McDowell Creek Tributary Initial Monitoring Report

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For City of Charlotte Stormwater Services

Executive Summary

Project Objectives and Tasks

The overall project objectives of the McDowell Creek (MC5) Monitoring Project is to ascertain whether current development practices and regulatory requirements in place in the City of Charlotte and Mecklenburg County serve to maintain post development stream water quality and hydrology in a representative developing Piedmont watershed. This report largely encompasses the pre development and early development phases of the McDowell Creek Monitoring Study, May 2015 through September 2017. The project comprises four main tasks: Water Budget Analysis; Sediment Transport Relationships/Sediment Budgets; Nutrient Budget Analysis; Measurement of Watershed Land Use Change.

Task 1 Water Budget Analysis

The water Balance for the McDowell Creek MC5 tributary for this report has been calculated for two water years: October 2015-September 2016 and October 2016-September 2017 (Bordia 2018, Appendix 1 Pages 35-40). We were unable to extend the water balance back beyond this date to the initiation of our water quality sampling in May 2015 owing to the unreliability of the stream stage data collected prior to the establishment of the USGS gaging station 0214265828 at McDowell Creek Tributary at SR 2131 near Hicks Crossroads, NC in August 2015. The water balances for water years 2015/2016 and 2016/2017 provide an initial point of comparison to which future water balances can be compared, as development progresses in the watershed. The initial two water years were characterized by similar precipitation totals 2015/2016- 128.59 cm (50.62") and 2016/2017- 124.67cm (49.08") but with significantly different seasonal precipitation totals. Dormant season (October-March) precipitation totals 2015/2016- 77.7 cm (30.59" or 60% of annual total precipitation) and 2016/2017- 41.04cm (16.16" or 33% of annual precipitation). The annual precipitation normal for Charlotte is 105.76 (cm) with the 2015/2016- water year 21.6% wetter than normal and the 2016/2017 water year 17.9% wetter than normal. The runoff coefficient (runoff depth/precipitation depth) for water year 2015/2016 was 17.0% and for 2016/2017 was 17.8%.

Planned work for the next reporting period: Update the water balance data for the 2016/2017 water period to include the 2017 GW data provided by the post restoration monitoring contractor (the data was provided too late to be included in the current report). Complete the 2017/2018 water balance. We also plan to further refine our evapotranspiration, soil and groundwater storage measurements to further constrain the catchment water balance. I will also recruit a student to begin to analyze the hydrographs for individual runoff events to document any changes in the runoff response to increasing watershed development.

Task 2 Sediment Transport Relationships/Sediment Budgets

The initial sediment/discharge relationships for the predevelopment/initial development period have been established as: TSS mg/L= 24.6 + 739.8 (m^3/s), R^2=0.84 (Bordia 2018, Appendix 1 Page 48). As expected TSS and Turbidity (Turbidity NTU= 46.3+ 904.6 (m^3/s), R^2=0.72 both display highly significant positive correlations with discharge. We have calculated an initial sediment yield of 230.6 kg/ha $\pm$ 23.2 kg/ha for the 2016/2017 water year which falls within the lower range of the sediment yields measured (2003-2012) for the forested Beaverdam Ck. sub watershed in western Mecklenburg County (Allan et al. 2013, Appendix 1, p. 98). The lower sediment yield could be expected given the smaller watershed size (lower stream power) and the relatively unstable channel reaches that characterize the BD1 sub watershed as compared to the vegetated and restored channel in the MC5 tributary. The initial sediment discharge relationships and sediment yield for the MC5 watershed provide an initial point of comparison to which future sediment discharge relationships and sediment yields can be compared as development progresses in the MC5 watershed.

Planned work for the next reporting period: We will continue our high intensity monitoring program to document any changes in the sediment/discharge relationship and sediment yield that might occur as development proceeds in the watershed. We will also explore the utility of utilizing the highly significant relationship established between Turbidity and TSS (TSS= 15.0 + 1.24 x (Turbidity NTU), R^2 0.89) in combination with the continuous turbidity record being recorded at the watershed outlet to refine our estimates for sediment export from the watershed. In addition, we have been collecting grab samples from each of the main tributaries in the watershed (Map in Appendix 1, Page 32) beginning in February 2016, one month prior to the extensive clearing and land grading that began in the catchment area draining to the East tributary. TSS and Turbidity data for the east tributary will be statistically compared to those values collected from the North and West tributaries to more clearly document the water quality impacts of on-going development in the MC 5 watershed.

