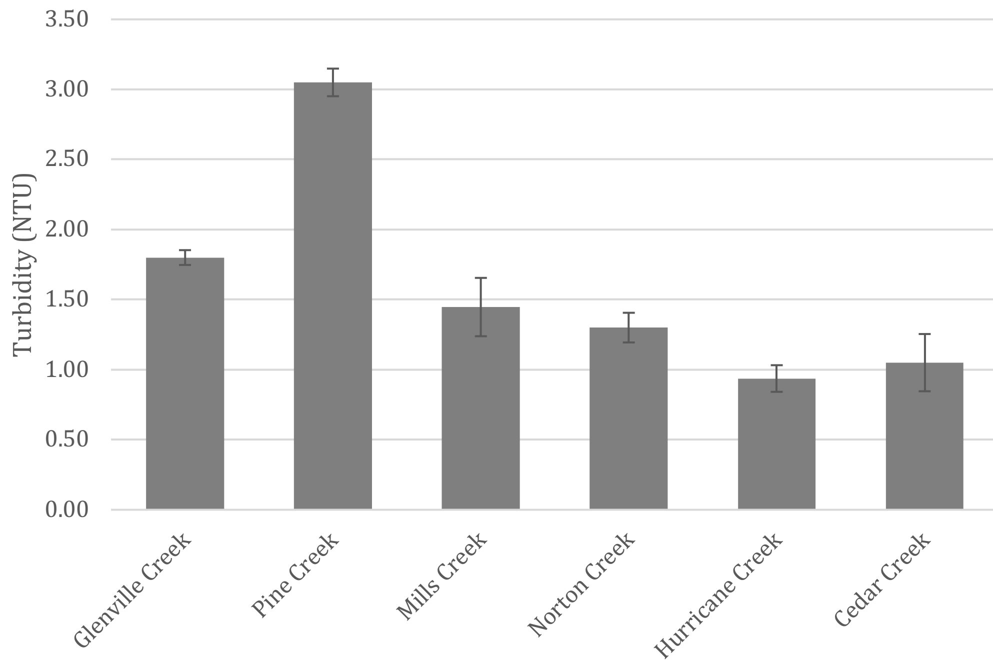
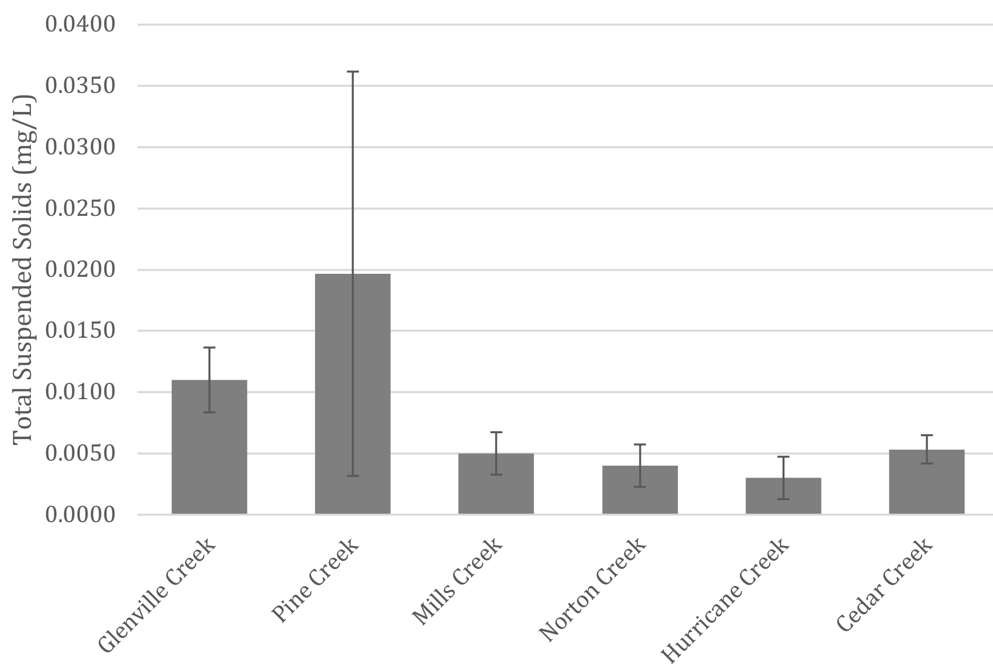
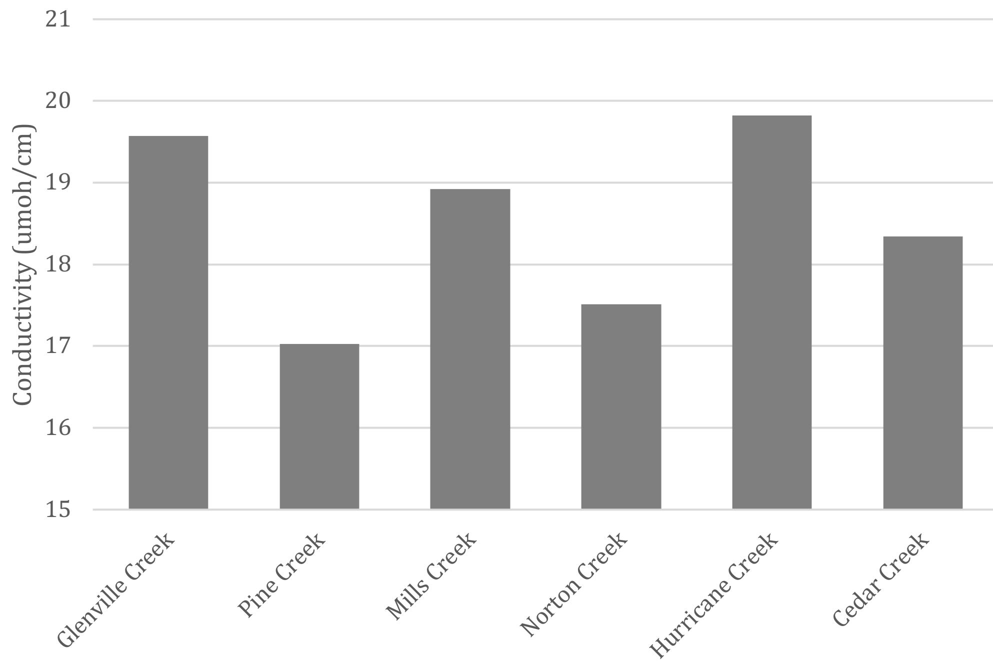


