Flint Nutrients TMDLs and Water Quality Improvement Plan

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Consultants often provide significant contributions with data collection, source assessment, and reporting. In the Flint watershed, multiple consultants were used for data collection during the course of this project.

Jess Clarke, a monitoring coordinator with DEQ, collected data for these TMDLs and performed the assessments required for this project to proceed. We would like to thank the administrative assistant staff for the Watershed Management Section of DEQ, for their time and efforts formatting this document.

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ACRONYM LIST

Acronym	Definition
AFDM	Ash Free Dry Mass
AFO	Animal Feeding Operation
ARM	Administrative Rules of Montana
BMP	Best Management Practices
CAFO	Concentrated (or Confined) Animal Feeding Operations
CFR	Code of Federal Regulations
CWA	Clean Water Act
DEQ	Department of Environmental Quality (Montana)
DNRC	Department of Natural Resources & Conservation (Montana)
EPA	Environmental Protection Agency (U.S.)
EQIP	Environmental Quality Initiatives Program
FWP	Fish, Wildlife & Parks (Montana)
GIS	Geographic Information System
GWIC	Groundwater Information Center
HBI	Hilsenhoff's Biotic Index
HRU	Hydrologic Response Units
INFISH	Inland Native Fish Strategy
IR	Integrated Report
LA	Load Allocation
MBMG	Montana Bureau of Mines and Geology
MCA	Montana Code Annotated
MEANSS	Method for Estimating Attenuation of Nutrients from Septic Systems
MGWPCS	Montana Ground Water Pollution Control System
MOS	Margin of Safety
MPDES	Montana Pollutant Discharge Elimination System
MSU	Montana State University
NA	Not Available
NASS	National Agriculture Statistic Services
NLCD	National Land Cover Dataset
NOAA	National Oceanographic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NRCS	National Resources Conservation Service
RIT/RDG	Resource Indemnity Trust/Reclamation and Development Grants Program
SDWIS	Safe Drinking Water Information System
SILC	Satellite Imagery land Cover
SMZ	Streamside Management Zone
SWAT	Soil & Water Assessment Tool
TIE	TMDL Implementation Evaluation
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TPA	TMDL Planning Area
USDA	United States Department of Agriculture

Acronym	**Definition**
USFS	United States Forest Service
USGS	United States Geological Survey
WLA	Wasteload Allocation
WLATP	Total Phosphorus Wasteload Allocation in lbs/day
WRP	Watershed Restoration Plan
WWTP	Wastewater Treatment Plant

DOCUMENT SUMMARY

This document presents a total maximum daily load (TMDL) and surface water quality improvement plan for six impaired waterbody segments in the Flint TMDL Planning Area (TPA).

The Montana Department of Environmental Quality (DEQ) develops TMDLs and submits them to the U.S. Environmental Protection Agency (EPA) for approval. The Montana Water Quality Act requires DEQ to develop TMDLs for streams and lakes that do not meet, or are not expected to meet, Montana water quality standards. A TMDL is the maximum amount of a pollutant a waterbody can receive and still meet water quality standards. TMDLs provide an approach to improve water quality so that streams and lakes can support and maintain their state-designated beneficial uses.

The Flint TPA is located in Granite and Deer Lodge counties and includes Flint Creek and its tributaries, from the headwaters upstream of Georgetown Lake to its confluence with the Clark Fork River near Drummond. The tributaries originate in the John Long Mountains to the west, the Flint Creek Range to the east, and the Anaconda Range to the south. The watershed drainage area encompasses about 318,537 acres, with federal, state, and private land ownership.

DEQ determined that six waterbody segments do not meet the applicable water quality standards for nutrients. The scope of the TMDLs in this document addresses problems with nutrients (see **Table DS-1**). Ten TMDLs were written to address 11 pollutant impairments and one non-pollutant impairment in the six waterbody segments (**Table 1-1**). Although DEQ recognizes that there are other pollutant listings for this TPA, this document addresses only nutrients. Non-pollutant impairments as well as impairments due to sediment and metals were addressed in the 2012 “Flint Creek Planning Area Sediment and Metals TMDLs and Framework Water Quality Improvement Plan” (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012a).

Nutrients were identified as impairing aquatic life and contact recreation in Barnes Creek (headwaters to mouth), Douglas Creek (confluence of Middle and South forks to mouth), Flint Creek (Georgetown Lake to confluence with Boulder Creek), Flint Creek (Boulder Creek to mouth), Princeton Gulch (headwaters to mouth), and Smart Creek (headwaters to mouth). Nutrients affect designated uses in these streams by enabling excess algal growth and altering aquatic insect communities. Water quality restoration goals for nutrients were established on the basis of DEQ’s draft numeric nutrient criteria (Suplee and Sada de Suplee, 2011; Suplee and Watson, 2013). DEQ believes that once these water quality goals are met, water uses will no longer be affected by nutrients in these streams.

DEQ quantified nutrient loads for natural background conditions, livestock grazing, agricultural crops, residential development, septic, and the Philipsburg Wastewater Treatment Plant. The Flint TPA Total Maximum Daily Loads (TMDLs) indicate that when reductions are needed, they range from 6% to 93%.

Recommended strategies for achieving the nutrients reduction goals are also presented in this plan. They include reducing total phosphorus from the Philipsburg Wastewater Treatment Plant and best management practices (BMPs) for livestock grazing, growing agricultural crops, building and maintaining roads, for harvesting timber, and for developing subdivisions. In addition, they includes BMPs for expanding riparian buffer areas and using other land, soil, and water conservation practices that improve stream channel conditions and associated riparian vegetation.

Implementation of most water quality improvement measures described in this plan is based on voluntary actions of watershed stakeholders. Ideally, local watershed groups and/or other watershed stakeholders will use this TMDL document, and associated information, as a tool to guide local water quality improvement activities. Such activities can be documented within a watershed restoration plan consistent with DEQ and EPA recommendations (U.S. Environmental Protection Agency, 2008; Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b).

A flexible approach to most nonpoint source TMDL implementation activities may be necessary as more knowledge is gained through implementation and future monitoring. The plan includes a monitoring strategy designed to track progress in meeting TMDL objectives and goals and to help refine the plan during its implementation.

Although most water quality improvement measures are based on voluntary measures, federal law specifies permit requirements developed to protect narrative water quality criterion, a numeric water quality criterion, or both, to be consistent with the assumptions and requirements of wasteload allocations (WLAs) on streams where TMDLs have been developed and approved by EPA. The Flint TPA has permitted dischargers requiring the incorporation of WLAs into permit conditions on both segments of Flint Creek.

Table DS-1. List of Nutrients Impaired Waterbodies and their Impaired Uses in the Flint Total Maximum Daily Load Planning Area with Completed Total Maximum Daily Loads (TMDLs) Contained in this Document

Waterbody & Location Description	TMDL Prepared	TMDL Pollutant Category	Impaired Use(s)[1]
Barnes Creek, from headwaters to mouth (Flint Creek)	Total Nitrogen, Total Phosphorus	Nutrients	Aquatic Life, Primary Contact Recreation
Douglas Creek, confluence of Middle and South forks to mouth (Flint Creek), T9N R13W S10	Nitrate[2] Total Phosphorus	Nutrients	Aquatic Life, Primary Contact Recreation
Flint Creek, Georgetown Lake to confluence with Boulder Creek	Total Phosphorus	Nutrients	Aquatic Life, Primary Contact Recreation
Flint Creek, Boulder Creek to mouth (Clark Fork River)	Total Nitrogen, Total Phosphorus	Nutrients	Aquatic Life, Primary Contact Recreation
Princeton Gulch, headwaters to mouth (Boulder Creek)	Nitrate[2]	Nutrients	Aquatic Life, Primary Contact Recreation
Smart Creek, headwaters to mouth (Flint Creek), T9N R13W S21	Total Nitrogen, Total Phosphorus	Nutrients	Aquatic Life, Primary Contact Recreation

[1] Impaired uses given in this table are based on updated assessment results and may not match the “2012 Water Quality Integrated Report.”

[2] Nitrate = Nitrates = Nitrogen, Nitrate = NO_2+NO_3 = Nitrite + Nitrate; The term “nitrate” is used throughout the document and refers to any of the various nitrate-related impairment causes listed in the “2012 Water Quality Integrated Report.”

1.0 PROJECT OVERVIEW

This document presents an analysis of water quality information and establishes total maximum daily loads (TMDLs) for nutrients problems in the Flint TMDL Planning Area (TPA). This document also presents a general framework for resolving these problems. **Figure 5-1**, found in **Section 5**, shows a map of waterbodies in the Flint TPA with nutrients pollutant listings.

1.1 WHY WE WRITE TOTAL MAXIMUM DAILY LOADS (TMDLS)

In 1972, the U.S. Congress passed the Water Pollution Control Act, more commonly known as the Clean Water Act (CWA). The CWA's goal is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The CWA requires each state to designate uses of their waters and to develop water quality standards to protect those uses.

Montana's water quality designated use classification system includes the following:
- fish and aquatic life
- wildlife
- recreation
- agriculture
- industry
- drinking water

Each waterbody in Montana has a set of designated uses from the list above. Montana has established water quality standards to protect these uses, and a waterbody that does not meet one or more standards is called an impaired water. Each state must monitor their waters to track if they are supporting their designated uses, and every two years the Montana Department of Environmental Quality (DEQ) prepares a Water Quality Integrated Report (IR) which lists all impaired waterbodies and their identified impairment causes. Impairment causes fall within two main categories: pollutant and non-pollutant.

Montana's biennial IR identifies all the state's impaired waterbody segments. The 303(d) list portion of the IR includes all of those waterbody segments impaired by a pollutant, which require a TMDL, whereas TMDLs are not required for non-pollutant causes of impairments. **Table A-1** in **Appendix A** identifies all impaired waters for the Flint TPA from Montana's 2012 303(d) List, and includes non-pollutant impairment causes included in Montana's "2012 Water Quality Integrated Report." **Table A-1** provides the current status of each impairment cause, identifying whether it has been addressed by TMDL development.

Both Montana state law (Section 75-5-701 of the Montana Water Quality Act) and section 303(d) of the federal CWA require the development of total maximum daily loads for all impaired waterbodies when water quality is impaired by a pollutant. A TMDL is the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards.

Developing TMDLs and water quality improvement strategies includes the following components, which are further defined in **Section 4.0**:

- Determining measurable target values to help evaluate the waterbody's condition in relation to the applicable water quality standards
- Quantifying the magnitude of pollutant contribution from their sources
- Determining the TMDL for each pollutant based on the allowable loading limits for each waterbody-pollutant combination
- Allocating the total allowable load (TMDL) into individual loads for each source

In Montana, restoration strategies and monitoring recommendations are also incorporated in TMDL documents to help facilitate TMDL implementation.

Basically, developing a TMDL for an impaired waterbody is a problem-solving exercise: The problem is excess pollutant loading that impairs a designated use. The solution is developed by identifying the total acceptable pollutant load (the TMDL), identifying all the significant pollutant-contributing sources, and identifying where pollutant loading reductions should be applied to achieve the acceptable load.

1.2 WATER QUALITY IMPAIRMENTS AND TOTAL MAXIMUM DAILY LOADS (TMDLS) ADDRESSED BY THIS DOCUMENT

Table 1-1 below lists all of the impairment causes from the "2012 Water Quality Integrated Report" that are addressed in this document. Each pollutant impairment falls within the nutrients TMDL pollutant category. Note that the term "nitrate" is used in **Table 1-1** and throughout the document and refers to any of the various nitrate-related impairment causes listed in the "2012 Water Quality Integrated Report."

New data assessed during this project identified three new nutrient impairment causes for waterbodies in the Flint TPA. These impairment causes are identified in **Table 1-1** and noted as not being on the 2012 303(d) List (within the integrated report). Instead, these waters will be documented within DEQ assessment files and incorporated into the 2014 IR.

TMDLs are completed for each waterbody – pollutant combination, and this document contains 10 TMDLs (**Table 1-1**) addressing 11 pollutants. There are several non-pollutant types of impairment that are also addressed in this document. As noted above, TMDLs are not required for non-pollutants, although in many situations the solution to one or more pollutant problems will be consistent with, or equivalent to, the solution for one or more non-pollutant problems. The overlap between the pollutant TMDLs and non-pollutant impairment causes is discussed in **Section 6.0**. **Section 6.0** also provides some basic water quality solutions to address those non-pollutant causes not specifically addressed by TMDLs in this document.

Sediment and metals TMDLs were previously completed for the Flint TPA in 2012 and are contained in the "Flint Creek Planning Area Sediment and Metals TMDLs and Framework Water Quality Improvement Plan" (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012a). **Table A-1** in **Appendix A** includes impairment causes with completed TMDLs, as well as non-pollutant impairment causes that were addressed by those TMDLs.

Table 1-1. Nutrients Water Quality Impairment Causes for the Flint Total Maximum Daily Load Planning Area Addressed within this Document

Waterbody & Location Description [1]	Waterbody ID	Impairment Cause [2]	Pollutant Category	Impairment Cause Status [2]	Included in 2012 Integrated Report [3]
Barnes Creek, from headwaters to mouth (Flint Creek)	MT76E003_070	TN	Nutrients	TN TMDL in this document	Yes
		Nitrate	Nutrients	Addressed by TN TMDL in this document	Yes
		TP	Nutrients	TP TMDL in this document	Yes
		Chlorophyll-*a*	Not Applicable; Non-pollutant	Addressed by TN and TP TMDLs in this document	Yes
Douglas Creek, confluence of Middle and South forks to mouth (Flint Creek), T9N R13W S10	MT76E003_020	Nitrate	Nutrients	Nitrate TMDL in this document	Yes
		TP	Nutrients	TP TMDL in this document	No
Flint Creek, Georgetown Lake to confluence with Boulder Creek	MT76E003_011	TP	Nutrients	TP TMDL in this document	No
Flint Creek, Boulder Creek to mouth (Clark Fork River)	MT76E003_012	TN	Nutrients	TN TMDL in this document	Yes
		TP	Nutrients	TP TMDL in this document	Yes
Princeton Gulch, headwaters to mouth (Boulder Creek)	MT76E003_090	Nitrate	Nutrients	Nitrate TMDL in this document	Yes
Smart Creek, headwaters to mouth (Flint Creek), T9N R13W S21	MT76E003_110	TN	Nutrients	TN TMDL in this document	No
		TP	Nutrients	TP TMDL in this document	Yes

[1] All waterbody segments within Montana's Water Quality Integrated Report are indexed to the National Hydrography Dataset

[2] TN = Total Nitrogen, TP = Total Phosphorus, Nitrate = Nitrates = Nitrogen, Nitrate = NO_2+NO_3 = Nitrite + Nitrate; The term "nitrate" is used throughout the document and refers to any of the various nitrate-related impairment causes listed in the "2012 Water Quality Integrated Report."

