Table of Contents

Project Title:
Blacktail Creek & Little Muddy River Project

Lead Project Sponsor:
Williams County Soil Conservation District
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State:
North Dakota

Hydrologic Code:
10110102

High Priority Watershed:
No

Project Type:
Watershed

Waterbody Types:
Groundwater
Lakes/Reservoirs
Rivers
Streams
Wetlands

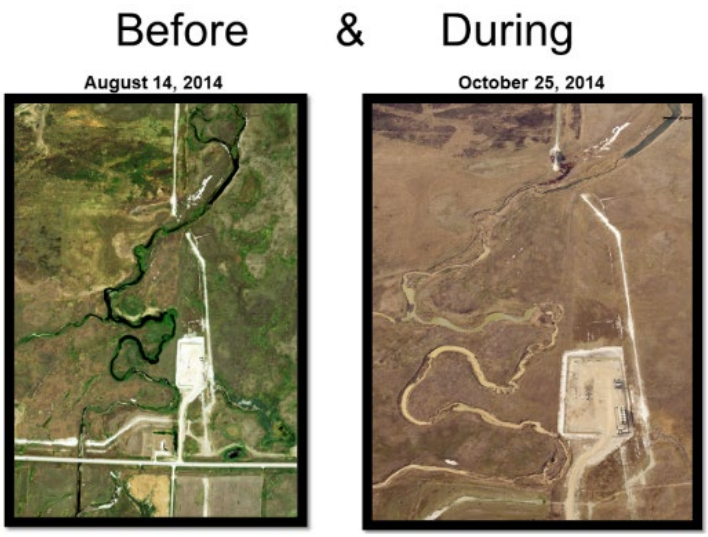
Project Location:
48.150262, -103.622218

Summarization of major goals: The primary goal of this project is to improve water quality and soil health by addressing non-point source pollution concerns, including E. coli, to improve and maintain recreational uses of water bodies within the Little Muddy River Watershed. These efforts will also support the health, habitat, and ecosystem services of the watershed to compensate for what was lost in the 2014 saline spill. Additionally, this project will prioritize erosion and runoff reduction and the maintenance of perennial cover around streams, rivers, and other bodies of water within the watershed.

Project Description: The Little Muddy Watershed covers 930 square miles of Williams and Divide County. The Williams County Soil Conservation District, based out of Williston, ND, is the lead project sponsor for the project. This project was created in response to the 2014 saline spill in the central part of the county, which impacted Blacktail Creek and the Little Muddy River. Through further assessment of these waterbodies, it was determined that recreation, water quality, and the overall health of the watershed were negatively impacted. The implementation of Best Management Practices is necessary to address nutrient concerns and mitigate non-point source pollution impacts within the watershed. As a result of the spill, a natural resources damages fine was levied against the responsible parties and formed an initial fund for a 10-year to cost-share beneficial practices within the watershed. With support from the 319 program, these funds will be able to meet landowner demand for conservation practices and create improvements in ecosystem health and water quality.

FY2023 Funds Requested: $369,910
319 Funded Full Time Personnel: 1

1. Introduction



In 2014, a pipeline spill released 29 million gallons of produced water into the Little Muddy River Watershed over almost five months. It ran into Blacktail Creek, a tributary of the river, before reaching the river and eventually Lake Sakakawea. The spill occurred due to negligence in the installation and operation of the pipeline by the company that owned the line (DOJ, 2021). The spill was also not reported and then underreported to the DEQ, prolonging the incident and complicating cleanup. A later study on water quality near the spill site found significantly increased conductivity, dissolved solids, ammonium, chloride, sodium, strontium, lithium, boron, bromide, calcite, hydrocarbons and a number of trace elements. The study also found impacts on estrogen receptor activity and possible reductions in fathead minnow survival. The study found negative impacts both at the immediate spill site and downstream (Cozzarelli et al., 2017).

Payments were later made to affected landowners and the companies were held responsible for the spill's cleanup. Out of this spill also came years of litigation and both civil and criminal fines for the responsible parties, Summit and Meadowlark Midstream Company, LLC, as well as a natural resources damages fine of 1.25 million dollars. An agreement was devised by the board of trustees involved in the legal response to the spill that set forth minimum requirements for the utilization of these funds. Preliminary reclamation response is taking place as part of the ongoing assessment phase and funds remaining will be utilized for conservation efforts within the impacted area. Additionally, surface water stream sampling along Blacktail and the Little Muddy River and lake sampling on Blacktail Dam identified the need for further Best Management Practice (BMP) implementation to address nutrients, sediments, and E. coli in the watershed. Therefore, this program is intended to cost-share practices that improve the water quality and ecological health of the Little Muddy River Watershed.

The Williams County Soil Conservation District (SCD) will prioritize improving soil health, reducing runoff and erosion, maintaining perennial cover and native habitat, and encouraging sustainable agriculture within the watershed. These principles will ensure that the watershed remains useable for recreation, agriculture, and as habitat for wildlife. A secondary goal is to reduce E. coli in the Little Muddy River, which currently threatens recreation. The SCD board

decided on a 70% cost share rate for BMPs and will use the settlement to supplement 319 funds to achieve this percentage.

1.2 Project Sponsors

The main project sponsor is the SCD, cooperating with the ND DEQ for guidelines, advice, and funding. The DEQ has agreed to provide reimbursement through the settlement for supplies, salaries, and cost-share as long as established guidelines are followed for BMPs and reimbursement requests. Other cooperating organizations include NRCS and the Game & Fish Department. As the project sponsor, the WCSCD handles the work of recruiting landowners interested in the program and developing contracts, with most of the routine work and sampling done by the watershed coordinator. The SCD board approves or denies contracts or makes recommendations to improve them to secure approval. Installation verification, as well as verification of correct operation and maintenance of BMPs, is done by the watershed coordinator to NRCS standards. Reimbursements are completed by the coordinator in conjunction with the SCD clerk. The local NRCS agent provides technical assistance with BMPs and help with evaluating sites. The local Game & Fish department has helped with the settlement requirement to improve two fishing access sites, as well as occasionally providing a boat and boat driver for sampling Blacktail Dam.

1.3 Available Programs

More demand for conservation exists than what the remaining settlement fund can supply. Since the program's official start in May, we have had a number of landowners and operators interested in possible cost-share, and the interest is likely to increase as word spreads within the area. NRCS and the Soil Conservation District offer cost-share programs for conservation, but these programs either have limited, competitive funding pools or low funding caps for each landowner. The watershed is about 930 square miles, so there is a significant area to improve and many potentially interested landowners.

1.4 Area Background

Williams County is at the center of North Dakota's hydraulic fracturing boom but remains largely agricultural in land use. The total population of the county is currently 40,950, with much of that number living in Williston.

Williston developed quite rapidly following the oil boom and expanded the amount of developed area surrounding the Little Muddy River. Most towns in the county experienced some population growth following the boom. The only other town within the watershed is Zahl,

a small unincorporated community. The boom has caused environmental issues related to pipeline construction that could be a target for this program. It is possible that fracking has impacted ground and surface waters in the area. Drilling mud, fracturing fluid, produced water, drilling cuttings, and flowback water have known impacts on both groundwater and surface water due to potentially toxic additives and contaminants. Fracking can also contribute to water stress due to increased water usage. Flowback water that enters surface water sources can also contribute to total dissolved solids (Gadhamshetty et al., 2015). Other analyses have found negative impacts on streams and their macroinvertebrate inhabitants from unconventional oil and gas development (Burton et al., 2014). Small spills are frequent within the watershed and the county.

Williams County lies within the boundaries of the Fort Union, Fox Hills-Hell Creek, and Dakota bedrock aquifers. Surficial aquifers include the Little Muddy, Ray, Smoky Butte, and West Wildrose aquifers. Water in all of these aquifers is high or locally high in arsenic, iron, manganese, sodium, and sulfate. The Little Muddy, Smoky Butte, and West Wildrose aquifers are mostly used for irrigation, while Ray is mostly used for rural water and industrial purposes per the ND DEQ groundwater monitoring program. There are a few small non-community source water protection areas north of Williston. The public supply per capita use of water for the county is 272 gallons per day, with 33,663 people served as of the 2015 USGS dataset (USGS, 2018). This data is closer to the peak of the oil boom and may be an overestimate due to a temporarily increased population, but it is the most recent data available.

Agricultural land use is divided between cropland, hayland, and rangeland. A map of crop types within the watershed is available in Appendix B: Images and Diagrams. Common crops include durum, spring wheat, canola, soybeans, small grains, and lentils. Irrigation is sporadic on cropland throughout the watershed. USGS data for 2015, the most recent available, records 22,000 acres of total irrigation. Within the watershed, rangeland is largely limited to the rougher, rockier areas surrounding the river and its tributaries. There is a strong skew towards land being operated by larger farms with a median farm size of 660 acres and a mean size of 1,756 acres. As of the 2017 NASS, there were 19,733 cattle in the county with very limited numbers of other types of livestock.

The watershed is split between the Coteau Slope and Missouri Coteau regions. The Missouri Coteau is defined by glacial landforms; the Coteau Slope has both erosional and glacial landforms. It is part of the Williston Basin geologic formation, as well as the Bakken oil formation. Coal formations are scattered throughout the county, and a few abandoned mines exist. These are not currently a concern due to their size, location, and available water quality data. The topography is one of gently rolling hills and the elevation ranges from 1850 to 2500 ft (Bluemle and Biek). The watershed is mostly split between MLRA 53A (Northern Dark Brown Glaciated Plains) and 53B (Central Dark Brown Glaciated Plains) with a small portion near the mouth of the river in 54 (Rolling Soft Shale Plain). Soils are generally deep and loamy apart from slopes and hilltops, and significant potential for wind and water erosion exists (NRCS, 2002). It is

largely in Ecoregion 42i, Glaciated Dark Brown Prairie, with a small portion in 42d, Northern Missouri Coteau. It is dominated by mixed-grass prairie with wooded areas on slopes and in draws (NRCS, 2022).

The climate is semi-arid: 53A receives an average of 11 to 15 inches of precipitation and 20 to 40 in of snow, 53B 13 to 21 inches of precipitation and 25 to 50 inches of snow (NRCA, 2022). NDAWN stations for Williston show a rainfall range of 4.5 to 20 inches of rain (NDAWN Station Williston) and a snowfall range of 23 to 76 in between 2000 and 2010, the most recent period available (NOAA, 2023).

The Little Muddy Watershed's major water bodies are the Little Muddy River, Blacktail Dam, Alkali Lake, Cottonwood Lake, Green Lake, Holm Lake, and the network of lakes and wetlands at Zahl National Wildlife Refuge. Of these, only Kettle Lake, Blacktail Dam, and Cottonwood Lake have had any sampling done. Many tributaries to the Little Muddy exist and most are intermittent. Aside from the three tested through the ongoing assessment program, which are not intermittent in a normal year, these have not been evaluated as to their water quality. The Little Muddy flows into Lake Sakakawea, a 303(d) listed water body that is also considered impaired for fish and shellfish consumption due to methylmercury. Cottonwood Lake and the main channel of the Little Muddy River are also 303(d) listed for recreation impairment – Cottonwood for nutrients, the Little Muddy for fecal coliform levels (Larsen et al., 2023). Cottonwood Lake's water quality and fish kill issues have been exacerbated by drought over the last 20 years. Blacktail Dam had a TMDL completed in 2008 but continues to be considered impaired for nutrients. No significant work was done to reduce nutrient loads until the advent of this program. The northern part of the watershed stretches into the prairie pothole region. Taken together with Lake Zahl NWR, many important wetlands exist within the area and merit increased attention and protection. A map of water bodies and wetlands is in Appendix B.

2.1 Sampling Program Background

Preliminary water sample results indicate some areas that meet recommendations and others that need greater attention. There are four sample sites including a lake (Blacktail) and three stream sites. A map is in Appendix B. All three stream sites are bridge sites with nesting swallows in late spring and early summer, which may contribute to E. coli loads. These sites are varied in their local contexts and represent the range of conditions seen in the watershed. The sampling and analysis plan (SAP) was developed by the DEQ and defines the analytes, testing sites and periods, and procedures to be followed in collecting samples. It is revisited each year and is subject to change based on sponsor input and the DEQ.

