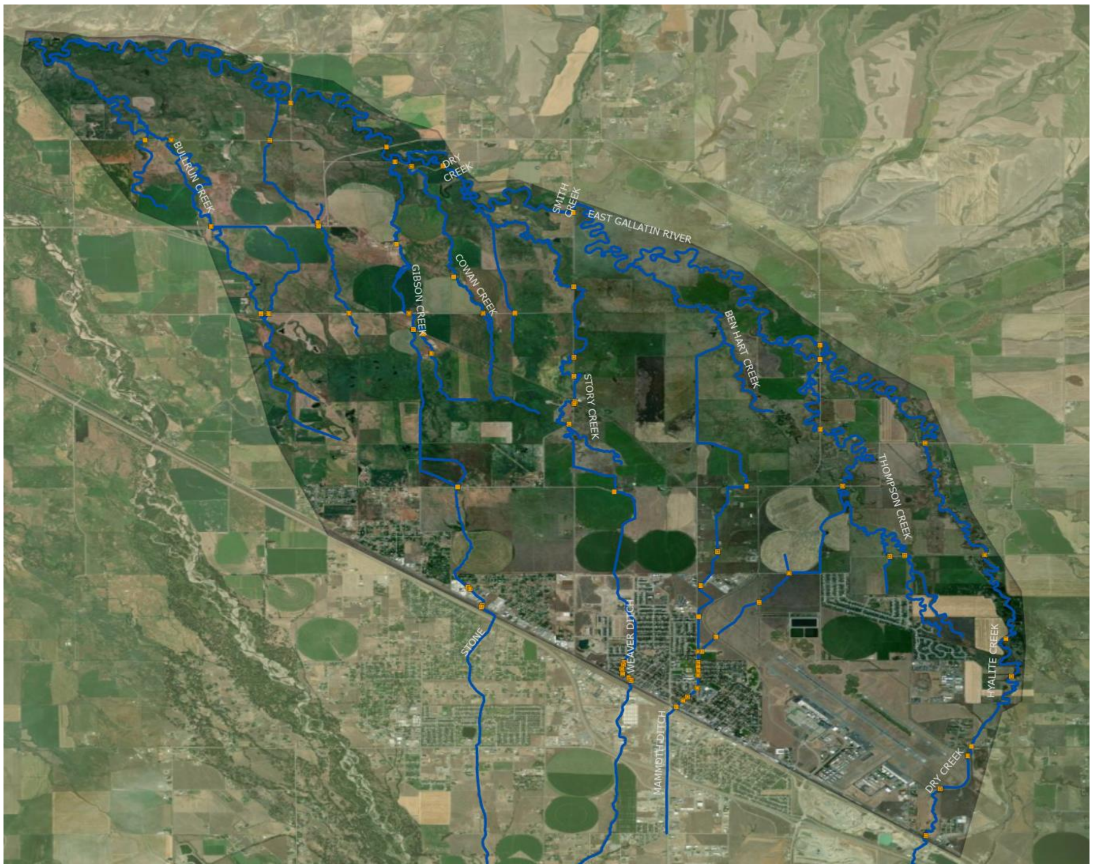
Belgrade Spring Creek
Synoptic Winter Sampling 2021



March 5th , 2025

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1.0 EXECUTIVE SUMMARY

The East Gallatin River is listed by the Montana Department of Environmental Quality (MDEQ) as impaired for Total Nitrogen (TN). A series of seven spring creeks drain into the East Gallatin in the impaired reach, and one of these creeks (Thompson) is also listed as impaired for TN. The seven spring creeks were monitored in December 2021 during winter baseflow conditions when all streamflow was derived from groundwater and when nutrient uptake by aquatic plants and algae would be low. Based on sampling at the mouths of the seven spring creeks, Ben Hart Creek had the highest concentration of Total Phosphorus (TP; 0.09 mg/L) and was tied with Cowen Creek for the highest concentration of TN (2.2 mg/L). Discharge at the Ben Hart Creek mouth (32.5 cfs) was more than twice that of the second highest discharge, measured at Thompson Creek (13.2 cfs). Ben Hart Creek contributed the largest loads of both TN (175 kg/day) and TP (7 kg/day) to the East Gallatin. The next largest nutrient loads came from Thompson and Story creeks, which had similar nitrogen and phosphorus loads to one another, each approximately one third that from Ben Hart. The TN load of 175 kg/day entering the East Gallatin River from Ben Hart was only slightly lower than that measured in the East Gallatin at the head of the study reach (TN load = 213 kg/day). The Total Phosphorus load of 7 kg/day entering from Ben Hart was greater than that in the East Gallatin at the head of the study reach (6 kg/day). A cursory evaluation of land use near the spring creeks indicated TN and TP concentrations were higher in the spring creeks with more residential development nearby, however groundwater catchment areas for the spring creeks are not well known and include areas far to the south beyond the study area for this project. Detailed source attribution is not possible based on this work, but evidence points more toward residential development than agriculture as the likely nutrient source.

2.0 BACKGROUND

The 2021-22 Belgrade Spring Creek Nutrient Project was a joint project by Montana State University Extension Water Quality (MSUEWQ) and the Gallatin Local Water Quality District (GLWQD). The project assessed nutrient concentrations in seven spring creek tributaries to the East Gallatin River near Belgrade, Montana. The spring creeks include Thompson Creek, Ben Hart Creek, Story Creek, Cowan Creek, Gibson Creek, Spaulding Brook, and Bull Run Creek. The project evaluated nitrogen and phosphorus concentrations and loads for the spring creeks, to assess the relative nutrient contributions to the East Gallatin River. This work was initiated to allow visualization of nutrient loads entering the East Gallatin and to provide a framework for potential follow up work to better understand controls on nutrient and total aquatic vegetation growth within the spring creeks. This work centered on a synoptic sampling event conducted on December 17th 2021, after the end of the aquatic vegetation growing season to minimize potential influence of plant uptake on nutrient concentrations. The timing of the sampling event was intended to identify the contribution of nutrients from groundwater, due to lack of irrigation and minimal surface runoff. MSU students were engaged in the planning and execution of this project to facilitate a learning opportunity and to lay a foundation for follow up student projects.

