Lower Gallatin 2008 Water Quality Sampling Report

Prepared for:

Greater Gallatin Watershed Council
PO Box 751
Bozeman, MT 59771

Prepared by:

Oasis Environmental

1 Ninth Street Island Drive
Livingston, MT 59047

Levia Shoutis
Environmental Scientist

John Gangemi
River Ecologist

- Page Intentionally Left Blank -

TABLE OF CONTENTS

- Page Intentionally Left Blank -

EXECUTIVE SUMMARY

This report summarizes the results of water quality monitoring on the Gallatin and East Gallatin Rivers and select tributary streams within the Lower Gallatin TMDL Planning Area (LGTPA) in late summer 2008. The LGTPA encompasses an area of approximately 997 square miles in Gallatin County in southwestern Montana, extending from below the confluence with Spanish Creek near the north end of Gallatin Canyon, downstream to its confluence with the Madison River. The goal of the 2008 sampling was to assess nutrient, *E. coli,* and algae levels during the low-flow conditions of late summer, in order to assist Montana Department of Environmental Quality (DEQ) in the development of a TMDL Plan within the LGTPA. Seventy-two sites were distributed across 18 streams representing a range of land uses within the Gallatin Valley, including urban, low-density development, agriculture, and U.S. Forest Service land. OASIS Environmental, Inc. conducted the sampling in August and September of 2008, and samples were analyzed at a State-approved laboratory. Water samples from all of the sites were analyzed for nutrients (nitrogen and phosphorus compounds), while algae samples were collected from sites along 14 of the streams. Samples from five of the streams, Reese, Smith, Sourdough, Camp, and Godfrey Creeks, were analyzed for *E. coli* pathogens. Nutrient and algae concentrations were generally higher in the East Gallatin River and its tributaries than in the Gallatin River, with the highest concentrations found in the lower reaches of the East Gallatin. *E. coli* concentrations exceeded the Montana water quality standards on all of the five streams sampled for *E. coli.* Due to laboratory analysis errors only a portion of the algae samples were correctly processed and available for water quality assessment. Of the correctly-processed algae samples none exceeded nuisance algal levels. Additional sampling of nutrients, algae and *E. coli* should be conducted in 2009 to further assess pollutant levels and sources in support of a TMDL Plan for the LGTPA.

- Page Intentionally Left Blank -

1. INTRODUCTION

The two primary water bodies within the Lower Gallatin TMDL Planning Area (LGTPA) are the Gallatin River and the East Gallatin River. The LGTPA encompasses an area of approximately 997 square miles in Gallatin County in southwestern Montana, extending from below the confluence with Spanish Creek near the north end of Gallatin Canyon, downstream to its confluence with the Madison River. Although Spanish Creek is the upstream boundary of the LGTPA on the Gallatin River, the headwaters of the Gallatin River extend into Yellowstone National Park (YNP). The river flows north from YNP through the forested Gallatin Canyon into primarily low-density residential development and agricultural lands within the Gallatin Valley.

The LGTPA encompasses the urban areas of Bozeman and Belgrade, as well as several smaller communities. The primary rural land uses within the LGTPA are agriculture, ranching, and recreational activities. A substantial portion of the tributary headwaters in the LGTPA serve as drinking water sources.

The East Gallatin River headwaters originate from several tributary streams, namely Jackson Creek, Meadow Creek and Rocky Creek. These creeks flow westward down Bozeman Pass east of Bozeman (Figure 1). A number of additional tributary streams enter the East Gallatin River, including Sourdough Creek (also known as Bozeman Creek), Bridger Creek, Smith Creek, and Hyalite Creek. The East Gallatin River enters the main stem of the Gallatin River north of Manhattan, at which point both rivers are of similar size.

This report summarizes the results of water quality monitoring on the Gallatin and East Gallatin Rivers and select tributary streams within the LGTPA in 2008. The Montana Department of Environmental Quality (DEQ) is responsible for the assessment of Montana surface water bodies and for the development of Total Maximum Daily Load (TMDL) plans for water bodies that do not meet established water quality criteria for the protection of human health and aquatic life. Such water bodies are placed on what is referred to as the “Montana 303d List” which is updated every two years and can be accessed at http://cwaic.mt.gov/.

The 2006 MT 303d List contains 15 stream segments within the LGTPA identified as impaired due to nutrients, *Escherichia coli* (*E. coli*), and/or algae. As part of the development of a TMDL Plan for the LGTPA, OASIS Environmental, Inc. (OASIS) conducted nutrient, *E. coli*, and algae sampling on the 15 listed stream segments, and on an additional 6 segments of interest not included on the 2006 List (Table 1). These combined segments encompassed 72 nutrient sampling sites, 44 algal sites and 17 sites for *E. coli*. Sampling occurred in August and September of 2008.

This report describes the field sampling methods, data analysis, and results for *E. coli,* nutrients and algae. The *Lower Gallatin TMDL Planning Area Sampling and Analysis Plan* (referred to as the LGTPA SAP) prepared by OASIS details the stream segments and impairments for each of the stream segments, sample site selection, sample collection, and analysis methods (OASIS 2008). Project deliverables including lab analysis data, field data, field data forms, representative photos of sample sites, and any changes to the SAP are reported in the *LGTPA Data Upload and QAQC,* submitted to DEQ by OASIS in February, 2009 (referred to as the "SAP Addendum"). The STORET data upload was completed in March 2009 and can be accessed at hhtp://www.montanastoret. com/mtwebsim/dw_home.

1.1. Sample Sites

Stream segments sampled in this assessment, including those segments that were listed on the 2006 303d List, are tabulated in Table 1. The 21 segments were distributed across 18 streams. The mainstem of the East Gallatin River was divided into three segments. Hyalite Creek consisted of two segments. The remaining segments were divided among the mainstem Gallatin River and tributary streams of both the Gallatin and the East Gallatin. The location of each site and associated field parameters sampled were mapped for the LGTPA (Figure 1). Site names are truncated to only the first four characters for ease of reporting in all tables and figures for this report (i.e. site EG02-M05EGALR01 is shortened to EG02).

Nutrients were sampled on all 21 segments (72 sites), while *E. coli* was sampled on 5 segments (17 sites) and chlorophyll *a* was sampled on 18 segments (44 sites). *E. coli* sampling occurred multiple times per segment in order to allow evaluation with state *E. coli* water quality standards, whereas algae and nutrients were sampled only once at each site during the study period. Nutrient sampling was repeated at select *E. coli* sampling sites. Streamflow was sampled concurrently with each nutrient and *E. coli* sampling event.

Sampled streams varied in size, riparian environment, and adjacent land use. Several sampling sites were located on small headwater streams such as upper Bear Creek, characterized by densely forested riparian zones, cold and turbulent water as well as a cobble bottom (Figure 2). In contrast, small streams located in the valley bottom agricultural areas, such as Smith Creek, were characterized by a grass/pasture land riparian zone, slow water, meandering channels, and a fine sediment bottom (Figure 3). Larger streams such as the East Gallatin River consisted of turbulent water in its upper reaches, a densely forested riparian canopy, and a rocky bottom (Figure 4) while in its lower reaches the channel was meandering, with a more open shrub riparian zone, and a finer substrate bottom (Figure 5).

Table 1. Stream segments and parameters sampled for each site.

	Stream Name	# Sites	Impaired Segment (2006 303d list)	*E. coli*	Nutrients	Chl-a	Flow
East Gallatin River	Bear Creek	5	x		x	x	x
	Ben Hart Creek	1			x		x
	Bridger Creek	6	x		x	x	x
	Dry Creek	3	x		x	x	x
	East Gallatin River Headwaters to Bridger Cr	3	x		x	x	x
	East Gallatin River Bridger Cr to Smith Cr	9	x		x	x	x
	East Gallatin River Smith Cr to Gallatin R	2	x		x	x	x
	East Gallatin River Unnamed Trib.	1			x		x
	Gibson Creek	1			x		x
	Godfrey Creek	6	x	x	x	x	x
	Hyalite Creek Headwaters to Bozeman water supply intake	2	x		x	x	x
	Hyalite Creek Water supply intake to E. Gallatin R.	2			x	x	x
	Jackson Creek	3	x		x	x	x
	Meadow Creek	1			x	x	x
	Reese Creek	2	x	x	x	x	x
	Rocky Creek	1	x		x	x	x
	Smith Creek	4	x	x	x	x	x
	Sourdough Creek	6	x	x	x	x	x
	Story Creek	1			x		x
	Thompson Spring Creek	2	x		x	x	x
Gallatin River	Gallatin River	7			x	x	x
	Camp Creek	4	x	x	x	x	x
	Total	**72**	**15**	**5**	**21**	**18**	**21**

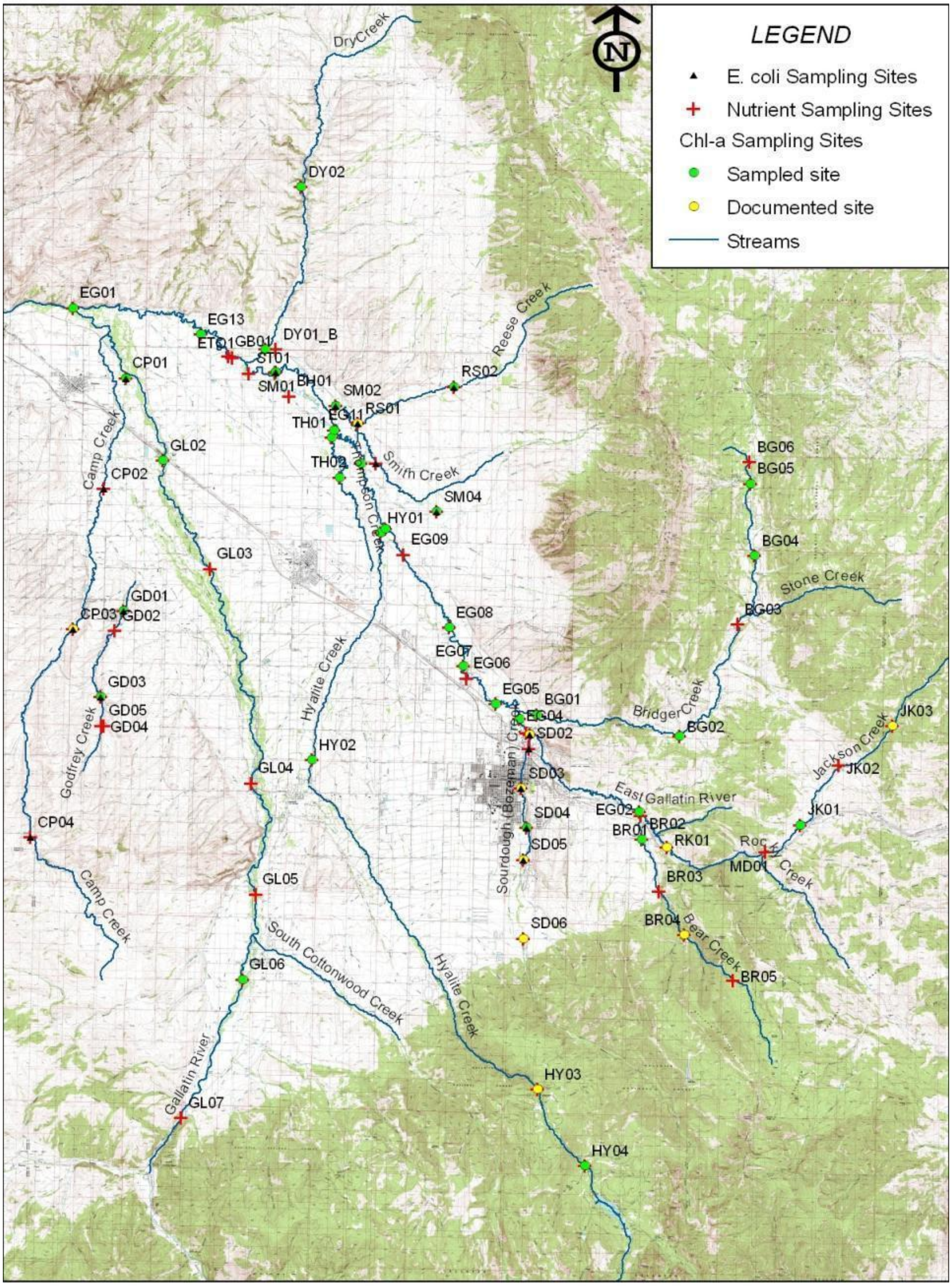

Figure 1. Sample site locations and field parameters within the LGTPA.

Figure 2. Site BR03 on Bear Creek, off of Bear Canyon road.

Figure 3. Site SM01 on Smith Creek, just above the confluence with the East Gallatin River.

Figure 4. Site EG02 on the upper East Gallatin River, at Rocky Creek Farm.

Figure 5. Site EG13 on the Lower East Gallatin River, below Spaulding Bridge road.