Task 3 Nutrient Budget Analysis

For this report we have calculated the initial hydrologic fluxes of all water quality constituents for the dormant season (October 1, 2015 to March 31, 2016) and growing season (April 1, 2016 to September 30, 2016) (Bordia 2018, Appendix 1 pages 58, 66, 74, 83 and 90). In addition we have also calculated the watershed mass balance (Precipitation inputs – stream exports) for these same water quality constituents for the growing season of water year 2016 (April 1, 2016 to September 31, 2016) for this report (Bordia 2018, Appendix 1 pages 59, 66, 74, 83 and 90). The period of record analyzed for this report was determined by the end date of the completed analyses at the time of this reports writing and the availability of precipitation chemistry for the watershed. Precipitation chemistry measurements began in spring 2016. The yield (kg/ha) of all but four water quality constituents was higher in the dormant season as compared to the 2016 growing season. The four water quality constituents which display significantly higher yield in the growing season of 2016 were TSS, PN, TP and PP, and were 1.14, 3.00, 3.70 and 5.59 times higher in the growing season 2016 than the preceding dormant season 2016.

The mass balance analysis of the growing season 2016 showed retention of all water quality constituents except Ca^{2+}, Mg^{2+}, HCO_3^-, and Na^+ which showed 33, 12, 0.60 and 0.04 times higher net export from the MC5 watershed as compared to the atmospheric inputs as measured by bulk precipitation. Our initial hydrochemical flux and mass balance estimates will be used as a point of comparison for subsequent data collected in the watershed to document changes as development continues in the watershed. Planned work for the next reporting period: We will update the hydrochemical flux and mass balance data with data collected after the Fall 2016 period.

Task 4 Land Use Change

Water quality monitoring by UNC Charlotte began on May 21, 2015 and the USGS outflow streamflow record began on August 4, 2015. The watershed land cover was primarily pastureland at this time (Figure 1). The first and second order streams originating from this watershed (approximate total original stream length of 2,370 m) were restored in the year 2012 through the implementation of a Natural Channel Design which included Bioengineering approaches (Environmental Banc & Exchange, 2013), resulting in 2,930 m of stream restoration, 305 m of stream enhancement and included the establishment of a 0.107 km^2 riparian buffer (Conservation Easement) and 0.0168 km^2 of riparian wetland creation, based on the soil assessment of the watershed.

Figure 1. 6/20/2015 MC5 Watershed Land Cover

Land clearing for the subdivision development was initiated in March 2016 in the eastern portion of the watershed drained by the East tributary. By October 2016, 81.1 acres (14%) of the watershed had been cleared with some grading and eight sediment control basins totaling 3.7 acres had been built (Figure 2). At this same time 1.2 miles of paved roads and 26 single family detached housing units were either built or under construction.

Figure 2. 10/20/2016 MC5 Watershed Land Cover

By September 2017, 101.9 acres of the watershed (17.7%) of the watershed had been cleared and graded and an additional 1 acre detention basin had been constructed (Figure 3). At this same time an additional 3.2 miles (4.4 miles total) of paved roads and an additional 89 (115 total) single family detached houses were either built or under construction. This total represents approximately 43% of the planned housing construction for the watershed. Future planned work: We will continue to analyze the Google Earth Imagery to track development progress within the study watershed. UNC Charlotte researchers will continue to note episodes of visibly degraded water quality (high turbidity) during field visits and attempt to ascribe these to observations with time specific construction activities.

Figure 3. 9/2/2017 MC5 Watershed Land Cover.

Summary of Monitoring Activities

Water Quality

UNC Charlotte began monitoring of the MC5 Sub watershed on May 21, 2015. The watershed outlet is sampled at least three times per week and more frequently during high flow events. Over the period May 21, 2015 to April 10, 2018, 569 water samples have been collected from the watershed outlet. In addition to the watershed outlet, water samples have collected from the three main tributaries (West, North and East) on a weekly to biweekly schedule beginning in February 2016. To date 81 to 94 tributary samples have been collected at each site (an additional 267 water samples in total). The number of tributary samples varies between sites owing to variable durations of no flow periods between tributaries. Bulk precipitation samples are also collected from the site on a weekly basis.

