Water Quality and Stream Flow Monitoring in the Blackfoot River Watershed

"By leveraging community volunteers, it puts the power of monitoring in citizen's hands and it reduces the cost of collecting high quality information. The data collected allows community members to track changes in their streams through time and it provides a connection to the ecosystems in which they live. It can provide highly valuable information for water stewards, fisheries biologists, help guide management actions, and emphasize the sensitivity of the systems to changes in climate and management." - SWCC

Caitlin Mitchell, Elaine Caton, and Jennifer Schoonen, Blackfoot Challenge
With technical support from Joann Wallenburn, Clearwater Resource Council
January 2018

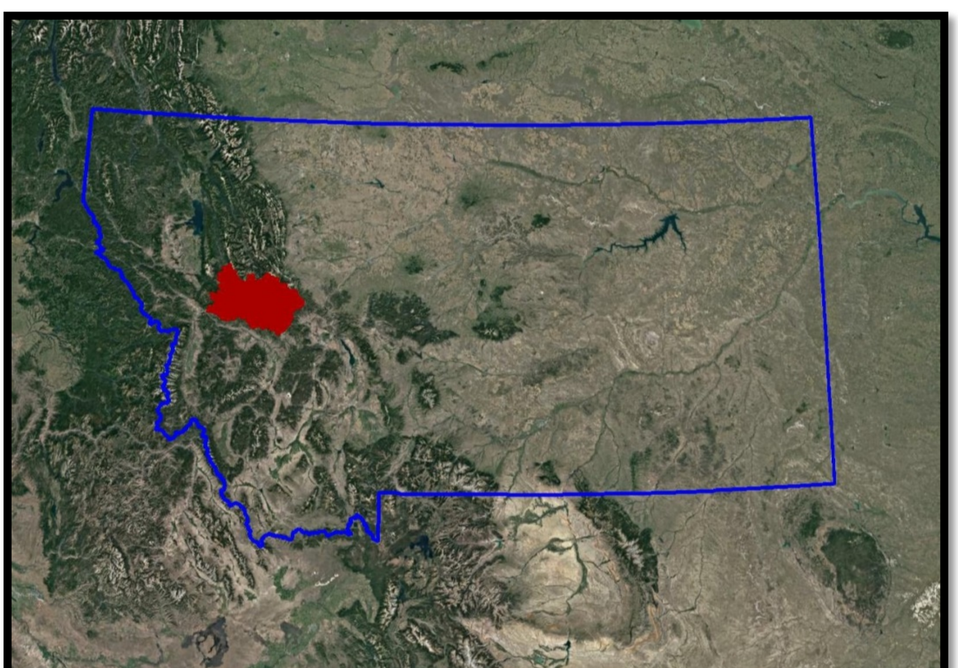


Figure 1 - The Blackfoot Watershed marked in solid red within the state of Montana, outlined in blue.

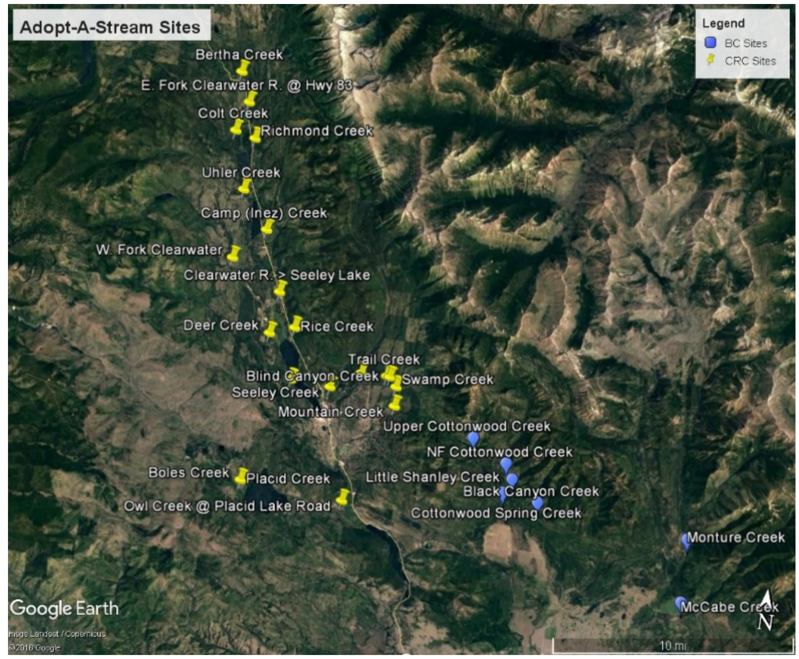


Figure 2 – Stream monitoring sites throughout the Blackfoot Challenge and Clearwater Resource Council project area

Introduction

The Blackfoot Challenge, Clearwater Resource Council, Swan Valley Connections, and the Southwest Crown Collaborative have partnered for the past two years to characterize the water flow patterns and run-off period water quality dynamics of headwater streams. The data collected provides baseline knowledge of stream health in proposed Collaborative Forest Landscape Restoration (CFLR) project areas—the Center Horse and Stonewall projects. In addition, the stream data collected supports goals outlined in the Blackfoot Watershed Restoration Plan adopted by the Montana Department of Environmental Quality in 2014. This monitoring program engages youth and local citizens in better understanding ecosystem processes and how resource management decisions might impact their public lands. The data synthesized also supports planning for partner stewardship work, such as fisheries habitat restoration and Blackfoot Drought Response coordination.

The Blackfoot Challenge (Challenge) involved youth from local schools in our monitoring of flow rates for two primary streams. Ovando school studied East Warren Creek in Upper Warren Basin, (12 Digit HUC: 170102030904) and Helena High School students, through a continued partnership between the Challenge and the Youth Forest Monitoring Program sponsored by the Lewis and Clark National Forest, helped study Poorman Creek in Poorman Basin (12 Digit HUC: 170102030302). The Challenge extended our youth education and involvement to the Potomac and Helmville Schools who studied two secondary streams: Union Creek and Nevada Creek, respectively.

Photo 1 – Blackfoot Challenge Citizen Science volunteer collecting water samples from North Fork Cottonwood Creek

The Challenge also worked with Citizen Science volunteers to monitor five perennial headwater streams in the Cottonwood sub-drainage (12 Digit HUC: 170102030909) and two additional streams in the Dick Creek and Monture Creek Basins (12 Digit HUCs: 170102030803 and 170102030801, respectively). The streams included in our study: Black Canyon Creek (2nd order), Little Shanley Creek (1st order), North Fork of Cottonwood Creek (3rd order), Upper Cottonwood Creek (2nd order), Cottonwood Spring Creek (3rd order), Monture Creek (4th order), and McCabe Creek (2nd order).

The U.S. Forest Service is the primary land manager in the study area, with some State and private land ownership in the foothills. Land cover consists of predominantly coniferous forest and some agricultural pastureland. Turbidity grab samples, stream stage data (water depth), and subjective visual assessments of water color and water clarity were collected on a weekly basis from early March to mid-June in both 2016 and 2017. Nutrients and Total Suspended Solids (TSS) were added to our water quality assessment in 2017 for a more specific evaluation of potential factors affecting stream health. Year-to-year data will be compared in this report.

Photo 2 – (left) Potomac School students prepare to take a flow measurement in Union Creek.

Photo 3 – (right) Ovando School students take a flow measurement in E. Warren Creek and learn about what their data signifies.

Methods and Materials

HOBO MX 2001-04 data loggers were installed in E. Warren Creek and Poorman Creek near the permanent staff gage to collect water depth and temperature data every two hours from April or May until October or November. Data from these loggers was downloaded at least twice over the monitoring season. Flow measurements were taken once every 3-4 weeks by a Swoffer 2100 current meter with 3.7' topset wading rod. The site selected for each stream was a cross-section through a run, with relatively defined banksides. The initial measuring site was used for all subsequent measurements with only two deviations when flow became too low to be registered by the instrument. In these instances the sample site was relocated downstream to an area of visible current.

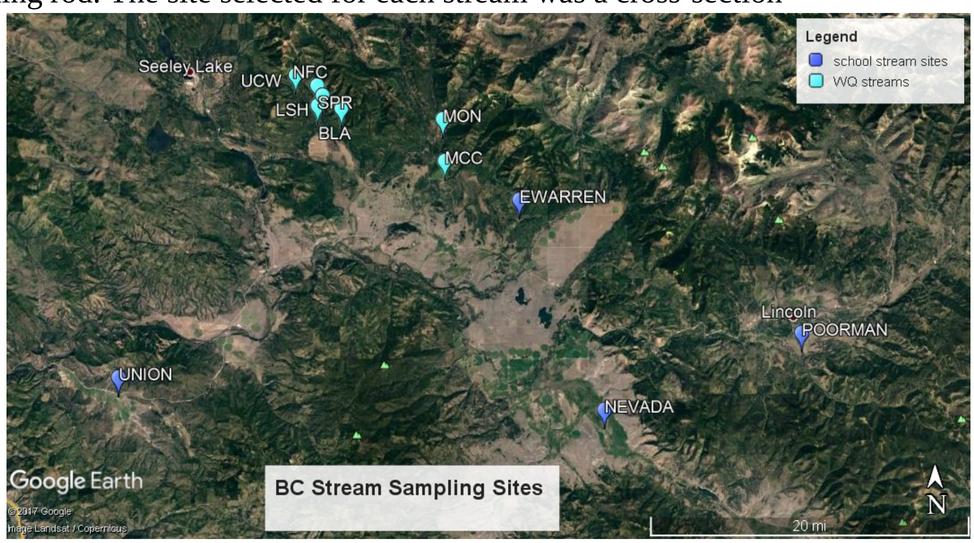


Figure 3 – The Blackfoot Challenge stream monitoring sites. Water quality sites are shown in teal and flow measurement sites are shown in indigo.

For the Cottonwood, Monture, and Dick creek study areas, the Challenge recruited volunteers and trained them how to properly collect water samples for nutrient, TSS, and turbidity analyses. Volunteers were also trained to record stream stage information and take visual assessments on stream color and clarity. After training, a volunteer-staff pair collected samples and processed them for analyses. Six volunteers participated in the water quality sampling.

All samples were collected in accordance with the Montana Department of Environmental Quality approved Sampling and Analysis Plan that was created for this project by the Clearwater Resource Council. Water samples to be analyzed for TSS and nutrients were packed in a cooler on ice and shipped to the Flathead Lake Biological Station. Nutrient analysis documented total nitrogen (TN) and total phosphorus (TP). TSS readings are reported in mg/L, TN and TP readings are reported in ug/L. Turbidity measurements were analyzed by Blackfoot Challenge personnel with a HACH 2100Q Surface Scatter Turbidimeter with readings reported in terms of nephelometric turbidity units (NTUs). Staff gage measurements were recorded to the nearest one quarter inch.

Results

Compared Years: Flow Monitoring

Five flow measurements were taken in East Warren Creek between April and August, with the logger collecting data from end of April to early November. A rating curve was derived from the flow measurements taken and used to convert depth measurements taken by the logger into flow rates for the entire logger collection period. In figure 4, the three years depicted express varying flow patterns. 2015 shows peak flow occurring in mid-March with a flow rate of 8.81 CFS. Peak flow in 2016 occurred later in mid to late April with a maximum flow rate of 5.56 CFS. And 2017 depicted high flows from mid-March through early May with its primary peak occurring around May 7 with a flow rate of 15.4 CFS. A secondary peak for 2017 occurred around June 13 with a rate of 5.48 CFS.