2. *E. COLI*/FECAL COLIFORM BACTERIA

E. coli was recently adopted as the indicator organism for pathogen pollutants in Montana water bodies. *E. coli* is a nonpathogenic bacteria often associated with fecal contamination and is assumed to indicate the presence of human pathogens. *E. coli* concentrations were measured to assess existing pathogen loads and to identify and quantify potential pathogen sources. Potential sources of pathogen pollutants within the LGTPA include waste from livestock, domestic pets and wildlife, malfunctioning septic systems, and potentially untreated municipal wastewater.

2.1. Sampling Activity

E. coli samples were collected at 17 sites, distributed across six stream segments. Each of the six stream segments was sampled five times within a 30-day period (August 20th-September 17th, 2008), as required by the 2006 Montana Standards for sampling *E. coli* in B-1 water bodies. The *E. coli* sampling effort was doubled on Sourdough Creek to better document the influence of urban conditions on water quality as it flows through Bozeman. This resulted in ten sampling events rather than five on Sourdough Creek. The 17 sites were distributed across the six stream segments (number of sampling events are in parenthesis), for a total of 35 *E. coli* sampling events.

1. Lower Camp Creek (downstream of Amsterdam) (5)
2. Upper Camp Creek (upstream of Amsterdam) (5)
3. Godfrey Creek (5)
4. Reese Creek (5)
5. Smith Creek (5)
6. Sourdough Creek (10)

2.2. Results

The threshold criteria for *E. coli* was exceeded for all of the six sampled stream segments in the LGTPA (Table 2). In 2006, the State of Montana adopted *Escherichia coli* (*E. coli*) as the indicator organism for pathogen pollutants [ARM 17.30.623 (2)(a)]. The newly adopted Montana standard for pathogen pollutants for B-1 water bodies specifies:

> *The geometric mean number of E. coli may not exceed 126 cfu/100 ml and 10% of the total samples may not exceed 252 cfu/100*ml *during any 30-day period between April 1 through October 31 [ARM 17.30.623 (2)(i)]. From November 1 through March 31, the geometric mean number of E. coli may not exceed 630 cfu/100*ml *and 10% of the samples may not exceed 1,260 cfu/100 ml during any 30-day period [ARM 17.30.623 (2)(ii)]. The E. coli bacteria standard is based on a minimum of five samples obtained during separate 24-hour periods during any consecutive 30-day period that are analyzed by the most probable number*

(MPN) or equivalent membrane filter method [ARM 17.30.620(2)]. The geometric mean is the value obtained by taking the Nth root of the product of the measured values where values below the detection limit are taken to be the detection limit [ARM 17.30.602(13)].

Smith Creek had the highest *E. coli* count, 2420 cfu/100 ml, found in a single sample (Figure 6), while Upper Camp Creek resulted in the highest geometric mean concentration (407 cfu/100 ml). *E. coli* values were significantly higher in the urban portion of Sourdough Creek than in the rural section*. E. coli* values in the urban section exceeded the DEQ criteria. Upper Sourdough Creek resulted in the lowest concentrations of all of the *E. coli* sample sites. *E. coli* counts fluctuated spatially and temporally for each for each of the five streams over the 30-day sampling period (Figures 7 through 11).

2.3. Discussion

All of the six stream segments sampled for *E. coli* within the LGTPA were not attaining *E.coli* water quality standards. Although an urban stream, Sourdough Creek had the lowest *E. coli* values, followed by Reese Creek and Lower Camp Creek. While the geometric mean number of colony forming units did not exceed the 126 cfu/100 ml threshold criteria on Lower Camp Creek and Sourdough Creek, the greater than 10% of the samples on these segments were higher than the 252 cfu/100 ml threshold, thus they exceeded the water quality criteria.

Table 2. *E. coli* sampling results for 6 stream segments (colony forming units(cfu)/ 100 ml). Upper and lower Sourdough Creek (rural versus urban) separated for data analysis purposes only.

Stream Segment	Mean (cfu/100 ml)	Greater than 126 cfu/100 ml	Highest value (cfu/100 ml)	10% of samples >242 cfu/100 ml	Determination
Lower Camp Creek	113		816	x	Criteria Exceeded
Upper Camp Creek	407	x	816	x	Criteria Exceeded
Godfrey Creek	335	x	1700	x	Criteria Exceeded
Reese Creek	130	x	423	x	Criteria Exceeded
Sourdough Creek All Sites	101		301	x	Criteria Exceeded
Sourdough Creek Below Bogert Park	164	x	301	x	Criteria Exceeded
Sourdough Creek Above Bogert Park*	**48**		**66**		**Criteria NOT Exceeded***
Smith Creek	244	x	2420	x	Criteria Exceeded

*Note that data on Sourdough Creek above Bogert Park is represented by only 4 samples and cannot officially be evaluated against the MT WQ Standard for *E. coli*

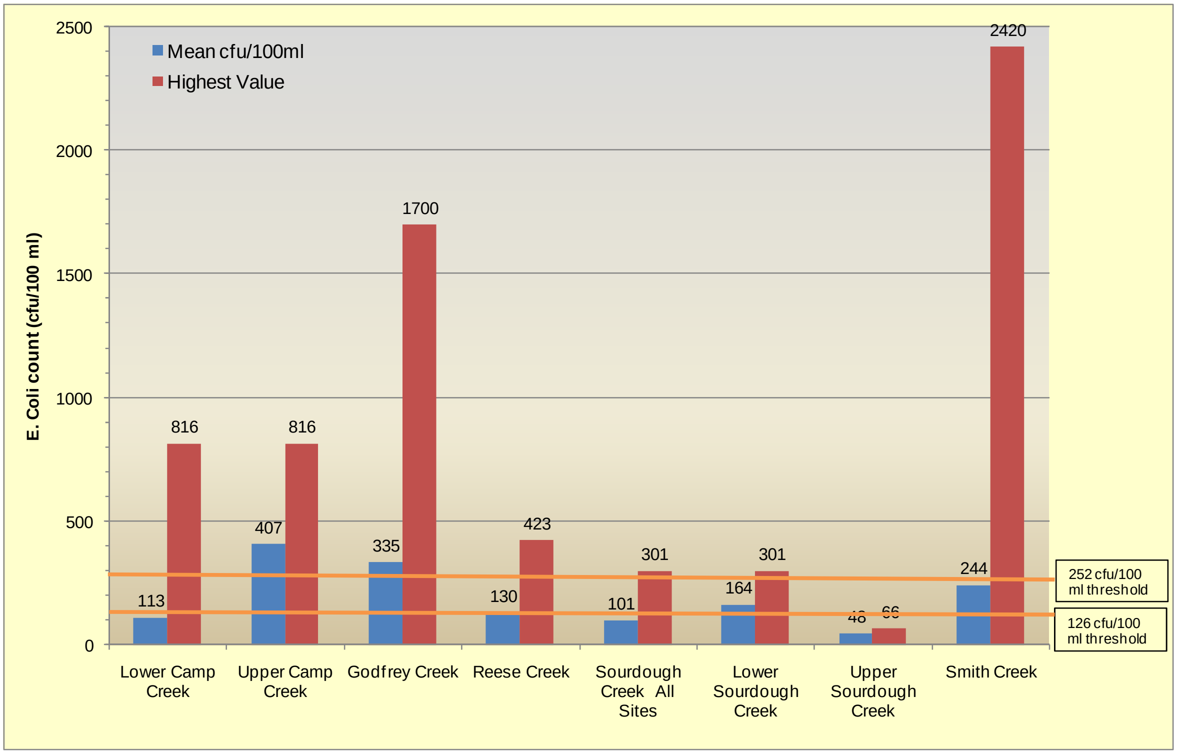

Figure 6. Geometric mean and highest values of *E. coli* counts for the six stream segments.

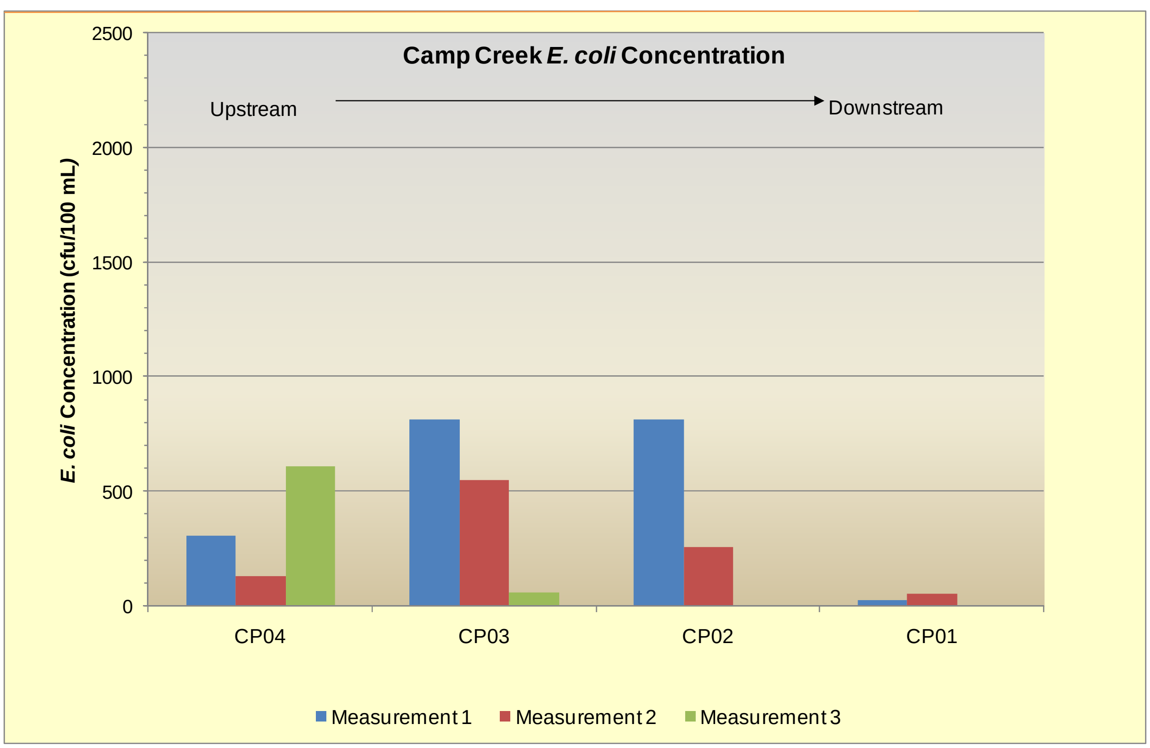

Figure 7. *E. coli* count in Camp Creek for the 30-day sampling period.

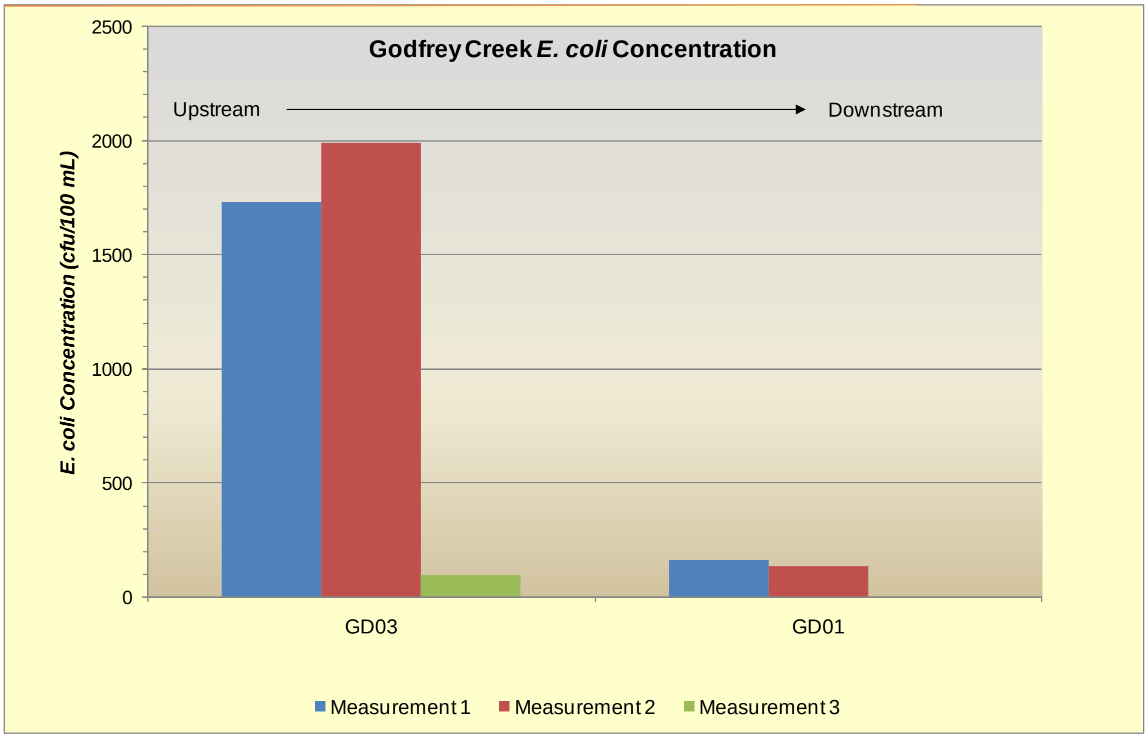

Figure 8. ***E. coli*** **count in Godfrey Creek for the 30-day sampling period.**