Figure 4. Mean total suspended solids concentrations at each monitoring site, December 2019



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) and are lower than the conductivity measurements observed in September 2019.

Figure 5. Conductivity levels at each monitoring site, December 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 creeks exceeded the EPA nutrient criteria for total phosphorous (Figure 6). All creeks exhibited a decrease in orthophosphate concentrations from observed September 2019 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. All creeks were within the ambient concentration "norm" (Figure 7) and were greatly reduced compared to concentrations observed in September 2019. The reduced ammonia concentrations in all creeks compared to those observed in September 2019 are likely the result of organic matter processing and nutrient cycling by microbial populations.

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 (Figure 8) and were higher than those observed in September 2019. This is not unexpected as ammonia is converted to nitrate in the nitrogen cycle. The reduced ammonia concentrations coupled with the increased nitrate concentrations suggest the influence of microbial activity on organic matter inputs and nutrient cycling. Additionally, nitrate concentrations were weakly correlated with turbidity suggesting the influence of soil erosion on nutrient concentrations.

While orthophosphate and nitrate concentrations exceeded the EPA nutrient criteria, it is important to note that no creek displayed visible signs of eutrophication in the form of algal blooms. Observed dissolved oxygen (DO) concentrations also suggest the ability of these creeks to effectively assimilate nutrient and support aquatic life. DO concentrations in all creeks measured well above the State of North Carolina's aquatic life standard of >6 mg/L for trout waters (Figure 9). The sufficient DO concentrations observed in these creeks suggests that nutrient concentrations are not negatively impacting nutrient cycling or ecosystem function at this time.

