APPENDIX F - NUTRIENT EXISTING LOAD SOURCE ASSESSMENT IN THE LOWER GALLATIN TMDL PLANNING AREA

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F1.0 INTRODUCTION

The appendix outlines the process by which existing nutrient loads were quantified and allocated to nonpoint sources in impaired stream segments at baseflow conditions using synoptic sampling events. These events were used to determine the load allocations (% per land use category) for each nutrient impaired waterbody. This process is what is outlined in **Appendix F**. Median flow and nutrient concentrations for each waterbody collected during the summer period (July 1 – September 30) were used in example TMDLs in **Section 6** to identify the necessary reductions and load allocations and to determine natural background loads for the source assessment. The exception to this are the middle and lower segments of the East Gallatin River where 14Q5 low flow values were used for discharge and the WRF contribution was modeled. Existing loads and TMDLs are included in **Section 6** in the document. **Appendix F** load allocations (%) do directly correlate with **Section 6**, however the synoptic sampling estimates of nutrient loads (lbs/day) do not directly correspond to the tables found in **Section 6.6.3** in the document.

This appendix contains an overview of the potential nutrient sources within the Lower Gallatin watershed and then presents the nutrient source assessment methodology. As described in **Section 6**, the existing nutrient loads for each stream were calculated based on the available data during the growing season (July 1 to September 30). However, this method of calculating loads cannot distinguish among the various nutrient sources. DEQ analyzed synoptic sampling data to determine the percentage of loading from individual sources (e.g., urban, cropland, pasture, etc.) per stream. These load percentages were then applied to the existing dataset (i.e., more than just the synoptic sampling data) to calculate the existing loads per source. This appendix describes the available synoptic sampling data for each stream, and provides the methodology for calculating the percentage of nutrient load from the existing sources for each nutrient impaired stream. The source assessment methodology is described in detail using Godfrey Creek and Bozeman Creek as examples because they have very differing land uses (i.e., agriculturally-dominated and mixed use, respectively). The same approach was used for all other nutrient-impaired streams; the associated source assessment results are shown in the figures and tables that follow the two examples.

F2.0 SOURCE ASSESSMENT METHODOLOGY

The relative load from nonpoint source categories (i.e. forest, agriculture, residential/developed, and subsurface wastewater disposal and treatment) was calculated by analyzing the changes in TN and TP loading between monitoring locations for synoptic samples. Specific calculations for sources of subsurface wastewater treatment and disposal are located in **Section F3.4**. Estimates of loading from point sources was done separately (see **Section 6.5.2**). For areas where the load decreased between sites, the contribution from sources within that portion of the watershed was considered negligible. However, for areas that the nitrogen or phosphorus load increased between sites, the source type composition and septic contribution within that part of each watershed was analyzed. Source type percentages were estimated using GIS land cover data (2009), a nutrient source assessment report (**Attachment B**), and the United States Department of Agriculture-National Agricultural Statistics Service (USDA-NASS) CropScape application. CropScape identifies inter-annual changes in agricultural practices from pasture/rangeland to irrigated and dryland cropping.

Because a source can contribute a disproportionate load relative to its area within a watershed, the contribution from sources in sections of the watershed where loading occurred were weighted. This was done by multiplying the percentage of the peak load attributed to each watershed section by its source type distribution. For instance, if a certain section of stream contributed 43% to the peak load during the synoptic sampling event, the percent comprised by each source category was multiplied by 43% (as shown in **Table F-11** for Godfrey Creek). Then, the percent contribution per source category was summed for all of the contributing areas to provide the estimated contribution of each source category to the peak load (**Table F-10**).

Source assessment assumptions:

- Synoptic sampling events were considered representative of existing flow and nutrient loading conditions on nutrient impaired waterbodies.
- Large irrigation diversions that substantially altered flow dynamics were considered and analyzed where observed to account for inflows and outflows from a system.
- Contributions from septic sources were categorized based on instream chemistry observations and septic densities in proximity to a waterbody.
- Nutrient loads were considered conservative and no attempts were made to account for uptake or assimilation except what was observed in the synoptic sampling events.
- Source contributions were determined based on their approximate land coverage as a percent of contributing area to a reach.
- If a synoptic sampling observed a decrease in a nutrient load in a given reach, a source assessment for that reach was not done as the load contribution was considered negligible.
- Source assessments for tributary streams were incorporated into source assessments for receiving waterbodies.
- The city of Bozeman MS4 discharges to Bozeman Creek, Bridger Creek, Mandeville Creek and the East Gallatin River. However, based on 30 years of precipitation data (1980–2009), ≥0.05 inch of precipitation falls, on average, 18.6 days from July 1–September 30. Activation of the MS4 is relatively infrequent during the summer period. Therefore, nutrient load contributions from the MS4 during the summer low flow period were considered negligible and were not included in the existing nutrient source assessment.
- Assumptions used for the source assessment specific to each assessment unit are outlined in their respective section.

After the initial source assessment was completed, natural background was calculated and the other nonpoint sources were uniformly decreased to account for natural background (**Section F3.6)**. Modeled point source contributions from the city of Bozeman Water Reclamation Facility were not decreased as the model included a composite of natural background and nonpoint sources in its calculation.

F3.0 Source Categories

The source area based loading assessment evaluated nutrient contributions from the following sources:

- Forest (and wetlands)
- Agriculture (cropping and pasture/rangeland)
- Residential/Developed (infrastructure including roads and residential development)
- Subsurface wastewater disposal and treatment (individual, community septic systems and WWTPs that discharge to groundwater)

- Point sources
- Natural background

Source assessment information for natural background as well as all sources evaluated within the area based approach is described in detail within this section.

F3.1 Forest

The forested areas in the Lower Gallatin watershed are heavily timbered. Additionally, coniferous forests do not lose a large percentage of their biomass each fall (as a deciduous forest does). Therefore, overall runoff values are low for forested areas because of their capacity to infiltrate, transpire, and otherwise capture rainfall.

Recent data collected by MBMG upstream of the forest boundary from streams draining the Bridger Range documented NO_3+NO_2 concentrations above reference concentrations for that ecoregion. Because the data could not be separated from natural background with high confidence, assessment units with headwaters in the Bridger Range combined load allocation to forest and natural background sources (Bridger Creek, Reese Creek, and Smith Creek).

F3.2 Agriculture

There are several possible mechanisms for the transport of nutrients from agricultural land to surface water during the growing season. The potential pathways include: the effect of winter grazing on vegetative health and its ability to uptake and nutrients and minimize erosion in upland and riparian areas, breakdown of excrement and loading via surface and subsurface pathways, delivery from grazed forest and rangeland during the growing season, transport of fertilizer applied in late spring via overland flow and groundwater, and the increased mobility of phosphorus caused by irrigation-related saturation of soils in pastures (Green and Kauffman, 1989).

Pastures/Rangeland
Pastures are managed for hay production during the summer and for grazing during the fall and spring. Hay pastures are fairly thickly vegetated in the summer; less so in the fall through spring. The winter grazing period is long (October–May), and trampling and feeding further reduces biomass when it is already low. Commercial fertilizers are used infrequently in the watershed, but cattle manure—naturally applied—occurs in higher quantities from October through May because of higher cattle density than that found on range and forested areas (PBS&J, 2007).

Rangeland differs from pasture in that rangeland has much less biomass therefore contributes fewer nutrients from biomass decay. However, manure deposition does play a role. Similar to the forest areas, rangeland is grazed during the summer in the watershed and is managed similarly to the grazing in the forest areas. This is sometimes an important contribution to an impaired waterbody via tributaries.

Irrigated and Dryland Cropping
Cropping in the Lower Gallatin TPA is predominately irrigated and dryland production of small grains, with smaller acreages of potatoes, peas, and corn (PBS&J, 2007). This category also includes sod farms. Irrigated lands are usually in continuous production and have annual soil disturbance and fertilizer inputs. Dryland cropping may have fallow periods of 16 to 22 months, depending on site characteristics

and landowner management. Nutrient pathways include overland runoff, deep percolation, and shallow groundwater flow, which transport nutrients off site.

F3.3 Residential/Developed

Developed areas contribute nutrients to the watershed by runoff from impervious surfaces, deposition by machines/automobiles, application of fertilizers, and increased irrigation on lawns. Golf courses are included in this category. Although developed areas often have the highest nutrient loading rates, in the Lower Gallatin watershed developed areas make up a small percentage of the overall area. For reference, the boundaries for the city of Bozeman are functionally identical to the sewered areas.

F3.4 Subsurface Wastewater Disposal and Treatment

Nitrogen and phosphorus discharge by septic systems that migrate to surface waters were initially determined using the Method for Estimating Attenuation of Nutrients from Septic Systems (MEANSS) model. MEANSS used septic location data in the Lower Gallatin TPA to calculate distance to perennial streams and calculate a load to surface water based on local soil types. The model accounted for identified septic systems (Gallatin City-County Health Department, 2009; Gallatin Local Water Quality District, 2010) and systems that have a Montana Ground Water Pollution Control System (MGWPCS) permit. For non-residential MGWPCS permitted systems where actual current wastewater flow rates are not available, design loading rates were used in the analysis. Although design rates are typically larger than average daily rates, they were used in the absence of an accurate method to estimate average rates. Due to the large amount of septic systems in the TPA, this potential error associated with these specific permitted systems should not have any significant effect on the final analysis.

The daily load from each system was based on literature values and conservative assumptions used during permitting for subdivisions in Montana (Montana Department of Environmental Quality, 2009). Because a complete system failure is typically addressed very quickly, conservative assumptions were used for the load. The model worked well in watersheds with medium to high septic density but often appeared to overestimate loads in watersheds with low septic density. Also, the model calculated annual loads whereas the TMDLs focus on summer loading (July 1 - September 30). Annual load estimates do not take into account higher uptake rates and changes in septic use during the summer period. Another assumption of the model was that perennial streams are gaining in all reaches which does not apply to many of the streams in the Lower Gallatin TPA. For these reasons, the results of the MEANSS model were not used as derived. Model estimates from MEANNS for nutrient loading were compared with the area-weighted approach but were not used in place of the area-weighted analysis as MEANSS tended to overestimate summer loading rates based on the reasons outlined above. An outline of the MEANSS model may be found in Appendix A of Montana's DRAFT policy for nutrient trading at http://deq.mt.gov/wqinfo/NutrientWorkGroup/default.mcpx.

The area-weighted approach assigned loads to septic systems based on relative septic density in the vicinity of the stream, dominant groundwater flow paths and changes to instream nutrient concentrations. In order to better define septic sources, available water chemistry data was reviewed to determine relative inorganic versus organic fractions of nitrogen and changes in total phosphorus fractions (dissolved versus particulate). The assumption being that phosphorus loading from septic systems is minor short of total system failure in close proximity to a waterbody and that a spike in inorganic nitrogen relative to the organic fraction is indicative of septic loading.

Separate from the MEANSS model, loading estimates for total nitrogen and total phosphorus were calculated using available influent water quality data and loading rates for wastewater treatment facilities discharging to groundwater in drainages with nutrient impaired streams. These calculations were done for the Belgrade WWTP (MTX000116), the Amsterdam-Churchill WWTP (MTUS00015), and the Riverside Water & Sewer District WWTP (unpermitted; private facility). Facility outlines and load calculation assumptions for these treatment facilities are provided below. Methods used to estimate nutrient loading to impaired waterbodies differed between the facilities based on facility design, current operation, available water quality data and geographic relation to nutrient impaired waterbodies.

Belgrade WWTP (MTX000116)

Overview

The City of Belgrade wastewater treatment plant is located approximately 2 miles northeast of Belgrade, MT in the Gallatin Valley. The facility has three outfalls to Rapid Infiltration Percolation (IP) Beds that discharge to Class 1 groundwater. The facility underwent a large upgrade in 2003-2004.

The facility consists of 3 lined treatment ponds/cells. The disposal method includes a spray irrigation system and 3 groups of IP beds which discharge to groundwater. Retention times in cell #1 and #2 combined is 53.9 days. Cell #3 is used for settling and storage prior to discharge and has a retention time of 137 days. The design capacity is 903,000 gpd with a design population of 3,918 single family residences (~10,500 persons).

IP Beds A were previously determined to be exempt from nondegradation significance review based on ARM 17.30.702(18)(b), which states that a facility that has been operational on or prior to April 29, 1993, is not required to meet the nondegradation criteria. Nondegradation significance reviews were conducted on IP beds B and C previously. The spray irrigation discharge is an exempt/non significant land application according to 75-5-317(2)(h), MCA.

Based on an annual average flow rate, the IP beds discharge approximately 644,000 gpd of effluent and 274,000 gpd is discharged by the spray irrigation system. This is a total of 918,000 gpd (102% of design capacity). Average groundwater flow direction has been determined as N 63° W due in part to mounding of the water table in the immediate vicinity of the IP beds. The soils in the area of the facility are comprised of gravelly and coarse sand and the subsoil is predominantly fine sand with medium gravel and gravel. The hydraulic conductivity has been estimated at 600 feet per day.

TN Analysis

The existing permit allows a TN load of 47.1 lbs/day from IP Beds A, 2.13 lbs/day from IP Beds B, and 24.2 lbs/day from IP Beds C. The mixing zone for IP Beds B is downgradient of the IP Beds A mixing zone and therefore the allowable load is very low. The total permitted TN load is 73.43 lbs/day from the 3 I/P beds. The permit requires that at the end of the 500-foot mixing zone the nitrate (as N) concentrations must not exceed 10 mg/L for IP Beds A and 5 mg/L for IP Beds B and C. Based on the average daily discharge and the mixing zone reduction requirements, the TN load to groundwater at the edge of the mixing zones from the Belgrade WWTP is permitted at 35.96 lbs TN/day.

Total phosphorus effluent limits were not calculated for this facility based on the 50-year breakthrough analysis. The 50-year breakthrough nondegradation criterion is based on the amount of soil available to absorb the phosphorus between the discharge point and the receiving waterbody using the average load of phosphorus from the wastewater source. For the permit, it was determined that the East

Gallatin River was the nearest waterbody located ~4 miles from the facility and, therefore, greater than the 50-year breakthrough analysis. However, this distance does not seem to have accounted for the smaller spring-fed streams draining the area north of the Belgrade WWTP.

The area north and east of Belgrade was historically an extensive riparian corridor in the Gallatin Valley due in part to low-elevation, spring-fed streams and a wide floodplain adjacent to the East Gallatin River. Downstream of the confluence of Hyalite Creek and the East Gallatin River, several spring-fed streams enter the East Gallatin River. In upstream to downstream order these streams are: Thompson Creek, Ben Hart Creek, Story Creek, Cowan Creek and Gibson Creek. Water quality data was collected by DEQ from these streams in September 2008 and September 2009.

Given the groundwater flow direction at the Belgrade WWTP and the elevation gradient north of the facility, Ben Hart Creek is the most likely receiving waterbody of the groundwater discharge from the Belgrade WWTP. As the other spring-fed streams have very similar land use characteristics, flow and concentration data were analyzed in comparison to the nutrient loads in Ben Hart Creek. Relative flows and nutrient loads in Thompson, Story, Gibson and Cowan Creeks were compared with Ben Hart Creek to identify the probable Ben Hart nutrient load without the influence of the Belgrade WWTP. Given the similar hydrologic characteristics and land uses in these adjacent systems, it was assumed that nutrient loads in the adjacent drainages would provide the average nutrient load in Ben Hart Creek if that waterbody was not under the influence of the Belgrade WWTP.

This analysis identified that groundwater discharge from the Belgrade WWTP constitutes 12% (16.74 lbs TN/day) of the Ben Hart TN load and 1.5% of the TN load to the lower segment of the East Gallatin River (**Table F-1**). If the Belgrade WWTP is meeting the permit requirements, the TN load at the end of the groundwater mixing zone is 35.96 lbs/day. The TN load of 16.74 lbs/day from the Belgrade WWTP in Ben Hart Creek is 47% of the permitted load at the end of the 500-foot mixing zone at the WWTP.

Table F-1. City of Belgrade WWTP TN Load Calculations to the East Gallatin River

Parameter	Value	Units	Notes
Discharge via I/P beds	644,000	gpd	When irrigation system in use
Discharge via I/P beds	0.9982	cfs	When irrigation system in use
Permitted load to I/P beds	73.43	lbs/day TN	
Permitted load at end of groundwater mixing zone	35.96	lbs/day TN	Based on permit requirements; estimated load to aquifer
Estimated load to Ben Hart Creek	16.74	lbs/day TN	
As % of existing TN load in Ben Hart Creek	12.0	%	
As % of existing TN load in the Lower East Gallatin River	1.5	%	
Existing load in the Lower East Gallatin River*	1114.98	lbs/day TN	80th percentile of all summer period water quality data (*n* = 12)

*Ben Hart Creek enters the East Gallatin River upstream of Smith Creek very near the boundary (Smith Creek) between the middle and lower segments of the river.

<u>TP Analysis</u>

Although the permit did not set a TP effluent limit given the 50-year breakthrough criterion, a flow/load analysis was also calculated for TP from the Belgrade facility. A total load from the end of mixing zone at the Belgrade WWTP was calculated using influent TP data collected at the Amsterdam-Churchill WWTP as no influent TP data could be obtained for the Belgrade WWTP. The analysis assumed a 30% reduction in influent concentrations before the outfall point and a 98% reduction by the end of the mixing zone.

This analysis found that the discharge load to the IP beds is approximately 173.40 lbs TP/day and 3.47 lbs TP/day at the end of the mixing zone (**Table F-2**). Using the same analysis outlined above, it was estimated that the Belgrade WWTP is discharging 1.03 lbs/day TP to Ben Hart Creek. This is 30% of the assumed TP load at the end of the 500-foot mixing zone at the plant.

Table F-2. City of Belgrade WWTP TP Load Calculations to the East Gallatin River

Parameter	Value	Units	Notes
Discharge via I/P beds	644,000	gpd	When irrigation system in use
Discharge via I/P beds	0.9982	cfs	When irrigation system in use
Median influent concentration	46.125	mg/L TP	*n* = 9
30% reduction concentration in facultative lagoon	32.29	mg/L TP	
Load (Discharge*concentration)	173.41	lbs/day TP	
98% removal efficiency in soil matrix for TP	3.47	lbs/day TP	Estimated load to aquifer
Estimated load to Ben Hart Creek	1.03	lbs/day TP	
As % of existing TP load in Ben Hart Creek	28.0	%	
As % of existing TP load in the Lower East Gallatin River	1.2	%	
Existing load in the Lower East Gallatin River*	86.55	lbs/day TP	80th percentile of all summer period water quality data (*n* = 13)

*Ben Hart Creek enters the East Gallatin River upstream of Smith Creek very near the boundary (Smith Creek) between the middle and lower segments of the river.

An analysis of the DEQ ambient water quality data identified that groundwater discharge from the Belgrade WWTP comprises 28% (1.03 lbs TP/day) of the Ben Hart TP load and 1.2% of the TP load to the lower segment of the East Gallatin River.

Summary

The Belgrade facility is currently operating above design capacity according to the most recent permit data. Analysis of flow and TN concentration in the spring-fed streams north of the Belgrade on the south side of the East Gallatin River determined that 12% of the TN load and 28% of the TP load in Ben Hart Creek is from the Belgrade WWTP. This corresponds to 1.5% of the TN load and 1.2% of the TP load in the lower segment of the East Gallatin River, which is impaired for total nitrogen and total phosphorus. There is still some question whether these estimates accurately quantify the impacts of the Belgrade WWTP on water quality in Ben Hart Creek and the East Gallatin River.

Amsterdam-Churchill WWTP (MTUS00015)

The Amsterdam-Churchill WWTP services approximately 927 persons in 335 households and includes a facultative lagoon and 2 storage lagoons for spray irrigation with a design capacity of 78,000 gallons per day (gpd). The existing system was installed in 1977. Currently, the facility receives 85,000 to 90,000 gpd. On-site measurements by DEQ in 2010 determined that the facility is leaking 85,000 gpd of poorly-treated wastewater to the groundwater aquifer from the storage lagoon. The system was designed to provide some treatment in the facultative lagoon with the storage lagoons periodically pumped out for land application. It is not known if the facility was ever utilized in this fashion.

The TN and TP load to groundwater was determined based on the daily leakage rate (85,000 gpd or 0.13175 cfs) and the median influent TN and TP concentrations. Estimated loads to groundwater were different for TN and TP. To determine treatment load reductions, a decay equation was used for TN while a general reduction of 30% was applied to TP concentrations (**Tables F-3** and **F-4**).

Table F-3. Amsterdam-Churchill WWTP TN Load Calculations to Camp Creek

Parameter	Value	Units	Notes
Lagoon Leakage	85,000	gpd	
Lagoon Leakage	0.13175	cfs	
Median influent concentration	45.5	mg/L TN	*n* = 9
Estimated lagoon retention time	79	days	75% of minimum of 105 days
Influent concentration * exp (-0.0075*Retention time)	25.16	mg/L TN	
Load (Leakage*concentration)	17.83	lbs/day TN	
76% removal efficiency in soil matrix for TN	4.28	lbs/day TN	Estimated load to aquifer
Change in load on 9/23/2009	1.35	lbs/day TN	Observed change in load between sample points bracketing WWTP
Existing load in Camp Creek	101.73	lbs/day TN	80th percentile of all summer period water quality data (*n* = 12)

In the case of TN, assuming a removal efficiency of 76% in the TN load between the bottom of cell 2 and Camp Creek, the estimated load from the Amsterdam-Churchill WWTP is 4.28 lbs/day TN. In the only bracket sampling event available for Camp Creek in the vicinity of the WWTP, the change in load from upstream to downstream of the WWTP was 1.354 lbs/day TN.

Table F-4. Amsterdam-Churchill WWTP TP Load Calculations to Camp Creek

Parameter	Value	Units	Notes
Lagoon Leakage	85,000	gpd	
Lagoon Leakage	0.13175	cfs	
Median influent concentration	46.125	mg/L TP	*n* = 9
30% TP reduction in facultative lagoon	32.29	mg/L TP	
Load (Leakage*concentration)	22.89	lbs/day TP	
98% removal efficiency in soil matrix for TP	0.46	lbs/day TP	Estimated load to aquifer
Change in load on 9/23/2009	0.127	lbs/day TP	Observed change in load between sample points bracketing WWTP
Existing load in Camp Creek	6.57	lbs/day TP	80th percentile of all summer period water quality data (*n* = 15)

For TP, a 98% removal efficiency was used to calculate the TP load to Camp Creek due to the leaking lagoon. The estimated load was 0.46 lbs/day TP. The observed change in TP load above and below the WWTP was 0.127 lbs/day TP on 9/25/2009.

Riverside Water & Sewer District WWTP (unpermitted; private facility)
Constructed in 1974, the Riverside Water and Sewer District WWTP is an unpermitted facility with a design capacity of 20,000 gpd. It services 124 households plus the clubhouse on the golf course for an estimated population of 325 persons plus 200 transient (clubhouse). The facility is comprised of an aeration pond (treatment cell) and a storage lagoon (holding cell). The original design called for the septic effluent to be stored in the lagoon following initial treatment and then pumped out and used to irrigate the Riverside golf course. According to current facility operator, it is not known that the system was ever utilized in this manner. This failing system is losing approximately 20,000 gpd to the underlying aquifer and is sited adjacent to the East Gallatin River downstream of the city of Bozeman Water Reclamation Facility.

Water quality data from the facility could not be used in the analysis as it failed DEQ QA/QC requirements for data acceptability. Instead, water quality influent data collected at the Amsterdam-Churchill WWTP was used in its stead; as these 2 facilities are comparable in the number of service connections and resident populations that they serve. Different removal efficiencies of TN and TP were used for the Riverside Water & Sewer District WWTP then were applied in the Amsterdam-Churchill WWTP analysis. This was done for several reasons including the lack of a fully functioning aeration pond at Riverside, the coarse soils and shallow depth to groundwater and the relatively short groundwater flow path from Riverside to the East Gallatin River. In comparison to the Amsterdam-Churchill WWTP, the TN removal efficiency was reduced from 76% to 25% and for TP from 98% to 40% (**Tables F-5** and **F-6**).

Table F-5. Riverside Subdivision District WWTP TN Load Calculations to the East Gallatin River

Parameter	Value	Units	Notes
Lagoon Leakage	20,000	gpd	
Lagoon Leakage	0.031	cfs	
Median influent TN concentration	45.5	mg/L TN	*n* = 9
Assumed retention time	79	days	75% of minimum of 105 days
Influent concentration * exp (-0.0075*Retention time)	25.16	mg/L TN	
Load (Leakage*concentration)	4.20	lbs/day TN	
25% removal efficiency in soil matrix for TN	3.22	lbs/day TN	Estimated load to aquifer
Change in load on 9/16/2009	-8.59	lbs/day TN	Observed change in load between sample points bracketing WWTP location
Existing load on East Gallatin River below WRF discharge and above Hyalite Creek	272.35	lbs/day TN	80th percentile of all summer period water quality data (*n* = 13)

Upstream of the Riverside Water & Sewer District WWTP, the City of Bozeman WRF discharges to the East Gallatin River. It was difficult to separate the Riverside Subdivision TN and TP contribution from the significant WRF loads. In the case of TN, samples bracketing the Riverside Water & Sewer District WWTP showed a decrease in the TN load on 9/19/2009 of 8.59 lbs/day TN.

Table F-6. Riverside Water and Sewer District WWTP TP Load Calculations to the East Gallatin River

Parameter	Value	Units	Notes
Lagoon Leakage	20,000	gpd	
Lagoon Leakage	0.031	cfs	
Median influent concentration	46.125	mg/L TP	*n* = 9
30% TP reduction in facultative lagoon	32.29	mg/L TP	
Load (Leakage*concentration)	5.37	lbs/day TP	
40% removal efficiency in soil matrix for TP	3.22	lbs/day TP	Estimated load to aquifer
Change in load on 9/16/2009	1.58	lbs/day TP	Observed change in load between sample points bracketing WWTP location
Existing load on East Gallatin River below WRF discharge and above Hyalite Creek	30.59	lbs/day TP	80th percentile of all summer period water quality data (*n* = 15)

On 9/16/2009, there was an observed increase of 1.58 lbs/day in the TP load in samples collected upstream and downstream of the Riverside Water & Sewer District WWTP. The increase was less than the estimated load of 3.22 lbs/day TP from Riverside.

F3.5 POINT SOURCES

Several nutrient point sources exist in the watershed that directly contribute loading to assessment units identified as impaired for nutrients. These include the city of Bozeman Water Reclamation Facility (WRF) (MT0022608), the City of Bozeman MS-4 stormwater system (MTR040002), and the USFWS Bozeman Fish Technology Center (MTG130006).

F3.6 NATURAL BACKGROUND

Once the source assessment for a given waterbody was completed, natural background was determined based on median values (50th percentile) for reference sites as compiled by the Montana Department of Environmental Quality (DEQ) in the associated ecoregions (**Table F-7**). With the exception of the middle and lower segments of the East Gallatin River, this was done by using the median stream discharge from all available sampling data for a given waterbody and the median instream nutrient concentration for reference streams as determined by DEQ to calculate the natural background load. Values used for the middle and lower East Gallatin River segments are discussed in detail in those sections.

For streams receiving natural flows from the Level IV Absaroka-Gallatin-Volcanics ecoregion water quality target values were used with relative flow contributions to calculate segment specific natural background concentrations for TN and TP (**Table F-8**). All other nutrient source categories were then uniformly decreased to account for natural background.

Table F-7. Natural background concentrations in the Lower Gallatin project area by ecoregion

Parameter	Median reference values	
	Middle Rockies (Level III)	Absaroka-Gallatin Volcanics Ecoregion (Level IV, within Middle Rockies)
Total nitrogen (TN)	0.095 mg/L	0.080 mg/L
Total phosphorous (TP)	0.010 mg/L	0.081 mg/L

Table F-8 Natural background concentrations in the Lower Gallatin project area per stream segment receiving flow from the Absaroka-Gallatin-Volcanics Level IV ecoregion

Stream segment	TN (mg/L)	TP (mg/L)
Bozeman Creek	0.085	0.055
East Gallatin between Bozeman and Bridger Creeks	0.091	0.031
East Gallatin between Bridger and Hyalite Creeks	0.095	0.010
Lower Hyalite Creek	0.084	0.063
East Gallatin between Hyalite Creek and Smith Creek	0.091	0.027
East Gallatin between Smith Creek and the Gallatin River	0.095	0.010

The exception to this approach is for streams listed for nitrite + nitrate ($N0_3$+ $N0_2$). DEQ has not compiled ecoregion statistics for natural background of inorganic nitrogen. For these cases, natural background was grouped with forest as instream water quality data collected upstream of the forest boundary in the Bridger Range suggested that there was a natural load of nitrite + nitrate ($N0_3$+ $N0_2$). It was not possible to separate the forest/natural background sources. This exception applies to Bridger Reese and Smith Creeks for nitrite + nitrate ($N0_3$+ $N0_2$) TMDL development.

The use of median concentrations to determine natural background differs from that outlined in **Section 6.4.2** in the document where the 75th percentile of the reference dataset was used to determine natural background nutrient concentrations. This is due to the fact that the reference dataset for the Level III Middle Rockies ecoregion includes few sites below the forest boundary in low valley landforms. In light of the uncertainty of background nutrient concentrations in these lower elevation systems, median values for nutrients in the reference dataset were deemed more appropriate to calculate natural background in nutrient impaired waterbodies below the forest boundary in the Lower Gallatin TMDL project area.

Geology

Portions of the Hyalite Creek and Bozeman Creek drainages upstream of the forest boundary are underlain by the Phosphoria Formation (Berg et al., 1999; Berg et al., 2000; Kellogg and Williams, 2006; Vuke et al., 2002). This formation has the potential to cause elevated phosphorus concentrations in groundwater and surface water. Studies done by the Gallatin National Forest and Montana State University in the 1970s documented phosphorus concentrations up to 0.50 mg/L (mean 0.07 mg/L) in Bozeman Creek above the forest boundary and elevated natural background concentrations in the Hyalite Creek drainage (Glasser and Jones, 1982; Schillinger and Stuart, 1978). Phosphorus concentrations were linked more strongly to natural processes by researchers than to land uses such as grazing and logging.

Wildlife

The effect of wildlife grazing and waste on nutrient loading is considered part of the natural background load. The contribution of wildlife was not evaluated during this project and may be greater in more heavily used areas of the watershed, however, in a multi-state study with varying densities of wildlife and livestock, wildlife were estimated to contribute a minimal nutrient load relative to livestock (Moffitt, 2009).

F4.0 Detailed Existing Load Source Assessments for Godfrey Creek and Bozeman Creek

Source assessments for Godfrey Creek and Bozeman Creek are provided in the following sections. Detailed explanations of how the source assessments were conducted and load allocations calculated are provided in these sections for 2 streams with different land use characteristics. Godfrey Creek watershed is dominated by agriculture whereas the Bozeman Creek drainage includes multiple nutrient sources such as agriculture, residential/developed areas, and subsurface wastewater treatment and disposal. These detailed summaries are provided as examples for how source assessments were conducted for nutrient impaired waterbodies in the Lower Gallatin TMDL project area.