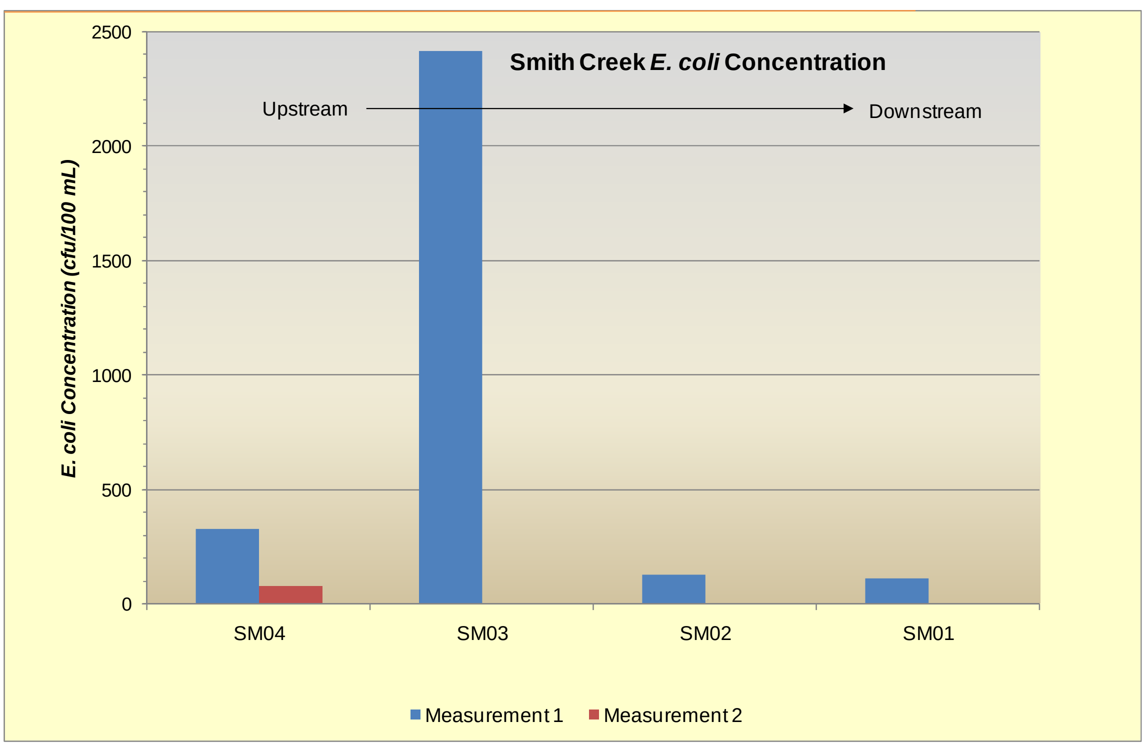

Figure 9. ***E. coli*** **count in Smith Creek for the 30-day sampling period.**

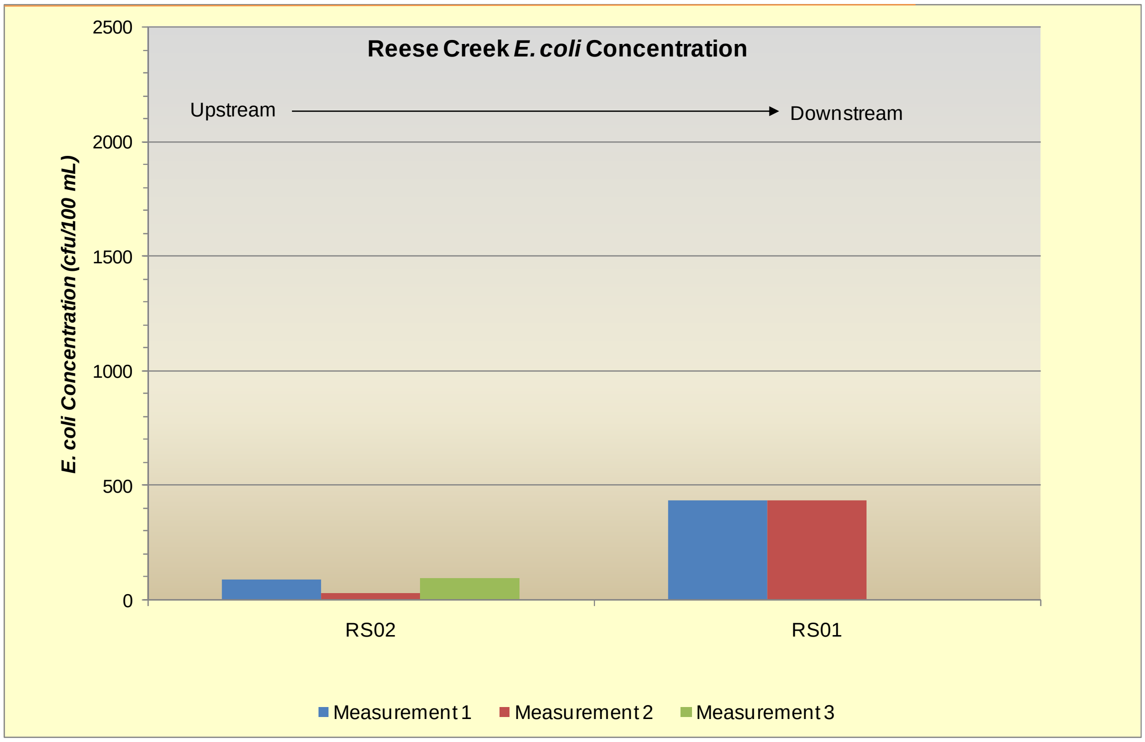

Figure 10. *E. coli* count in Reese Creek for the 30-day sampling period.

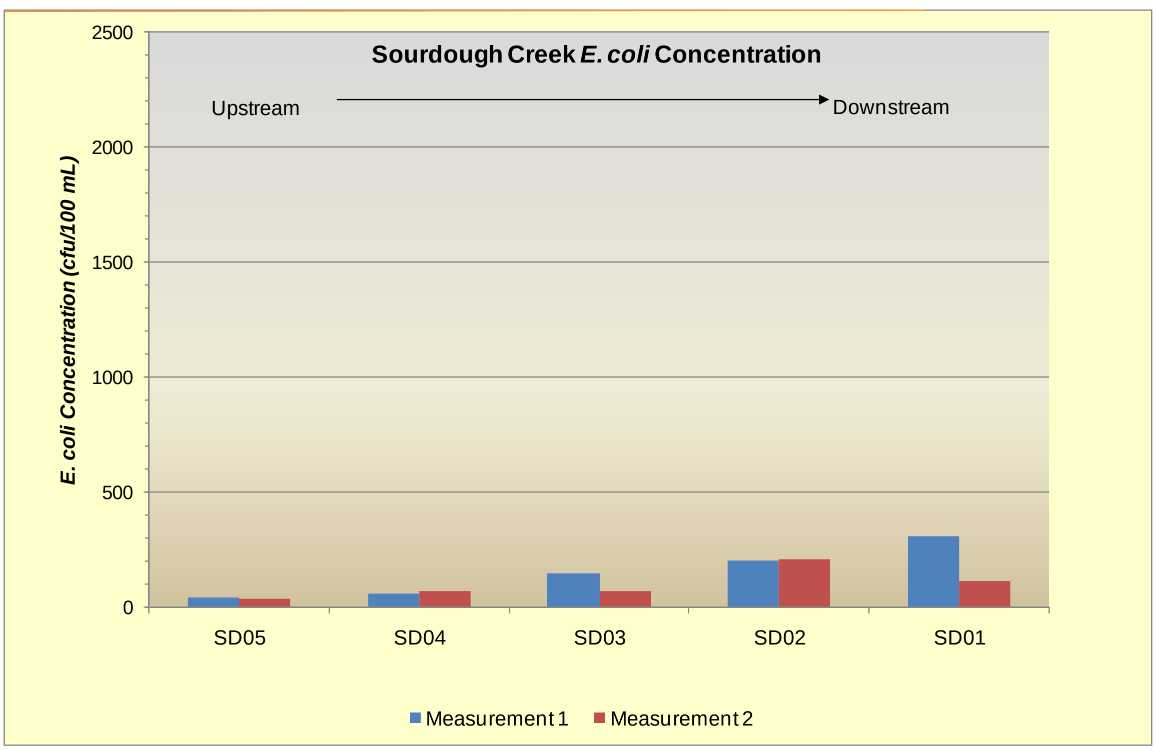

Figure 11. *E. coli* count in Sourdough Creek for the 30-day sampling period.

3. NUTRIENTS

Nutrients are required for the growth of aquatic plants and animals. In an undisturbed condition, nitrogen and phosphorus are limited in most cold water streams. When nitrogen and phosphorus are introduced to streams from natural or anthropogenic sources excessive algal growth can be stimulated degrading water quality. This water quality degradation can be manifested in the form of lower oxygen, increased odor, aesthetic impacts, and habitat loss. Potential sources of nitrogen and phosphorus within the LGTPA include; wildlife, livestock and pet waste, lawn and agricultural fertilizers, municipal wastewater outflows, septic systems, and phosphorus attached to sediment. A number of these sources cause nitrogen and/or phosphorus to enter streams when overland flow runs off the surrounding landscape.

The primary nitrogen compounds found in streams are nitrates (NO_3^-), nitrites (NO_2^-) and ammonia (NH_3^+), which can be toxic to aquatic life at certain concentrations. Nitrates and nitrites are commonly measured together as the sum of both parameters, as nitrites rapidly oxidize to nitrate under normal stream conditions. Total nitrogen is measured for the purpose of assessing all of the different sources of nitrogen present in a stream and is the sum of all inorganic (including nitrates, nitrites and ammonia), and organic forms of nitrogen. Total phosphorus was measured in this assessment to account for all forms of phosphorus, both organic (such as phosphate, PO_4^{-3}) and inorganic.

Montana's water quality standards for nutrients (nitrogen and phosphorous forms) are narrative and are addressed via narrative criteria. These narrative criteria do not allow for "*substances attributable municipal, industrial, agricultural practices or other discharges that will...(e) create conditions which will produce undesirable aquatic life*" (ARM 17.30.637). Chlorophyll-a concentrations in excess of 150 mg/m^2 are categorized by the DEQ as 'undesirable aquatic life' (see section 4 for more information on chlorophyll-a), and can be the direct result of elevated nitrogen and/or phosphorus concentrations.

3.1. Sampling Activity

OASIS sampled the following nutrients in August and September 2008 at all of the sampling sites within the LGTPA:

- Nitrogen: nitrate-nitrite, ammonia, and total nitrogen
- Phosphorus: total phosphorus

3.2. Results

Nutrient concentrations were higher in the East Gallatin River and its tributaries compared to the Gallatin River. For tributary streams, the site nearest to the confluence with the Gallatin and the East Gallatin respectively, was used for the representative nutrient concentration to calculate loading from upstream to downstream in the watershed. For example, sample site SD01 is the lowest sample site on Sourdough Creek, located just above its confluence with the East Gallatin River.

While the concentration of a substance is important for assessing compliance with MT State Water Quality Standards (DEQ 2004), water quality managers are also interested in the total amount of a substance present in a stream, or the *contaminant loading,* expressed as pounds of contaminant per day. The purpose of calculating contaminant loading is to express concentration in a sample relative to the volume of water found in the stream at the time the sample was measured. This removes the effects of dilution, allowing the comparison of contaminant levels between sites either upstream-downstream, or between streams of interest. It is also used to assess the relative impact of contaminant inputs from tributaries entering larger water bodies. Therefore, in addition to concentration, loading of nitrate-nitrites, total nitrogen and total phosphorus were also assessed within the East Gallatin and Gallatin Rivers, and in their respective tributaries.

3.2.1. East Gallatin River and Tributaries

Detailed maps of the sample sites on the East Gallatin and tributaries required two figures due to the large geographic expanse. The lower sites on the East Gallatin from Thompson Creek downstream are displayed in Figure 12, while the upper sites from Rocky Creek to Thompson Creek are displayed in Figure 13.