The logger data also collected water temperature readings throughout the monitoring season. Temperatures seem fairly consistent over the three years of data collected on East Warren Creek, figure 5.

Eight flow measurements were taken in Poorman Creek between April and November, with the logger installed from end of April to early November*. A rating curve was derived from the eight flow measurements collected, and then used to convert logger depths, measured and interpolated, into flow rates for the entire logger collection period. In figure 6, the four years of data express varying flow patterns, with 2014 and 2017 data corresponding fairly well and 2015 and 2016 corresponding well. 2014 data collection began at the end of April right before peak run-off with the highest flow occurring only a month later with a rate of 67.43 CFS. 2015 data depicts a low flow year with no significant peaks. The highest flow rate recorded was on June 10, 2015 with a rate of 15.52 CFS. 2016 data also depicts a relatively low flow year. Although run-off did have a distinct peak from end of April to early May with a maximum flow rate 24.75 CFS occurring on April 24. Flow data for 2017 shows much greater values than those for 2015 and 2016 and similar values to 2014. The primary peak flow occurred on June 13, 2017 with a rate of 61.57 CFS. A secondary peak flow occurred on May 8, 2017 with a rate of 56.99 CFS. The Poorman Creek logger also collected water temperature data over the course of its operation*. In figure 7, temperatures seem fairly similar over the four-year sampling period with the exception of some lower water temperatures recorded in 2014. These low temperatures occur during the period of greatest flow rate in 2014.

Peak run-off dates for East Warren and Poorman Creeks in 2017 coordinate very closely, in addition to coordinating with peaks in turbidity data for this year.

*Due to a technical malfunction, the logger only collected data for two weeks before shutting down. The malfunction was not identified until mid-August when it was corrected, allowing the logger to begin collecting data again. The logger continued to collect accurate data from mid-August until it was manually shut-off in early November. A linear regression curve for stream depth was created by using the four staff gage measurements taken manually while the logger was down, logger data collected before and after the malfunction, and data from a USGS stream gage #12335500 located in Nevada Creek above the reservoir near Helmville, MT. This regression curve equation was then used to calculate missing stream depth data for Poorman Creek (y) using the nearby Nevada Creek station data (x). Lost temperature readings were not able to be determined due to no temperature data collected by the USGS Nevada Creek stream gage.

Compared Years: 2017 and 2016 Water Quality Monitoring- Turbidity

2017 turbidity values for each stream, shown in figure 8, indicate two peaks for run-off. The first peak occurred around March 15, 2017, for the majority of streams and March 24 for Black Canyon* and Little Shanley Creeks. The second peak occurred around May 12, 2017, for all streams. In contrast, the 2016 turbidity values, shown in figure 9, indicate only one significant peak during run-off, which occurred around April 7, 2016. Overall, turbidity values for 2017 seem higher than those for 2016.

*Stream acronyms are as follows: Black Canyon Creek**- BLA**, Little Shanley Creek**- LSH**, North Fork Cottonwood Creek- **NFC**, Cottonwood Spring Creek**- SPR**, Upper Cottonwood Creek**- UCW**, McCabe Creek**- MCC**, and Monture Creek- **MON**

Turbidities over the entire monitoring season are depicted in a Box and Whiskers plots for all streams. 2017 turbidity values were generally more spread out, indicating a more gradual run-off period. In contrast, the plot for 2016 turbidity values, show major outliers with the two middle quartiles very close to the mean turbidity value. Plots for 2017 turbidities are placed side-by-side with those for 2016, figures 10 and 11 respectively, with the same y-axis values, in order to visualize differences.

2017 and 2016 Turbidity Comparisons: Individual streams

Each monitored stream has one graph for 2017 next to one for 2016, both depicted gage height and turbidity measurements for each year. The y-axes are made to be the same for both years to ease comparison.

Black Canyon Creek shows increased gage heights and turbidities in 2017 compared to 2016, figures 12 and 13. The ratio between gage height and turbidity tends to be smaller for 2017 than that for 2016. Turbidity measurements in 2017 depicted two peaks of 3.05NTU on March 24 and 2.6NTU on May 12 with turbidity values remaining relatively low before, after and in-between. In 2016 turbidity measurements remained very low all season with a peak of 1NTU on April 13.

Little Shanley Creek shows overall increased gage height and turbidities in 2017 compared to 2016 with the exception of when turbidity peaked for 2016 at 6.88NTU on April 7, figures 14 and 15. Both gage heights and turbidity measurements stayed greater longer in 2017 (high values for both measurements occurred from end of March all the way until mid-May with a peak of 6.73NTU on March 24); whereas 2016 measurements remained fairly low with a large spike through April.

North Fork Cottonwood Creek data clearly reflects the two run-off peaks in 2017 and one peak in 2016, figures 16 and 17. Gage heights after the April 14, 2016, peak remained consistently high while turbidity measurements spiked at 3.01NTU then gradually decreased. Similarly, in 2017, gage heights remained relatively consistent after the first peak around March 16, while turbidity spiked up to 6.3NTU, then tapered down to 1.45NTU before spiking again to 7.11NTU around May 12.

Cottonwood Spring Creek 2017 gage height to turbidity ratios are fairly similar to those of 2016 especially for peak run-off and the data following, figures 18 and 19. In 2017, turbidities peaked much sooner than in 2016. Once turbidities peaked at 6.36NTU on March 13, 2017, they remained high until the second peak of 6.47 NTU on May 4. In 2016 turbidity measurements stayed fairly low except for right before and after the spike to 5.86 NTU on April 14.

Upper Cottonwood Creek depicts overall higher turbidity measurements for 2017 compared to 2016, figures 20 and 21. However both remain fairly low throughout their respective seasons, with the exception of the two peak run-off periods in 2017. Turbidity spiked to 11.34 NTU on March 16, 2017 and then again, but only to 5.18 NTU, on May 12 when gage height also spiked. The rest of the sampling period turbidity measurements for 2017 averaged between 2 and 4 NTUs or lower. In 2016 turbidity measurements remained between 0.3 and 2.35 NTUs the entire season. A stream gage was installed April 19, 2016 and subsequent readings remained fairly consistent with the first.

McCabe Creek data, figures 22 and 23, reflects that of Upper Cottonwood Creek with two spikes in turbidity measurements in 2017 of 9.29 NTU on March 16 and 6.16 NTU on May 12 with the rest of the season's measurements remaining consistently low. In 2016, also, McCabe Creek turbidities remained between 0.21 and 2.07 NTUs throughout the entire season. Gage heights for 2017 were reflective of those for Upper Cottonwood Creek as well. No gage heights were measured in 2016 for McCabe.

Monture Creek shows greater turbidity values for 2017 than for 2016, figures 24 and 25. Gage height was only measured in April of 2016. However, those measurements around the 2016 turbidity spike of 4.84 NTU on April 14 are comparable to the gage heights measured around the third turbidity spike in 2017 of 7.47 NTU on May 25. The first 2017 turbidity spike of 7.81NTU occurred on March 15 and the second of 12.48 NTU occurred on May 12. Higher turbidity measurements occurred late in 2017 compared to when they occurred in 2016. This seems to be an overall trend throughout the streams for 2017 compared to 2016.

2017 Nutrient levels and Total Suspended Solids

Total Nitrogen (TN) levels from each stream sample taken over the course of the monitoring period are shown in figure 26. Cottonwood Spring Creek consistently returned the highest levels of TN with a peak at 473ug/L, over twice as much as the next streams' (Little Shanley Creek) highest TN level of 220ug/L and (North Fork Cottonwood Creek) of 213ug/L. All of which occurred on March 15. Aside from Cottonwood Spring Creek's peak TN level and the gradual decrease, and the two TN spikes for Little Shanley and N. Fork Cottonwood Creeks, all other TN values stayed between 45 and 170ug/L. McCabe and Upper Cottonwood Creeks, on average, maintained the lowest levels of TN, between 50 and 100ug/L, throughout the monitoring period. With the exception when Upper Cottonwood Creek's peak TN occurred at 155ug/L on March 15 with a second peak of 137ug/L on May 17, and McCabe Creek's only peak of 143ug/L on May 17.

Total Phosphorus (TP) trends, figure 27, over the monitoring season closely follow those of TN. Cottonwood Spring Creek exhibited the overall highest TP amounts throughout the sampling period with a peak of 39.9ug/L on March 15. Little Shanley Creek's TP peak followed at 28.4ug/L that same date. McCabe and Upper Cottonwood Creek's again returned consistently with the lowest TP levels. Both Creeks only exceeded their upper limit of 5.4ug/L during the run-off peak on May 12, when McCabe Creek reached 13.6ug/l and Upper Cottonwood Creek reached 15.5ug/L. Aside from the run-off peaks, all streams remained below 20ug/L TP.

Total Suspended Solid levels for each stream shown in figure 28 are generally low. However, Little Shanley and Cottonwood Spring creeks show high TSS levels of 16.0mg/L and 9.1mg/L respectively, on the March 15peak run-off date. On the second peak run-off, May 12, Monture Creek exhibited a spike of 22.4mg/L, In addition, high levels of TSS are seen on that date in McCabe (10.9mg/L), North Fork Cottonwood (10.9mg/L), and Little Shanley (8.7mg/L) Creeks. On average TSS levels for all streams throughout the monitoring period remained between 0 and 5mg/L. when Turbidity levels also spiked, around March 15 and May 12, 2017.

Figures 29 - 49 show TN, TP, and TSS levels for individual streams. This data is the same as what is shown on figures 26, 27, and 28. Individual stream charts better express that stream's trend in TN, TP, and TSS over the course of the monitoring period.

Discussion

Flow Monitoring: East Warren Creek and Poorman Creek

2017 completes the third consecutive year for stream flow and temperature monitoring in East Warren Creek with student participation each year. The data shows the flow rate variation from year to year, including differences of when peak flow occurred and amount of annual discharge. Four years of consecutive flow and temperature monitoring have now been completed in Poorman Creek. The flow rate data collected for Poorman Creek show variation among years, but some similarities between non-consecutive years. Data from years 2015 and 2016 is fairly similar over the run-off period, which shows consistent trends over time. Flow rates from 2014 also somewhat align with those of 2017, especially at the onset of increased run-off. These four years of data show the oscillations of discharge rate and annual amounts from year to year, with 2017 the only recorded year not to reach 0 CFS during the monitoring period. The discharge variation from year to year, shown by data from both East Warren and Poorman Creeks, indicates differences in amount of snow pack for those respective winters. Both Creeks also exhibit minimal water temperature variation from year to year with few exceptions.

Water Quality Monitoring: Cottonwood and Monture Basins

Dedicated volunteers ensured the success of the Challenge's second water quality monitoring season. The data collected this season corresponds across parameters to show peak run-off occurring two different times. The early peak consistently occurred around March 15 and the later around May 12. Data values for most parameters before and after the March 15 peak date are fairly minimal in their weekly differences demonstrating periods of slow melt-off. Parameter values following the second peak exhibit a gradual decline from that peak value, indicating a more rapid melt-off period. The TSS level trends correlate well with turbidity signifying a direct relationship between the two. Correlations were also seen between total Phosphorus levels and turbidity levels. This information is important for determining whether turbidity analysis alone could be sufficient in deciding water quality. Because 2017 was the first year for expanding water quality monitoring with nutrient and TSS analysis, a few more years of data with high correlation among parameters would be necessary to draw a significant conclusion.