F4.1 Godfrey Creek Existing Load Source Assessment for TN and TP

Godfrey Creek is listed as impaired for total nitrogen and total phosphorus on the 2012 303(d) List. Godfrey Creek flows 9 miles from the headwaters on the Madison Plateau (Camp Creek Hills) through the town of Churchill to the mouth where is flows into Moreland Ditch, an irrigation canal. Water quality sampling was conducted in 2008 and 2009 (**Figure F-1**).

From **Attachment B:** Godfrey Creek is impacted by agricultural practices throughout most of its seven mile length. Pastures and livestock confinement areas were identified as the most significant sources of nutrients to Godfrey Creek, but the abundance of irrigated croplands was also considered a significant pollutant source. The potential impact of these land uses was accentuated by the general lack of best management practices. Narrow pasture buffers were common in the middle and lower reaches, but generally absent in the upper reaches. The lack of riparian enclosure fencing allowed livestock full access to the stream even where pasture buffers were present. The only riparian fencing noted during the assessment was located upstream of Cameron Bridge Road, which was effectively keeping cattle out of the riparian zone. However, it should be recognized that only areas that could be accessed from road crossings were observed and some BMP's were likely missed in the assessment.

The stream was more impacted in the upper two reaches than in the lower two reaches. Reach GOD 01 N was less impacted upstream of Little Holland Road (**Figure F-1**), with a denser riparian and less bank erosion observed. Downstream of Little Holland Road was the most significantly impacted by grazing and livestock confinement areas, resulting in trampled, eroding banks, and very poor riparian zone quality. The lower reaches were less impacted by grazing and livestock operations, with less bank erosion and a denser riparian zone observed.

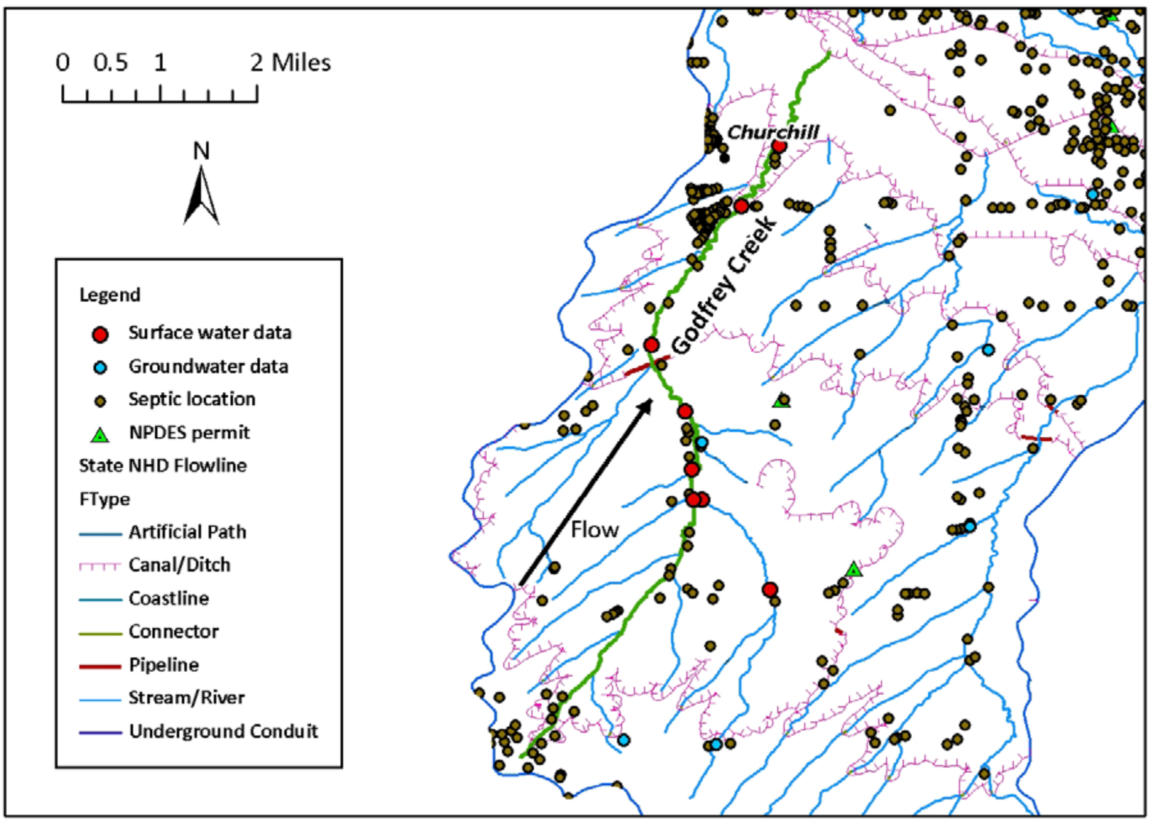

Figure F-1. Spatial data used for the Godfrey Creek existing load source assessment

In **Table F-9**, peak load refers to the highest observed load (lbs/day) on Godfrey Creek on 9/25/2009 which was 34.024 lbs TN/day. GD05 is located on the mainstem just upstream of the confluence of a tributary that enters Godfrey Creek from the east. GD04 is taken at the mouth of that tributary (**Figure F-2**). For total nitrogen samples collected on 9/25/2009, loading from the upper reaches (GD05, GD04) comprise 87% of the peak load observed on that day (**Table F-9**). This portion of the watershed is dominated by dryland cropping and pasture/rangeland. TN loads and concentrations decrease moving downstream and a substantial drop-off in concentration at GD01. Valley Ditch, which diverts water from the West Gallatin River, merges with Godfrey Creek just downstream of site GD02 on the north side of Cameron Bridge Road. Godfrey Creek/Valley Ditch continues downstream for ~125 feet before Valley Ditch is redirected to the west of the Godfrey Creek channel. The dilution effects of Valley Ditch are the main reason for the sudden decrease in TN concentration.

Table F-9. Total nitrogen loading on 9/25/2009 on Godfrey Creek

Site ID	Flow (cfs)	TN (mg/L)	TN load (lbs/day)	Change in load from upstream (lbs/day)	% of peak load
GD05	0.88	3.1	14.649	14.649	43%
GD04 (Tributary)	1.45	1.91	14.872	14.872	44%
GD03A	2.45	2.5	32.891	3.37*	10%
GD03	2.98	2.1	33.605	0.714	2%
GD02A	2.88	2.2	34.024	0.419	1%
GD02	3.22	1.96	33.891	-0.133	NA
GD01	4.06	0.32	6.978	-26.913	NA

*The sum of GD04 and GD05 were subtracted from GD03A to determine the change in TN load [(14.649+14.827)-(32.891) = 3.37].

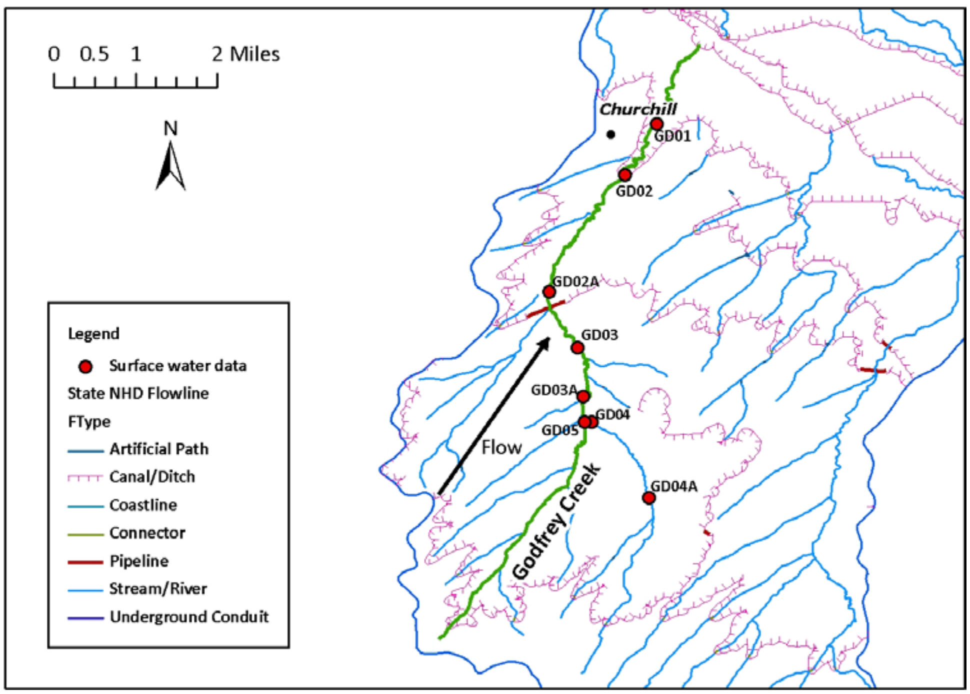

Figure F-2. Site IDs for surface water data points on Godfrey Creek

Using the available data sources including the source assessment and the NASS CropScape application, percentages per source category were assigned for the each sample location where an increase in TN load was observed between adjacent sampling locations (i.e. on 9/25/2009 the TN load increased from 33.605 lbs/day TN at GD03 to 34.024 lbs/day TN at GD02A). Values were then weighted based on the % of peak load at each sample location identified in **Table F-10** and then summarized for the entire stream segment. Peak load is the highest observed load on the day of sampling. Results were compared to other available TN data.

Table F-10. Existing load source assessment for anthropogenic sources for total nitrogen on Godfrey Creek for 9/25/2009

Source category	GD05	GD04	GD03A	GD03	GD02A	Total
Forest	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	40.04	43.71	9.71	1.97	1.21	96.63
Residential/Developed	0.86	0.00	0.20	0.04	0.02	1.13
Subsurface wastewater disposal and treatment	2.15	0.00	0.00	0.08	0.00	2.24
% of peak load	43.05	43.71	9.90	2.10	1.23	100.00

As an example, source assessment calculations for the GD05 column are shown in **Table F-11**. From **Table F-9**, the TN load at GD05 was 43.05% (=14.649/34.024) of the highest observed TN load on 9/25/2009. The far-right column of **Table F-11** corresponds to the GD05 column in **Table F-10**.

Table F-11. Example calculation of area-weighted source assessment for total nitrogen at site GD05 on Godfrey Creek for 9/25/2009

Source category	GD05 source allocation (%)	GD05 as fraction of peak load	GD05 as fraction of total load (%) on Godfrey Creek
Forest	0	x 0.4305	0.00
Agriculture	93	x 0.4305	40.04
Residential/Developed	2	x 0.4305	0.86
Subsurface wastewater disposal and treatment	5	x 0.4305	2.15
Total	100	-	43.05

As outlined in **Section F2.1**, natural background was calculated based on the median flow observation for Godfrey Creek using the available data (2.48 cfs) and the median TN concentration in the reference dataset for the Middle Rockies ecoregion (0.095 mg/L TN). The median observed TN concentration in Godfrey Creek was 1.41 mg/L TN for an existing TMDL load of 18.81 lbs TN/day (**Table F-12**).

Table F-12. Godfrey Creek values used to determine total nitrogen existing load and natural background.

Median discharge	Median reference concentration for Godfrey Creek	Natural background load	Median observed concentration	Existing Load
2.48 cfs	0.095 mg/L TN	1.26 lbs TN/day	1.41 mg/L TN	18.81 lbs TN/day

The natural background load of 1.26 lbs TN/day is 6.74% of the existing load using the median values. All other source categories were uniformly decreased to account for the calculated natural background load (**Table F-13**).

Table F-13. Uniform decrease of source allocations to account for natural background in Godfrey Creek total nitrogen source assessment.

Source allocation	Existing load	
	Without NB (%)	With NB (%)
Natural background	-	6.74
Agriculture	96.63	90.12
Residential/Developed	1.13	1.05
Subsurface Wastewater Treatment and Disposal	2.24	2.09
Total	100.00	100.00

This method determined natural background to be ~7% of the TN load in Godfrey Creek. The source categories' percentages were uniformly decreased to account for the calculated natural background TN load (**Figure F-3**).

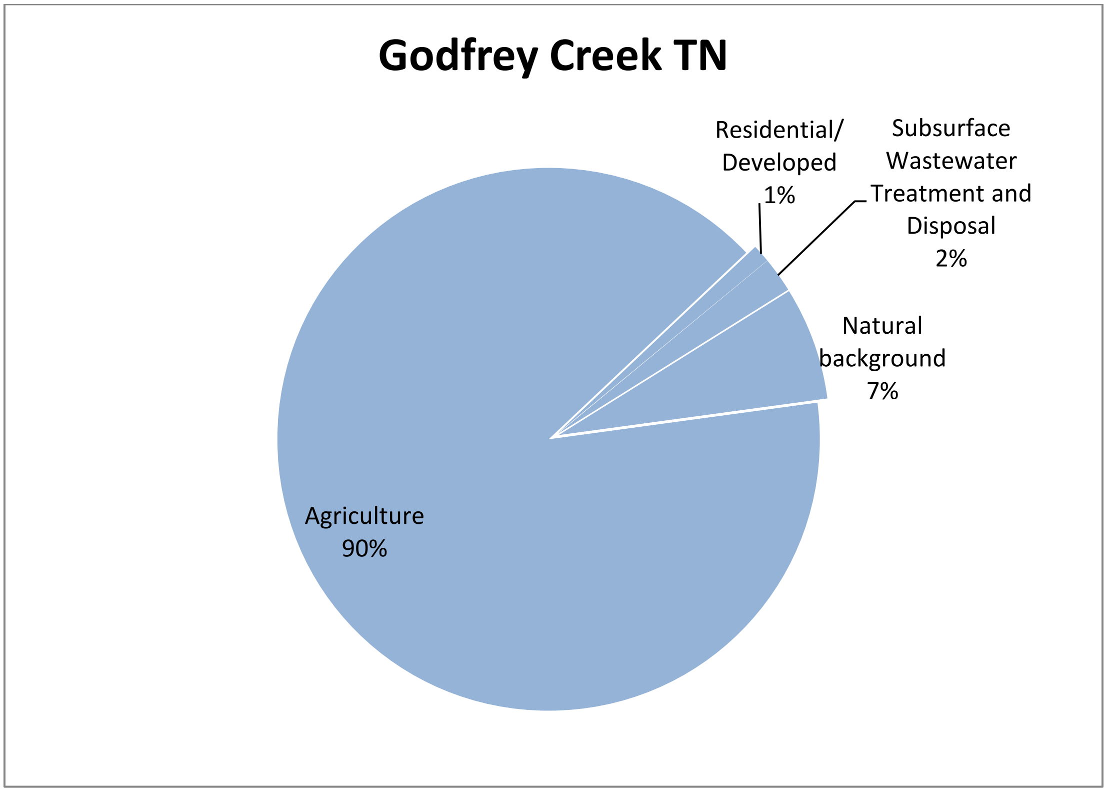

Figure F-3. Existing TN sources for Godfrey Creek

In Godfrey Creek, it was determined that agriculture is the dominant source of TN loads in the stream based on data collection efforts in 2008 and 2009, the nutrient source assessment and NASS CropScape.

For TP on Godfrey Creek, the same methodology was used (**Table F-14; Table F-15**).

Table F-14. Total phosphorus loading on 9/25/2009 on Godfrey Creek

Site ID	Flow (cfs)	TP (mg/L)	TP load (lbs/day)	Change in load from upstream (lbs/day)	% of peak load
GD05	0.88	0.09	0.43	0.43	40%
GD04 (tributary)	1.45	0.059	0.46	0.46	43%
GD03A	2.45	0.06	0.79	-0.10	NA
GD03	2.98	0.041	0.66	-0.13	NA
GD02A	2.88	0.054	0.84	0.18	17%
GD02	3.22	0.021	0.36	-0.47	NA
GD01	4.06	0.016	0.35	-0.01	NA

*The sum of GD04 and GD05 were subtracted from GD03A to determine the change in TN load [(0.43+0.46)-(0.79) = -0.10].

The TP impairment on Godfrey Creek is likely tied to the sediment impairment. TP loads decrease from the main source area in the upper reaches but rise again at GD02A. This is likely due to a TP source in the reach upstream of the sampling location and may be linked to an animal confinement area in the vicinity of the sampling point.

Table F-15. Existing load source assessment for anthropogenic sources for total phosphorus on Godfrey Creek for 9/25/2009

Source category	GD05	GD04	GD03A	GD03	GD02A	Total
Forest	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	40.83	3.44	32.39	0.00	17.57	94.23
Residential/Developed	2.20	0.07	1.70	0.00	0.92	4.89
Subsurface wastewater disposal and treatment	0.88	0.00	0.00	0.00	0.00	0.88
% of peak load	43.90	3.51	34.09	0.00	18.49	100

As outlined in **Section F2.1**, natural background was calculated based on the median flow observation for Godfrey Creek using the available data (2.48 cfs) and the median TP concentration in the reference dataset for the Middle Rockies ecoregion (0.010 mg/L TP). The median observed TP concentration in Godfrey Creek was 0.054 mg/L TP for an existing TMDL load of 0.72 lbs TP/day (**Table F-16**).

Table F-16. Godfrey Creek values used to determine total phosphorus existing load and natural background.

Median discharge	Median reference concentration for Godfrey Creek	Natural background load	Median observed concentration	Existing Load
2.48 cfs	0.010 mg/L TP	0.13 lbs TP/day	0.054 mg/L TP	0.72 lbs TP/day

The natural background load of 0.13 lbs TP/day is 18.52% of the existing load using the median values. All other source categories were uniformly decreased to account for the calculated natural background load (**Table F-17**).

Table F-17. Uniform decrease of source allocations to account for natural background in Godfrey Creek total phosphorus source assessment.

Source allocation	Existing load	
	Without NB (%)	With NB (%)
Natural background		18.52
Agriculture	94.23	76.78
Residential/Developed	4.89	3.99
Subsurface Wastewater Treatment and Disposal	0.88	0.72
Total	100.00	100.00

This method determined natural background to be ~18% of the TN load in Godfrey Creek. The source categories' percentages were uniformly decreased to account for the calculated natural background TP load (**Figure F-4**).

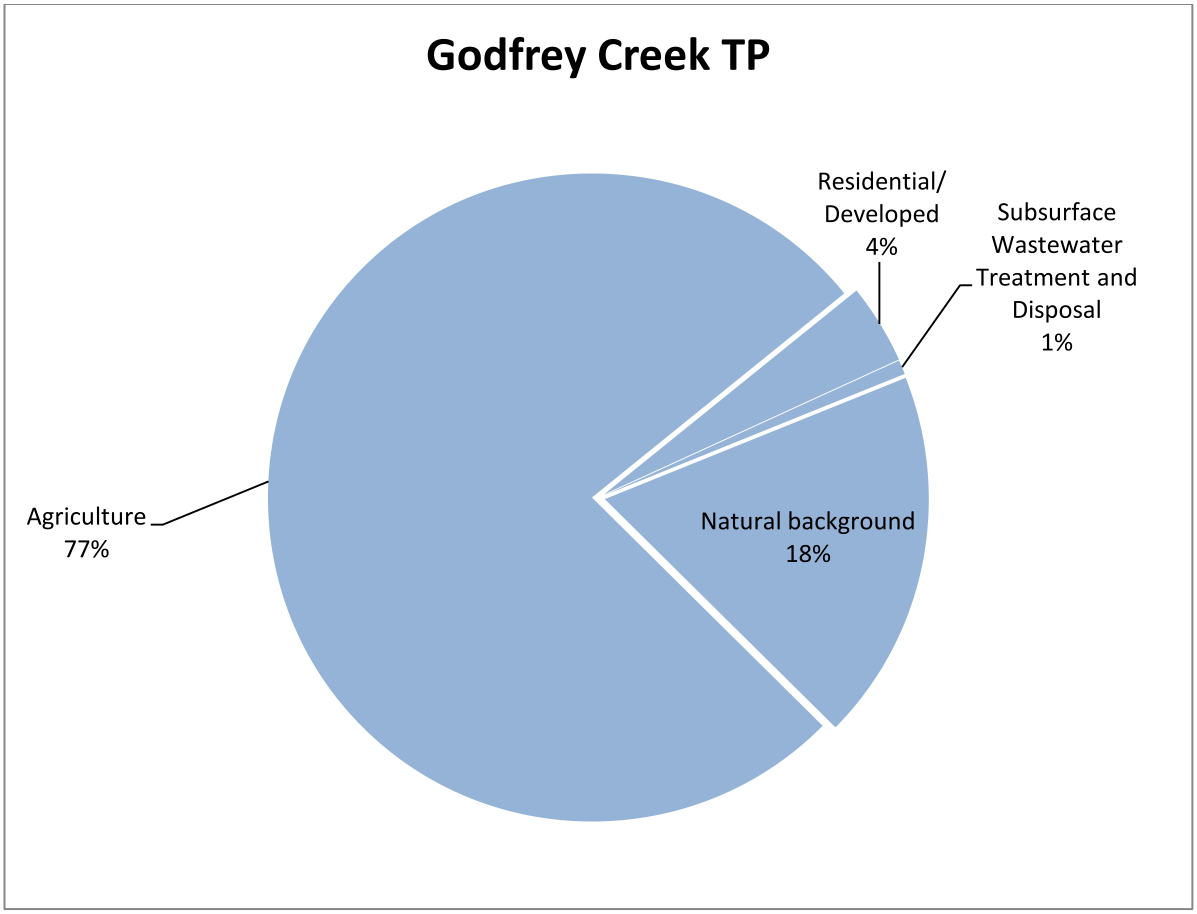

Figure F-4. Existing TP sources for Godfrey Creek

F4.2 Bozeman Creek Existing Load Source Assessment for TN

Lower Bozeman Creek is listed on the 2012 303(d) List for a total nitrogen (TN) impairment. The lower segment of Bozeman Creek flows 4.9 miles from the confluence with Limestone Creek to the mouth (East Gallatin River). Bozeman Creek originates in the Gallatin Range and flows out of Sourdough Canyon. The total length of the stream is 14 miles from the confluence of North Fork and South Fork to the mouth (East Gallatin River). Extensive water quality data is available for Bozeman Creek with the primary collection efforts occurring in 2008 and 2009 and is the most well sampled waterbody in the project area and the analysis included data collected upstream of the assessment unit and from several tributaries to Bozeman Creek (**Table F-18; Figure F-5**).

From **Attachment B**: Bozeman Creek is progressively more impacted from upstream to downstream along its 14 mile length. From its headwaters, downstream to the Bozeman Creek trailhead, Sourdough Creek is minimally impacted as it flows through Gallatin National Forest land. From the Bozeman Creek trailhead to approximately Goldenstein Rd it is an agricultural stream, with adjacent pasture land and hay fields. Between Goldenstein Rd, downstream to Bogert Park, residential and urban impacts increase. However, where residential lawns do not encroach on the stream, the riparian vegetation is still relatively healthy and bank erosion is limited to areas of pasture and lawn encroachment. The greatest potential water quality influences to these reaches are likely tributary streams (Limestone Creek, Nash Spring Creek) and residential lawn encroachment along South Church Street. Urban impacts greatly increase downstream of Bogert Park as the streamflows through downtown Bozeman and residential areas along Rouse Ave. This is by far the most impacted reach along the entire stream with several potential nutrient sources. Residential lawns encroach directly on the stream for most of the length, banks were generally eroding and trampled, and the riparian quality was very poor to nonexistent in most areas. The most downstream reach, from Tamarack St to the confluence with the East Gallatin River, was less impacted by urban development than the upstream reach; with a wider riparian buffer, less residential lawn and pasture encroachment, and minimal bank erosion. This reach did flow through some livestock grazing and industrial areas, both of which are likely nutrient sources.

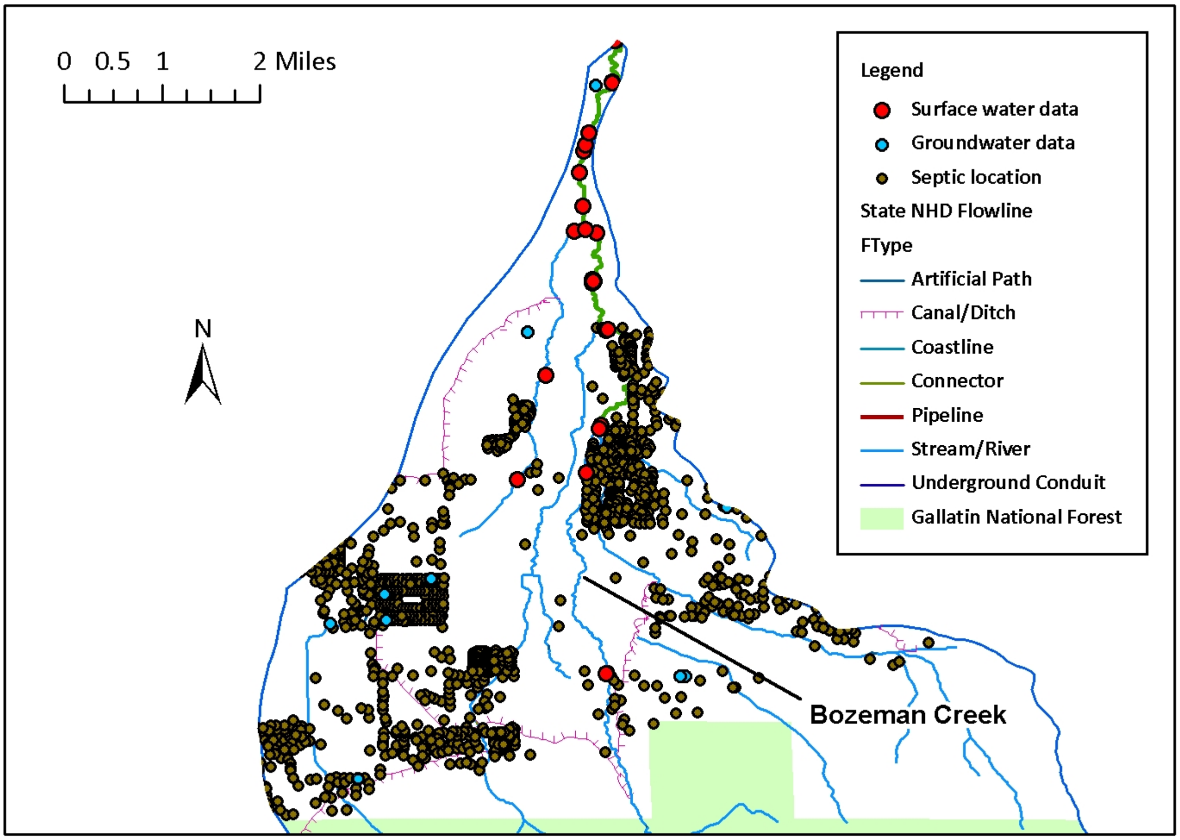

Figure F-5. Spatial data used for the lower Bozeman Creek existing load source assessment

For Bozeman Creek, there were 2 available sampling dates when water quality samples were collected at numerous points along the stream on a single day (**Figure F-6**). Therefore, loading was analyzed for both dates in addition to tributary water quality data to determine the existing sources of the TN in Bozeman Creek.

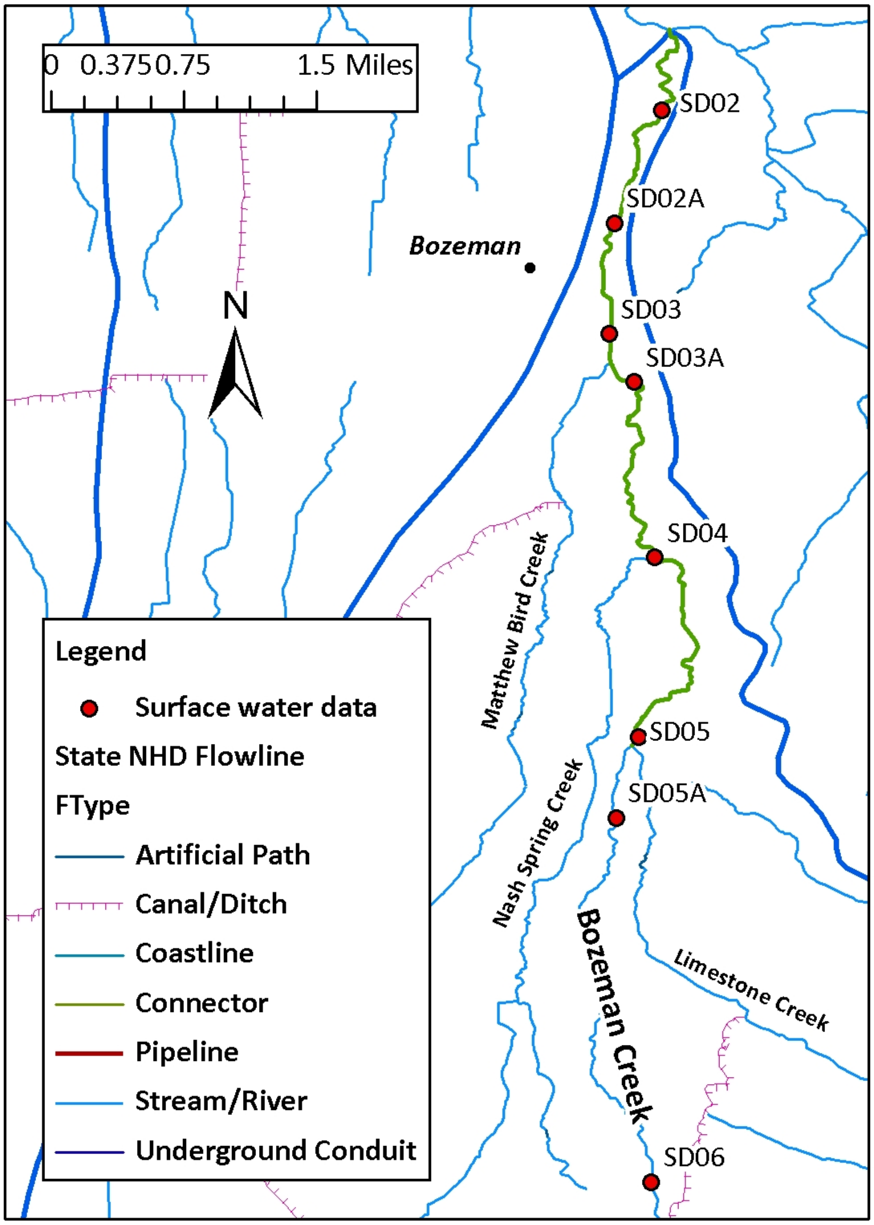

Figure F-6. Site IDs for surface water data points on Bozeman Creek

In **Figure F-6**, important additions and diversions include the tributaries of Nash Spring Creek which joins Bozeman Creek immediately upstream of SD04 and Matthew Bird Creek which flows into Bozeman Creek immediately upstream of SD03. A large irrigation diversion on Bozeman Creek is the Mill-Willow irrigation canal which diverts Bozeman Creek downstream of the confluence of Matthew Bird Creek and Bozeman Creek and upstream of sampling point SD03. The distance between the Matthew Bird Creek confluence and the Mill-Willow Canal is ~500 ft. Based on flow measurements in the 9/15/2009 sampling event, the Mill-Willow canal diverted 4.73 cfs assuming no inflow to Bozeman Creek between sampling points SD03A and SD03. This was 22% of the Bozeman Creek flow at the diversion on that date. This loss in load and flow from Bozeman Creek was accounted for in the following TN source assessments.