Nitrate-nitrite and total nitrogen concentrations in the East Gallatin River and its tributaries were higher relative to the values recorded in the Gallatin River (Table 3). A number of the East Gallatin tributaries including Sourdough, Thompson, Ben Hart, Smith Story and an unnamed tributary of the East Gallatin had nitrate-nitrite concentrations nearly equivalent to the East Gallatin (Figures 14 and 15). In contrast, Bridger Creek, Hyalite Creek and Dry Creek had relatively low concentrations compared to the mainstem East Gallatin sample sites. The spatial variability in nutrient concentrations on the tributary streams corresponds to patterns in land use for the respective watersheds. The highest concentrations on the mainstem East Gallatin were reported at sites EG07, EG08, EG10 and EG11. Site EG07 is immediately downstream from the Bozeman wastewater treatment plant outfall.

Nitrate-nitrite and total nitrogen loading in the East Gallatin increased in a predictable downstream pattern (Figures 16 and 17). Nutrient concentrations in the upper reaches of the East Gallatin above sample site EG02 were very low, thus the contributions of Jackson Creek, Rocky Creek, Meadow Creek, and Bear Creek do not exhibit loading inputs. The loading figures also depict discharge volume longitudinally at each of the sampling sites including the additive contribution of each tributary stream.

Nutrient loading increased in the East Gallatin below the confluence of Sourdough Creek. The majority of this loading, 100 lbs/day, was attributed to Sourdough Creek inputs to the East Gallatin. Downstream from this confluence, nitrate-nitrite loads were relatively minor until site EG07, located at the Bozeman Municipal Water Treatment effluent outflow. At site EG07, loads increased to approximately 600 lbs/day. Loads decreased at sites EG08 and EG09 then increased again at site EG10, located at Hamilton Road east of Dry Creek Road. Loads steadily increased thereafter in a downstream direction with several tributary streams entering prior to the confluence with the Gallatin River.

Total phosphorus concentrations and loading were relatively low in the upper East Gallatin (Figures 18 and 19). Phosphorus levels increased substantially at sites EG07 and EG08, downstream of the wastewater treatment plant effluent outflow. Farther downstream from these sites, total phosphorus levels decreased but remained higher than the inputs recorded upstream of the sewage treatment plant outfall. The highest tributary influx of total phosphorus was from Hyalite Creek.

Table 3. Nitrate-nitrite, total nitrogen, and total phosphorus concentration and loading in the East Gallatin River and tributaries (in bold).

Site	Graph Label	Date	Nitrate-Nitrite Conc. (mg/L)	Nitrate-Nitrite Load (lbs/day)	Total Nitrogen Conc. (mg/L)	Total Nitrogen Load (lbs/day)	Total Phosphorus Conc. (mg/L)	Total Phosphorus (lbs/day)
EG02-M05EGALR01	EG02	8/28/2008	0.06	6.70	0.05	5.58	0.014	1.56
Sourdough Creek	**SD01**	**9/2/2008**	**0.75**	**102.05**	**0.77**	**104.77**	**0.044**	**5.99**
EG03-M05EGALR02	EG03	9/2/2008	0.44	125.64	0.40	114.22	0.036	10.28
EG04-M05EGALR03	EG04	9/2/2008	0.44	140.21	0.30	95.60	0.033	10.52
Bridger Creek	**BG01**	**8/27/2008**	**0.11**	**12.10**	**0.22**	**24.20**	**0.005**	**0.55**
EG05-M05EGALR04	EG05	9/5/2008	0.35	114.85	0.37	121.42	0.024	7.88
EG06-M05EGALR05	EG06	9/8/2008	0.30	125.14	0.26	108.46	0.015	6.26
EG07-M05EGALR06	EG07	9/8/2008	1.26	600.61	1.12	533.88	0.245	116.79
EG08	EG08	9/5/2008	1.23	457.96	1.22	454.24	0.343	127.71
EG09-M05EGALR07	EG09	9/1/2008	0.72	232.86	0.74	239.32	0.189	61.12
Hyalite Creek	**HY01**	**8/29/2008**	**0.20**	**32.69**	**0.35**	**57.21**	**0.077**	**12.59**
EG10	EG10	8/28/2008	1.00	616.78	1.10	678.46	0.149	91.90
Thompson Creek	**TH01**	**9/1/2008**	**0.80**	**71.88**	**0.70**	**62.89**	**0.008**	**0.72**
EG11-M05EGALR08	EG11	9/1/2008	1.02	884.46	0.99	858.45	0.127	110.12
Ben Hart Creek	**BH01**	**9/3/2008**	**0.93**	**118.86**	**0.75**	**95.86**	**0.033**	**4.22**
EG12	EG12	9/3/2008	0.89	1,002.70	0.72	811.17	0.097	109.28
Smith Creek	**SM01**	**9/3/2008**	**1.11**	**234.65**	**0.52**	**109.93**	**0.013**	**2.75**
Story Creek	**ST01**	**9/5/2008**	**0.73**	**43.54**	**0.72**	**42.94**	**0.026**	**1.55**
Dry Creek	**DY01**	**9/5/2008**	**0.31**	**11.60**	**0.36**	**13.47**	**0.024**	**0.90**
East Gallatin Unnamed Trib.	**ET01**	**9/5/2008**	**0.90**	**32.52**	**0.77**	**27.82**	**0.023**	**0.83**
Gibson Creek	**GB01**	**9/5/2008**	**0.54**	**27.08**	**0.55**	**27.58**	**0.016**	**0.80**
EG13-M05EGALR09	EG13	9/5/2008	0.88	1,324.11	0.71	1,068.31	0.073	109.84
EG01-M05EGALR10	EG01	9/8/2008	0.67	1,323.20	0.63	1,244.20	0.05	98.75

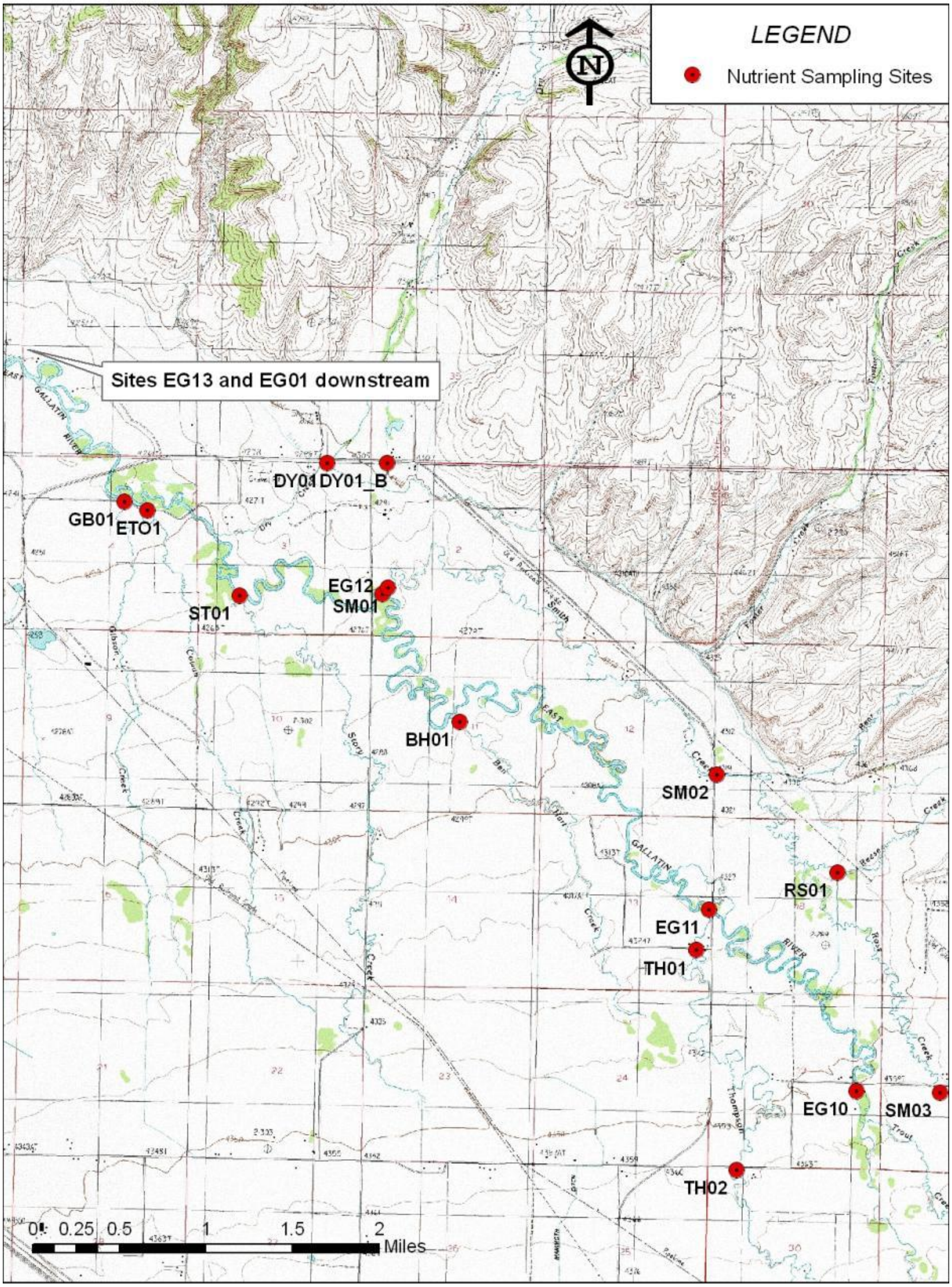

Figure 12. Sites on the lower East Gallatin River and its tributaries.

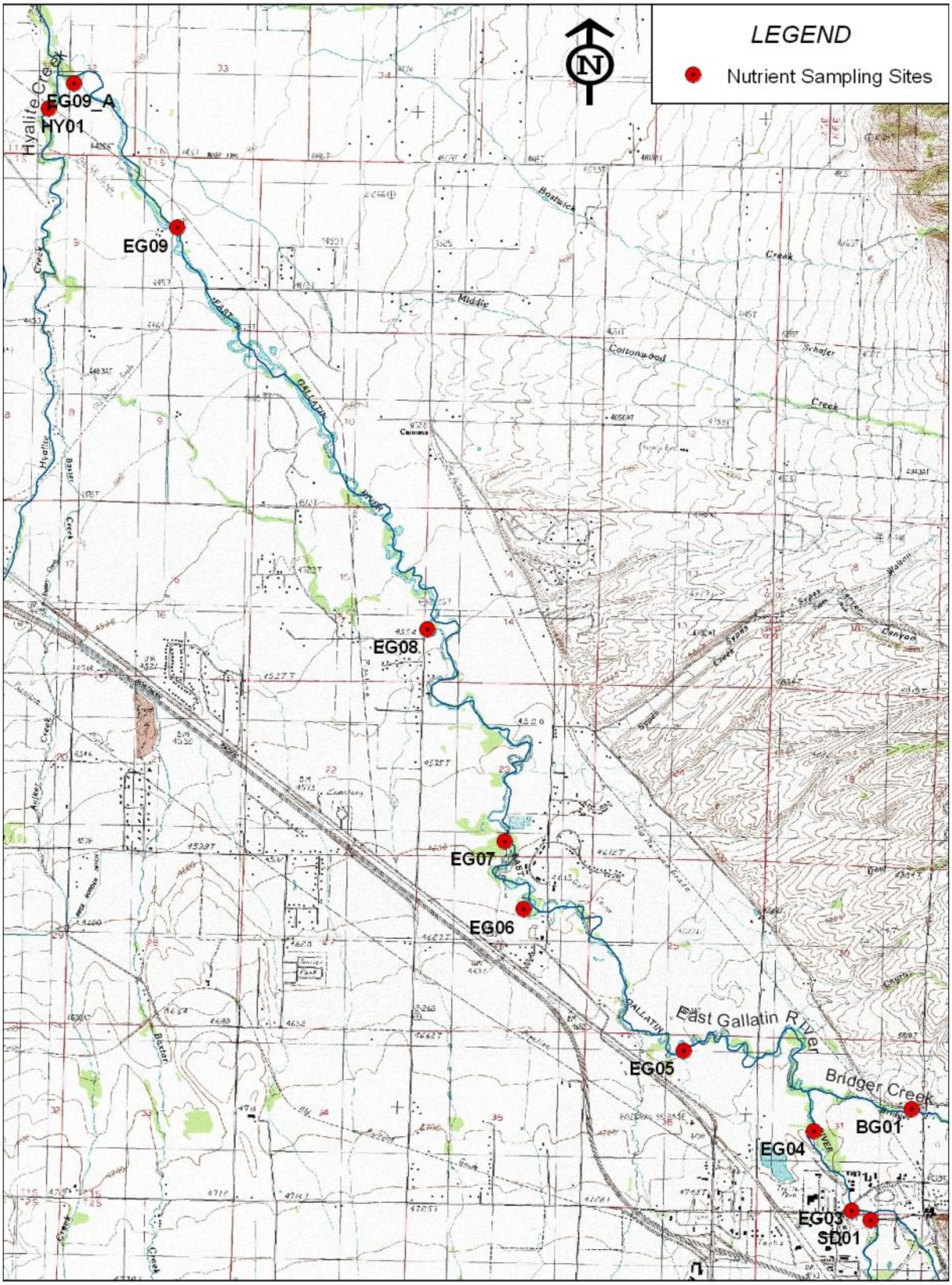

Figure 13. Sites on the upper East Gallatin River and its tributaries.