Site Name	Site Code	Type	Tests	Sampling Frequency	Testing Period
Blacktail Dam	380540	Lake	Nutrients Dissolved Solids Metals Cations/anions Chlorophyll Temperature Dissolved Oxygen pH	2 times/month	June 1 – October 31
Little Muddy - Alamo	386055	Stream	Nutrients E. Coli* Dissolved Solids	6 times/month	June 1 – Ice over
Blacktail Creek	386056	Stream	Nutrients E. Coli* Dissolved Solids	6 times/month	June 1 – Ice over
Little Muddy - Williston	380540	Stream	Nutrients E. Coli* Dissolved Solids	6 times/month	June 1 – Ice over

Blacktail Metals Tested	Blacktail Cations/Anions Tested	Nutrients Tested (All sites)
Aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chloride, chromium, copper, fluoride, iron, lead, magnesium, manganese, molybdenum, nickel, potassium, selenium, silver, sodium, thallium, and zinc	Alkalinity (CACO3) (total), anion sum, bicarbonate (HCO3), carbonate (CO3), cation sum, conductivity, hardness (total), hydroxide, and percent sodium, and sulfate	Nitrate and nitrite, Kjeldahl nitrogen, total nitrogen, ammonia, and phosphorus

*E. coli is only sampled until September 31st.

Graphs and tables for all parameters except metals can be found in Appendix A.

2.2 Site Background and Initial Results

Blacktail Dam is a 155-acre lake used largely for recreational purposes. There are homes bordering the lake, along with campsites, fishing areas, and both public and private boat ramps. It is roughly 25 miles north of Williston. It has experienced minor issues with algae blooms and is currently listed as threatened due to “eutrophication from nutrient enrichment, low dissolved

oxygen concentrations, and sedimentation" (NDDEQ, 2019). It sometimes floods during the spring snowmelt, which causes issues for homeowners living in cabins built below the level of the emergency spillway. Blacktail Creek flows from it before joining the Little Muddy River. Comparisons between the 2023 data and earlier analyses (Appendix B, Blacktail Dam) indicates that about half of the parameters are increasing relative to 2014 and the historical median. The other half are stable or decreasing. Images of all sites and a map are in Appendix B.

The Little Muddy tributary near Alamo is the northernmost of the three stream sampling sites. Like the other three sites it is surrounded by farmland with little development nearby. Overall it has the best water quality of the three streams, with one parameter increasing (nitrate/nitrite) and the other six stable or decreasing. Most results were higher at the beginning of the season and trended lower as time went on. This may be part of a cyclic pattern and not an absolute decrease, so an additional focus will be placed on BMPs that will mitigate spring/early summer runoff. Conversion to perennial cover, cover crops, and field borders/buffers will be a target to help remedy this problem.

Blacktail Creek runs directly off of Blacktail Dam and has generally demonstrated the most concerning water quality results. There is a combination of rangeland and cropland nearby, with cattle sometimes grazing and wading in the stream directly downstream of our sampling site. It is the closest sampling site to where the original spill was. Four parameters are increasing, with the other three stable or decreasing slightly (Appendix A). These results may be due to the higher concentration of cattle in this portion of the watershed and possible discharges from Blacktail Dam. E. coli in particular has had cyclically high results, as high as 6500 cfu/mL, which may be due to cattle directly accessing the waterway or areas near it.

The Little Muddy tributary near Williston is the widest of the three streams, the furthest south, and the closest to the main channel of the river. It is surrounded by rangeland and cropland and is the closest to the town of Williston. All of its parameters are stable or decreasing. It has had a few E. coli results that were relatively high despite a geometric mean below 126 cfu/mL and the decreasing trend. This is not unusual for the three sites in general, which occasionally have high E. coli results.

Macroinvertebrate sampling was also conducted in early September of 2023 at four sites to more holistically assess the habitat and water quality of the watershed. Results are expected by the end of 2024 and will be incorporated into our goals and priorities moving forward.

The three stream sites and one lake site may be varied in their results, but point to actionable items for the watershed project. Like in all agricultural watersheds, fertilizer and manure runoff is a problem. This has contributed to the algae blooms on Blacktail Dam and Cottonwood Lake's impairment listing for nitrogen and phosphorus. Combined with increasingly hot summers in North Dakota, the subbasin may begin to see more algae blooms if BMPs are not implemented on a larger scale. Moreover, reducing runoff and erosion would make local ponds, streams, and lakes better habitat for aquatic and terrestrial wildlife. E. coli is also a

known issue for the subbasin with the problem partially confirmed by assessment sampling. The Little Muddy River will continue to be considered impaired if E. coli inputs from its tributaries are not addressed. In the long term, we would like to see all parameters stable or decreasing and a reduction of the spring/early-summer spike observed for many parameters.

3.1 Environmental and Programmatic Goals

Goal 1: Reduce erosion and nutrient runoff into creeks. Soil erosion contributes to sediment loading in the streams, while nutrient runoff can lead to algal blooms in ponds and lakes. Both can affect aquatic life.

Objective 1.1: Implement at least 1000 acres of continuous or perennial cover. Protect and conserve at least 500 acres of the range/pastureland buffer that surrounds the river and its tributaries to maintain its runoff-reducing effects.

Task: BMPs to be implemented for both objectives include grass seedings, riparian tree plantings, grassed waterways, and filter/buffer strips.

Task: Employ a watershed coordinator responsible for planning and communicating with landowners on BMP efforts.

Goal 2: Reduce E. coli inputs. This is a secondary goal of the settlement as well as a concern for recreation on the Little Muddy River.

Objective 2.1: Implement 1000 acres of rotational grazing plans.

Objective 2.2: Promote the fencing out of creeks and the river, implementing at least 20 linear miles of fencing on or within 1000 feet of a creek or river.

Goal 3: Reduce damage to wetlands and riparian areas to preserve wetlands' reduction of pollutants and flood-buffering effects. Riparian areas are important for wildlife and can be vulnerable to erosion if frequented by livestock.

Objective 3.1: Implement 100 acres of riparian easements on pasture/rangeland and 3 miles of fencing around wetland areas, in addition to 50 acres of wetland restoration. Easements will be held by the District, valued using average county rental rates, and managed according to the BMP guidelines.

Reduce the need for livestock access to bodies of water to protect riparian areas.

Task: Implement 5 new wells, 5 new trough/tanks and 4 miles of pipeline.

Goal 4: Promote landowner understanding of water quality, watershed health, and sustainable agriculture.

Objective: Continue to publish new articles in our newsletter (four per year), handouts, and flyers about these aspects of watershed management. Increase watershed outreach at local and SCD-held or sponsored events.

Goal 5: Contribute to the development of a TMDL for the Little Muddy River and Cottonwood Lake.

Objective: Continue to sample the watershed as per the SAP. Contact other local organizations to inquire about potential water sampling efforts on Cottonwood Lake.

Goal 6: Maintain stable or decreasing trends in water quality parameters, reduce those that are increasing, and identify the cause of cyclic trends within sampling years.

Objective 6.1: Promote BMPs that will reduce nutrient loads – see goal #1.

Objective 6.2: Increase networking in the area along Blacktail Creek. As this area has the worst sample results, there is a need to target these landowners to see improvements in the results.

Task: Mail targeted handouts, flyers, and increased attention in articles, as well as connect and have conversations with those landowners to determine their needs and priorities.

Objective 6.3: Run further analyses and comparisons with other streams to determine whether spring/early summer parameter spikes are due to runoff.

Milestone Table:

Task	Relevant parties	Task/output	Expected Completion Date

Increase the ecological function in the watershed (settlement requirement) by completing goals/tasks relevant to runoff/erosion (goal 1) and wetland/riparian areas (goal 3)	SCD, landowners, NRCS	BMP implementation	10/31/2028 (Year 4)
Reduce E. coli in Little Muddy (settlement requirement)	SCD, landowners, NRCS	BMP implementation	10/31/2028 (Year 4)
Overall BMP implementation objectives	SCD, landowners, NRCS	BMP implementation	10/31/2028 (Year 4)

4.1 Outreach and Public Involvement

At the beginning of the program, a landowner input meeting was conducted for the watershed's stakeholders. From this the SCD fielded questions and surveyed landowner priorities and concerns. Following this meeting, the SCD developed a brochure that was sent out to landowners and producers within the watershed.

Regular updates are posted in the SCD newsletter and Facebook page and have information about the program on the SCD website. The SCD has developed articles, handouts, flyers, and infographics on the program and related topics available at the SCD office. Specific goals include educating locals and landowners on basic watershed science and the impact of sustainable agricultural practices on environmental health. The district plans on continuing to provide updates and information at SCD events, which are hosted regularly throughout the year.

5.1 Data Collection and Storage

Data is stored and managed in two DEQ-developed databases, one for funding and expenditures and the other for BMPs and landowner information. All sensitive or private information is password protected or kept in a locked cabinet. Load reductions will be calculated with the PLET once more data has been gathered. We will comply with DEQ requirements to submit existing data as required.

6.1 Budget

	2025	2026	2027	2028	Total Costs	Cash Match (Settlement Funds)	319 Funds
Personnel/support							
Salary/Fringe	65,000	67,000	69,000	71,000	272,000	108,800	163,200
Office Rent/Utilities	0	0	0	0	0	0	0
Travel	2200	2200	2200	2200	8,800	3520	5280
Sampling Equipment/Supplies	250	260	270	280	1,060	424	636
Equipment/supplies	200	200	200	200	800	320	480
Training	250	250	250	250	1,000	400	600
Total for personnel/support	**67,900**	**69,910**	**71,920**	**73,930**	**283,660**	**113,464**	**170,196**
BMPs							
Goal 1: Runoff/erosion reduction	35,000	35,000	35,000	35,000	140,000	20,000	120,000
Goal 2: Rotational Grazing Plans	10,000	10,000	10,000	10,000	40,000	5,714	34,286
Goal 3: Wetland/Riparian	13,000	13,000	13,000	13,000	52,000	7,429	44,571
Goal 4: Landowner Outreach	250	250	250	250	1000	143	857
Total for BMPs	**58,250**	**58,250**	**58,250**	**58,250**	**233,000**	**33,286**	**199,714**
Overall Total	**126,150**	**128,160**	**130,170**	**132,180**	**516,660**	**146,750**	**369,910**

This budget is based on current costs for the settlement program as of October 2023 and estimates of BMP costs. Most sampling equipment has already been purchased, but additional needs may surface as time goes on. Rent and utilities are paid for by NRCS and the SCD.

Citations

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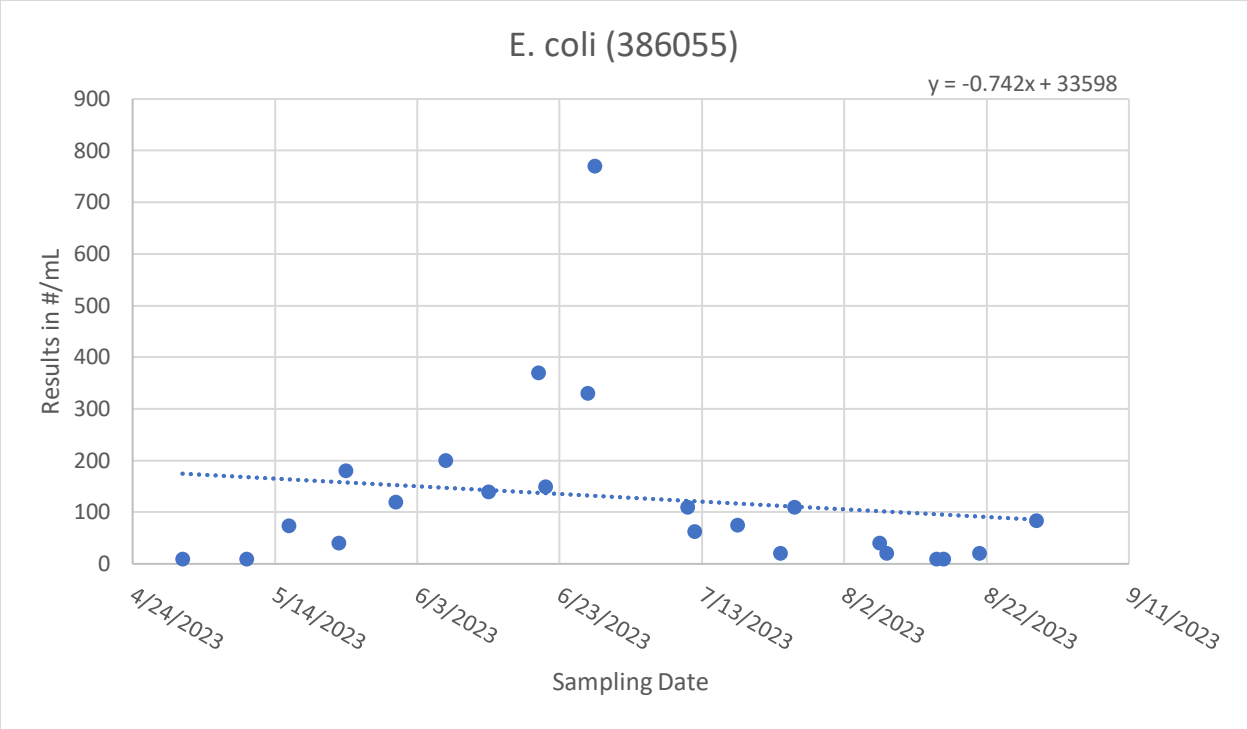
USGS Water Use Data for North Dakota: Williams County. (2018, June).