[3] Impairment causes not in the "2012 Water Quality Integrated Report" were recently identified and will be included in the 2014 Integrated Report.

1.3 WHAT THIS DOCUMENT CONTAINS

This document addresses all of the required components of a TMDL and includes an implementation and monitoring strategy, as well as a strategy to address impairment causes other than nutrients (i.e., chlorophyll-*a*). The TMDL components are summarized within the main body of the document. Additional technical details are contained in the appendices. In addition to this introductory section, this document includes:

Section 2.0 Flint Watershed Description:
Describes the physical characteristics and social profile of the watershed.

Section 3.0 Montana Water Quality Standards
Discusses the water quality standards that apply to the Flint watershed.

Section 4.0 Defining TMDLs and Their Components
Defines the components of TMDLs and how each is developed.

Sections 5.0 Nutrients TMDL components:
This section includes (a) a discussion of the affected waterbodies and the pollutant's effect on designated beneficial uses, (b) the information sources and assessment methods used to evaluate stream health and pollutant source contributions, (c) water quality targets and existing water quality conditions, (d) the quantified pollutant loading from the identified sources, (e) the determined TMDL for each waterbody, (f) the allocations of the allowable pollutant load to the identified sources.

Section 6.0 Other Identified Issues or Concerns:
Describes other problems that could potentially be contributing to water quality impairment and how the TMDLs in the plan might address some of these concerns. This section also provides recommendations for combating these problems.

Section 7.0 Water Quality Improvement Plan:
Discusses water quality restoration objectives and a strategy to meet the identified objectives and TMDLs.

Section 8.0 Monitoring for Effectiveness:
Describes a water quality monitoring plan for evaluating the long-term effectiveness of the" Flint Nutrients TMDLs and Water Quality Improvement Plan."

Section 9.0 Public Participation & Public Comments:
Describes other agencies and stakeholder groups who were involved with the development of this plan and the public participation process used to review the draft document. Addresses comments received during the public review period.

2.0 FLINT WATERSHED DESCRIPTION

This section includes a summary of the physical characteristics and social profile of the Flint Creek watershed.

2.1 PHYSICAL CHARACTERISTICS

The following information describes the physical characteristics of the Flint Creek watershed.

2.1.1 Location

The Flint Creek TMDL planning area (TPA) is located in the Pend Oreille River Basin (Accounting Unit 170102) of western Montana, as shown on **Figure B-1** in **Appendix B** (for a map of waterbody segments for which nutrients Total Maximum Daily Loads (TMDLs) are written see **Figure 5-1**). The TPA is located within the Middle Rockies Level III Ecoregion. Four Level IV Ecoregions are mapped within the TPA (Woods et al., 2002). These include: Flint Creek – Anaconda Mountains (17am), Alpine (17h), Deer Lodge – Philipsburg – Avon Grassy Intermontane Hills and Valleys (17ak) and Rattlesnake – Blackfoot – South Swan – Northern Garnet – Sapphire Mountains (17x) (**Figure B-2** in **Appendix B**). The majority of the TPA is within Granite County, with a minor percentage (near Georgetown Lake) in Deerlodge County.

The TPA is bounded by the Flint Creek Range to the east, the Anaconda Range to the south, and the John Long Mountains to the west. The total area is 318,537 acres, or approximately 498 square miles.

Topography

Elevations in the TPA range from approximately 3,900 to 9,000 feet above mean sea level (**Figure B-3**, **Appendix B**). The highest point in the watershed is Twin Peaks, at 9,067 feet. The lowest point is in the Drummond valley where Flint Creek drains into the Clark Fork River.

The TPA includes two basins: the Philipsburg Valley and the Drummond Valley. The valleys are separated by a narrow canyon. The canyon is confined by Henderson Mountain, a promontory of the John Long Mountains that abuts the Flint Creek Range north of Philipsburg. The Philipsburg Valley ranges from 5,000 to 6,000 feet above sea level, and the Drummond Valley from 4,000 to 4,600 feet above sea level.

2.1.2 Climate

Climate in the area is typical of mid-elevation intermontane valleys in western Montana. Voeller and Waren (1997) described the climate as “modified continental”, characterized by low overnight temperatures. The local climate is milder in the lower elevation Drummond Valley than in the Philipsburg Valley.

Precipitation is most abundant in May and June. Philipsburg receives an annual average of 14.8 inches of moisture, compared to 11.8 reported at Drummond. The mountains may exceed 40 inches average annual moisture (Voeller and Waren, 1997). See **Tables 2-1** and **2-2** for climate summaries; **Figure B-4** in **Appendix B** shows the distribution of average annual precipitation.

Climate Stations

Climate data for the TPA is based upon the stations at Philipsburg and Drummond (although the latter is located outside the TPA). The United States Department of Agriculture (USDA) Natural Resources

Conservation Service (NRCS) operates three SNOTEL snowpack monitoring stations within the TPA: Black Pine, Combination and Peterson Meadows. **Figure B-4** in **Appendix B** shows the locations of the National Oceanographic and Atmospheric Administration (NOAA) and SNOTEL stations, in addition to average annual precipitation. The precipitation data is mapped by Oregon State University's PRISM Group, based on the records from NOAA stations (PRISM Group, 2004). Climate data is provided by the Western Regional Climate Center, operated by the Desert Research Institute of Reno, Nevada.

Table 2-1. Monthly Climate Summary: Drummond

Drummond Aviation, Montana (242500) Period of Record : 6/ 1/1963 to 4/30/2012													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Ave Max Temp (F)	31.8	38.2	47.9	57.8	66.7	74.4	84.7	83.6	72.8	58.9	41.4	31.3	57.5
Ave Min Temp (F)	12.3	15.6	21.8	27.8	34.8	42.0	45.0	43.5	36.3	28.4	20.0	12.2	28.3
Ave Tot. Precip. (in.)	0.85	0.57	0.76	0.99	1.76	2.00	1.10	1.18	1.12	0.82	0.76	0.84	12.75
Ave Snowfall (in.)	8.0	5.3	6.0	3.9	1.8	0.3	0.0	0.1	0.6	1.2	5.4	7.9	40.5
Ave Snow Depth (in.)	3	2	1	0	0	0	0	0	0	0	1	2	1
Drummond FAA Airport, Montana (242511) Period of Record : 11/1/1928 to 5/31/1963													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Ave Max Temp (F)	28.2	34.0	42.1	55.9	64.6	71.1	82.3	80.7	69.4	57.1	40.9	32.8	54.9
Ave Min Temp (F)	5.9	11.1	18.2	26.5	34.1	40.1	43.8	42.0	34.4	26.7	17.5	12.1	26.0
Ave Tot. Precip. (in.)	0.61	0.55	0.67	0.78	1.59	1.87	1.00	0.86	0.91	0.80	0.67	0.58	10.89
Ave Snowfall (in.)	6.7	7.3	5.3	2.2	0.7	0.0	0.0	0.0	0.3	1.4	4.9	5.8	34.7
Ave Snow Depth (in.)	3	4	2	0	0	0	0	0	0	0	1	2	1

Table 2-2. Monthly Climate Summary: Philipsburg

Philipsburg Ranger Station, Montana (246472) Period of Record : 10/13/1955 to 4/30/2012													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Ave Max Temp (F)	33.2	37.4	44.3	53.0	62.2	70.4	80.2	79.8	69.8	58.0	41.9	33.9	55.3
Ave Min Temp (F)	13.6	16.0	20.5	26.3	33.0	39.6	42.6	41.3	34.4	28.1	20.3	14.4	27.5
Ave Tot. Precip. (in.)	0.64	0.47	0.85	1.36	2.26	2.49	1.25	1.51	1.31	1.08	0.72	0.64	14.5
Ave Snowfall (in.)	8.9	5.4	7.2	4.4	1.3	0.0	0.0	0.0	0.2	1.2	5.0	5.6	39.3
Ave Snow Depth (in.)	3	3	1	0	0	0	0	0	0	0	1	2	1
Philipsburg, Montana (246470) Period of Record : 9/16/1903 to 10/12/1955													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Ave Max Temp (F)	30.8	35.2	42.2	53.7	61.6	69.3	80.5	79.2	68.7	57.4	43.5	33.9	54.7
Ave Min Temp (F)	11.7	14.6	19.8	27.0	33.3	39.1	43.8	41.9	35.5	28.9	21.5	15.5	27.7
Ave Tot. Precip. (in.)	0.81	0.78	1.03	1.30	2.15	2.82	1.34	1.03	1.40	1.00	0.81	0.68	15.17
Ave Snowfall (in.)	9.7	9.6	11.4	8.8	5.9	1.5	0.0	0.2	1.2	4.0	8.0	8.2	68.6
Ave Snow Depth (in.)	3	3	1	0	0	0	0	0	0	0	1	2	1

2.1.3 Hydrology

2.1.3.1 Surface Water

Flint Creek drains from Georgetown Lake to the Clark Fork River near Drummond, a distance of approximately 36 miles. Flint Creek hydrography is illustrated on **Figure B-5** in **Appendix B**.

Flint Creek has three significant tributaries: Fred Burr Creek, Boulder Creek and Lower Willow Creek. Fred Burr Creek enters Flint Creek in the Philipsburg Valley, while Boulder and Lower Willow Creeks join Flint Creek in the Drummond Valley. An interbasin diversion to Trout Creek (described below) has significantly increased flow in that tributary, which drains into Flint Creek in the Philipsburg Valley. Flow in Flint Creek can also be augmented by the inter-basin diversion from Silver Lake to Georgetown Lake.

The Silver Lake – Georgetown Lake diversion can be reversed (Kendy and Tresch, 1996). Flow from Silver Lake drains to Warm Springs Creek, which meets the Clark Fork River in the Deer Lodge valley.

One hundred forty five lakes are present in the TPA (Montana Department of Natural Resources and Conservation, 2008). Of these, only 22 are large enough to be named. The largest are reservoirs (described below). The other named lakes are generally tarns present in the higher portions of the Flint Creek range, particularly in the upper Boulder Creek watershed.

Impoundments

Two impoundments are located within the watershed: Georgetown Lake (31,000 acre-feet) and Lower Willow Creek Reservoir (4,800 acre-feet). Georgetown Lake was created for hydroelectric power in 1900 by flooding Georgetown Flat (Montana Department of Environmental Quality, 2009a). A third impoundment, the East Fork Rock Creek Reservoir (16,000 acre-feet), is within the adjacent Rock Creek watershed but stores water for agricultural use within the Flint Creek watershed. Water from this reservoir is diverted to the Flint Creek basin via the Flint Creek Main Canal, built in 1938. This canal drains to Trout Creek, a tributary of Flint Creek (Voeller and Waren, 1997).

Due to concerns that residential development around Georgetown Lake may be making the lake more eutrophic, Stafford (2013) studied the water quality of Georgetown Lake from 2009-2011 and compared recent water quality data to that collected at various times since the 1970s. The results of this study indicated that since the 1970s, total phosphorus concentrations and phytoplankton abundance have declined, blue green algae (which can produce toxins) have become a smaller proportion of the phytoplankton community, and dissolved oxygen concentrations can be very low at the end of winter (Stafford, 2013). The study did not determine the cause(s) of the water quality trends.

Stream Gaging Stations

The United States Geological Survey (USGS) and Department of Natural Resources & Conservation (DNRC) maintain(ed) 11 gauging stations within the watershed (**Table 2-3**). Recent funding limitations have reduced the gauging network in this watershed. The Flint Creek near Drummond station was deactivated in 2004. The Flint Creek at Maxville and Boulder Creek at Maxville stations were converted to seasonal operations in November 2006. The USGS stations are situated on stream, while the DNRC stations are situated on canals and diversions to measure irrigation withdrawals. The USGS gauging stations are shown on **Figure B-5** in **Appendix B**.

Table 2-3. Stream Gages

Name	Number	Drainage Area	Agency	Period of Record
Flint Creek near Southern Cross	12325500	53 miles^2	USGS	1940-
Flint Creek Main Canal below Headgate	76E 02000	—	DNRC	1961-1980, 1982-
Flint Creek Main Canal below County Bridge	76GJ02089	—	DNRC	1961-1980, 1982-
Marshal Canal below Headgate	76GJ04000	—	DNRC	1961-1980, 1982-
Trout Creek below Marshal Canal Diversion	76GJ05000	—	DNRC	1961-1980, 1982-
Fred Burr Creek near Philipsburg	12327100	15.7 miles^2	USGS	1994-1996
Flint Creek at Maxville	12329500	208 miles^2	USGS	1942-
Boulder Creek at Maxville	12330000	71 miles^2	USGS	1940-
Allendale Canal below Headgate	76GJ08000	—	DNRC	1961-
Allendale Canal above Tail End	76GJ08080	—	DNRC	1961-1985, 1987-
Flint Creek near Drummond	12331500	490 miles^2	USGS	1991-2002, 2003-2004

Streamflow

Streamflow data is based on records from the USGS stream gages described above, and is available on the Internet from the USGS (2007). Flows in Flint Creek and its tributaries vary considerably over a calendar year. Hydrographs from stations at Flint Creek near Southern Cross (**Figure B-6**; 2007-2011), Flint Creek at Maxville (**Figure B-7**; 2007-2011), Flint Creek near Drummond (**Figure B-8**; 2007-2011), Fred Burr Creek near Philipsburg (**Figure B-9**; 1994-1996), and Boulder Creek at Maxville (**Figure B-10**; 2007-2011) are attached in **Appendix B**. Due to data gaps as described above, the date ranges for each hydrograph are not identical.

In the tributaries, peak discharges statistically occur in June, with a steadily declining flow to September, and then a slight increase in flow occurring in the fall; after which flows decline again gradually to a low flow condition through much of the winter until spring runoff. These patterns may in part relate to irrigation practices, with the flows declining steadily through summer as water is used to irrigate hayfields, and then, when fall comes the slight increase, or bump, in the hydrograph may illustrate the discontinuing of irrigation and/or irrigation returns at this time.