Using the available data sources, including the source assessment and the CropScape application, percentages per source category were assigned for the each sample location where an increase in TN load was observed. Values were then weighted based on the % of peak load at each sample location and then totaled for the entire stream segment. Results were compared to other available TN data.

Table F-18 and **F-19** are the results of the TN load analysis for samples collected on 9/2/2008.

Table F-18. Total nitrogen loading on 9/2/2008 on Bozeman Creek

Site ID	Flow (cfs)	TN (mg/L)	TN load (lbs/day)	Change in load from upstream	% of peak load
SD06	19.62	0.025	2.63	2.63	2%
SD05A	Not sampled				
SD05	15.23	0.17	13.90	11.27	9%
SD04	19.02	0.30	30.64	30.64	14%
SD03A	Not sampled				
SD03	25.70	0.77	106.27	75.63	62%
SD02A	Not sampled				
SD02	25.81	0.88	121.97	15.70	13%

Table F-19. Existing load source assessment for anthropogenic sources for total nitrogen on Bozeman Creek for 9/2/2008

Source category	SD06	SD05	SD04	SD03	SD02	Total
Forest	2.16	0.46	0.00	0	0	2.62
Agriculture	0.00	0.00	2.75	31	0	33.75
Residential/Developed	0.00	5.08	5.49	24.8	12.87	48.24
Subsurface wastewater disposal and treatment	0.00	3.69	5.49	6.2	0	15.39
% of peak load	2.16	9.23	13.73	62	12.87	100

Table F-20 and **F-21** are the results of the TN load analysis for samples collected on 9/15/2009. Nash Spring Creek enters Bozeman Creek upstream of SD04 and Matthew Bird Creek joins Bozeman Creek between SD03 and SD03A. Data collected from these tributaries on 9/15/2009 was used in the analysis for the mainstem.

Table F-20. Total nitrogen loading on 9/15/2009 on Bozeman Creek

Site ID	Flow (cfs)	TN (mg/L)	TN load (lbs/day)	Change in load from upstream	% of peak load
SD06	7.27	0.025	0.98	0.98	1%
SD05A	9.21	0.27	13.35	12.38	18%
SD05	10.18	0.27	14.76	1.41	2%
Nash Spring Creek	3.10	1.55	25.85	NA	NA
SD04	13.31	0.75	53.61	38.85	56%
SD03A	14.46	0.74	57.46	3.86	6%
Matthew Bird Creek	7.46	0.81	32.45	NA	NA
SD03	17.19	0.75	69.23	11.77	17%
SD02A	18.61	0.69	68.96	-0.28	NA
SD02	17.57	0.73	68.88	-0.08	NA

* Nash Spring Creek and Matthew Bird Creek are tributaries to Bozeman Creek and data collection efforts were incorporated into the source assessment.

Table F-21. Existing load source assessment for anthropogenic sources for total nitrogen on Bozeman Creek for 9/15/2009

Source category	SD06	SD05A	SD05	SD04	SD03A	SD03	Total
Forest	1.41	0.00	0.1	0.00	0.39	0.00	1.9
Agriculture	0.00	6.62	0.00	8.42	3.06	8.5	26.6
Residential/Developed	0.00	6.79	1.12	25.2	1.67	6.8	41.63
Subsurface wastewater disposal and treatment	0.00	4.47	0.81	22.4	0.45	1.7	29.87
% of peak load	1.41	17.88	2.03	56.02	5.57	17	100

The existing source allocations for anthropogenic sources in the Bozeman Creek drainage was calculated by taking the mean of the 9/2/2008 and 9/15/2009 analyses (**Table F-22**).

Table F-22. Mean of 9/2/2008 and 9/15/2009 source assessments

Source category	9/2/2008	9/15/2009	Mean
Forest	2.62	1.9	2.26
Agriculture	33.75	26.6	30.17
Residential/Developed	48.24	41.63	44.94
Subsurface wastewater disposal and treatment	15.39	29.87	22.63
% of peak load	100	100	100

As outlined in **Section F2.1**, natural background was calculated based on the median flow observation for Boxeman Creek using the available data (23.95 cfs) and the median TN concentration in the reference dataset as determined for Bozeman Creek (0.085 mg/L TN; **Table F-23**). The median observed TP concentration in Bozeman Creek was 0.73 mg/L TN for an existing TMDL load of 94.06 lbs TN/day (**Table F-23**).

Table F-23. Bozeman Creek values used to determine total nitrogen existing load and natural background.

Median discharge	Median reference concentration for Bozeman Creek	Natural background load	Median observed concentration	Existing Load
23.95 cfs	0.085 mg/L TP	10.95 lbs TN/day	0.73 mg/L TN	94.06 lbs TN/day

The natural background load of 10.95 TN/day is 11.64% of the existing load using the median values. All other source categories were uniformly decreased to account for the calculated natural background load (**Table F-24**).

Table F-24. Uniform decrease of source allocations to account for natural background in Bozeman Creek total nitrogen source assessment.

Source allocation	Existing load	
	Without NB (%)	With NB (%)
Natural background		11.64
Forest	2.26	2.00
Agriculture	30.17	26.66
Residential/Developed	44.94	39.71
Subsurface Wastewater Treatment and Disposal	22.63	20.00
Total	100.00	100.00

The method outlined in **Table F-23** determined natural background to be 11% of the TN load in Bozeman Creek. Source categories were adjusted to account for this percentage (**Figure F-7**).

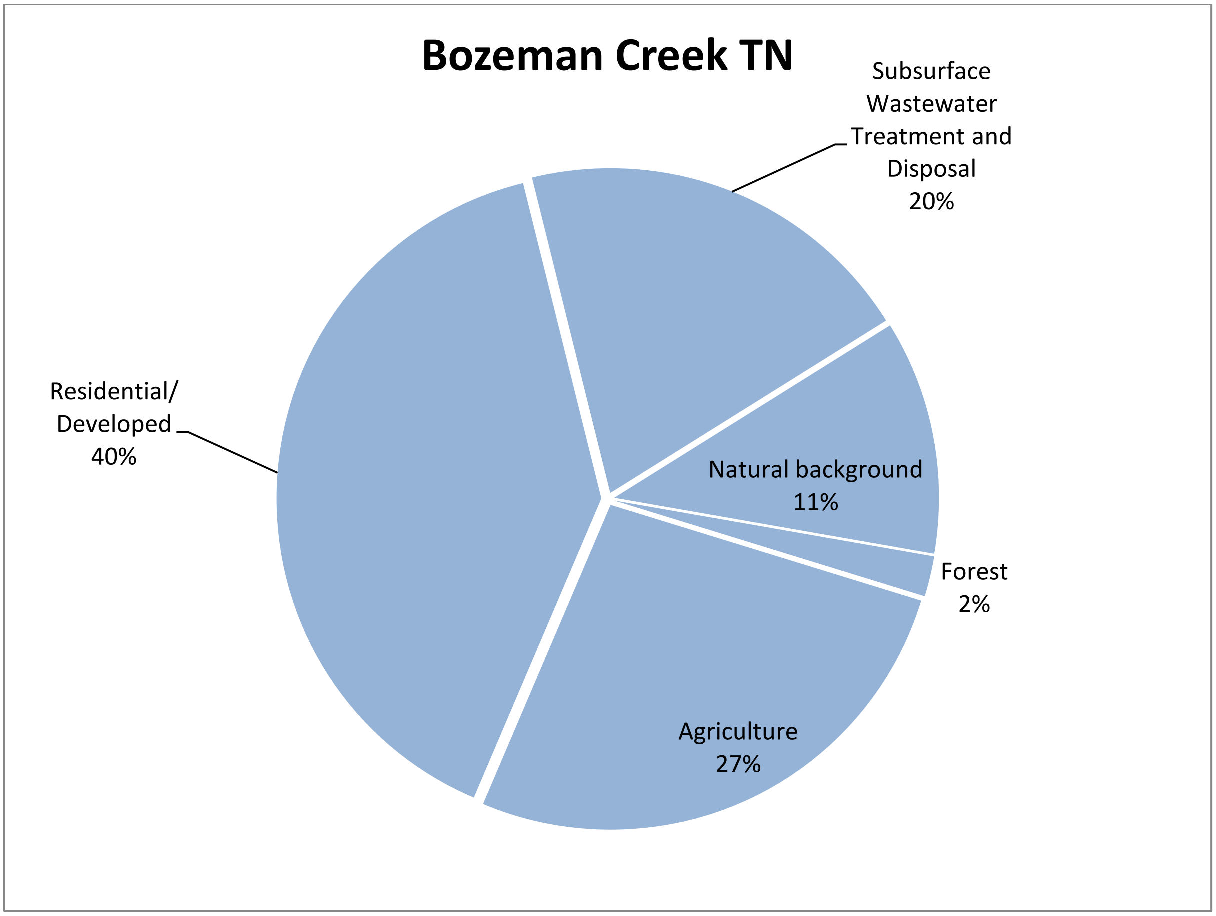

Figure F-7. Existing TN sources for Bozeman Creek

Matthew Bird Creek and Nash Spring Creek contribute large TN loads to Bozeman Creek, while Limestone Creek was found to contribute only small nutrient additions to Bozeman Creek. The existing load assessment used data collected on those tributaries to determine % loads to Bozeman Creek. In addition, the Mill-Willow irrigation canal diverts flow from Bozeman Creek and actually reduces TN loads immediately downstream of the Matthew Bird Creek and Bozeman Creek confluence. This was also accounted for in the analysis. Finally, the 9/2/2008 and 9/15/2009 data analyses had good agreement with the load increases observed in the 2008-2011 Greater Gallatin Watershed Council data collected on Bozeman Creek. In Bozeman Creek, TN sources include both agriculture and urban/residential nonpoint sources.

F5.0 Existing Load Source Assessments for Remaining TMDL Streams Except East Gallatin River

Figures displaying spatial data used in the source assessments per waterbody identify all surface water data locations but labels are only provided for those points sampled in the synoptic events used for the source assessment.

F5.1 Bear Creek

Bear Creek is listed as impaired for total phosphorus on the 2012 303(d) List. Figures and analysis for TP source allocation are provided in this section. **Figure F-8** displays the stream sampling locations and other environmental data including septic density and hydrography.

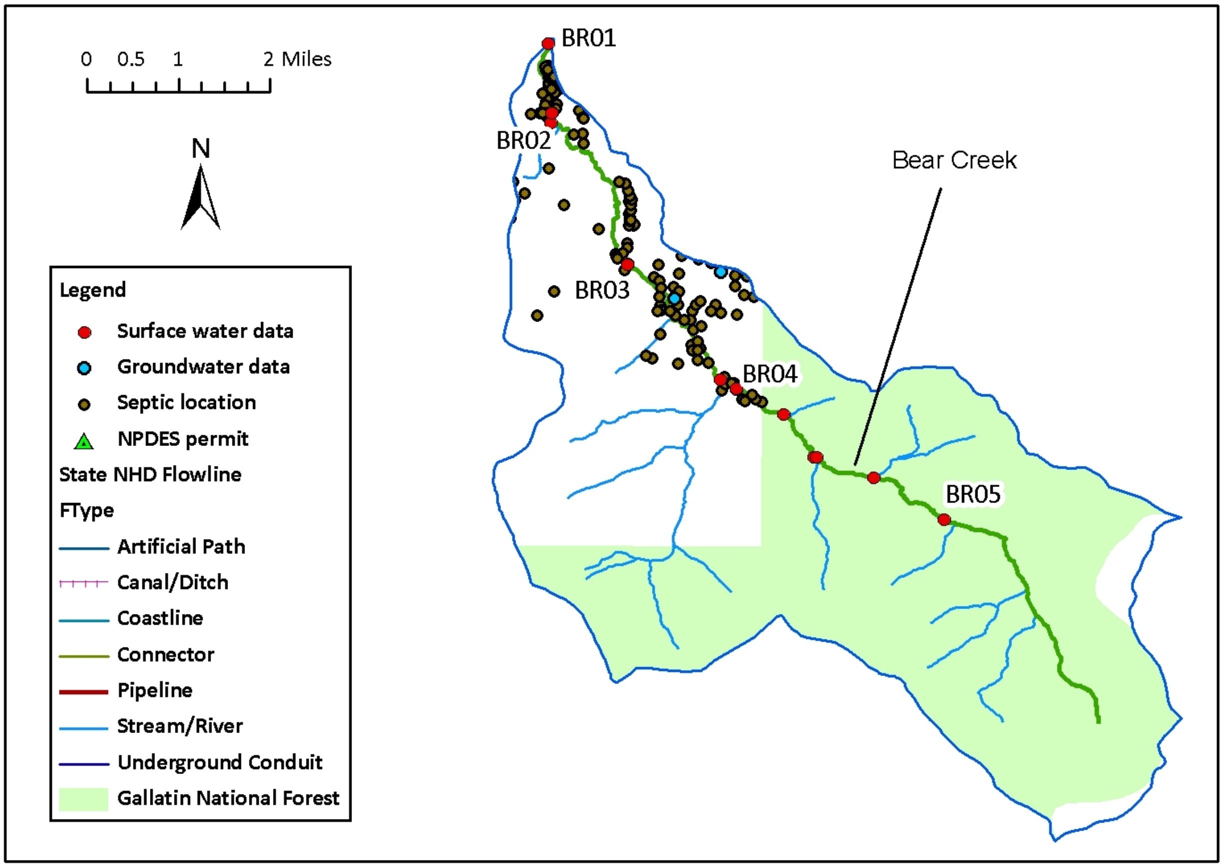

Figure F-8. Spatial data used for the Bear Creek existing load source assessment

Two synoptic sampling events were available for Bear Creek. Load calculations and source assessments are included in the following tables (**Tables F-25, F-26, F-27, and F-28**).

Table F-25. Total phosphorus loading on 8/26/2008 on Bear Creek

Site ID	TP load (lbs/day)	Change in load from upstream	% of peak load
BRO5	5.16	0.474	65%
BRO4	2.78	0.251	34%
BRO3	3.47	0.003	0.4%
BRO2	4.97	-0.265	NA
BRO1	6.24	-0.096	NA

Table F-26. Existing load source assessment for total phosphorus on Bear Creek for 8/26/2008

Source category	BRO5	BRO4	BRO3	Total
Forest	55.34	27.75	0.25	83.35
Agriculture	9.77	4.14	0.06	13.97
Residential/Developed	0.00	0.00	0.04	0.04
Subsurface wastewater disposal and treatment	0.00	2.59	0.06	2.65
% of peak load	65.11	34.48	0.41	100

Table F-27. Total phosphorus loading on 9/18/2009 on Bear Creek

Site ID	TP load (lbs/day)	Change in load from upstream	% of peak load
BRO5	Not sampled		
BRO4	0.32	0.32	93%
BRO3	0.35	0.02	7%
BRO2	0.21	-0.14	NA
BR01	0.18	-0.02	NA

Table F-28. Existing load source assessment for total phosphorus on Bear Creek for 9/18/2009

Source category	BRO4	BRO3	Total
Forest	75.13	4.00	79.13
Agriculture	11.2	1.00	12.2
Residential/Developed	0.00	0.67	0.67
Subsurface wastewater disposal and treatment	7.00	1.00	8
% of peak load	93.33	6.67	100

Mean percentages from the 2 sampling date analyses were calculated for the Bear Creek existing load assessment which did not include natural background. The source assessment determined that most of the phosphorus in the system originated upstream of the national forest boundary with only minor additions in the reaches downstream of the forest. Natural background was calculated to be 42% of the TP load in Bear Creek. Source categories were uniformly decreased to account for this percentage (**Figure F-9**).

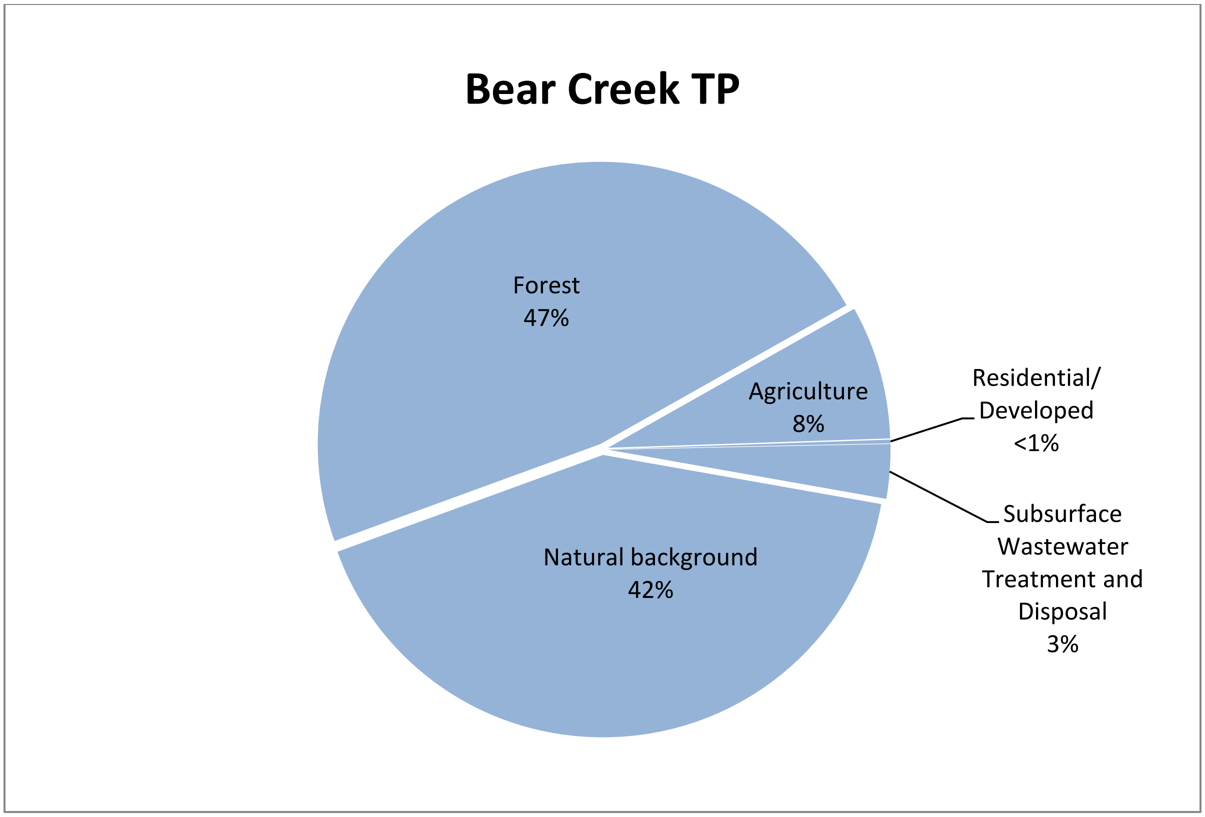

Figure F-9. Existing TP sources for Bear Creek

F5.2 Bridger Creek

Bridger Creek is listed as impaired for nitrite + nitrate (NO_3+NO_2) on the 2012 303(d) List. Figures and analysis for $N0_3$+ $N0_2$ source allocation are provided in this section. **Figure F-10** displays the stream sampling locations and other environmental data including septic density and hydrography.

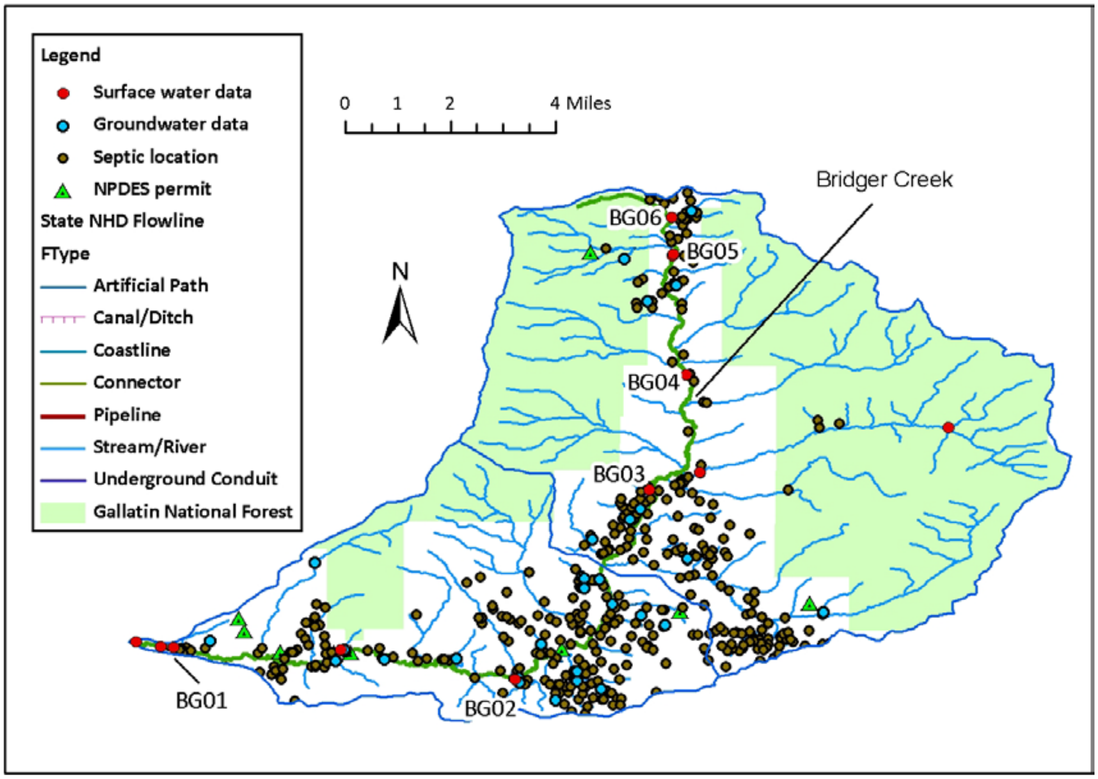

Figure F-10. Spatial data used for the Bridger Creek existing load source assessment

One synoptic sampling event was available for Bridger Creek. Load calculations and source assessments are included in the following tables (**Tables F-29, and F-30**).

Table F-29. $N0_3$+ $N0_2$ loading on 8/27/2008 on Bridger Creek

Site ID	TP load (lbs/day)	Change in load from upstream	% of peak load
BG06	0.04	0.04	0.0%
BG05	0.71	0.67	6%
BG04	0.88	0.17	1%
BG03	1.99	1.11	9%
BG02	6.25	4.26	35%
BG01	12.10	5.85	48%

Most of the inorganic nitrogen loading in Bridger Creek occurs in the lower reaches below the canyon mouth and the USFWS Fish Tech Center and exceedances of the water quality target are limited to the reach below the Lyman Creek confluence.

Table F-30. Existing load source assessment for anthropogenic sources for NO_3+NO_2 on 8/27/2008 on Bridger Creek

Source category	BG06	BG05	BGO4	BGO3	BGO2	BGO1	Total
Forest	0.35	0.83	0.21	1.38	5.28	0.97	9.01
Agriculture	0.00	1.38	0.83	5.53	22.89	4.83	35.46
Residential/Developed	0.00	1.65	0.21	1.38	3.52	27.43	34.19
Subsurface wastewater disposal and treatment	0.01	1.65	0.14	0.92	3.52	9.67	15.91
USFWS Fish Tech	0.00	0.00	0.00	0.00	0.00	5.43	5.43
% of peak load	0.36	5.51	1.39	9.21	35.21	42.9	100

Natural background was estimated based on flow statistics for the 8/27/2008 sampling event and on data collected from spring sources in the Lyman Creek drainage and in Bridger Creek downstream of the canyon mouth. Flow and water quality data from tributary streams, particularly Lyman Creek, were determined to constitute a large source of $N0_3$+ $N0_2$ from natural background and forest sources. The data was not comprehensive enough to separate these sources. This analysis determined forest/natural background to be 48% of the $N0_3$+ $N0_2$ load in Bridger Creek. Source categories were adjusted to account for this percentage (**Figure F-11**).

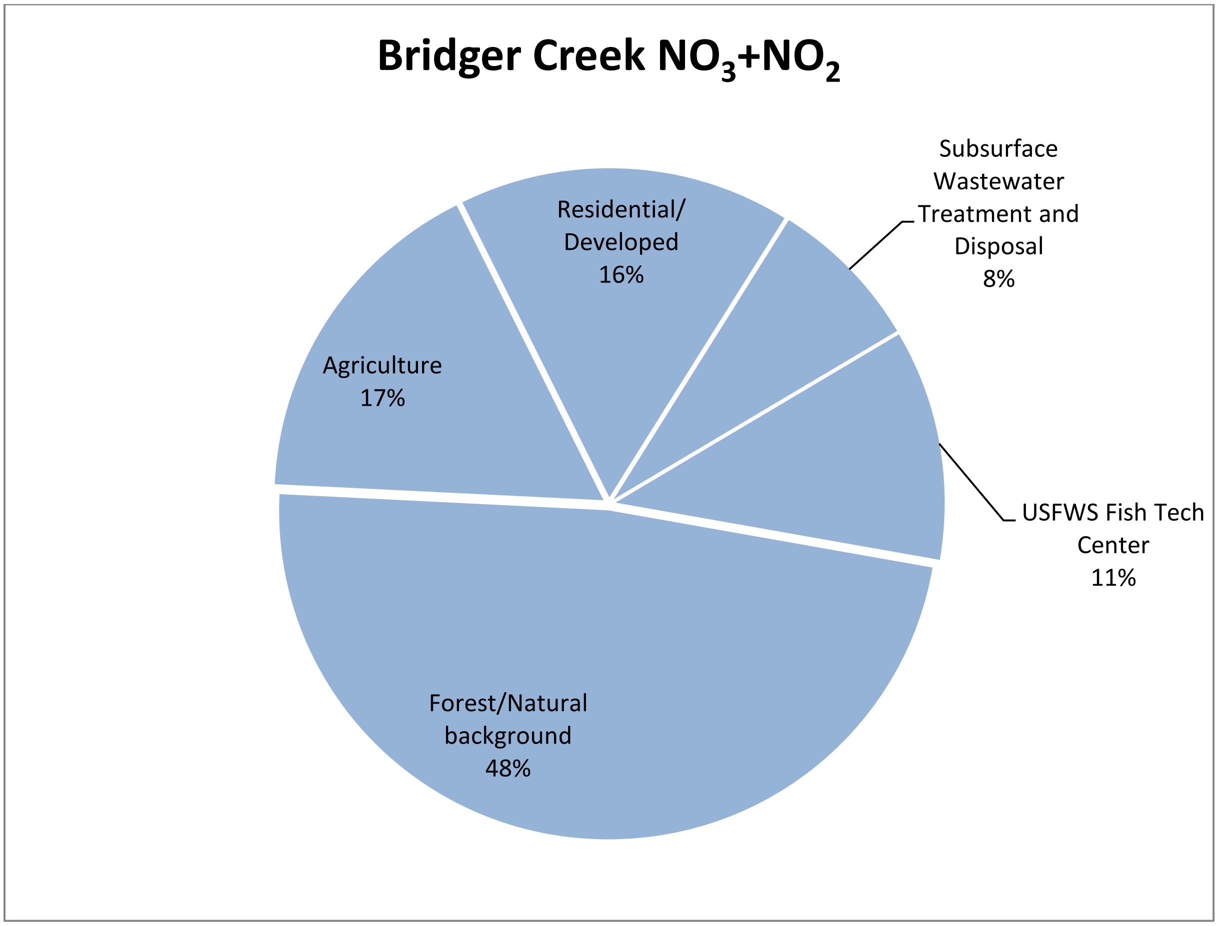

Figure F-11. Existing NO_3+NO_2 sources for Bridger Creek

F5.3 Camp Creek

Camp Creek is listed as impaired for total phosphorus and total nitrogen on the 2012 303(d) List. Figures and analysis for TP and TN source allocations are provided in this section. **Figure F-12** displays the stream sampling locations and other environmental data including septic density and hydrography.

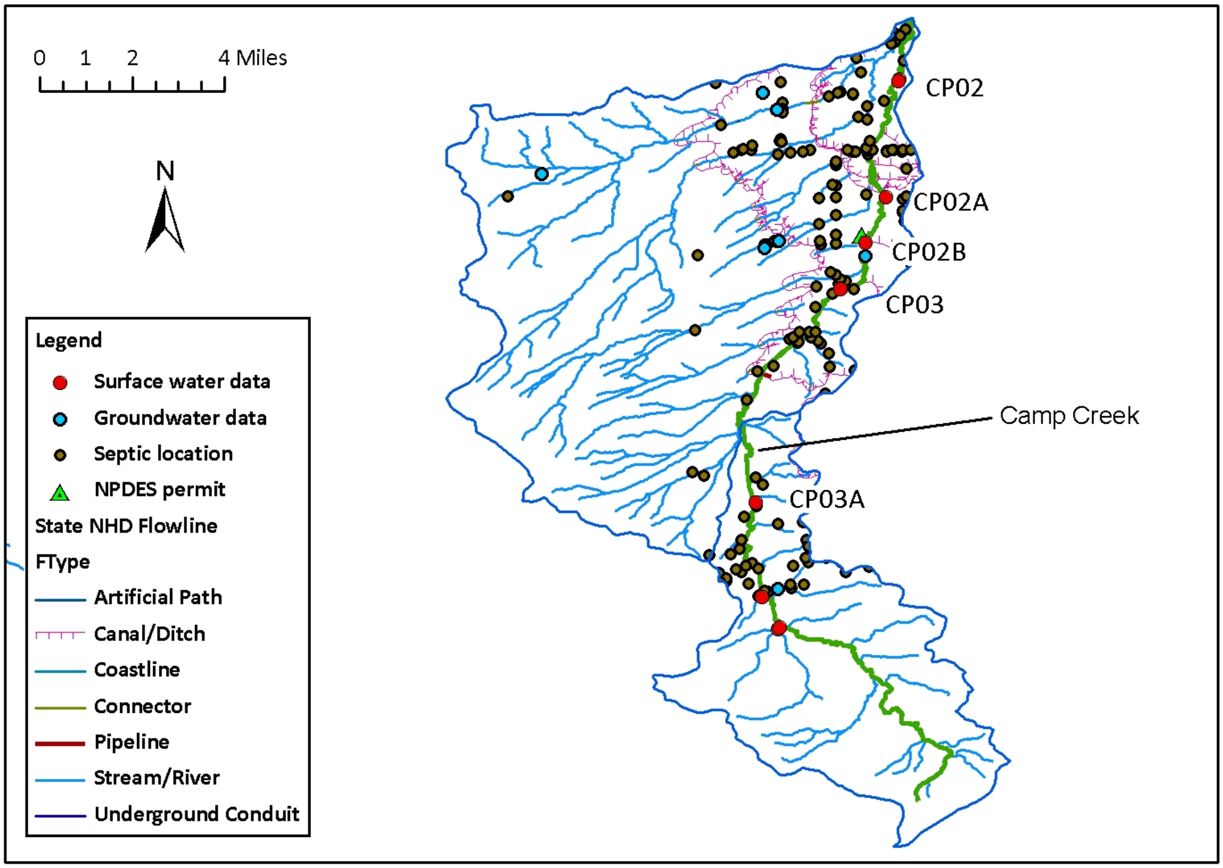

Figure F-12. Spatial data used for the Camp Creek existing load source assessment

Valley Ditch, which transports flows from the West Fork Gallatin River and Godfrey Creek joins Camp Creek downstream of CP02B and is re-diverted from Camp Creek ~400 feet downstream of where it entered north of Amsterdam Road. This inter-basin water transfer is part of the change in load seen between CP02B and CP02A for TN and TP. Between CP02A and CP02, 4 irrigation ditches flow into Camp Creek. Moreland Ditch, which Godfrey Creek flows into, joins Camp Creek channel downstream of CP02A for a distance of ~125 feet before being re-diverted. The White Ditch also joins Camp Creek before being re-diverted a short distance downstream. Two smaller ditches, the Lewis Overflow ditch and the Lewis Ditch terminate in Camp Creek. These additions to the channel are likely a large portion of the observed TN and TP load increase in the reach between CP02A and CP02.