Appendix A: Graphs and Data

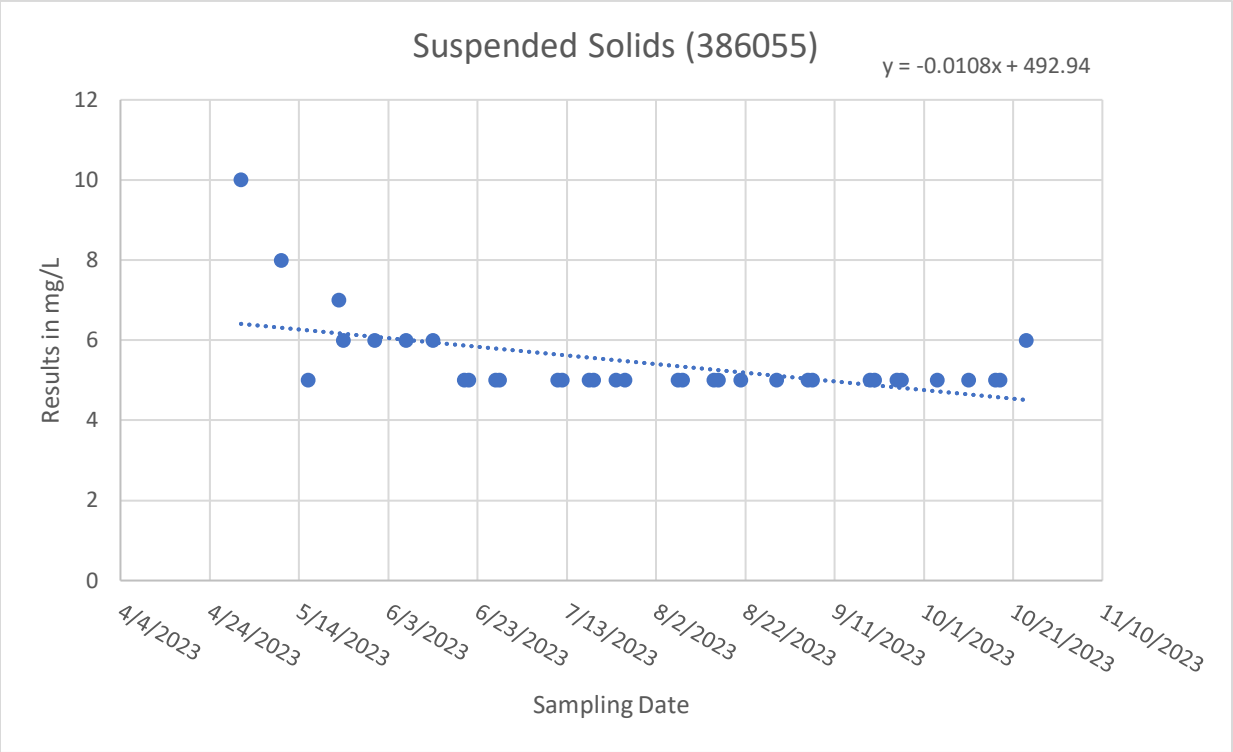
Note: Analyses use all of the data from the 2023 sampling season. 2014 analysis and historical medians based on the 2014 Blacktail Dam assessment, with supplemental analyses of existing data.

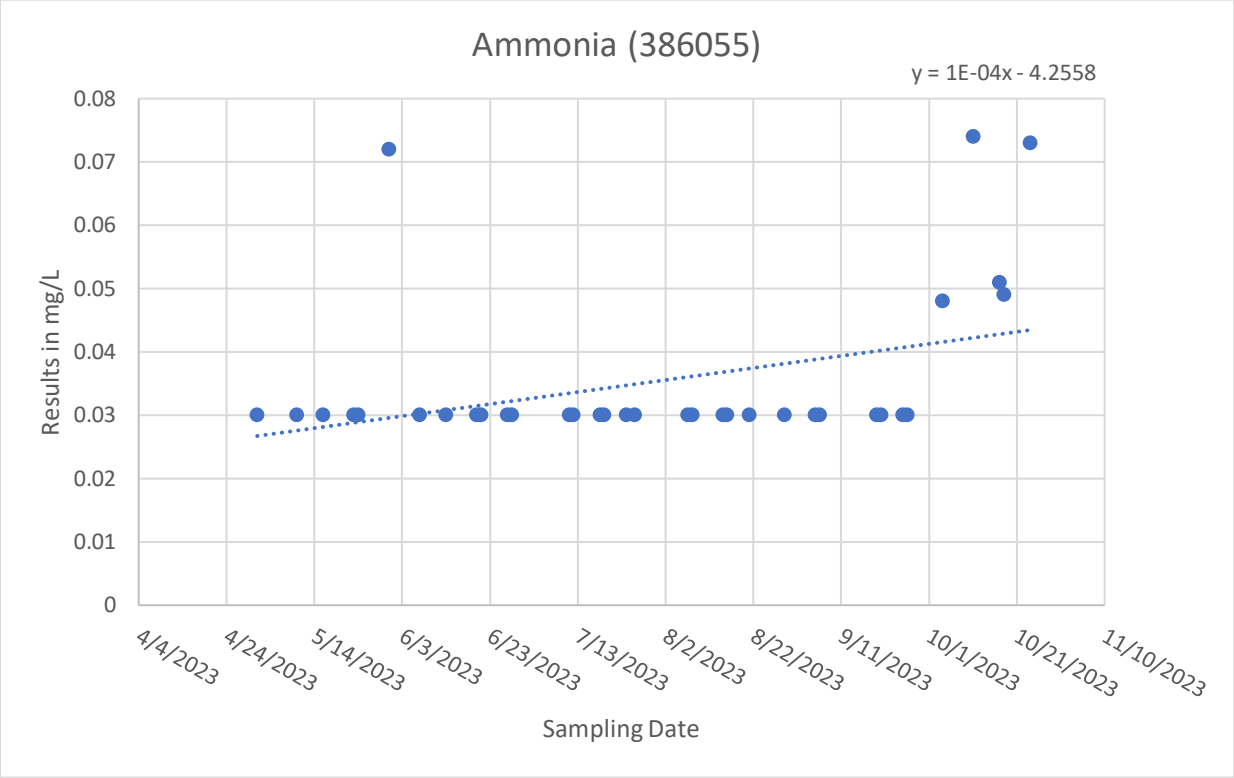
Blacktail Dam			
Measure	2023 Analysis	2014 Analysis	Historical Median
Alkalinity	226 mg L^{-1}	244 mg L^{-1}	270.5 mg L^{-1}
Ammonia	0.03 mg L^{-1}	0.03 mg L^{-1}	0.03 mg L^{-1}
Bicarbonate (HCO^{-}_{3})	253 mg L^{-1}	283 mg L^{-1}	301 mg L^{-1}
Calcium (Ca2+)	114 mg L^{-1}	115 mg L^{-1}	86.3 mg L^{-1}
Carbonate ($CO2^{-}_{3}$)	12 mg L^{-1}	6 mg L^{-1}	13.5 mg L^{-1}
Chlorophyll A	7.06 µg L^{-1}	16.8 µg L^{-1}	7.70 µg L^{-1}
Chlorophyll B	Non-detect	Non-detect	Non-detect
Conductivity	1970 µS cm^{-1}	1840 µS cm^{-1}	1770 µS cm^{-1}
Dissolved Solids	1430 mg L^{-1}	1390 mg L^{-1}	1285 mg L^{-1}
Magnesium (Mg^{2+})	133 mg L^{-1}	119 mg L^{-1}	97 mg L^{-1}
Nitrate + Nitrite	0.03 mg L^{-1}	Non-detect	0.02 mg L^{-1}
Nitrogen	1.08 mg L^{-1}	0.94 mg L^{-1}	0.05 mg L^{-1}
Sodium (Na+)	174 mg L^{-1}	150 mg L^{-1}	178.5 mg L^{-1}
Sulfate ($SO2^{-}_{4}$)	849 mg L^{-1}	826 mg L^{-1}	720 mg L^{-1}

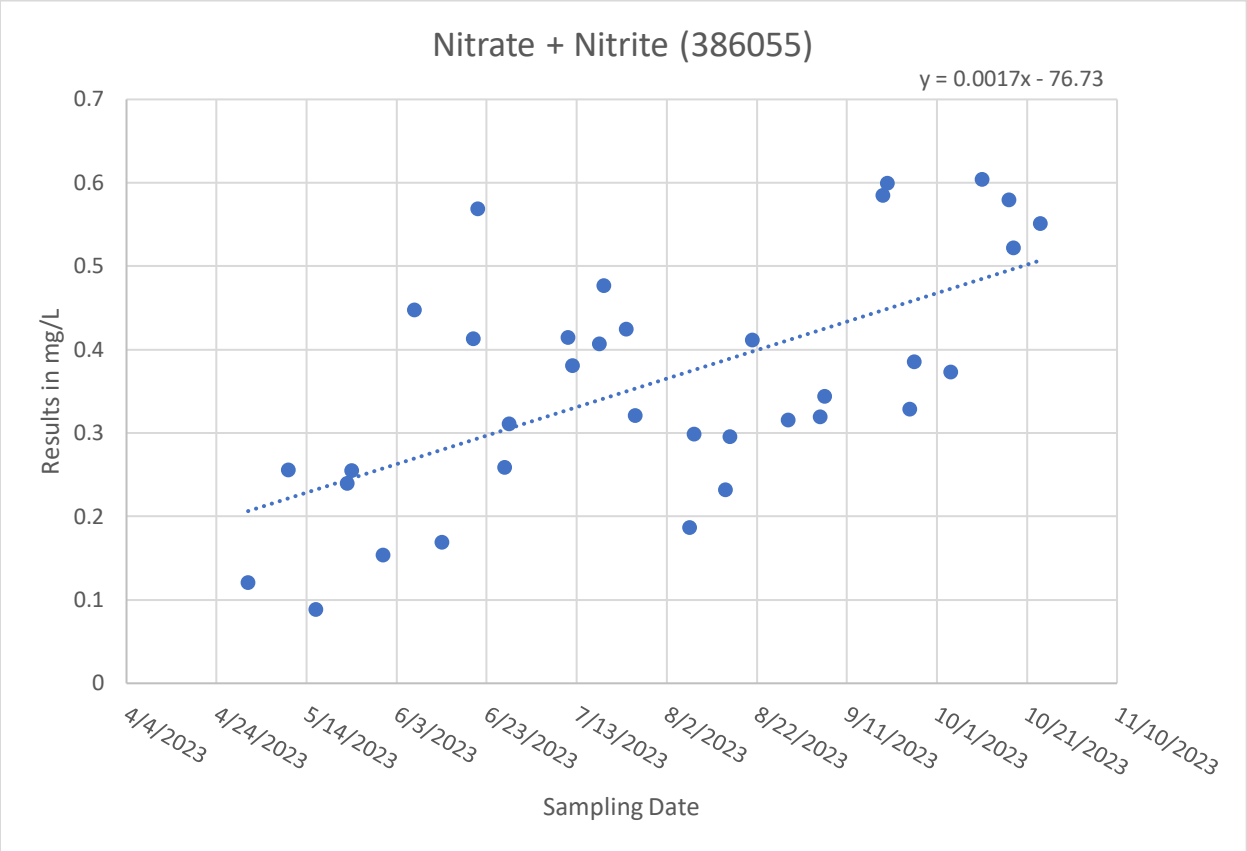
Little Muddy – Alamo (386055)