The study area focuses on seven spring creeks near Belgrade, Montana. The area is delineated as the landscape draining into the East Gallatin River from the south, bounded on the west by the West Gallatin River, on the East by Hyalite Creek, and on the south by I-90. The study area is 35 square miles (90 km^2) with land use classified as approximately 75% agriculture (68% hay/pasture, 7% cropland), 13% developed, 11% other vegetation. The primary irrigation ditches entering the study area under I-90 were confirmed to be dry on the day of sampling, so no known surface water was entering the study area on the day of sampling. Most of the groundwater feeding these spring creeks almost certainly enters the study area in groundwater flowing under I-90 and is derived from the Gallatin Mountains and seepage from irrigation conveyances traversing the valley to the southeast of the study area. Constraining the study area to north of I-90 provided focus on the area immediately surrounding the spring creeks, where land use may have a more direct effect on water quality than more distal land uses up gradient.

The goals of this project were:

1. To measure nutrient loads (concentrations and discharge) on seven Belgrade area spring creeks near the confluence with the East Gallatin River to determine which creeks are contributing the largest nutrient loads to the East Gallatin.
2. To assess the size of the nutrient load to the study area spring creeks that is not entering from groundwater by quantifying nutrient loads in the primary ditches flowing into the spring creeks. (D*itches were dry during scouting in November and confirmed to be dry on the day of sampling, so the nutrient load entering from ditches during sampling was zero.)*

3.0 METHODS

A synoptic water sampling event was conducted on December 17th, 2021 covering 10 sites on seven spring creeks and the East Gallatin River. Three additional ditch sites along the southern edge of the study area near I-90 were also observed to verify that these sites were dry and no surface water flow was entering the study area. Four teams of two individuals conducted the sampling and the sites monitored by each team are depicted in Figure 2. The only deviation from this map was that Team 2 (Sigler and Conti) made the observations of no-flow conditions at the three ditch sites (STONE-SUN, WEAV-FRNT, MAM-FRNT).

Flow was measured at each site using the cross-section and velocity method, field parameters were measured with multi-parameter meters, and samples were collected for analysis at Energy Laboratories in Billings and at the Environmental Analytical Lab on the MSU Campus.

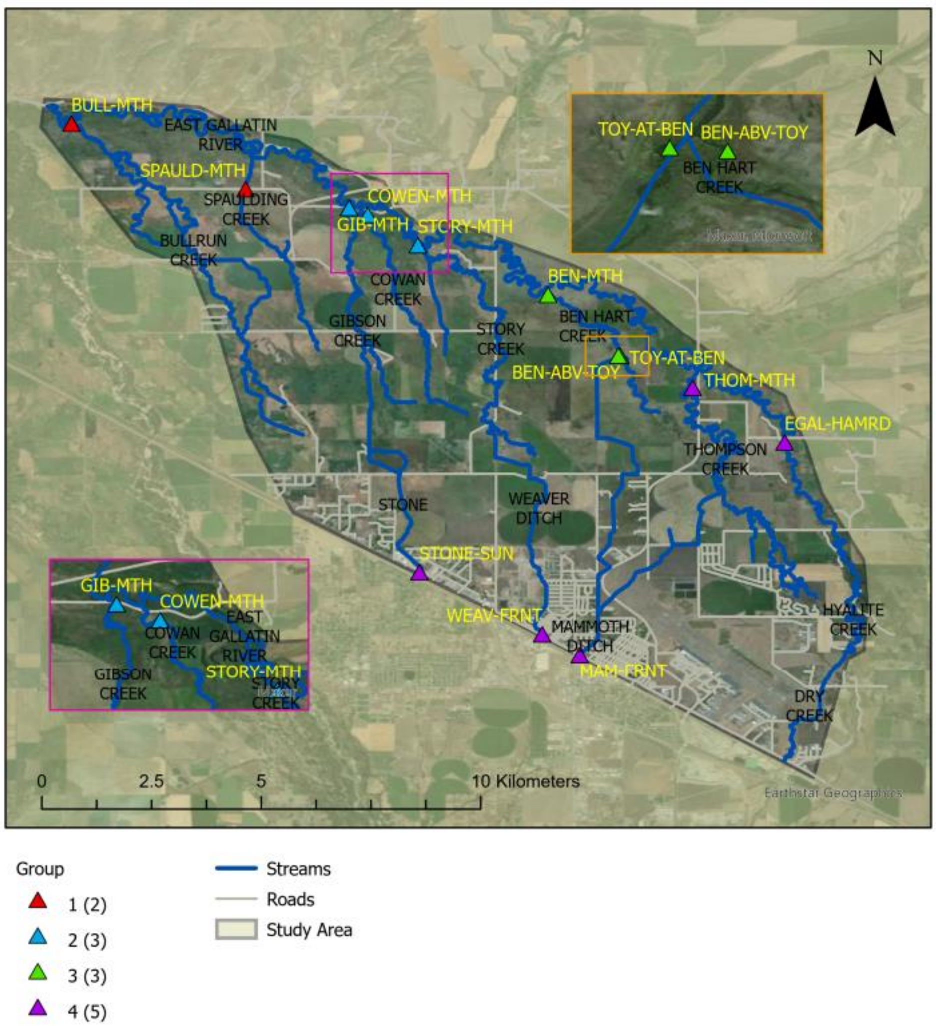


Figure 1. Site Map. Imagery from ESRI World Imagery; Streams from USGS National Hydrology Dataset; Roads from Montana Transportation Framework. Triangle colors indicate groups with numbers in the legend (the value in parentheses is the number of sites that team was initially assigned).