Acknowledgments

The Challenge would like to thank Martha Swanson, Steve Holden, Tim Lenzmeier, Lauren Sullivan, Jerry Hathaway, and Elaine Caton for volunteering to collect stream samples for our water quality analysis work. A special thank you to the Lolo National Forest and the SWCC CFLR program coordinator, Cory Davis, for providing funding to support our water quality monitoring program and involvement with citizen scientist volunteers. Thank you to the Helena-Lewis and Clark National Forest for their continued partnership through the Youth Forest Monitoring Program, and to our DNRC area hydrologist, Aaron Fiaschetti, and retired USFS emeritus fisheries scientist, Bruce Rieman, for their help with organizing and interpreting our stream flow data. The Challenge would also like to thank the teachers at Ovando, Hemlville, and Potomac schools for their help in taking the science classroom outside and into the water, and their assistance in providing consistent flow measurements.

For more information on the Blackfoot Challenge monitoring program please visit www.blackfootchallenge.org, call us at (406) 793- 3900, or stop by our office 405 Main Street, Ovando MT 59854

Appendix A:

Compared Years: Flow Monitoring

Upper Warren Creek Basin: **East Warren Creek** 3rd order tributary.

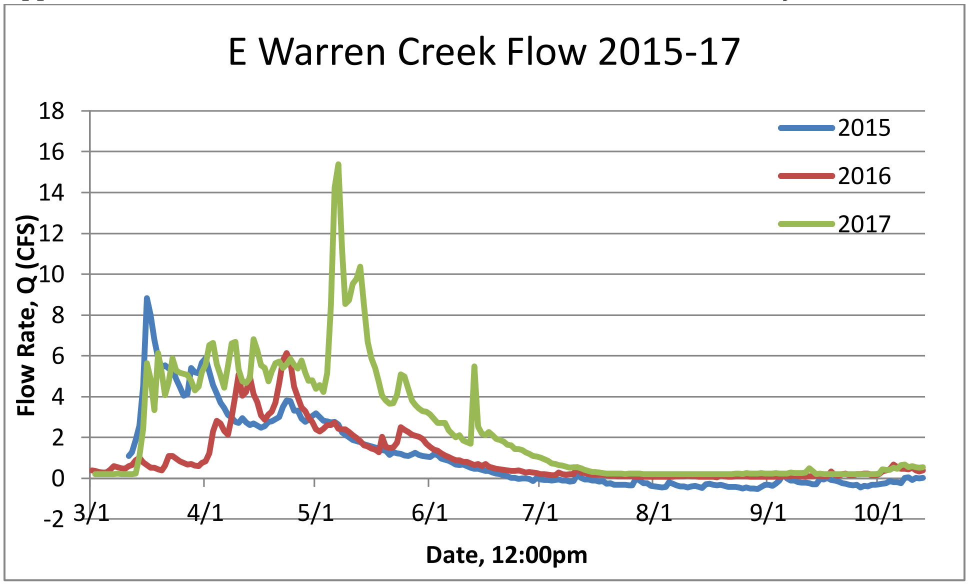


Figure 4 – Flow rates over time for years 2015, 2016, and 2017. Rates are derived from logger depths entered in to a rating curve created by manual flow measurements. A separate rating curve was created from data for each year.

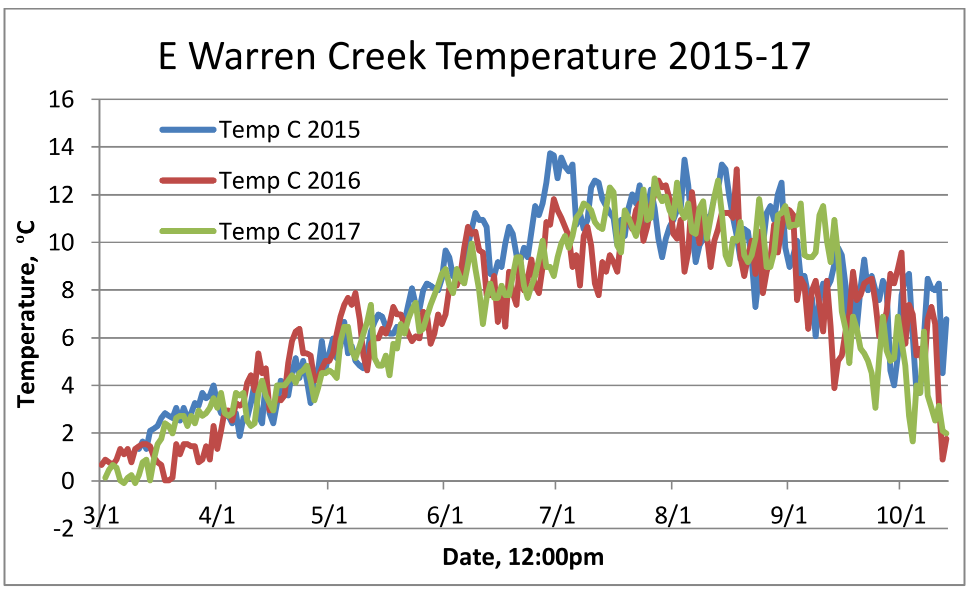


Figure 5 – Temperature readings taken by a data logger for years 2015, 2016, and 2017.

Poorman Creek Basin: **Poorman Creek** 4th order tributary

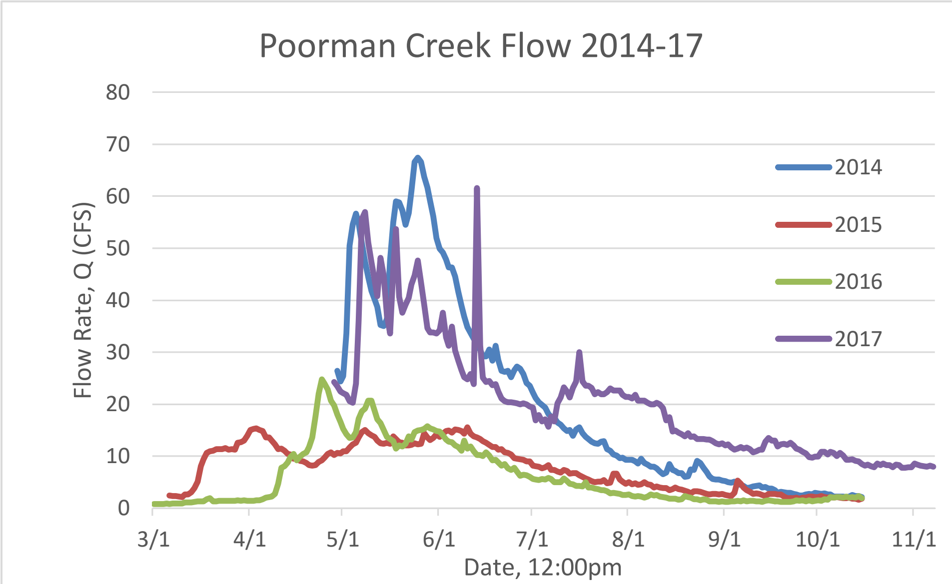


Figure 6 – Flow rates over time for years 2014, 2015, 2016, and 2017. Rates are derived from logger depths entered in to a rating curve created by manual flow measurements. A separate rating curve was created from data for each year.

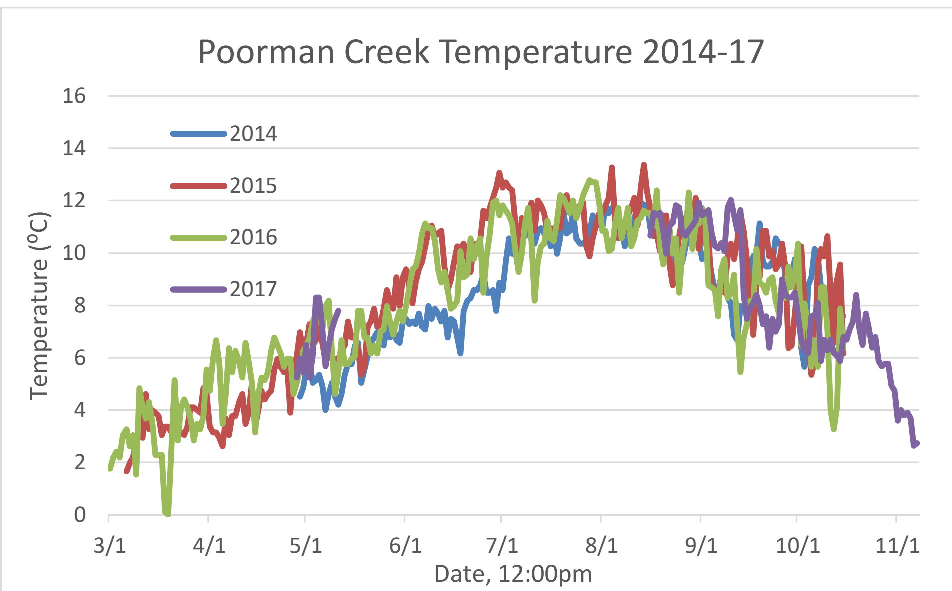


Figure 7 – Temperature readings taken by a data logger for years 2014, 2015, 2016, and 2017.

Appendix B:

Water Quality Monitoring

Compared Years: 2017 and 2016 Turbidity

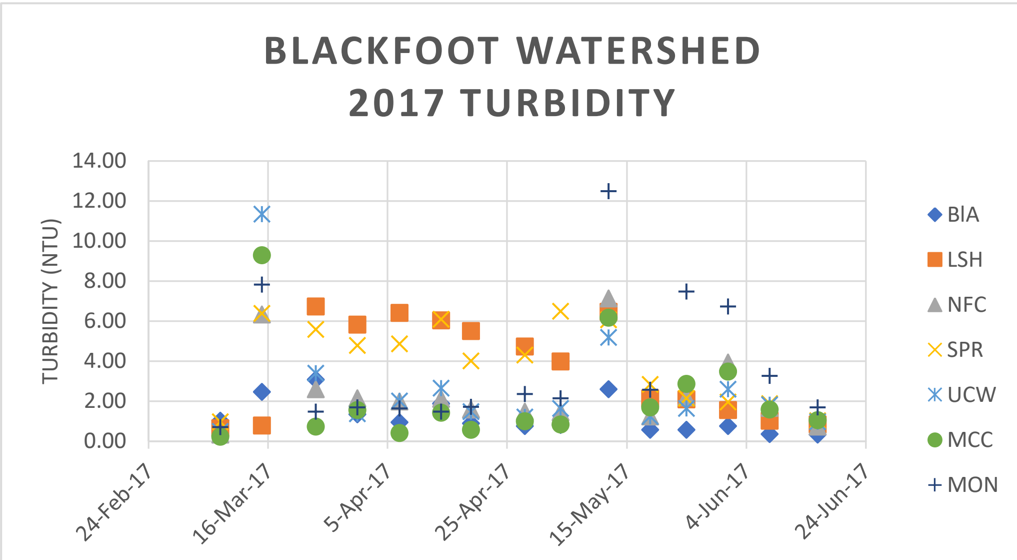


Figure 8 – Turbidity analysis results for all streams in our study over the entire sampling period of 2017.