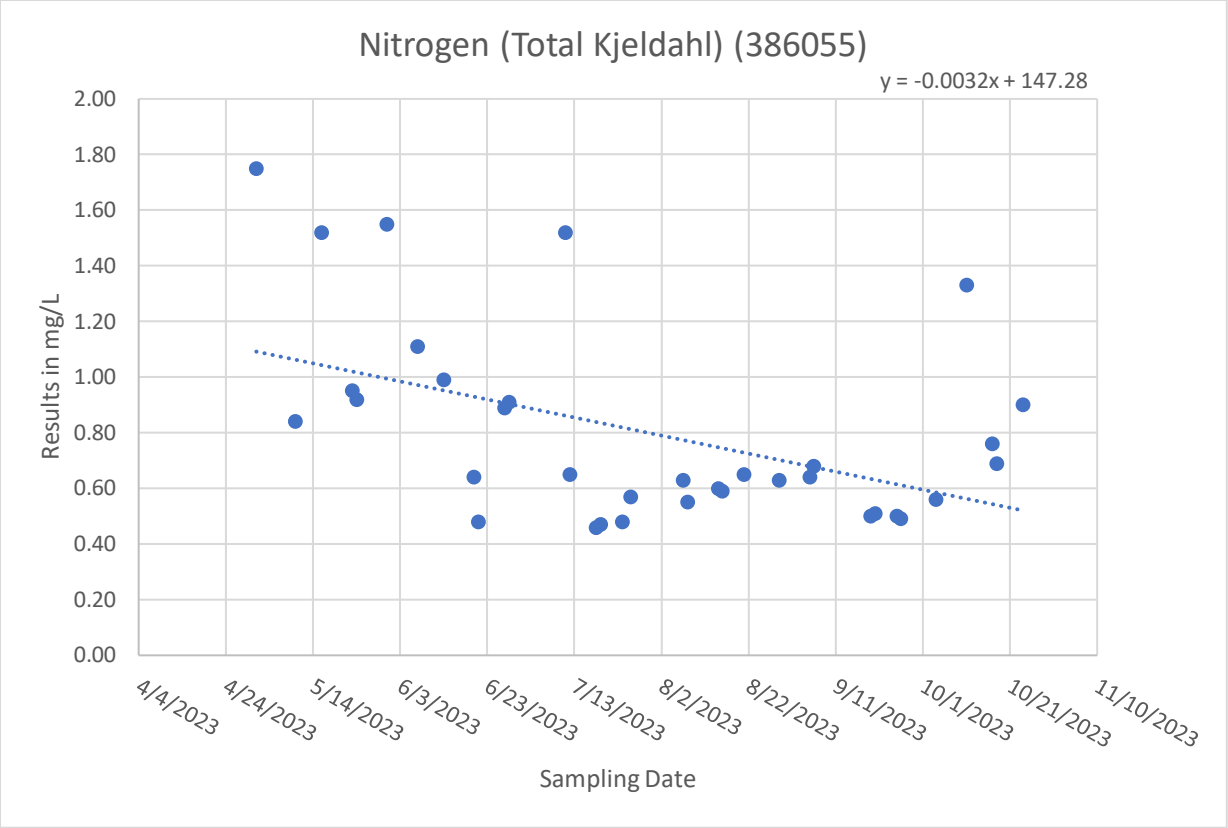


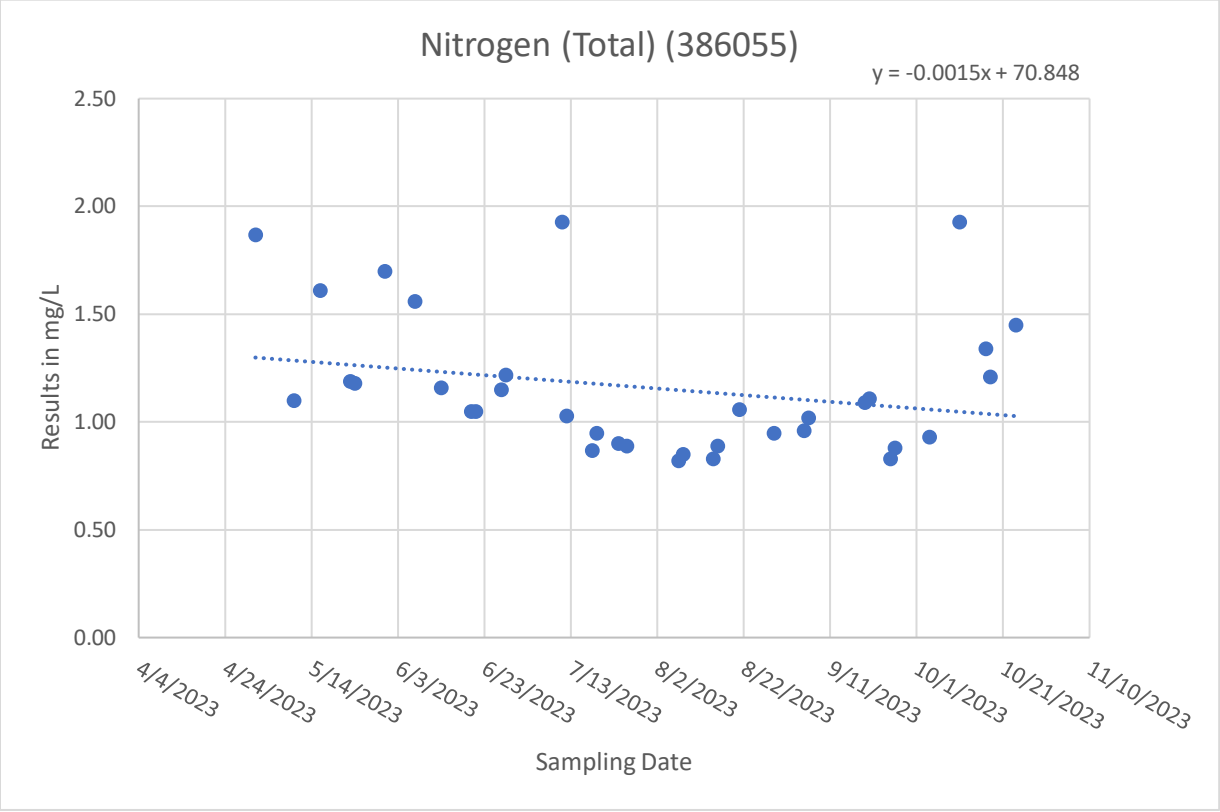
E.coli geometric mean: 64.438

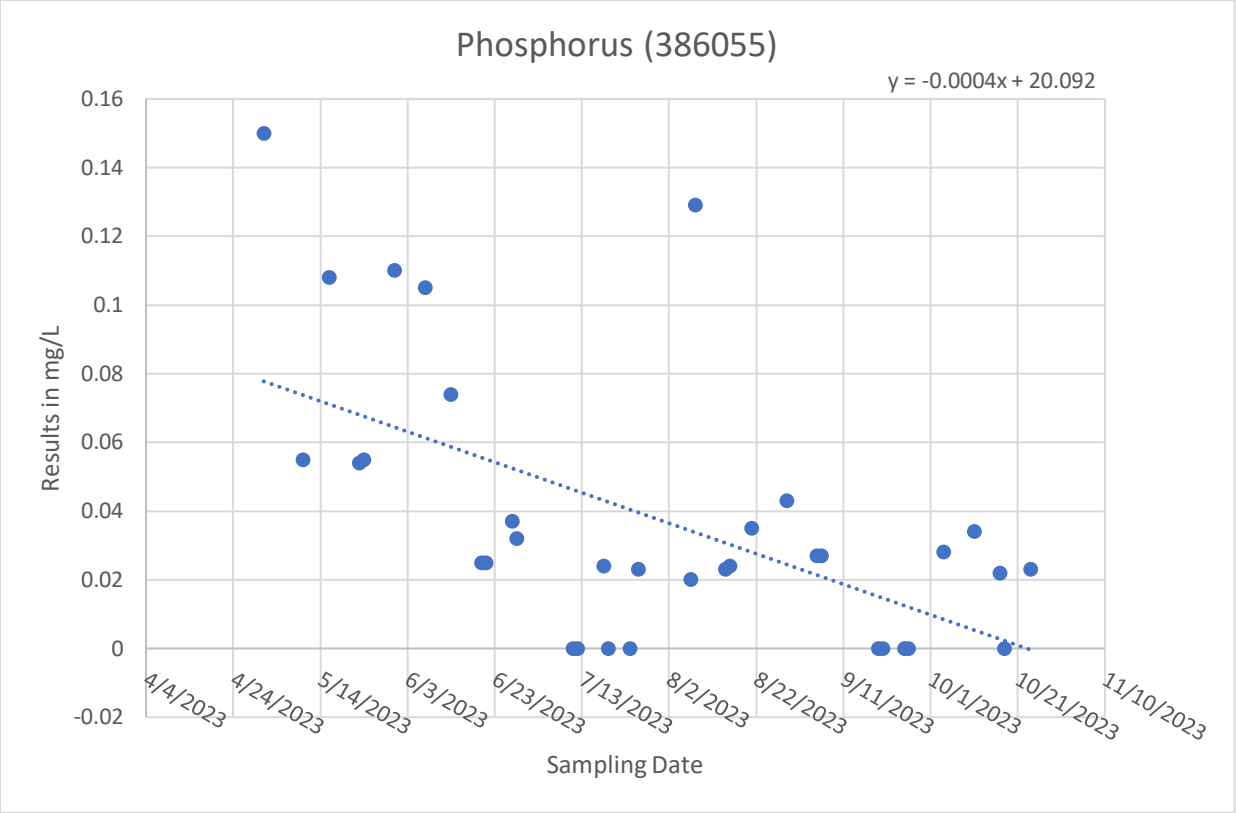



Ammonia (386055)
y = 1E-04x - 4.2558
Results in mg/L
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
4/4/2023
4/24/2023
5/14/2023
6/3/2023
6/23/2023
7/13/2023
8/2/2023
8/22/2023
9/11/2023
10/1/2023
10/21/2023
11/10/2023
Sampling Date

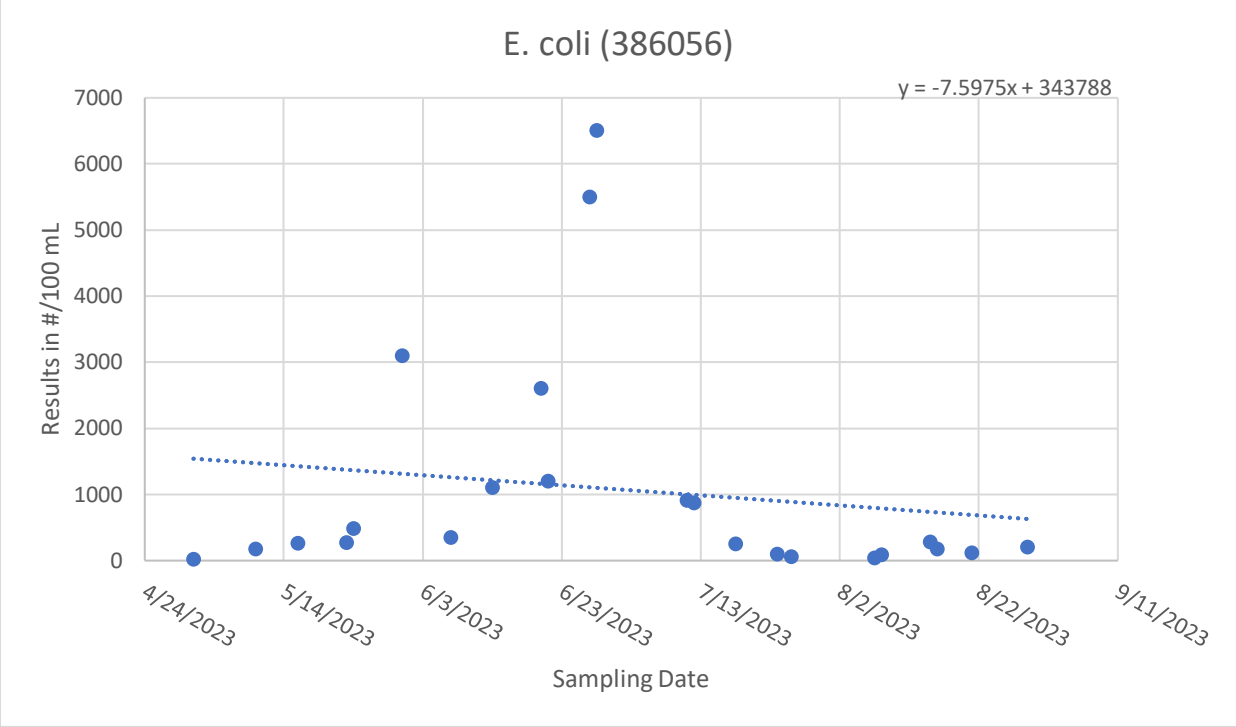

Nitrate + Nitrite (386055)
y = 0.0017x - 76.73
Results in mg/L
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
4/4/2023
4/24/2023
5/14/2023
6/3/2023
6/23/2023
7/13/2023
8/2/2023
8/22/2023
9/11/2023
10/1/2023
10/21/2023
11/10/2023
Sampling Date


Nitrogen (Total Kjeldahl) (386055)
y = -0.0032x + 147.28
Results in mg/L
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
4/4/2023
4/24/2023
5/14/2023
6/3/2023
6/23/2023
7/13/2023
8/2/2023
8/22/2023
9/11/2023
10/1/2023
10/21/2023
11/10/2023
Sampling Date