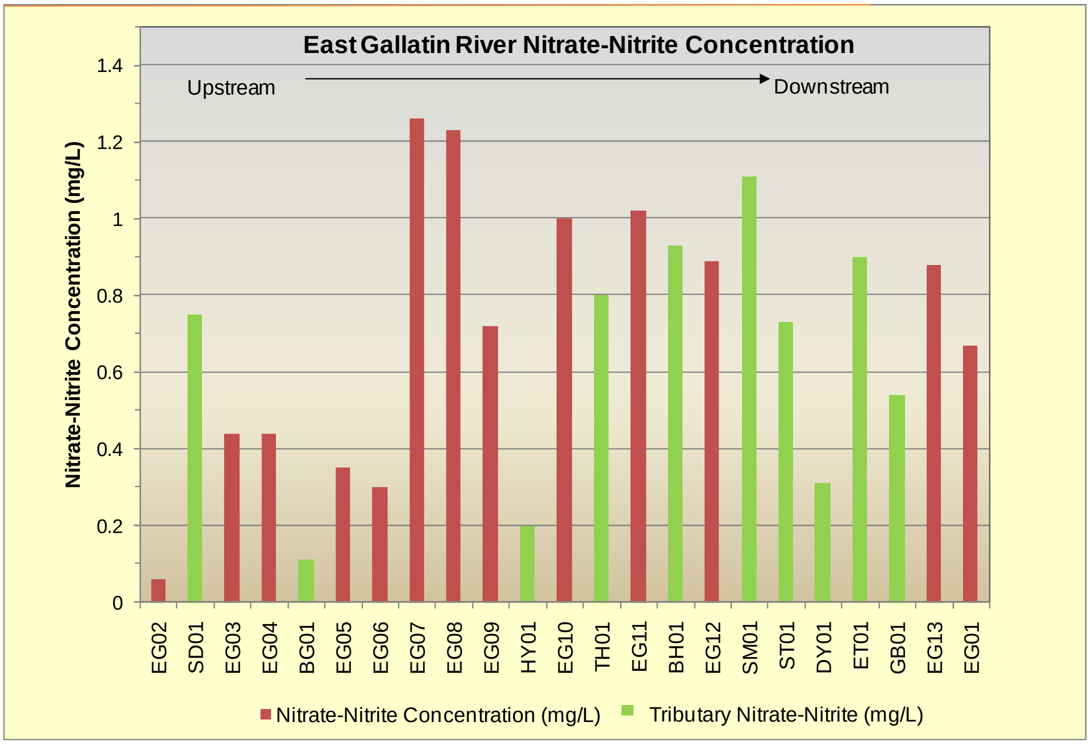

Figure 14. Nitrate-nitrite concentrations in the East Gallatin River and tributaries.

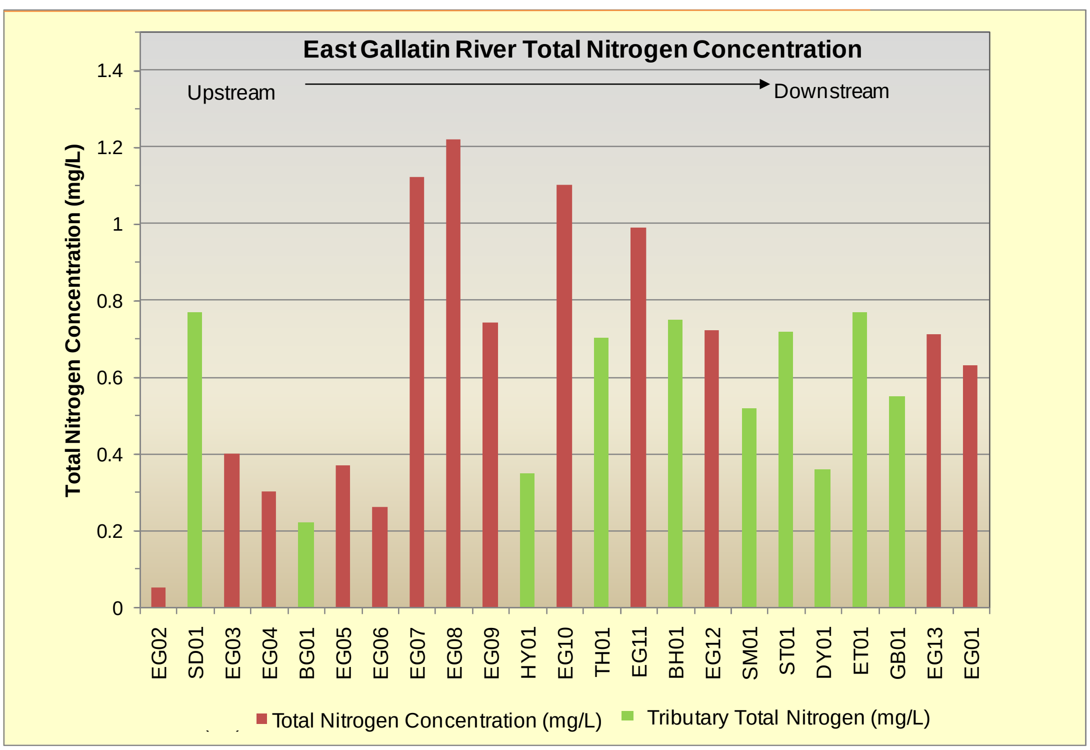

Figure 15. Total nitrogen concentrations in the East Gallatin River and tributaries.

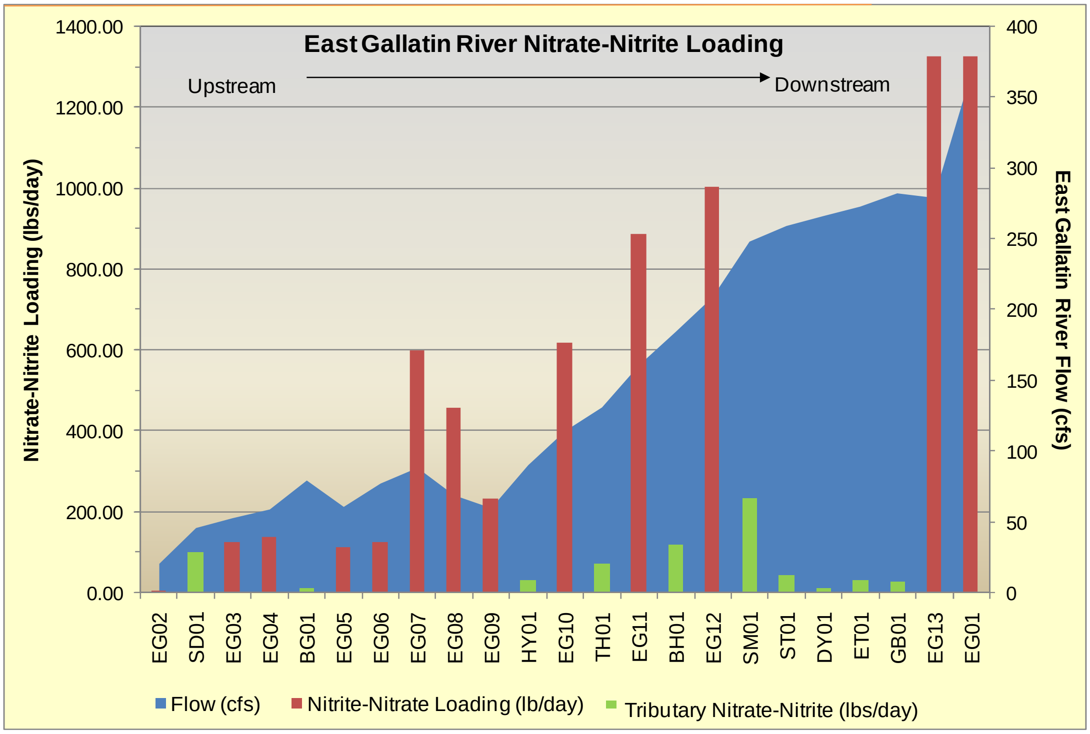

Figure 16. Flow volume and nitrate-nitrite loading in the East Gallatin River and tributaries.

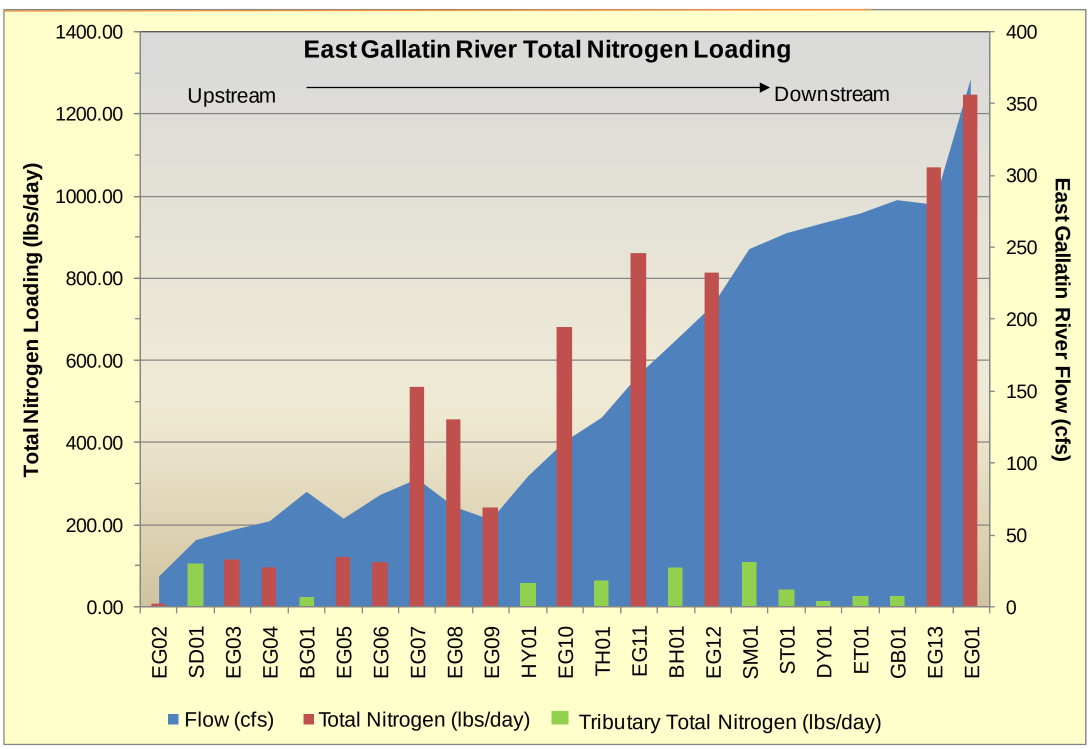

Figure 17. Flow volume and total nitrogen loading in the East Gallatin River and tributaries.

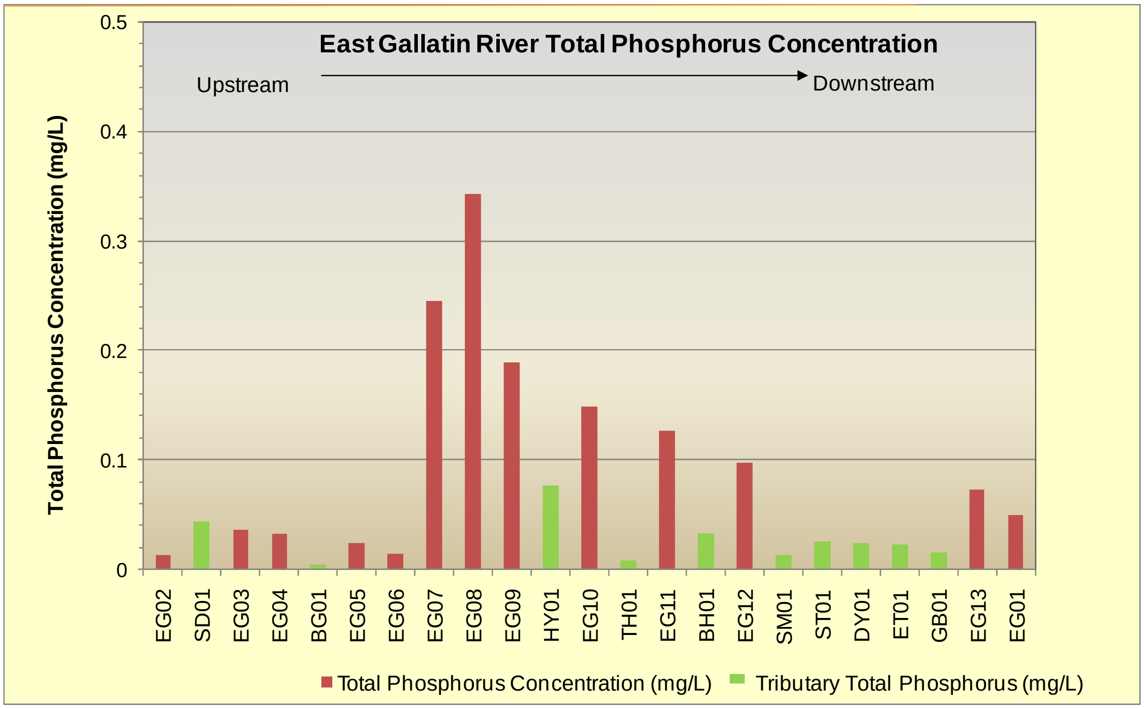

Figure 18. Total phosphorus concentration in the East Gallatin River and tributaries.