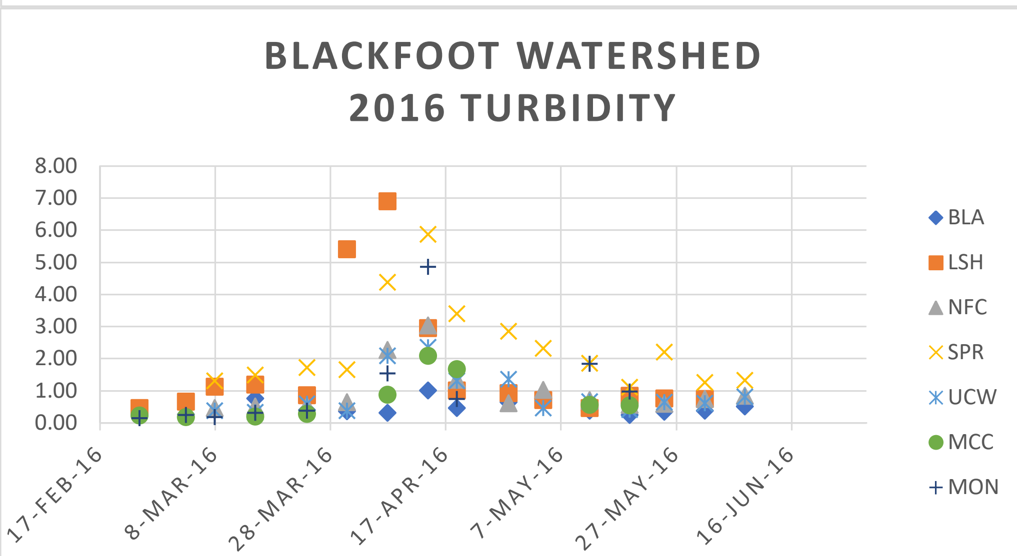
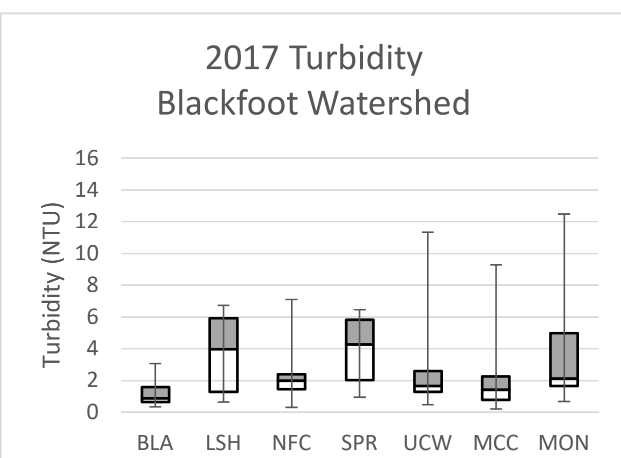
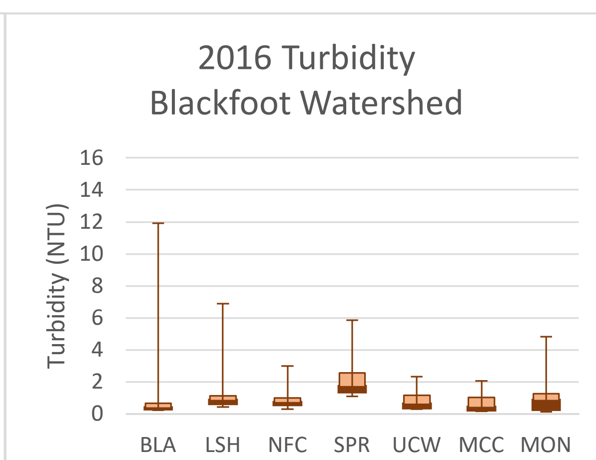


Figure 9 – Turbidity analysis results for all streams in our study over the entire sampling period of 2016.

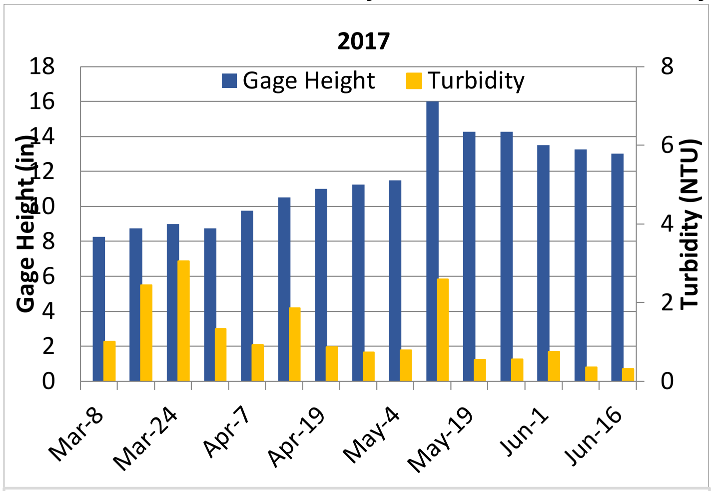


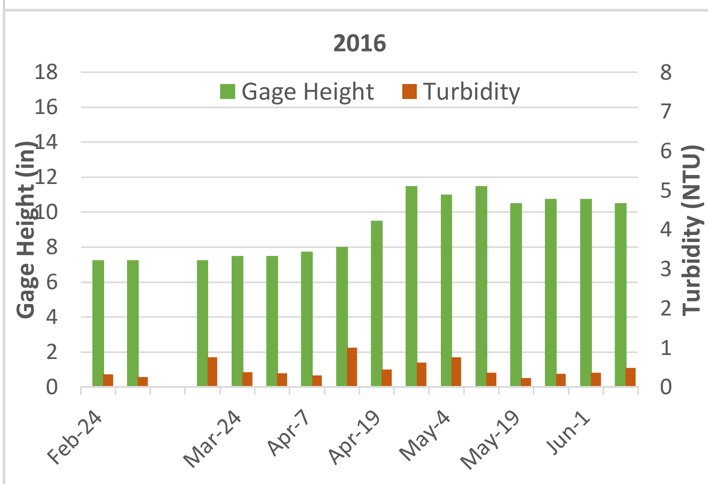


Figures 10 and 11 – A side-by-side comparison of turbidity analysis results from 2017 and 2016 sampling. Data is formatted here as a Box and Whiskers plot to better express averages and outliers. The "Box" represents the middle 50% of the data, with the center line being the mean value. The top "Whisker" represents the upper quartile (25%) and the bottom "Whisker" represents the lower quartile of data.

2017 and 2016 Turbidity Comparisons: Individual streams

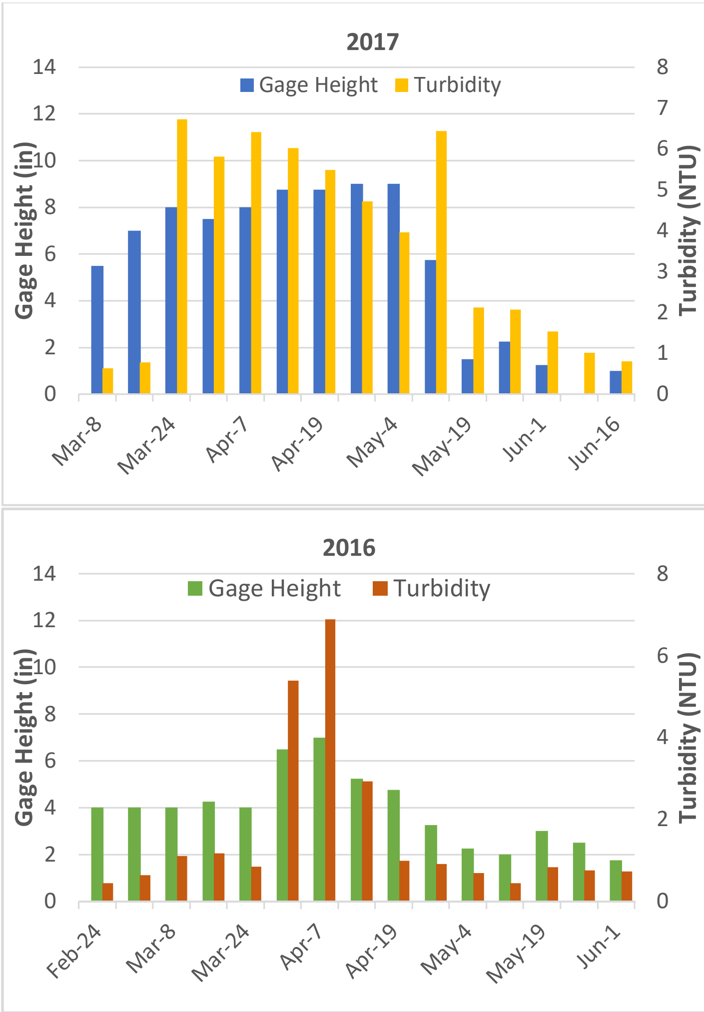
Cottonwood Basin: **Black Canyon Creek** 2nd order tributary.





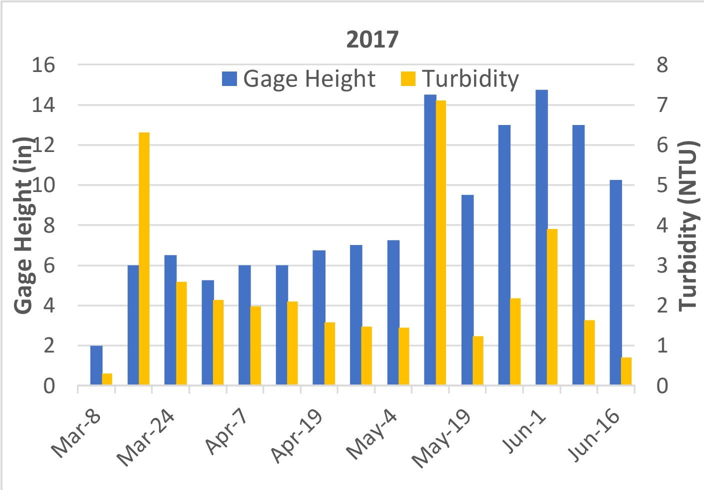
Figures 12 and 13– Gage height (water level) relative to turbidity results for each week of sampling during years 2017 and 2016

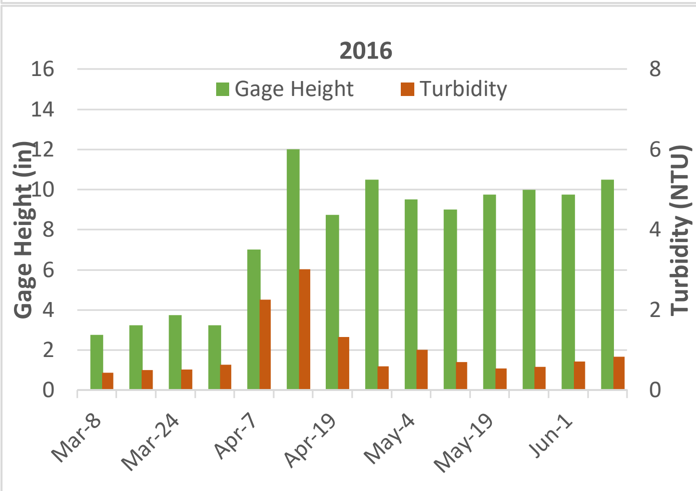
Cottonwood Basin: **Little Shanley Creek** 1st order tributary.