The hydrographs from Flint Creek exhibit a slightly different pattern, with a decline from peak flow being much more gradual and even plateauing through some summer months. These somewhat unusual extended high flows and prolonged decline of the hydrograph may reflect the dam management of water releases from Georgetown Lake, coupled with the influence of irrigation practices in the valley.

Rodeo Ground Spring, located near Drummond, flows directly into the Clark Fork River. The spring exists due to Flint Creek return flows (Voeller and Waren, 1997).

The Flint Creek near Drummond (12331500) stream gage does not record total basin outflow. Flood irrigation diversions that enter the Clark Fork River as springs or return flow bypass this stream gage. Voeller and Waren (1997) estimated that the total basin outflow was underrepresented by 35 cubic feet per second (cfs) from July 1 through September 30, and by 20 cfs in all other months.

2.1.3.2 Groundwater

Hydrogeology

Two distinct basins comprise the Flint TPA. Groundwater flow within these valleys is typical of intermontane basins. Groundwater flows towards the center of the basin from the head and sides, and then down valley along the central axis.

The hydrogeology of the lower portion of the TPA is described in Kendy and Tresch (1996), in discussion of the Upper Clark Fork River basin. The Montana Department of Natural Resources Conservation (DNRC) completed a study on irrigation return flow in the Flint Creek watershed (Voeller and Waren, 1997). This report describes the geology, hydrogeology and hydrology of the Philipsburg and Drummond valleys in considerable detail.

While the bedrock surrounding the valleys hosts groundwater, Voeller and Waren (1997) studied only the valley aquifers and assumed that the bedrock-sediment interfaces at the valley margins are flow barriers. This is valid for the purposes of their study, and the average groundwater flow velocity in the bedrock is probably several orders of magnitude lower than in the valley fill sediments. However, carbonate and siliciclastic sedimentary rocks in the mountains may have zones of significant permeability. The hydrologic role of the structural geology (faults and folds) is uncertain. Faults may act as flow conduits or flow barriers. No studies of the bedrock hydrogeology were identified.

Natural recharge occurs from infiltration of precipitation, stream loss and flow out of the adjacent bedrock aquifers. Flood irrigation is a major source of recharge to the valley aquifers, particularly on the benches that flank the modern floodplain.

The canyon between the Philipsburg and Drummond Valleys is presumed to act as a groundwater bottleneck. Voeller and Waren (1997) assumed that all water leaving the Philipsburg basin does so as surface water in Flint Creek (and therefore measurable at the Flint Creek at Maxville stream gage). They made no mention of hyporheic water in streambed sediments, which would presumably represent a marginal increase in the total basin discharge.

Groundwater Quality

The Montana Bureau of Mines and Geology (MBMG) Groundwater Information Center (GWIC) program monitors and samples a statewide network of wells (Montana Bureau of Mines and Geology, 2007). Additionally, the GWIC program is engaged in a statewide characterization of aquifers and groundwater resources, by region. The TPA is in Region 5, the Upper Clark Fork River basin.

As of January 2007, the GWIC database reports 1,111 wells within the TPA (Montana Department of Natural Resources and Conservation, 2008). Water quality data is available for 42 of those wells. Of these wells, 24 are in the Philipsburg Valley, and 18 are in the Drummond Valley. The locations of these data points are shown on **Figure B-11** in **Appendix B**.

The water quality data include general physical parameters: temperature, pH and specific conductance, in addition to inorganic chemistry (common ions, metals and trace elements). MBMG does not analyze groundwater samples for organic compounds. Groundwater quality data is available from the GWIC database. Data from groundwater sampling sites within the Flint Creek watershed have also been retrieved and included with the DEQ TMDL development files.

A review of GWIC data reports for agricultural chemical monitoring programs did not yield any data points for Granite County.

There are 15 public water supplies within the TPA. The majority of these are small transient, non-community systems (*i.e.*, that serve a dynamic population of more than 25 persons daily) located around Georgetown Lake. The Town of Philipsburg uses surface water; all other public water supplies in the TPA utilize groundwater. Water quality data is available from these utilities via the Safe Drinking Water Information System (SDWIS) State database (Montana Department of Environmental Quality, 2007), although the data reflect the finished water provided to users, not raw water at the source.

2.1.4 Geology and Soils

Figure B-12 in **Appendix B** provides an overview of the geology, based on the most recent geologic map of the Butte 1° x 2° quadrangle (Lewis, 1998). Description of the geology is derived from more recent, larger-scale mapping projects. The geology of selected areas of the TPA has been described and mapped in detail by Portner and Hendrix (2005) and Lonn et al., (2003). The geology of the Flint Creek area is complex, and has been subjected to considerable reinterpretation in recent years. Much of the recent debate is beyond the scope of this characterization. In summary, recognition of the Anaconda metamorphic core complex (O'Neill et al., 2002), led to the interpretation that the major folds and faults of the Flint Creek Range were produced by extensional and compressional forces.

In general, the Flint TPA encompasses fault-bounded valleys and the bedrock mountains that surround them. At the eastern edge of the Philipsburg Valley, the Philipsburg-Georgetown Thrust defines the eastern edge of a structural unit formerly called the Sapphire Block (no longer considered an intact body), which extends west to the Bitterroot detachment fault (Lonn et al., 2003). This structural unit has also been referred to as the Western Structural Block.

Bedrock

The 'Sapphire Block' includes the John Long Mountains, which separate the Flint Creek and Rock Creek watersheds. Like the Sapphire Mountains, the John Long Mountains are composed of Middle Proterozoic (~1.5 billion years old) Belt Supergroup rocks. These rocks are interpreted as passive margin deposits, and the dominant lithologies are siltstone, sandstone and limestone (and their metamorphic equivalents). Volcanics of Tertiary age are also present, including the Rock Creek volcanic field (in the adjacent watershed), a rhyolitic flow believed to be the source of the eponymous sapphires. These rocks are less resistant than the granitic rocks in surrounding mountain ranges, giving the Sapphire and John Long ranges their subdued topography and lower elevations.

The Flint Creek Range is composed of folded and faulted sedimentary rocks ranging in age from Cambrian (540 million years ago) through Cretaceous (65 million years ago), with overthrusts of Belt Supergroup rocks mapped in places. Cretaceous rocks are the most extensive sedimentary rocks; Portner and Hendrix (2005) report that the Cretaceous section in the northern Flint Creek range is one of the thickest in Montana. The Cretaceous sediments are predominantly fine-grained rocks such as siltstones and shales.

This package of sedimentary rocks has been intruded by several generations of Cretaceous and Tertiary igneous rocks. The range is cored by the Philipsburg pluton, a body of resistant Cretaceous granodiorite that holds up the higher peaks. Metamorphism and hydrothermal activity associated with these rocks produced ores that made Philipsburg a significant silver mining district. Pleistocene glaciation sculpted the Flint Creek range, producing the rugged alpine geomorphology.

Basin Sediments

In the Northern Rockies, the Tertiary is generally characterized as a time of basin filling, followed by renewed uplift, stream erosion and downcutting in the Quaternary. The basins are filled with several thousand feet of Tertiary basin-fill sediments, with a veneer of overlying Quaternary deposits. Stalker and Sherriff (2004) estimate the Tertiary rocks reach a maximum of 4,000 feet thick in the center of the Flint Creek basin (Drummond Valley). Large-scale mapping of the unconsolidated sediments is not available, although cross-sections were prepared by Voeller and Waren (1997). Quaternary sediments include fluvial, colluvial, glacial and proglacial deposits. The lower portion of the Drummond Valley was inundated by Glacial Lake Missoula, and lacustrine sediments are likely.

Voeller and Waren (1997) reported that the upper several hundred feet of basin sediments are dominated by shale and clay. Coarse-grained sediments are limited, generally occurring as alluvium or gravel caps on benches.

The benches above the modern alluvial valley are generally capped by a coarsening-upward sequence of 15-20 feet of sandy or gravelly sediment. In their review of well logs across the watershed, Voeller and Waren (1997) identified a common sequence of shale at depth, commonly overlain by up to 100 feet of clay, with silty sand, gravel and cobble deposits at the surface. A bouldery debris-flow deposit (Beaty,

1961) just north of the [Boulder Creek] canyon mouth is up to 50 feet thick, and hosts a gravel pit (Voeller and Waren, 1997).

Glacial History

The glacial history of the watershed is presumably similar to that of the rest of the Central and Northern Rockies, although no detailed studies were identified. While evidence of earlier glaciations (before 150,000 years ago) is not well-preserved, there is widespread evidence for two recent episodes of significant glacial activity. The earlier (Bull Lake) is generally dated to ~130,000 years ago, and the later (Pinedale) to 23,000 – 16,000 years ago (Pierce et al., 1976; Chadwick et al., 1997). The dates are general; alpine glacial activity varied somewhat according to elevation and other local variables. Each period of glaciation included multiple advances and retreats.

In the absence of detailed Quaternary mapping, discussion of the glacial history is based on aerial photograph interpretation. Bull Lake -aged features are subdued and indistinct, due to their long exposure to weathering. Pinedale -aged features are much easier to identify. The Fred Burr drainage displays distinctive glacial morphology. The valley is a classic U-shaped glacial trough, and a prominent terminal moraine is present just beyond the valley's mouth. A broad sheet of glacial outwash extends northwestward towards Flint Creek. Fred Burr Creek has incised this deposit.

The Fred Burr glacier is the only valley glacier that extended to the basin floor, and this is the only moraine mapped in the TPA by Alden (1953). The Boulder Creek valley and several of its tributaries were also glaciated, but the (Pinedale-aged) glacier terminated near Princeton Gulch, and did not reach the Drummond Valley. Beaty (1961) reports "stranded lateral moraines from an earlier glaciation" along the walls of the canyon as far as its mouth, but notes that the canyon morphology is inconsistent with recent glaciation.

Soils

The USGS Water Resources Division (Schwarz and Alexander, 1995) created a dataset of hydrology-relevant soil attributes, based on the USDA Natural Resources Conservation Service (NRCS) STATSGO soil database. The STATSGO data is intended for small-scale (watershed or larger) mapping, and is too general to be used at scales larger than 1:250,000. It is important to realize, therefore, that each soil unit in the STATSGO data may include up to 21 soil components. Soil analysis at a larger scale should use NRCS Soil Survey Geographic database (SSURGO) data. The soil attributes considered in this characterization are erodibility and slope.

Soil erodibility is based on the Universal Soil Loss Equation K-factor (Wischmeier and Smith, 1978). K-factor values range from 0 to 1, with a greater value corresponding to greater potential for erosion. Susceptibility to erosion is mapped on **Figure B-13** (**Appendix B**), with soil units assigned to the following ranges: low (0.0-0.2), moderate-low (0.2-0.29) and moderate-high (0.3-0.4). Values of >0.4 are considered highly susceptible to erosion. No values greater than 0.4 are mapped in the TPA.

Several patterns are apparent in the distribution of mapped K-factors. The low and moderate-to-low susceptibility soils correspond to timbered uplands, and moderate-to-high susceptibility soils are confined to the valleys. Moderate-to-high susceptibility soils coincide with areas where Tertiary sediments are mapped, and the Quaternary alluvial valleys incised into these deposits generally have moderate-to-low susceptibility. The majority of the low-susceptibility soils coincide with the granitic rocks of the Philipsburg pluton. A smaller area of low K-factor soils occurs in a band at the southwestern margin of the Drummond Valley, against the foot of the John Long Mountains. The geology of this area is mapped as Tertiary sediments (**Figure B-13, Appendix B**). These may correspond to gravelly fanglomerate deposits; available geologic maps are of insufficient resolution to differentiate these deposits from the other Tertiary deposits.

The majority of the soil units within the watershed are mapped with slopes ranging from 21°-34°. The alluvium alongside Flint Creek in the Philipsburg valley has a slope of 1.2°. Much of the Drummond Valley (corresponding to the gravel benches) has slopes of 1.2°-21°.

A map of soil slope is provided in **Figure B-14** (**Appendix B**).

2.2 ECOLOGICAL PROFILE

The following information describes the ecological profile of the Flint Creek watershed.

2.2.1 Vegetation

The primary cover in the uplands is conifer forest. Conifers are dominated by Lodgepole pine, giving way to Douglas fir at lower elevations. The valleys are characterized by grassland and irrigated agricultural land, with minor shrublands. Landcover is shown in **Figures B-15** and **B-16** in **Appendix B**. Data sources include the University of Montana's Satellite Imagery land Cover project (University of Montana, 2002), and USGS National Land Cover Dataset (NLCD) mapping (Montana State Library, 1992).

2.2.2 Aquatic Life

Native fish species present in the TPA include: bull trout, westslope cutthroat trout, mountain whitefish, largescale sucker and longnose sucker. Native redside shiner are present in Georgetown and Echo lakes. Bull trout and westslope cutthroat trout are designated "Species of Concern" by Montana Department of Fish, Wildlife & Parks (FWP). Bull trout are further listed as "threatened" by the US Fish and Wildlife Service. Reaches of the Flint Creek watershed have been designated as critical habitat for bull trout (U.S. Office of the Federal Register, 2013).

As mapped by FWP, bull trout and western cutthroat trout inhabit different portions of the Flint Creek watershed. Bull trout are mapped along the full length of Flint Creek, and in its tributaries of Marshall Creek and Boulder Creek. A small (0.05 mile) length of Fred Burr Creek is mapped with bull trout. Bull trout are not mapped in any tributaries of Boulder Creek. Bull trout are not present in Lower Willow Creek or its tributaries. Westslope cutthroat trout are not present in Flint Creek, but are mapped in its tributary drainages, and in the tributaries of Lower Willow Creek and Boulder Creek.

Introduced species are also present, including: brook, rainbow and brown trout, and kokanee salmon. Additionally, Yellowstone cutthroat trout are reported in Middle Altoona and Lower Boulder Lakes, outside of their native range.

Data on fish species distribution is collected, maintained and provided by Montana Department of Fish, Wildlife and Parks (2011). Fish species distribution is shown on **Figure B-17** (**Appendix B**) and tabulated in **Table C-1** (**Appendix C**).