4.0 RESULTS

Air temperatures on the sampling day were well below freezing, resulting in minimal if any snowmelt occurring during sampling and hence no overland flow entering the stream during the event. TN, TP, and nitrate concentrations are listed in Table 1 along with measured discharge values and instantaneous loads calculated from discharge and concentration. Nutrient concentrations as well as chloride concentrations are presented in Figure 2. Nutrient loads are mapped in Figures 3 and 4. Discharge is plotted in Figure 5 and is mapped in Appendix 3). TN and TP loads are plotted and mapped in Figures 6-8. Land use and rough stream proximity areas are mapped in Figure 9. Land use areas for the stream proximity areas are listed in Table 2. TN and TP correlation to stream primary land uses in proximity to streams is summarized in Table 3. TN and TP regressions to percent land use in areas proximate to streams are plotted in Figure 10.

WATER QUALITY

Table 1. Discharge, nutrient concentration, and nutrient load results.

Station ID	Discharge (cfs)	Nitrate (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen Load (kg/day)	Total Phosphorus Load (kg/day)
EGAL-HAMRD	51.2	1.25	1.7	0.048	213.1	6.0
THOM-MTH	13.2	1.64	1.8	0.067	58.1	2.2
TOY-AT-BEN	13.1	1.89	1.9	0.044	61.1	1.4
BEN-ABV-TOY	20.0	1.75	2	0.098	98.2	4.8
BEN-MTH	32.5	1.66	2.2	0.091	175.2	7.2
STORY-MTH	11.1	1.68	1.9	0.082	51.5	2.2
COWEN-MTH	5.4	1.76	2.2	0.051	29.1	0.7
GIB-MTH	8.9	1.17	1.3	0.007	28.2	0.2
SPAULD-MTH	0.5	1.06	1.3	0.01	1.6	0.0
BULL-MTH	8.5	1.34	1.5	0.025	31.2	0.5

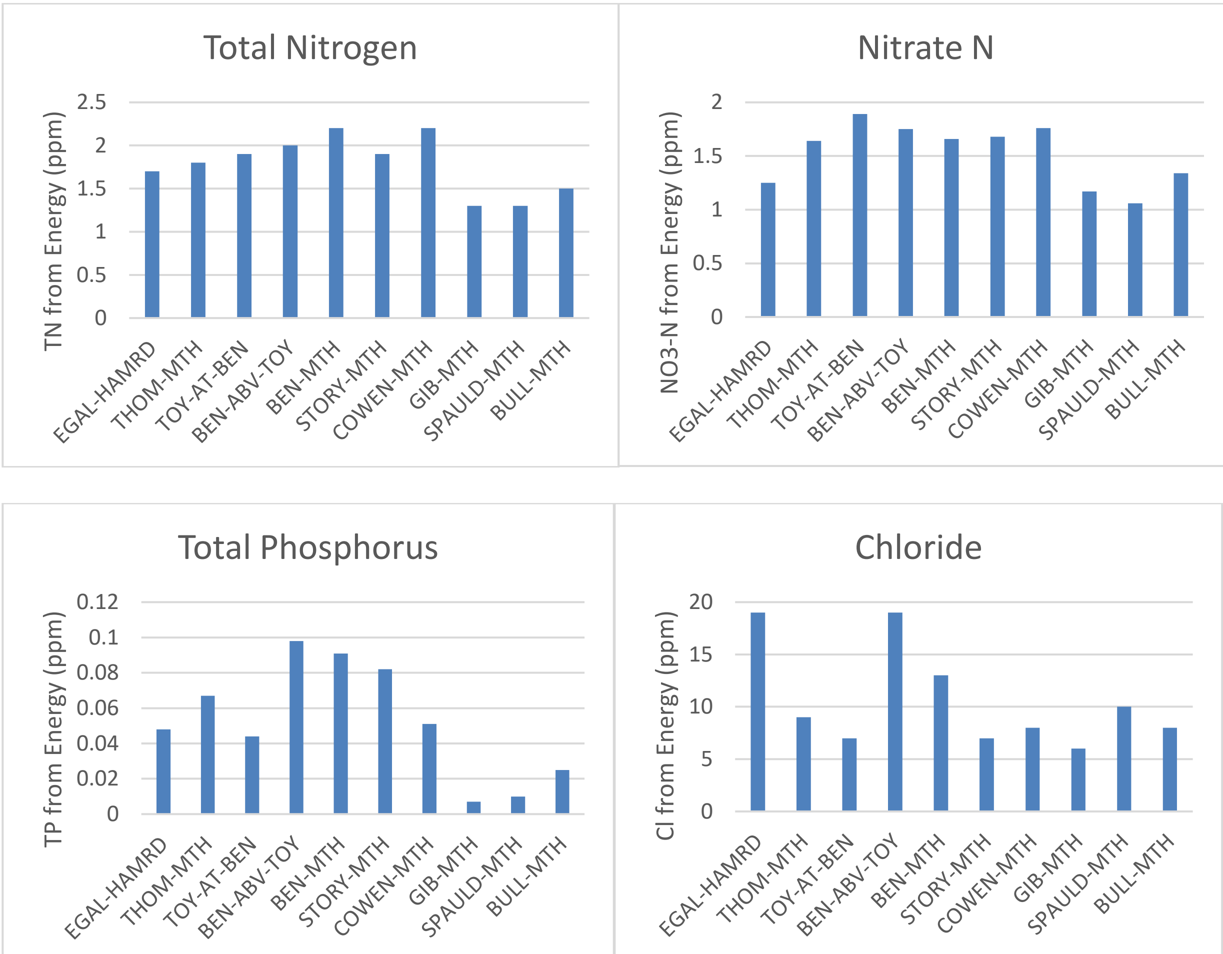


Figure 2. Nutrient and chloride concentrations from samples collected on December 17th 2021.