It is worth noting that all instream water quality concentrations for TN and TP upstream of site CP02 exceeded water quality targets. While irrigation ditch networks added nutrient loads that originated outside the Camp Creek basin between CP02B and CP02, the Camp Creek watershed is still impaired for TN and TP from large additions within the Camp Creek watershed.

One synoptic sampling event was available for Camp Creek. Load calculations and source assessments are included in the following tables (**Tables F-31, F-32, F-33, and F-34**).

Table F-31. Total nitrogen loading on 9/23/2009 on Camp Creek

Site ID	TN load (lbs/day)	Change in load from upstream	% of peak load
CP03A	9.01	9.01	6%
CP03	30.23	21.22	14%
CP02B	36.35	6.12	4%
CP02A	37.70	1.35	1%
CP02	151.83	114.12	75%

Table F-32. Existing load source assessment for anthropogenic sources for total nitrogen on 9/23/2009 on Camp Creek

Source category	CP03A	CP03	CP02B	CP02A	CP02	Total
Forest	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	5.34	11.74	2.02	0.76	57.13	76.99
Residential/Developed	0.00	1.40	1.61	0.09	7.52	10.62
Subsurface wastewater disposal and treatment*	0.59	0.84	0.40	0.04	10.52	12.39
% of peak load	5.93	13.98	4.03	0.89	75.17	100

*Includes loading estimate from the Amsterdam-Churchill WWTP

Natural background was determined to be 7% of the TN load. Source categories were adjusted to account for this percentage (**Figure F-13**).

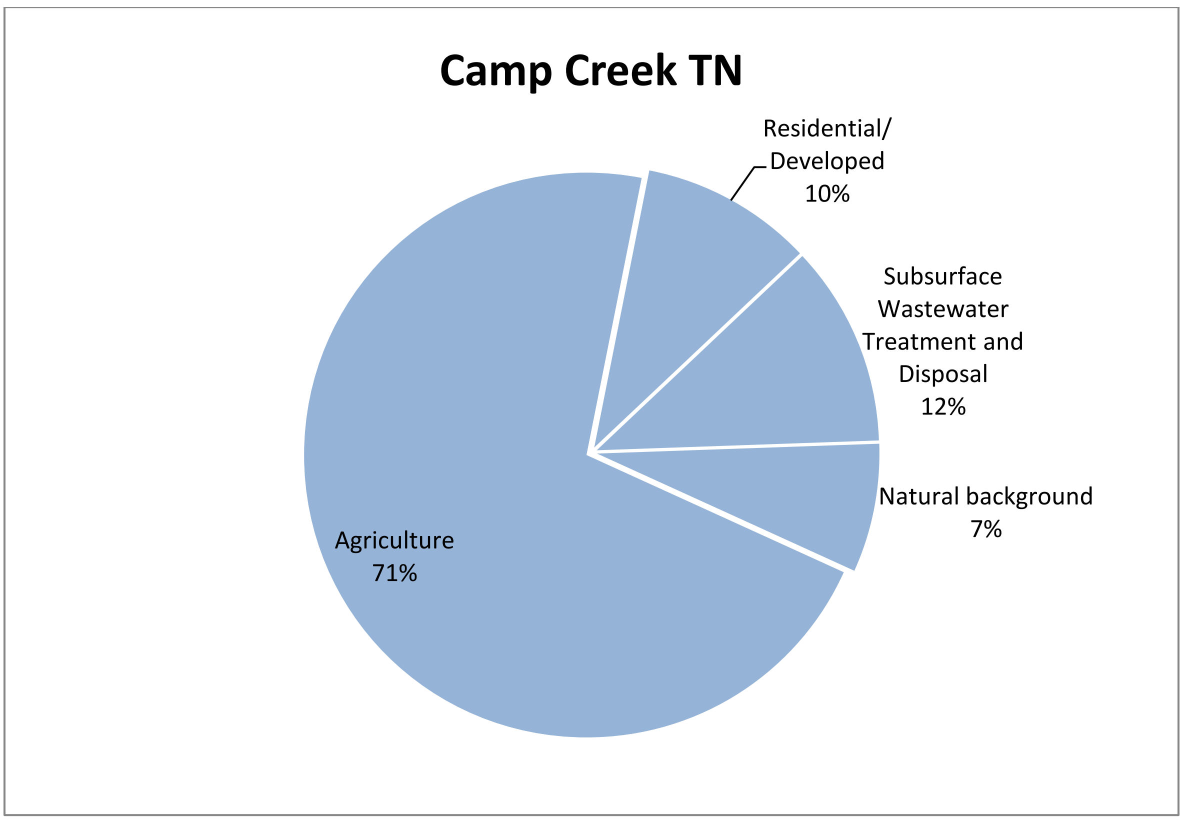

Figure F-13. Existing TN sources for Camp Creek

Table F-33. Total phosphorus loading on 9/23/2009 on Camp Creek

Site ID	TP load (lbs/day)	Change in load from upstream	% of peak load
CP03A	0.59	0.59	22%
CP03	1.80	1.21	46%
CP02B	2.00	0.20	8%
CP02A	2.16	0.16	6%
CP02	2.65	0.49	18%

Table F-34. Existing load source assessment for anthropogenic sources for total phosphorus on 9/23/2009 on Camp Creek

Source category	CP03A	CP03	CP02B	CP02A	CP02	Total
Forest	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	21.05	39.93	4.99	3.09	13.75	82.81
Residential/Developed	0.00	4.59	2.30	0.59	2.75	10.24
Subsurface wastewater disposal and treatment*	1.11	1.38	0.38	2.26	1.83	6.96
% of peak load	22.16	45.90	7.67	5.94	18.34	100

*Includes loading estimate from the Amsterdam-Churchill WWTP

Natural background was determined to be 10% of the TP load. Source categories were adjusted to account for this percentage (**Figure F-14**).

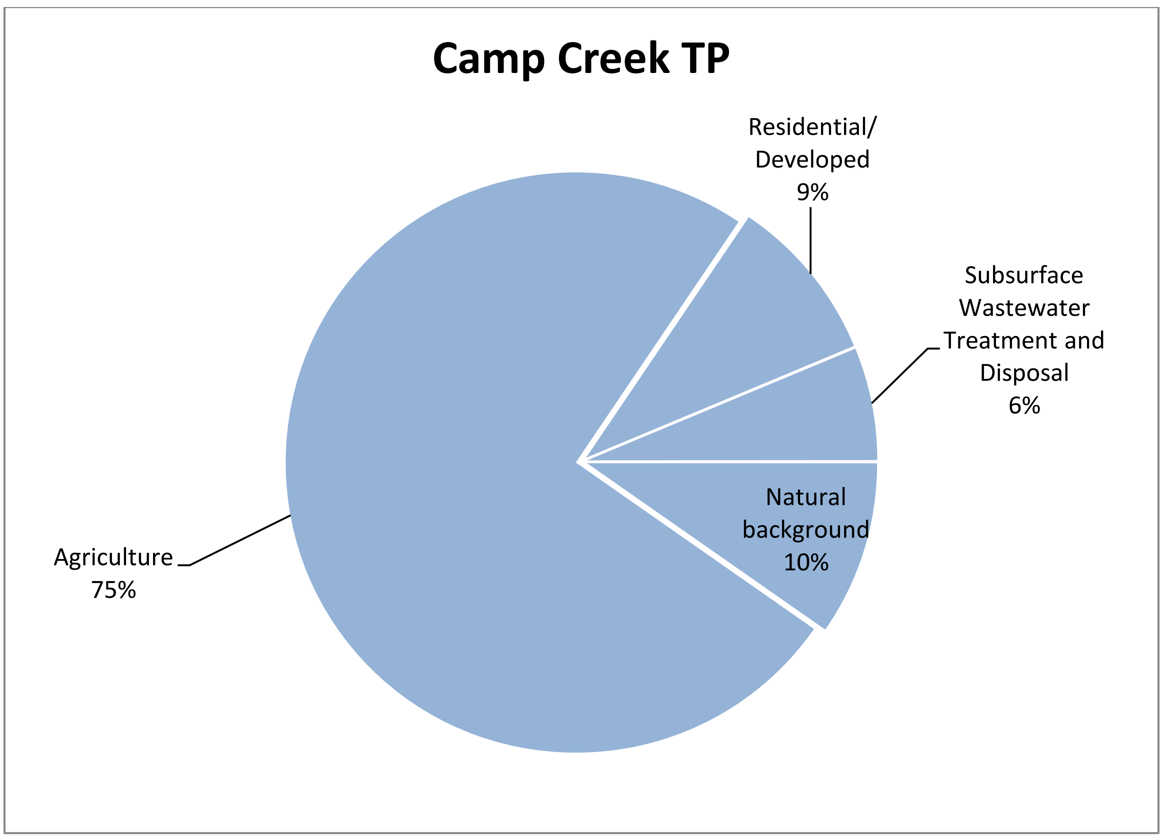

Figure F-14. Existing TP sources for Camp Creek

E5.4 Dry Creek

Dry Creek is listed as impaired for total phosphorus and total nitrogen on the 2012 303(d) List. Figures and analysis for TP and TN source allocations are provided in this section. **Figure F-15** displays the stream sampling locations and other environmental data including septic density and hydrography.

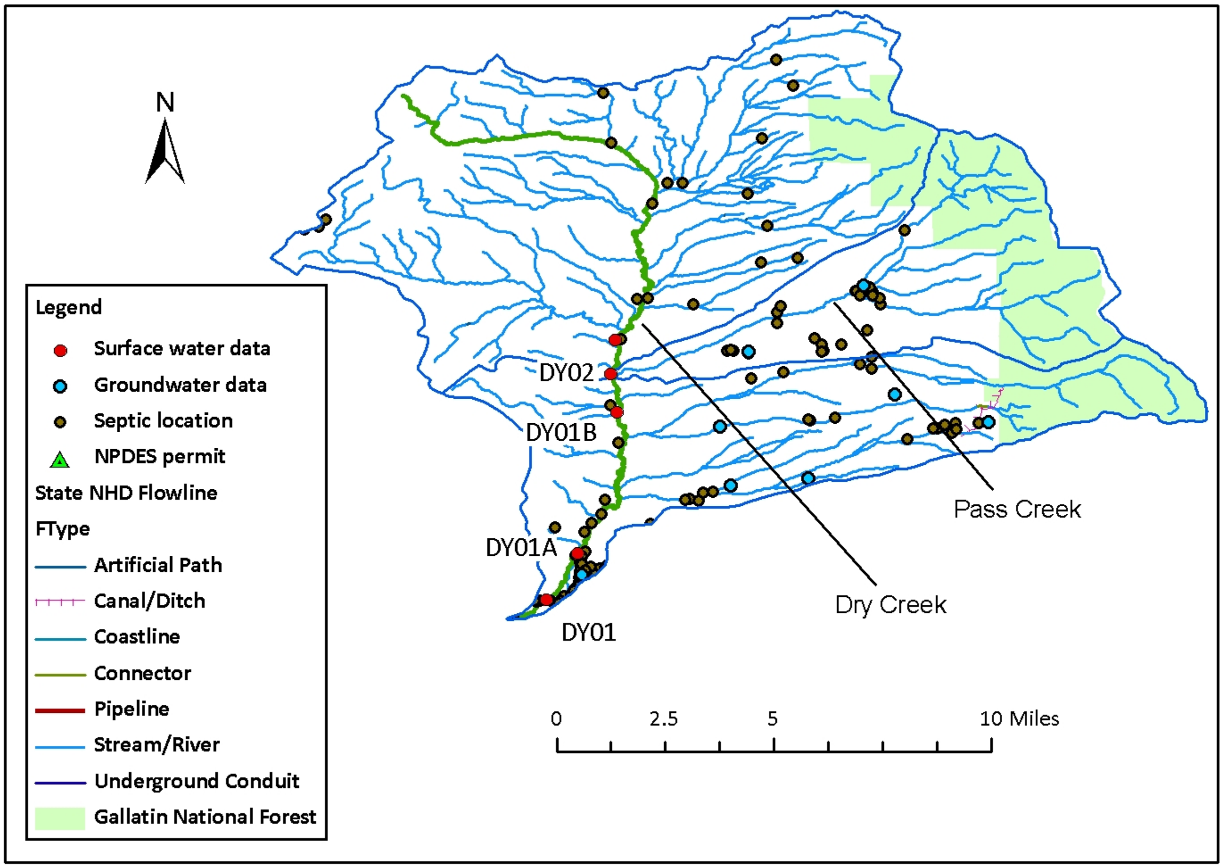

Figure F-15. Spatial data used for the Dry Creek existing load source assessment

Pass Creek flows into Dry Creek immediately downstream of site DY02 and was found to be a significant source area for TN and TP.

One synoptic sampling event was available for Dry Creek. Load calculations and source assessments are included in the following tables (**Tables F-35, F-36, F-37, and F-38**).

Table F-35. Total nitrogen loading on 9/21/09 on Dry Creek

Site ID	TP load (lbs/day)	Change in load from upstream	% of peak load
DY02	8.32	8.32	16%
DY01B	45.90	37.58	74%
DY01A	23.25	-22.65	NA
DY01	28.43	5.18	10%

Table F-36. Existing load source assessment for anthropogenic sources for total nitrogen on 9/21/2009 on Dry Creek

Source category	DY02	DY01B	DY01	Total
Forest	0.48	4.44	0.00	4.92
Agriculture	15.20	64.38	5.50	85.08
Residential/Developed	0.16	0.74	1.50	2.40
Subsurface wastewater disposal and treatment	0.16	4.44	3.00	7.60
% of peak load	16.00	74.00	10.00	0.00

Natural background was determined to be 22% of the total nitrogen load in Dry Creek. Source categories were adjusted to account for this percentage (**Figure F-16**).

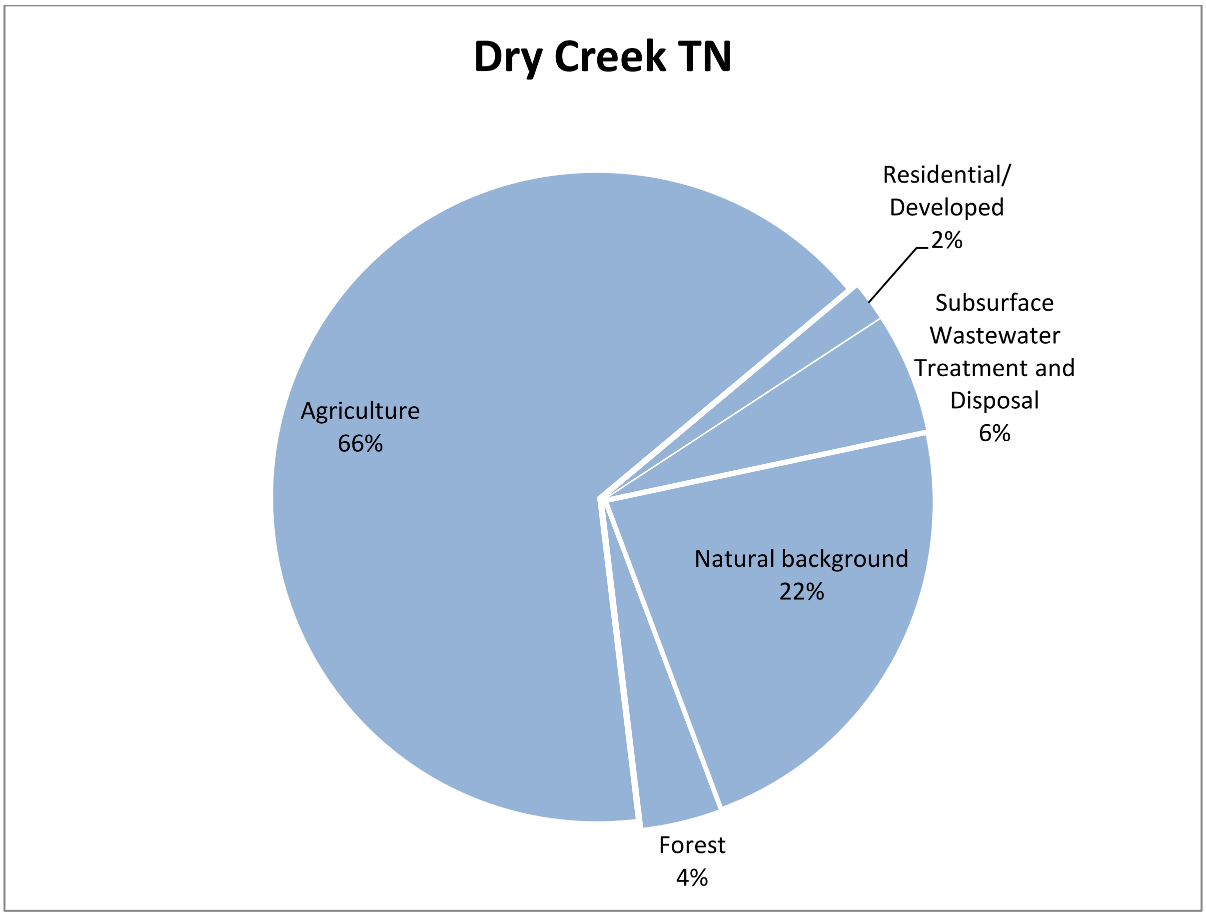

Figure F-16. Existing TN sources for Dry Creek

Table F-37. Total phosphorus loading on 9/21/09 on Dry Creek

Site ID	TP load (lbs/day)	Change in load from upstream	% of peak load
DY02	0.55	0.55	44%
DY01B	1.16	0.61	49%
DY01A	1.18	0.02	2%
DY01	1.24	0.06	5%

Table F-38. Existing load source assessment for anthropogenic sources for total phosphorus on 9/21/2009 on Dry Creek

Source category	DY02	DY01B	DY01A	DY01	Total
Forest	2.2	1.96	0	0	4.16
Agriculture	34.76	34.79	1.50	3.75	74.80
Residential/Developed	7.04	8.82	0.40	1.00	17.26
Subsurface wastewater disposal and treatment	0.00	3.43	0.10	0.25	3.78
% of peak load	44.00	49.00	2.00	5.00	0.00

Natural background was determined to be 48% of the total phosphorus load in Dry Creek. Source categories were adjusted to account for this percentage (**Figure F-17**).

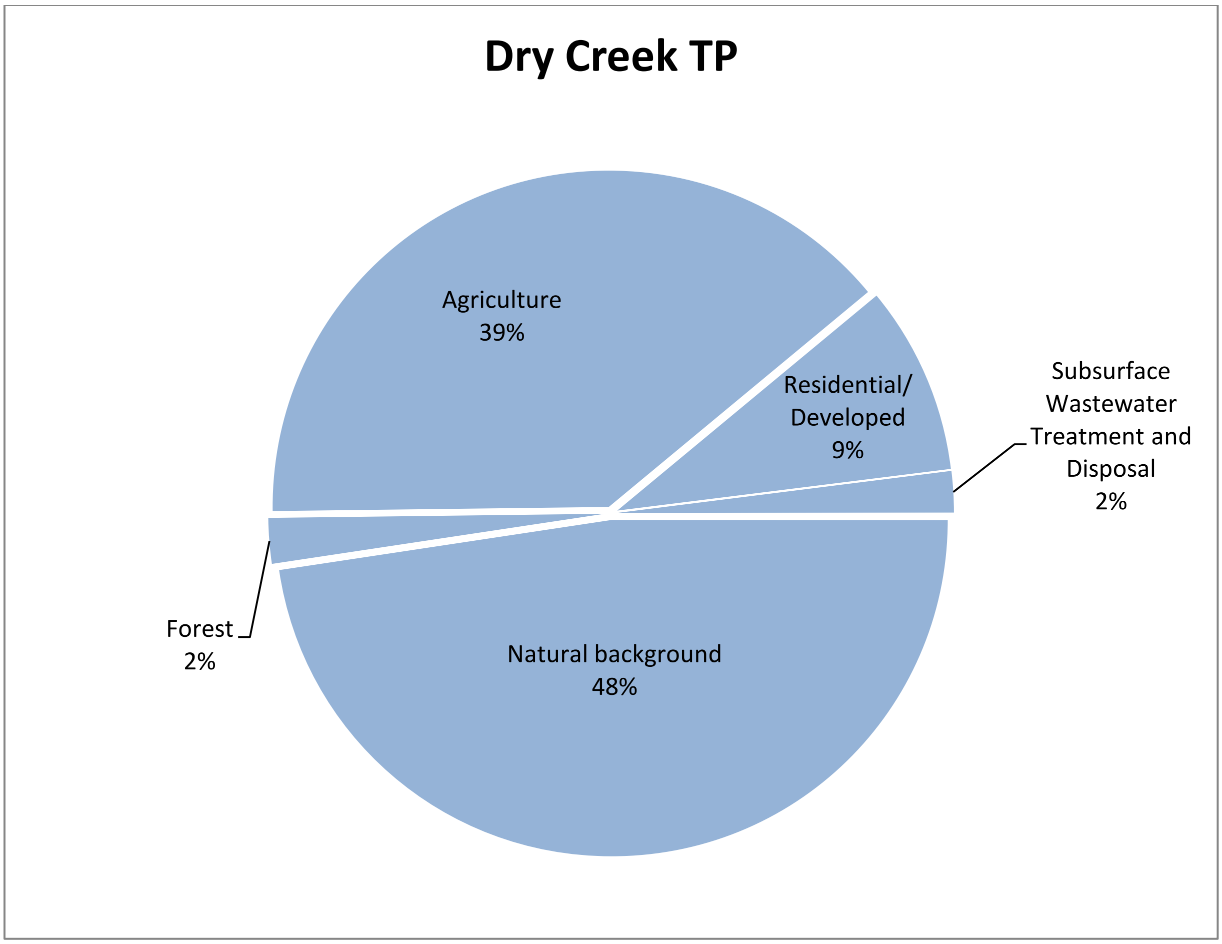

Figure F-17. Existing TP sources for Dry Creek

F5.5 LOWER HYALITE CREEK

The lower segment of Hyalite Creek below the forest boundary is listed as impaired for total nitrogen on the 2012 303(d) List. Figures and analysis for TN source allocations are provided in this section.

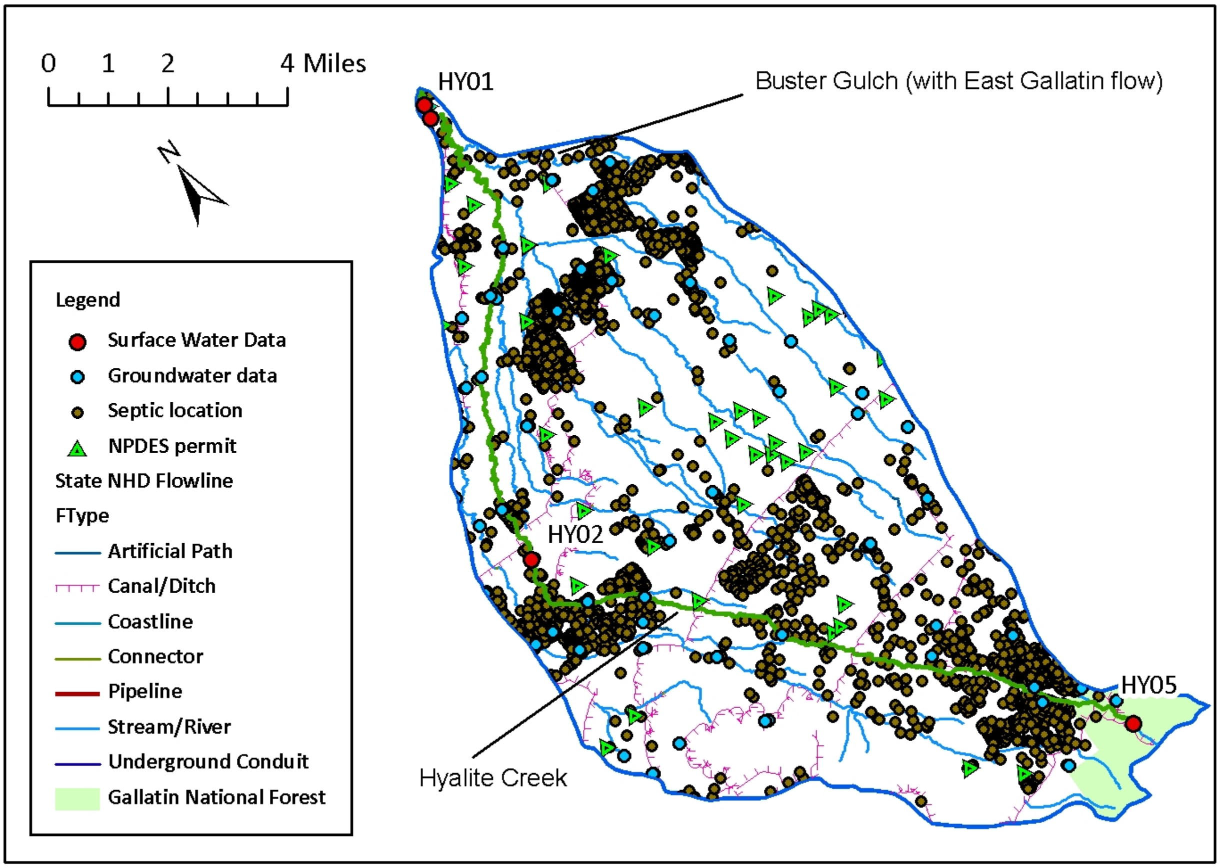

Figure F-18. Spatial data used for lower Hyalite Creek existing load source assessment

A complete synoptic sampling event was completed on the full length of Hyalite Creek on 9/14/2009 from the upper segment to the mouth (**Table F-39**). This provided relative load and flow data for calculating forest TN loads from above the forest boundary. Sites upstream of HY05 are not displayed in **Figure F-18** as they are in the middle and upper Hyalite Creek assessment units.

Table F-39. Total nitrogen loading on 9/14/2009 Hyalite Creek

Hyalite Creek AU	Site ID	TN Load (lbs/day)	Change in load from upstream	% of peak load
UPPER	HY08	4.68	4.68	2%
MIDDLE	HY04	52.41	47.73	15%
MIDDLE	HY03	51.72	-0.69	NA
LOWER	HY05	42.03	-9.70	NA
LOWER	HY02	22.75	-19.28	NA
LOWER	HY01	285.85	263.10	83%

Flow data from the sampling event indicate the impacts of irrigation and water supply diversions from Hyalite Creek (**Table F-40**). In examining the flow data in **Table F-40**, the large decreases in flow between HY05 and HY02 are due to significant water diversions for municipal and agricultural uses including the city of Bozeman diversion and several irrigation canals.

Table F-40. Discharge at sampled locations on 9/14/2009 Hyalite Creek

Site ID	Flow (cfs)
HY08	9.68
HY04	61.0
HY03	68.8
HY05	65.22
HY02	6.62
HY01	27.87

This swing in flow and load is also reflected in **Table F-41** which identifies the large decrease and subsequent increase in load from upstream (HY05) to downstream (HY01) in the 21-mile long segment. For this reason, the source assessment focused on the lower half of the assessment unit as most of the nutrient load is diverted from the main channel in the upper portions of the assessment unit.

Table F-41. Total nitrogen loading on 9/14/09 on Lower Hyalite Creek

Site ID	TP load (lbs/day)	Change in load from upstream	% of peak load
HY05	42.03	42.03	18%
HY02	22.75	-19.28	NA
HY01	209.24	186.49	82%

For the source assessment using the 9/14/2009 data, the load to Hyalite Creek via Buster Gulch was omitted as that source is being addressed by a different TMDL on the middle segment of the East Gallatin River (**Table F-41 and F-42**).

Table F-42. Existing load source assessment for anthropogenic sources for total nitrogen on 9/14/2009 Lower Hyalite Creek

Source category	HY05	HY01	Total
Forest	Omitted as influence is negligible due to diversions	0.00	0.00
Agriculture		47.00	47.00
Residential/Developed		12.00	12.00
Subsurface wastewater disposal and treatment		41.00	41.00
% of peak load	0.00	100.00	100.00

Figure F-19 reflects the existing source assessment for Lower Hyalite Creek minus the TN load transported to Hyalite Creek from the East Gallatin River via Buster Gulch. Buster Gulch flows into Hyalite Creek ~ 1.5 miles above the mouth (East Gallatin River) and has little impact on the overall water quality of the reach which is 21 miles in length. Flow in Buster Gulch was assumed to be a constant 8 cfs and approximately 24% of the TN load at the mouth of Hyalite Creek based on East Gallatin River TN concentrations upstream of the Buster Gulch diversion. The Buster Gulch TN load was removed from the Hyalite Creek source assessment as it impacts only the very downstream end of the assessment unit and its nutrient loads are being addressed in a separate assessment unit (**Section F6.2 -** middle segment of the East Gallatin River between Bridger Creek and Hyalite Creek confluences).

Natural background was determined to be 19% of the existing TN load in the lower segment of Hyalite Creek downstream of the forest boundary.