2.2.3 Fires

One significant burn is mapped within the TPA (University of Montana, 2002), stretching from South Fork Lower Willow Creek to Smart Creek (**Figure B-18**, **Appendix B**). Aerial photographs taken in July

2005 reveal that vegetation is returning to this area. Abundant roads suggest that this area experienced a timber harvest either pre- or post-fire.

The United States Forest Service (USFS) remote sensing applications center provides data on fire locations from 2001 to the present (**Figure B-18**, **Appendix B**). No fires from 2001 or 2002 are mapped within the TPA (U.S. Forest Service, 2008). Isolated fires are mapped from 2003 to 2006, mostly on the western flanks of the Flint Creek range. These are difficult to identify as burned areas on aerial photographs. In general, the TPA has not experienced significant burns in recent years.

2.3 SOCIAL PROFILE

The following information describes the social profile of the Flint Creek watershed.

2.3.1 Population

An estimated 1,951 persons lived within the Flint TPA in 2000. This is an increase of 16% from an estimated 1,682 in 1990. Population estimates are derived from census data (United States Census Bureau, 2000), with spatial analysis of census blocks performed by NRIS' thematic mapper (Montana Department of Natural Resources and Conservation, 2008). The denser populations are located along Montana Highway 1, which links Georgetown Lake with the towns of Philipsburg, Maxville, Hall and Drummond.

2.3.2 Transportation Networks

Roads

The principal transportation route in the TPA is Montana Highway 1. Highway 1 connects Anaconda to Drummond, via Georgetown Lake and Philipsburg. An estimated 613 miles of paved roadways were present in 2000 (Montana Department of Natural Resources and Conservation, 2008). The network of unpaved roads on public and private lands will be further characterized as part of the source assessment.

Railroads

No active railways are present in the TPA. Montana Rail Link maintains 32 miles of railroad rights-of-way in the TPA (Montana Department of Natural Resources and Conservation, 2008). During the peak years of mining and milling, a rail line connected Philipsburg to Drummond, with a spur extending up Douglas Creek.

2.3.3 Land Ownership

Slightly more than one-half of the Flint TPA is under private ownership. The dominant landholder is the USFS, which administers 42.5% of the TPA (**Table 2-4**). There is a distinct pattern of ownership, with private land concentrated in the basins and USFS land concentrated in the uplands (**Figure B-19**, **Appendix B**).

Table 2-4. Land Ownership

Owner	Acres	Square Miles	% of Total
Private	165,387	258.4	51.9%
US Forest Service	135,334	211.5	42.5%
US Bureau of Land Management	8,538	13.3	2.7%
State Trust Land	5,764	9.0	1.8%

Table 2-4. Land Ownership

Owner	Acres	Square Miles	% of Total
Other State Land	333	0.5	0.1%
Water	3,180	5.0	1.0%
Total	318,537	497.7	—

2.3.4 Land Use

Land use within the Flint TPA is dominated by forest and agriculture. Agriculture in the valley is primarily related to the cattle industry: irrigated hay and dry grazing (**Table 2-5**). Information on land use is based on the National Land Cover Dataset (NLCD), from mapping completed by the USGS circa 1992. Land use categories are based on a combination of observed existing land use and existing land cover vegetation analysis. The data is at 1:250,000 scale. Census trends from 1990 to 2000 (described above) suggest that the percentage of residential use has probably increased, but aerial photographs from 2005 show that the watershed is still relatively sparsely populated. Agricultural land use is illustrated in **Figure B-20** (**Appendix B**).

Table 2-5. Land Use

Land Use	Acres	Square Miles	% of Total
Evergreen Forest	170,033	265.7	53.4%
Mixed Rangeland	72,183	112.8	22.7%
Crop/Pasture	38,119	59.6	12.0%
Brush Rangeland	14,125	22.1	4.4%
Grass Rangeland	7,500	11.7	2.4%
Deciduous Forest	5,748	9.0	1.8%
Exposed Rock	3,832	6.0	1.2%
Reservoir	2,816	4.4	0.88%
Mixed Forest	1,836	2.9	0.58%
Residential	743	1.2	0.23%
Mine/Quarry	657	1.0	0.21%
Lake	229	0.4	0.072%
Wetland (Existing Woody and/or Emergent Herbaceous Wetland Vegetation)	142	0.2	0.045%
Mixed Urban	128	0.2	0.040%
Transportation/Utilities	93	0.1	0.029%
Other Urban	63	0.1	0.020%
Other Agriculture	54	0.1	0.017%
Commercial	51	0.1	0.016%

Information on agricultural land use can be obtained from Department of Revenue data. Nearly 16,000 acres of irrigated land is reported in the TPA. Voeller and Waren (1997) found that a detailed survey of irrigated acreage in a 1959 report prepared by the State Engineer's Office (now DNRC) was still relevant in the mid-1990s. According to this data, 8,200 acres are irrigated in the Philipsburg Valley, and 17,000 acres in the Drummond Valley. Despite the age of the data, these numbers are probably more realistic than the Department of Revenue data, which assigns an agricultural use only if more than 50% of a given parcel is so used. Irrigation infrastructure includes interbasin diversions and impoundments as described above in **Section 2.1.3**.

Mining

The Flint TPA was the scene of considerable mining activity. Like many other mining districts, much of the metal production began with gold placers. Lode mines, particularly silver, and eventually tungsten, manganese and phosphate, came to be of particular importance. The Philipsburg district was a major silver producer, and the hills east of Philipsburg exhibit the highest density of abandoned mine sites (Montana Department of Environmental Quality, 2007). MBMG completed an environmental survey of 119 abandoned mining sites in the Flint Creek and Rock Creek watersheds in the mid-1990s (Marvin et al., 1995). The study was limited to sites on Deer Lodge National Forest property.

Milling was performed at many locations within the TPA, both in Philipsburg and at many of the now abandoned mining camps. Waste rock and tailings are still present in many locations. No active mines are present as of early 2007, according to DEQ Environmental Management Bureau files.

Livestock Operations

The Montana Pollution Discharge Elimination System (MPDES) does not include any regulated concentrated animal feeding operations (CAFOs) within the Flint Creek watershed. From interpretation of aerial photographs, DEQ identified 12 denuded areas that are potential livestock operations. Four of these locations are directly adjacent to surface waterbodies.

Wastewater

One municipal wastewater system is located within the TPA. The town of Philipsburg is sewered, and the wastewater lagoons are located northwest of town, adjacent to Flint Creek. The discharge location is shown in **Figure B-21** (**Appendix B**).

Septic system density is estimated from the 2000 census block data, based on the assumption that one septic tank and drainfield is installed for each 2.5 persons (Montana Department of Natural Resources and Conservation, 2008). Septic system density is classified as low (<50 per square mile), moderate (51-300 per square mile) or high (>300 per square mile). Nearly all of the TPA is mapped as low septic system density, with very limited areas of moderate (347 acres) and high (2 acres) density. The moderate density locations are found primarily around Georgetown Lake, outside Philipsburg, and in and around Maxville. The high density areas are limited to two ~1 acre areas south and east of Georgetown Lake. Septic system density is illustrated in **Figure B-21** (**Appendix B**).

3.0 MONTANA WATER QUALITY STANDARDS

The federal Clean Water Act provides for the restoration and maintenance of the chemical, physical, and biological integrity of the nation's surface waters so that they support all designated uses. Water quality standards are used to determine impairment, establish water quality targets, and to formulate the TMDLs and allocations.

Montana’s water quality standards and water quality standards in general include three main parts:
1. Stream classifications and designated uses
2. Numeric and narrative water quality criteria designed to protect designated uses
3. Nondegradation provisions for existing high-quality waters

Montana’s water quality standards also incorporate prohibitions against water quality degradation as well as point source permitting and other water quality protection requirements.

Nondegradation provisions are not applicable to the total maximum daily loads (TMDL) developed within this document because of the impaired nature of the streams addressed. Those water quality standards that apply to this document are reviewed briefly below. More detailed descriptions of Montana’s water quality standards may be found in the Montana Water Quality Act (75-5-301,302 MCA), and Montana’s Surface Water Quality Standards and Procedures (ARM 17.30.601-670).

3.1 STREAM CLASSIFICATIONS AND DESIGNATED BENEFICIAL USES

Waterbodies are classified based on their designated uses. All Montana waters are classified for multiple uses. All of the nutrients impaired streams within the Flint watershed are classified as B-1. Waters classified as B-1 are to be maintained suitable for:
- Drinking, culinary, and food processing purposes, after conventional treatment
- Bathing, swimming, and recreation
- Growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers
- Agriculture and industrial water supply

While some of the waterbodies might not actually be used for a designated use (e.g., drinking water supply), their water quality still must be maintained suitable for that designated use. More detailed descriptions of Montana’s surface water classifications and designated uses are provided in **Appendix D**. DEQ’s water quality assessment method for nutrients is designed to evaluate the most sensitive use for that pollutant group, thus ensuring protection of all designated uses (Suplee and Sada de Suplee, 2011). For streams in Western Montana, the most sensitive uses assessed for nutrients are aquatic life and primary contact recreation. DEQ determined that six waterbody segments in the Flint TMDL Planning Area (TPA) do not meet the nutrients water quality standards (**Table 3-1**).

Table 3-1. Impaired Waterbodies and their Impaired Designated Uses in the Flint Total Maximum Daily Load Planning Area with Completed Nutrients TMDLs Contained in this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause*	Impaired Use(s)
Barnes Creek, from headwaters to mouth (Flint Creek)	MT76E003_070	TN, Nitrate, TP	Aquatic Life Primary Contact Recreation
Douglas Creek, confluence of Middle and South forks to mouth (Flint Creek), T9N R13W S10	MT76E003_020	Nitrate, TP	Aquatic Life Primary Contact Recreation
Flint Creek, Georgetown Lake to confluence with Boulder Creek	MT76E003_011	TP	Aquatic Life Primary Contact Recreation
Flint Creek, Boulder Creek to mouth (Clark Fork River)	MT76E003_012	TN, TP	Aquatic Life Primary Contact Recreation
Princeton Gulch, headwaters to mouth (Boulder Creek)	MT76E003_090	Nitrate	Aquatic Life Primary Contact Recreation
Smart Creek, headwaters to mouth (Flint Creek), T9N R13W S21	MT76E003_110	TN, TP	Aquatic Life Primary Contact Recreation

* Only includes those pollutant impairments addressed by TMDLs in this document; TN = Total Nitrogen, TP = Total Phosphorus, Nitrate = Nitrates = Nitrogen, Nitrate = NO_2+NO_3 = Nitrite + Nitrate; The term “nitrate” is used throughout the document and refers to any of the various nitrate-related impairment causes listed in the “2012 Water Quality Integrated Report.”

3.2 NUMERIC AND NARRATIVE WATER QUALITY STANDARDS

In addition to the use classifications described above, Montana’s water quality standards include numeric and narrative criteria that protect the designated uses. Numeric criteria define the allowable concentrations, frequency, and duration of specific pollutants so as not to impair designated uses.

Narrative standards are developed when there is insufficient information to develop specific numeric standards and/or the natural variability makes it impractical to develop numeric standards. Narrative standards describe the allowable or desired condition. This condition is often defined as the allowable increase above “naturally occurring.” DEQ often uses the naturally occurring condition, called a “reference condition,” to help determine whether or not narrative standards are being met (see **Appendix D**). Although narrative standards currently apply to nutrients in the Flint TPA, DEQ is pursuing numeric standards for nutrients (e.g., total nitrogen and total phosphorus) throughout the state (see **Appendix D**).

4.0 DEFINING TOTAL MAXIMUM DAILY LOADS (TMDLS) AND THEIR COMPONENTS

A total maximum daily load (TMDL) is a tool for implementing water quality standards and is based on the relationship between pollutant sources and water quality conditions. More specifically, a TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive from all sources and still meet water quality standards.

Pollutant sources are generally defined as two categories: point sources and nonpoint sources. Point sources are discernible, confined and discrete conveyances, such as pipes, ditches, wells, containers, or concentrated animal feeding operations, from which pollutants are being, or may be, discharged. Some sources such as return flows from irrigated agriculture are not included in this definition. All other pollutant loading sources are considered nonpoint sources. Nonpoint sources are diffuse and are typically associated with runoff, streambank erosion, most agricultural activities, atmospheric deposition, and groundwater seepage. Natural background loading is a type of nonpoint source.

As part of TMDL development, the allowable load is divided among all significant contributing point and nonpoint sources. For point sources, the allocated loads are called “wasteload allocations” (WLAs). For nonpoint sources, the allocated loads are called “load allocations” (LAs).

A TMDL is expressed by the equation: $TMDL = \Sigma WLA + \Sigma LA$, where:

ΣWLA is the sum of the wasteload allocation(s) (point sources)
ΣLA is the sum of the load allocation(s) (nonpoint sources)

TMDL development must include a margin of safety (MOS), which can be explicitly incorporated into the above equation. Alternatively, the MOS can be implicit in the TMDL. A TMDL must also ensure that the waterbody will be able to meet and maintain water quality standards for all applicable seasonal variations (e.g., pollutant loading or use protection).

Development of each TMDL has four major components:

- Determining water quality targets
- Quantifying pollutant sources
- Establishing the total allowable pollutant load
- Allocating the total allowable pollutant load to their sources

Although the way a TMDL is expressed can vary by pollutant, these four components are common to all TMDLs, regardless of pollutant. Each component is described in further detail in the following subsections.

Figure 4-1 illustrates how numerous sources contribute to the existing load and how the TMDL is defined. The existing load can be compared to the allowable load to determine the amount of pollutant reduction needed.