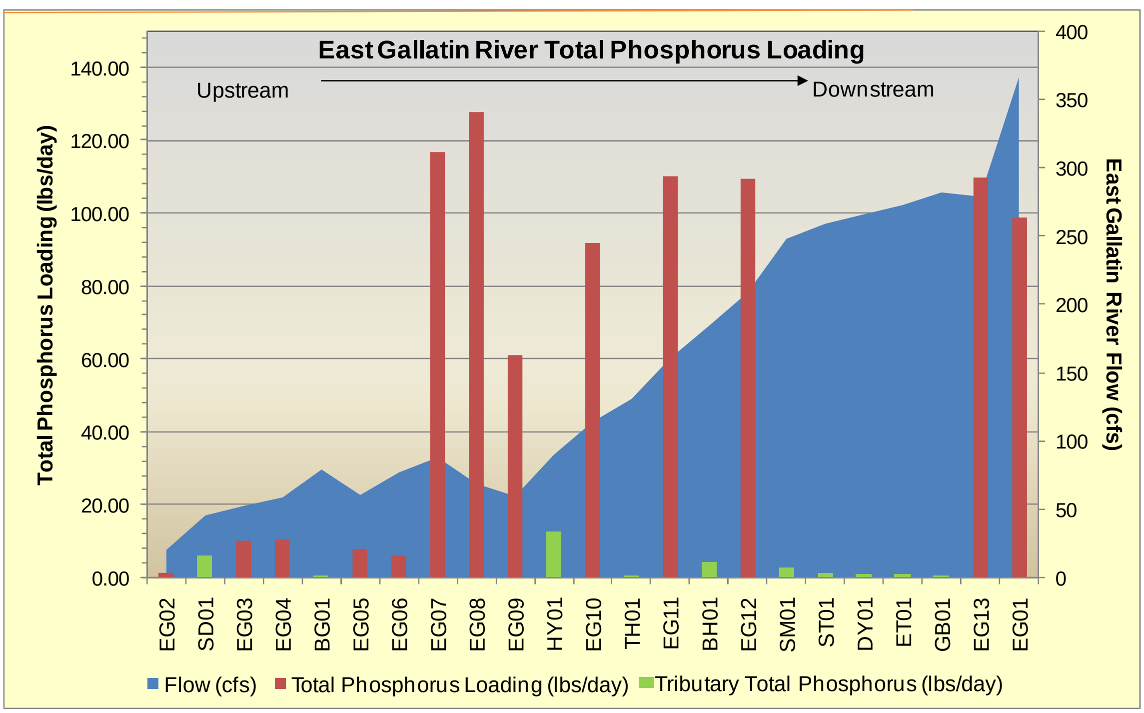

Figure 19. Flow volume and total phosphorus loading in the East Gallatin River and tributaries.

3.2.2. Gallatin River and Tributaries

Camp Creek and the East Gallatin River were the only tributary streams of the Gallatin River sampled in this assessment. The East Gallatin River flows into the Gallatin River north of Manhattan and was considered a tributary to the Gallatin for the purpose of this assessment. Camp Creek enters the Gallatin River north of Dry Creek road approximately 3 miles east of Manhattan. The mapped 303d-listed stream coverage erroneously shows Camp Creek flowing into the Gallatin River approximately 1-2 miles downstream of its true confluence (Figure 1). This 303d stream identified in Figure 1 is, in reality, a large irrigation ditch. The correct location of Camp Creek at the confluence with the Gallatin was sampled in this assessment. Godfrey Creek was most likely a tributary to the Gallatin River. Agriculture and irrigation practices altered the stream channel for Godfrey Creek. Currently, Godfrey Creek terminates at sample site GD01, just north of Churchill, and does not flow into the Gallatin River.

Nitrate-nitrite and total nitrogen concentrations in the Gallatin River and Camp Creek were far lower than concentrations in the East Gallatin River and its tributaries (Figures 20 and 21). The largest contributions of nitrate-nitrite and total nitrogen to the Gallatin River were from Camp Creek and the East Gallatin River. Concentration levels at sites GL02, GL06 and GL07 were below the laboratory analytical detection limits for both nitrate-nitrite and total nitrogen, and levels for these parameters at sites GL05, GL04 and GL03 were low, at or below 0.06 mg/l (Table 4).

Nitrate-nitrite and total nitrogen loading exhibited similar upstream to downstream patterns (Figures 22 and 23). Because the concentrations at sites GL07 and GL06 were below the laboratory detection limits, the load was calculated at zero or minimal. At site GL05 the load was 100 lbs/day but decreased at site GL02, where nitrate-nitrite and total nitrogen were below the detection limit. Camp Creek contributed 100 lbs/day while the East Gallatin delivered the bulk of the loading, approximately 1,300 lbs/day. Total phosphorus loading in the Gallatin was significantly lower than in the East Gallatin, exhibiting similar patterns as nitrate-nitrite and total nitrogen (Figures 24 and 25). Flow measurements at sites GL02 and GL06 were measured in a single channel, thus total flow volume at those sites is estimated for display purposes (Figures 22, 23 and 25).

3.3. Discussion

Nitrate-nitrite, total nitrogen, and total phosphorus concentrations and loading were significantly higher in the East Gallatin River compared to the Gallatin River. All tributary streams sampled in this assessment flowed directly into the East Gallatin except for Camp Creek which flowed directly into the Gallatin. A number of the East Gallatin tributaries flowed though urban areas (e.g. Sourdough Creek) or through agricultural lands. In contrast, many tributary streams to the Gallatin River (not on the TMDL 303d-List and therefore not sampled in this assessment) have headwaters composed of undeveloped forest lands with lower road densities or low density residential development. The lower nutrient concentrations on these tributary streams are likely a reflection of less residential development and disturbance in these watersheds.

Table 4. Nitrate-nitrite, total nitrogen, and total phosphorus concentration and loading in the Gallatin River and tributaries (in bold). Note that nitrate-nitrite and total nitrogen were below laboratory detection levels at sites GL07, GL06 and GL02.

Site	Graph Label	Date	Nitrate-Nitrite (mg/L)	Nitrate-Nitrite Load (lbs/day)	Total Nitrogen (mg/L)	Total Nitrogen Load (lbs/day)	Total Phosphorus (mg/L)	Total Phosphorus (lbs/day)
GL07-M05LGALR02	GL07	9/5/2008	<0.10	<32.4	<0.50	<162. 0	0.01	17.49
GL06-2539GA01	GL06	9/5/2008	<0.10	<33.6	<0.50	<168.0	0.017	3.11
GL05-M05LGALR06	GL05	9/5/2008	0.05	94.03	0.06	112.84	0.012	22.57
GL04-M05LGALR07	GL04	9/3/2008	0.04	66.98	0.04	66.98	0.012	20.09
GL03	GL03	9/3/2008	0.04	22.69	0.05	28.36	0.012	6.81
GL02-M05LGALR10	GL02	9/5/2008	<0.10	<12.0	<0.50	<60.0	0.01	2.77
Camp Creek	**CP01**	**9/15/2008**	**0.20**	**109.16**	**0.17**	**92.32**	**0.005**	**0.97**
East Gallatin River	**EG01**	**9/8/2008**	**0.67**	**1,323.20**	**0.63**	**1,244.20**	**0.05**	**98.75**
GL01-M05LGALR13	GL01	9/8/2008	0.44	1,245.75	0.47	1,330.69	0.032	90.60

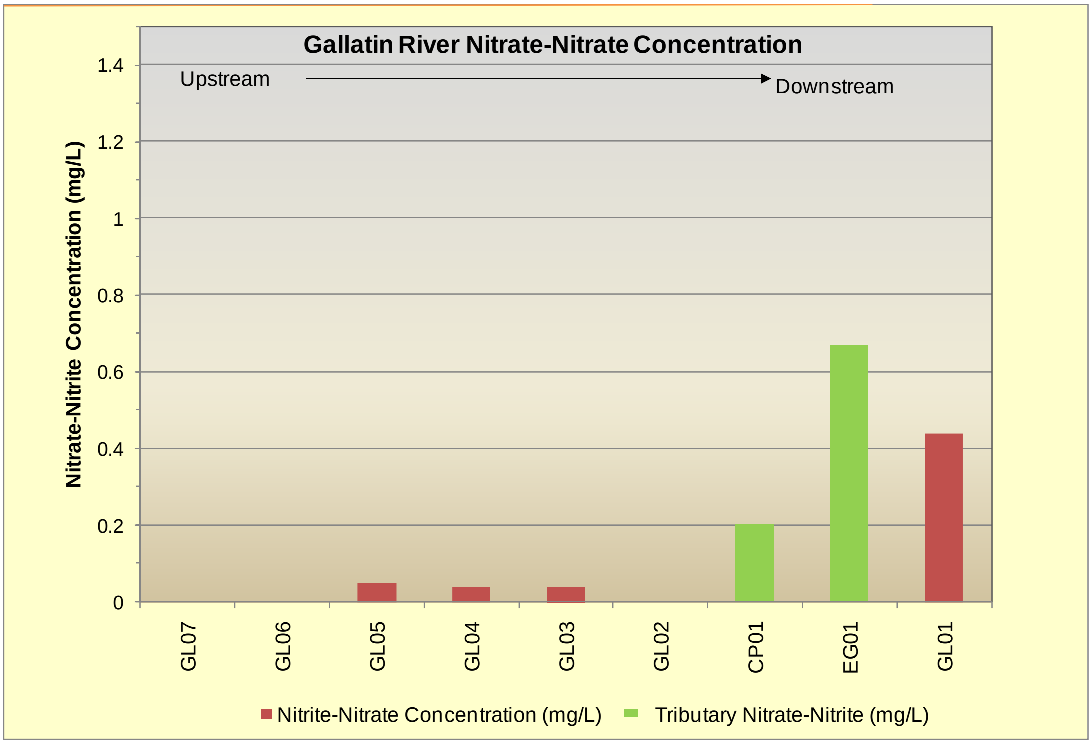

Figure 20. Nitrate-nitrite concentration in the Gallatin River and tributaries.

