WATER QUALITY MONITORING REPORT 2008

Upper Gallatin TMDL Planning Area

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 Introduction

The Montana Department of Environmental Quality is required to develop Total Maximum Daily Loads (TMDLs) for the Upper Gallatin TMDL Planning Area (TPA) in order to satisfy Montana state law[1] as well as federal court requirements[2]. This report addresses pathogen, nutrient and chlorophyll *a* monitoring conducted in the West Fork Gallatin River watershed in July and August of 2008 in support of TMDL development. Data generated during this assessment will provide information useful in evaluating pathogen and nutrient related water quality conditions in the Upper Gallatin TPA.

1.1 Montana Standards

In the State of Montana, the growth and propagation of fish and associated aquatic life, drinking water, agriculture, industrial supply, recreation, and wildlife are considered beneficial uses of water bodies. Beneficial use support is determined based on comparison with Montana's ambient surface water quality standards. Water bodies failing to support one or more beneficial uses are listed as impaired on the *303(d) List of Impaired and Threatened Waterbodies in Need of Water Quality Restoration*. The development of TMDLs is required for all pollutants responsible for impairment. The 2006 303(d) List indicates that *E. coli*, nutrients and sediment are causes of impairment for streams in the West Fork Gallatin River watershed and, consequently, require the development of total maximum daily loads.

1.1.1 Pathogen Standards

The State of Montana's standards for pathogen pollutants vary based on the classification of the water body. The Gallatin River and its tributary streams outside of Yellowstone National Park are classified **B-1 water bodies** by the State of Montana.

> *Waters classified B-1 are to be maintained suitable for drinking, culinary and food processing purposes, after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply [MCA 17.30.623(1)].*

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/100mL and 10% of the total samples may not exceed 252 cfu/100mL during any 30-day period between April 1 through October 31* [ARM 17.30.623 (2)(i)] (**Table 1-1**). *From November 1 through March 31, the geometric mean number of E. coli may not exceed 630 cfu/100mL and 10% of the samples may not exceed 1,260 cfu/100mL during any 30-day period* [ARM

[1] MCA 75-5-703
[2] Settlement Agreement: *Friends of the Wild Swan v. EPA*

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)].

Table 1-1. Montana Standards for Pathogen Pollutants for B-1 Water Bodies.

Applicable Period	Standard	Geometric mean of 5 samples collected over a 30-day time period	No more than 10% of the samples shall exceed:
April 1 - October 31 ("summer")	The geometric mean number of ***E-coli*** may not exceed 126 colony forming units per 100 milliliters and 10% of the total samples may not exceed 252 colony forming units per 100 milliliters during any 30-day period (ARM 17.30.623 (2)(i)).	<126 cfu/100mL	252 cfu/100mL
November 1 - March 31 ("winter")	The geometric mean number of ***E-coli*** may not exceed 630 colony forming units per 100 milliliters and 10% of the samples may not exceed 1,260 colony forming units per 100 milliliters during any 30-day period (ARM 17.30.623 (2)(ii)).	<630 cfu/100mL	1,260 cfu/100mL

1.1.2 Nutrient Standards

Waters in Montana are protected from excessive nutrient concentrations by narrative standards, which stipulate:

> "*State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will create conditions which produce undesirable aquatic life*" [ARM 17.30.637 (1)(e)].

Montana has recently developed recommended numeric nutrient and benthic algae targets, which are presented in **Table 1-2** for the Middle Rockies Level III Ecoregion in which the West Fork Gallatin River watershed is located (Suplee et al. 2008). These water quality targets are applicable between July 1st and September 30th.

Table 1-2. Recommended Numeric Nutrient and Benthic Algae Targets for the Middle Rockies Ecoregion (Suplee et al. 2008).

Parameter	Criteria
Total Phosphorus	0.048 mg/L
Total Nitrogen	0.320 mg/L
Nitrate+Nitrite Nitrogen	0.100 mg/L
Benthic Algae / Chlorophyll *a* concentration	150 mg/m²

2.0 Study Design

The objectives of this assessment are to:

- Quantify pathogen (*E. coli*) levels throughout the West Fork Gallatin River watershed.
- Identify potential sources of pathogens throughout the West Fork Gallatin River watershed.
- Provide additional information regarding chlorophyll *a* concentrations and algae growth in the West Fork Gallatin River watershed.

To accomplish these objectives, *E. coli*, nutrient and chlorophyll *a* samples were collected within the West Fork Gallatin River watershed in July and August of 2008. Additional information regarding monitoring parameters, assessment sites and methodologies is available in the sampling and analysis plans for this project:

> *Upper Gallatin TMDL Planning Area Pathogen Monitoring Sampling and Analysis Plan Addendum, July 3, 2008*, which presents modifications to the *Upper Gallatin TMDL Planning Area Pathogen Monitoring Sampling and Analysis Plan* prepared in June of 2006.
>
> *Upper Gallatin TMDL Planning Area Biological Monitoring Sampling and Analysis Plan Addendum, July 3, 2008*, which presents modifications to the *Upper Gallatin TMDL Planning Area Biological Monitoring Sampling and Analysis Plan* prepared in September of 2005.

2.1 Monitoring Sites

Pathogen, nutrient and chlorophyll *a* monitoring was conducted in the Upper Gallatin TPA during two monitoring events in the summer of 2008. Monitoring was conducted during the July 21st-24th timeframe and the August 25th-28th timeframe. Monitoring was targeted to capture mid-summer pathogen concentrations and algae growth. Pathogen monitoring occurred at 24 sites and chlorophyll *a* monitoring occurred at 12 sites.

2.1.1 Pathogen and Nutrient Monitoring Sites

A total of **24 monitoring sites** were assessed for *E.coli*, nutrients and total suspended solids (TSS), including:

- six sites on the Middle Fork West Fork Gallatin River,
- four sites on un-named tributaries of the Middle Fork West Fork Gallatin River,
- one site on Beehive Creek,
- one site on the North Fork West Fork Gallatin River,
- six sites on the West Fork Gallatin River,
- three sites on the South Fork West Fork Gallatin River,
- one site on a tributary to the South Fork West Fork Gallatin River,

- one site on Swan Creek, and
- one site on Hell Roaring Creek.

Pathogen and nutrient monitoring sites in the West Fork Gallatin River watershed are presented in **Figure 2-1** and in **Appendix A,** while sites outside of the West Fork Gallatin River watershed are presented in **Figure 2-2**.

2.1.2 Chlorophyll *a* Monitoring Sites

A total of **12 monitoring sites** were assessed for chlorophyll *a*, including:

- three sites on the Middle Fork West Fork Gallatin River,
- six sites on the West Fork Gallatin River, and
- three sites on the South Fork West Fork Gallatin River.

Chlorophyll *a* monitoring sites in the West Fork Gallatin River watershed are presented in **Figure 2-3** and in **Appendix B**.

2.2 Monitoring Parameters

2.2.1 Escherichia coli (*E. coli*)

E. coli was recently adopted as the indictor organism for pathogen pollutants in Montana water bodies. *E. coli* is bacteria that is usually associated with pathogens transmitted by fecal contamination. While the presence of *E. coli* does not always prove or disprove the presence of human pathogen bacteria, viruses, or protozoans, *E. coli* is assumed to indicate the presence of human pathogens (USEPA 2001). Monitoring of the indicator organism is done since it is more easily sampled and measured. Thus, *E. coli* concentrations were measured to assess existing pathogen loads and to identify and quantify potential pathogen sources.

2.2.2 Nutrients

Nitrate+nitrite nitrogen, total nitrogen and total phosphorus concentrations were measured during this study as supporting information to help evaluate potential sources of nitrogen and pathogen loading, and to evaluate attainment of water quality targets (**Table 1-2**).