Figures 14 and 15 – Gage height (water level) relative to turbidity results for each week of sampling during years 2017 and 2016

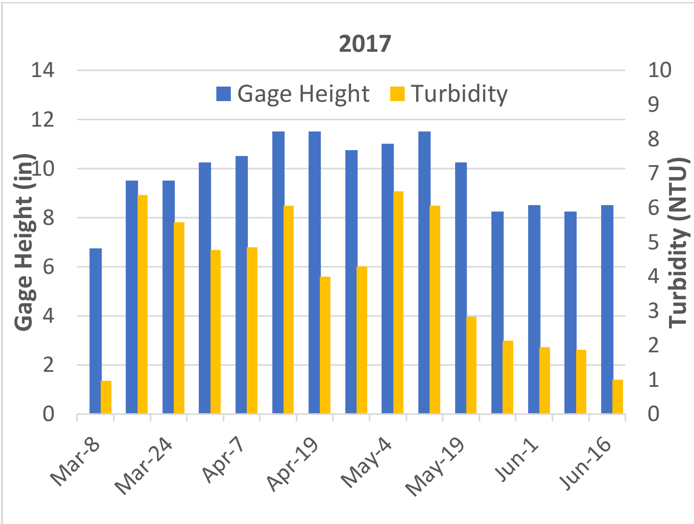
Cottonwood Basin: **N. Fork Cottonwood Creek** 3rd order tributary.



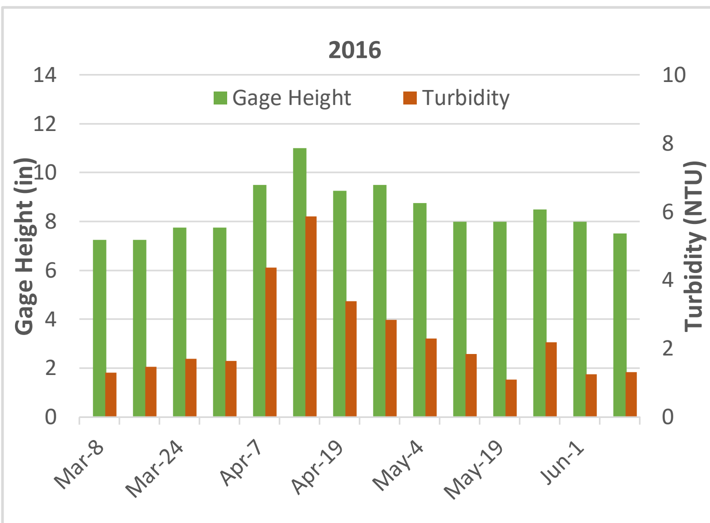


Figures 16 and 17 – Gage height (water level) relative to turbidity results for each week of sampling during years 2017 and 2016

Cottonwood Basin: **Cottonwood Spring Creek** 3rd order tributary

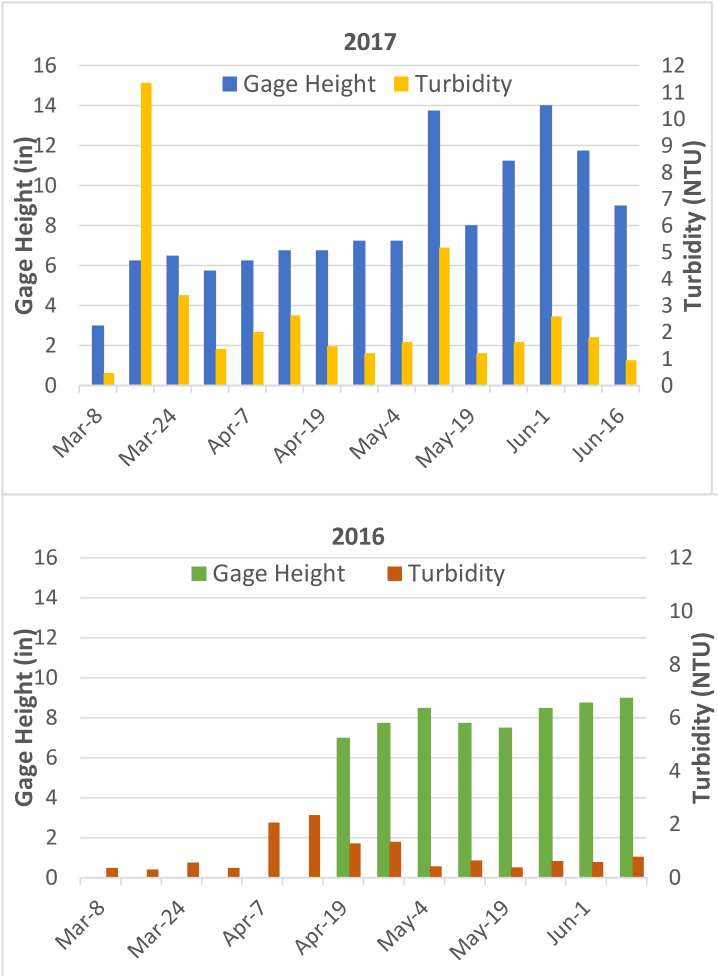


.



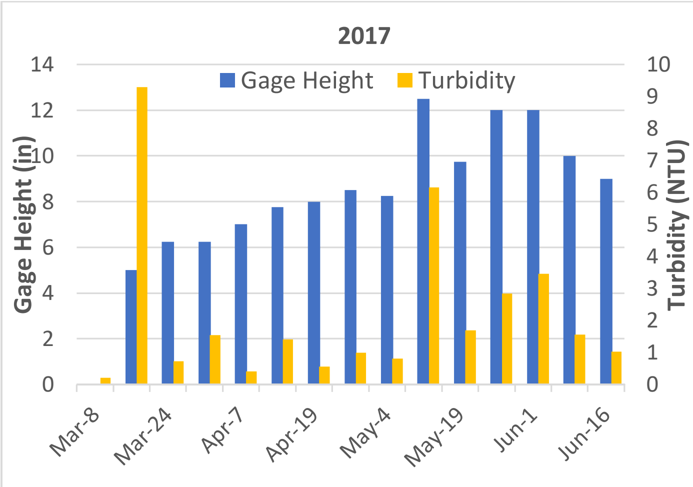
Figures18 and 19 – Gage height (water level) relative to turbidity results for each week of sampling during years 2017 and 2016

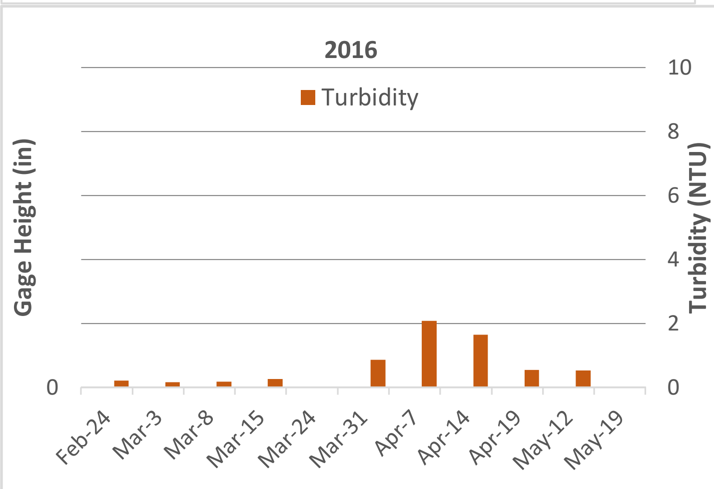
Cottonwood Basin: **Upper Cottonwood Creek** 2nd order tributary.



Figures 20 and 21 – Gage height (water level) relative to turbidity results for each week of sampling during years 2017 and 2016

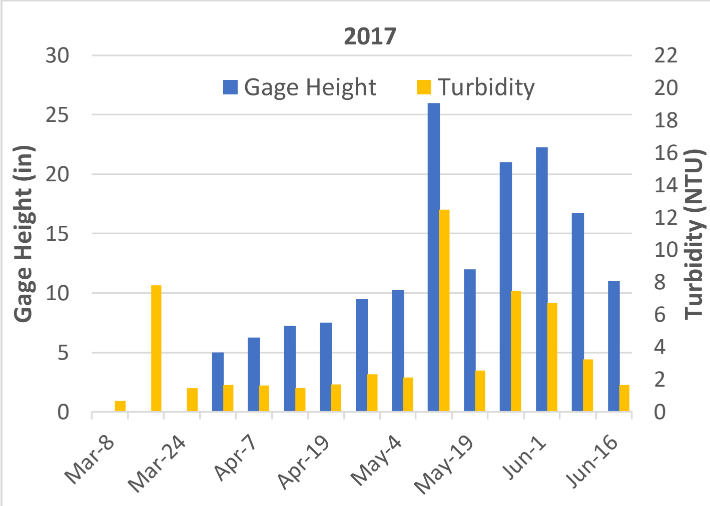
Dick Creek Basin: **McCabe Creek** 3rd order tributary

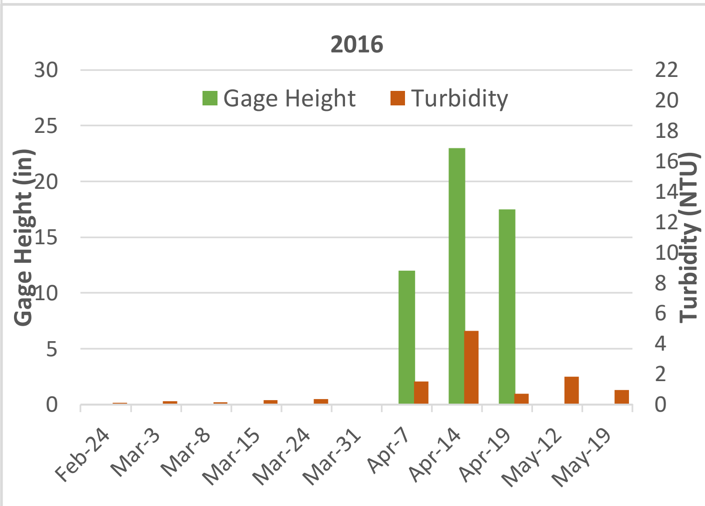




Figures 22 and 23 – Gage height (water level) relative to turbidity results for each week of sampling during years 2017 and 2016 Note that no gage height data was collected in 2016 for McCabe Ck

Upper Monture Basin: **Monture Creek** 4th order tributary





Figures 24 and 25 – Gage height (water level) relative to turbidity results for each week of sampling during years 2017 and 2016 Note that in 2016 gage height data was only collected 4/7, 4/14, and 4/19 for Monture Ck.