All water samples are directly analyzed for the following water quality constituents: pH, specific conductance, turbidity, Total Suspended Solids (TSS), Total Phosphorus (TP), Total Dissolved Phosphorus (TDP), ortho-Phosphorus (PO_4^{3-}), Total Nitrogen (TN), Total Dissolved Nitrogen (TDN), Nitrate (NO_3^-), Ammonium (NH_4^+), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^+), Potassium (K^+), Chloride (Cl^-), Sulfate (SO_4^{2-}), Fluoride (F^-), Bromide (Br^-), Total Organic Carbon (TOC) and Dissolved Organic Carbon (DOC). In addition to these water quality constituents the following water quality species are calculated from the directly measured constituents listed above: Particulate Phosphorus (PP), Dissolved Organic Phosphorus (DOP), Particulate Nitrogen (PN), Dissolved Organic Nitrogen (DON), Bicarbonate ion (HCO_3^-) and Particulate Carbon (PC).

To date full water quality analyses have been performed on 301 (53%) of the outlet samples. TSS, pH, specific conductance and turbidity analyses have been completed for all (100%) outflow and tributary samples. Major ion (cation (Ca, Mg, Na, K, NH_4) and anion (SO_4, Cl, NO_3, PO_4, Br, F) analyses have been completed for 522 (92%) outflow samples and 52 (20%) tributary samples. Remaining TP, TDP, TN, TDN, TOC and DOC analyses are expected to be completed during summer 2018.

Hydrometeorology

In addition to water quality samples UNC Charlotte researchers are measuring a variety of meteorological and hydrological constituents at each site. These measurements are used to expand the scientific scope of the study and/or to continue measurements that have been discontinued or measurements that proved unreliable that were previously made by the post restoration consulting firm. Precipitation has been measured continuously since 03/31/2016 with a tipping bucket recorder and is corrected to standard rain gauge totals measured at the same site. Bulk Precipitation chemistry has been collected from the site since 12/2016. Continuous measurements of soil moisture were initiated at six sites in the MC5 riparian zone beginning in 03/2016 to help quantify changes in storage (ΔS) in order to help constrain the water balance for the watershed. Beginning at the same time UNC Charlotte researchers installed an atmometer at the site to make direct measurements of potential evaporation. This device is monitored during the frost free season (April-October) and is used to help constrain the monthly water balance for the site. A groundwater well was installed in the MC5 floodplain on 01/09/2018 and groundwater levels are now measured continuously to help quantify changes in storage (ΔS) in order to help constrain the water balance for the watershed. Air temperature and relative humidity (RH) measurements at the site commenced on 01/15/2018.

Active Construction Water Quality Trends

In Figures 4, 5, 6 and 7 we present the water quality trends for Turbidity, TSS, ammonium, nitrate and ortho-phosphorus, respectively. These water quality constituents were selected owing to the completeness of the laboratory analyses to date. In Figures 4 and 5 we can see that peak Turbidity and TSS values were recorded in May 2016 after land clearing began in March 2016. Post disturbance monitoring of the three tributaries consistently indicate that elevated turbidity and TSS levels were associated with the East Tributary which drains the area currently been developed. Initial inspection of the temporal trends in ammonium seem to indicate a reduction in the post development ammonium concentrations, with largely non-detectable levels from 07/2017 to 01/2018. Land development impacts are unclear for nitrate and ortho-phospate with post land disturbance concentrations falling within the range observed during the pre-disturbance period. Bordia (2018) examined the water quality trends for the initial development period and noted significantly higher and greater variability in total dissolved phosphorus (TDP) values in the period after initial land clearing as compared to pre development values (Appendix 1, Figure 28a, pg. 73). The higher TDP levels and increased variability were related to dissolved organic phosphorus trends rather than changes to ortho-P or particulate phosphorus levels. (Appendix 1, Figure 31a, pg. 78). Significant increases in particulate nitrogen (PN) concentrations were also observed in the immediate aftermath of land clearing with levels appearing to return to predevelopment levels in Fall 2016. (Appendix 1, Figure 34a, pg. 82). Finally, significant reductions in the concentrations of Total Organic Carbon (TOC) were observed immediately after land clearing began in the East Tributary (Appendix 1, Figure 38a, pg. 89). This reduction was almost entirely attributable to a decrease in particulate organic carbon (POC) from the watershed (Appendix 1, Figure 40a, pg. 93).