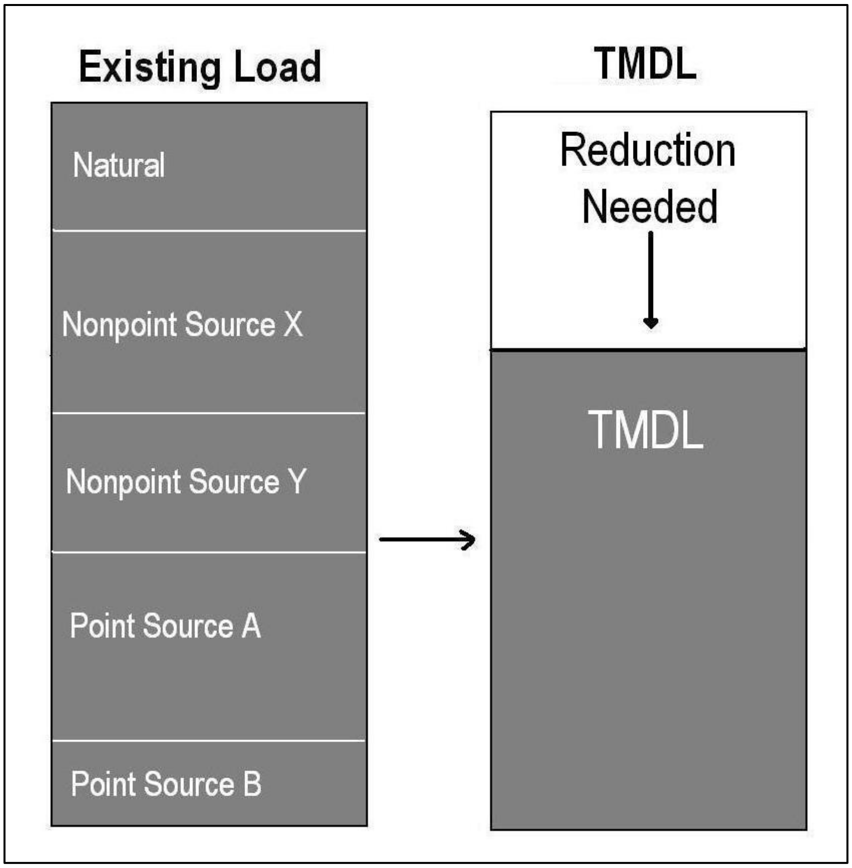

Figure 4-1. Schematic Example of Total Maximum Daily Load Development

4.1 DEVELOPING WATER QUALITY TARGETS

TMDL water quality targets are a translation of the applicable numeric or narrative water quality standard(s) for each pollutant. For pollutants with established numeric water quality standards, the numeric value(s) are used as the TMDL targets. For pollutants with narrative water quality standard(s), the targets provide a waterbody-specific interpretation of the narrative standard(s).

Water quality targets are typically developed for multiple parameters that link directly to the impaired beneficial use(s) and applicable water quality standard(s). Therefore, the targets provide a benchmark by which to evaluate attainment of water quality standards. Furthermore, comparing existing stream conditions to target values allows for a better understanding of the extent and severity of the problem.

4.2 QUANTIFYING POLLUTANT SOURCES

All significant pollutant sources, including natural background loading, are quantified so that the relative pollutant contributions can be determined. Because the effects of pollutants on water quality can vary throughout the year, assessing pollutant sources must include an evaluation of the seasonal variability of the pollutant loading. The source assessment helps to define the extent of the problem by linking the pollutant load to specific sources in the watershed.

A pollutant load is usually quantified for each point source permitted under the Montana Pollutant Discharge Elimination System (MPDES) program. Nonpoint sources are quantified by source categories (e.g., septic) and/or by land uses (e.g., crop production or forestry). These source categories and land uses can be divided further by ownership, such as federal, state, or private. Alternatively, most, or all, pollutant sources in a sub-watershed or source area can be combined for quantification purposes.

Because all potentially significant sources of the water quality problems must be evaluated, source assessments are conducted on a watershed scale. The source quantification approach may produce reasonably accurate estimates or gross allotments, depending on the data available and the techniques used for predicting the loading (40 CFR Section 130.2(I)). Montana TMDL development often includes a combination of approaches, depending on the level of desired certainty for setting allocations and guiding implementation activities.

4.3 ESTABLISHING THE TOTAL ALLOWABLE LOAD

Identifying the TMDL requires a determination of the total allowable load over the appropriate time period necessary to comply with the applicable water quality standard(s). Although “TMDL” implies “daily load,” determining a daily loading may not be consistent with the applicable water quality standard(s), or may not be practical from a water quality management perspective. Therefore, the TMDL will ultimately be defined as the total allowable loading during a time period that is appropriate for applying the water quality standard(s) and which is consistent with established approaches to properly characterize, quantify, and manage pollutant sources in a given watershed. For example, sediment TMDLs may be expressed as an allowable annual load.

If a stream is impaired by a pollutant for which numeric water quality criteria exist, the TMDL, or allowable load, is typically calculated as a function of streamflow and the numeric criteria. This same approach can be applied when a numeric target is developed to interpret a narrative standard.

Some narrative standards, such as those for sediment, often have a suite of targets. In many of these situations it is difficult to link the desired target values to highly variable, and often episodic, instream loading conditions. In such cases the TMDL is often expressed as a percent reduction in total loading based on source quantification results and an evaluation of load reduction potential (**Figure 4-1**). The degree by which existing conditions exceed desired target values can also be used to justify a percent reduction value for a TMDL.

Even if the TMDL is preferably expressed using a time period other than daily, an allowable daily loading rate will also be calculated to meet specific requirements of the federal Clean Water Act. Where this occurs, TMDL implementation and the development of allocations will still be based on the preferred time period, as noted above.

4.4 DETERMINING POLLUTANT ALLOCATIONS

Once the allowable load (the TMDL) is determined, that total must be divided among the contributing sources. The allocations are often determined by quantifying feasible and achievable load reductions through application of a variety of best management practices and other reasonable conservation practices.

Under the current regulatory framework (40 CFR 130.2) for developing TMDLs, flexibility is allowed in allocations in that “TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure.” Allocations are typically expressed as a number, a percent reduction (from the current load), or as a surrogate measure (e.g., a percent increase in canopy density for temperature TMDLs).

Figure 4-2 illustrates how TMDLs are allocated to different sources using WLAs for point sources and LAs for natural and nonpoint sources. Although some flexibility in allocations is possible, the sum of all allocations must meet the water quality standards in all segments of the waterbody.

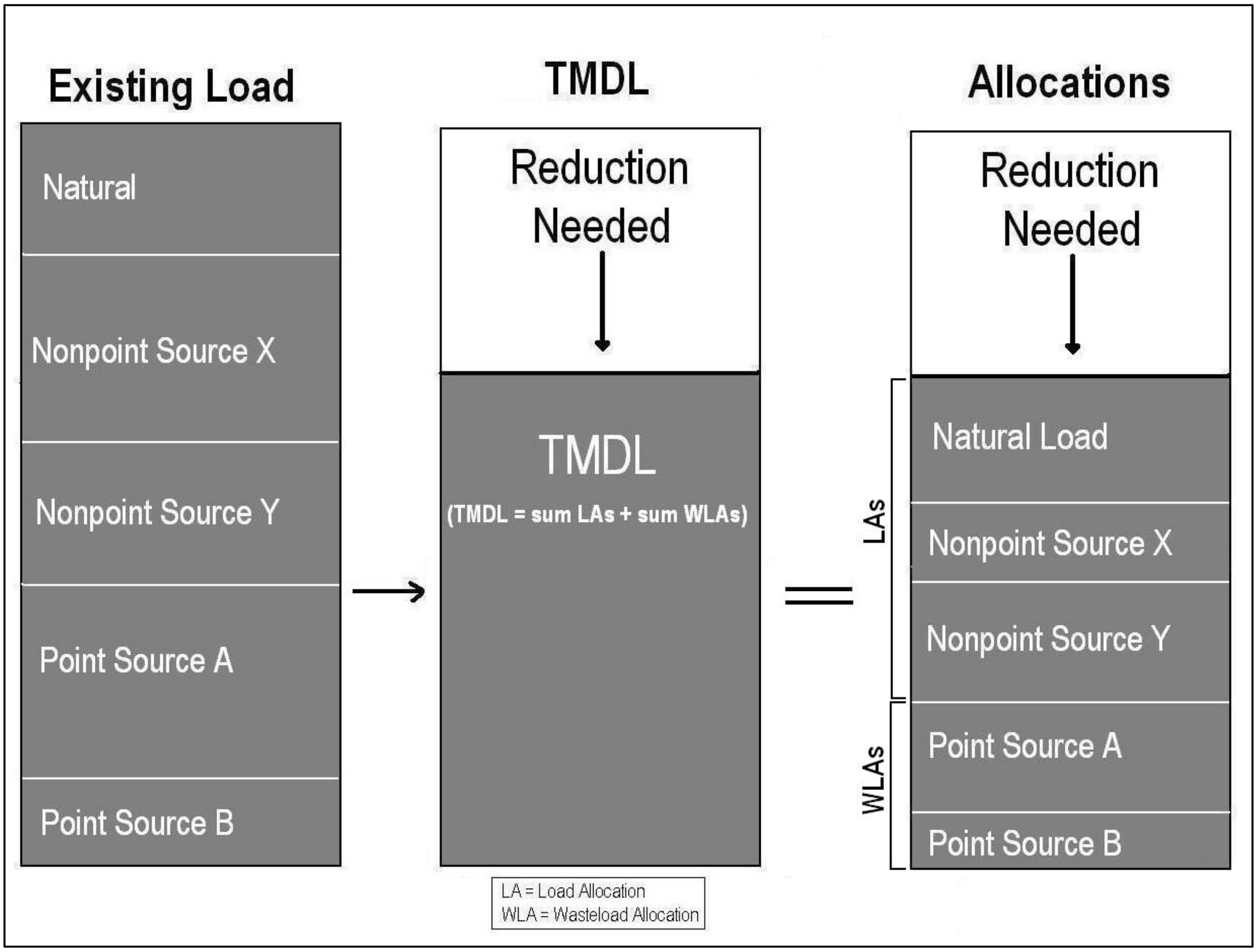

Figure 4-2. Schematic Diagram of a Total Maximum Daily Load and its Allocations

TMDLs must also incorporate a margin of safety. The margin of safety accounts for the uncertainty, or any lack of knowledge, about the relationship between the pollutant loads and the quality of the receiving waterbody. The margin of safety may be applied implicitly by using conservative assumptions in the TMDL development process, or explicitly by setting aside a portion of the allowable loading (i.e., a TMDL = WLA + LA + MOS) (U.S. Environmental Protection Agency, 1999). The margin of safety is a required component to help ensure that water quality standards will be met when all allocations are achieved. In Montana, TMDLs typically incorporate implicit margins of safety.

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions. For TMDLs in this document where there is a combination of nonpoint sources and one or more permitted point sources discharging into an impaired stream reach, the permitted point source WLAs are not dependent on implementation of the LAs. Instead, Department of Environmental Quality (DEQ) sets the WLAs and LAs at levels necessary to achieve water quality standards throughout the watershed. Under these conditions, the LAs are developed independently of the permitted point source WLA such that they would satisfy the TMDL target concentration within the stream reach immediately above the point source. In order to ensure that the water quality standard or target concentration is achieved below the point source discharge, the WLA is based on the point source's discharge concentration set equal to the standard or target concentration for each pollutant.

4.5 IMPLEMENTING TOTAL MAXIMUM DAILY LOAD (TMDL) ALLOCATIONS

The Clean Water Act (CWA) and Montana state law (Section 75-5-703 of the Montana Water Quality Act) require wasteload allocations to be incorporated into appropriate discharge permits, thereby providing a regulatory mechanism to achieve load reductions from point sources. Nonpoint source reductions linked to load allocations are not required by the CWA or Montana statute, and are primarily implemented through voluntary measures. This document contains several key components to assist stakeholders in implementing nonpoint source controls. **Section 7.0** discusses a restoration and implementation strategy by pollutant group and source category, and provides recommended best management practices (BMPs) per source category (e.g., grazing, cropland, urban, etc.). **Section 7.5** discusses potential funding sources that stakeholders can use to implement BMPs for nonpoint sources. Other site-specific pollutant sources are discussed throughout the document, and can be used to target implementation activities. DEQ's Watershed Protection Section helps to coordinate nonpoint implementation throughout the state and provides resources to stakeholders to assist in nonpoint source BMPs. Montana's Nonpoint Source Management Plan (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b; available at http://www.deq.mt.gov/wqinfo/nonpoint/NonpointSourceProgram.mcpx) further discusses nonpoint source implementation strategies at the state level.

DEQ uses an adaptive management approach to implementing TMDLs to ensure that water quality standards are met over time (outlined in **Section 8.1**). This includes a monitoring strategy and an implementation review that is required by Montana statute (see **Section 8.2**). TMDLs may be refined as new data become available, land uses change, or as new sources are identified.

5.0 NUTRIENTS TOTAL MAXIMUM DAILY LOAD (TMDL) COMPONENTS

This section focuses on nutrients (nitrate, total nitrogen (TN) and total phosphorus (TP) forms) as a cause of water quality impairment in the Flint Total Maximum Daily Load Planning Area (TPA). It includes 1) nutrient impairment of beneficial uses; 2) specific stream segments of concern; 3) currently available data on nutrient impairment assessment in the watershed, including target development and a comparison of existing water quality targets; 4) quantification of nutrient sources based on recent studies; and 5) identification and justification for nutrient total maximum daily loads (TMDLs) and TMDL allocations.

5.1 EFFECTS OF EXCESS NUTRIENTS ON BENEFICIAL USES

Nitrate, TN, and TP are natural background chemical elements required for the healthy and stable functioning of aquatic ecosystems. Streams in particular are dynamic systems that depend on a balance of nutrients, which is affected by nutrient additions, consumption by autotrophic organisms, cycling of biologically fixed nitrogen and phosphorus into higher trophic levels, and cycling of organically fixed nutrients into inorganic forms with biological decomposition. Additions from natural landscape erosion, groundwater discharge, and instream biological decomposition maintain a balance between organic and inorganic nutrient forms. Human influences may alter nutrient cycling pathways, causing damage to biological stream function and water quality degradation.

Excess nitrogen in the form of dissolved ammonia (which is typically associated with human sources) can be toxic to aquatic life. Elevated nitrates in drinking water can inhibit normal hemoglobin function in infants. Besides the direct effects of excess nitrogen, elevated inputs of nitrogen and phosphorus from human sources can accelerate aquatic algal growth to nuisance levels. Respiration and decomposition of excessive algal biomass depletes dissolved oxygen, which can kill fish and other forms of aquatic life. Nutrient concentrations in surface water can lead to blue-green algae blooms (Priscu, 1987), which can produce toxins lethal to aquatic life, wildlife, livestock, and humans.