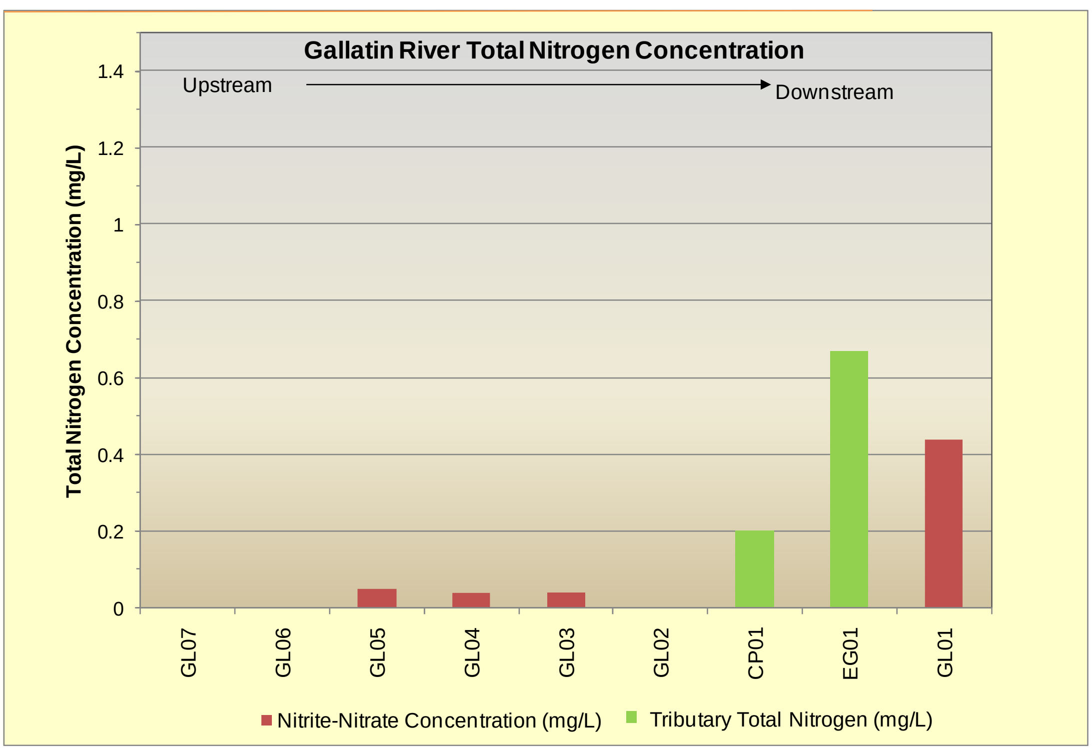

Figure 21. Total nitrogen concentration in the Gallatin River and tributaries

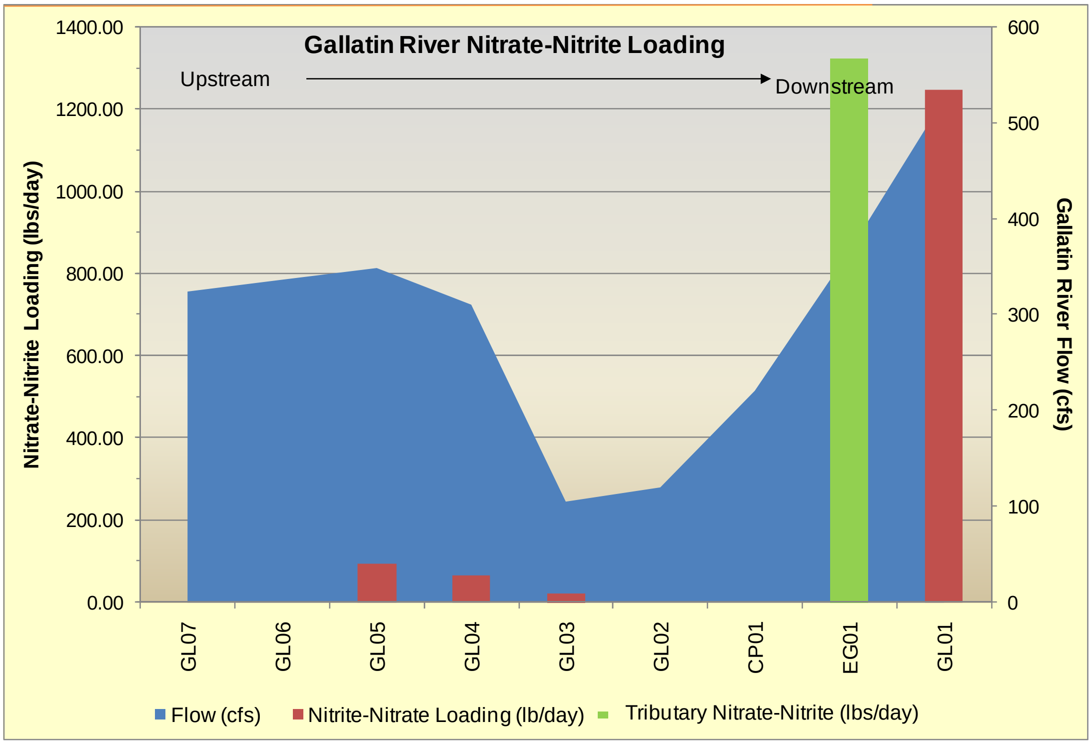

Figure 22. Flow volume and nitrate-nitrite loading in the Gallatin River and tributaries.

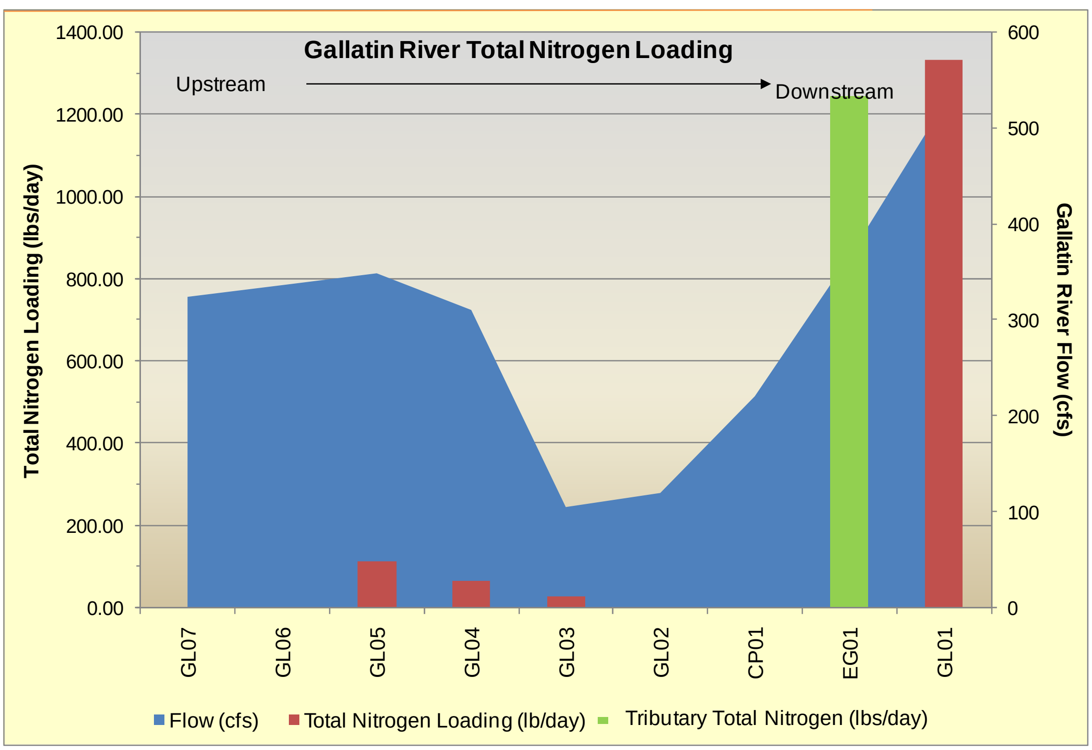

Figure 23. Flow volume and total nitrogen loading in the Gallatin River and tributaries.

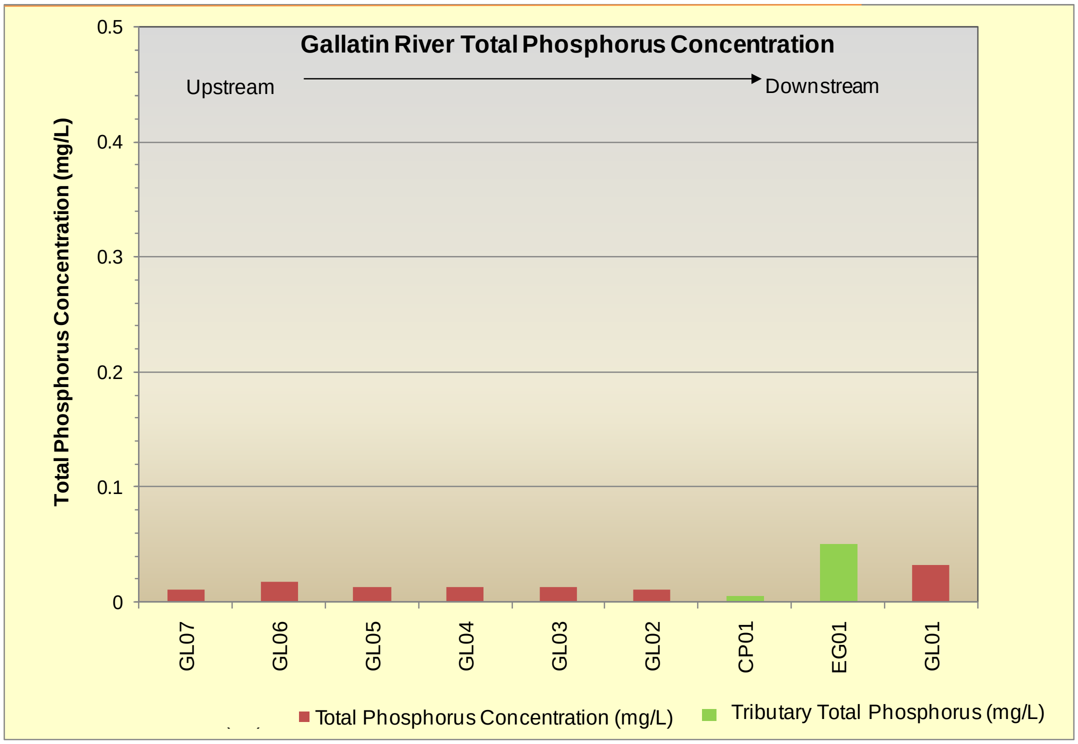

Figure 24. Total phosphorus concentration in the Gallatin River and tributaries.

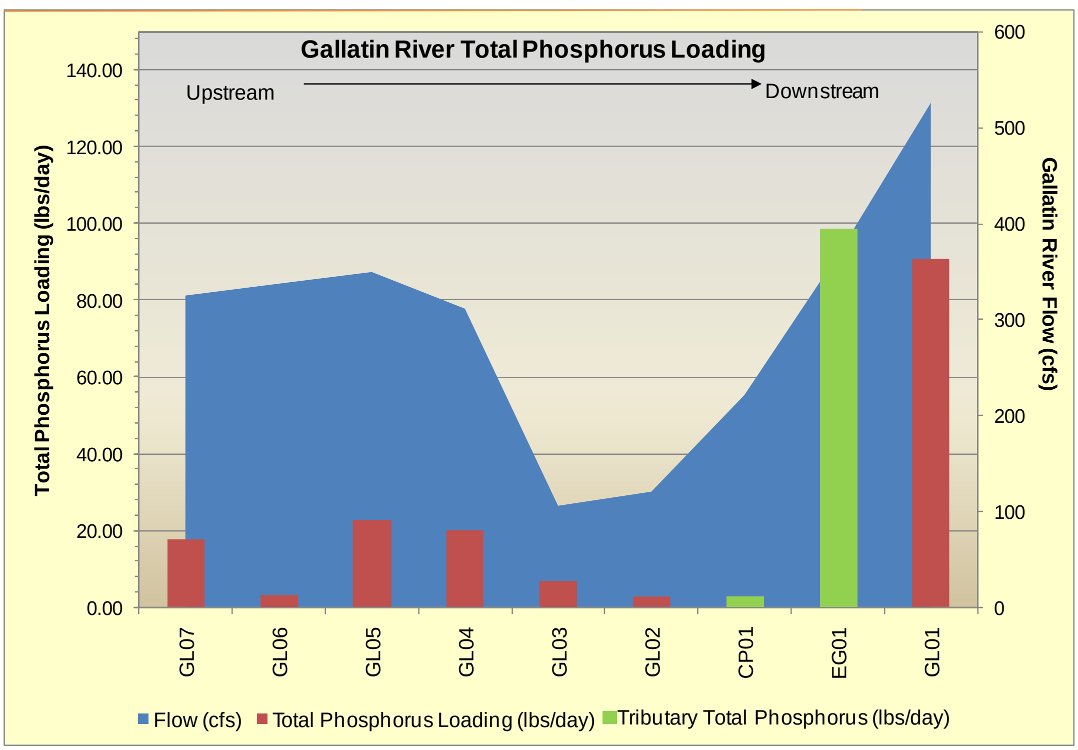

Figure 25. Flow volume and total phosphorus loading in the Gallatin River and tributaries

4. ALGAE/CHLOROPHYLL-A

Some streams are naturally high in nutrients and therefore have greater densities of algae present in the stream. Excess algal growth beyond natural conditions poses a threat to aquatic life as well as an aesthetic concern. High algal densities decrease the amount of habitat available for aquatic insects, in turn, impacting the fish that feed on those insects. Algal decomposition depletes oxygen concentrations resulting in impacts to aquatic life. Several factors contribute to algae growth including lack of streamside shading, water temperature, and inputs of nitrogen and phosphorus to a stream. Therefore, while the measurement of nutrients and physical parameters provide information on conditions at the time of sampling, quantification of algal growth itself serves as an indicator of stream conditions over a longer period of time.

The concentration of chlorophyll *a* per square meter serves as one of several repeatable methods for quantifying algal densities. Chlorophyll *a* is one of the pigments in plants used in the photosynthetic process. The method requires collecting algae from a standard sized surface area of stream bottom. Samples are homogenized and analyzed on a spectrophotometer to quantify chlorophyll a concentrations. The results are reported as the amount of chlorophyll *a* in milligrams present per square meter, or mg/m^2. In this assessment, three field methods were used to sample algae from the stream sites; template, core and hoop methods. The actual field method used was dependent on the type of stream substrate in a given sample transect (e.g. rocky versus muddy) and algae type (e.g. short versus stringy). Example photos of algae sampling methods are presented in Figures 26, 27 and 28. Attachment G of the *LGTPA Data Upload and QAQC Report* (OASIS 2009) provides additional photos of the algae conditions present at each sample site.