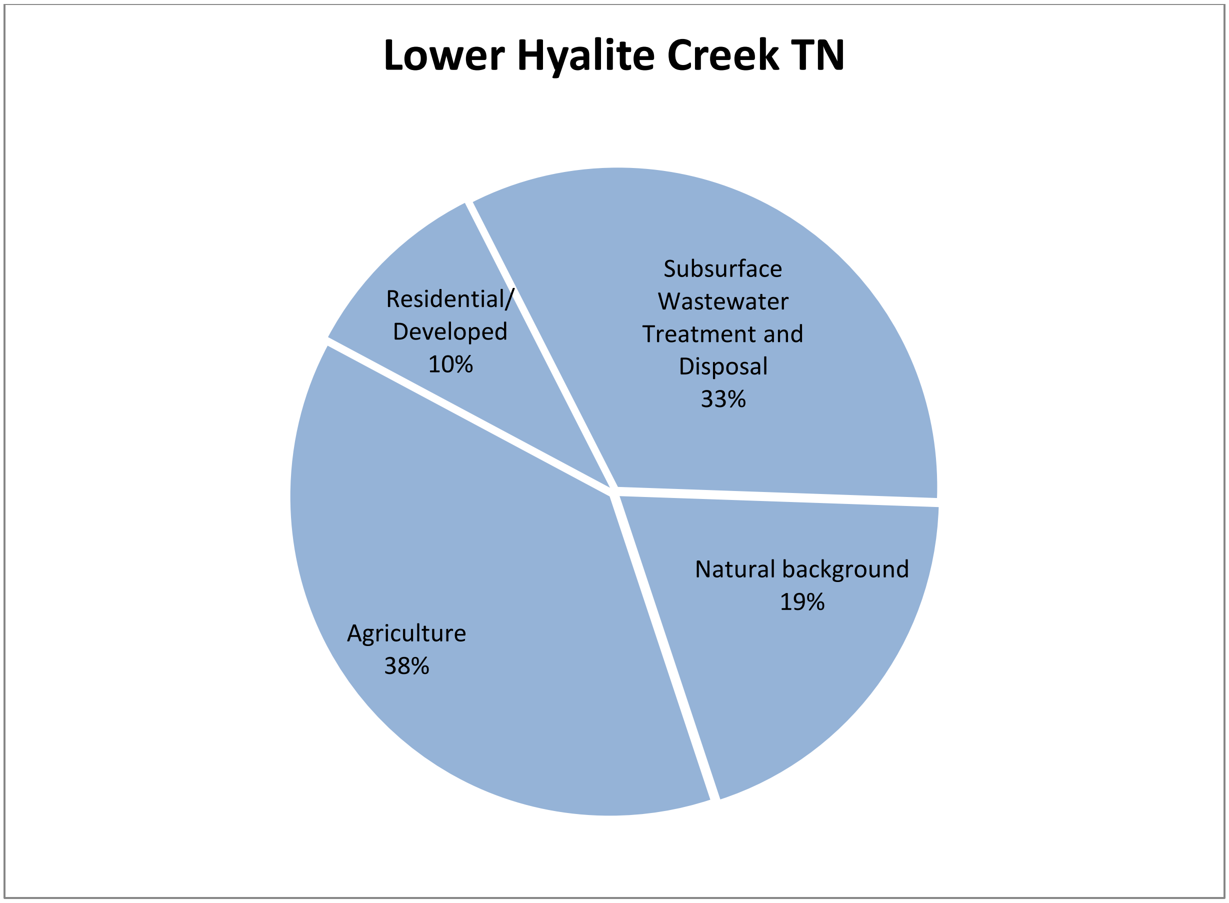

Figure F-19. Existing TN sources for Lower Hyalite Creek

F5.6 Jackson Creek

Jackson Creek is listed as impaired for total phosphorus on the 2012 303(d) List. Figures and analysis for TP source allocations are provided in this section. **Figure F-20** displays the stream sampling locations and other environmental data including septic density and hydrography.

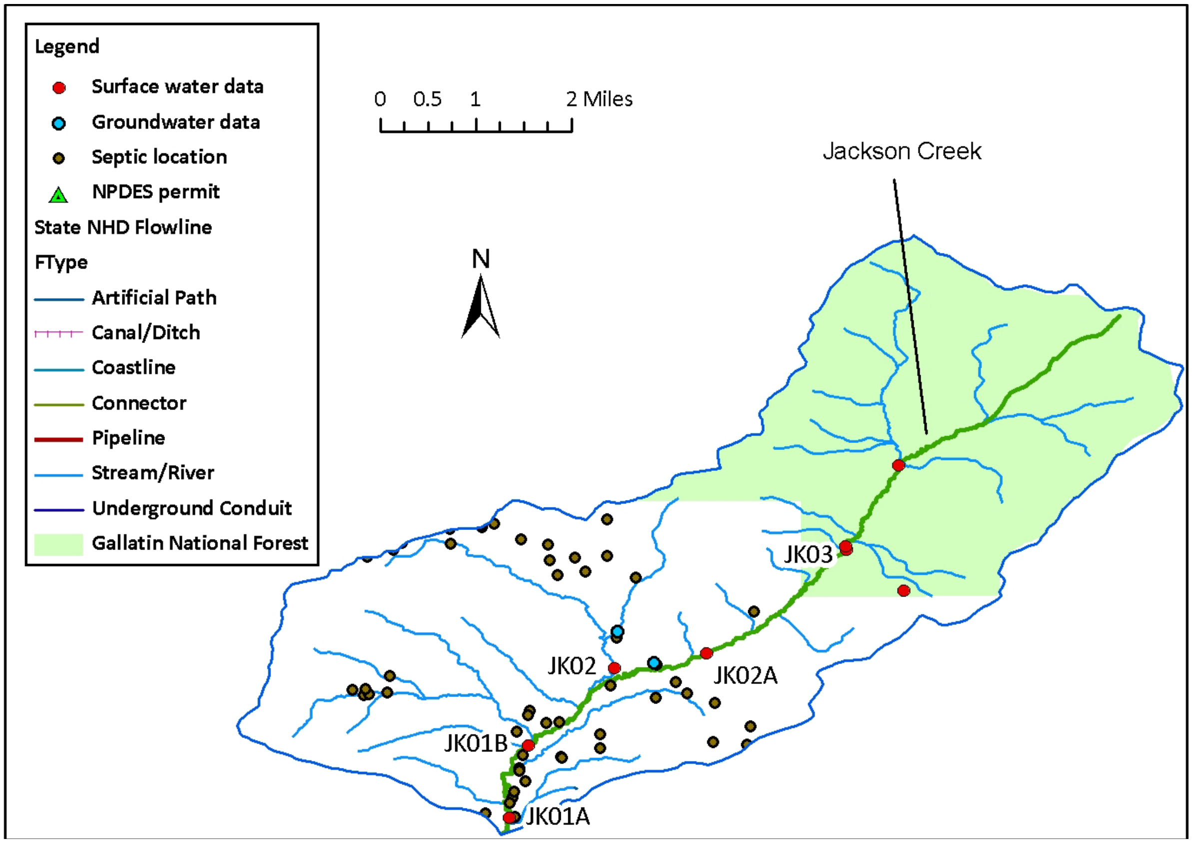

Figure F-20. Spatial data used for the Jackson Creek existing load source assessment

Two synoptic sampling events were available for Jackson Creek. Load calculations and source assessments are included in the following tables (**Tables F-43, F-44, F-45, and F-46**).

Table F-43. Total phosphorus loading on 8/28/2008 on Jackson Creek

Site ID	TP load (lbs/day)	Change in load from upstream	% of peak load
JK03	0.09	0.09	0.21
JK02	0.44	0.34	0.79

Table F-44. Existing load source assessment for anthropogenic sources for total phosphorus on 8/28/2008 on Jackson Creek

Source category	JK03	JK02	Total
Forest	13.90	7.86	21.76
Agriculture	3.21	58.97	62.17
Residential/Developed	4.28	11.79	16.07
Subsurface wastewater disposal and treatment	0.00	0.00	0.00
% of peak load	21.39	78.62	100.00

Table F-45. Total phosphorus loading on 9/18/2009 on Jackson Creek

Site ID	TP load (lbs/day)	Change in load from upstream	% of peak load
JK02A	0.08	0.08	33%
JK01B	0.18	0.09	36%
JK01A	0.26	0.08	31%

Table F-46. Existing load source assessment for anthropogenic sources for total phosphorus on 9/18/2009 on Jackson Creek

Source category	JK02A	JK01B	JK01A	Total
Forest	26.20	1.82	0.00	28.02
Agriculture	1.64	31.01	29.23	61.88
Residential/Developed	4.91	1.82	0.00	6.73
Subsurface wastewater disposal and treatment	0.00	1.82	1.54	3.36
% of peak load	32.75	36.47	30.77	100.00

Mean percentages from the 2 sampling date analyses were calculated for the Jackson Creek existing load assessment which did not include natural background. Natural background was determined to be 77% of the TP load in Jackson Creek as Jackson Creek is relatively un-impacted by anthropogenic TP sources. Source categories were adjusted to account for this percentage (**Figure F-21**).

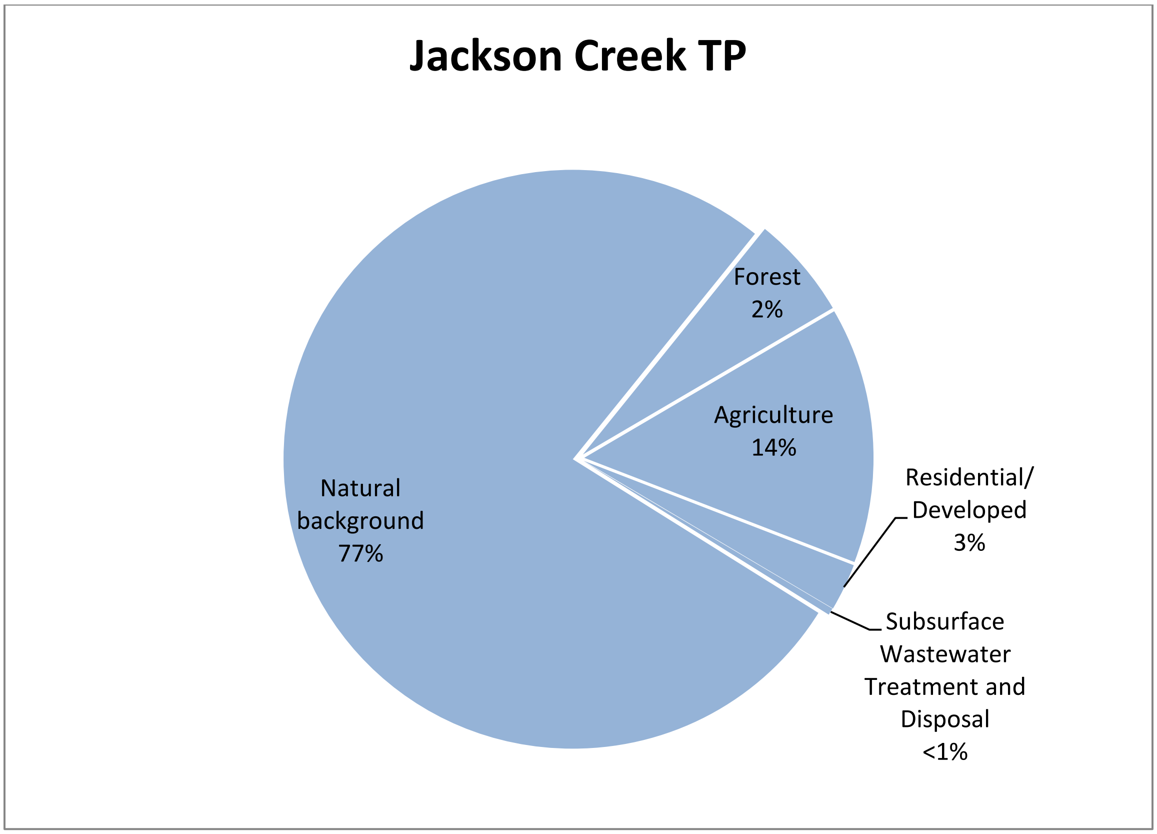

Figure F-21. Existing TP sources for Jackson Creek

F5.7 Mandeville Creek

Mandeville Creek is impaired for total phosphorus and total nitrogen based on available water quality data. Mandeville Creek does not appear on the 2012 303(d) List but will be added to the 2014 303(d) List. Figures and analysis for TP and TN source allocations are provided in this section. **Figure F-22** displays the stream sampling locations and other environmental data including septic density and hydrography.

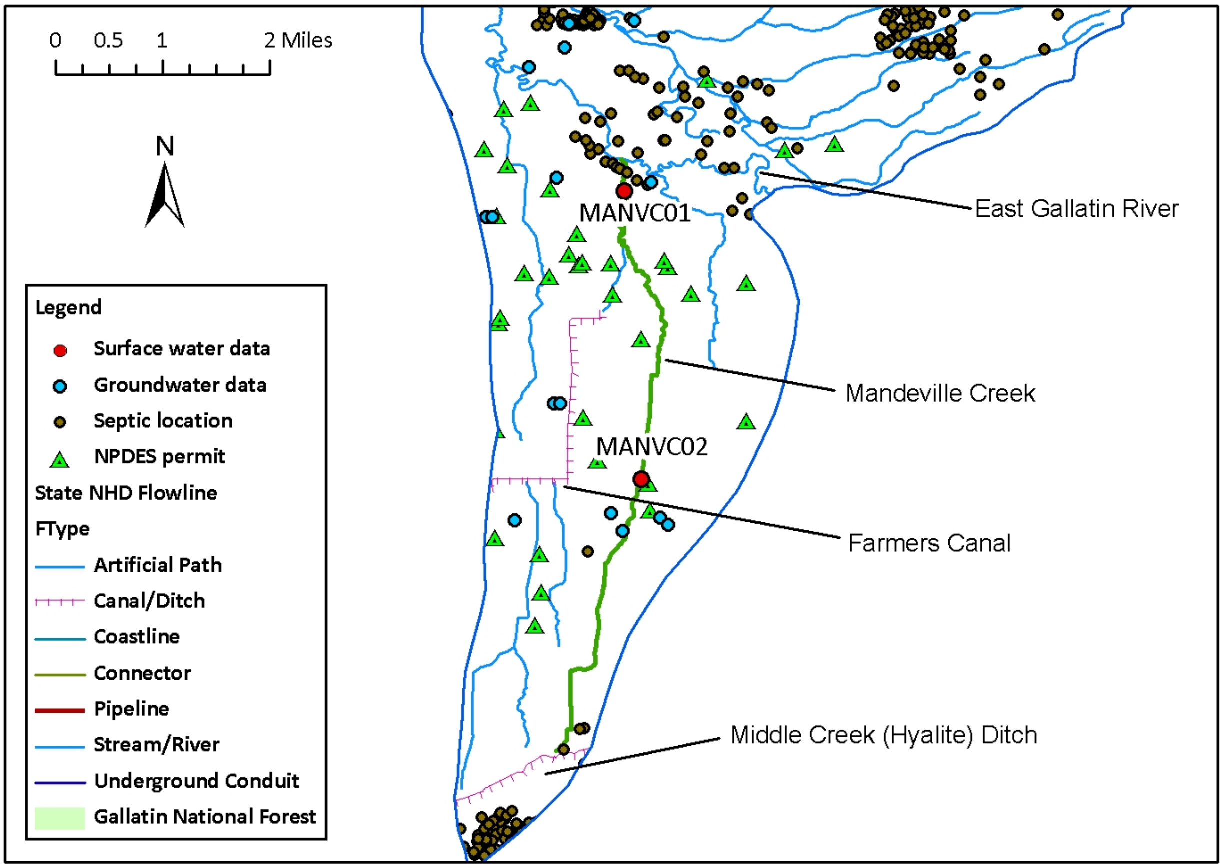

Figure F-22. Spatial data used for the Mandeville Creek existing load source assessment

In the lower segment of Mandeville Creek, Farmers Canal terminates in the creek. The load from this source area is difficult to quantify but was assumed to comprise a large portion of the observed load increases between MANVCO2 and MANVC01. The Middle Creek Ditch carrying flows from Hyalite Creek passes through the uppermost are of the basin but did not appear to contribute flows to Mandeville Creek.

Mandeville Creek was sampled at both sample locations in 9 separate events from 2009-2011. The complete dataset was analyzed to determine the relative total load contributions at each sampling point. For total nitrogen, 22.9% of the TN load was observed at MANCOV2 and 77.1% was observed at the downstream location MANCOV1 on average. These relative percentages were used to determine the existing source allocation (**Table F-47**). Natural background was determined to be 6% of the TN load. Source categories were adjusted to account for this percentage (**Figure F-23**).

Table F-47. Existing load source assessment for anthropogenic sources for total nitrogen for Mandeville Creek

Source category	MANCOV2	MANCOV1	Total
Forest	0.00	0.00	0.00
Agriculture	19.46	36.24	55.71
Residential/Developed	3.44	38.55	41.99
Subsurface wastewater disposal and treatment	0.00	2.31	2.31
% of peak load	22.90	77.10	100.00

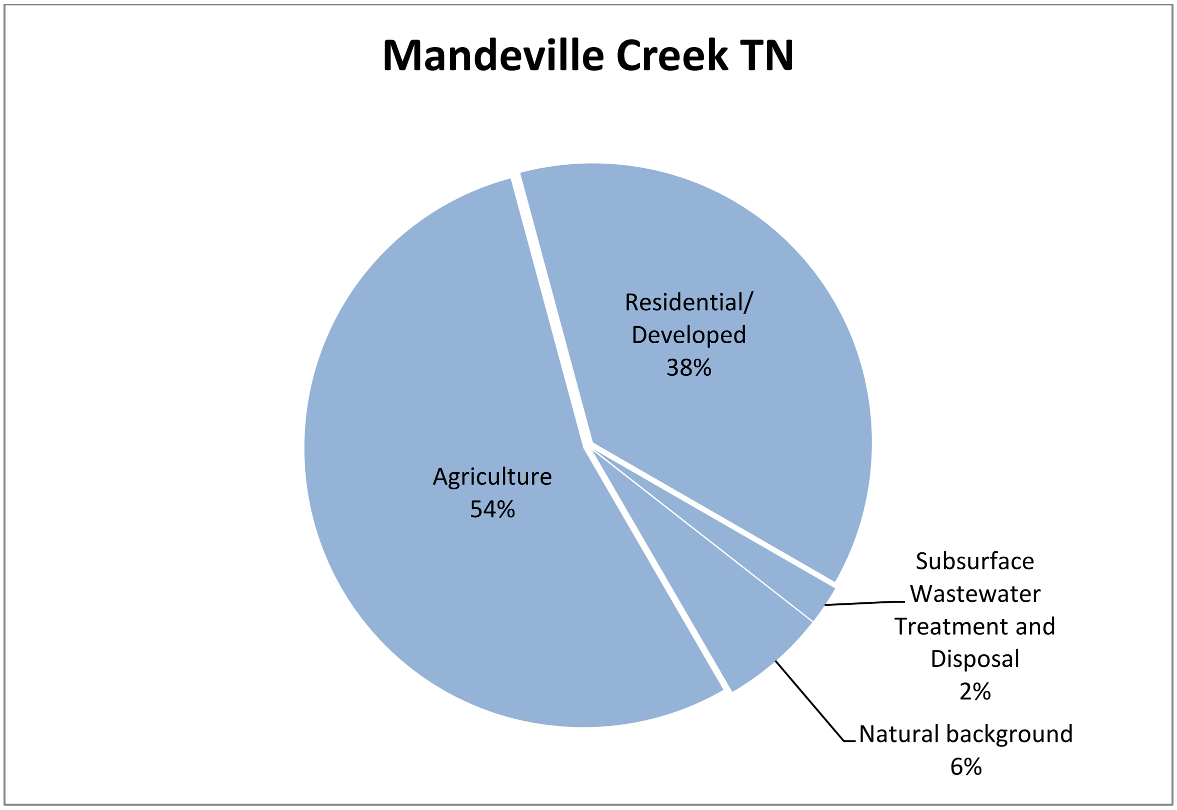

Figure F-23. Existing TN sources for Mandeville Creek

Analyzing the available dataset for total phosphorus, 19.9% of the TP load was observed at MANCOV2 and 80.1% was observed at the downstream location MANCOV1 on average. These relative percentages were used to determine the existing source allocation (**Table F-48**). Natural background was determined to be 12% of the TP load. Source categories were adjusted to account for this percentage (**Figure F-24**).

Table F-48. Existing load source assessment for anthropogenic sources for total phosphorus for Mandeville Creek

Source category	MANCOV2	MANCOV1	Total
Forest	0.00	0.00	0.00
Agriculture	16.92	32.04	48.96
Residential/Developed	2.99	47.26	50.24
Subsurface wastewater disposal and treatment	0.00	0.80	0.80
% of peak load	19.91	80.10	100.00

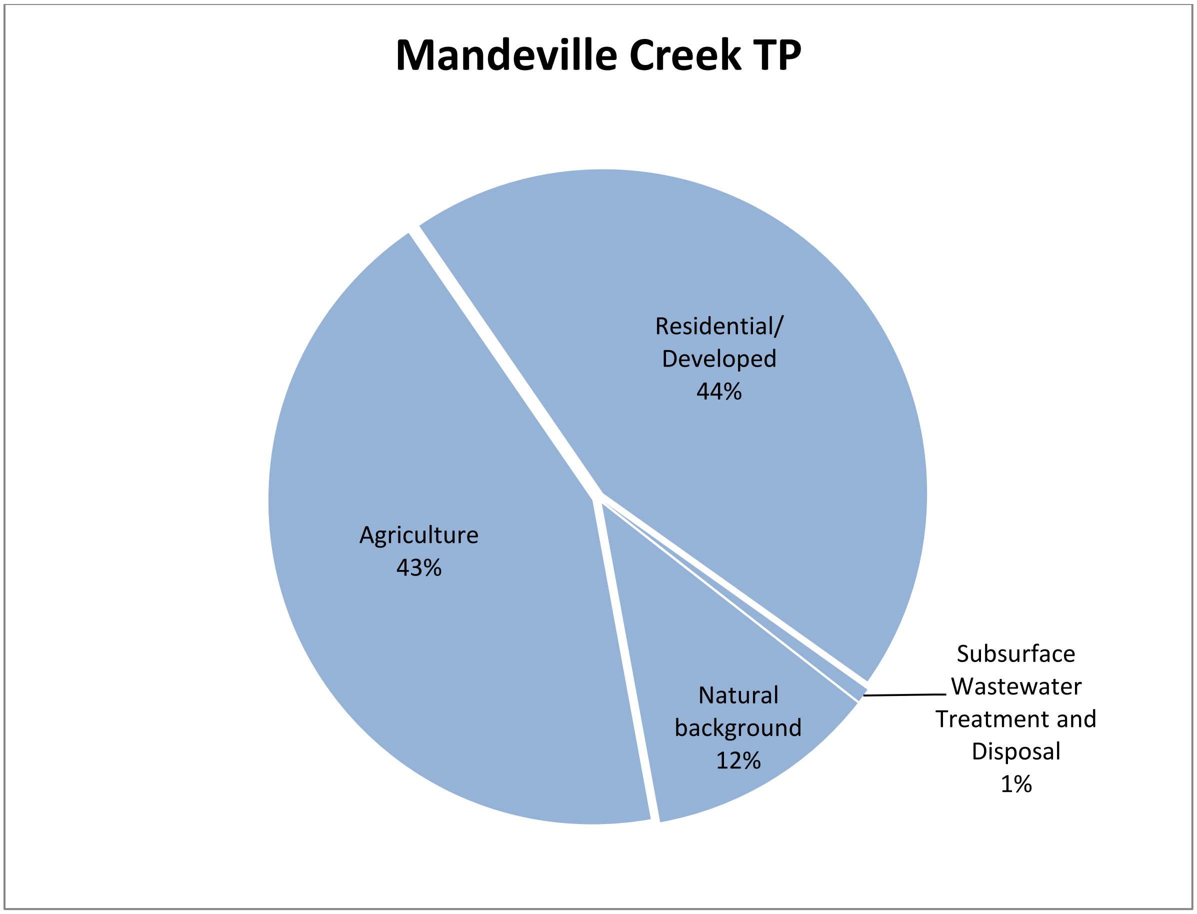

Figure F-24. Existing TP sources for Mandeville Creek

F5.8 Reese Creek

Reese Creek is listed as impaired for total nitrogen and nitrite+nitrate ($N0_3$+ $N0_2$) on the 2012 303(d) List. Figures and analysis for TN and $N0_3$+ $N0_2$ source allocations are provided in this section. **Figure F-25** displays the stream sampling locations and other environmental data including septic density and hydrography.

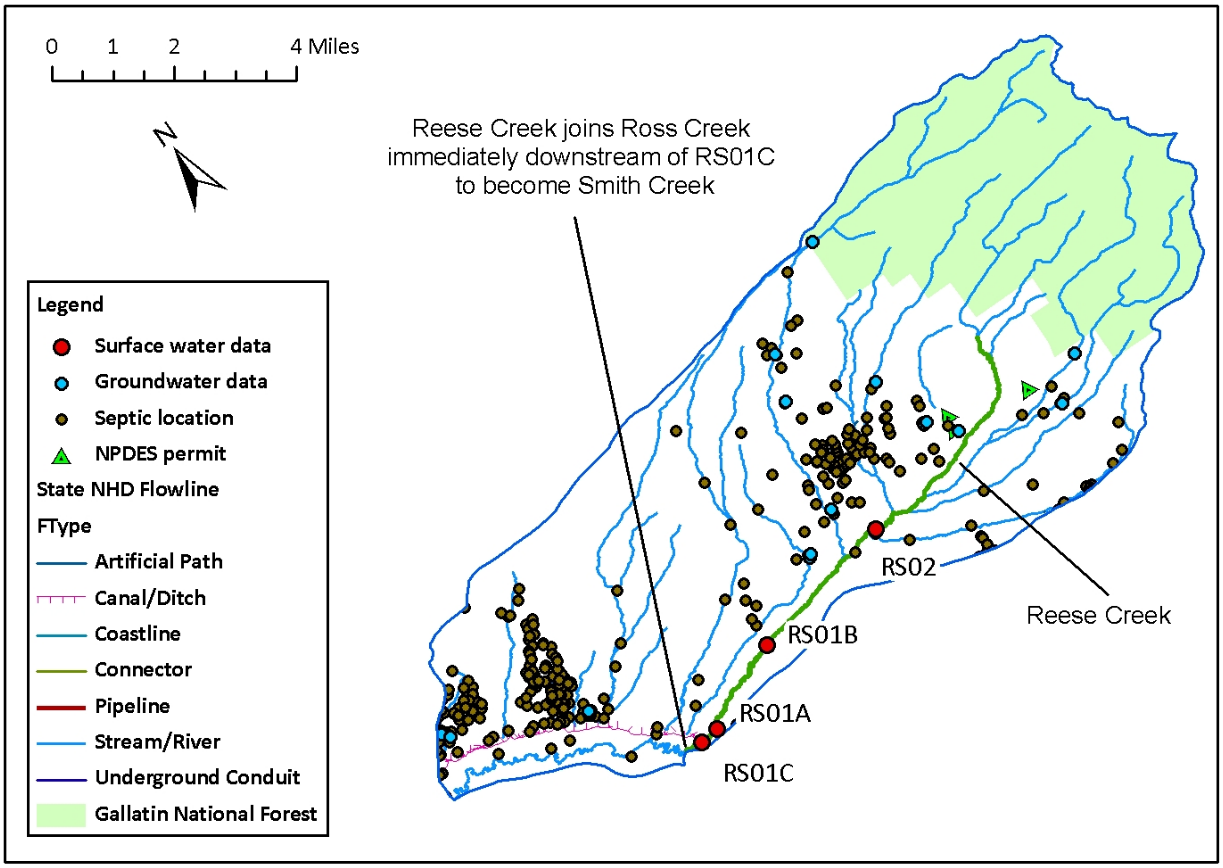

Figure F-25. Spatial data used for the Reese Creek existing load source assessment

One synoptic sampling event was available for Reese Creek on 9/17/2009 (**Table F-49 and F-50**).

Table F-49. Total nitrogen loading on 9/17/2009 on Reese Creek

Site ID	TP load (lbs/day)	Change in load from upstream	% of peak load
RS02	20.06	20.06	0.50
RS01B	40.06	20.01	0.50
RS01A	26.98	-13.08	NA
RS01C	18.61	-8.38	NA

Table F-50. Existing load source assessment for anthropogenic sources for total nitrogen on 9/17/2009 on Reese Creek

Source category	RS02	RS01B	Total
Forest	12.50	11.50	24.00
Agriculture	34.00	30.50	64.50
Residential/Developed	0.00	0.50	0.50
Subsurface wastewater disposal and treatment	3.50	7.50	11.00
% of peak load	50.00	50.00	100.00

Natural background was determined to be 13% of the existing load**.** Source categories were adjusted to account for this percentage (**Figure F-26**).

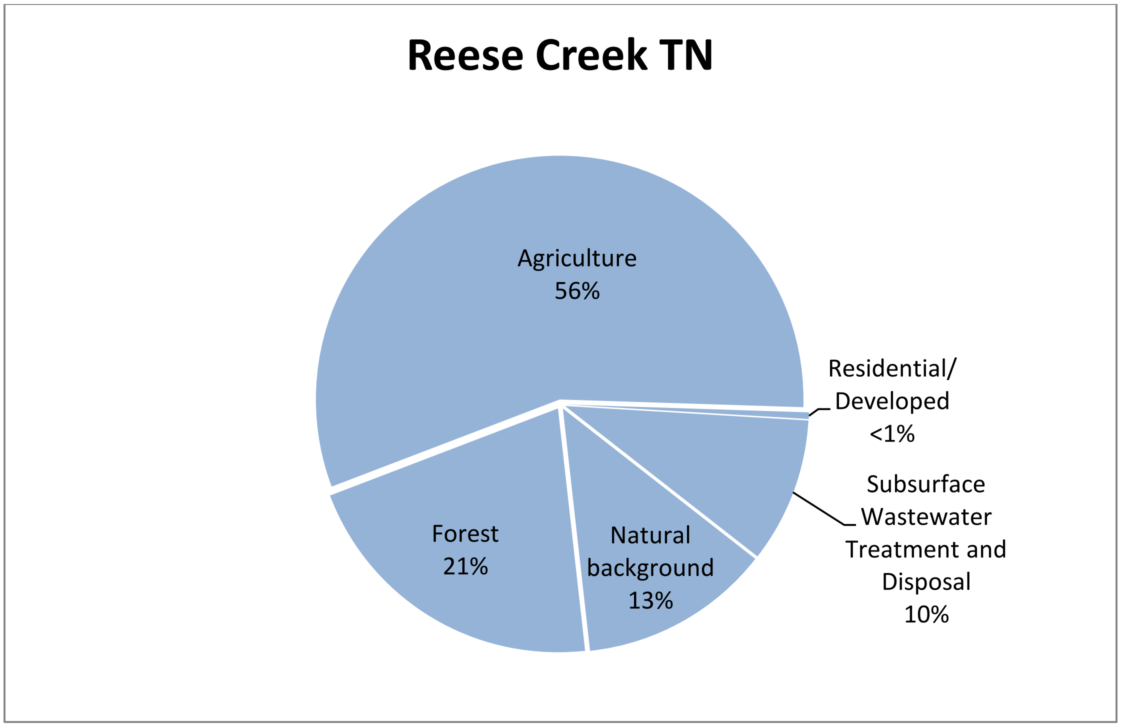

Figure F-26. Existing TN sources for Reese Creek

Table F-51. NO_3+NO_2 loading on 9/17/2009 on Reese Creek

Site ID	TP load (lbs/day)	Change in load from upstream	% of peak load
RS02	15.03	12.96	40%
RS01B	34.26	19.22	60%
RS01A	22.75	-11.50	NA
RS01C	14.69	-8.06	NA

Table F-52. Existing load source assessment for anthropogenic sources for NO_3+NO_2 on 9/17/2009 on Reese Creek

Source category	RS02	RS01B	Total
Forest	8.78	10.10	18.88
Agriculture	32.91	40.40	73.31
Residential/Developed	0.00	0.56	0.56
Subsurface wastewater disposal and treatment	2.19	5.05	7.24
% of peak load	43.88	56.12	100.00

For natural background, water quality data collected by the MBMG above the forest boundary was used to estimate the natural background load in Reese Creek and was incorporated into the source assessment methodology outlined in **Table F-51 and F-52.** The combined forest/natural background allocation to the existing load was determined to be 19%. Source categories were adjusted to account for this percentage (**Figure F-27**).