Aside from toxicity, nuisance algae can shift the macroinvertebrate community structure, which also may affect fish that feed on macroinvertebrates (U.S. Environmental Protection Agency, 2010). Additionally, changes in water clarity, fish community structure, and aesthetics can harm recreational uses, such as fishing, swimming, and boating (Suplee et al., 2009). Nuisance algae can increase treatment costs of drinking water or pose health risks if ingested in drinking water (World Health Organization, 2003).

5.2 STREAM SEGMENTS OF CONCERN

There are five waterbody segments in the Flint Total Maximum Daily Load Planning Area (TPA) that are present on the 2012 Montana 303(d) List for phosphorus and/or nitrogen impairments. These impairments occur on Barnes Creek, Douglas Creek, Flint Creek (Boulder Creek to mouth), Princeton Gulch, and Smart Creek (**Table 5-1**). Although Flint Creek (Georgetown Lake to confluence with Boulder Creek) is not on the 2012 Montana 303(d) List, the Montana Department of Environmental Quality (DEQ) has concluded that it is impaired for TP. This change in impairment status is the result of the assessment process and will be updated on the 2014 Montana 303(d) List.

Table 5-1. Waterbody Segments in the Flint Total Maximum Daily Load Planning Area with Nutrient Probable Causes on the 2012 303(d) List

Stream Segment	Waterbody ID
BARNES CREEK, headwaters to mouth	MT76E003_070
DOUGLAS CREEK, confluence of Middle and South forks to mouth	MT76E003_020
FLINT CREEK, Georgetown Lake to confluence with Boulder Creek	MT76E003_011
FLINT CREEK, Boulder Creek to mouth	MT76E003_012
PRINCETON GULCH, headwaters to mouth	MT76E003_090
SMART CREEK, headwaters to mouth	MT76E003_110

5.3 INFORMATION SOURCES AND ASSESSMENT METHODS

To assess nutrient conditions for TMDL development, DEQ compiled nutrient data and undertook additional monitoring. The following data sources represent the primary information used to characterize water quality.

1) **DEQ TMDL Sampling:** DEQ conducted water quality sampling from 2002 through 2012 to update impairment determinations and assist with the development of nutrient TMDLs. Most of the data was collected during 2008 and 2009. All waterbody segments were sampled over a minimum of three years.

Sample locations were generally such that they provided a comprehensive upstream to downstream view of nutrient levels (**Figure 5-1**). The location of sample collection also allowed for analysis of potential source impacts (e.g., mine presence, changes in land use, septic influence). All data used in TMDL development was collected during the summer growing season for algae in the Middle Rockies Level III Ecoregion (July 1 – September 30). Benthic algae samples were collected from 2007 through 2009. Each stream segment had at least four samples collected. These samples were analyzed for chlorophyll-*a* concentration. Macroinvertebrate samples were collected from Barnes Creek and Smart Creek between 2004 and 2011. Ash free dry mass (AFDM) is a measurement that captures both living and dead algal biomass and is particularly helpful for streams where some or all of the algae are dead (because chlorophyll-*a* measures only living algae). AFDM was not measured for this project but will be used in the future as an indicator of waterbody health in the Flint TPA.

2) **DEQ Assessment Files:** These files contain information used to make the existing nutrient impairment determinations.

Growing season nutrient data used for impairment assessment purposes and TMDL development are included in **Appendix C**. Other nutrient data from the watershed is publicly available through the Environmental Protection Agency’s (EPA) EPA STOrage and RETrieval database (STORET) and DEQ’s EQuIS water quality databases.

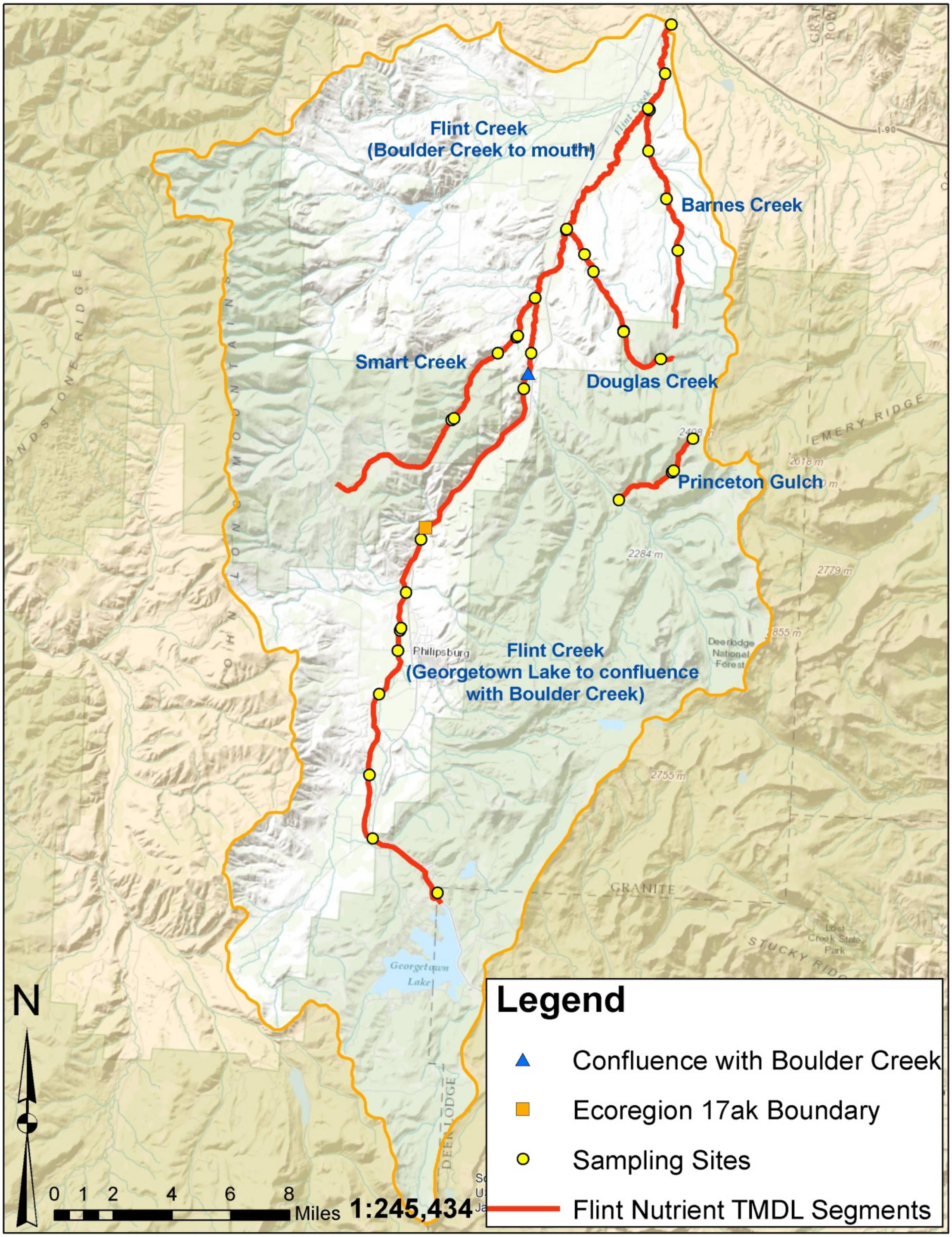

Figure 5-1. Nutrient Impaired Streams in the Flint Total Maximum Daily Load Planning Area and Associated Sampling Locations

The confluence of Flint Creek with Boulder Creek and the ecoregion 17ak boundary are shown for reference.

Additional sources of information used to develop TMDL components (**Section 4.0**) include the following:
- Streamflow data
- Geographic Information System (GIS) data layers
- Outside agency and university websites and documentation
- Land-use information

The above information and water quality data are used to compare existing conditions to waterbody restoration goals (targets), to assess nutrient pollutant sources, and to help determine TMDL allocations. Field data sheets were reviewed to rule out irregularities in collection methods or sample quality assurance/quality control. Laboratory methods and quality assurance/quality control criteria were also reviewed to ensure these values were accurate. There was no indication that any results were anomalous.

5.4 WATER QUALITY TARGETS

TMDL water quality targets are numeric indicator values used to evaluate whether water quality standards have been met. These are discussed further in **Section 4.0**. This section presents nutrient water quality targets and compares them with recently collected nutrient data in the Flint TPA following DEQ's assessment methodology (Suplee and Sada de Suplee, 2011). To be consistent with DEQ's assessment methodology, and because of improvements in analytical methods, only data from the past 10 years are included in the review of existing data.

5.4.1 Nutrient Water Quality Standards

Montana's water quality standards for nutrients (nitrogen and phosphorous) are narrative and are addressed via narrative criteria. Narrative criteria require state surface waters to be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will: 1) produce conditions that create concentrations or combinations of material toxic or harmful to aquatic life, and 2) create conditions that produce undesirable aquatic life (ARM 17.30.637 (1) (d-e)). DEQ is currently developing numeric nutrient criteria for TN and TP that will be established at levels consistent with narrative criteria requirements. These draft numeric criteria are the basis for the nutrient TMDL targets and are consistent with EPA's guidance on TMDL development and federal regulations.

5.4.2 Nutrient Target Values

Nutrient water quality targets include nutrient concentrations in surface waters and measures of benthic algae (a form of aquatic life that at elevated concentrations is undesirable) chlorophyll-*a* concentrations and AFDM. The target concentrations for nitrogen and phosphorus are established at levels believed to prevent excess growth and proliferation of algae which can cause harm to aquatic life, fishes, and contact recreation. Since 2002, DEQ has conducted a number of studies in order to develop numeric criteria for nutrients (N and P forms). DEQ is developing draft numeric nutrient standards for TN and TP based on 1) public surveys defining what level of algae was perceived as "undesirable" (Suplee et al., 2009) and 2) the outcome of nutrient stressor-response studies that determine nutrient concentrations that will maintain algal growth below undesirable and harmful levels (Suplee et al., 2008; Suplee and Watson, 2013).

Nutrient targets for TN and TP (which are also draft numeric criteria), chlorophyll-*a*, and AFDM are based on Suplee and Watson (2013) and can be found in **Table 5-2**. The nitrate target is based on research by Suplee et al. (2008) and can also be found in **Table 5-2**. DEQ has determined that the values for nitrate, TN, and TP provide an appropriate numeric translation of the applicable narrative nutrient water quality standards based on existing water quality data in the Flint TPA (Deer Lodge-Philipsburg-Avon Grassy Intermontane Hills and Valleys, Flint Creek-Anaconda Mountains, and Rattlesnake-Blackfoot-South Swan-Northern Garnet-Sapphire Mountains). The target values are based on the most sensitive uses; therefore, the nutrient TMDLs are protective of all designated uses. When the draft criteria for TN and TP become numeric standards they will be in DEQ's DEQ-12 circular.

A macroinvertebrate biometric (Hilsenhoff's biotic index (HBI) score) is also considered in further evaluation of compliance with nutrient targets **Table 5-2**. An HBI score of greater than 4.0 may be used along with nutrient, chlorophyll-*a*, and AFDM data to indicate nutrient impairment.

Because numeric nutrient chemistry values are established to maintain algal levels below target chlorophyll-*a* concentrations and AFDM, target attainment applies and is evaluated during the summer growing season for algae (July 1–September 30 for the Middle Rockies Level III Ecoregion and Flint Creek, from Georgetown Lake outlet to the ecoregion 17ak boundary) when algal growth will most likely affect beneficial uses. Targets listed here have been established specifically for nutrient TMDL development in the Flint TPA and may or may not be applicable to streams in other TMDL project areas. The target values for total nitrogen and total phosphorus will be used to develop TMDLs. See **Section 8-1** for the adaptive management strategy as it relates to nutrient water quality targets.

Table 5-2. Nutrient Targets for the Flint Total Maximum Daily Load Planning Area

Parameter	Middle Rockies Level III Ecoregion Target Value	Flint Creek, from Georgetown Lake outlet to the ecoregion 17ak boundary(1)
Nitrate(2)	≤ 0.100 mg/L	≤ 0.100 mg/L
Total Nitrogen(3)	≤ 0.300 mg/L	≤ 0.500 mg/L
Total Phosphorus(3)	≤ 0.030 mg/L	≤ 0.072 mg/L
Chlorophyll-*a*(3)	≤ 125 mg/m²	≤ 150 mg/m²
Ash Free Dry Mass(3)	≤ 35 g /m²	≤ 45 g /m²
Hilsenhoff's Biotic Index	< 4.0	< 4.0

(1) Values are only applicable to the specific portion of Flint Creek.
(2) Value is from Suplee et al. (2008)
(3) Value is from Suplee and Watson (2013)

5.4.3 Existing Conditions and Comparison to Targets

To evaluate whether attainment of nutrient targets has been met, the existing water quality conditions in each waterbody segment are compared to the water quality targets in **Table 5-2** using the methodology in the DEQ guidance document "2011 Assessment Methodology for Determining Wadeable Stream Impairment due to Excess Nitrogen and Phosphorus Levels" (Suplee and Sada de Suplee, 2011). This approach provides DEQ with updated impairment determinations used for TMDL development. Because the original impairment listings are based on old data or were listed before developing the numeric criteria, each stream segment will be evaluated for impairment from nitrate, TN, and TP using data collected within the past 10 years.

The assessment methodology uses two statistical tests (Exact Binomial Test and the One-Sample Student's T-test for the Mean) to evaluate water quality data for compliance with established target values. In general, compliance with water quality targets is <u>not</u> attained when nutrient chemistry data shows a target exceedance rate of >20% (Exact Binomial Test), when mean water quality nutrient chemistry exceeds target values (Student T-test), or when a single chlorophyll-*a* exceeds benthic algal target concentrations (125 mg/m^2 or 35 g Ash Free Dry Weight/m^2). Where water chemistry and algae data do not provide a clear determination of impairment, or where other limitations exist, a macroinvertebrate biometric (HBI) is considered in further evaluating compliance with nutrient targets. Lastly, inherent to any impairment determination is the existence of human sources of pollutant loading. Human-caused sources of nutrients must be present for a stream to be considered impaired. Note: to ensure a higher degree of certainty for removing an impairment determination and making any new impairment determination, the statistical tests are configured differently for an unlisted nutrient form than for a listed nutrient form. This can result in a different number of allowable exceedances for nutrients within a single stream segment. Such tests help assure that assessment reaches do not vacillate between listed and delisted status by the change in results from a single additional sample. When applying the T-test for assessment and sample values that were below detection limits, one-half the detection limit was used.