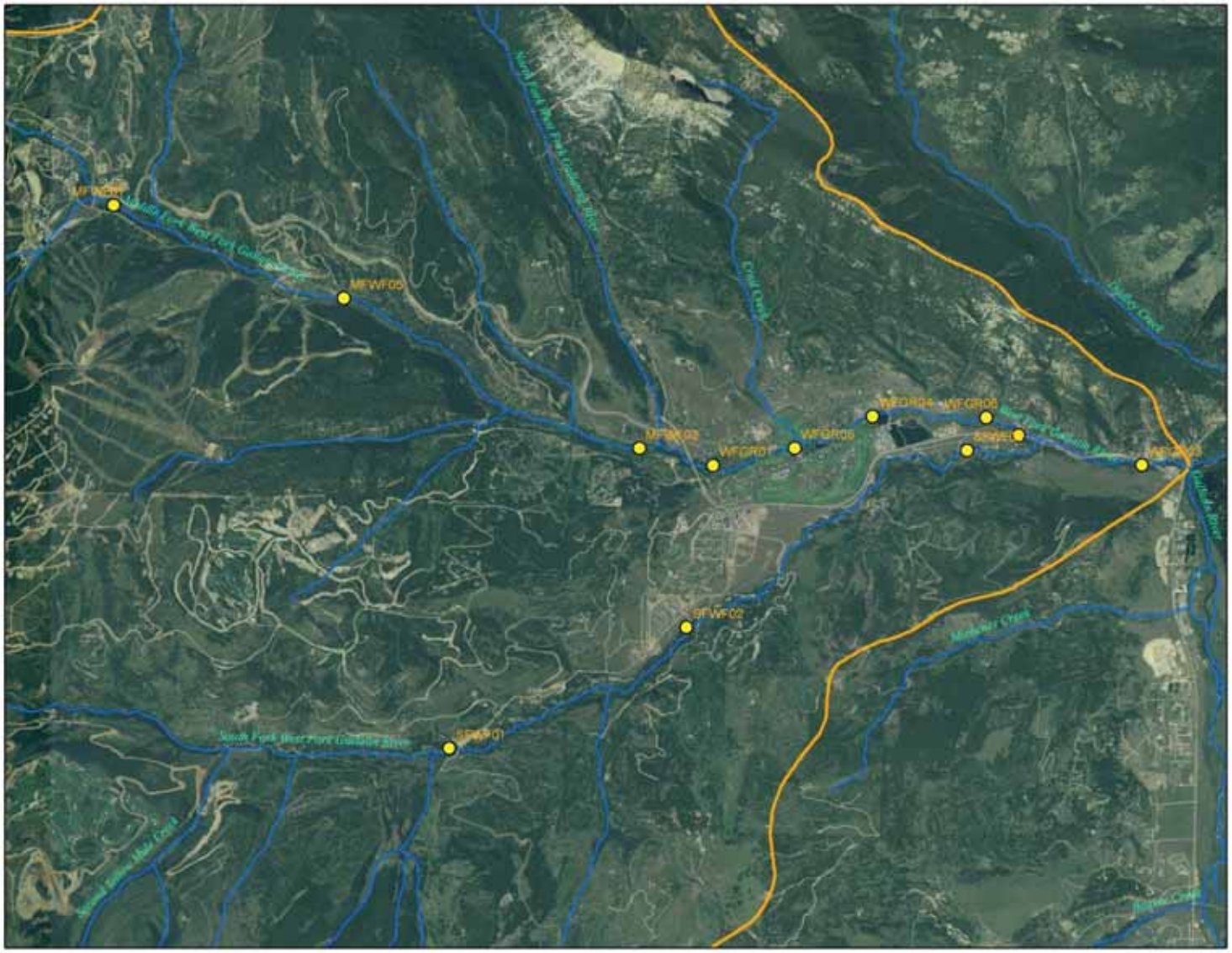
2.2.3 Chlorophyll *a*

Excessive levels of benthic algae growth on stream substrates due to nutrient enrichment can impair the recreation and possibly the aquatic life and coldwater fisheries beneficial uses. When excessive algae growth occurs, Montana's narrative standard relating to "undesirable aquatic life" may be exceeded. Benthic algae growth can by quantified be measuring Chlorophyll *a* concentrations, making this parameter useful in evaluating attainment of water quality targets and in the development of nutrient TMDLs. In addition, chlorophyll *a* data helps provide a better understanding of the cumulative and intermittent impacts that may have occurred over time in a stream.

Figure 2-1. Pathogen and Nutrient Monitoring Sites in the West Fork Gallatin River Watershed.

Figure 2-2. Pathogen and Nutrient Monitoring Sites outside of the West Fork Gallatin River Watershed.

Figure 2-3. Chlorophyll *a* Monitoring Sites in the West Fork Gallatin River Watershed.



3.0 Results

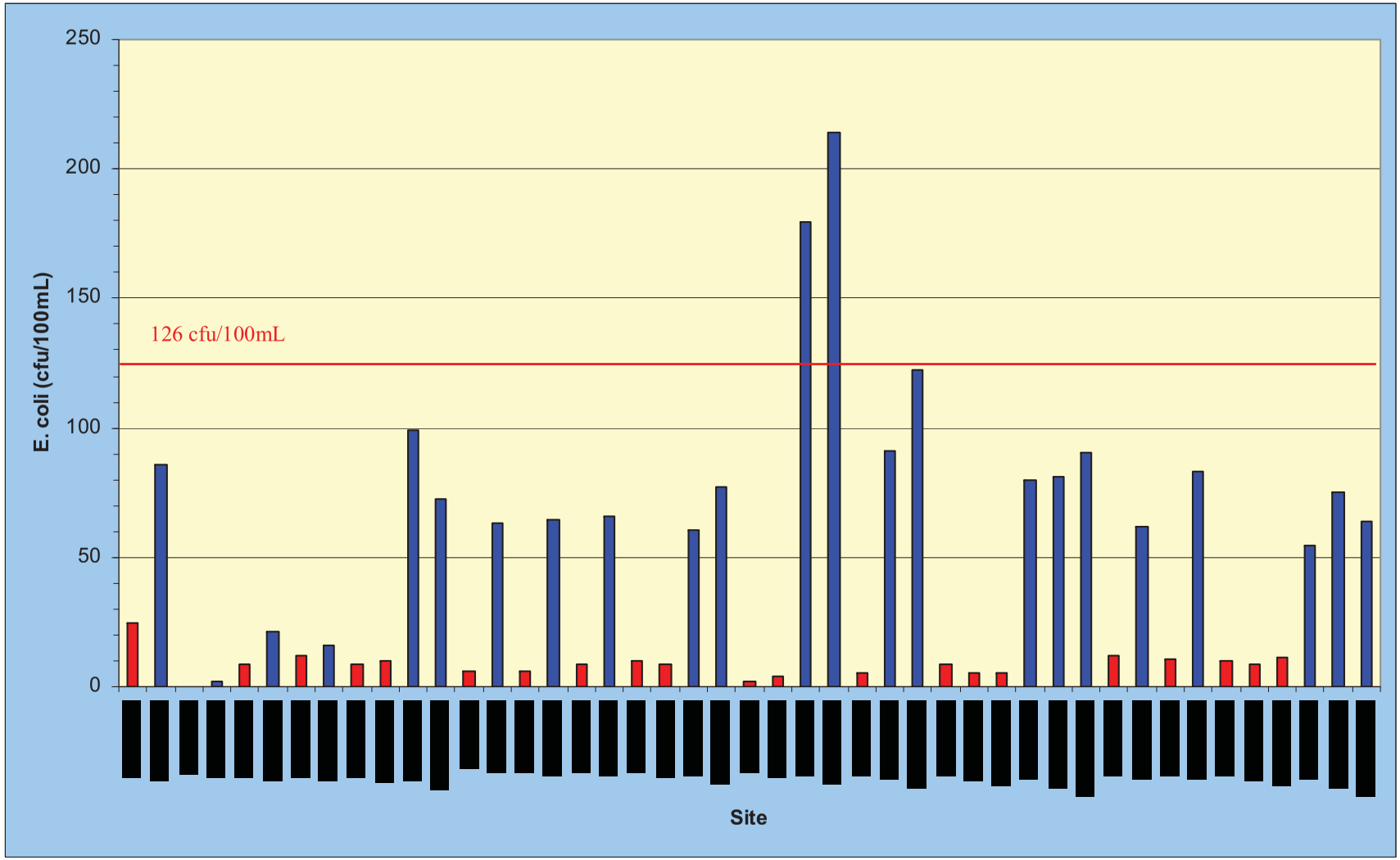
3.1 Pathogen Data

Pathogen concentrations remained relatively low at all sites during the July monitoring event, with a maximum value of 72 cfu/100mL at Antler (MFTR05), which is a site on a small un-named tributary to the Middle Fork West Fork Gallatin River that was referred to as Antler Creek during for the purposes of this assessment. All other sites remained below a concentration of 25 cfu/100mL in July. Pathogen concentrations increased between the July and August monitoring events at all sites as depicted in **Figure 3-1**. This may be due to a decrease in streamflows between July and August. During the August monitoring event, the maximum *E. coli* concentration was 365 cfu/100mL at Sitting Bull 2 (MFTR02), which is a small un-named tributary of the Middle Fork West Fork Gallatin River that flows into Lake Levinsky. Thirteen out of the 24 sample sites had *E. coli* concentrations in the range of 50-100 cfu/100mL during the August monitoring event, including sites on the Middle Fork West Fork Gallatin River, South Fork West Fork Gallatin River, West Fork Gallatin River, and two of the tributaries of the Middle Fork West Fork Gallatin River.