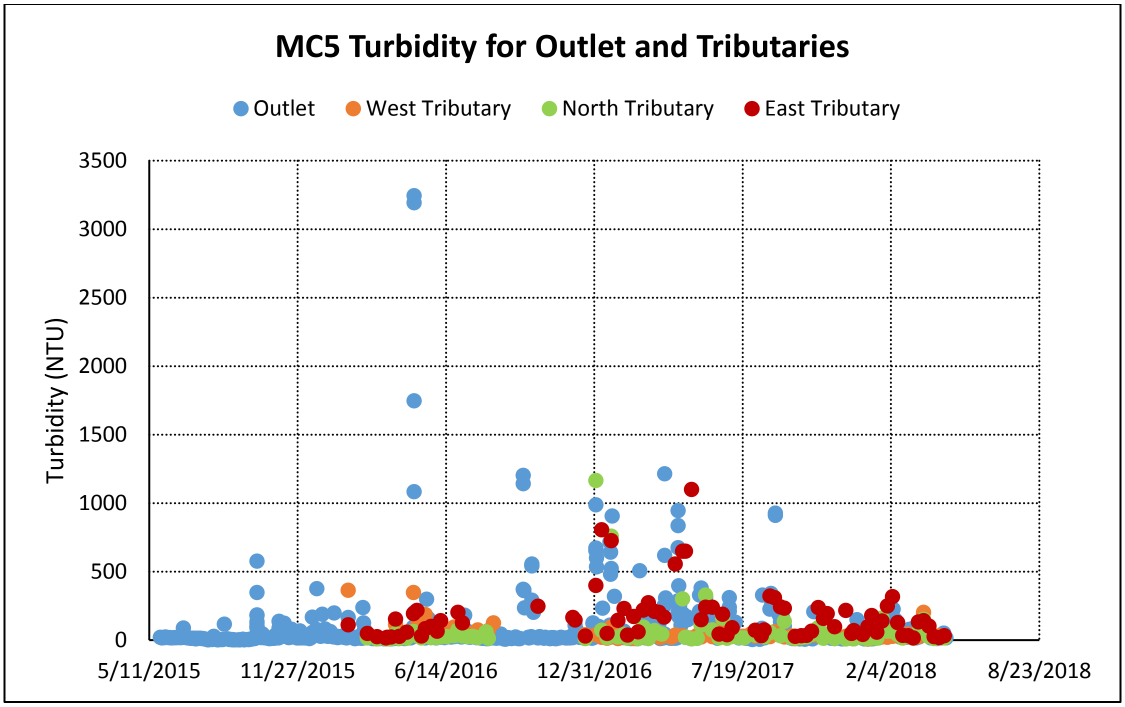

Figure 4. Turbidity (NTU) for the MC5 Outlet, West, North and East Tributary's 5/26/2016 to 4/17/2018.