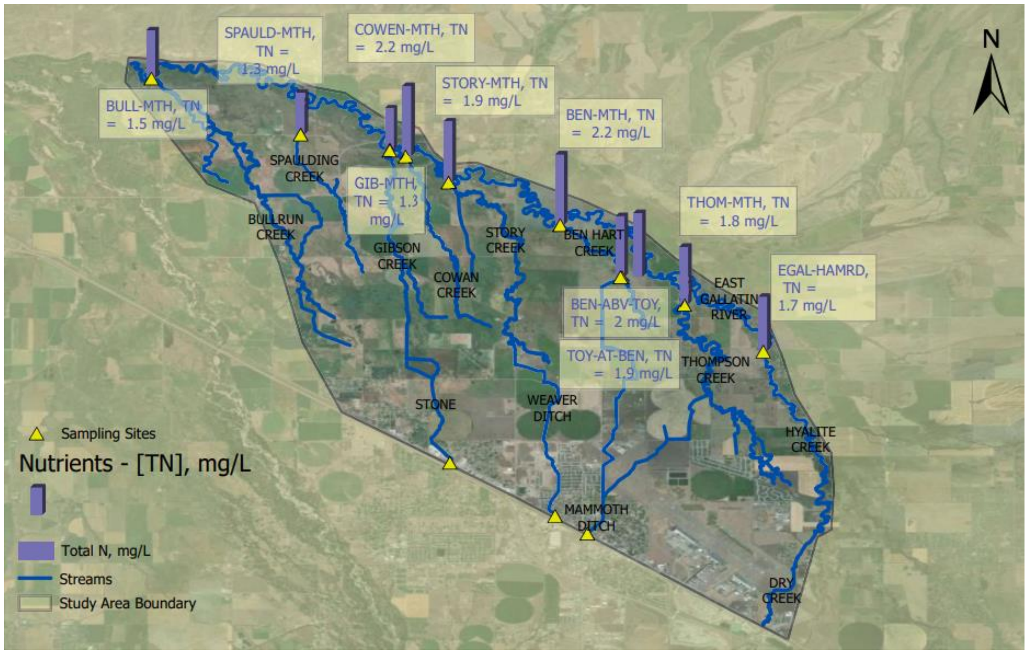


Figure 3. Map of total nitrogen concentrations. Imagery from ESRI World Imagery; Streams from USGS National Hydrology Dataset; Roads from Montana Transportation Framework; water quality data from this project.

Figure 4. Map of total phosphorus concentrations. Imagery from ESRI World Imagery; Streams from USGS National Hydrology Dataset; Roads from Montana Transportation Framework; water quality data from this project.

DISCHARGE AND NUTRIENT LOADS

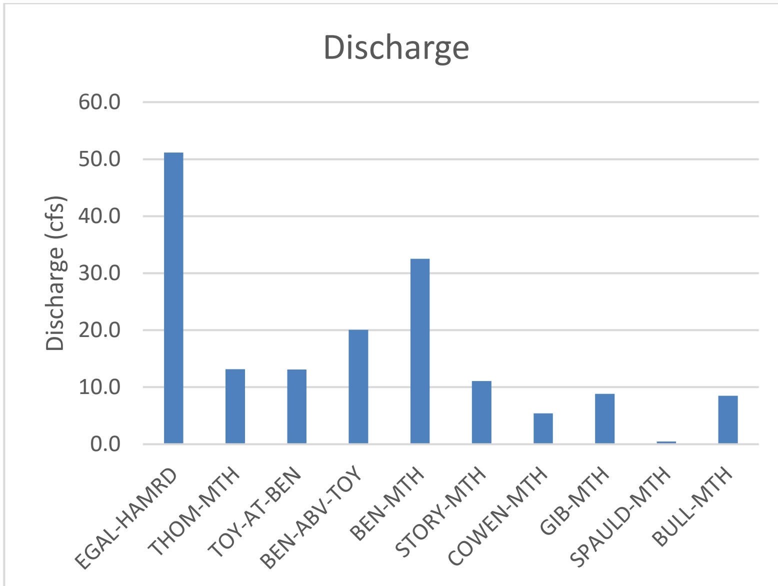


Figure 5. Discharge measured at the 10 sample sites on December 17th 2021.

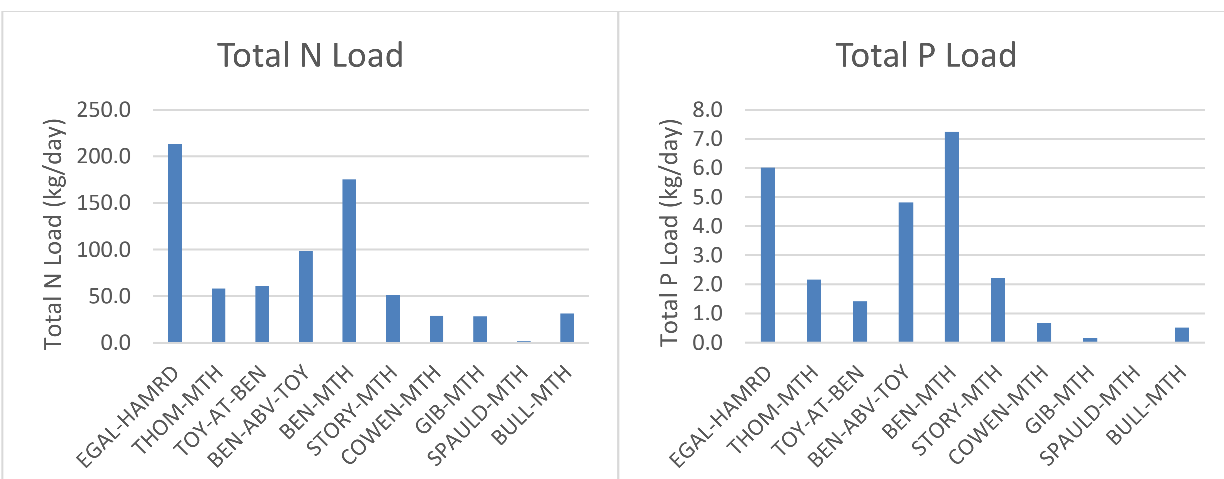


Figure 6. Total nitrogen and total phosphorus loads at the 10 sample sites on December 17th 2021.