3.2 Nutrient Data

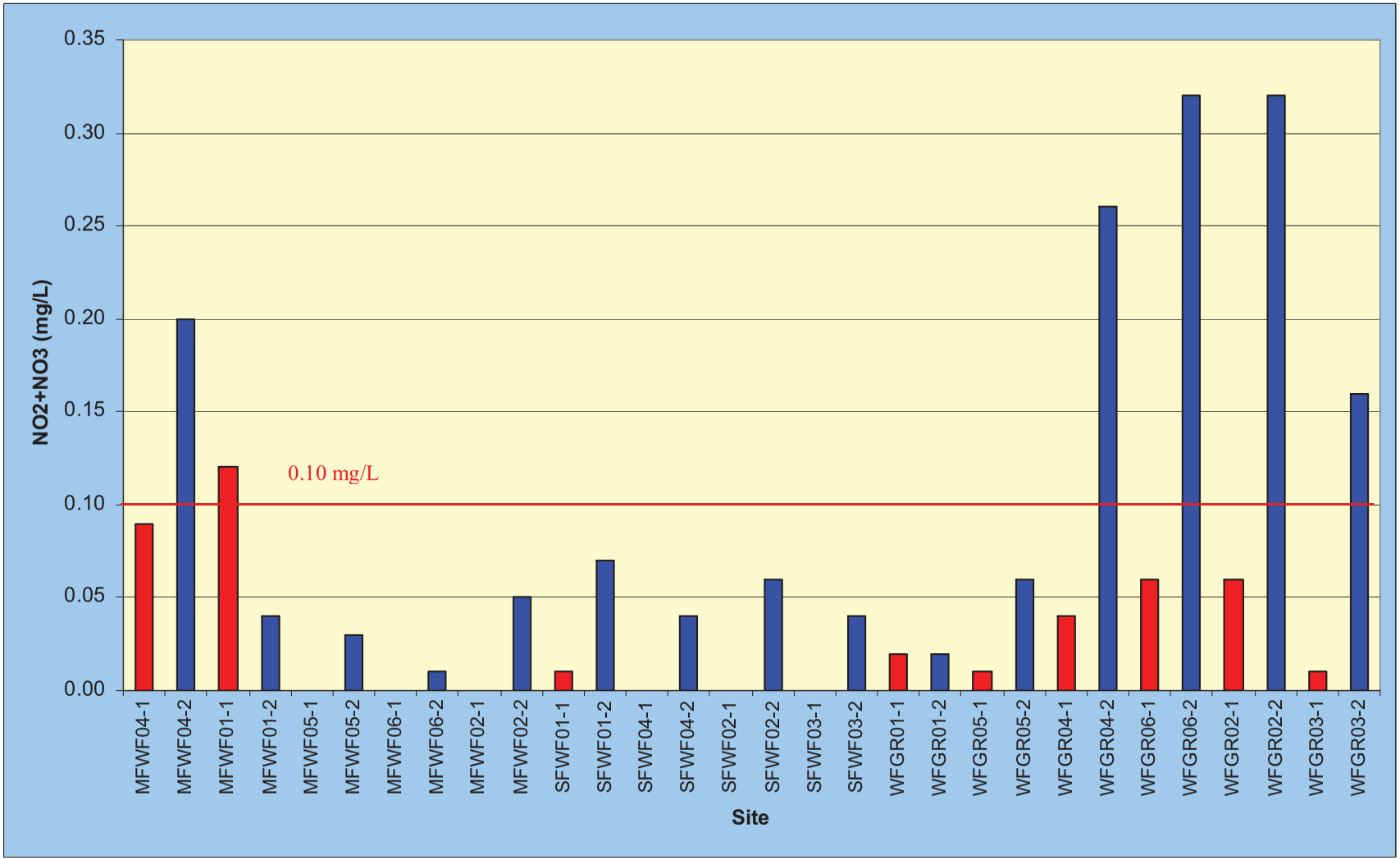
Nitrate+nitrite nitrogen, total nitrogen and total phosphorus concentrations were generally higher during the August monitoring event than during the July monitoring event. This may be due to greater streamflows during the July monitoring event, which were approximately four times higher on average than streamflows during the August monitoring event. During the August monitoring event, elevated nitrate+nitrite concentrations were documented in the Middle Fork West Fork Gallatin River upstream of Lake Levinsky (MFWF04) and in the West Fork Gallatin River starting at the Little Coyote site (WFGR04), which is located at the downstream end of the golf course (**Figure 3-2**). A maximum nitrate+nitrite concentration of 0.32 mg/L was measured at both the BSWSD site (WFGR06) and the J Walker site (WFGR02) during the August monitoring event. Total nitrogen concentrations mirrored the nitrate+nitrite concentrations, with elevated levels in the Middle Fork West Fork Gallatin River headwaters and along the West Fork Gallatin River from the golf course downstream (**Figure 3-3**). A maximum total nitrogen concentration of 0.52 mg/L was measured at the BSWSD site (WFGR06) during the August monitoring event. Total phosphorus concentrations were relatively low throughout the study area, with a maximum total phosphorus concentration of 0.020 mg/L recorded at the Sitting Bull 1 site (MFWF04) during the August monitoring event (**Figure 3-4**).

Figure 3-1. Pathogen Concentrations, July 23 and August 27, 2008.



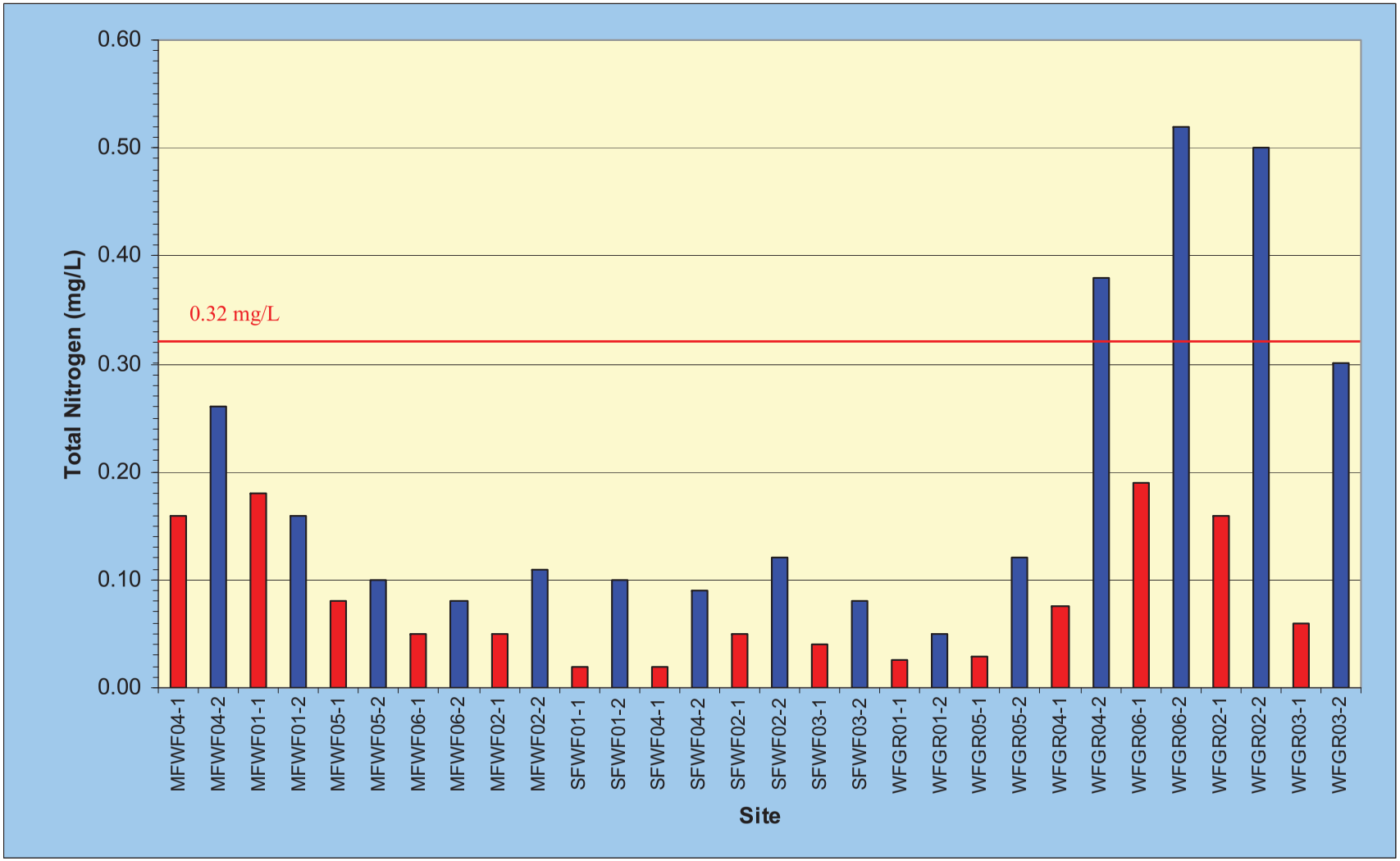
Red = July (1), Blue = August (2). Replicate samples depicted as: -11, -22. Triplicate samples depicted as: -111, -222. Chart does not include tributary sites. Water quality standard of 126 cfu/100mL included for reference, though the standard is evaluated as the geometric mean of five samples and not the result of a single sample, which is presented here.