5.4.3.1 Barnes Creek

Barnes Creek is on the 2012 303(d) List as impaired for nitrate, TN, TP, and chlorophyll-*a*. The impaired segment of Barnes Creek begins at the headwaters on the edge of the Flint Creek Range and flows north 8.9 miles until its termination at the confluence with Flint Creek. Potential nutrient sources within the impaired segment include natural, livestock, agriculture, and septic systems.

Summary nutrient data statistics and assessment method evaluation results for Barnes Creek are provided in **Tables 5-3 and 5-4**, respectively. Eleven nitrate samples were collected between 2004 and 2009; values ranged from < 0.01 to 0.30 mg/L with seven samples exceeding the nitrate target of 0.100 mg/L. Nine TN samples were collected between 2007 and 2009; values ranged from 0.23 to 1.81 mg/L with eight samples exceeding the TN target of 0.300 mg/L. Eleven TP samples were collected between 2004 and 2009; values ranged from 0.043 to 0.45 mg/L with all 11 samples exceeding the TP target of 0.030 mg/L.

Five chlorophyll-*a* and zero AFDM samples were collected from Barnes Creek between 2007 and 2008. Chlorophyll-*a* values ranged from 3 to 721 mg/m^2 with two exceeding the target of 125 mg/m^2. There were two macroinvertebrate samples collected from Barnes Creek in 2004. HBI values ranged from 5.0 to 6.4; both exceeded the target of 4.0.

Assessment results shown in **Table 5-4** indicate that Barnes Creek is impaired for nitrate, TN and TP. DEQ will take the approach of addressing the nitrate listing with a TN TMDL. As a result TMDLs will be written for TN and TP. The chlorophyll-*a* impairment cause will be retained for Barnes Creek. Since chlorophyll-*a* is not a pollutant, but instead considered and observed effect, it will be by addressed by the nutrient TMDLs.

Table 5-3. Nutrient Data Summary for Barnes Creek

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1]	Max	Median
Nitrate, mg/L	2004-2009	11	< 0.01	0.30	0.145
TN, mg/L	2007-2009	9	0.23	1.81	0.525
TP, mg/L	2004-2009	11	0.043	0.45	0.1395
Chlorophyll-*a*, mg/m^2	2007-2008	5	3	721	4

Table 5-3. Nutrient Data Summary for Barnes Creek

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1]	Max	Median
AFDM, g/m^2	NA	0	NA	NA	NA
Macroinvertebrate HBI	2004	2	5.04	6.37	5.70

[1] Values preceded by a "<" symbol are detection limits for that parameter. The actual sample value was below the detection limit.

Table 5-4. Assessment Method Evaluation Results for Barnes Creek

Nutrient Parameter	Sample Size	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	Macro Test Result	TMDL Required ?
Nitrate	11	0.100	7	FAIL	FAIL	FAIL	NA	FAIL	YES
TN	9	0.300	8	FAIL	FAIL				YES
TP	11	0.030	11	FAIL	FAIL				YES

5.4.3.2 Douglas Creek

Douglas Creek is on the 2012 303(d) List as impaired for Nitrate. The impaired segment of Douglas Creek begins at the confluence of the Middle Fork Douglas and South Fork Douglas creeks in the Flint Creek Range and flows northwest 7.1 miles until its termination at the confluence with Flint Creek. Potential nutrient sources within the impaired segment include natural, livestock, agriculture, mining, and timber harvest.

Summary nutrient data statistics and assessment method evaluation results for Douglas Creek are provided in **Tables 5-5 and 5-6**, respectively. Thirteen nitrate samples were collected between 2007 and 2009; values ranged from 0.04 to 0.173 mg/L with seven samples exceeding the nitrate target of 0.100 mg/L. Thirteen TN samples were collected between 2007 and 2009; values ranged from < 0.05 to 0.29 mg/L with zero samples exceeding the TN target of 0.300 mg/L. Thirteen TP samples were collected between 2007 and 2009; values ranged from 0.023 to 0.066 mg/L with seven samples exceeding the TP target of 0.030 mg/L.

Eight chlorophyll-*a* and zero AFDM samples were collected from Douglas Creek between 2007 and 2008. Chlorophyll-*a* values ranged from 5 to 354 mg/m^2 with two exceeding the target of 125 mg/m^2. There were zero macroinvertebrate samples collected from Douglas Creek.

Assessment results shown in **Table 5-6** indicate that Douglas Creek is impaired for Nitrate and TP. As a result TMDLs will be written for these nutrients.

Table 5-5. Nutrient Data Summary for Douglas Creek

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1]	Max	Median
Nitrate, mg/L	2007-2009	13	0.04	0.173	0.11
TN, mg/L	2007-2009	13	< 0.05	0.29	0.16
TP, mg/L	2007-2009	13	0.023	0.066	0.033
Chlorophyll-*a*, mg/m^2	2007-2008	8	5	354	24
AFDM, g/m^2	NA	0	NA	NA	NA
Macroinvertebrate HBI	NA	0	NA	NA	NA

[1] Values preceded by a "<" symbol are detection limits for that parameter. The actual sample value was below the detection limit.

Table 5-6. Assessment Method Evaluation Results for Douglas Creek

Nutrient Parameter	Sample Size	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	Macro Test Result	TMDL Required?
Nitrate	13	0.100	7	FAIL	FAIL	FAIL	NA	NA	YES
TN	13	0.300	0	PASS	PASS				NO
TP	13	0.030	7	FAIL	FAIL				YES

5.4.3.3 Flint Creek (Georgetown Lake to confluence with Boulder Creek)

Flint Creek (Georgetown Lake to confluence with Boulder Creek) is not on the 2012 303(d) List as impaired for nutrients. DEQ's Monitoring and Assessment section recently performed an assessment of this waterbody segment and determined that is impaired for TP. This new listing will appear in the 2014 Integrated Report (IR). The impaired segment is about 28.1 miles long and flows north. Potential nutrient sources within the impaired segment include natural, livestock, agriculture, septic systems, municipal wastewater, mining, and timber harvest.

Summary nutrient data statistics and assessment method evaluation results for Flint Creek (Georgetown Lake to confluence with Boulder Creek) are provided in **Tables 5-7 and 5-8**, respectively. Twenty-one nitrate samples were collected between 2007 and 2009; values ranged from < 0.05 to 0.15 mg/L with three samples exceeding the target of 0.100 mg/L. Nineteen TN samples were collected between 2007 and 2009; values ranged from 0.11 to 0.39 mg/L with zero samples exceeding the TN target of 0.500 mg/L in the reach from Georgetown Lake to the ecoregion 17ak boundary and zero samples exceeding the target of 0.300 mg/L in the reach from the ecoregion 17ak boundary to the confluence with Boulder Creek. Sixty-three TP samples were collected between 2005 and 2009; values ranged from 0.01 to 0.161 mg/L with 15 samples exceeding the TP target of 0.072 reach from Georgetown Lake to the ecoregion 17ak boundary and one exceeding the target of 0.030 mg/L in the reach from the ecoregion 17ak boundary to the confluence with Boulder Creek.

Eleven chlorophyll-*a* and zero AFDM samples were collected from this segment of Flint Creek between 2007 and 2008. Chlorophyll-*a* values ranged from 8 to 535 mg/m² with three exceeding the target of 150 g/m² in the reach from Georgetown Lake to the ecoregion 17ak boundary and zero exceeding the target of 125 g/m² in the reach from the ecoregion 17ak boundary to the confluence with Boulder Creek. There were zero macroinvertebrate samples collected.

Assessment results shown in **Table 5-8** indicate that Flint Creek (Georgetown Lake to confluence with Boulder Creek) is impaired for TP. As a result a TMDL will be written for this nutrient.

Table 5-7. Nutrient Data Summary for Flint Creek (Georgetown Lake to confluence with Boulder Creek)

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1]	Max	Median
Nitrate, mg/L	2007-2009	21	< 0.05	0.15	0.022
TN, mg/L	2007-2009	19	0.11	0.39	0.22
TP, mg/L	2005-2009	63	0.01	0.161	0.033
Chlorophyll-*a*, mg/m^2	2007-2008	11	8	535	71
AFDM, g/m^2	NA	0	NA	NA	NA
Macroinvertebrate HBI	NA	0	NA	NA	NA

[1] Values preceded by a "<" symbol are detection limits for that parameter. The actual sample value was below the detection limit.

Table 5-8. Assessment Method Evaluation Results for Flint Creek (Georgetown Lake to confluence with Boulder Creek)

Nutrient Parameter	Sample Size	Target Value(1) (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	TMDL Required?
Nitrate	21	0.100	3	PASS	PASS	FAIL	NA	NO
TN	19	0.500/ 0.300	0	PASS	PASS			NO
TP	61(2)	0.072/ 0.030	16	FAIL	PASS			YES

(1) For TN and TP the values represent proposed criteria for specific areas in the following order: Flint Creek from Georgetown Lake outlet to the ecoregion 17ak boundary/ Middle Rockies Level III Ecoregion.
(2) Two samples were excluded from assessment analysis due to a lack of spatial independence.

5.4.3.4 Flint Creek (Boulder Creek to mouth)

Flint Creek (Boulder Creek to mouth) is on the 2012 303(d) List as impaired for TN and TP. The impaired segment is 16.9 miles long and flows north. Potential nutrient sources within the impaired segment include natural, livestock, agriculture, septic systems, municipal wastewater, mining, and timber harvest.

Summary nutrient data statistics and assessment method evaluation results for Flint Creek (Boulder Creek to mouth) are provided in **Tables 5-9** and **5-10**, respectively. Fourteen nitrate samples were collected between 2002 and 2009; values ranged from < 0.01 to 0.09 mg/L with zero samples exceeding the nitrate target of 0.100 mg/L. Thirteen TN samples were collected between 2007 and 2009; values ranged from 0.09 to 0.30 mg/L with zero samples exceeding the TN target of 0.300 mg/L. Fourteen TP samples were collected between 2002 and 2009; values ranged from 0.02 to 0.116 mg/L with eleven samples exceeding the TP target of 0.030 mg/L.

Ten chlorophyll-*a* and zero AFDM samples were collected from this segment of Flint Creek between 2007 and 2009. Chlorophyll-*a* values ranged from < 0.28 to 297 mg/m² with three exceeding the target of 125 mg/m². There were zero macroinvertebrate samples collected.

Assessment results shown in **Table 5-10** indicate that Flint Creek (Boulder Creek to mouth) is impaired for TN and TP. Although there were zero TN exceedances, the previous listing for TN and the three exceedances of the chlorophyll-*a* target led DEQ to retain this impairment. As a result a TMDL will be written for each of these nutrients.

Table 5-9. Nutrient Data Summary for Flint Creek (Boulder Creek to mouth)

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1]	Max	Median
Nitrate, mg/L	2002-2009	14	< 0.01	0.09	0.03
TN, mg/L	2007-2009	13	0.09	0.30	0.22
TP, mg/L	2002-2009	14	0.02	0.116	0.0385
Chlorophyll-*a*, mg/m²	2007-2009	10	< 0.28	297	94
AFDM, g/m²	NA	0	NA	NA	NA
Macroinvertebrate HBI	NA	0	NA	NA	NA

[1] Values preceded by a "<" symbol are detection limits for that parameter. The actual sample value was below the detection limit.

Table 5-10. Assessment Method Evaluation Results for Flint Creek (Boulder Creek to mouth)

Nutrient Parameter	Sample Size	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	Macro Test Result	TMDL Required?
Nitrate	14	0.100	0	PASS	PASS	FAIL	NA	NA	NO
TN	13	0.300	0	PASS	PASS				YES
TP	14	0.030	11	FAIL	FAIL				YES

5.4.3.5 Princeton Gulch

Princeton Gulch is on the 2012 303(d) List as impaired for nitrate. The impaired segment of Princeton Gulch begins at the headwaters in the Flint Creek Range and flows southwest 3.9 miles until its termination at the confluence with Boulder Creek. Potential nutrient sources within the impaired segment include natural, mining, and timber harvest.

Summary nutrient data statistics and assessment method evaluation results for Princeton Gulch are provided in **Tables 5-11 and 5-12**, respectively. Ten nitrate samples were collected between 2007 and 2012; values ranged from < 0.01 to 0.05 mg/L with zero samples exceeding the nitrate target of 0.100 mg/L. Eleven TN samples were collected between 2007 and 2012; values ranged from < 0.1 to 0.11 mg/L with zero samples exceeding the TN target of 0.300 mg/L. Eleven TP samples were collected between 2007 and 2012; values ranged from 0.009 to 0.058 mg/L with two samples exceeding the TP target of 0.030 mg/L.

Six chlorophyll-*a* and zero AFDM samples were collected from Princeton Gulch between 2007 and 2009. Chlorophyll-*a* values ranged from 3 to 626 mg/m² with two exceeding the target of 125 mg/m². There were zero macroinvertebrate samples collected from Princeton Gulch.

Assessment results shown in **Table 5-12** indicate that Princeton Gulch is impaired for nitrate. Although there were zero nitrate exceedances, the previous listing for nitrate, a lack of data, and the two exceedances of the chlorophyll-*a* target led DEQ to retain this impairment. As a result a TMDL will be written for this nutrient.

Table 5-11. Nutrient Data Summary for Princeton Gulch

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1]	Max	Median
Nitrate, mg/L	2007-2009	10	< 0.01	0.05	0.03
TN, mg/L	2007-2012	11	< 0.01	0.11	0.05
TP, mg/L	2007-2012	11	0.009	0.058	0.015
Chlorophyll-*a*, mg/m²	2007-2009	6	3	626	22
AFDM, g/m²	NA	0	NA	NA	NA
Macroinvertebrate HBI	NA	0	NA	NA	NA

[1] Values preceded by a "<" symbol are detection limits for that parameter. The actual sample value was below the detection limit.

Table 5-12. Assessment Method Evaluation Results for Princeton Gulch

Nutrient Parameter	Sample Size	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	Macro Test Result	TMDL Required ?
Nitrate	10	0.100	0	PASS	PASS	FAIL	NA	NA	YES
TN	11	0.300	0	PASS	PASS				NO
TP	11	0.030	2	PASS	PASS				NO

5.4.3.6 Smart Creek

Smart Creek is on the 2012 303(d) List as impaired for TP. The impaired segment of Smart Creek begins at the headwaters in the John Long Mountains and flows northeast 11.6 miles until its termination at the confluence with Flint Creek. Potential nutrient sources within the impaired segment include natural, livestock, agriculture, septic systems, mining, and timber harvest.