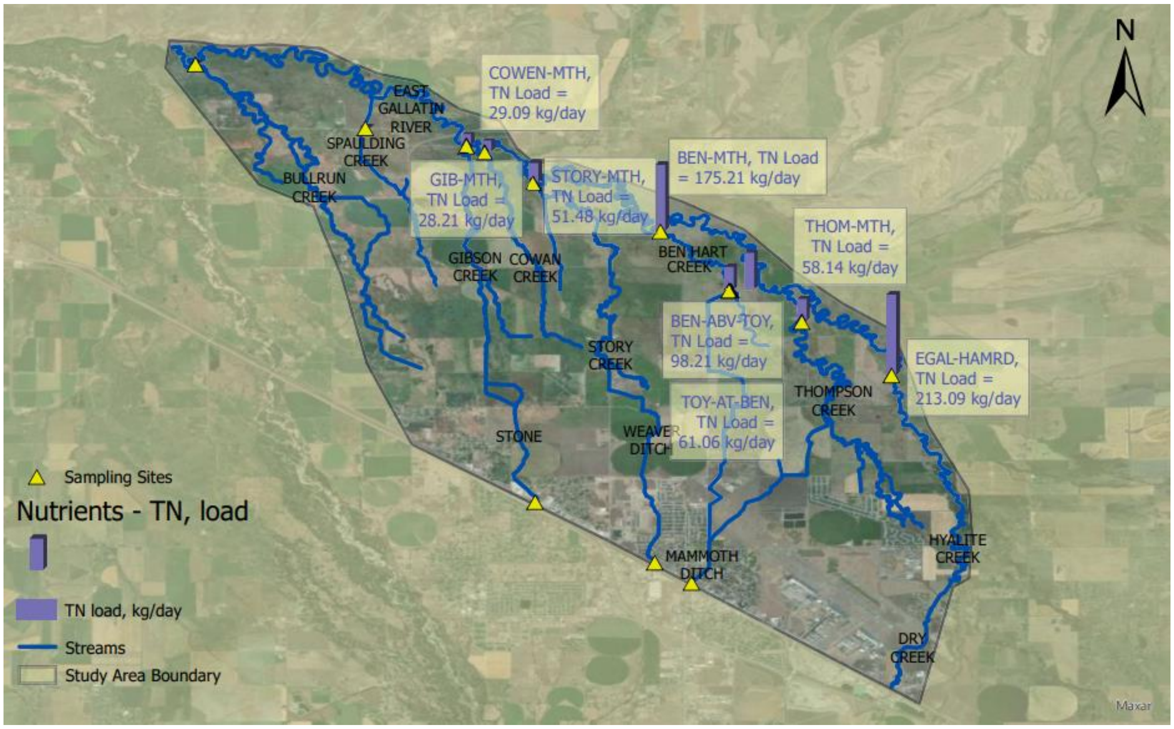


Figure 7. Map of total nitrogen loads. Imagery from ESRI World Imagery; Streams from USGS National Hydrology Dataset; Roads from Montana Transportation Framework; water quality data from this project.

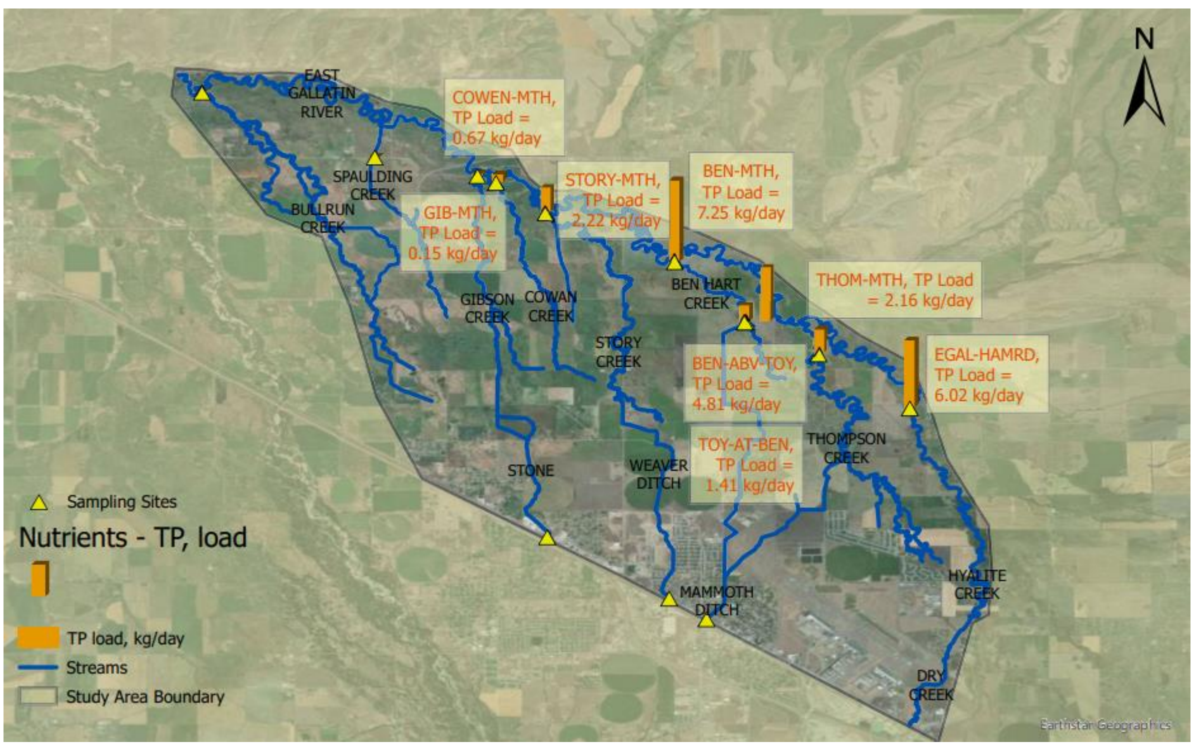
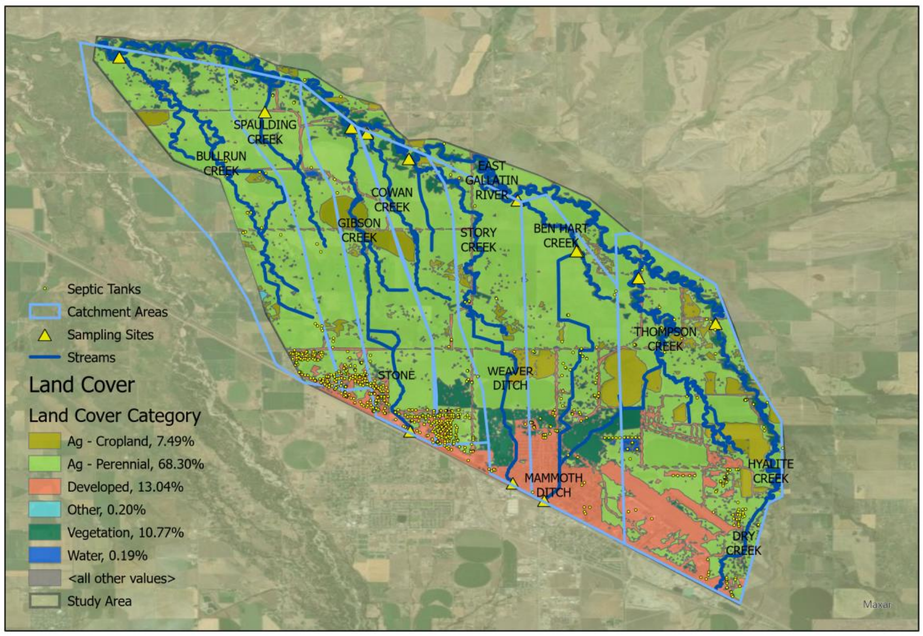