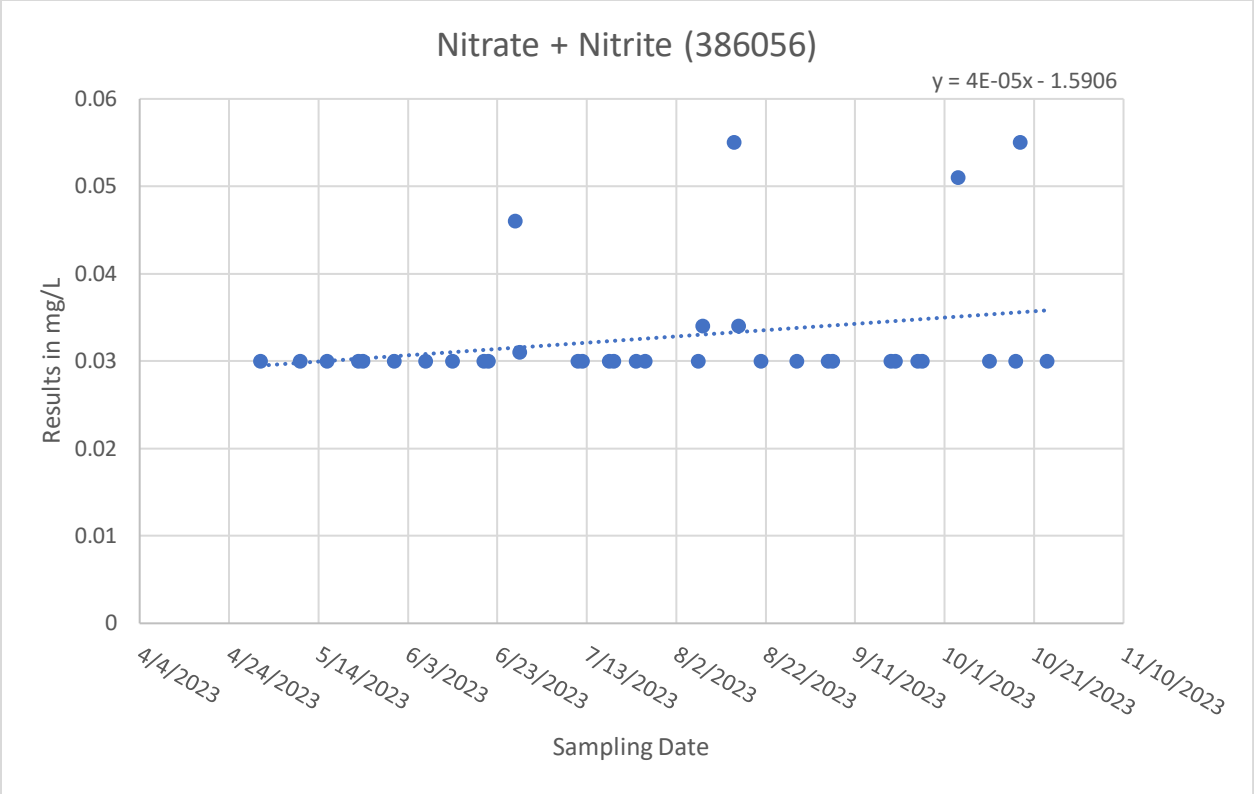

Nitrogen (Total) (386055)
y = -0.0015x + 70.848
Results in mg/L
2.50
2.00
1.50
1.00
0.50
0.00
4/4/2023
4/24/2023
5/14/2023
6/3/2023
6/23/2023
7/13/2023
8/2/2023
8/22/2023
9/11/2023
10/1/2023
10/21/2023
11/10/2023
Sampling Date

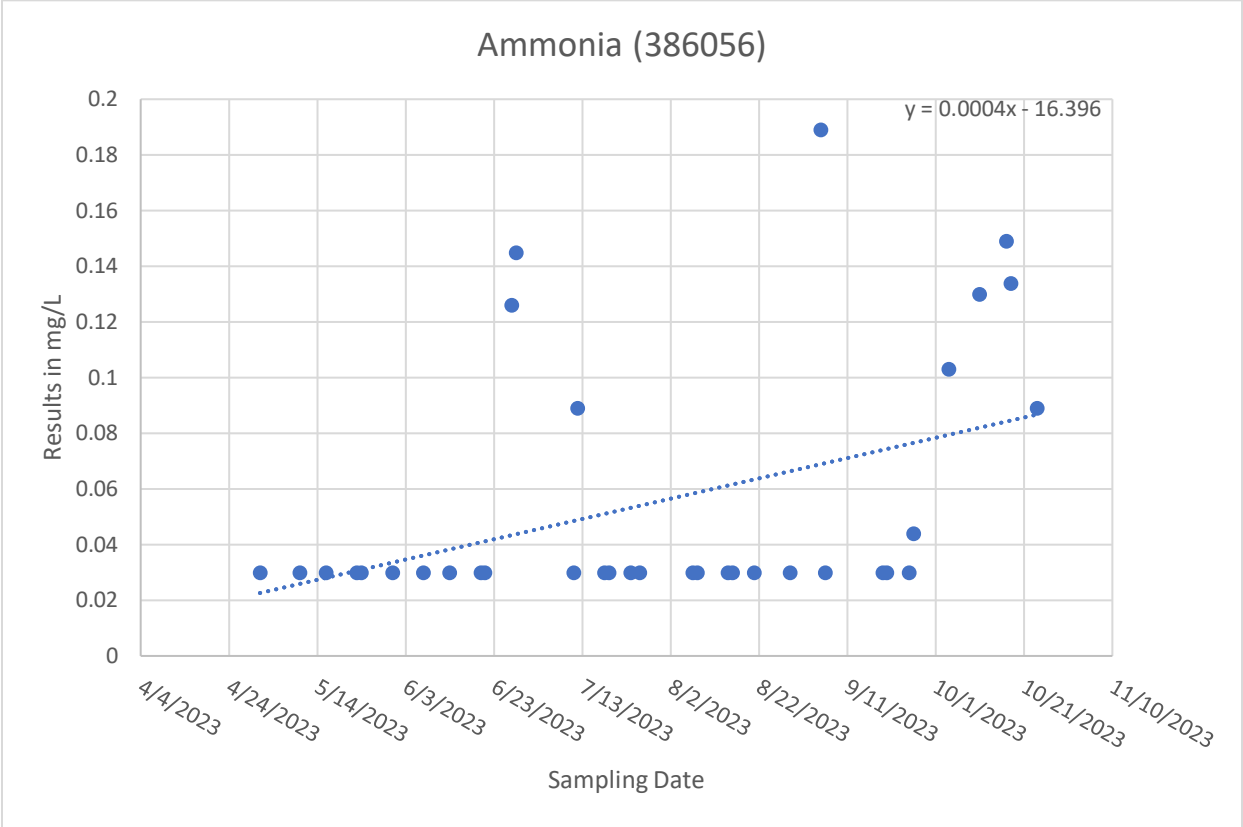


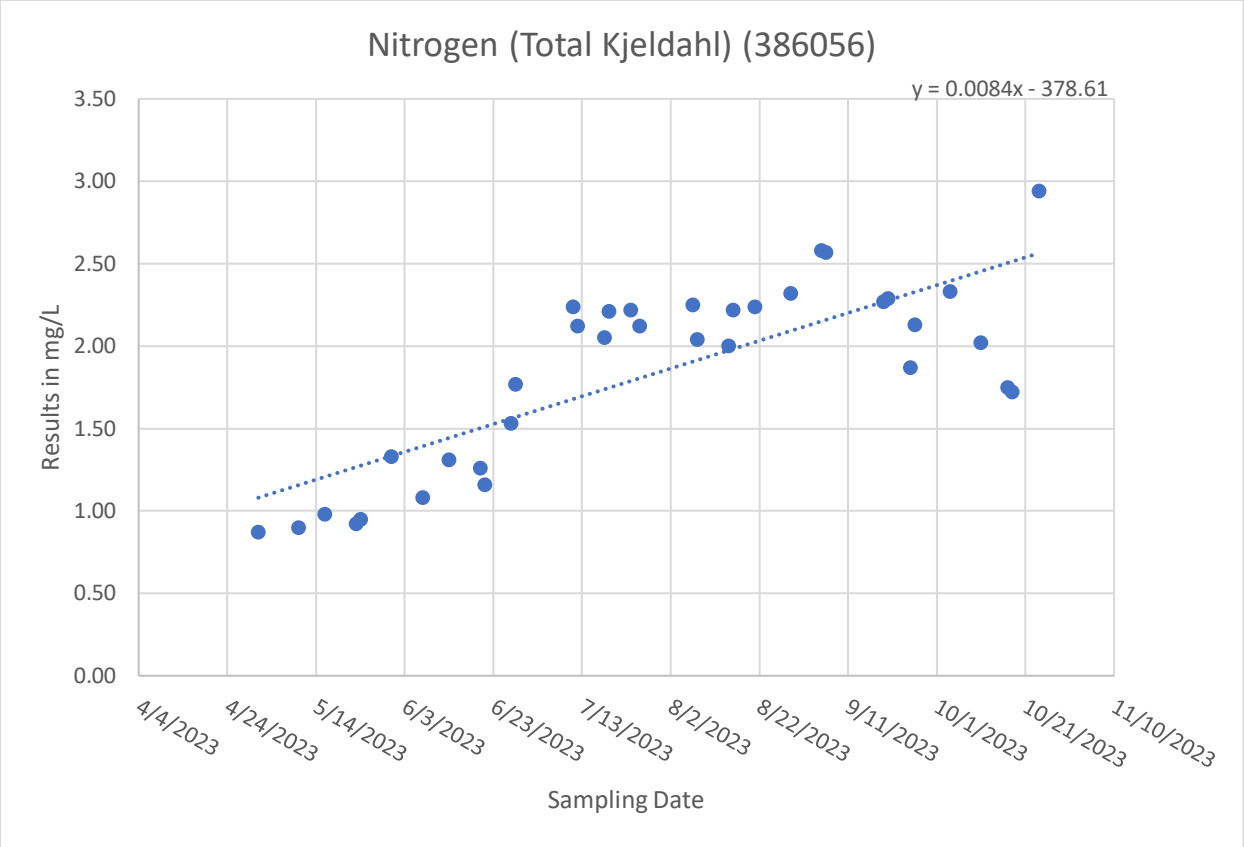
Blacktail Creek (386056)