Figure 3-2. Nitrate+nitrite Concentrations, July 23 and August 27, 2008.



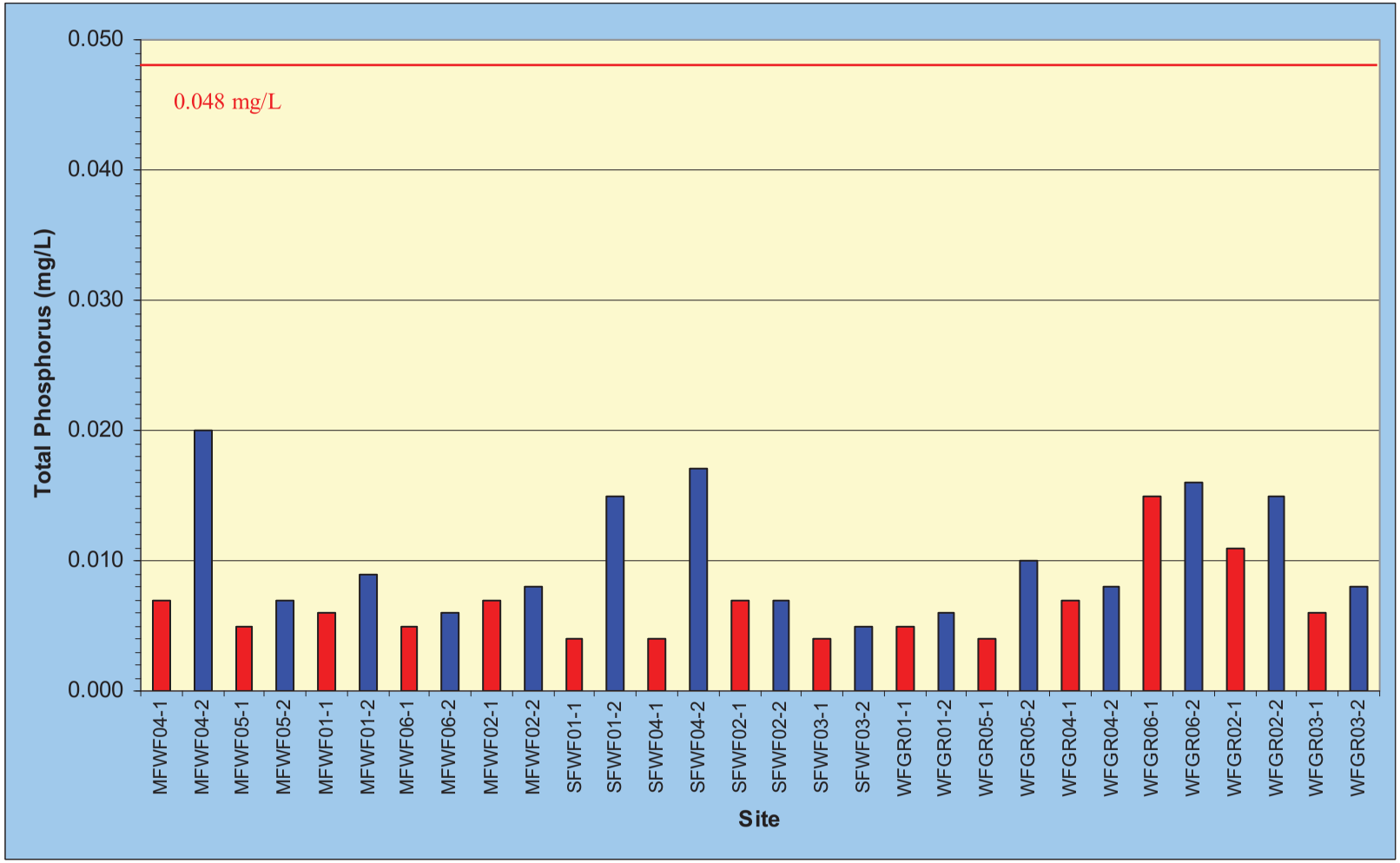
Red = July (1), Blue = August (2). Chart does not include tributary sites. Recommended nitrate+nitrite target of 0.10 mg/L for the Middle Rockies ecoregion included for reference.

Figure 3-3. Total Nitrogen Concentrations, July 23 and August 27, 2008.



Red = July (1), Blue = August (2). Chart does not include tributary sites. Recommended total nitrogen target of 0.32 mg/L for the Middle Rockies ecoregion included for reference.

Figure 3-4. Total Phosphorus Concentrations, July 23 and August 27, 2008.

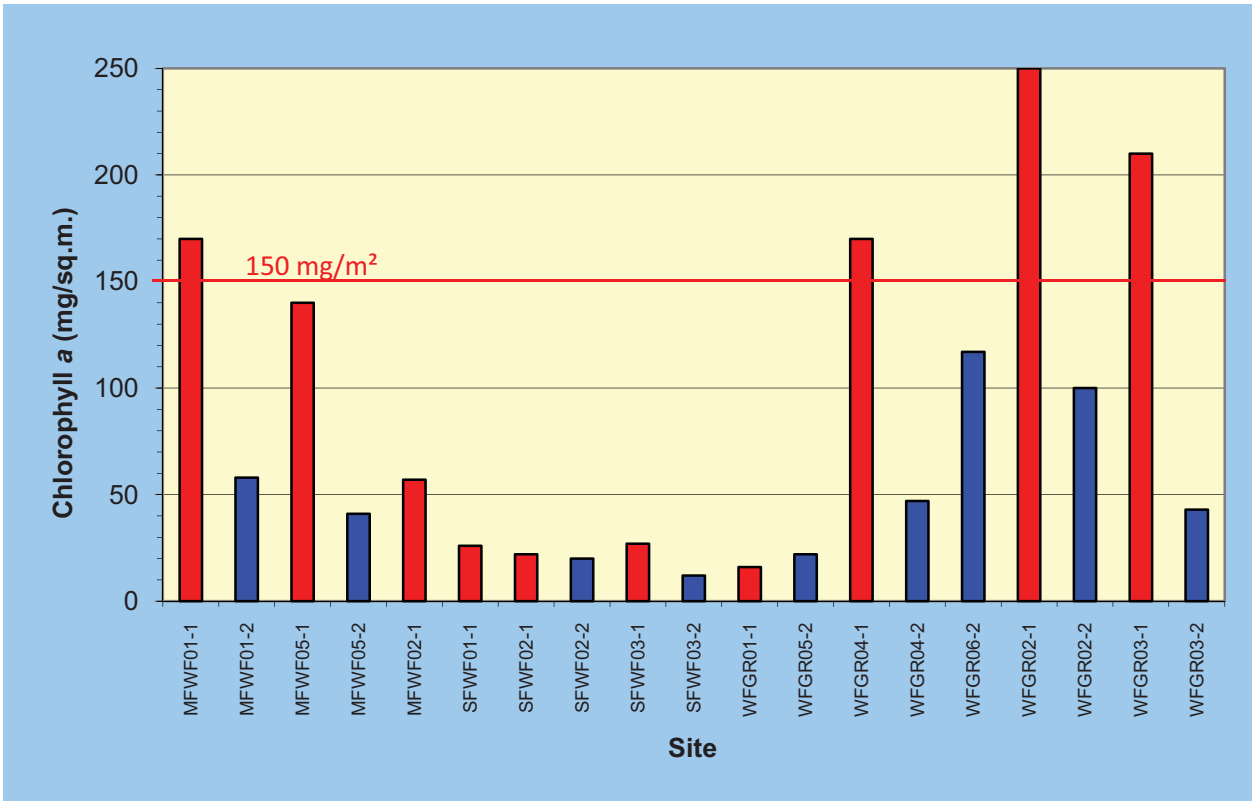


Red = July (1), Blue = August (2). Chart does not include tributary sites. Recommended total phosphorus target of 0.048 mg/L for the Middle Rockies ecoregion included for reference.