Figure 8. Map of total phosphorus loads. Imagery from ESRI World Imagery; Streams from USGS National Hydrology Dataset; Roads from Montana Transportation Framework; water quality data from this project.

LAND USE

Belgrade Nutrients Project - Land Cover and Septic Systems



Imagery from ESRI World Imagery; Streams from USGS National Hydrology Dataset; Roads from Montana Transportation Framework; Landcover from USGS Cropscape data; Catchment areas drawn from USGS DEM.

Figure 9. Land use in proximity to spring creeks. Land area near streams is delineated by the blue lines, which are labeled "catchment areas" on the map, but the true catchment areas extend far to the south outside the study area and are not well known. These straight lines around streams were drawn to facilitate a very course level assessment of the land use in proximity to each stream and are not intended to represent the true catchment areas for the groundwater entering the streams.

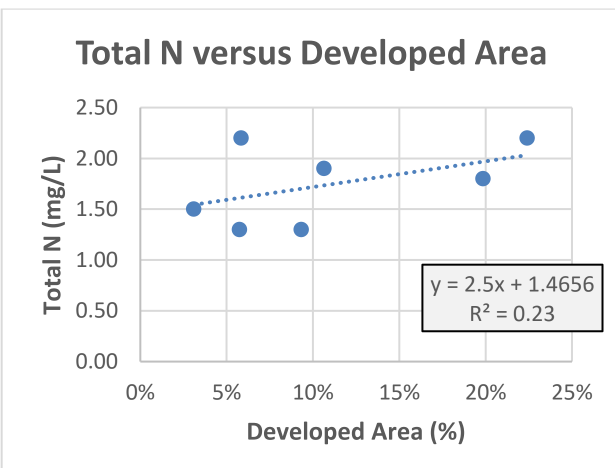
Table 2. Land use for areas proximate to streams, labeled as "catchment areas" in Figure 9.

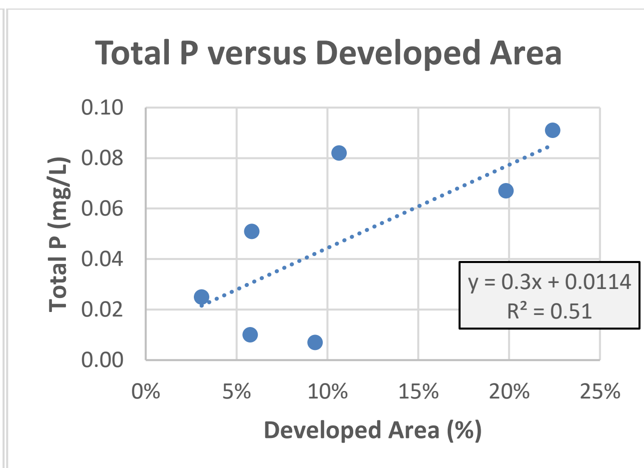
Station	Perennial Crop	Developed	Annual Crop	Natural Veg	Water	Other	Septic Count
THOM-MTH	57.29%	19.83%	13.18%	9.11%	0.43%	0.16%	132
BEN-MTH	59.45%	22.39%	6.72%	11.19%	0.12%	0.12%	88
STORY-MTH	71.54%	10.63%	5.98%	11.76%	0.00%	0.09%	12
COWEN-MTH	75.19%	5.83%	5.07%	13.70%	0.00%	0.22%	172
GIB-MTH	77.15%	9.31%	8.17%	5.36%	0.00%	0.00%	126
SPAULD-MTH	83.83%	5.73%	3.90%	5.85%	0.57%	0.11%	97
BULL-MTH	88.35%	3.07%	3.07%	5.22%	0.00%	0.29%	125

Table 3. Relationship between nutrient concentration and land use in proximity to spring creeks in Table 2. A positive slope indicates an increase nutrient concentration for an increase in percent land use in proximity to the stream. The R^2 value indicates how strong the correlation is between nutrient concentration and land use.

	Total Nitrogen		Total Phosphorus	
Land Use	**Slope**	**R^2**	**Slope**	**R^2**
Developed Area	+	0.23	+	0.51
Cropland agriculture	+	0.02	+	0.10
Perennial vegetation agriculture	-	0.38	-	0.61

Figure 10. Regression between nutrient concentration at the mouth of each spring creek and the percent of area proximate to the stream (Figure 9 and Table 2) that is categorized as developed land use.