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

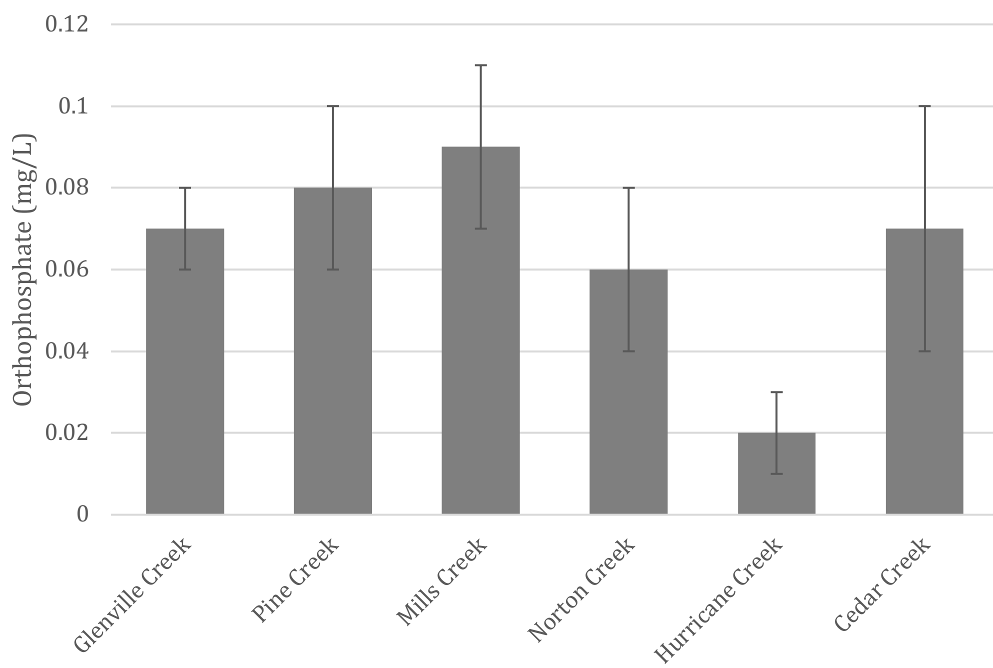


Figure 7. Mean ammonia concentrations at each monitored site, December 2019