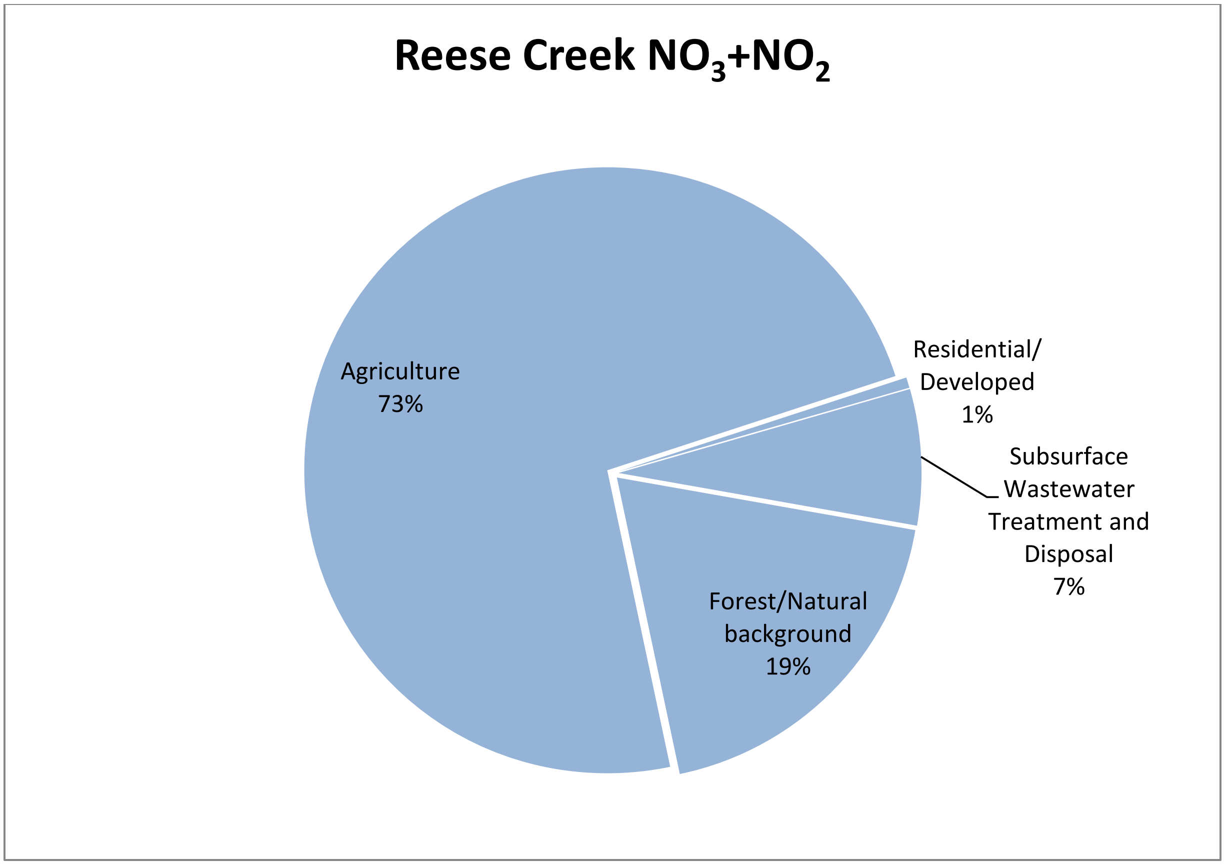

Figure F-27. Existing NO_3+NO_2 sources for Reese Creek

F5.9 Smith Creek

Smith Creek is listed as impaired for total nitrogen and nitrite+nitrate ($N0_3$+ $N0_2$) on the 2012 303(d) List. Figures and analysis for TN and $N0_3$+ $N0_2$ source allocations are provided in this section.

Smith Creek presented an interesting case where an irrigation canal conveyed East Gallatin River water to the Smith Creek drainage. The Dry Creek Irrigation Canal flows northward from the East Gallatin River and intersects Ross Creek (**Figure F-28**). At this point, flows from the canal and Ross Creek continue northward in the same channel. Ross Creek originally continued northeastward to its confluence with Smith Creek but is now channelized along a private road to where it meets Reese Creek. At this intersection of flow, Ross Creek/Dry Creek Irrigation Canal flow up from the south and join Reese Creek from the east. The Dry Creek Irrigation Canal continues northward. The confluence marks the start of Smith Creek which flows westward to the East Gallatin River. As there is not a headgate or diversion that separates flows at this intersection, water quality analyses assumed that during the summer period Reese Creek flows are forced into the Dry Creek Irrigation Canal which flows northward with a mix of Ross Creek, Reese Creek and East Gallatin River flows. Smith Creek flows westward with a mixture of Ross Creek and East Gallatin River flow. Under this assumption, the Reese Creek watershed is not a source area of nutrient impairments on Smith Creek during the summer period when the irrigation canal is flowing. The nutrient load from the East Gallatin River was included in the analyses because it impacts the entire length of Smith Creek.

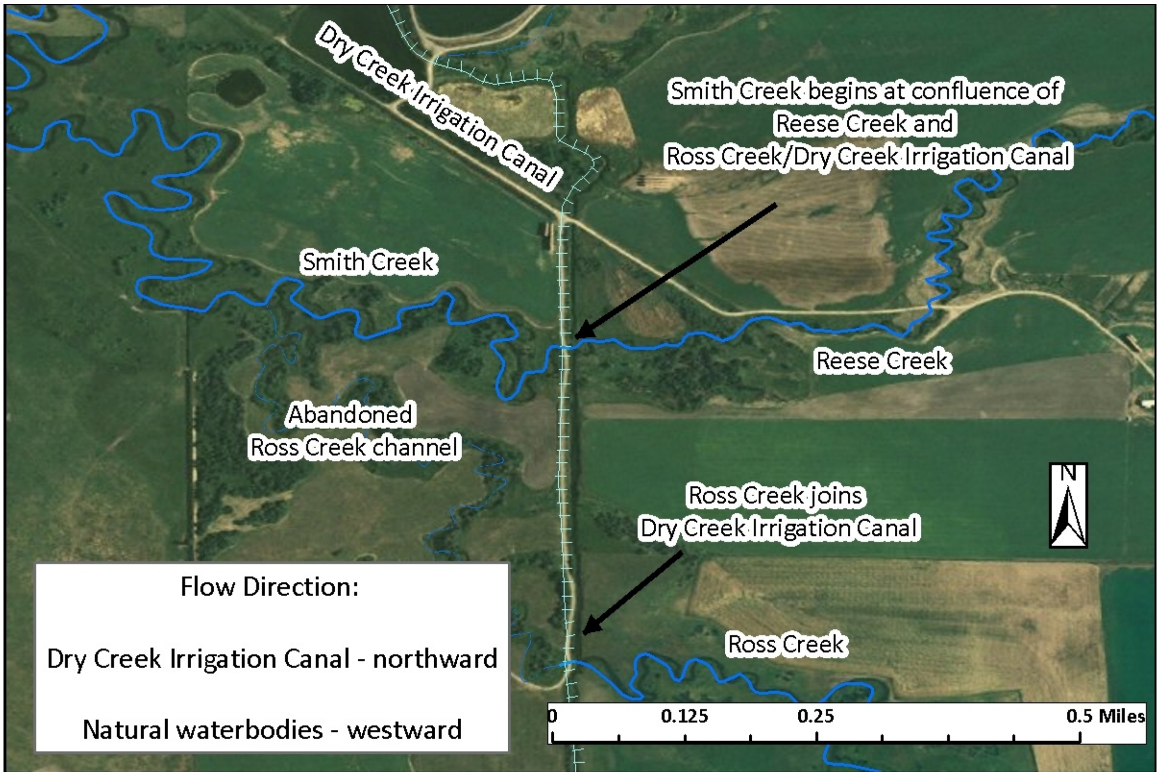

Figure F-28. Confluence of Ross, Reese, and Smith Creeks and influence of Dry Creek Irrigation Canal

The source assessment of the existing load used data collected on the East Gallatin River as well as the Ross Creek drainage. **Figure F-29** displays only those sample locations on Smith Creek.

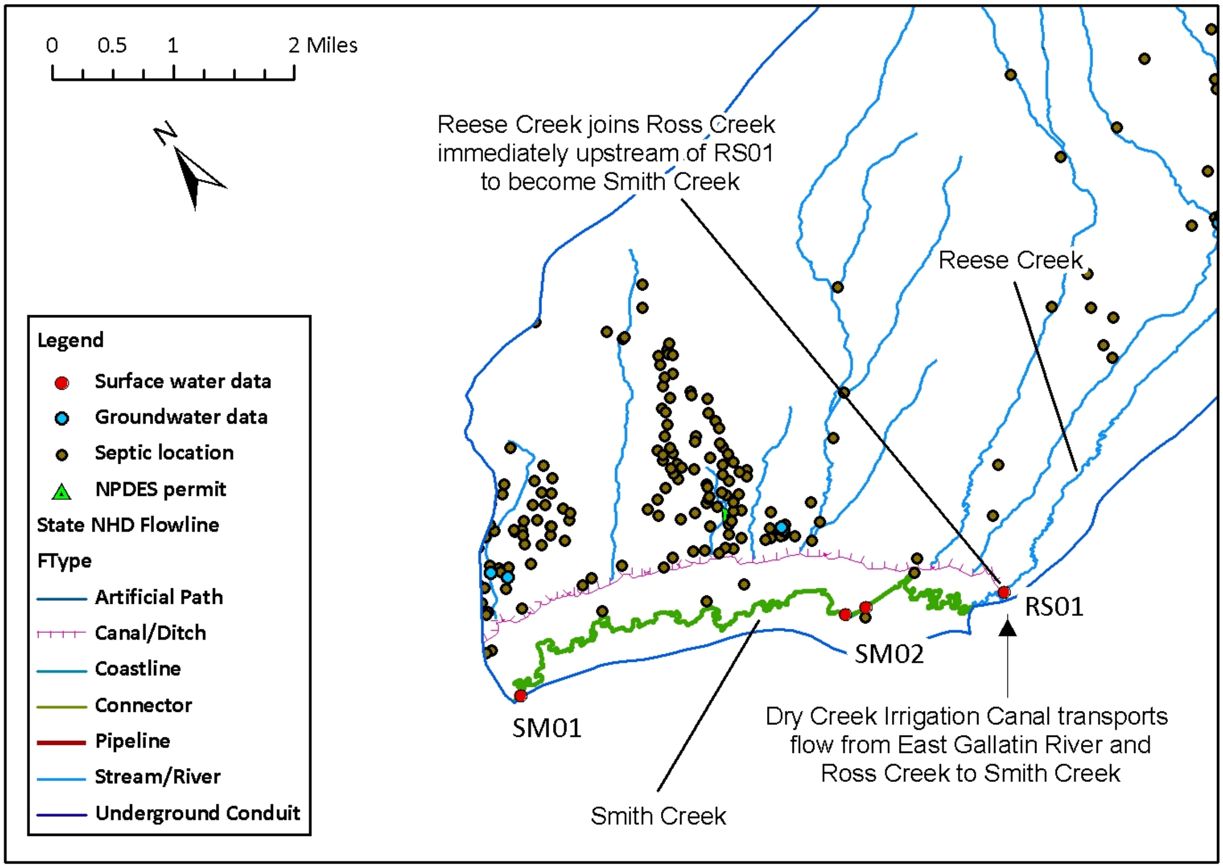

Figure F-29. Spatial data used for the Smith Creek existing load source assessment

Flow and nutrient load analyses determined that 63% of the load in Smith Creek originated from the East Gallatin River and 37% from the Ross Creek drainage (**Table F-53**). TN loads did not increase in the Smith Creek basin between sampling points.

Table F-53. Existing load source assessment for anthropogenic sources for total nitrogen on 9/17/2009 on Smith Creek

Source category	From East Gallatin River	From Ross Creek drainage	From Smith Creek drainage	Total
Forest	3.15	3.42	0.00	6.57
Agriculture	22.70	33.25	0.00	55.95
Residential/Developed	2.52	0.00	0.00	26.45
Subsurface wastewater disposal and treatment	10.70	0.32	0.00	11.03
City of Bozeman WRF	23.93	0.00	0.00	23.93
% of peak load	63.01	36.99	0.00	100.00

In order to identify the source assessment specific to the Smith Creek drainage without the influence of the Dry Creek irrigation canal, the Smith Creek source assessment (**Table F-54**) includes only the source assessment for the Ross Creek drainage, as TN concentrations did not increase between sampling locations on Smith Creek. This removes the East Gallatin River TN load from the Smith Creek assessment as that source is addressed in a separate source assessment and TMDL (**Section F6.2**).

Table F-54. Existing load source assessment for anthropogenic sources for total nitrogen on 9/17/2009 on Ross Creek

Source category	From Ross Creek drainage
Forest	9.25
Agriculture	89.89
Residential/Developed	0.00
Subsurface wastewater disposal and treatment	0.87
% of peak load	100.00

Natural background was determined to be 21% of the existing load in Smith Creek after removing the influence of flow and load from the Dry Creek Irrigation Canal (source = East Gallatin River) (**Figure F-30**).

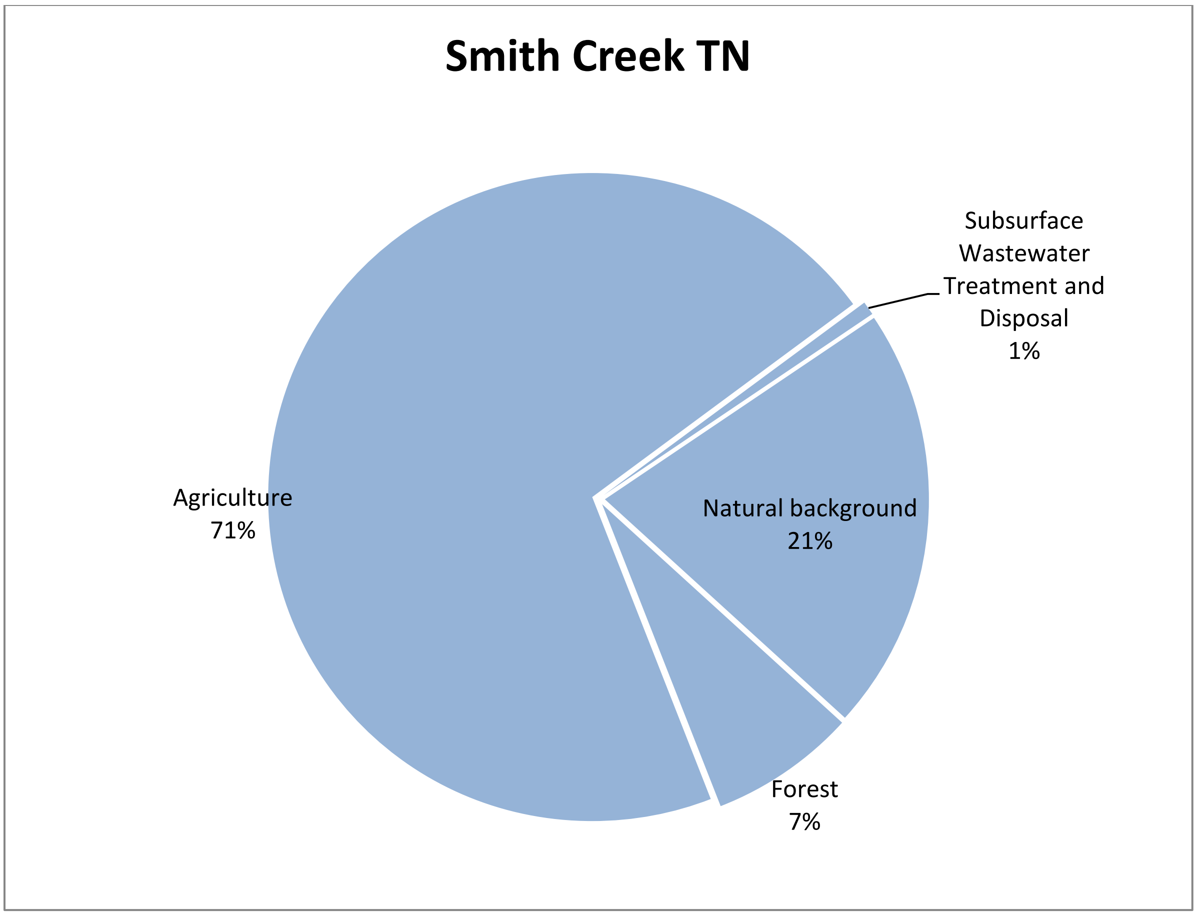

Figure F-30. Existing TN sources for Smith Creek

For NO_3+NO_2 flow and load analyses determined that 61% of the load in Smith Creek originated from the East Gallatin River and 39% from the Ross Creek drainage (**Table F-55**). Nitrate+nitrite (NO_2+NO_3) loads did not increase in Smith Creek between sampling points.

Table F-55. Existing load source assessment for anthropogenic sources for NO_3+NO_2 on 9/17/2009 on Smith Creek

Source category	From East Gallatin River	From Ross Creek drainage	From Smith Creek drainage	Total
Forest/Natural background	3.50	3.60	0.00	7.11
Agriculture	25.21	35.05	0.00	60.27
Residential/Developed	2.80	0.00	0.00	2.80
Subsurface wastewater disposal and treatment	11.82	0.34	0.00	12.16
City of Bozeman WRF	17.67	0.00	0.00	17.67
% of peak load	61.00	39.00	0.00	100.00

In order to identify the source assessment specific to the Smith Creek drainage without the influence of the Dry Creek irrigation canal, the Smith Creek source assessment (**Table F-56**) includes only the source assessment for the Ross Creek drainage, as TN concentrations did not increase between sampling locations on Smith Creek. This removes the East Gallatin River NO_3+NO_2 load from the Smith Creek assessment as that source is addressed in a separate source assessment and TMDL (**Section F6.2**).

Table F-56. Existing load source assessment for anthropogenic sources for NO_3+NO_2 on 9/17/2009 on Ross Creek

Source category	From Ross Creek drainage
Forest/Natural background	9.24
Agriculture	89.88
Residential/Developed	0.00
Subsurface wastewater disposal and treatment	0.87
% of peak load	100.00

For natural background, water quality data collected by the MBMG above the forest boundary was used to estimate the natural background load in Ross Creek and was incorporated into the source assessment methodology outlined in **Table F-55** for Smith Creek**.** The forest/natural background load was determined to be 9% of the existing load. Source categories were adjusted to account for this percentage (**Figure F-31**).

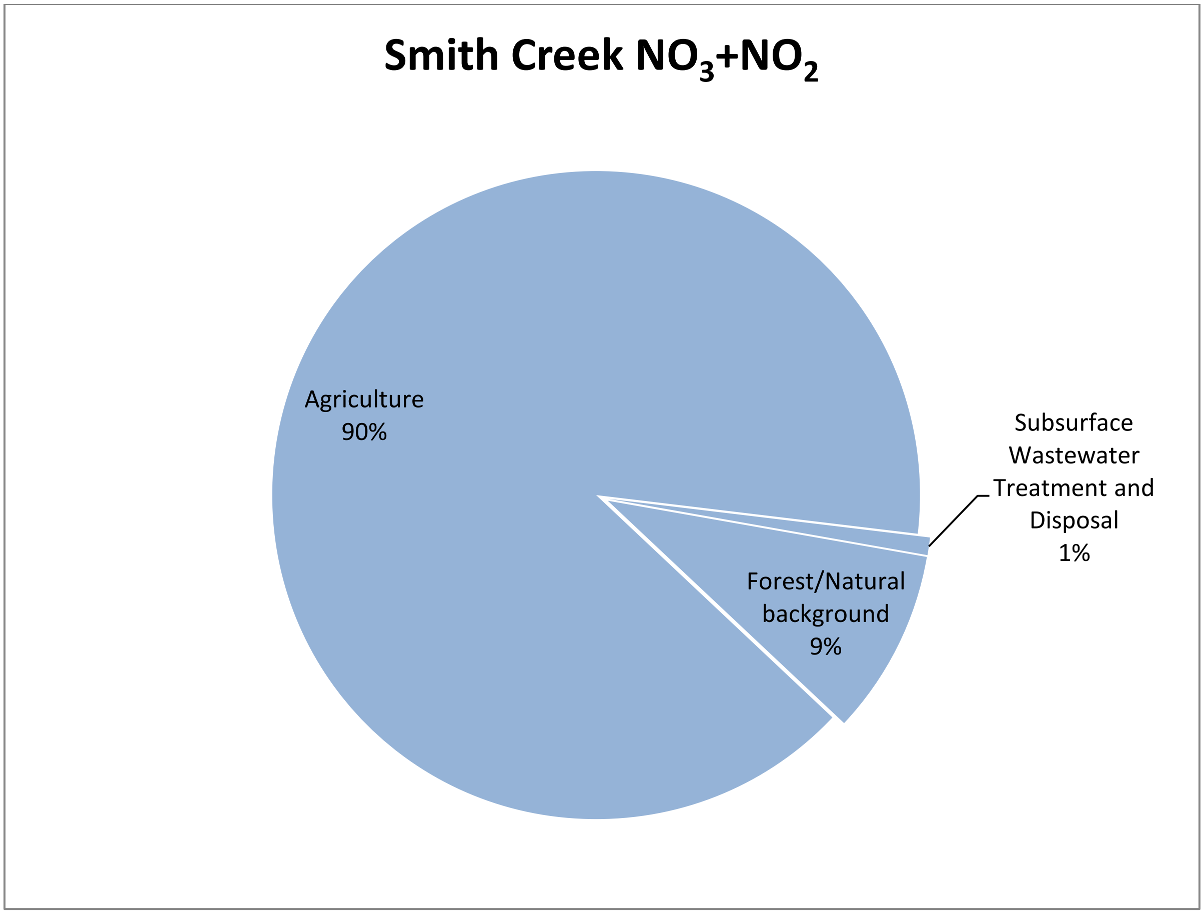

Figure F-31. Existing NO_3+NO_2 sources for Smith Creek

F5.10 THOMPSON CREEK

Thompson Creek is listed as impaired for total nitrogen on the 2012 303(d) List. Figures and analysis for TN source allocations are provided in this section. **Figure F-32** displays the stream sampling locations and other environmental data including septic density and hydrography.

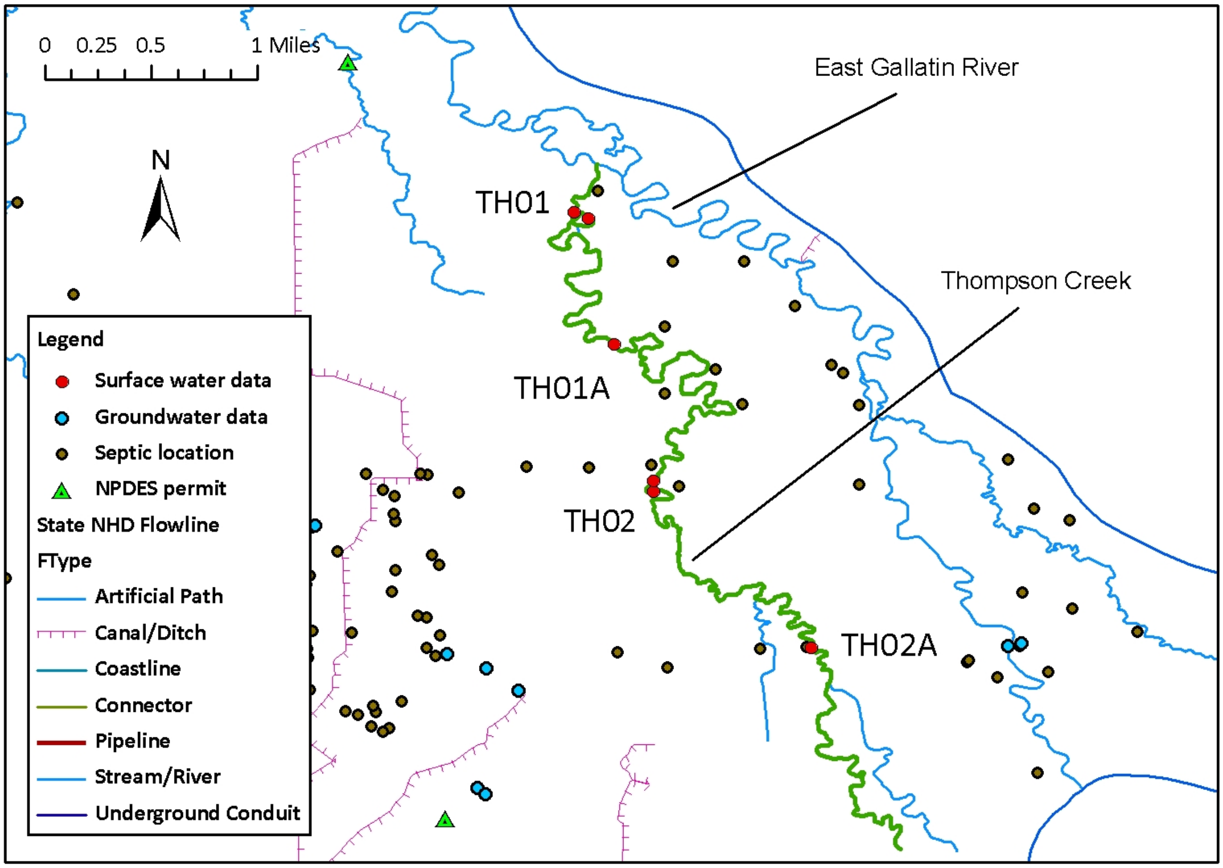

Figure F-32. Spatial data used for the Thompson Creek existing load source assessment

One synoptic sampling event was available for Thompson Creek. Load calculations and source assessments are included in the following tables (**Tables F-57 and F-58**).

Table F-57. TN loading on 9/21/2009 on Thompson Creek

Site ID	TP load (lbs/day)	Change in load from upstream	% of peak load
TH02A	16.54	16.54	18%
THO2	43.51	26.97	30%
THO1A	88.57	45.06	50%
THO1	89.49	0.92	1%

Table F-58. Existing load source assessment for anthropogenic sources for total nitrogen on 9/21/2009 on Thompson Creek

Source category	TH02A	THO2	THO1A	THO1	Total
Forest	0.00	0.00	0.00	0.00	0.00
Agriculture	17.93	27.43	45.82	0.99	92.16
Residential/Developed	0.18	1.81	3.52	0.04	5.56
Subsurface wastewater disposal and treatment	0.37	0.90	1.01	0.00	2.28
% of peak load	18.48	30.14	50.35	1.03	100.00

Natural background was calculated using flow statistics and DEQ reference data. Natural background was calculated as 9% of the existing load. Source categories were adjusted to account for this percentage (**Figure F-33**).

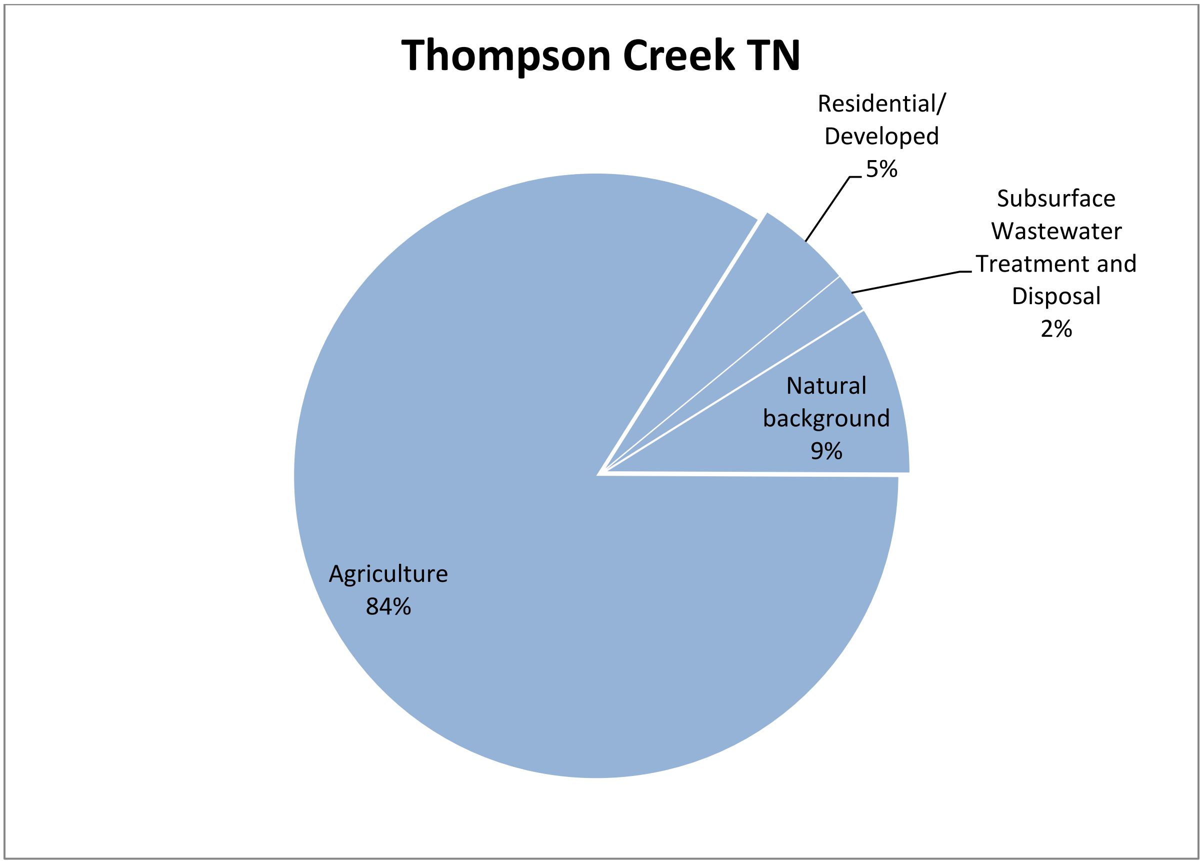

Figure F-33. Existing TN sources for Thompson Creek

F6.0 Existing Load Source Assessments for the East Gallatin River

Source assessments for TN and TP on the East Gallatin River presented some unique challenges, foremost among them determining the effect of upgrades to the city of Bozeman WRF in 2007 and 2011 on downstream water quality. As outlined in **Appendix G**, a simple concentration based model was created in order to determine the relative concentration attributable to the WRF at distances downstream based on the long-term facility discharge and design performance for nutrient treatment. The results for this model were used for source assessments in the middle and lower segments of the East Gallatin River.