3.3 Chlorophyll *a* Data

Chlorophyll *a* concentrations were assessed at 12 sites within the West Fork Gallatin River watershed. Chlorophyll *a* concentrations were higher during July than during August (**Figure 3-5**). During the July chlorophyll *a* monitoring event, a total of 12 sites were examined for chlorophyll *a* concentrations and samples were collected at 10 of these sites. No chlorophyll *a* samples were collected at sites WFGR05 and WFGR06 in July since algae concentrations appeared to resemble concentrations at sampled sites that were in close proximity (WFGR01 and WFGR02, respectively). During the August chlorophyll *a* monitoring event, a total of 12 sites were examined for chlorophyll *a* concentrations and samples were collected at 9 of these sites. No chlorophyll *a* samples were collected at the following sites since algae concentrations were thought to be below 50 mg/m²: SFWF01, MFWF02, and WFGR01. During the August monitoring event, samples were collected at sites WFGR05 and WFGR06 in an attempt to pinpoint the location of increased algae concentrations in the West Fork Gallatin River. Only photos were recorded at these sites during the July monitoring event.

Figure 3-5. Chlorophyll *a* Concentrations, July and August, 2008.



Red = July (1), Blue = August (2). Recommended chlorophyll *a* target of 150 mg/m² for the Middle Rockies ecoregion included for reference.

3.3.1 Middle Fork West Fork Gallatin River

A total of three sites were assessed on the Middle Fork West Fork Gallatin River.

At the site below Lake Levinsky (MFWF01), chlorophyll *a* data was collected in both July and August. In July, a chlorophyll *a* concentration of 170 mg/m² was recorded, while in August a chlorophyll *a* concentration of 58 mg/m² was recorded (**Figure 3-6**).

Figure 3-6. MFWF01 (below Lake Levinsky) on July 22 (170 mg/m²) and August 25 (58 mg/m²), 2008.

At the Lone Moose site (MFWF05), chlorophyll *a* data was collected in both July and August. In July, a chlorophyll *a* concentration of 140 mg/m² was recorded, while in August a chlorophyll *a* concentration of 41 mg/m² was recorded (**Figure 3-7**).

Figure 3-7. MFWF05 (Lone Moose) on July 22 (140 mg/m²) and August 25 (41 mg/m²), 2008.

The Beaver Dam site (MFWF02) was assessed during both July and August. In July, there was a thin layer of brown algae on the rocks and a chlorophyll *a* concentration of 57 mg/m² was

recorded (**Figure 3-8**). In August, the streambed appeared free of any algae and no sample was collected.

Figure 3-8. MFWF02 (Beaver Dam) on July 22 (57 mg/m²) and August, 2008.

Overall, algae growth appeared to decrease in the downstream direction in the Middle Fork West Fork Gallatin River.

3.3.2 South Fork West Fork Gallatin River

A total of three sites were assessed on the South Fork West Fork Gallatin River.

The site upstream of Ousel Falls (SFWF01) was assessed during both July and August. In July, there was a thin layer of "slippery" brown algae on the rocks and a chlorophyll *a* concentration of 26 mg/m² was recorded (**Figure 3-9**). In August, the streambed appeared free of any algae and no sample was collected. During the August monitoring event, the streambed in the swiftly flowing portion of the channel was free of algae and siltation, though a fine layer of sediment was trapped by algae on rocks located in shallow and slow flowing portions of the channel (**Figure 3-10**).

Figure 3-9. SFWF01 (above Ousel Falls) on July 21 (26 mg/m²) and August 25, 2008.

Figure 3-10. SFWF01 Fine Sediment Accumulations, August 25, 2008.

At the Streamside site (SFWF02), chlorophyll *a* data was collected in both July and August. In July, a chlorophyll *a* concentration of 22 mg/m² was recorded, while in August a chlorophyll *a* concentration of 20 mg/m² was recorded (**Figure 3-11**). During both monitoring events, a bright green band of filamentous algae was observed along the river left side of the channel extending downstream of the erosive hillslope along the river left bank. This band of bright green algae was more pronounced during August (**Figure 3-12**).

Figure 3-11. SFWF02 (Streamside) on July 21 (22 mg/m²) and August 25 (20 mg/m²), 2008.

Figure 3-12. SFWF02 Algae Growth along the River Left Side of the Channel, August 25, 2008.

At the Elkhorn site (SFWF03), chlorophyll *a* data was collected in both July and August. In July, a chlorophyll *a* concentration of 27 mg/m² was recorded, while in August a chlorophyll *a* concentration of 12 mg/m² was recorded (**Figure 3-13**). In July, there was a thin layer of "slippery" brown algae on the rocks, while filamentous green algae was observed in August. Similar to the Streamside site (SFWF02), algae coverage at this site was also "spotty" in August (**Figure 3-14**).

Figure 3-13. SFWF03 (Elkhorn) on July 21 (27 mg/m²) and August 25 (12 mg/m²), 2008.

Figure 3-14. SFWF03 Algae Growth, August 25, 2008.

Overall, chlorophyll *a* concentrations were relatively low in the South Fork West Fork Gallatin River during monitoring in 2008. In July, chlorophyll *a* concentrations remained relatively constant between the three sites. In August, the maximum chlorophyll *a* concentration was recorded at the Streamside site (SFWF02) and decreased slightly at the Elkhorn site (SFWF03).

3.3.3 West Fork Gallatin River

A total of six sites were assessed on the West Fork Gallatin River.

The Two Moons site (WFGR01) was assessed during both July and August. In July, there was a thin layer of "slippery" brown algae on the rocks and a chlorophyll *a* concentration of 16 mg/m² was recorded (**Figure 3-15**). In August, the streambed appeared free of any algae and no sample was collected.

Figure 3-15. WFGR01 (Two Moons) on July 21 (16 mg/m²) and August 25, 2008.

At the Golf 1.5 site (WFGR05), chlorophyll *a* data was assessed in both July and August. In July, no sample was collected since algae conditions resembled those of the site upstream (WFGR01), which had a chlorophyll *a* concentration of 16 mg/m². In August, a chlorophyll *a* concentration of 22 mg/m² was recorded (**Figure 3-16**).

Figure 3-16. WFGR05 (Golf 1.5) on July 21 and August 25 (22 mg/m²), 2008.

At the Little Coyote site (WFGR04), chlorophyll *a* data was collected in both July and August. In July, a chlorophyll *a* concentration of 170 mg/m² was recorded, while in August a chlorophyll *a* concentration of 47 mg/m² was recorded (**Figure 3-17**). During the July monitoring event, chlorophyll *a* concentrations increased from a value of 16 mg/m² at the Two Moons site (WFGR01), which is located upstream of the golf course, to 170 mg/m² at the Little Coyote site, which is located at the downstream end of the golf course. During the August monitoring event, chlorophyll *a* concentrations increased from 22 mg/m² at the Golf 1.5 site (WFGR05), which is near the upstream end of the golf course, to 47 mg/m² at the Little Coyote site. During August, chlorophyll *a* concentrations increased to 117 mg/m² at the BSWSD site (WFGR06), which is the next site downstream.

Figure 3-17. WFGR04 (Little Coyote) on July 21 (170 mg/m²) and August 26 (47 mg/m²), 2008.

At the BSWSD site (WFGR06), chlorophyll *a* data was assessed in both July and August. In July, no sample was collected since algae conditions resembled those of the next site downstream (WFGR02), which had a chlorophyll *a* concentration of 250 mg/m². In August, a chlorophyll *a* concentration of 117 mg/m² was recorded (**Figure 3-18**). Bright green filamentous algae was observed during the August monitoring event (**Figure 3-19)**.

Figure 3-18. WFGR06 (BSWSD) on July 22 and August 27 (117 mg/m²), 2008.