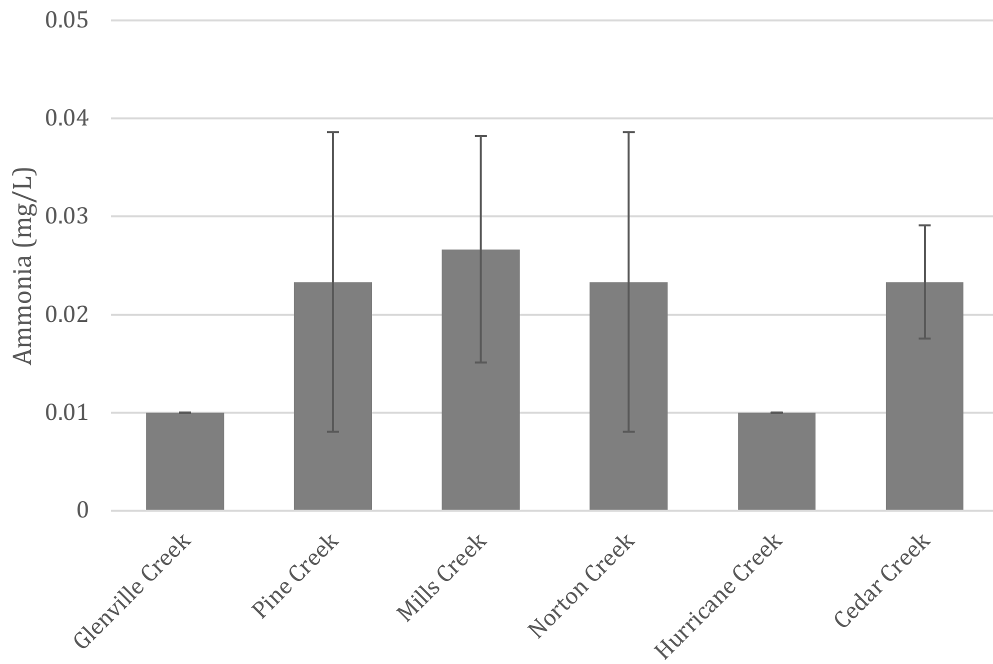


Figure 8. Mean nitrate concentrations at each monitored site, December 2019

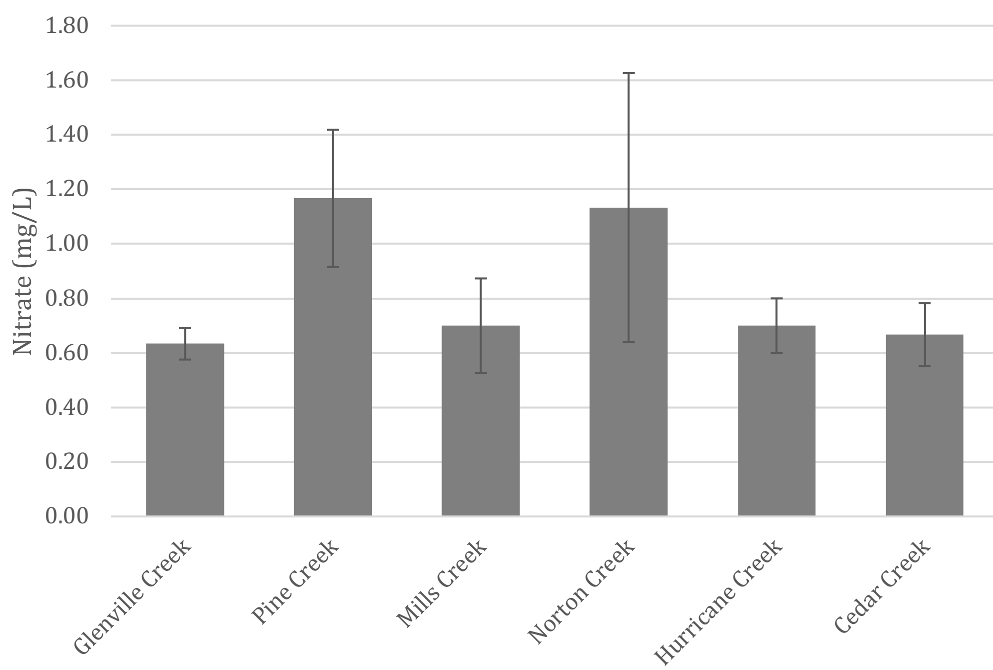
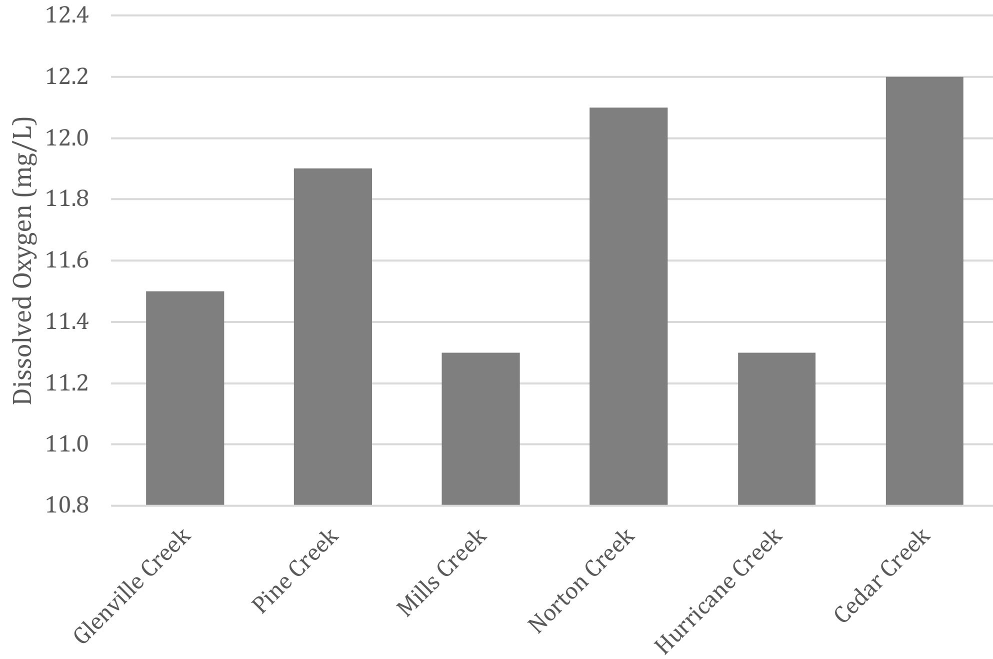