Due to the influence of the Level IV Absaroka-Gallatin-Volcanics on water quality targets in the East Gallatin River, source assessments in the East Gallatin River will be presented as defined by instream water quality targets for TN and TP. This is same approach used in **Section 6** in the document to present the TMDLs. For the upper East Gallatin River, this means that the source assessment is presented for the reaches upstream and downstream of the Bozeman Creek confluence. For the middle segment, this approach was also used to describe the source assessments upstream and downstream of the Hyalite Creek confluence.

F6.1 UPPER EAST GALLATIN RIVER

The upper segment of the East Gallatin River is listed as impaired for total phosphorus and total nitrogen on the 2012 303(d) List. Figures and analysis for TP and TN source allocations are provided in this section. **Figure F-35** displays the stream sampling locations and other environmental data including septic density and hydrography. In **Figure F-35**, Bozeman Creek flows into the East Gallatin River ~0.3 miles upstream of site EG03.

Upstream tributary data from Bear, Rocky and Jackson Creeks were used to determine the source allocations in upper reaches of the segment (**Figure F-34**). As most of the nutrient loading originates in the Bozeman Creek drainage which flows in to the East Gallatin River immediately upstream of EG03, sample data and existing load allocations from the Bozeman Creek watershed were used for the upper segment of the East Gallatin River as well. The upper segment does not include Bridger Creek which is the start of the middle segment of the East Gallatin River.

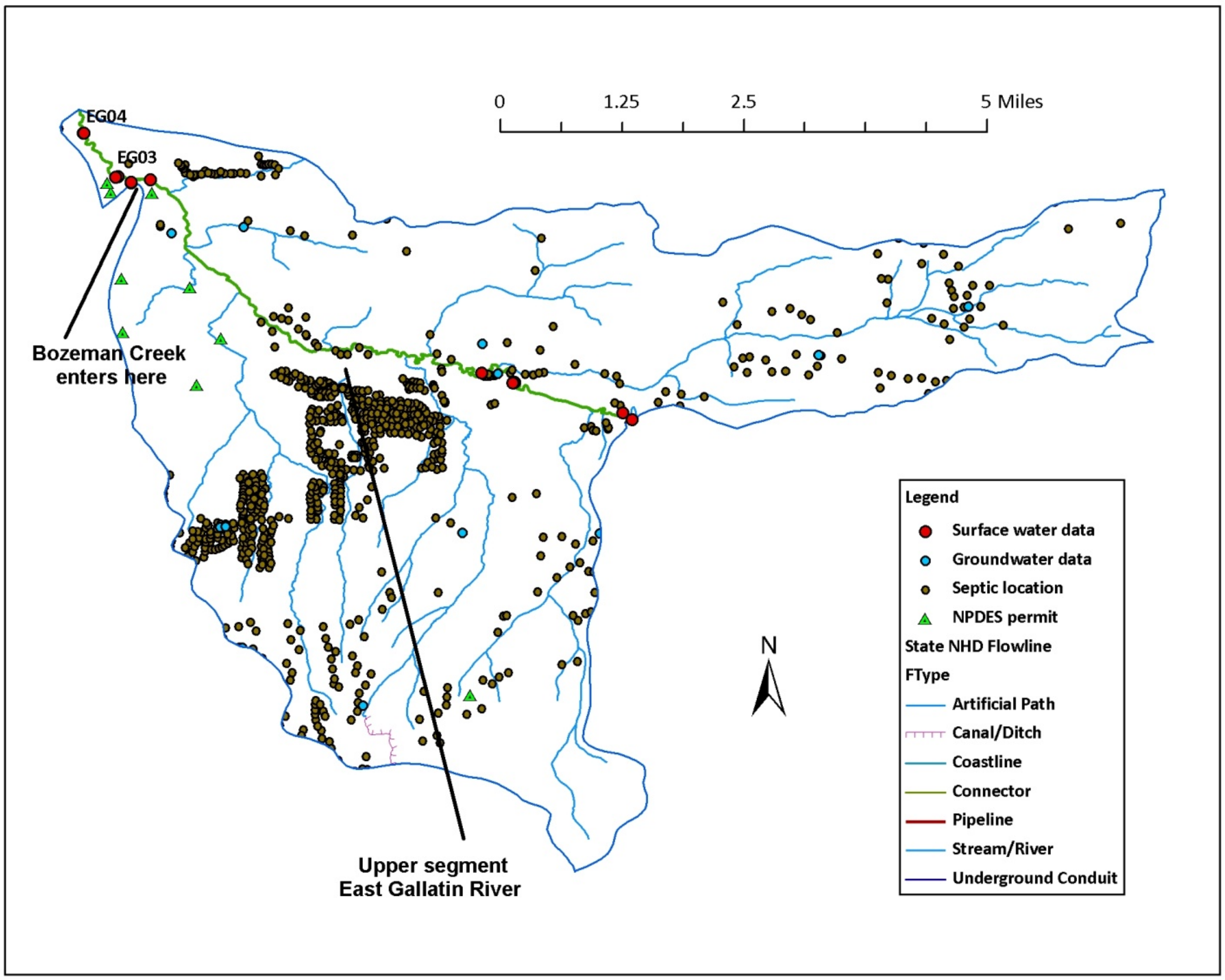

Figure F-34. Spatial data used for the Upper East Gallatin existing load source assessment

One synoptic sampling event was available for the upper segment of the East Gallatin River. Load calculations and source assessments are included in the following tables (**Tables F-59, F-60**). Sampling locations EG03 and EG04 are located on the East Gallatin River downstream of the Bozeman Creek confluence and upstream of the Bridger Creek confluence.

Table F-59. Total nitrogen loading on 9/2/2008 on the East Gallatin River from Rocky and Bear Creeks to Bridger Creek

Site ID	TN load (lbs/day)	Change in load from upstream	% of peak load
EG03	113.74	113.74	100%
EG04	96.50	-17.24	NA

Table F-60. Existing load source assessment for anthropogenic sources for total nitrogen on 9/2/2008 on the East Gallatin River from Rocky and Bear Creeks to Bridger Creek

Source category	EG03	Total
Forest	4	4
Agriculture	40	40
Residential/Developed	36	36
Subsurface wastewater disposal and treatment	20	20
% of peak load	100	100

As there are different natural background concentrations for the East Gallatin River upstream and downstream of the Bozeman Creek confluence, the source assessment was further divided to reflect these differences. For the upper segment, source assessments for Bear Creek and Rocky/Jackson Creeks were used. For the lower segment, the relative flow contribution from Bozeman Creek in conjunction with a source assessment for the East Gallatin River between the Bozeman Creek and Bridger Creek confluences was used.

In **Table F-61**, the main differences in the source assessment as defined by the entry of Bozeman Creek are a decrease in the influence of agriculture and an increase in residential/developed sources.

Table F-61. Existing load source assessment for anthropogenic sources for total nitrogen on 9/2/2008 on the East Gallatin River upstream of Bridger Creek

Source category	Upstream of Bozeman Creek	Downstream of Bozeman Creek
Forest	3.77	3.20
Agriculture	54.72	35.49
Residential/Developed	16.98	40.10
Subsurface wastewater disposal and treatment	24.53	21.21
% of peak load	100.00	100.00

Upstream of Bozeman Creek, natural background was determined to be 22% of the existing TN load (**Figure F-35**). Downstream of Bozeman Creek and upstream of Bridger Creek, natural background was determined to be 26% of the existing TN load (**Figure F-36**). Existing load source assessments were uniformly decreased to account for calculated natural background and source area differences (Bozeman Creek drainage versus the Rocky and Bear Creek drainages). The median flow and TN and TP concentrations for the different segments as defined by Bozeman Creek were used to determine natural background.

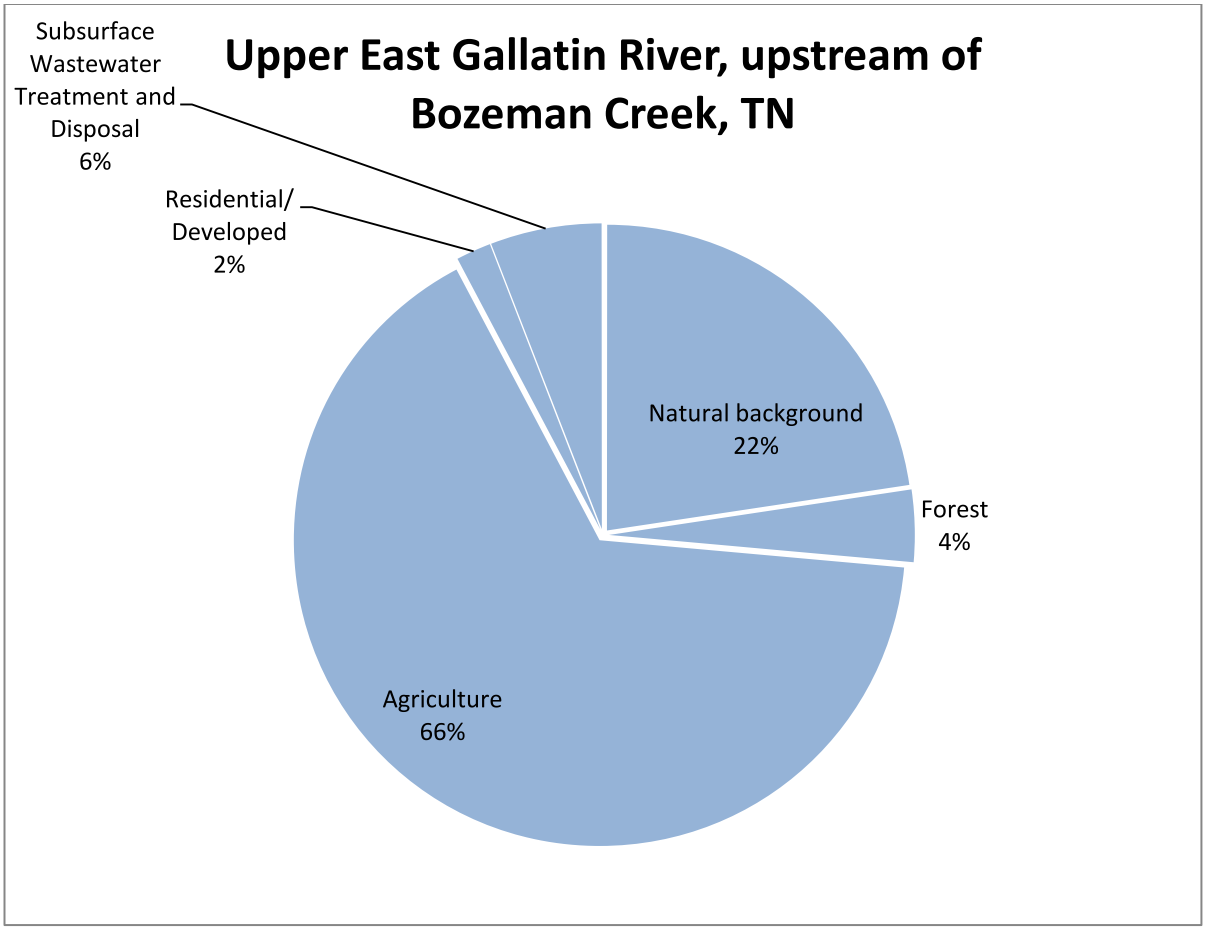

Figure F-35. Existing TN sources for Upper East Gallatin River upstream of Bozeman Creek

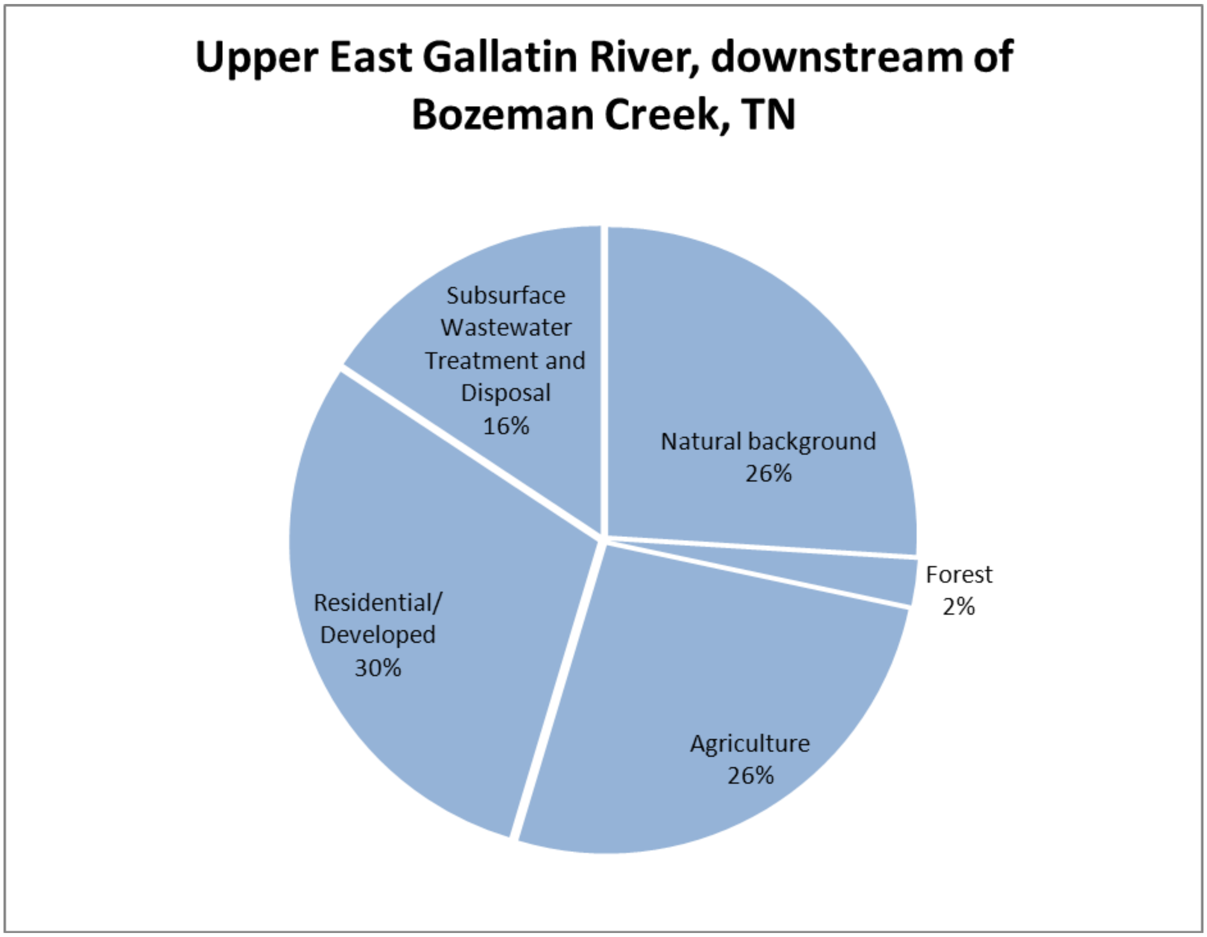

Figure F-36. Existing TN sources for Upper East Gallatin River downstream of Bozeman Creek

The same method used to determine existing sources upstream and downstream of Bozeman Creek for TN in the upper segment of the East Gallatin River was applied for TP (**Table F-62 and F-63**).

Table F-62. Total phosphorus loading on 9/2/2008 on the East Gallatin River from Rocky and Bear Creeks to Bridger Creek

Site ID	TP load (lbs/day)	Change in load from upstream	% of peak load
EG03	10.24	10.24	96.5%
EG04	10.61	0.39	3.5%

Table F-63. Existing load source assessment for anthropogenic sources for total phosphorus on 9/2/2008 on the East Gallatin River from Rocky and Bear Creeks to Bridger Creek

Source category	EG03	EG04	Total
Forest	16.60	0.00	16.60
Agriculture	24.59	0.35	24.94
Residential/Developed	43.03	2.45	45.48
Subsurface wastewater disposal and treatment	12.29	0.70	12.99
% of peak load	96.5	3.5	100.00

In **Table F-64**¸the biggest differences in TP sources as defined by the confluence of Bozeman Creek were a decrease in forest and agricultural sources and a large increase in residential and subsurface wastewater disposal and treatment sources.

Table F-64. Existing load source assessment for anthropogenic sources for total nitrogen on 9/2/2008 on the East Gallatin River upstream of Bridger Creek

Source category	Upstream of Bozeman Creek	Downstream of Bozeman Creek
Forest	40.26	9.52
Agriculture	48.05	19.05
Residential/Developed	7.79	52.38
Subsurface wastewater disposal and treatment	3.90	19.05
% of peak load	100.00	100.00

Natural background was determined to be 44% of the existing TP load in the reach upstream of the Bozeman Creek confluence (**Figure F-37**) and 86% in the reach between the Bozeman Creek confluence and the Bridger Creek confluence (**Figure F-38**). This is a result of the naturally occurring phosphorus in the Level IV ecoregion Absaroka-Gallatin-Volcanics which occurs in the upper reaches of Bozeman Creek and Hyalite Creek in the East Gallatin River watershed.

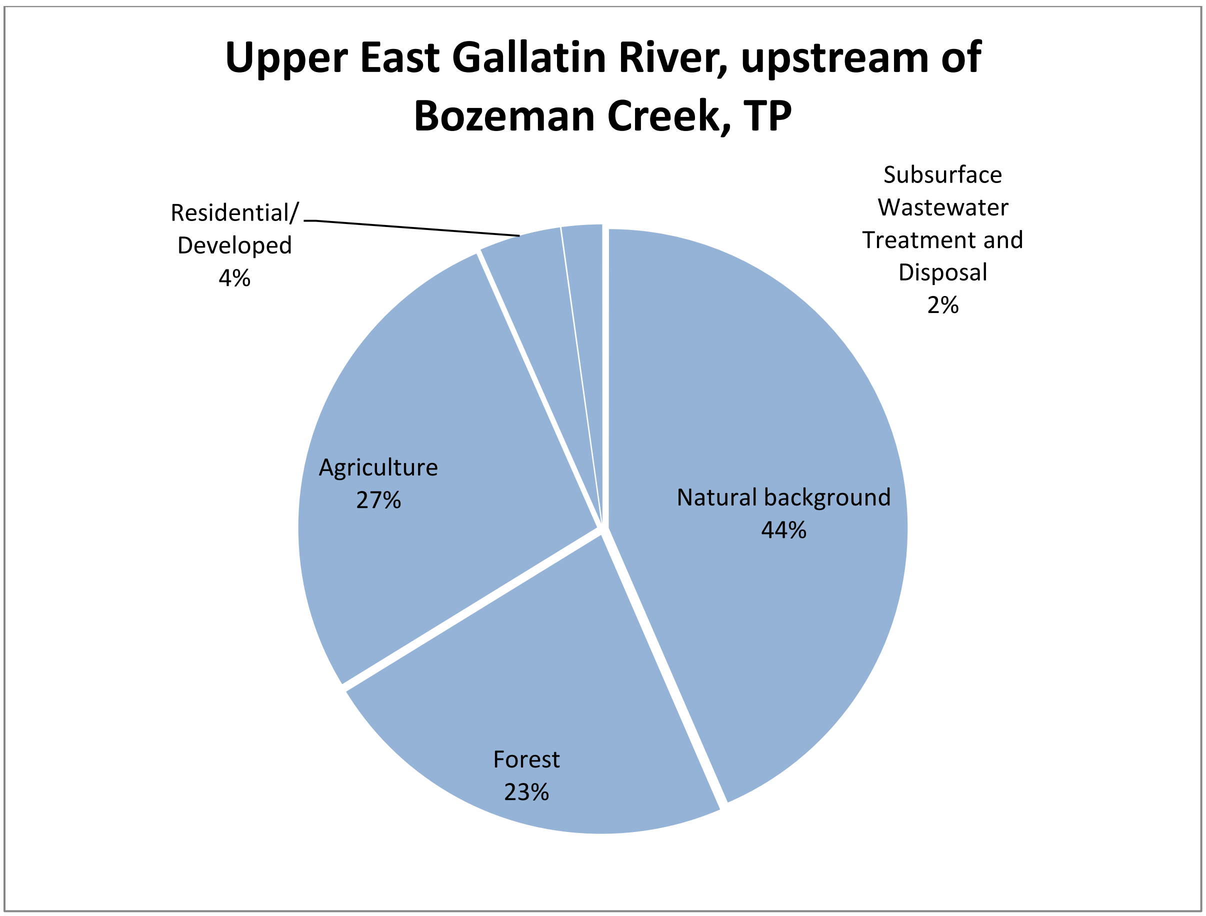

Figure F-37. Existing TP sources for Upper East Gallatin River upstream of Bozeman Creek

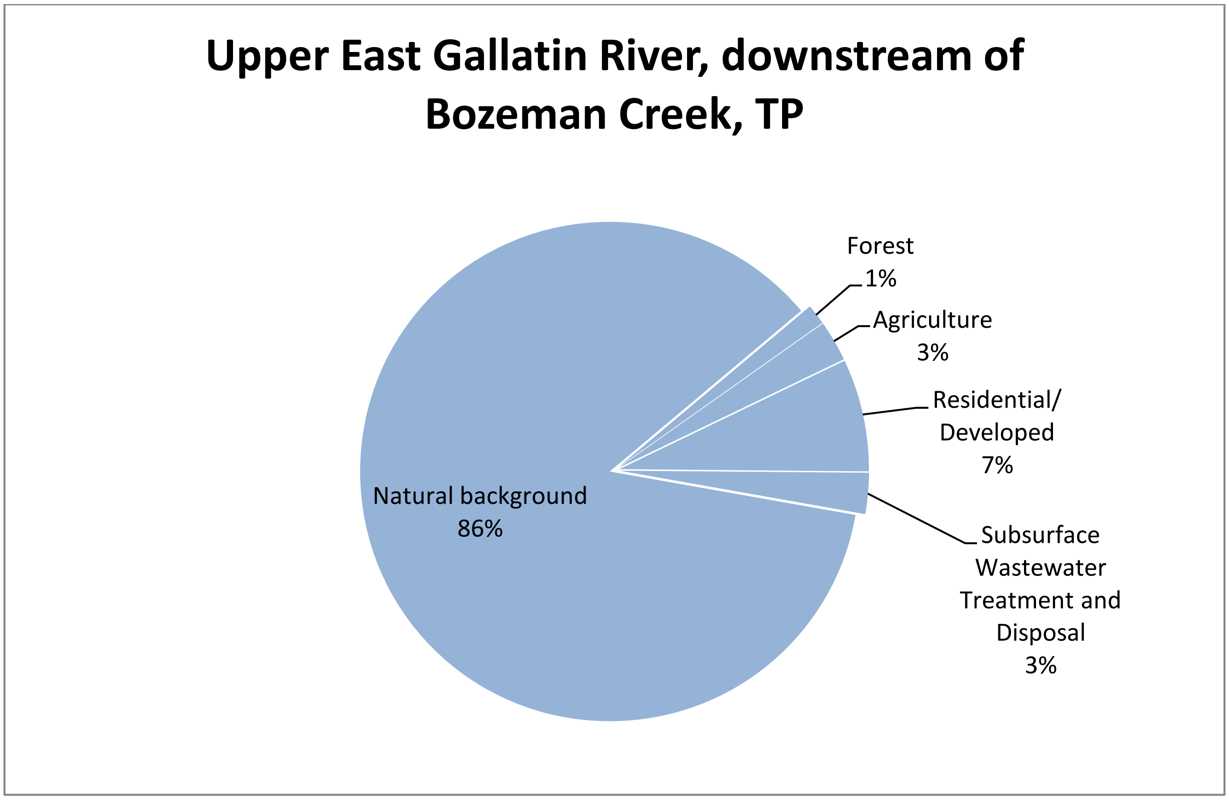

Figure F-38. Existing TP sources for Upper East Gallatin River downstream of Bozeman Creek

F6.2 Middle East Gallatin River

The middle segment of the East Gallatin River is listed as impaired for total phosphorus and total nitrogen on the 2012 303(d) List. Figures and analysis for TP and TN source allocations are provided in this section. **Figure F-40** displays the stream sampling locations and other environmental data including septic density and hydrography.

In the middle segment of the East Gallatin River, tributary data from both TMDL streams and unlisted waterbodies was used to evaluate and determine existing load source allocations. A concentration model was developed to determine water quality conditions in the East Gallatin River downstream of the WRF discharge (**Appendix G**). There was extensive data available for this segment which was used in addition to the synoptic sampling to calibrate the concentration model which assumed tributary flows and loads from the 2009 synoptic sampling event are representative of low flow conditions in the lower East Gallatin River watershed. This segment includes the discharge from the city of Bozeman Water Reclamation Facility (WRF) and the subsurface wastewater treatment and disposal loads from the Belgrade area via Ben Hart Creek and the Riverside Water and Sewer District WWTP. The following source assessments for the middle and lower segments of the East Gallatin River are for low flow conditions (14Q5) and assume the WRF is discharging to the East Gallatin River at the design performance of the new facility (7.5 mg/L TN and 1.0 mg/L TP). **Appendix G** contains the full description of the model and how it was created and calibrated.

As outlined earlier, 2 source assessments were done for the middle segment as split by Hyalite Creek which enters the East Gallatin River between sampling locations EG09 and EG10 (**Figure F-39**). Existing load and natural background calculations were not determined using median values of all available instream water quality data as was done for other nutrient impaired waterbodies in the Lower Gallatin project area. Because of the complex nature of the East Gallatin River with large nutrient point sources (city of Bozeman WRF) and substantial irrigation diversions and returns (i.e. Buster Gulch, Dry Creek Irrigation Canal), load estimates and natural background calculations were determined using specific site data for each segment. Sites were selected that best represented hydrologic and water quality conditions. For the middle segment of the East Gallatin River upstream of Hyalite Creek, flow and water quality data from site EG07 was used and downstream of the Hyalite Creek confluence data from site EG10 was used. Sites EG07 and EG10 are located 0.5 miles and 10.8 miles downstream of the WRF discharge point respectively.

Site EG07 is located downstream of the WRF discharge to the East Gallatin River and upstream of the Buster Gulch diversion. Site EG10 is located downstream of the Hyalite Creek confluence (and Buster Gulch return) and upstream of the Dry Creek Irrigation Canal diversion.

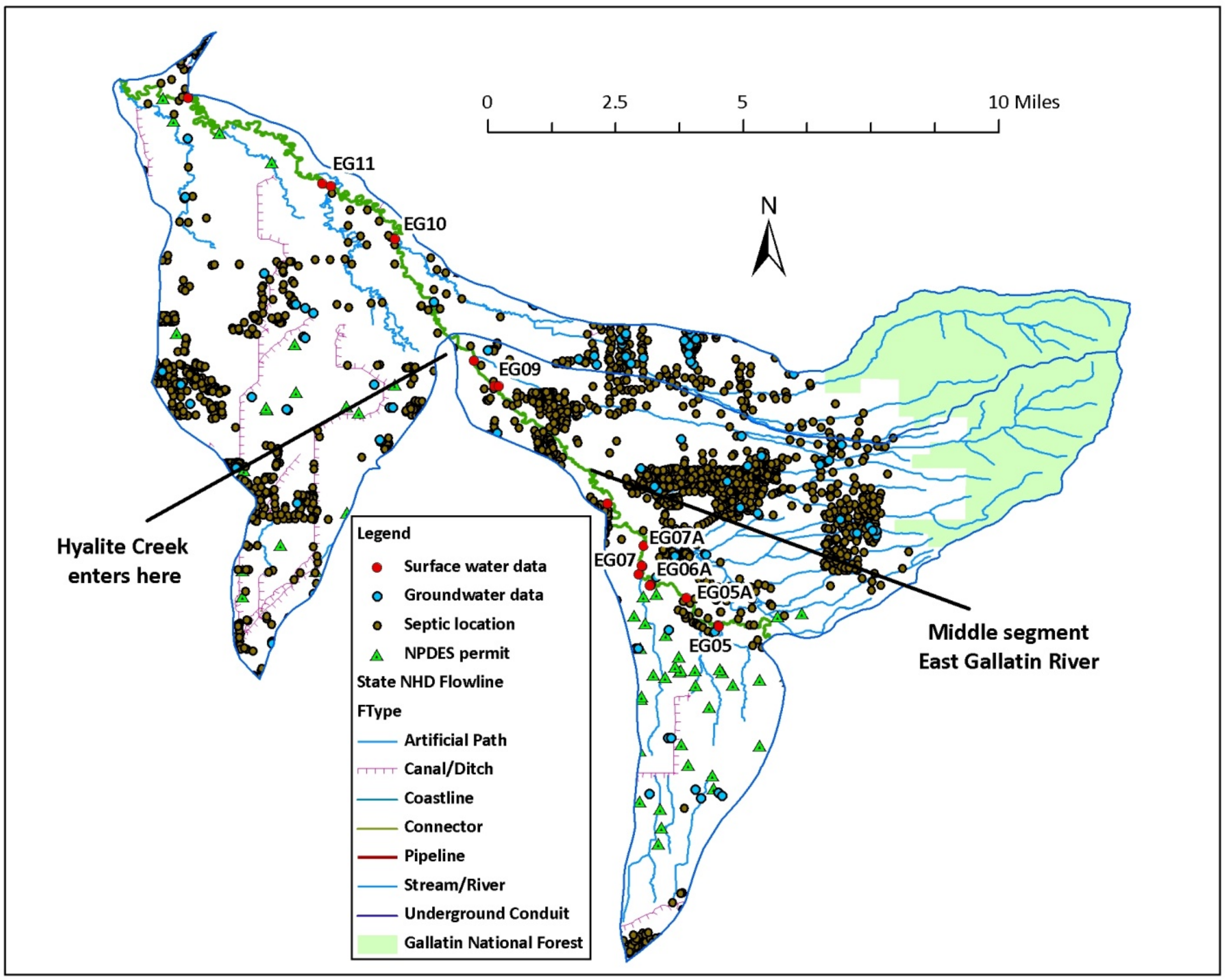

Figure F-39. Spatial data used for the Middle East Gallatin existing load source assessment

One synoptic sampling event was available for the middle segment of the East Gallatin River. Load calculations and source assessments for the middle segment upstream of the Hyalite Creek confluence are included in the following tables (**Tables F-65 and F-66**). **Figures F-40 and F-41** are the existing load allocations for TN and TP from the source assessment. In **Table F-65**, the most significant increase in the TN load occurs at EG07 downstream of the WRF discharge.