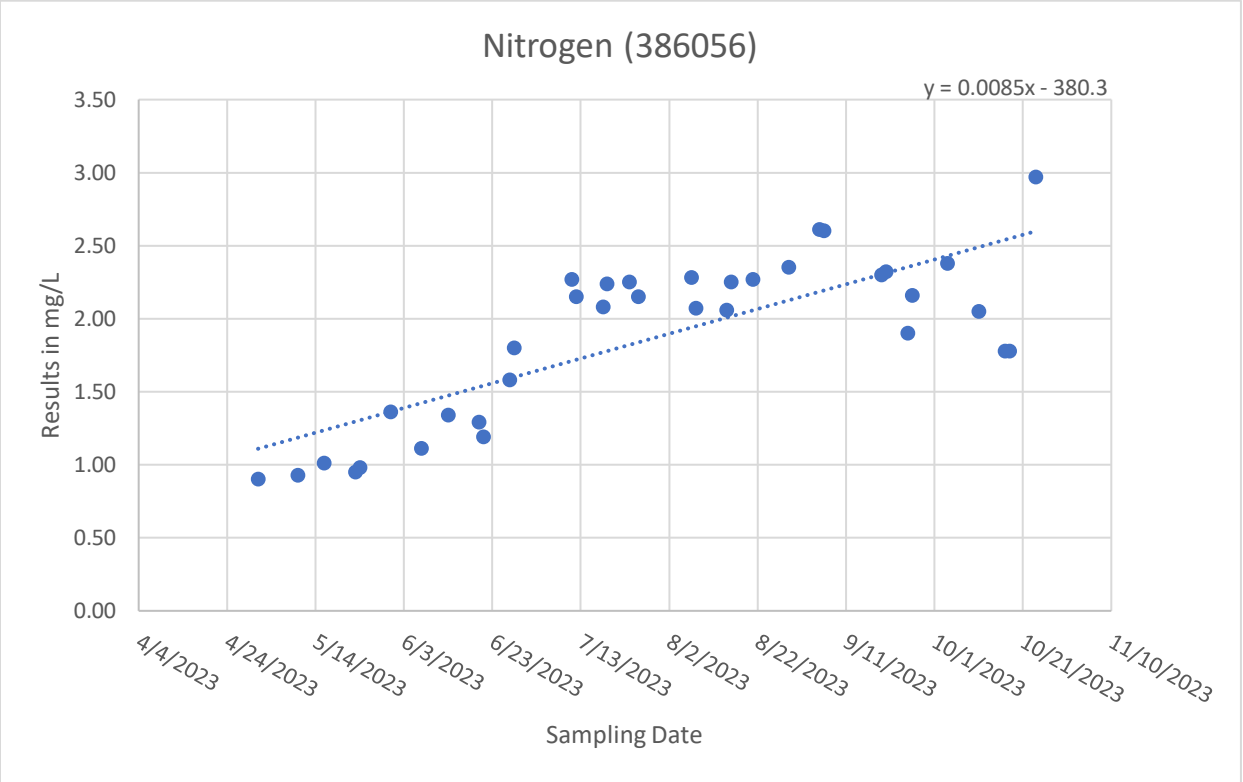


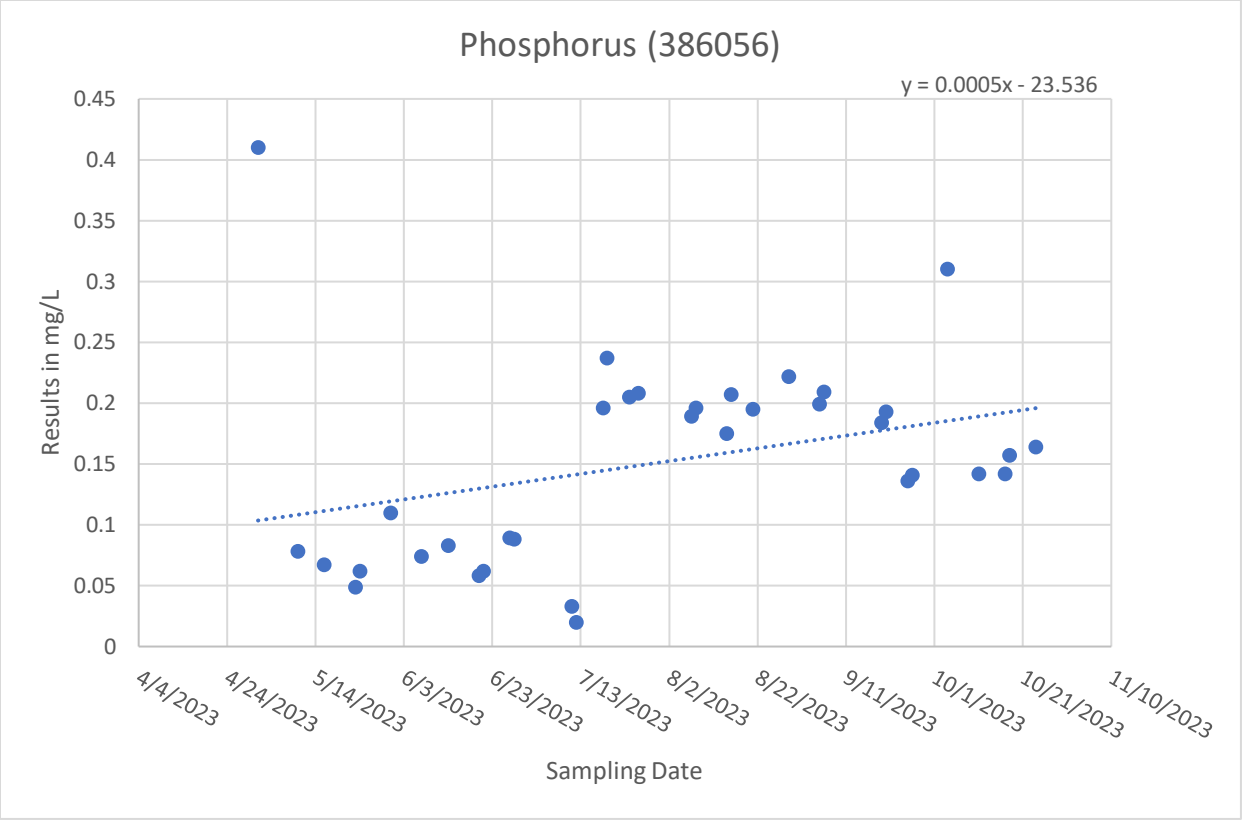
E. coli geometric mean: 358.220


Nitrate + Nitrite (386056)
y = 4E-05x - 1.5906
Results in mg/L
0.06
0.05
0.04
0.03
0.02
0.01
0
4/4/2023
4/24/2023
5/14/2023
6/3/2023
6/23/2023
7/13/2023
8/2/2023
8/22/2023
9/11/2023
10/1/2023
10/21/2023
11/10/2023
Sampling Date

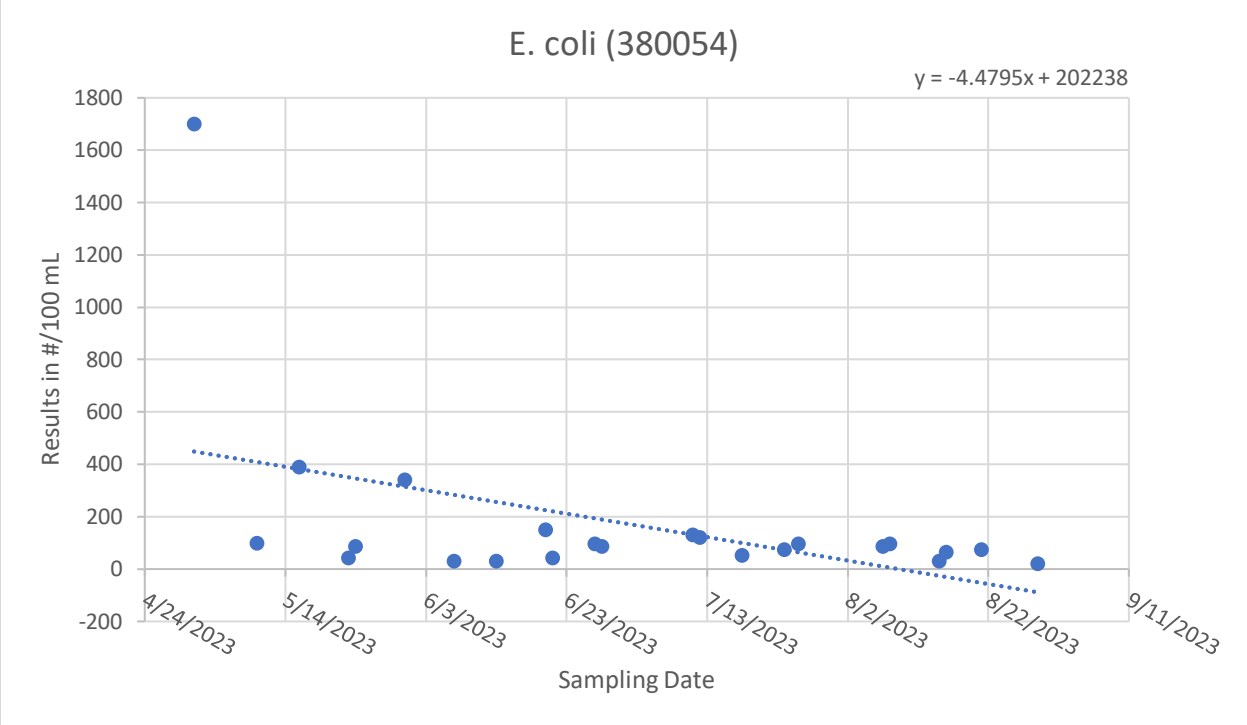

Ammonia (386056)
y = 0.0004x - 16.396
Results in mg/L
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
4/4/2023
4/24/2023
5/14/2023
6/3/2023
6/23/2023
7/13/2023
8/2/2023
8/22/2023
9/11/2023
10/1/2023
10/21/2023
11/10/2023
Sampling Date


Nitrogen (Total Kjeldahl) (386056)
y = 0.0084x - 378.61
Results in mg/L
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
4/4/2023
4/24/2023
5/14/2023
6/3/2023
6/23/2023
7/13/2023
8/2/2023
8/22/2023
9/11/2023
10/1/2023
10/21/2023
11/10/2023
Sampling Date

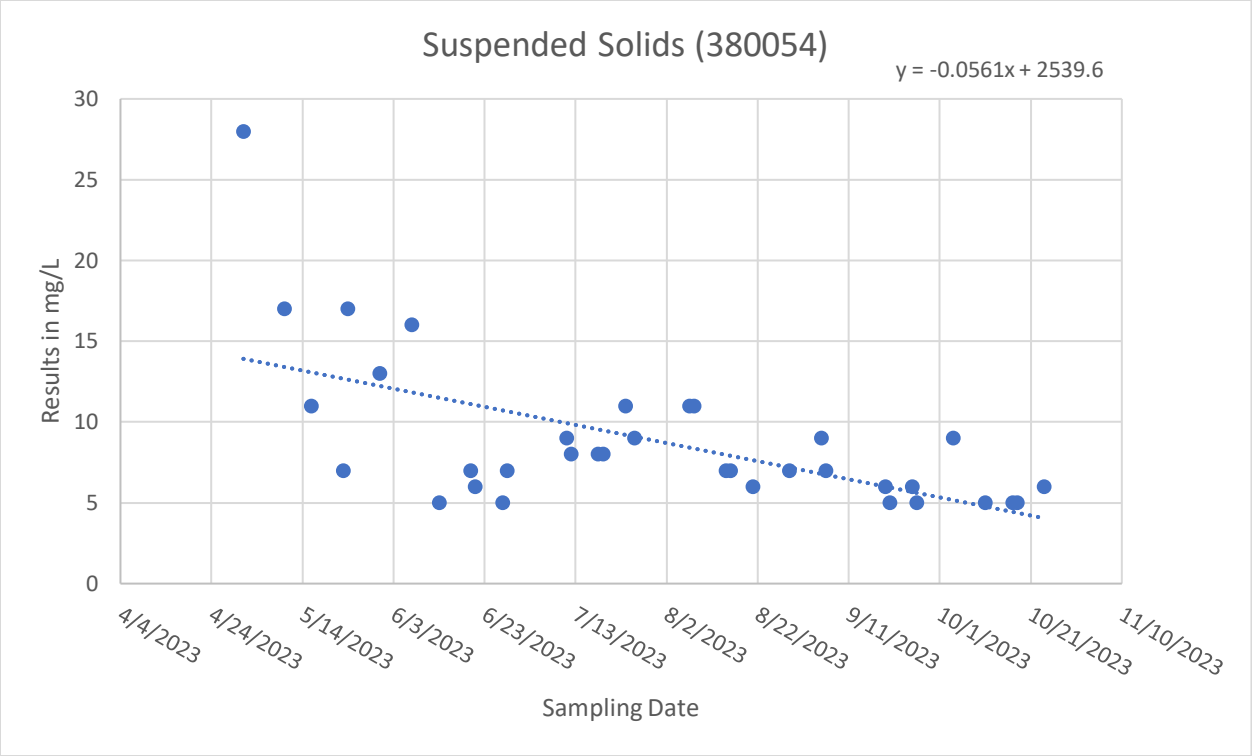

Nitrogen (386056)
y = 0.0085x - 380.3
Results in mg/L
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
4/4/2023
4/24/2023
5/14/2023
6/3/2023
6/23/2023
7/13/2023
8/2/2023
8/22/2023
9/11/2023
10/1/2023
10/21/2023
11/10/2023
Sampling Date