2017 Data Summaries: Nutrient levels and Total Suspended Solids

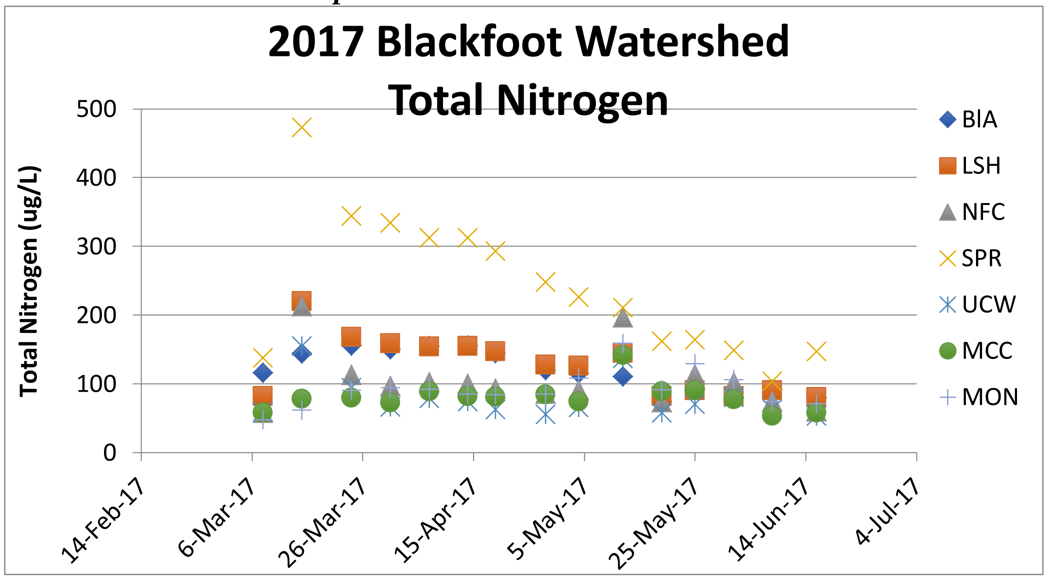


Figure 26 – Total Nitrogen amounts for each stream over the 2017 sampling period

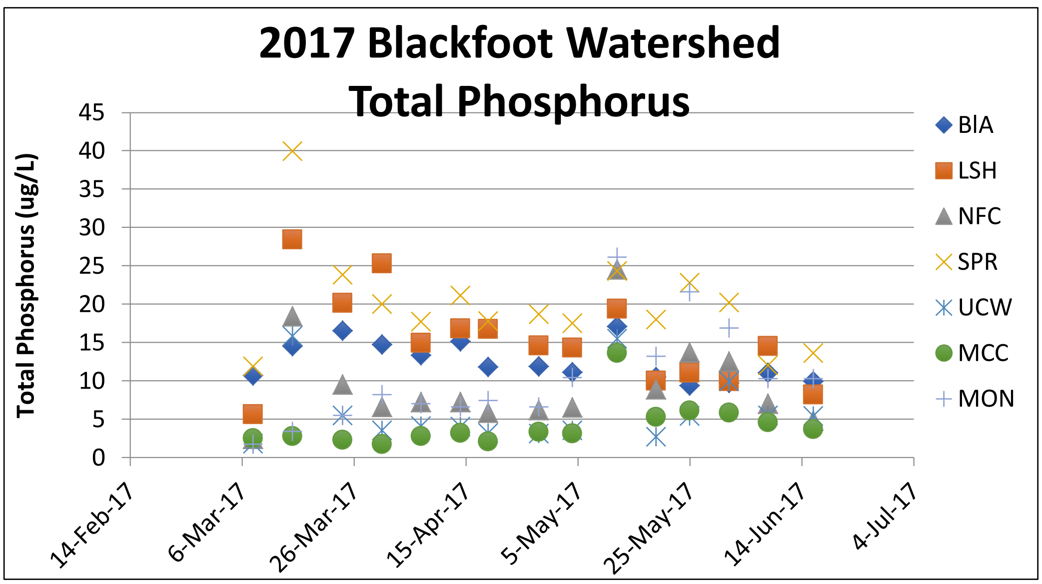


Figure 27 – Total Phosphorus amounts for each stream over the 2017 sampling period

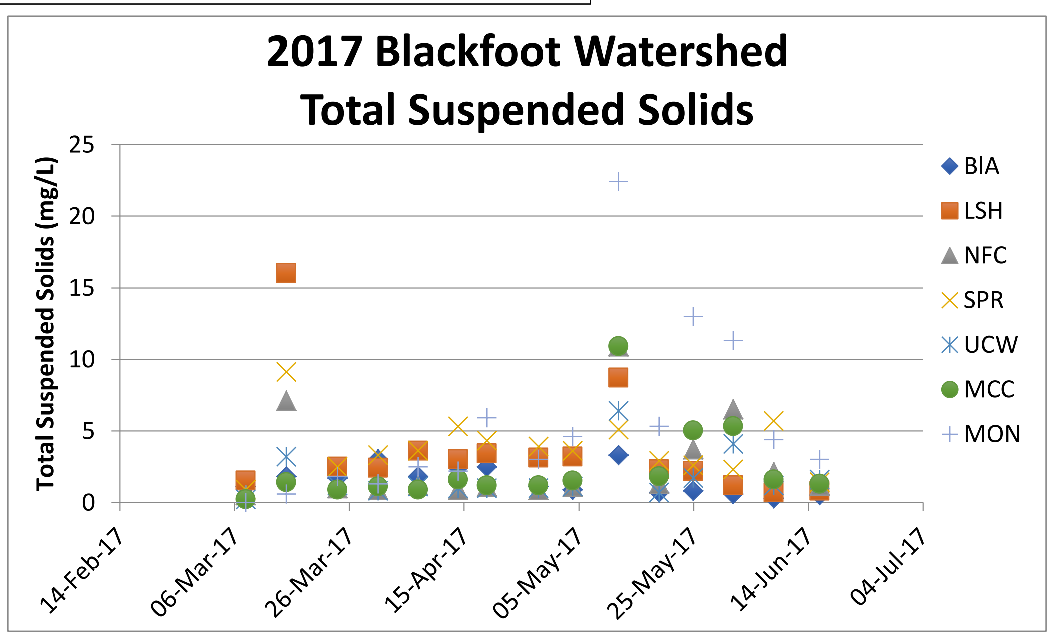


Figure 28 – Total Suspended Solids for each stream over the 2017 sampling period

2017 Individual Stream Data: Water Quality Monitoring

Cottonwood Basin: **Black Canyon Creek** 2nd order tributary, 15 samples.

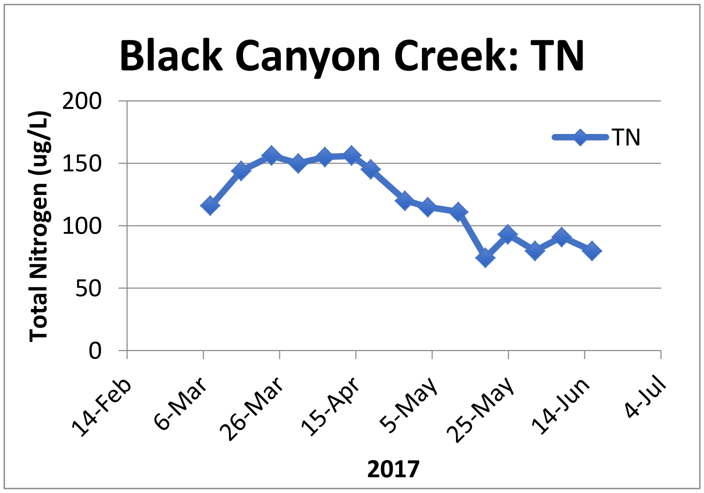


Figure 29 – Total Nitrogen results for each week of sampling.

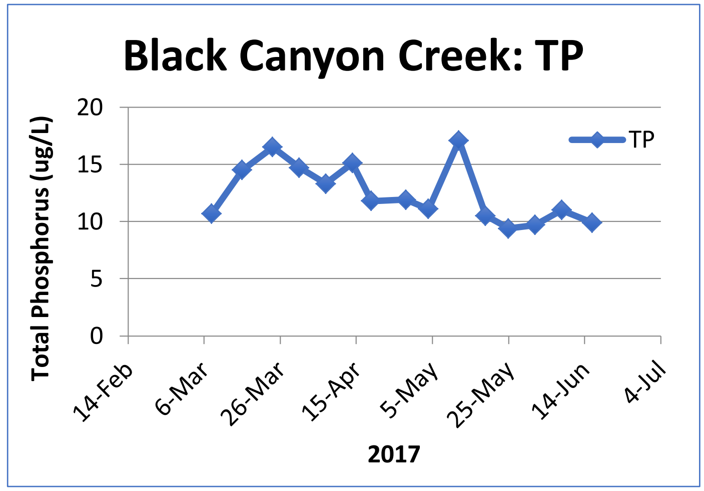


Figure 30 – Total Phosphorus results for each week of sampling.

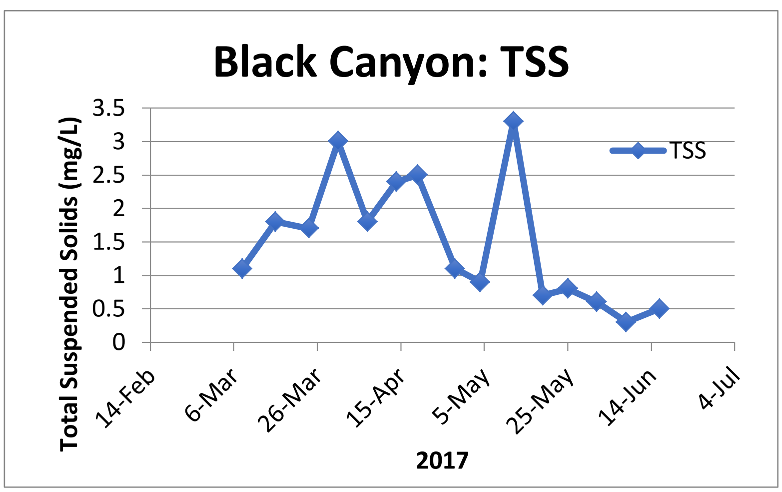
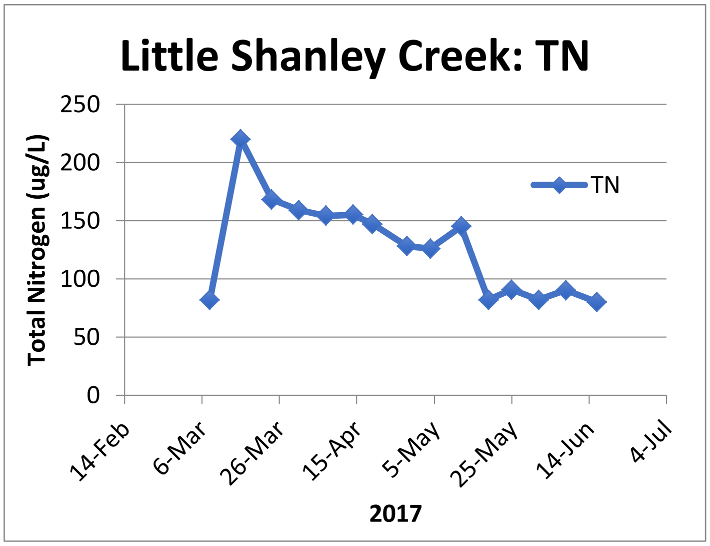


Figure 31 – Total Suspended Solids results for each week of sampling.

Cottonwood Basin: **Little Shanley Creek** 1st order tributary, 15 samples.



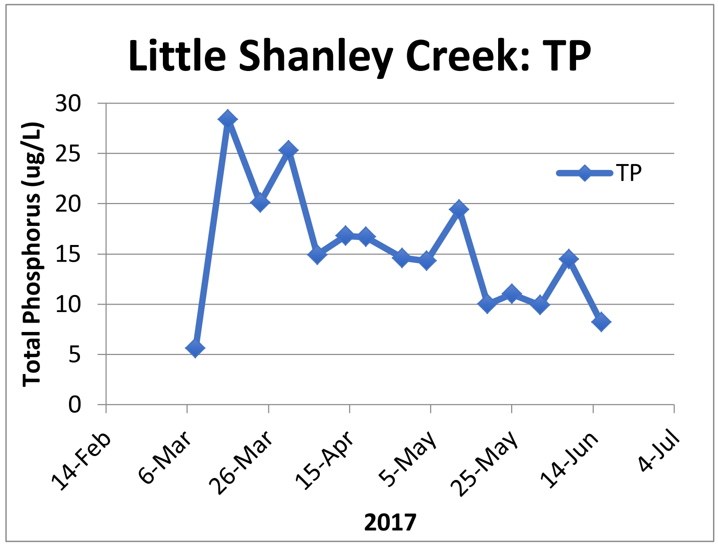


Figure 32 – Total Nitrogen results for each week of sampling.

Figure 33– Total Phosphorus results for each week of sampling.