4.1. Sampling Activity

Algal density was measured at 44 of the 72 sample sites, distributed across 14 streams. At 10 of these 44 algal sites, sampling was limited to a visual estimate only. Visual estimates were recommended by DEQ for locations where chlorophyll *a* concentrations were estimated to be less than 50 mg/m^2. Sites considered less than 50 mg/m^2 were documented with field notes describing algal conditions and photos. These sites did not warrant further quantitative field sampling. This visual estimation itself provides valuable information that the site does not have excessive algae growth. The sites visually estimated are highlighted in bold in Table 5. The remaining 34 sites were sampled using the quantitative field methods.

4.2. Results

Chlorophyll *a* results spanned a wide range of values (Table 5), from no chlorophyll *a* detected at sites such as upper Hyalite and upper Sourdough creeks (Figure 29), to over 1,700 mg/m^2 measured on the lower sites of the East Gallatin River (Figure 30). Unfortunately, the laboratory contracted to analyze the algal samples failed to adhere to the prescribed analysis procedure for 26 of the 34 quantitative samples. DEQ quality control specialists analyzed the laboratory data to determine what was acceptable for the LGTPA. The quality control specialists coded the laboratory errors as “none”, “minor” and “major”. In the end, DEQ determined that 26 of the 34 samples had “minor” and “major” quality control issues. The integrity of these 26 samples was compromised and, therefore, rejected from the analysis and reporting. The remaining eight samples did not have any lab errors and were coded as “None” by DEQ (Table 5).

The 8 samples labeled as “None” in the quality control codes are graphed in Figure 31. Thirteen additional samples coded as “Minor” are graphed in Figure 32. Note that while these 13 samples are estimates and cannot be used to develop a TMDL, they are useful for assessing a rough concentration of the chlorophyll *a* present at each of the sites. With the exception of one site, EG01, all of the chlorophyll *a* samples coded as “None” or “Minor” were below 100 mg/m^2. Site EG01 resulted in 1,795 mg/m^2 of chlorophyll *a.* Sixteen sample sites contained less than 50 mg/m^2 of chlorophyll *a*. These laboratory results support visual estimates for the 10 sites where chlorophyll *a* concentrations were estimated to be less than 50 mg/m^2.

4.3. Discussion

Because data from 26 of the algae sample sites was rejected due to laboratory errors, it is difficult to summarize the longitudinal patterns in algal densities for the LGTPA. Based on the 10 samples sites that were visually estimated to have less than 50 mg/m^2 algae and on the remaining 8 samples, algae concentrations within the LGTPA were relatively low, with the exception of the lower East Gallatin River which had high levels of algae growth. Further algal monitoring will be necessary to conclusively assess algae levels within the LGTPA and longitudinal influence of nutrients on algal densities.

Figure 26. Template method used for scraping algae from stream substrate.

Figure 27. Filtering algae scraped from a sampled rock.

Figure 28. Sampling algae in Thompson Spring Creek using the hoop method.

Figure 29. Upper Sourdough Creek visually estimated to have less than 50 mg/m^2 of chlorophyll *a.*

Figure 30. Dense stringy algae in the lower East Gallatin River.

Table 5. Results of Chlorophyll *a* analysis at the 44 sampled sites. Sites visually estimated are in bold.

Site	Stream	Results (mg/m2)	QC Code*
BG01	Bridger Creek	26.7	None
BG02-M05BRIDC03	Bridger Creek	1.18	Minor
BG04	Bridger Creek	6.74	None
BG05-M05BRIDC04	Bridger Creek	1.35	None
BR02	Bear Creek	/	Major
BR04-M05BEARC05	**Bear Creek**	**<50**	**Visually Estimated**
CP01	Camp Creek	/	Major
CP03-M05CAMPC03	**Camp Creek**	**<50**	**Visually Estimated**
DY01	Dry Creek	18.4	Minor
DY02	Dry Creek	51.6	Minor
EG01-M05EGALR10	East Gallatin River	1796	Minor
EG02-M05EGALR01	East Gallatin River	31.5	Minor
EG04-M05EGALR03	East Gallatin River	6.92	Minor
EG05-M05EGALR04	East Gallatin River	34.9	Minor
EG07-M05EGALR06	East Gallatin River	80.1	Minor
EG08	East Gallatin River	/	Major
EG09_A	East Gallatin River	58.4	Minor
EG10	East Gallatin River	/	Major
EG11-M05EGALR08	East Gallatin River	/	Major
EG12	East Gallatin River	/	Major
EG13-M05EGALR09	East Gallatin River	/	Major
GD01-2738GO01	Godfrey Creek	42.4	None
GD03	Godfrey Creek	/	Major
GL02-M05LGALR10	Gallatin River	10.6	None
GL06-2539GA01	Gallatin River	30.2	None
HY01	Hyalite Creek	/	Major
HY02	Hyalite Creek	24.3	None
HY03	**Hyalite Creek**	**<50**	**Visually Estimated**
HY04	Hyalite Creek	0.383	None
JK01-M05JAKSC02	Jackson Creek	85.7	Minor
JK03-WMTP990749	**Jackson Creek**	**<50**	**Visually Estimated**
RK01	**Rocky Creek**	**<50**	**Visually Estimated**
RS01	**Reese Creek**	**<50**	**Visually Estimated**
RS02	**Reese Creek**	10.8	Minor
SD01-M05BOZMC01	**Sourdough Creek**	**<50**	**Visually Estimated**
SD03	**Sourdough Creek**	**<50**	**Visually Estimated**
SD04	Sourdough Creek	Non-Detect	Minor
SD05-M05SOURC01	**Sourdough Creek**	**<50**	**Visually Estimated**
SD06	**Sourdough Creek**	**<50**	**Visually Estimated**
SM01	Smith Creek	/	Major
SM02	Smith Creek	Non-Detect	Minor
SM04	Smith Creek	/	Major
TH01-M05TMPSC01	Thompson Spring Cr	/	Major
TH02-M05TMPSC02	Thompson Spring Cr	/	Major

*Major: samples rejected due to lab analysis errors
*Minor: fewer lab errors, sample excluded from analysis

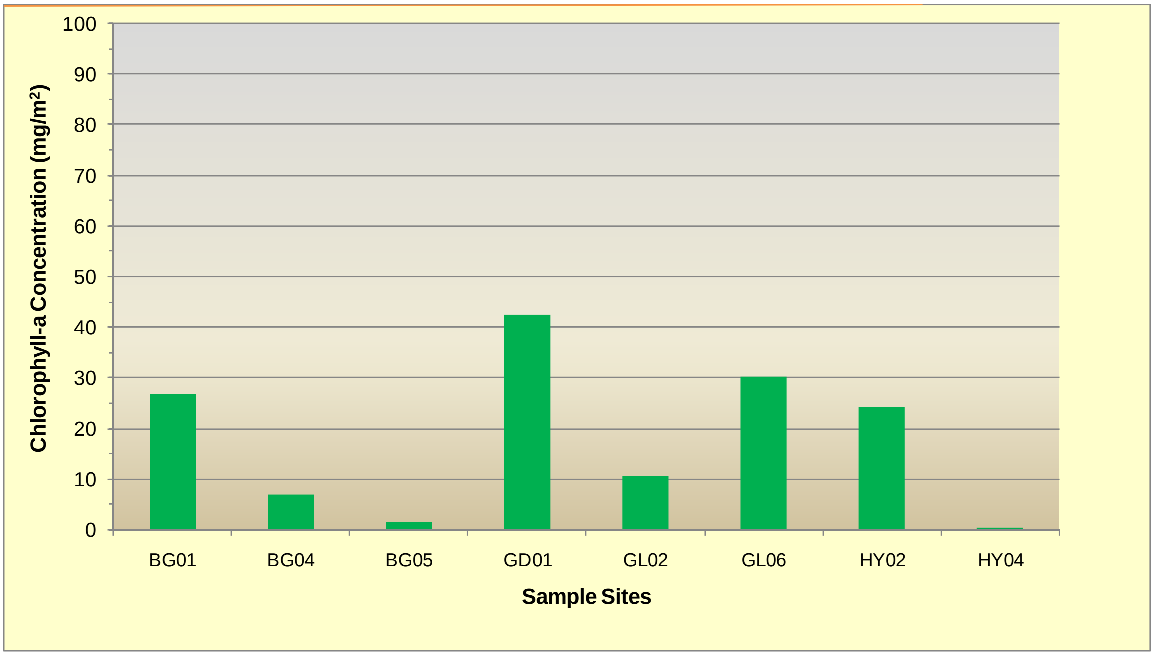

Figure 31. Chlorophyll *a* concentration at the eight sample sites where no lab errors occurred.

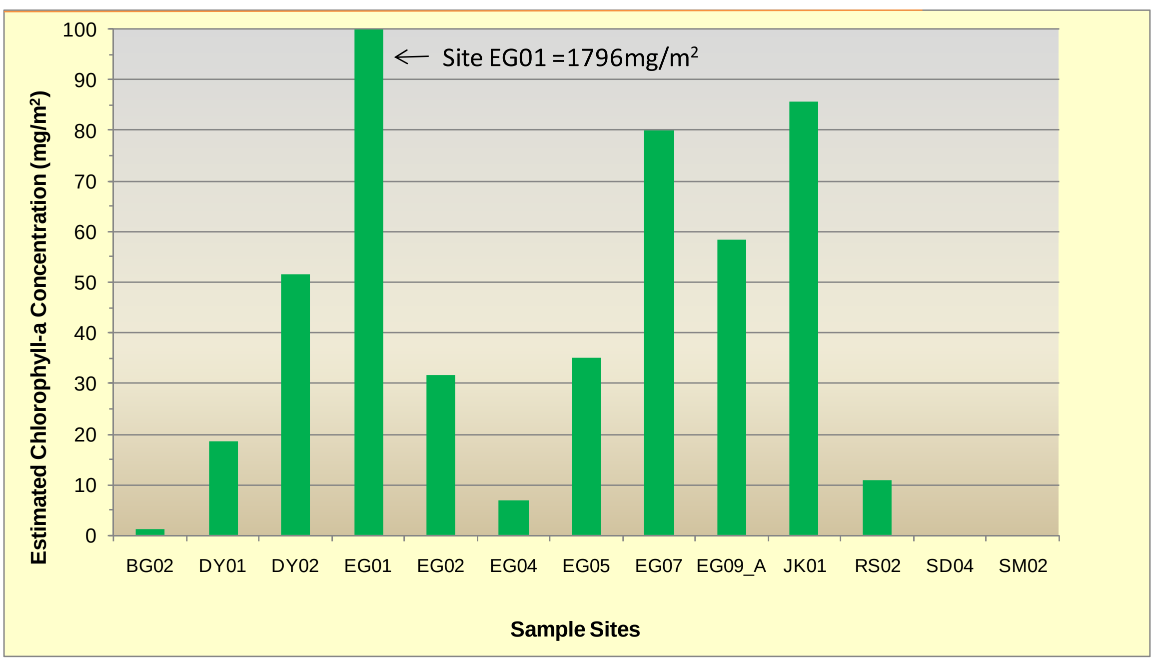

Figure 32. Chlorophyll *a* ESTIMATED concentration at the thirteen sample sites where lab errors occurred (coded as "Minor"). Note that this data will not be used to develop a TMDL but is useful for estimating algae concentration.

5. CONCLUSIONS

Data collected during the late summer, low flow conditions in the LGTPA indicates that the East Gallatin River and its tributary streams have areas of higher nutrients, chlorophyll *a*, and *E. coli,* primarily in the lower elevations of the watershed. In contrast, the forested headwater segments at higher elevations have relatively low nutrient and chlorophyll *a* concentrations. The Gallatin River had lower nutrient and chlorophyll *a* concentrations upstream of the confluence with the East Gallatin River which delivered the highest nutrient load to the Gallatin River. Results indicated that Reese, Smith, Sourdough, Upper Camp, Lower Camp, and Godfrey Creeks were all impaired due to *E. coli*, which could in turn be delivering high *E. coli* concentrations to the East Gallatin and Gallatin Rivers. Additional sampling of nutrients, algae and *E. coli* should be conducted in 2009 to further assess pollutant levels and sources in support of a TMDL Plan for the LGTPA.

None of the 8 quantitative algal samples exceeded nuisance algal levels of 150 mg/m^2. Due to significant errors handling algal samples at the laboratory, further sampling will be necessary to assess algae growth across the LGTPA.

6. REFERENCES

Department of Environmental Quality, DEQ. 2004. Montana Numeric Water Quality Standards, Circular WQB-7. 38 pp.

OASIS Environmental, Inc. 2008. Lower Gallatin TMDL Planning Area Nutrient, *E. coli,* and Algae Sampling and Analysis Plan. August 18, 2008.

OASIS Environmental, Inc. 2009. Lower Gallatin TMDL Planning Area Data Upload and QAQC Report. February 2009.