Figure 3-19. WFGR06 Algae Growth, August 26, 2008.

At the J Walker site (WFGR02), chlorophyll *a* data was collected in both July and August. In July, a chlorophyll *a* concentration of 250 mg/m² was recorded, while in August a chlorophyll *a* concentration of 100 mg/m² was recorded (**Figure 3-20**). Algae coverage was relatively homogenous at this site. Sites WFGR02 and WFGR06 are located downstream of the waste water treatment ponds. These sites are within close proximity and may approximate a replicate sample. This conclusion is supported by similar values at these two sites in August of 2008, with a chlorophyll *a* concentration of 117 mg/m² at site WFGR06 and a concentration of 100 mg/m² at site WFGR02.

Figure 3-20. WFGR05 (J Walker) on July 22 (250 mg/m²) and August 25 (100 mg/m²), 2008.

At the West site (WFGR03), chlorophyll *a* data was collected in both July and August. In July, a chlorophyll *a* concentration of 210 mg/m² was recorded, while in August a chlorophyll *a* concentration of 43 mg/m² was recorded (**Figure 3-21**). Similar to the Streamside (SFWF02) and Elkhorn (SFWF03) sites, algae coverage at this site was also "spotty" in August of 2008, with long strands of bright green filamentous algae growing in the portion of the channel with swiftly flowing water (**Figure 3-22**).

Figure 3-21. WFGR03 (West) on July 22 (210 mg/m²) and August 26 (43 mg/m²), 2008.

Figure 3-22. WFGR03 Algae Growth, August 25, 2008.

Algae growth within the West Fork Gallatin River varies along its length. There was relatively little growth at the upper end of the stream, which is formed at the confluence of the North Fork West Fork Gallatin River and the Middle Fork West Fork Gallatin River. Algae growth increases in a downstream direction along the golf course and the waster water treatment ponds, with generally homogenous growth across the entire streambed at the sites just upstream of the confluence with the South Fork West Fork Gallatin River. Downstream of the confluence with the South Fork West Fork Gallatin River, algae growth is more "spotty" and is concentrated in areas with rapidly flowing water. This is similar to conditions found on the South Fork West Fork upstream of the confluence with the West Fork Gallatin River. Thus, the mainstem of the

West Fork Gallatin River may more closely resemble conditions of the South Fork West Fork Gallatin River downstream of the their confluence.

4.0 Pollutant Loading Calculations

Pathogen and nutrient loading calculations were performed in an attempt to identify potential sources of pollutants. Pathogen and nutrient loads were compared cumulatively progressing in a downstream direction for the two monitoring events that were conducted throughout the West Fork Gallatin River watershed in 2008. A similar assessment was performed for the pathogen and nutrient data collected in 2006 and 2007 and can be reviewed in *Pathogen Monitoring Report 2006-2007* (PBS&J 2008). *E. coli* and nitrate+nitrite pollutant load calculations for each site are presented in **Appendix C**.

4.1 Pathogen Loads

E. coli loads were generally higher during the August monitoring timeframe than during the July monitoring timeframe, though two of the sites on the Middle Fork West Fork Gallatin River downstream of Lake Levinsky, along with Beehive Creek and the North Fork West Fork Gallatin River had lower *E. coli* loads in August. During the July monitoring event, *E. coli* loads increased in a downstream direction along the Middle Fork West Fork Gallatin River and West Fork Gallatin River, with a steady increase between the Two Moons site and the BSWSD site on the West Fork Gallatin River (**Figure 4-1**). In August, the highest *E. coli* load was recorded at the Two Moons site, while the load remained relatively stable downstream to the confluence with the South Fork West Fork Gallatin River (**Figure 4-2**).

4.2 Nutrient Loads

Nitrate+nitrite loads were lower during the August monitoring timeframe for the majority of the sites on the Middle Fork West Fork Gallatin River, while sites on the West Fork Gallatin River tended to have higher nitrate+nitrite loads in August. During both the July and August monitoring timeframes, the nitrate+nitrite load increased notably between the Golf 1.5 site and the Little Coyote site on the West Fork Gallatin River and then continued to increase downstream to the BSWSD site (**Figures 4-3** and **4-4**).

Figure 4-1. *E .coli* Loads Progressing Downstream, July 23, 2008.

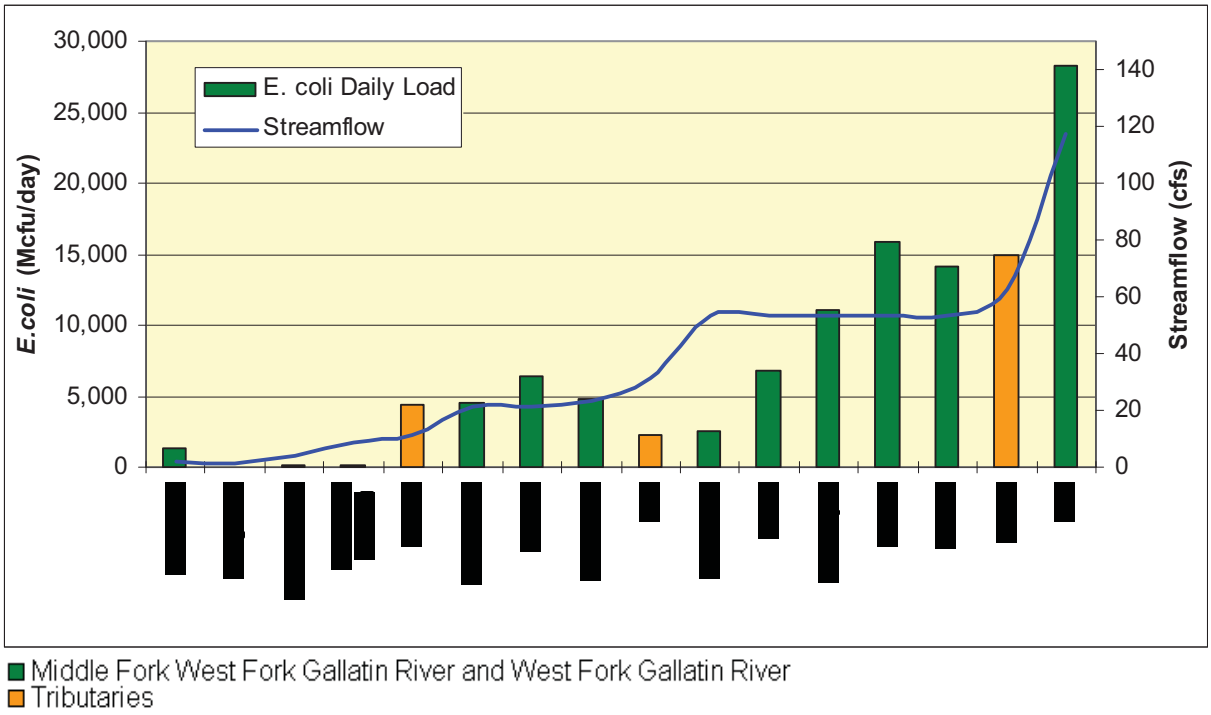


Figure 4-2. *E .coli* Loads Progressing Downstream, August 27, 2008.