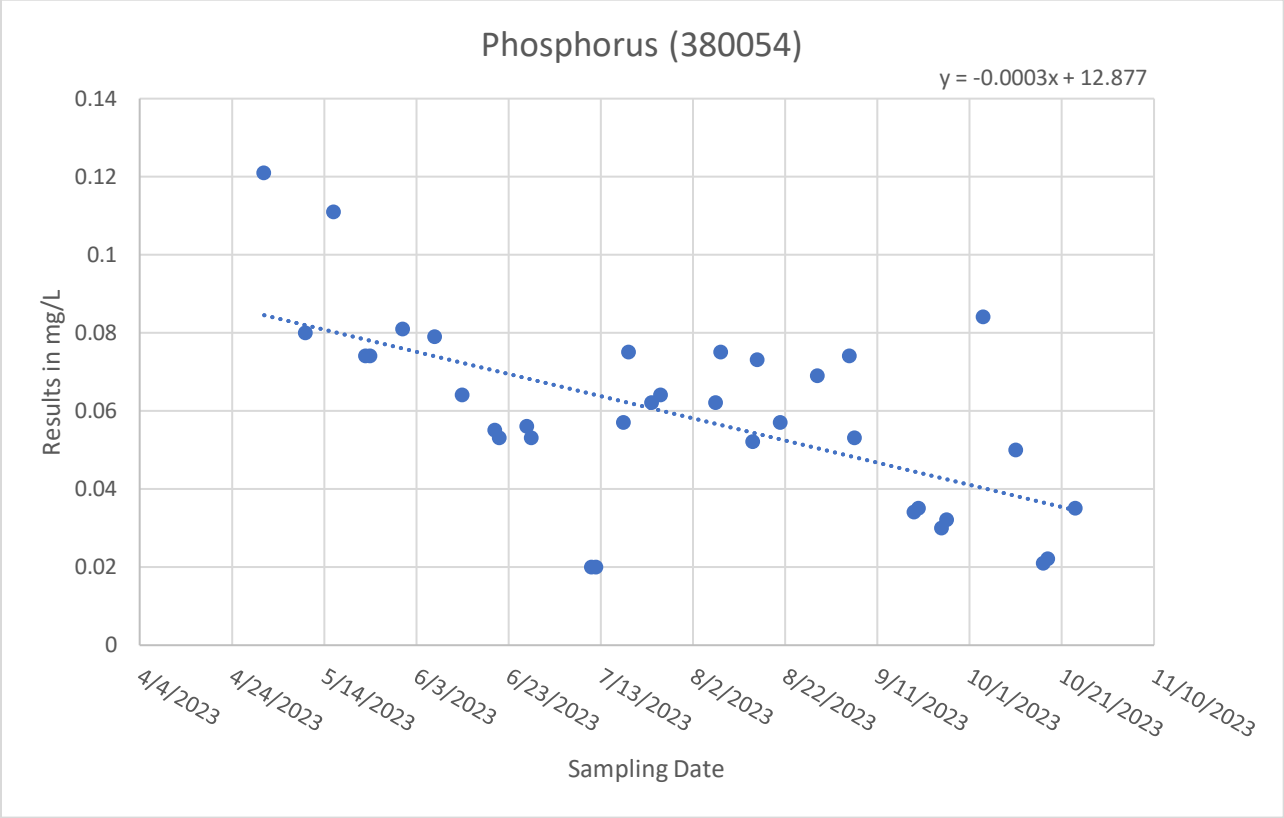


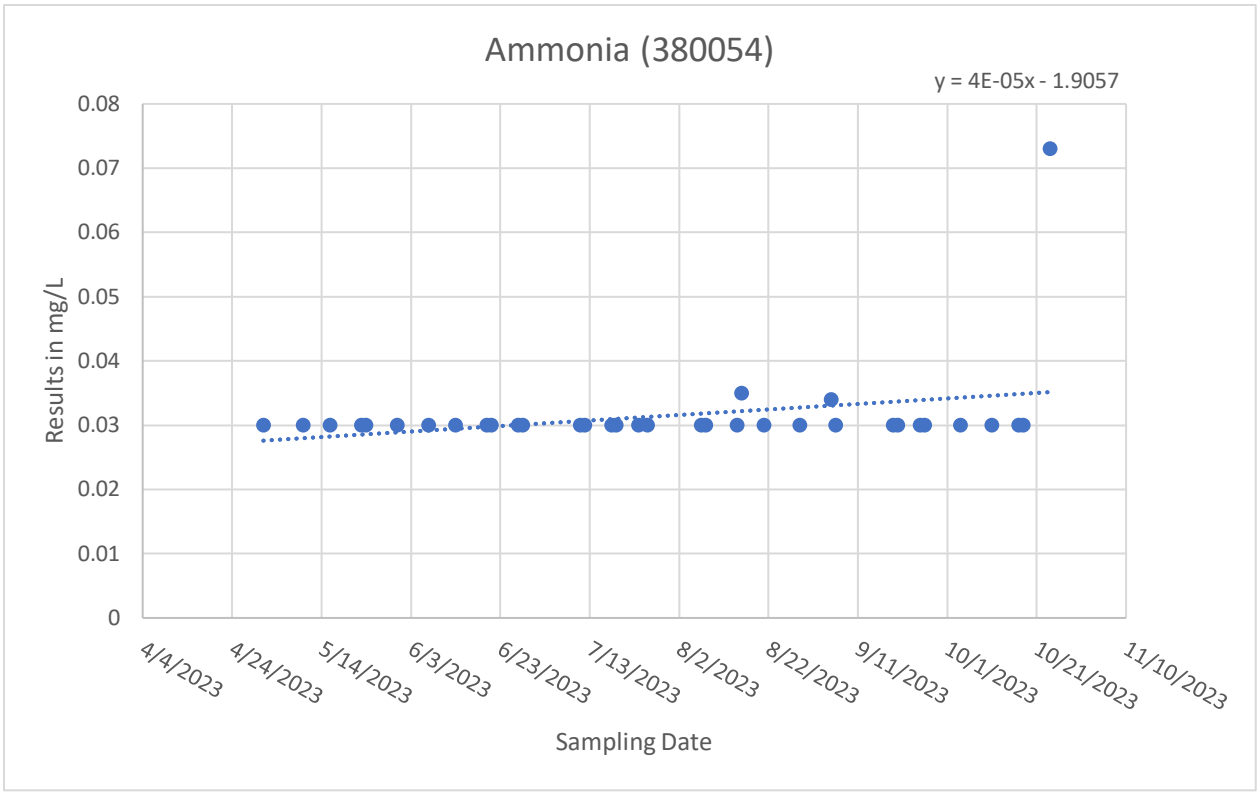
Little Muddy – Williston (380054)