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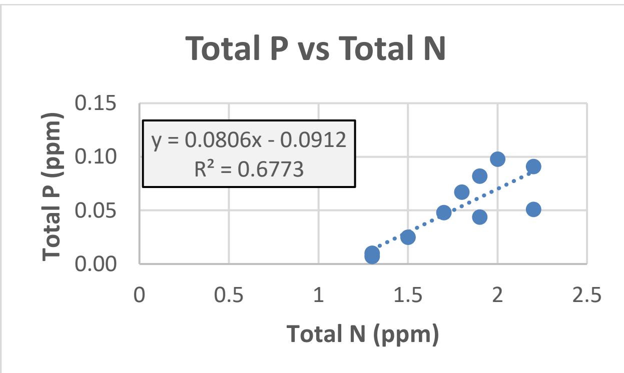
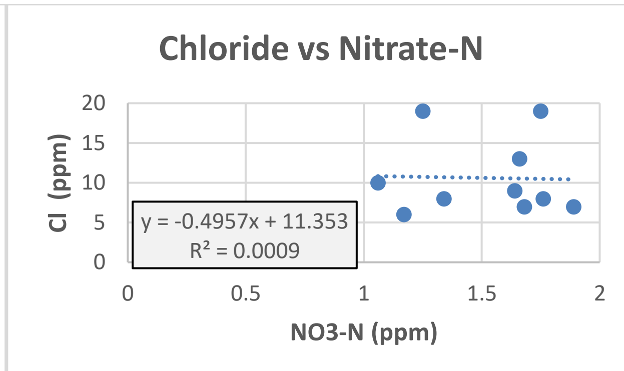
APPENDIX 1. RELATIONSHIPS BETWEEN WATER QUALITY PARAMETERS

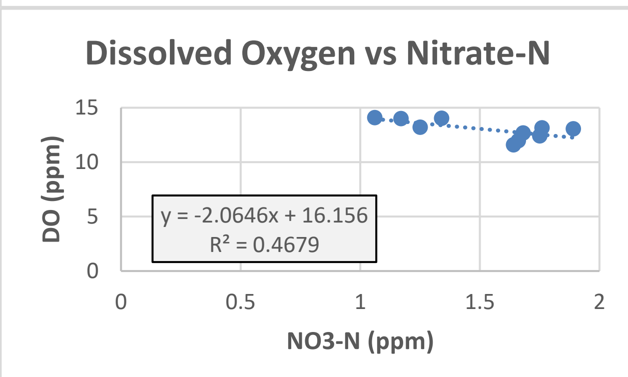
The concentrations of total phosphorus and total nitrogen are correlated across sample sites.

Chloride and nitrate concentrations do not show a relationship. Chloride is commonly evaluated as a possible indicator that nitrate may be derived from wastewater disposal, but this approach assumes high levels of chloride in wastewater and does not account for nitrate losses in transport due to denitrification.

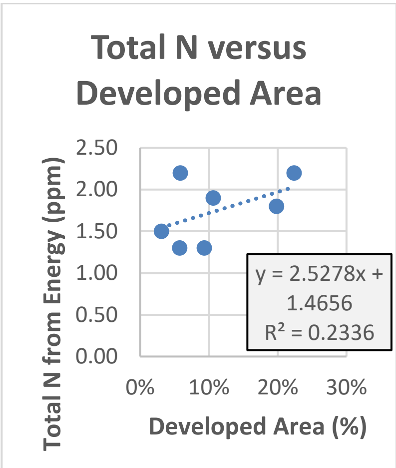
A negative correlation observed between dissolved oxygen and nitrate concentration raises questions about higher denitrification potential in streams with higher nitrate concentrations.

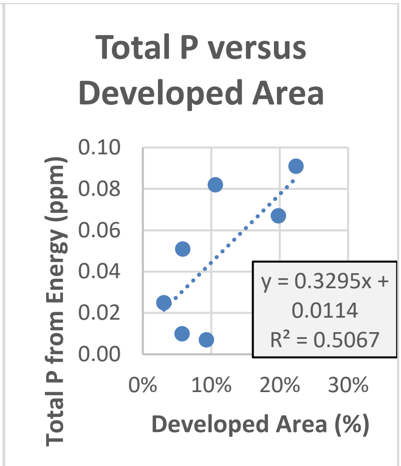


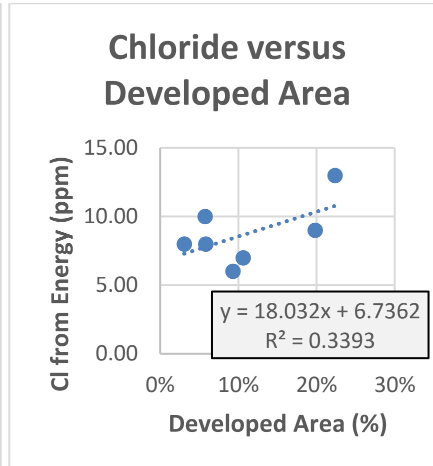


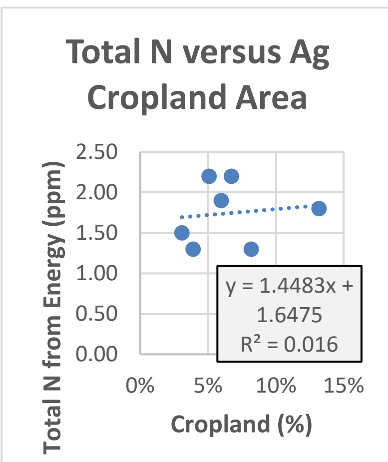


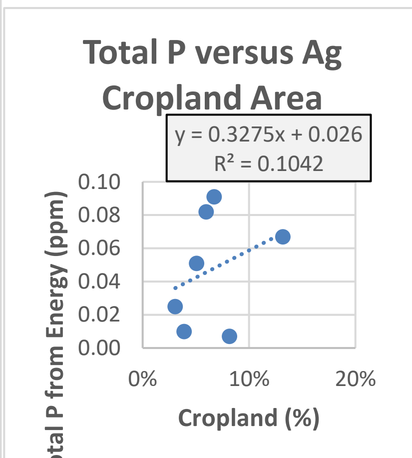
APPENDIX 2. WATER QUALITY VERSUS LAND USE