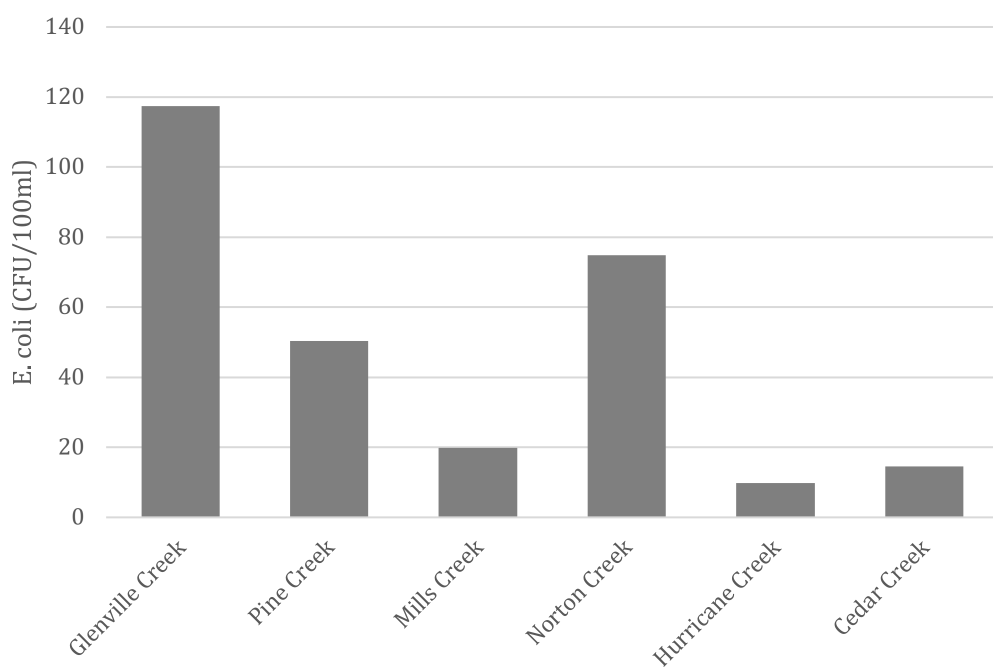
Figure 9. Dissolved oxygen levels at each monitoring site, December 2019



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. All creeks exhibited *E. coli* concentrations below this regulatory standard (Figure 10). *E. coli* concentrations in these waters continue to be influenced in part by seasonality, and future sampling events will continue to examine the 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, December 2019



Conclusions

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 December 5, 2019, is acceptable but there is evidence to suggest the influence of soil erosion on nutrient concentrations. The next quarterly monitoring event will take place in February 2020. 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.