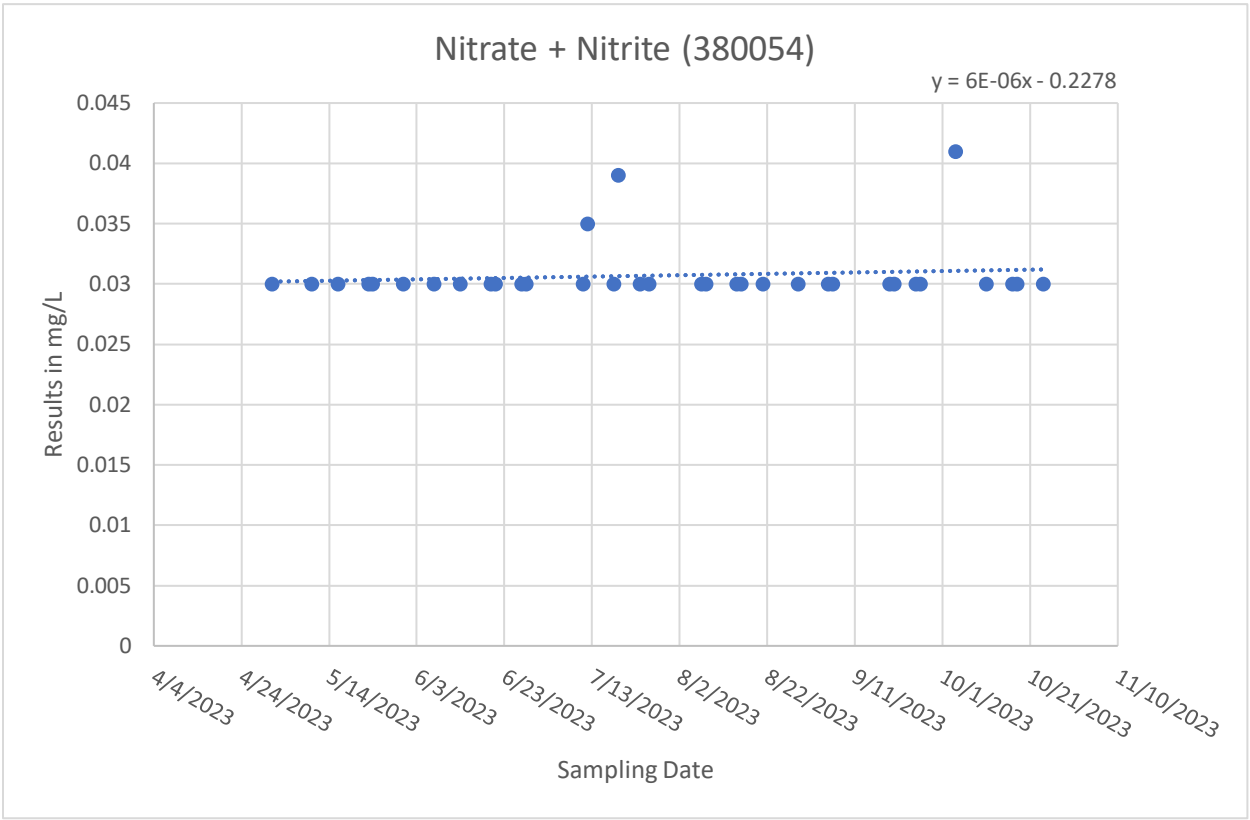


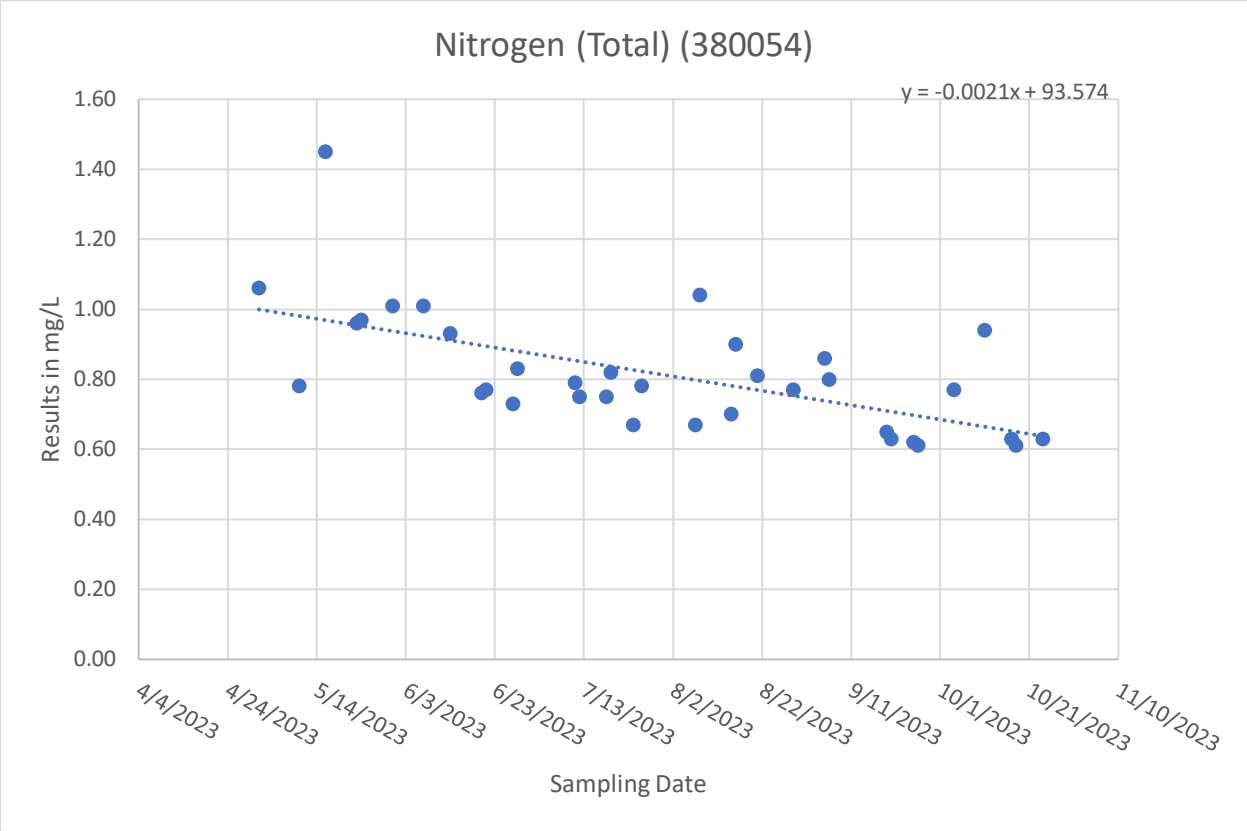
E. coli geometric mean: 87.759

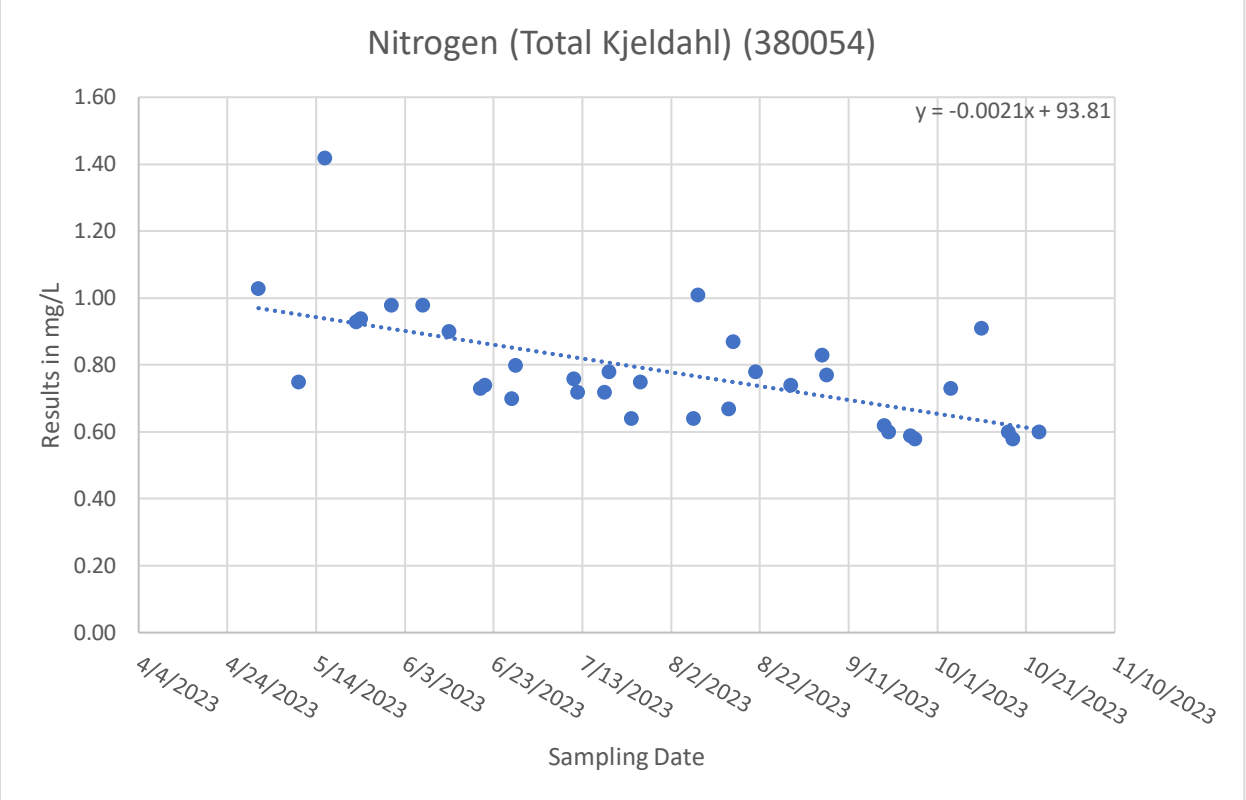

Suspended Solids (380054)
y = -0.0561x + 2539.6
Results in mg/L
30
25
20
15
10
5
0
4/4/2023
4/24/2023
5/14/2023
6/3/2023
6/23/2023
7/13/2023
8/2/2023
8/22/2023
9/11/2023
10/1/2023
10/21/2023
11/10/2023
Sampling Date


Phosphorus (380054)
y = -0.0003x + 12.877
Results in mg/L
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
4/4/2023
4/24/2023
5/14/2023
6/3/2023
6/23/2023
7/13/2023
8/2/2023
8/22/2023
9/11/2023
10/1/2023
10/21/2023
11/10/2023
Sampling Date


Ammonia (380054)
y = 4E-05x - 1.9057
Results in mg/L
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
4/4/2023
4/24/2023
5/14/2023
6/3/2023
6/23/2023
7/13/2023
8/2/2023
8/22/2023
9/11/2023
10/1/2023
10/21/2023
11/10/2023
Sampling Date


Nitrate + Nitrite (380054)
y = 6E-06x - 0.2278
Results in mg/L
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
4/4/2023
4/24/2023
5/14/2023
6/3/2023
6/23/2023
7/13/2023
8/2/2023
8/22/2023
9/11/2023
10/1/2023
10/21/2023
11/10/2023
Sampling Date


Nitrogen (Total) (380054)
y = -0.0021x + 93.574
Results in mg/L
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
4/4/2023
4/24/2023
5/14/2023
6/3/2023
6/23/2023
7/13/2023
8/2/2023
8/22/2023
9/11/2023
10/1/2023
10/21/2023
11/10/2023
Sampling Date


Nitrogen (Total Kjeldahl) (380054)
y = -0.0021x + 93.81
Results in mg/L
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
4/4/2023
4/24/2023
5/14/2023
6/3/2023
6/23/2023
7/13/2023
8/2/2023
8/22/2023
9/11/2023
10/1/2023
10/21/2023
11/10/2023
Sampling Date

Appendix B: Images and Maps

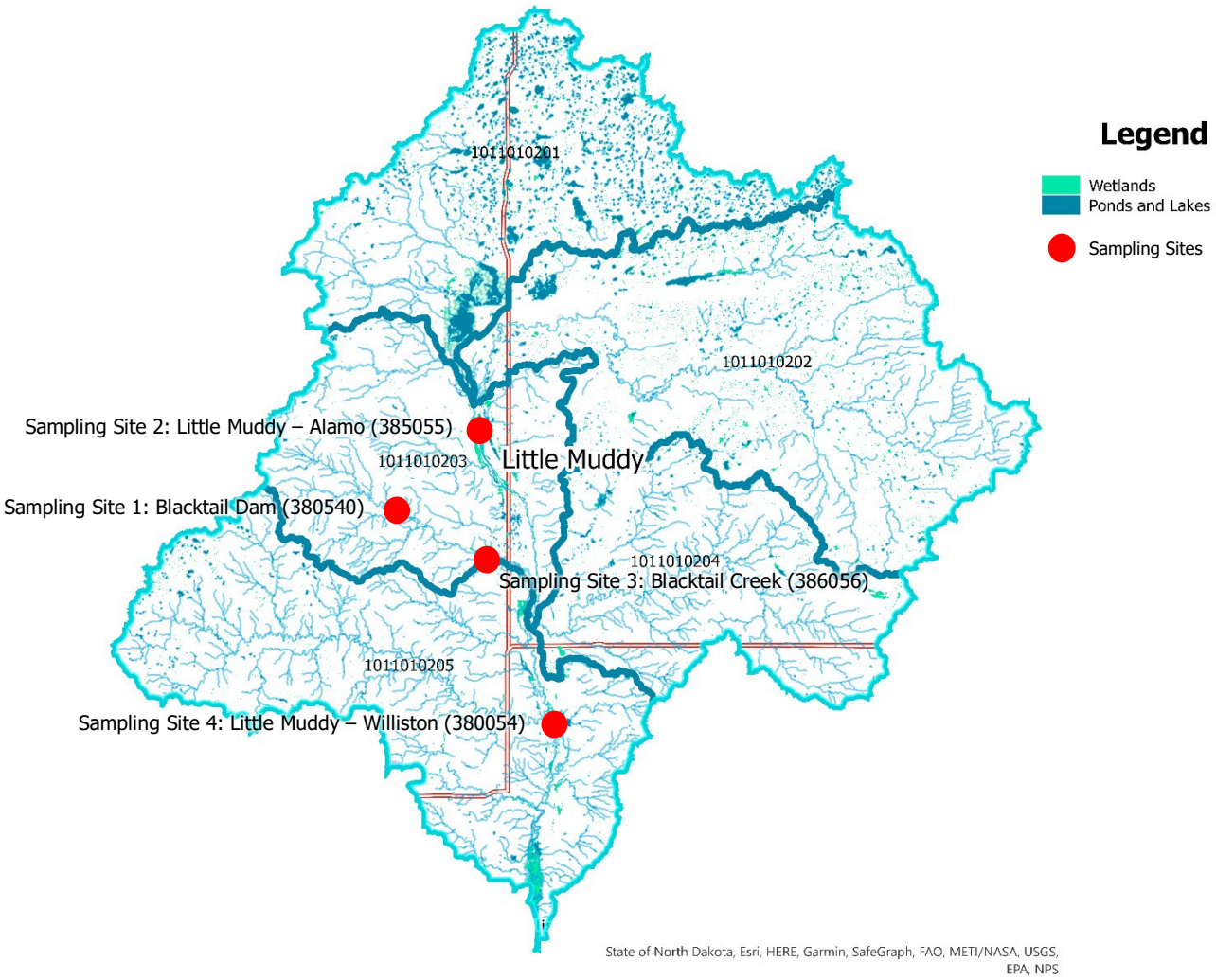


Figure 1. Map of streams, rivers, wetlands, bodies of water, and sampling sites.

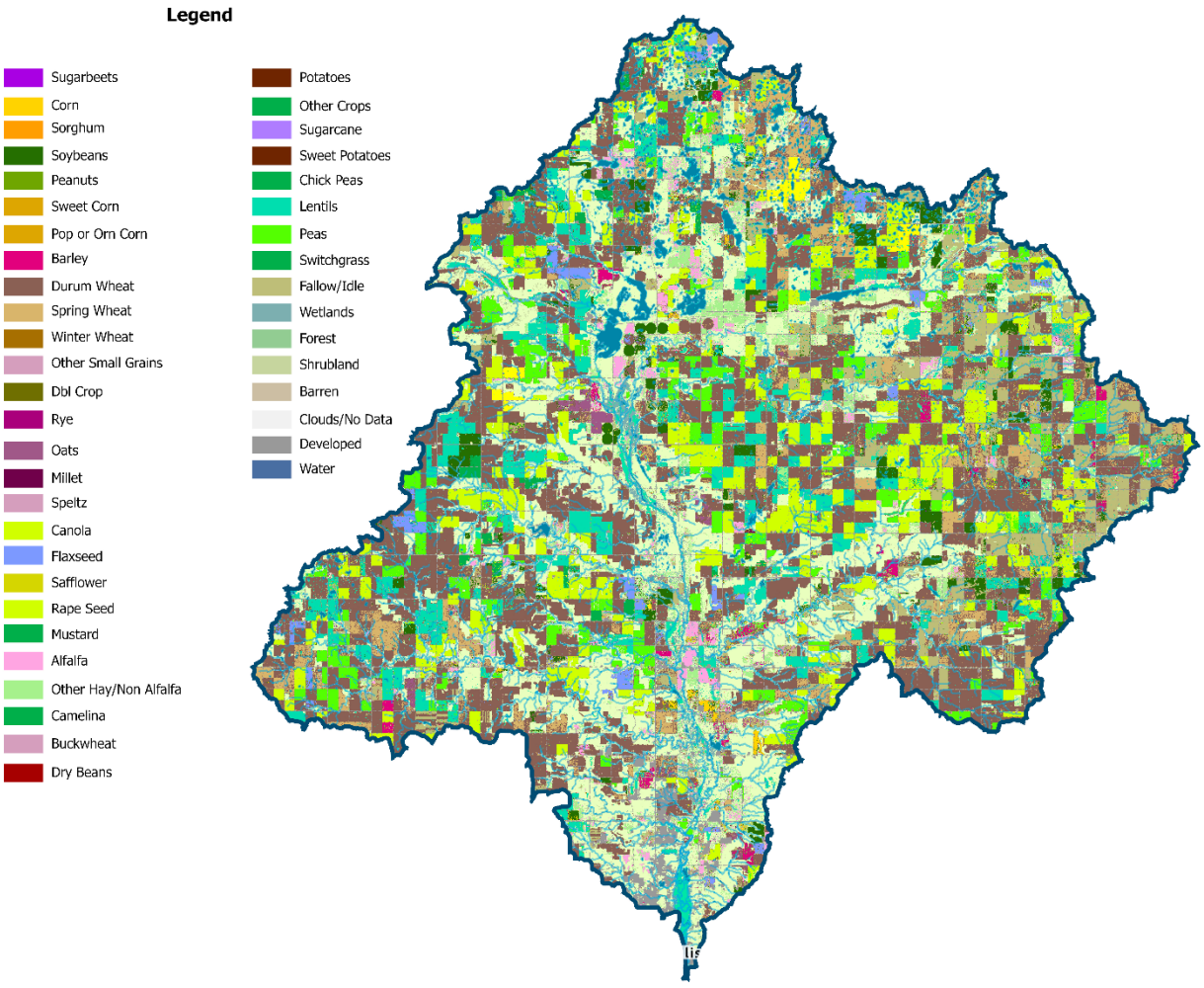


Figure 2. Map of land use types in the watershed.

Sampling site #1: Blacktail Dam

Sampling site #2: Little Muddy – Alamo

Sampling Site #3: Blacktail Creek

Sampling site #4: Little Muddy - Williston