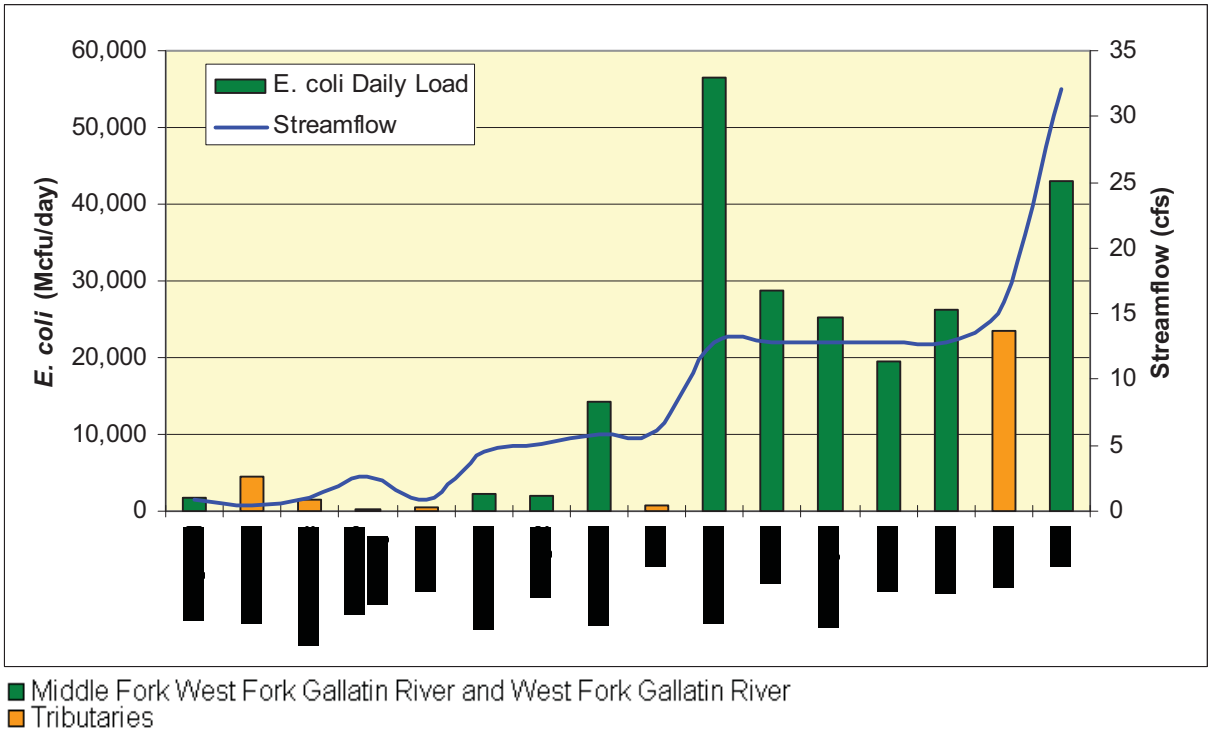


Figure 4-3. Nitrate+Nitrite Loads Progressing Downstream, July 23, 2008.

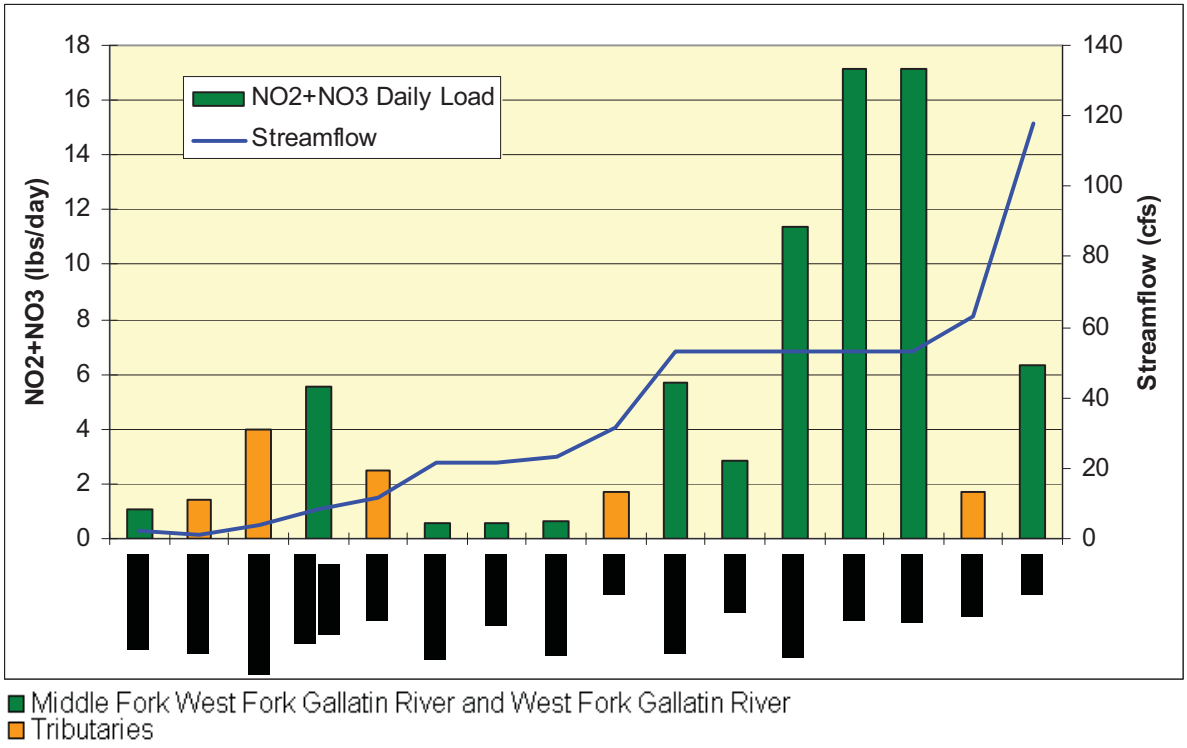
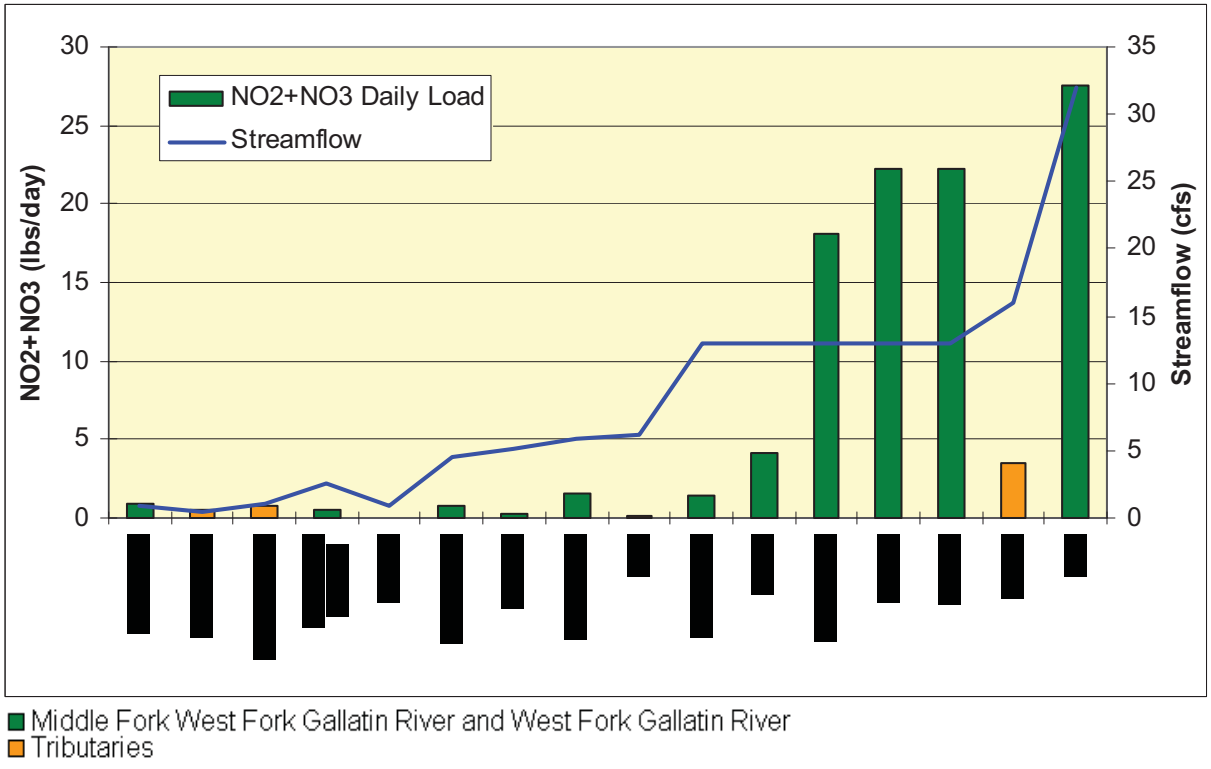


Figure 4-4. Nitrate+Nitrite Loads Progressing Downstream, August 27, 2008.



5.0 Discussion & Summary

Water samples were collected and analyzed for pathogens and nutrients at 24 sites throughout the Upper Gallatin TPA in July and August of 2008, while chlorophyll *a* data was collected at 12 sites.

Major findings of this study include:

- Pathogen concentrations remained relatively low at all sites during the July monitoring event. Pathogen concentrations increased between the July and August monitoring events at all sites. This may be due to a decrease in streamflow between the July and August monitoring events.

- During the July monitoring event, *E. coli* loads increased notably between the Two Moons site and the BSWSD site on the West Fork Gallatin River, while in August, the highest *E. coli* load was recorded at the Two Moons site.