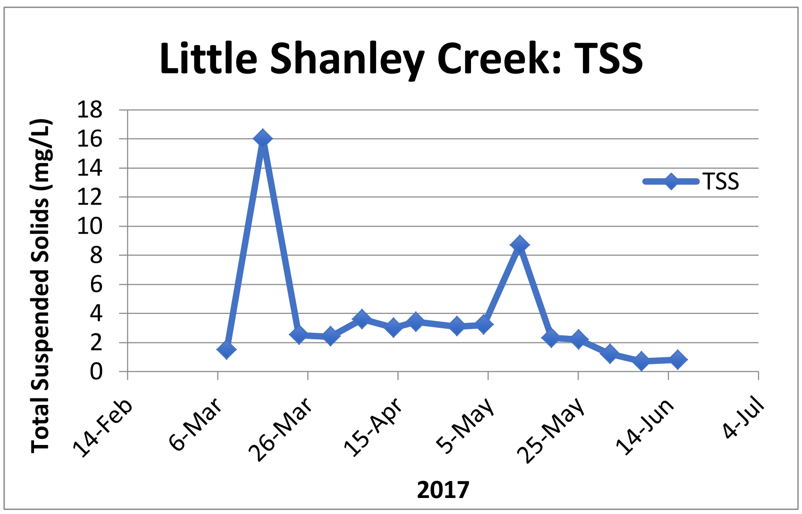
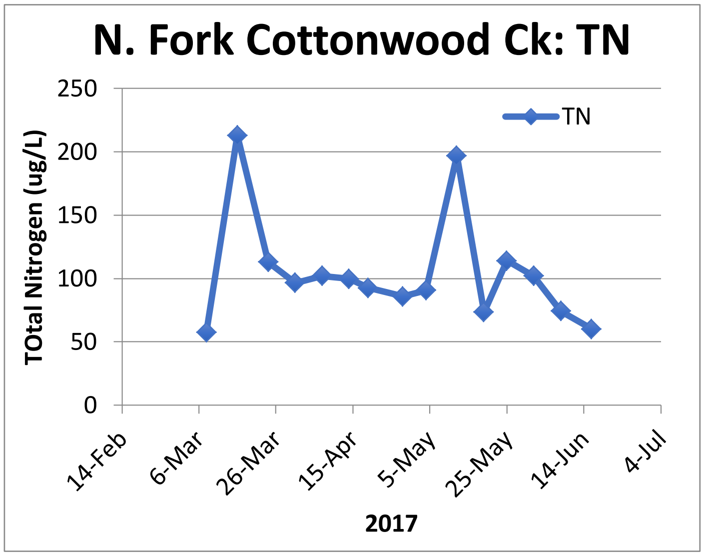


Figure 34 – Total Suspended Solids results for each week of sampling.

Cottonwood Basin: **North Fork Cottonwood Creek** 3rd order tributary, 15 samples.



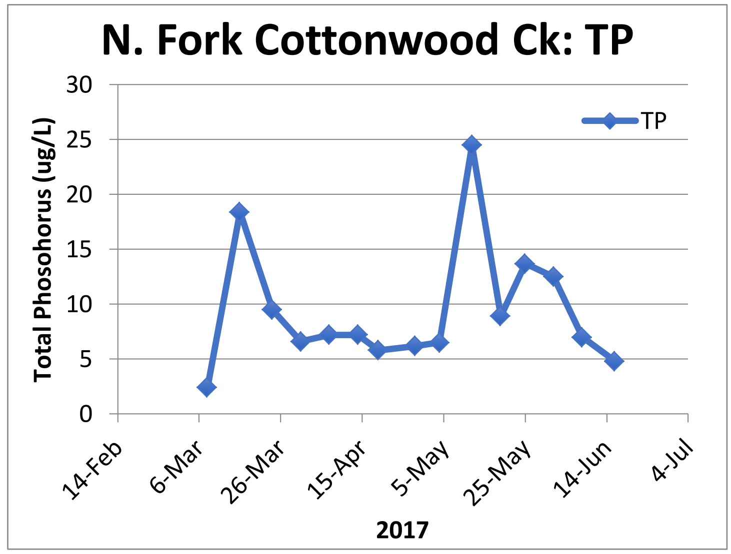


Figure 35 – Total Nitrogen results for each week of sampling.

Figure 36 – Total Phosphorus results for each week of sampling.

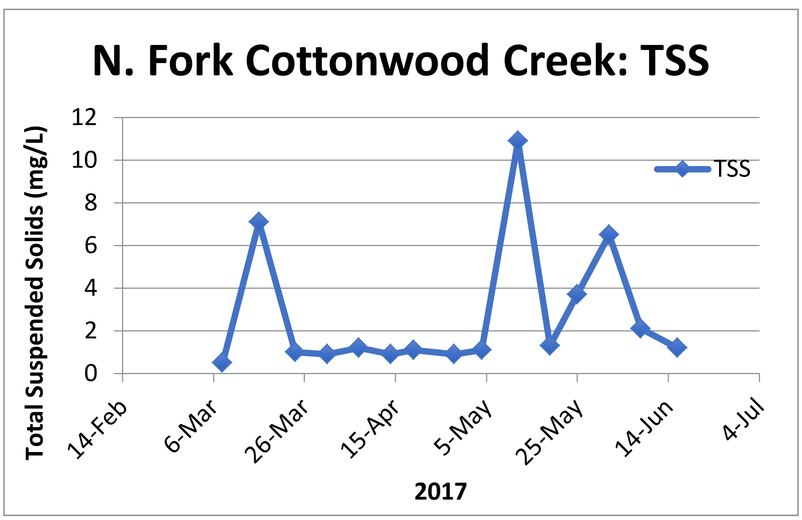


Figure 37 – Total Suspended Solids results for each week of sampling.

Cottonwood Basin: **Cottonwood Spring Creek** 3rd order tributary, 15 samples.

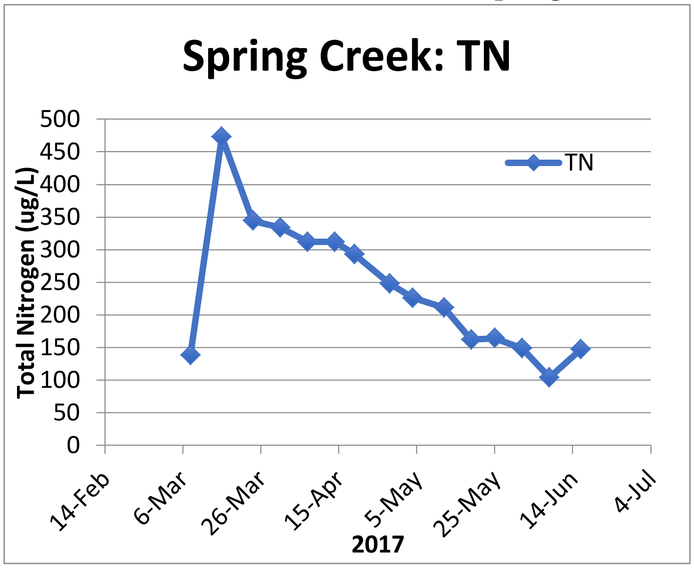


Figure 38 – Total Nitrogen results for each week of sampling.

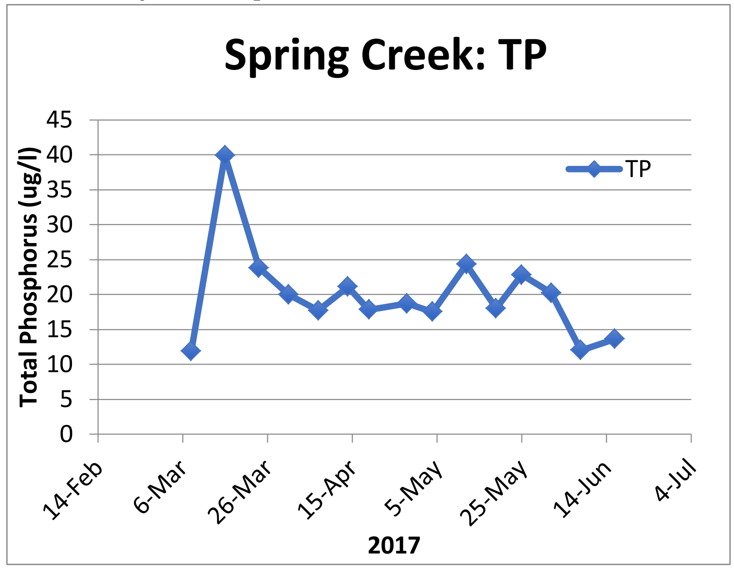


Figure 39 – Total Phosphorus results for each week of sampling.

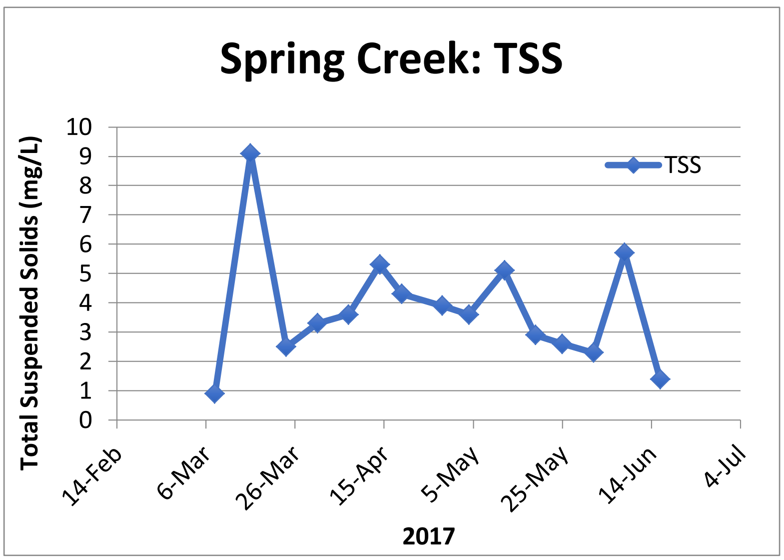
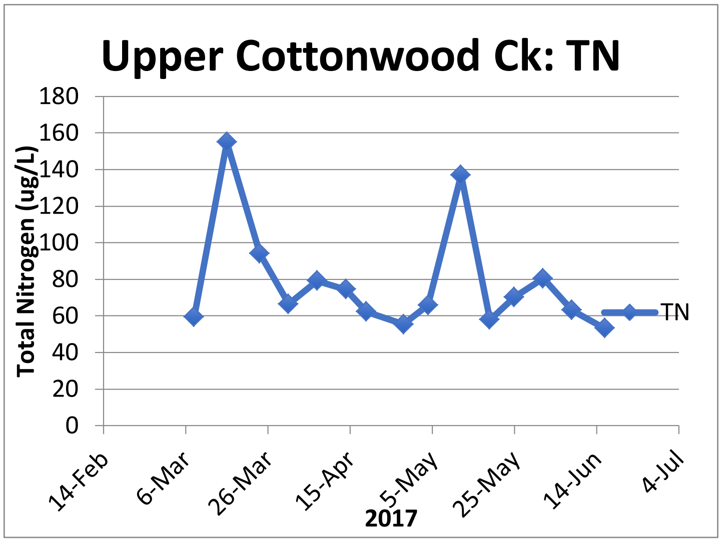


Figure 40 – Total Suspended Solids results for each week of sampling.

Cottonwood Basin: **Upper Cottonwood Creek** 2nd order tributary, 15 samples.