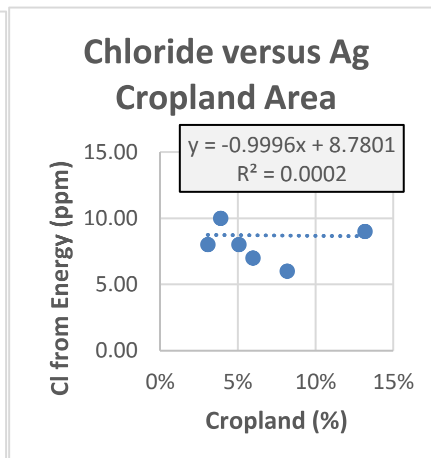


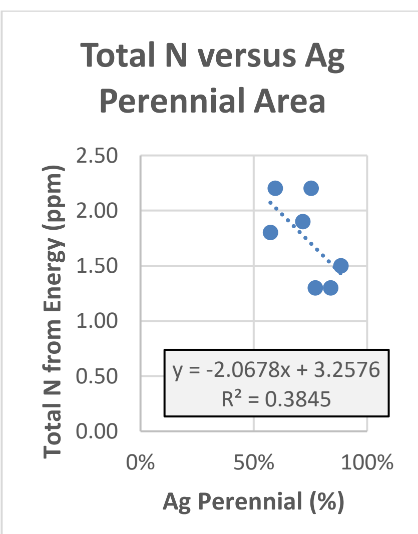


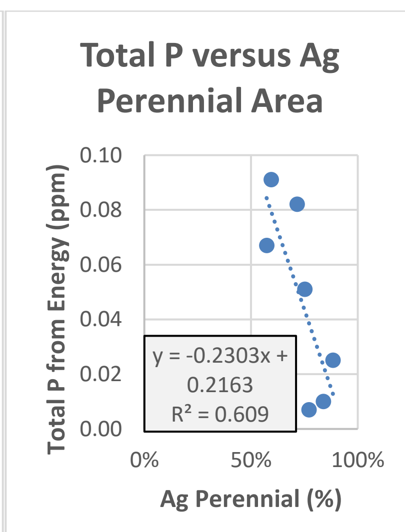


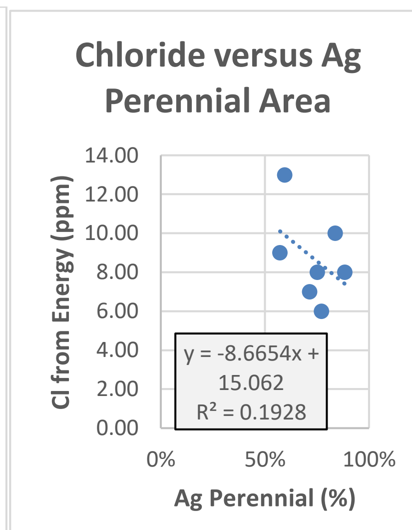












APPENDIX 3. DISCHARGE MAP

APPENDIX 4. MONITORING LOCATIONS

Table 2. Monitoring Locations.

Stream	Station ID	Site Name	Site Description	Latitude	Longitude
East Gallatin	EGAL-HAMRD	East Gallatin River at Hamilton Rd	East Gallatin accessed from Hamilton road, immediately upstream from the bridge.	45.82456	-111.14222
Ben Hart	BEN-MTH	Ben Hart Creek at confluence with East Gallatin	Ben Hart Creek approximately 100 meters above the confluence with the East Gallatin.	45.85352	-111.19039
Ben Hart	BEN-ABV-TOY	Ben Hart Creek above Toohey Ditch	Ben Hart Creek about 10 meters above inflow from Toohey ditch	45.84106	-111.17563
Ben Hart	TOY-AT-BEN	Toohey Ditch at confluence with Ben Hart Creek	Toohey ditch about 10 meters above confluence with Ben Hart Creek	45.84108	-111.17598
Bull Run	BULL-MTH	Bullrun Creek at mouth (East Gallatin River)	Bull Run Creek about 50 meters upstream from confluence with East Gallatin on State Land	45.88853	-111.28790
Cowen	COWEN-MTH	Cowen Creek at mouth (East Gallatin River)	Cowen Creek about 150 meters upstream from confluence with East Gallatin	45.86989	-111.22728
Gibson	GIB-MTH	Gibson Creek, below Dry Creek School Rd	Gibson Creek at Dry Creek School Road crossing	45.87130	-111.23109
Story	STORY-MTH	Story Creek, at confluence with East Gallatin River	Story Creek less than 150 meters from confluence with East Gallatin	45.86315	-111.21641
Thompson	THOM-MTH	Thompson Creek at mouth (East Gallatin River)	Thompson Creek approximately 1500 feet upstream from mouth, just south of gravel road crossing	45.83451	-111.16079
Spaulding	SPAULD-MTH	Spaulding Brook at near confluence with East Gallatin	Spaulding Brook at Sales Road approximately 700 meters upstream of confluence with East Gallatin	45.87513	-111.25227
Stone Ditch	STONE-SUN	Stone Creek at Sunfield Road	Stone Creek at Sunfield Drive upstream from hydrography showing flow into Gibson Creek	45.79678	-111.21669
Weaver Ditch	WEAV-FRNT	Weaver Ditch at Frontage Road	Weaver Ditch at the Frontage Road upstream from hydrography showing flow into Story Creek	45.78409	-111.19157
Mammoth Ditch	MAM-FRNT	Mammoth Ditch at Frontage Road	Mammoth Ditch at the Frontage Road upstream from hydrography showing flow into Ben Hart and Thompson Creeks	45.77984	-111.18388