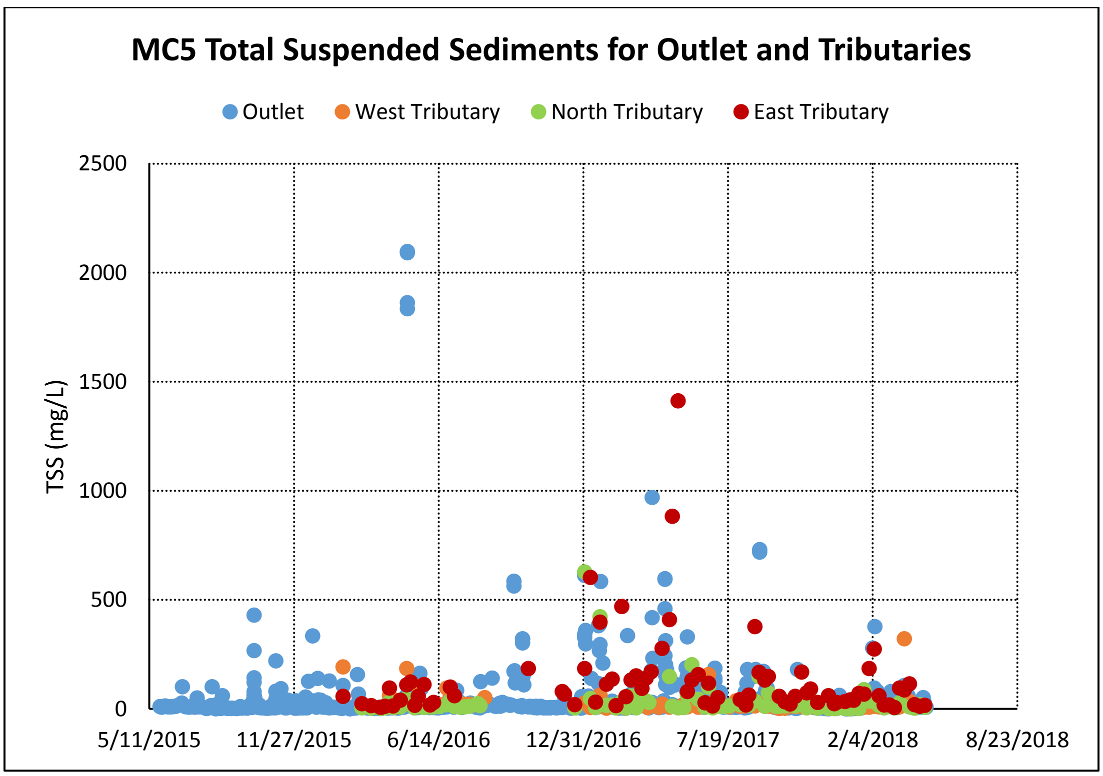

Figure 5. TSS (mg/L) for the MC5 Outlet, West, North and East Tributary's 5/26/2016 to 4/17/2018.