- Nitrate+nitrite nitrogen and total nitrogen concentrations were generally higher during the August monitoring event than during the July monitoring event. This may be due to a decrease in streamflow between the July and August monitoring events. During the August monitoring event, elevated nitrate+nitrite nitrogen and total nitrogen concentrations were documented in the Middle Fork West Fork Gallatin River upstream of Lake Levinsky and in the West Fork Gallatin River starting at the Little Coyote site.

- During both the July and August monitoring timeframes, the nitrate+nitrite load increased notably between the Golf 1.5 site and the Little Coyote site on the West Fork Gallatin River and then continued to increase downstream to the BSWSD site.

- Total phosphorus concentrations were generally higher during the August monitoring event, but remained relatively low throughout the study area.

- Chlorophyll *a* concentrations were higher in July than in August.

- Chlorophyll *a* concentrations were relatively low in the South Fork West Fork Gallatin River during monitoring in 2008 and remained relatively constant between the three sites.

- Algae growth within the West Fork Gallatin River increased in a downstream direction along the golf course and the waste water treatment ponds, with generally homogenous growth across the entire streambed at the sites just upstream of the confluence with the South Fork West Fork Gallatin River. Downstream of the confluence with the South Fork West Fork Gallatin River, algae growth is more "spotty" with bright green filamentous strands in areas with rapidly flowing water. This is similar to conditions found in the lower reaches of the South Fork West Fork Gallatin River.

6.0 References

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Appendix A

PATHOGEN AND NUTRIENT MONITORING SITES

Upper Gallatin TMDL Planning Area

Stream Segment	Site ID	Site Name	Frequency	Status
Middle Fork West Fork Gallatin River	MFWF04	Sitting Bull 1	2	existing
Tributary to Middle Fork West Fork Gallatin River	MFTR02	Sitting Bull 2	2	existing
Tributary to Middle Fork West Fork Gallatin River	MFTR03	Moose Tracks	2	existing
Middle Fork West Fork Gallatin River	MFWF01	below Lake Levinsky	2	existing
Middle Fork West Fork Gallatin River	MFWF05	Lone Moose	2	existing
Middle Fork West Fork Gallatin River	MFWF06	Orange 2	2	new
Tributary to Middle Fork West Fork Gallatin River	MFTR04	Stony	2	new
Tributary to Middle Fork West Fork Gallatin River	MFTR05	Antler	2	new
Middle Fork West Fork Gallatin River	MFWF02	Beaver Dam	2	existing
North Fork West Fork Gallatin River	NFWF02	LMR	2	existing
West Fork Gallatin River	WFGR01	Two Moons	2	existing
West Fork Gallatin River	WFGR05	Golf 1.5	2	new
West Fork Gallatin River	WFGR04	Little Coyote	2	existing
West Fork Gallatin River	WFGR06	BSWSD	2	new
West Fork Gallatin River	WFGR02	J Walker	2	existing
West Fork Gallatin River	WFGR03	West	2	existing
South Fork West Fork Gallatin River	SFWF01	above Ousel Falls	2	new
South Fork West Fork Gallatin River	SFWF02	Streamside	2	new
South Fork West Fork Gallatin River	SFWF04	Sky	2	new
South Fork West Fork Gallatin River	SFWF03	Elkhorn	2	existing
Beehive Creek	BEHV01	Beehive	2	existing
Hell Roaring Creek	HLRG01	Hell Roaring	2	new
Swan Creek	SWAN03	Swan	2	new
First Yellow Mule Creek	SFTR01	First Yellow Mule	2	new

new pathogen monitoring sites denoted in blue

Appendix B

CHLOROPHYLL A MONITORING SITES

Upper Gallatin TMDL Planning Area

Stream Segment	Site ID	Site Name	Frequency	Status
Middle Fork West Fork Gallatin River	MFWF01	below Lake Levinsky	2	existing
Middle Fork West Fork Gallatin River	MFWF05	Lone Moose	2	new
Middle Fork West Fork Gallatin River	MFWF02	Beaver Dam	2	existing
West Fork Gallatin River	WFGR01	Two Moons	2	existing
West Fork Gallatin River	WFGR05	Golf 1.5	2	new
West Fork Gallatin River	WFGR04	Little Coyote	2	new
West Fork Gallatin River	WFGR06	BSWSD	2	new
West Fork Gallatin River	WFGR02	J Walker	2	existing
West Fork Gallatin River	WFGR02	West	2	existing
South Fork West Fork Gallatin River	SFWF01	above Ousel Falls	2	existing
South Fork West Fork Gallatin River	SFWF02	Streamside	2	existing
South Fork West Fork Gallatin River	SFWF03	Elkhorn	2	existing

new chlorophyll a monitoring sites denoted in blue

Appendix C

E. COLI AND NITRATE+NITRITE LOAD CALCULATIONS

Upper Gallatin TMDL Planning Area

Site Name	Sample ID	Collection Date	Streamflow (cfs)	*E. coli* (cfu/100mL)	*E. coli* Daily Load (cfu/day)	NO2+NO3 (mg/L)	NO2+NO3 Daily Load (lb/day)
Sitting Bull 1	MFWF04-1	07/23/08	2.2	24.3	1,296,220,221	0.09	1.1
Sitting Bull 2	MFTR02-1	07/23/08	1.3	<1	15,782,498	0.21	1.5
Moose Tracks	MFTR03-1	07/23/08	3.9	2.0	190,858,114	0.19	4.0
below Lake Levinsky	MFWF01-1	07/23/08	8.6	<1	104,604,928	0.12	5.5
Beehive	BEHV01-1	07/23/08	11.5	15.8	4,457,613,594	0.04	2.5
Lone Moose	MFWF05-1	07/23/08	21.4	8.6	4,503,272,727	non detect	0.6
Orange 2	MFWF06-1	07/23/08	21.6	12.1	6,389,293,458	non detect	0.6
Beaver Dam	MFWF02-1	07/23/08	23.2	8.5	4,814,885,302	non detect	0.6
LMR	NFWF02-1	07/23/08	31.4	3.0	2,304,978,760	0.01	1.7
Two Moons	WFGR01-1	07/23/08	53.0	2.0	2,595,180,969	0.02	5.7
Golf 1.5	WFGR05-1	07/23/08	53.0	5.2	6,747,470,518	0.01	2.9
Little Coyote	WFGR04-1	07/23/08	53.0	8.5	11,029,519,116	0.04	11.4
BSWSD	WFGR06-1	07/23/08	53.0	12.2	15,830,603,908	0.06	17.1
J Walker	WFGR02-1	07/23/08	53.0	10.9	14,143,736,279	0.06	17.1
Elkhorn	SFWF03-1	07/23/08	62.9	9.7	14,938,758,199	non detect	1.7
West	WFGR03-1	7/23/08	117.7	9.8	28,212,010,195	0.01	6.3
Sitting Bull 1	MFWF04-2	08/27/08	0.9	85.7	1,782,443,500	0.20	0.9
Sitting Bull 2	MFTR02-2	08/27/08	0.5	365.4	4,381,074,596	0.22	0.6
Moose Tracks	MFTR03-2	08/27/08	1.1	54.6	1,442,887,341	0.13	0.8
below Lake Levinsky	MFWF01-2	08/27/08	2.6	2.0	126,749,363	0.04	0.6
Beehive	BEHV01-2	08/27/08	0.9	18.7	388,934,579	non detect	0.0
Lone Moose	MFWF05-2	08/27/08	4.6	21.1	2,354,308,241	0.03	0.7
Orange 2	MFWF06-2	08/27/08	5.1	16.1	2,024,906,712	0.01	0.3
Beaver Dam	MFWF02-2	08/27/08	5.9	99.0	14,195,439,252	0.05	1.6
LMR	NFWF02-2	08/27/08	6.1	5.2	778,701,105	non detect	0.2
Two Moons	WFGR01-2	08/27/08	12.9	179.3	56,596,037,383	0.02	1.4
Golf 1.5	WFGR05-2	08/27/08	12.9	90.8	28,661,016,143	0.06	4.2
Little Coyote	WFGR04-2	08/27/08	12.9	79.8	25,188,866,610	0.26	18.1
BSWSD	WFGR06-2	08/27/08	12.9	62.0	19,570,297,366	0.32	22.2
J Walker	WFGR02-2	08/27/08	12.9	83.3	26,293,641,461	0.32	22.2
Elkhorn	SFWF03-2	08/27/08	16.0	60.2	23,494,878,505	0.04	3.4
West	WFGR03-2	08/27/08	32.1	54.8	42,975,864,061	0.16	27.6