Table F-65. Total nitrogen loading on 9/16/2009 on the East Gallatin River from Bridger Creek to Hyalite Creek confluence

Site ID	TN load (lbs/day)	Change in load from upstream	% of peak load
EG05	87.50	87.50	22%
EG05A	129.22	41.72	10%
EG06A	99.04	-30.18	NA
EG07	370.58	271.54	67%
EG07A	373.88	3.30	1%
EG09	226.29	-147.59	NA

Table F-66. Existing load source assessment for anthropogenic sources for total nitrogen on the East Gallatin River from Bridger Creek to Hyalite Creek confluence

Source category	EG05	EG05A	EG07	EG07A	Total
Forest	1.71	0.00	0.00	0.00	1.78
Agriculture	6.27	6.09	4.03	0.00	19.65
Residential/Developed	8.55	3.87	10.75	0.00	24.85
Subsurface wastewater disposal and treatment*	4.99	0.36	0.00	0.20	7.09
USFWS Fish Tech Center	0.14	0.00	0.00	0.00	0.71
City of Bozeman WRF	0.00	0.00	52.42	0.62	45.91
% of peak load	21.66	10.33	67.20	0.82	100.00

*Includes loading estimate from the Riverside Water and Sewer District WWTP

Based on the estimated 14Q5 flow and modeled TN concentration at EGO9, natural background in the segment upstream of the Hyalite Creek confluence was determined to be 7% of the existing load (**Figure F-40**). The city of Bozeman WRF is the largest TN source in this segment.

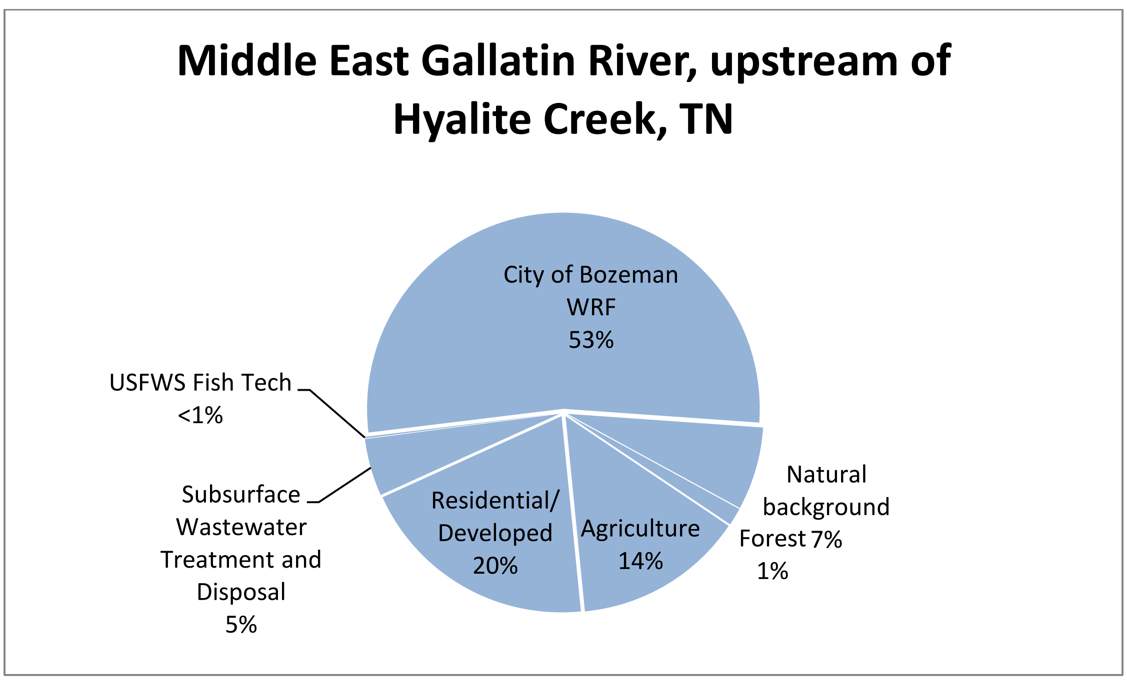

Figure F-40. Existing TN sources for the Middle East Gallatin River upstream of Hyalite Creek

Load calculations and source assessments for the middle segment downstream of the Hyalite Creek confluence are included in the following tables (**Tables F-67 and F-68**).

Table F-67. Total nitrogen loading on the East Gallatin River from Hyalite Creek to Smith Creek confluence

Site ID	TN load (lbs/day)	Change in load from upstream	% of peak load
EG10	341.00	341.00	94%
EG11	363.28	22.28	6%

Hyalite Creek, which flows into the middle segment of the East Gallatin River upstream of EG10, delivers a large TN load and flow contribution to the East Gallatin River. Overall, agriculture and the WRF are the two largest contributors to the existing TN load.

Table F-68. Existing load source assessment for anthropogenic sources for total nitrogen on the East Gallatin River from Hyalite Creek to Smith Creek confluence

Source category	EG10	Total
Forest	1.04	1.04
Agriculture	34.2	34.2
Residential/Developed	5.49	5.49
Subsurface wastewater disposal and treatment*	17.17	17.17
City of Bozeman WRF	42.1	42.1
% of peak load	100.00	100.00

*Includes loading estimate from the Riverside Water and Sewer District WWTP

Based on the estimated 14Q5 flow and modeled TN concentration at EG10, natural background in the segment downstream of the Hyalite Creek confluence was determined to be 8% of the existing load (**Figure F-41**).

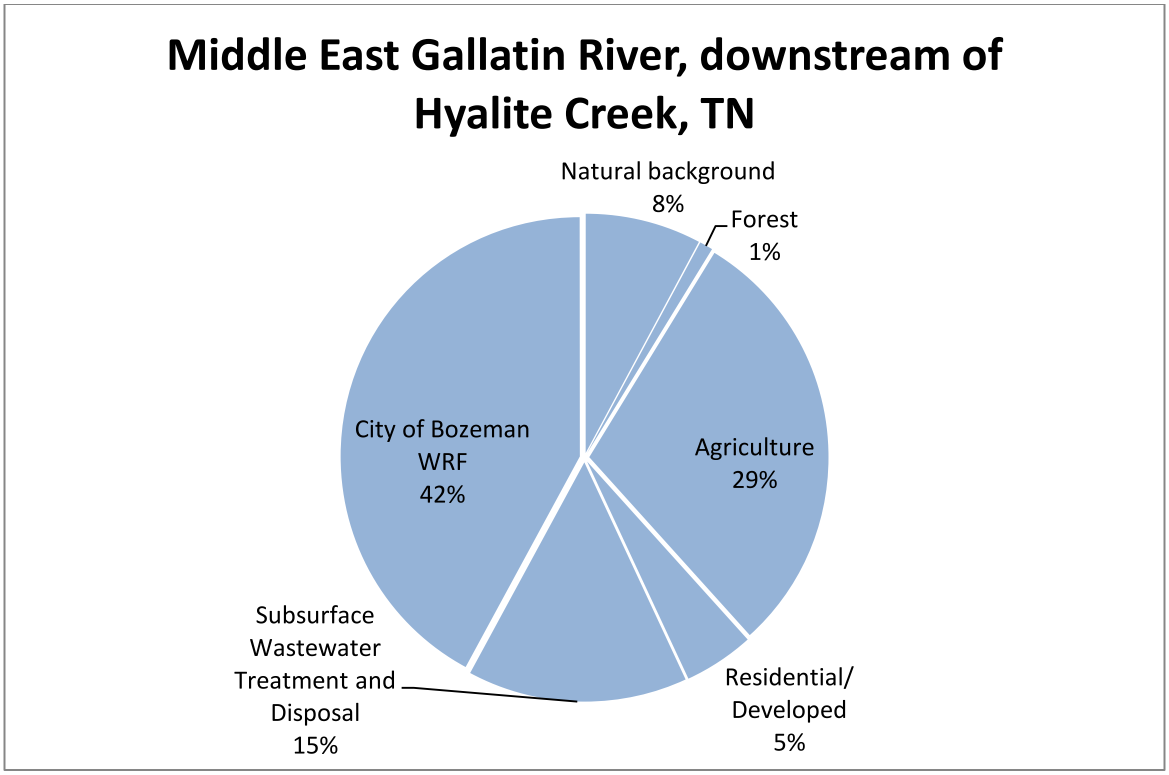

Figure F-41. Existing TN sources for the Middle East Gallatin River downstream of Hyalite Creek

Total phosphorus load calculations and source assessments for the middle segment upstream of the Hyalite Creek confluence are included in the following tables (**Tables F-69 and F-70**).

Table F-69. Total phosphorus loading on 9/16/2009 on the East Gallatin River from Bridger Creek to Hyalite Creek confluence

Site ID	TP load (lbs/day)	Change in load from upstream	% of peak load
EG05	4.47	4.47	10%
EG05A	5.92	1.45	3%
EG06A	5.48	-0.44	NA
EG07	44.15	38.67	87%
EG07A	43.67	-0.48	NA
EG09	20.13	-23.36	NA

Table F-70. Existing load source assessment for anthropogenic sources for total phosphorus on 9/16/2009 on the East Gallatin River from Bridger Creek to Hyalite Creek confluence

Source category	EG05	EG05A	EG07	Total
Forest	1.65	0.00	0.00	1.65
Agriculture	2.54	1.63	0.00	4.17
Residential/Developed	4.57	1.59	4.94	11.11
Subsurface wastewater disposal and treatment	1.27	0.03	2.69	3.99
City of Bozeman WRF	0.00	0.00	79.09	79.09
% of peak load	10.03	3.25	86.72	100.00

*Includes loading estimate from the Riverside Water and Sewer District WWTP

Based on the estimated 14Q5 flow and modeled TN concentration at EGO9, natural background in the segment upstream of the Hyalite Creek confluence was determined to be 8% of the existing TP load (**Figure F-42**). The largest contributing source is the city of Bozeman WRF.

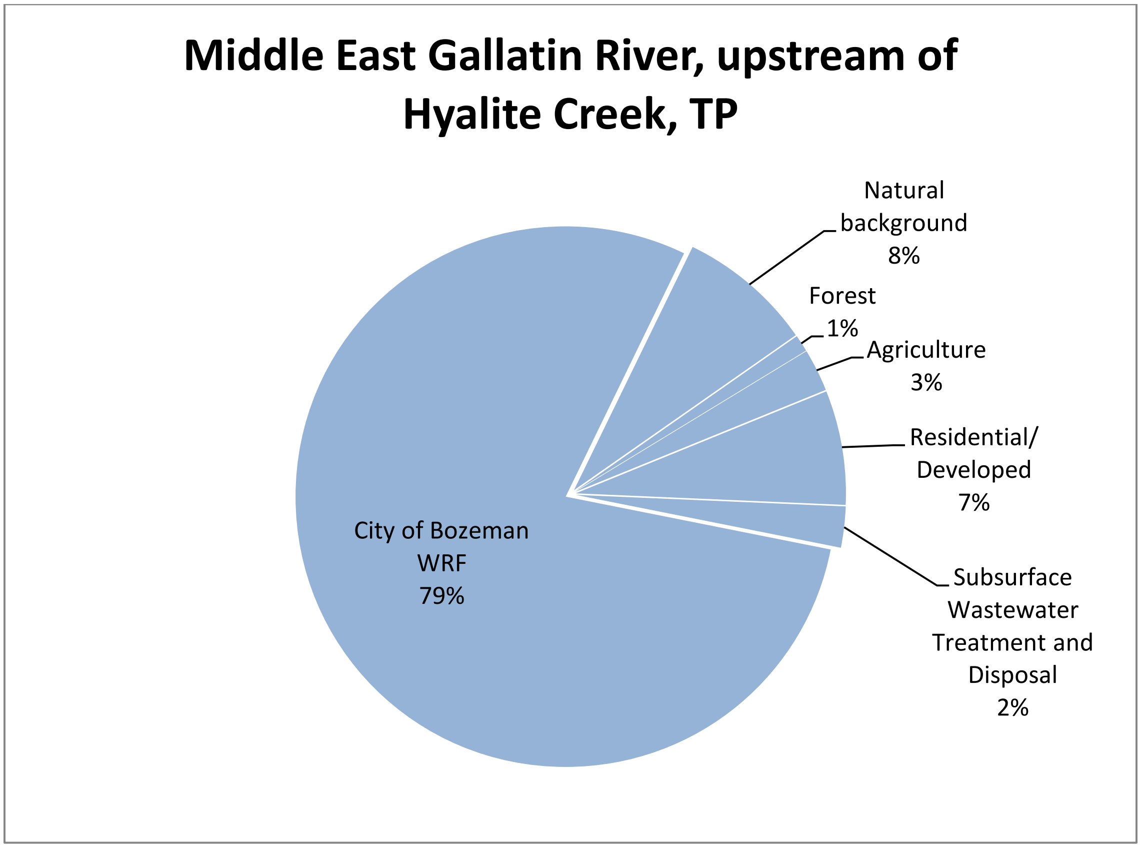

Figure F-42. Existing TP sources for the Middle East Gallatin River downstream of Hyalite Creek

Total phosphorus load calculations and source assessments for the middle segment downstream of the Hyalite Creek confluence are included in the following tables (**Tables F-71 and F-72**).

Table F-71. Total phosphorus loading on 9/16/2009 on the East Gallatin River from Hyalite Creek to Smith Creek confluence

Site ID	TP load (lbs/day)	Change in load from upstream	% of peak load
EG10	28.40	15.29	100
EG11	23.93	-4.47	NA

Table F-72. Existing load source assessment for anthropogenic sources for total phosphorus on 9/16/2009 on the East Gallatin River from Hyalite Creek to Smith Creek confluence

Source category	EG10	Total
Forest	0.00	0.00
Agriculture	27.15	27.15
Residential/Developed	18.10	18.10
Subsurface wastewater disposal and treatment	9.05	9.05
City of Bozeman WRF	45.70	45.70
% of peak load	100.00	100.00

*Includes loading estimate from the Riverside Water and Sewer District WWTP

Based on the estimated 14Q5 flow and modeled TP concentration at EG10, natural background in the segment downstream of the Hyalite Creek confluence was determined to be 33% of the existing load (**Figure F-43**). The increase in natural background load compared with the segment upstream of Hyalite Creek is due to the naturally occurring phosphorus loads in Level IV ecoregion Absaroka-Gallatin-Volcanics which occurs in the upper reaches of Hyalite Creek. The largest contributing source is the city of Bozeman WRF discharge.

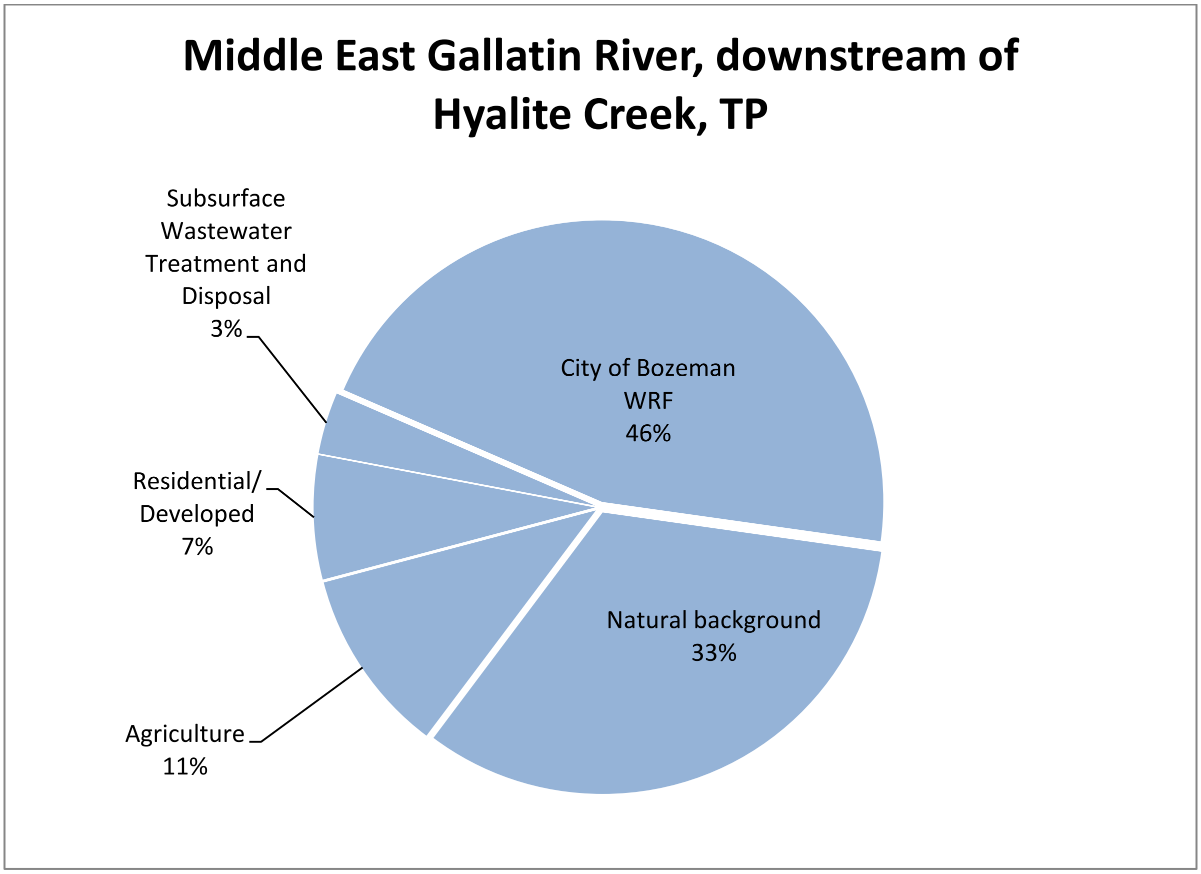

Figure F-43. Existing TP sources for the Middle East Gallatin River downstream of Hyalite Creek

F6.3 Lower East Gallatin River

The lower segment of the East Gallatin River is listed as impaired for total phosphorus and total nitrogen on the 2012 303(d) List. Figures and analysis for TP and TN source allocations are provided in this section. **Figure F-44** displays the stream sampling locations and other environmental data including septic density and hydrography.

Although there was a good dataset available for this segment, there were few synoptic sampling events. However, the September 2009 sampling event did sample many of the smaller tributaries to the lower segment including Ben Hart Creek, Cowan Creek, Gibson Creek, Stony Creek, Thompson Creek, and Ben Hart Creek in addition to sites on the mainstem. Source assessment work was also done on Dry Creek and Smith Creek which flow into the East Gallatin River in this segment. These resources were used to determine the existing load source allocation for the lower segment. The Manhattan WWTP discharges to groundwater which drains to the Gallatin River and was not included in the Lower East Gallatin River existing load assessment as it does not impact the East Gallatin River.

Because of the complex nature of the East Gallatin River with large nutrient point sources (city of Bozeman WRF) and substantial irrigation diversions and returns (i.e. Buster Gulch, Dry Creek Irrigation Canal), load estimates and natural background calculations were determined using specific site data for each segment. Sites were selected that best represented hydrologic and water quality conditions. For the lower segment of the East Gallatin River downstream of Smith Creek, median flow and water quality data from site EG13 was used to calculate the existing load and natural background. Site EG13 is located 26.6 miles downstream of the WRF discharge point.

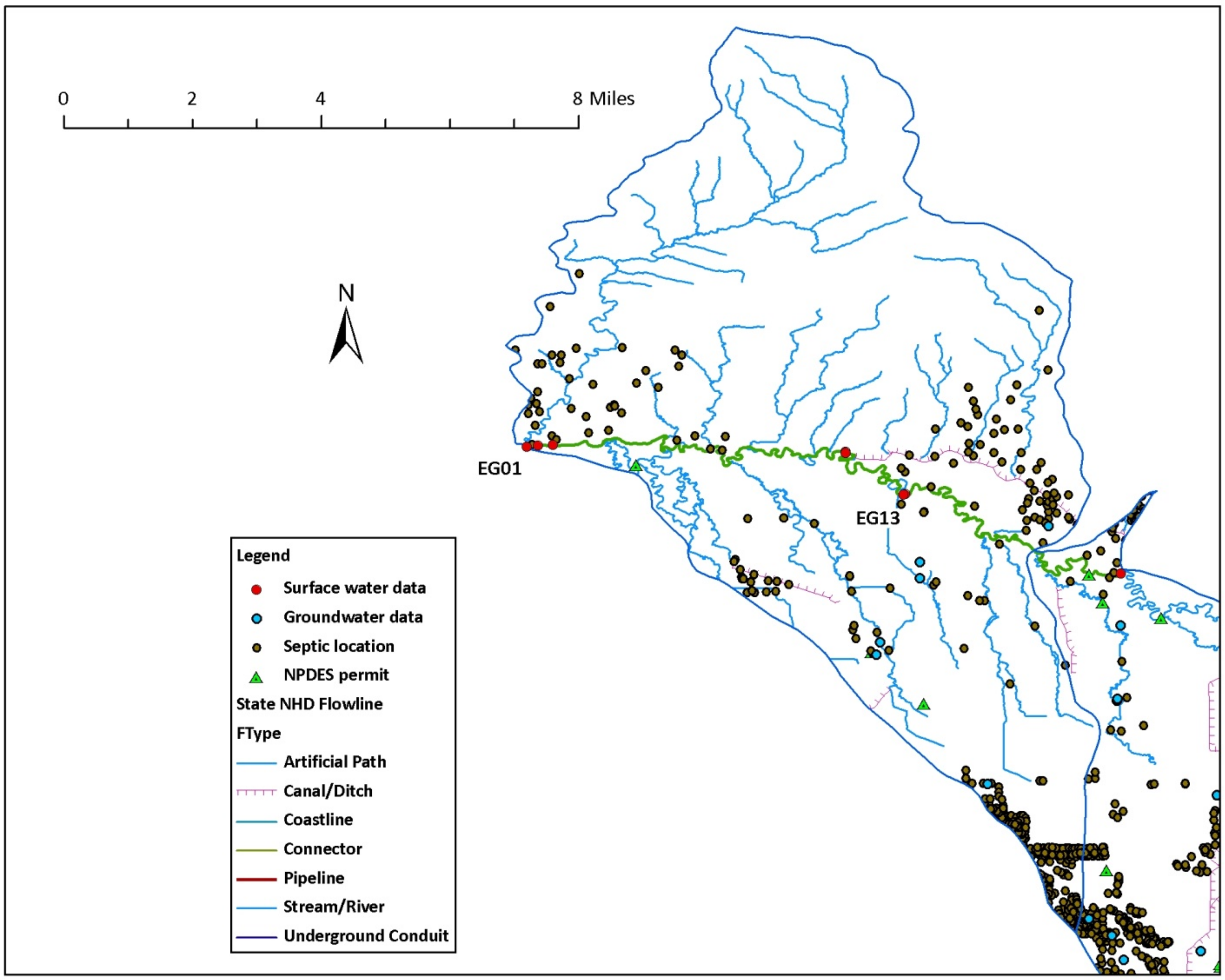

Figure F-44. Spatial data used for the Lower East Gallatin existing load source assessment

One synoptic sampling event was available for the lower segment of the East Gallatin River. Load calculations and source assessments are included in the following tables (**Tables F-73 and F-74**).

Table F-73. Total nitrogen loading on 9/16/2009 on the East Gallatin River from Smith Creek to the Gallatin River

Site ID	TN load (lbs/day)	Change in load from upstream	% of peak load
EG13	472.10	472.10	95%
EG01	498.55	26.45	5%

Table F-74. Existing load source assessment for anthropogenic sources for total nitrogen on 9/16/2009 on the East Gallatin River from Smith Creek to the Gallatin River

Source category	EG13	EG01	Total
Forest	0.97	0.00	0.97
Agriculture	57.92	4.64	62.56
Residential/Developed	10.27	0.05	10.32
Subsurface wastewater disposal and treatment	9.53	0.05	9.58
City of Bozeman WRF	16.00	0.56	16.57
% of peak load	94.69	5.31	100.00

*Includes loading estimate from the Riverside Water and Sewer District WWTP and the city of Belgrade WWTP

Based on the estimated 14Q5 flow and modeled TN concentration at EG13, natural background in the segment downstream of the Hyalite Creek confluence was determined to be 16% of the existing load (**Figure F-45**).

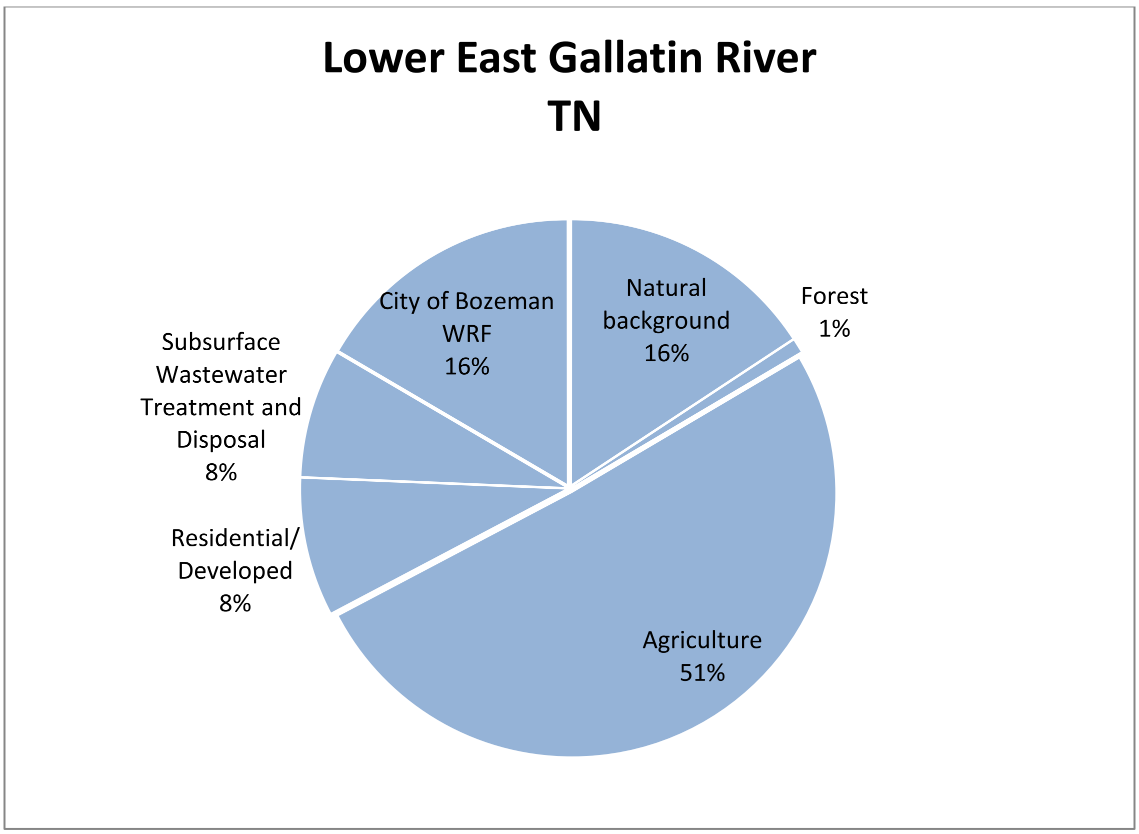

Figure F-45. Existing TN sources for the Lower East Gallatin River

One synoptic sampling event was available for the lower segment of the East Gallatin River. Load calculations and source assessments are included in the following tables (**Tables F-75 and F-76**).

Table F-75. Total phosphorus loading on the East Gallatin River from Smith Creek to the Gallatin River

Site ID	TP load (lbs/day)	Change in load from upstream	% of peak load
EG13	11.78	11.78	100%
EG01	6.90	-4.88	NA

Table F-76. Existing load source assessment for anthropogenic sources for total phosphorus on the East Gallatin River from Smith Creek to the Gallatin River

Source category	EG13	Total
Forest	2.60	2.60
Agriculture	52.41	52.41
Residential/Developed	15.65	15.65
Subsurface wastewater disposal and treatment	7.44	7.44
City of Bozeman WRF	21.90	21.90
% of peak load	100.00	100.00

*Includes loading estimate from the Riverside Water and Sewer District WWTP and the city of Belgrade WWTP

Based on the estimated 14Q5 flow and modeled TP concentration at EG13, natural background was determined to be 66% of the existing load (**Figure F-46**).

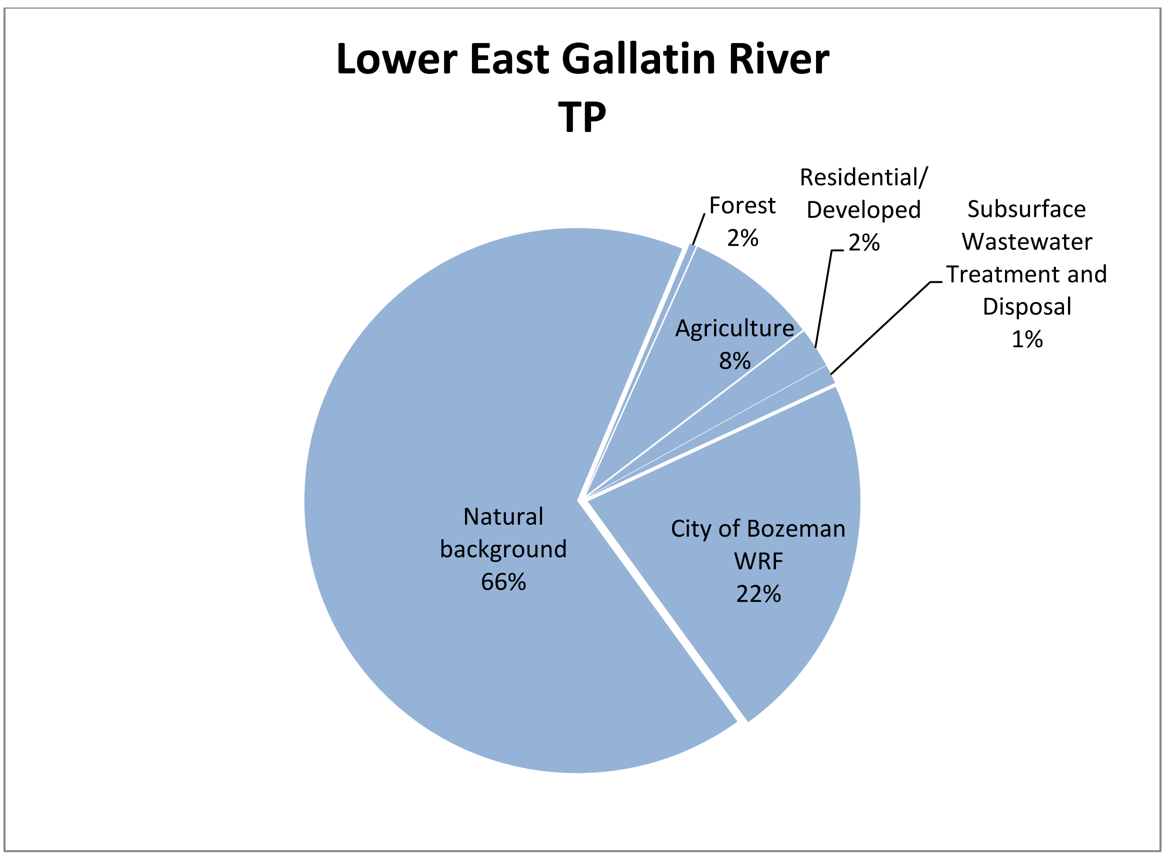

Figure F-46. Existing TP sources for the Lower East Gallatin River

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