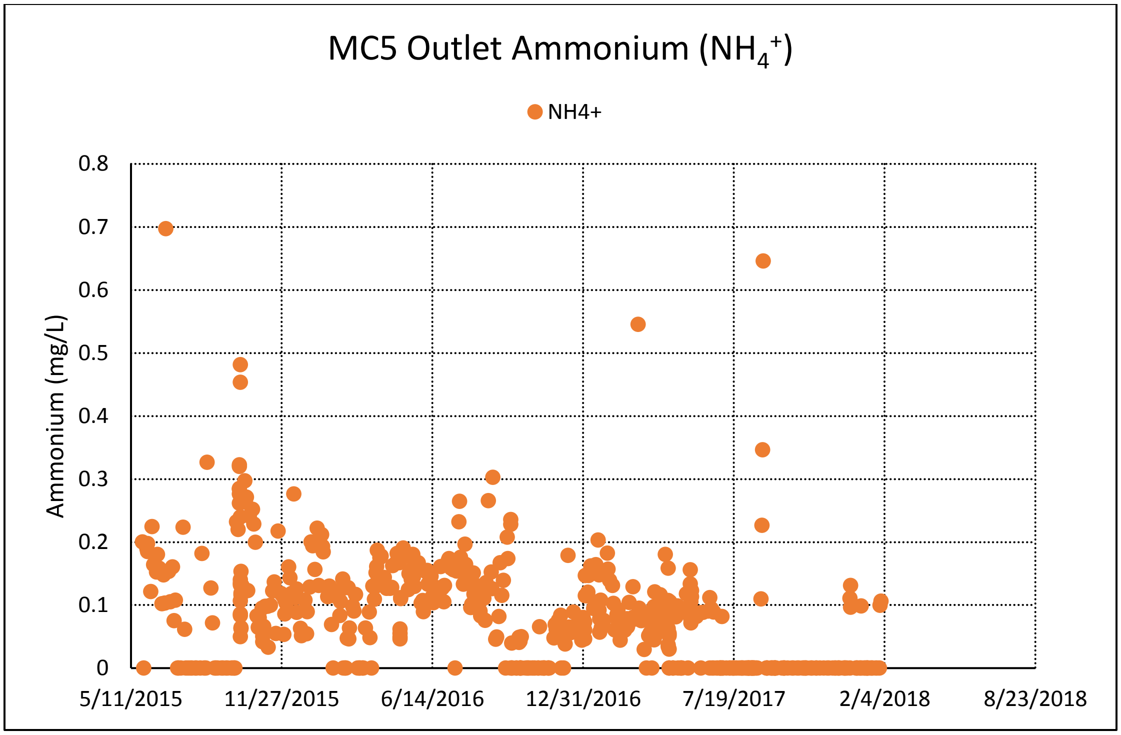

Figure 6. Ammonium (mg/L) for the MC5 Outlet, West, North and East Tributary's 5/26/2016 to 1/29/2018.

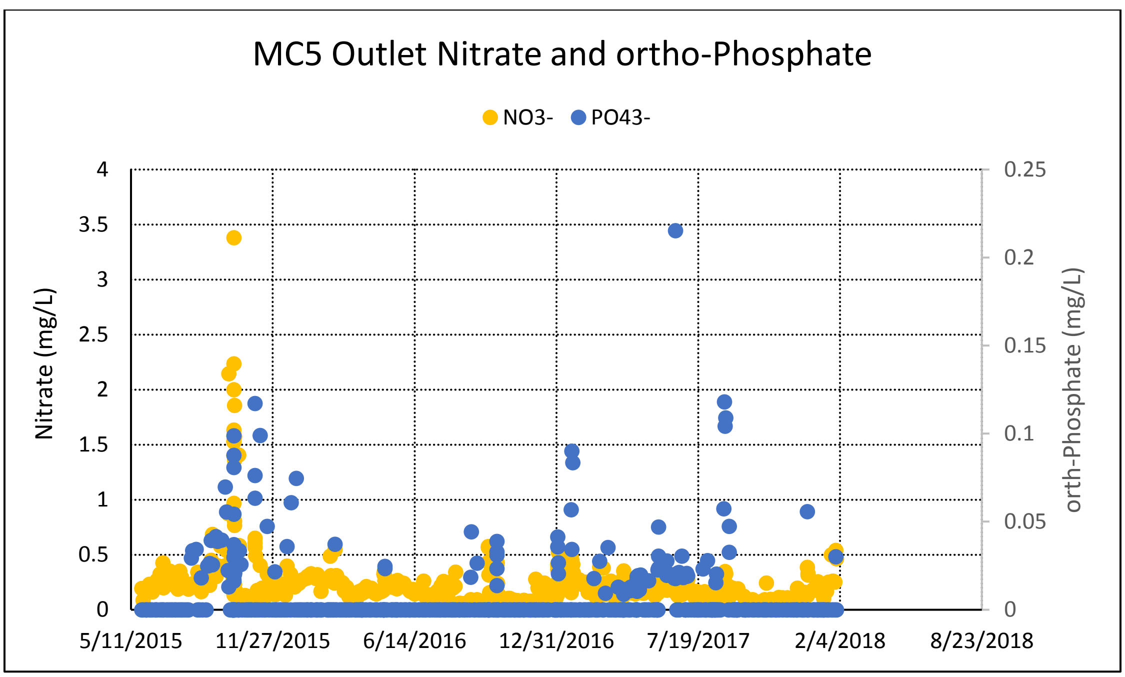

Figure 7. Nitrate and ortho-Phosphate (mg/L) for the MC5 Outlet, West, North and East Tributary's 5/26/2016 to 1/30/2018.

References

Allan, C. J., Diemer, J. A., Gagrani, V., Jennings, G., Zink, J., Price, Z., & Penrose, D. (2013). Beaverdam Creek Watershed Study Report. 147 p.

Bordia, P. (2018). Hydrology and Hydrochemical Transport in a Suburbanizing Piedmont Watershed. UNC Charlotte MS Earth Sciences Final Project Report, 125 p.

Environmental Banc & Exchange. (2013). As-built Mitigation Report, McDowell Tributaries Stream and Wetland Restoration.

Appendix 1 HYDROLOGY AND HYDROCHEMICAL TRANSPORT IN A SUBURBANIZING PIEDMONT WATERSHED