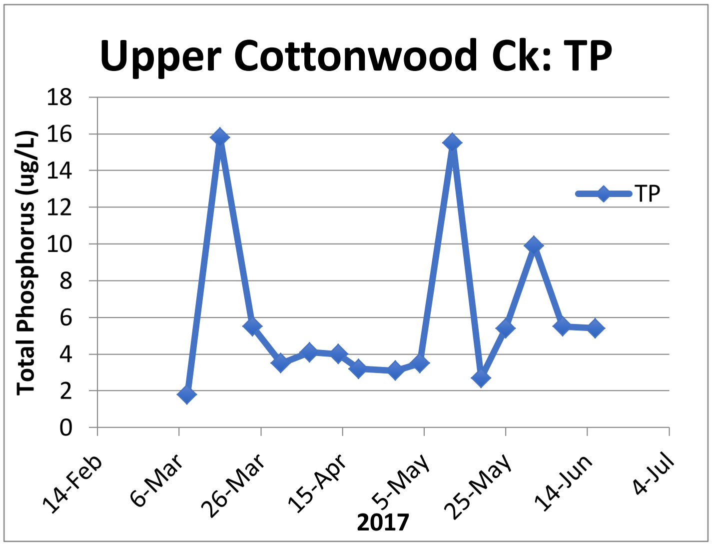


Figure 41 – Total Nitrogen results for each week of sampling.

Figure 42 – Total Phosphorus results for each week of sampling.

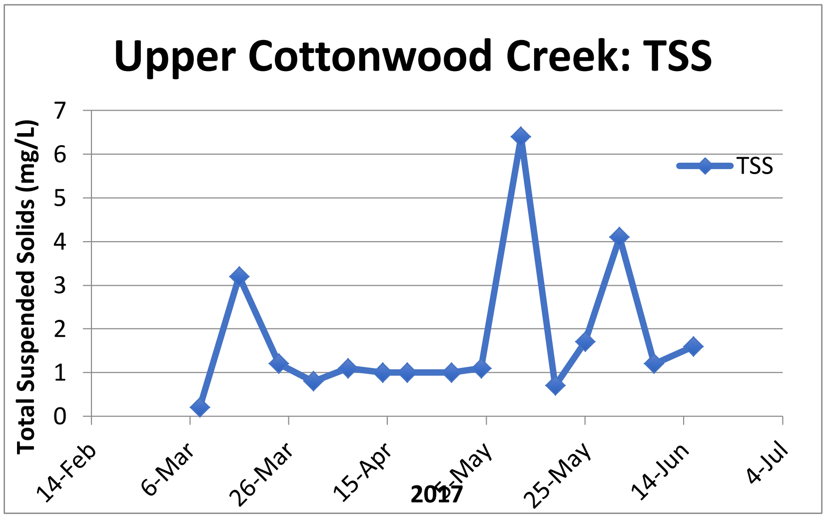


Figure 43 – Total Suspended Solids results for each week of sampling.

Dick Creek Basin: **McCabe Creek** 2nd order tributary, 15 samples.

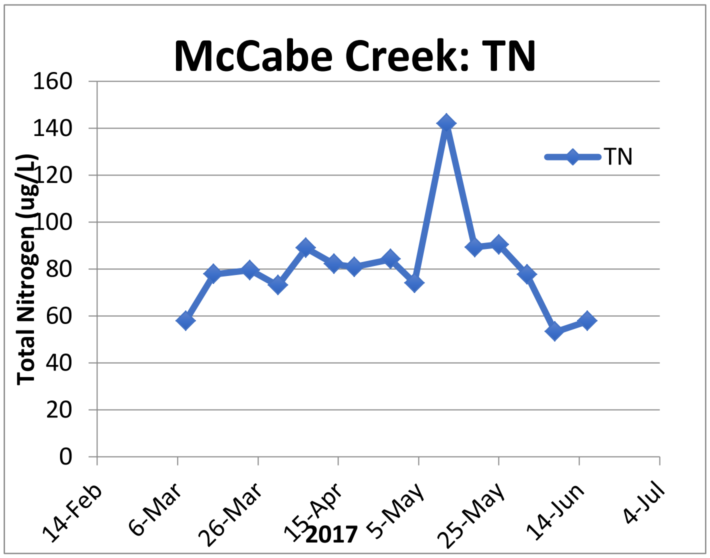


Figure 44 – Total Nitrogen results for each week of sampling.

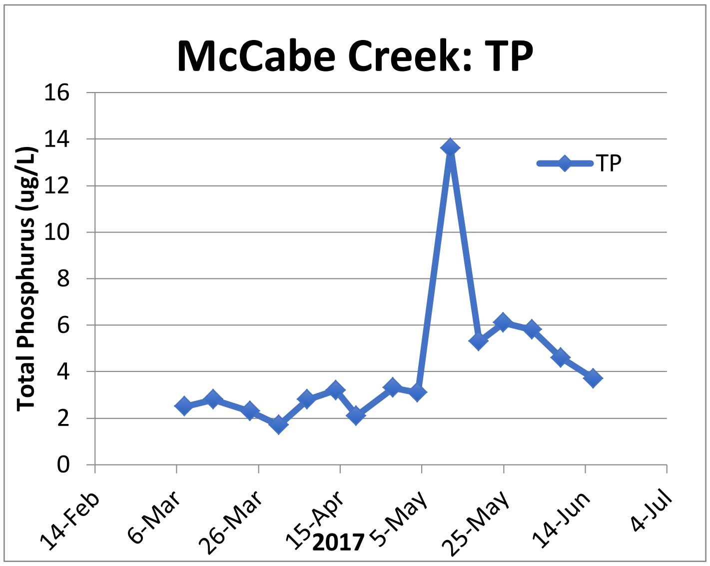


Figure 45 – Total Phosphorus results for each week of sampling.

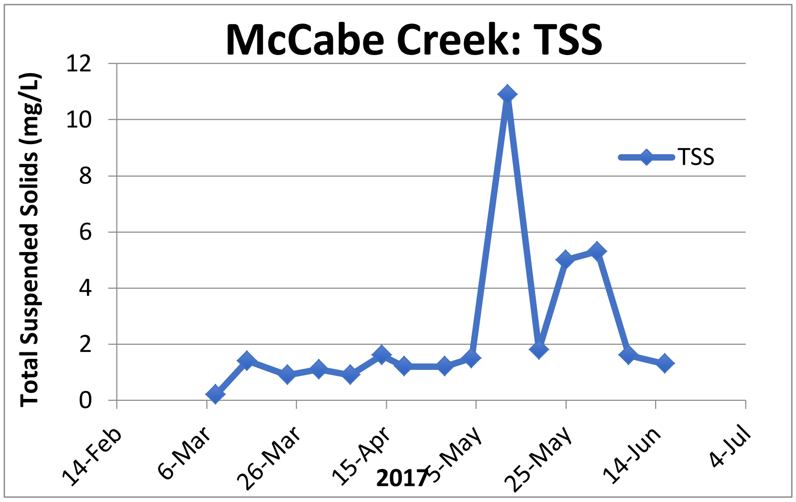


Figure 46 – Total Suspended Solids results for each week of sampling.

Upper Monture Basin: **Monture Creek** 4th order tributary, 15 samples

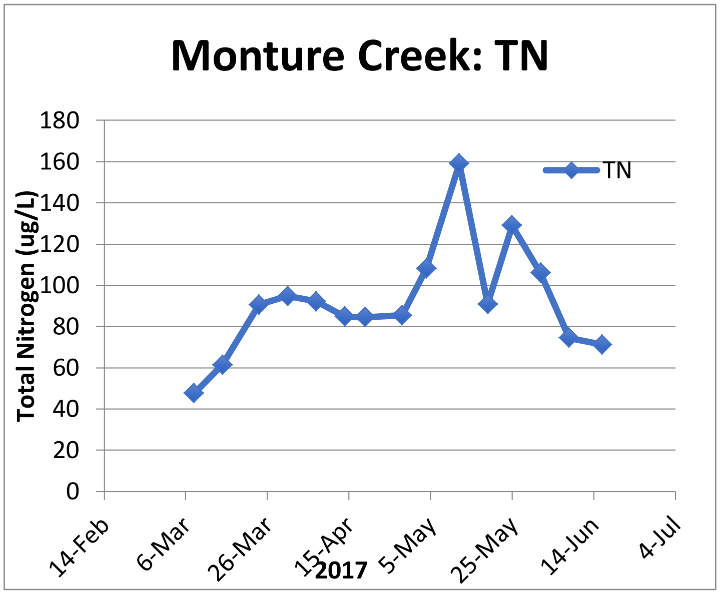


Figure 47 – Total Nitrogen results for each week of sampling.

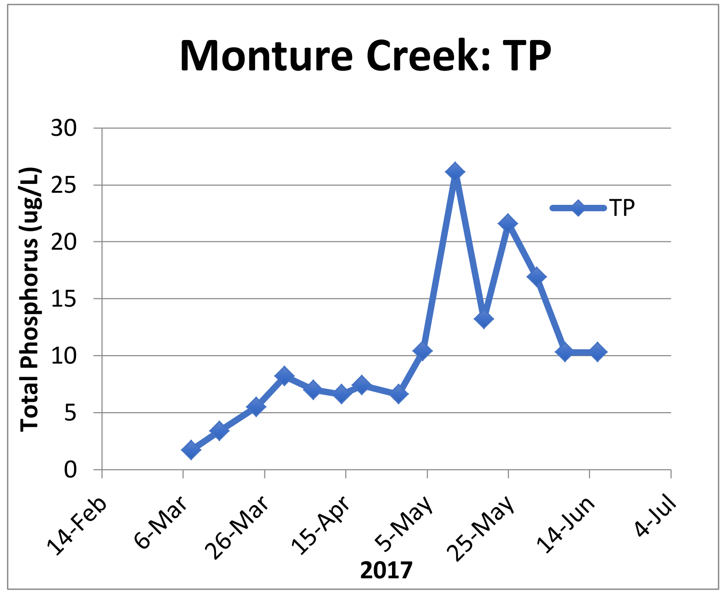


Figure 48 – Total Phosphorus results for each week of sampling.

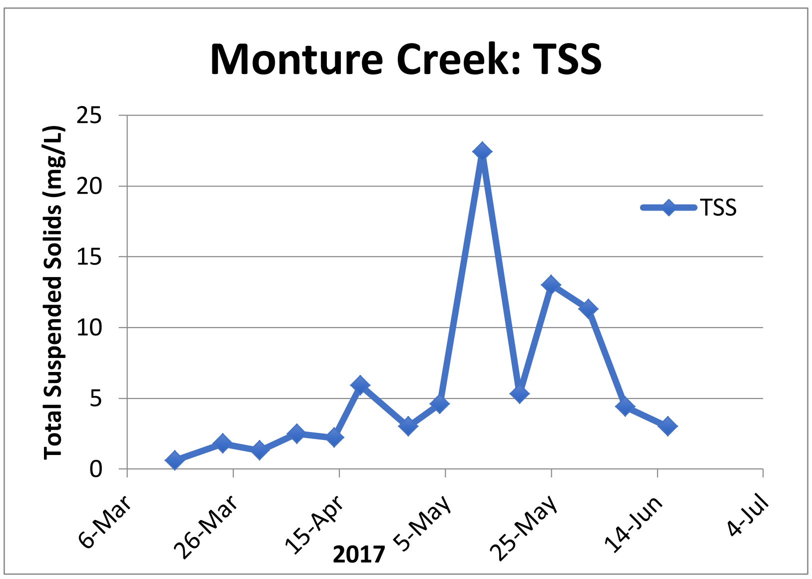


Figure 49 – Total Suspended Solids results for each week of sampling.