Summary nutrient data statistics and assessment method evaluation results for Smart Creek are provided in **Tables 5-13 and 5-14**, respectively. Twelve nitrate samples were collected between 2005 and 2009; values ranged from < 0.005 to 2.0 mg/L with two samples exceeding the nitrate target of 0.100 mg/L. Ten TN samples were collected between 2007 and 2009; values ranged from 0.08 to 2.28 mg/L with three samples exceeding the TN target of 0.300 mg/L. Twelve TP samples were collected between 2005 and 2009; values ranged from 0.011 to 0.132 mg/L with nine samples exceeding the TP target of 0.030 mg/L.

Four chlorophyll-*a* and zero AFDM samples were collected from Smart Creek between 2007 and 2008. Chlorophyll-*a* values ranged from 4.1 to 153 mg/m² with one exceeding the target of 125 mg/m². There were three macroinvertebrate samples collected from Smart Creek from 2005 to 2011; HBI values ranged from 3.6 to 5.2. One HBI value exceeded the target of 4.0.

Assessment results shown in **Table 5-14** indicate that Smart Creek is impaired for TN and TP. As a result a TMDL will be written for each of these nutrients.

Table 5-13. Nutrient Data Summary for Smart Creek

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1]	Max	Median
Nitrate, mg/L	2005-2009	12	< 0.005	2.0	0.015
TN, mg/L	2007-2009	10	0.08	2.28	0.145
TP, mg/L	2005-2009	12	0.011	0.132	0.0435
Chlorophyll-*a*, mg/m^2	2007-2008	4	4.1	153	40.5
AFDM, g/m^2	NA	0	NA	NA	NA
Macroinvertebrate HBI	2005-2011	3	3.6	5.2	3.6

[1] Values preceded by a "<" symbol are detection limits for that parameter. The actual sample value was below the detection limit.

Table 5-14. Assessment Method Evaluation Results for Smart Creek

Nutrient Parameter	Sample Size	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	Macro Test Result	TMDL Required?
Nitrate	12	0.100	2	PASS	FAIL	FAIL	NA	FAIL	NO
TN	10	0.300	3	PASS	FAIL				YES
TP	12	0.030	9	FAIL	FAIL				YES

5.4.4 Nutrient Total Maximum Daily Load Development Summary

Table 5-15 summarizes the nutrient impairment determinations for the Flint TPA, along with the summary of the nutrient pollutants for which TMDLs will be prepared based on DEQ's updated assessments for these streams. Changes from the 2012 303(d) List are because of limited data collection at the time the waterbody segments were initially listed and the improved assessment method along with significant data collection since original impairment determinations. The updated impairment determinations will be reflected in the 2014 Water Quality IR. Note that as per **Table 5-15** a total of 10 separate nutrient TMDLs will be developed for six stream segments. These 10 TMDLs address 11 nutrient impairment causes and 1 chlorophyll-*a* (non-pollutant) impairment cause.

Table 5-15. Summary of Nutrient Total Maximum Daily Load Development Determinations

Stream Segment	Waterbody ID	Updated 303(d) Nutrient Impairment(s)	TMDLs Prepared
BARNES CREEK, headwaters to mouth	MT76E003_070	Nitrate[1], Total Nitrogen, Total Phosphorus, Chlorophyll-*a*[2]	Total Nitrogen, Total Phosphorus
DOUGLAS CREEK, confluence of Middle and South forks to mouth	MT76E003_020	Nitrate, Total Phosphorus	Nitrate, Total Phosphorus
FLINT CREEK, Georgetown Lake to confluence with Boulder Creek	MT76E003_011	Total Phosphorus	Total Phosphorus
FLINT CREEK, Boulder Creek to mouth	MT76E003_012	Total Nitrogen, Total Phosphorus	Total Nitrogen, Total Phosphorus
PRINCETON GULCH, headwaters to mouth	MT76E003_090	Nitrate	Nitrate
SMART CREEK, headwaters to mouth	MT76E003_110	Total Nitrogen, Total Phosphorus	Total Nitrogen, Total Phosphorus

[1] Nitrate remains a nutrient impairment for Barnes Creek. The TN TMDL will address both TN and nitrate.

[2] Non-pollutant; remains an impairment cause and is addressed via nutrient TMDLs.

5.5 SOURCE ASSESSMENT AND QUANTIFICATION, TOTAL MAXIMUM DAILY LOADS, ALLOCATIONS, REDUCTIONS, AND BEST MANAGEMENT PRACTICE SCENARIOS

This section provides the overall approach used for source assessment, TMDL development, allocations, reductions, and Best Management Practice (BMP) scenarios. This approach was applied to each of the six stream segments.

5.5.1 Source Assessment Approach

Assessment of existing nutrient (i.e., nitrate, nitrogen and phosphorus) sources is needed to develop load allocations to specific source categories. Water quality sampling data collected from 2004 through 2012 represents the most recent data for determining existing nutrient water quality conditions. This data was collected with the objectives of 1) evaluating attainment of water quality targets and 2) assessing load contributions from nutrient sources within the Flint TPA. These data form the primary dataset from which existing water quality conditions were evaluated and from which nitrate, TN, and TP loading estimates are derived. Data used to conduct these analyses are publicly available at: http://www.epa.gov/storet/dw_home.html.

This section characterizes the type, magnitude, and distribution of sources contributing to nutrient loading to impaired streams, provides loading estimates for significant source types, and establishes the approach applied toward establishing the TMDLs for each stream and allocations to specific source categories. Source types include natural, livestock (pasture and rangeland), agriculture (crops), point sources (Philipsburg wastewater treatment plant (WWTP)), septic, and residential development and are described in further detail for each stream. Source characterization links nutrient sources, nutrient loading to streams, and water quality response, and supports the formulation of the load allocation portion of the TMDL. As described in **Section 5.4.2**, nitrate, TN, and TP water quality targets are applicable during the summer growing season for algae (i.e., July 1 – September 30). Consequently, source characterizations are focused mainly on sources and mechanisms that influence nutrient contributions during this period. Loading estimates and load allocations are established for the summer growing season time period and are based on observed water quality data and flow conditions measured during this time period.

Monitoring data collected from the TPA from 2002 through 2012 was used to determine spatial patterns in nutrient concentrations, and biological response. To display this information, box plots are used. In descriptive statistics, box plots are a convenient way of graphically depicting groups of numerical date through their five number summaries. Box plots depict the smallest observation (sample minimum), 25th percentile, median, 75th percentile, and the largest observation (sample maximum). Box plots display differences between the data without making any assumptions of the underlying statistical distribution of the data. The spacing between the different parts of the box indicates the degree of dispersion and skewness in data and identifies outliers. When sample data used in boxplots was below detection limits the detection limit was used. Source characterization and assessment was conducted using a computer watershed model, the Soil and Water Assessment Tool (SWAT).

Managed land use in the Flint TPA primarily consists of livestock grazing and agricultural fields. In addition there has been historical mining and timber harvest. Two of the nutrient impaired waterbodies in the Flint TPA also have a contributing source from the same site with an Montana Pollutant Discharge Elimination System (MPDES) surface water point source permit. Nutrient sources therefore consist primarily of 1) natural sources derived from airborne deposition, vegetation, soils, and geologic weathering; 2) non-permitted human-caused sources (livestock, agriculture, septic, residential development); and 3) permitted human-caused sources (i.e., Philipsburg WWTP). These sources may include a variety of discrete and diffuse pollutant inputs that have differing pathways to a waterbody. Although portions of the Flint TPA overlay the Phosphoria Formation, mining was not included as a source category for nutrients because all reviewed data (which includes groundwater data from existing groundwater wells, twelve surface water samples in the Montana Bureau of Mines database with source listed as “Mine” or “Mine Drainage,” a search of data from the DEQ’s abandoned mine database, and a review of the Natural Resources Conservation Service (NRCS) soil database) indicate predominantly low and below detection nutrient values from mining activity. Timber harvest also was not included as a source category (although it was simulated in the watershed model) because a very small proportion (1.1% of the watershed) has been recently harvested as determined by air photo analysis between 1990 and 2009. It is unlikely that this amount of harvest has caused a detectable change in water quality and any potential increase in nutrients would likely be short-term (Feller and Kimmins, 1984; Likens et al., 1978; Martin and Harr, 1989).

5.5.2 Soil & Water Assessment Tool (SWAT) Model

SWAT is a physically based watershed-scale loading model and was used to model the Flint watershed. SWAT models the nitrogen and phosphorus cycles in soil. Precipitation dissolves mineral nitrogen and phosphorus from the soil surface and transports it in surface runoff. Water percolates through the soil and dissolves mineral nitrogen and phosphorus, which is then carried into streams via lateral (soil) flow and shallow groundwater flow. Rainfall deposits nitrogen (but not phosphorus) on the land surface due to atmospheric deposition. Dead and dying biomass is picked up by surface runoff and carried into receiving streams as well, delivering organic nitrogen and organic phosphorus with it. Additionally, other nutrient sources such as cattle manure, human wastewater, and fertilizer application are present within the watershed. These processes affect each land-use type to differing degrees based on the amount of biomass, infiltration capacity, soil types, and size of each land-use type, as well as the external loading applied.

SWAT also models a number of instream processes, including algal growth and uptake, the nitrogen and phosphorus cycles, organic settling, and carbonaceous biological oxygen demand, to name a few. These processes depend on many variables such as water quality, climatic data, point sources, and sub-basin specific loading rates.

SWAT was used to estimate nutrient loading from various sources within the watershed and to estimate the reductions that would result from various best management practice (BMP) scenarios. Specific information regarding SWAT and how it was used for the Flint TPA can be found in **Appendix E**.

5.5.2.1 Model Setup Overview

The Flint watershed was divided into 41 sub-basins within the model, including a sub-basin for each stream segment (i.e., reach) requiring a TMDL. Each sub-basin was further divided into areas with unique land use, slope, and soil attributes called hydrologic response units (HRUs). Land management practices (e.g., irrigation, grazing, etc.) were then applied as applicable to each HRU. HRUs are not spatially connected within each sub-basin, and all HRUs route directly into the stream reach. The model hydrology was calibrated to three United States Geological Survey (USGS) gages (Flint Creek near Drummond, Flint Creek at Maxville, and Boulder Creek at Maxville) using discharge and climatic data. The model uses daily inputs and can generate outputs on timescales ranging from daily to annual. Because the nutrient targets apply from July 1 through September 30, model outputs summarized in source assessments are for that time frame only.

5.5.3 Source Categories

There is one permitted nutrient point source discharge (Philipsburg WWTP) in the watershed in the Flint TPA. In addition to that point source, the model evaluated loading from the following nonpoint sources:

- Natural Background
- Livestock (pasture and rangeland)
- Agriculture (crops)
- Urban (septic, residential development, and roads)

For the purposes of the source assessment, the estimated loading values and percent contribution results from the SWAT model represent nutrients being loaded to the streams from each type of land use and do not account for uptake once they enter the water. However, **Sections 5.6.1 – 5.6.6** do include instream nutrient reductions for the BMP scenarios that account for instream uptake and nutrient cycling. Source assessment information for natural background as well as all sources evaluated within the SWAT model is described in detail within these sections.

5.5.3.1 Natural Background

The natural background component of nutrient loading was not explicitly evaluated by the model, but a significant component of the forest category and portions of all other categories are associated with background loading.

Geology

The geology of the watershed is incorporated through the chemical and physical characteristics of the soil profile. The NRCS soil database is used in the model to populate those physical and chemical characteristics in the model. Those characteristics can be modified by the user during the model calibration process within acceptable ranges as necessary.

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).

Forest

The forested areas in the Flint 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 due to their capacity to infiltrate, transpire, and otherwise capture rainfall. Additionally, the amount of soil exposed to erosion for forested areas, which is referred to as the C factor, is low.

Wetlands

Wetlands have high biomass quantities (and thus high transpiration capacities), but low infiltration rates. Although they are mixed in with the forested areas, it was assumed they are not grazed. Therefore, natural nutrient processes are the only contributors in the wetland areas. Because wetlands make up such a small percentage of the loading and are considered natural sources of nutrients, modeled loads from this source were aggregated into the load for forests.

5.5.3.2 Livestock

Although the majority of cattle are typically not grazing along the valley bottoms during the growing season, there are several possible mechanisms for the transport of nutrients from grazed land to surface water during the growing season. The potential pathways include: the effect of grazing on vegetative health and its ability to uptake nutrients and minimize erosion in upland and riparian areas, breakdown of excrement and loading via surface and subsurface pathways, delivery from grazed rangeland during the growing season, transport of manure applied from fall through the 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). Grazing on rangeland and in pastures is common in the Flint TPA. Livestock are allowed to roam and are not deliberately concentrated along the valley bottoms during the growing season.

Pasture

Pasture is managed for hay production during the summer, and for grazing feed 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 (November – May) and trampling and consumption reduces biomass at a time of the year when it is already low. Commercial fertilizers are used infrequently in the watershed, but cattle manure is applied naturally from November through May in larger quantities per acre (higher cattle density) than on the summer range areas. Livestock manure and grass consumption input values were based on literature values and information from the Technical Advisory Group.

Rangeland

Rangeland has much less biomass than other land uses, and therefore contributes fewer nutrients from biomass decay. However, grazing impacts do factor in. Rangeland is grazed during the summer months (June – October) in the watershed. This grazing is simulated in the watershed model by distributing livestock throughout the watershed on the lands classified as rangeland. To simulate livestock rotation, lands that had more biomass (as simulated in the model) were grazed heavier than areas with less biomass. Grazing is simulated in the model by including biomass consumed, biomass trampled, and manure deposition. To simulate rangeland grazing, 1% of the manure nutrients from livestock present in a watershed were input directly to the impaired stream. This was done because when allowed to roam freely, cattle spend about 1% of their time near a stream (Porath et al., 2002; Sheffield et al., 1997).

Forest

Discussion with the local NRCS and United States Forest Service offices indicates that grazing does not generally occur in forested areas of the Flint watershed. Therefore, in the watershed model, cattle were not grazed on forested areas.

5.5.3.3 Agriculture

Crops

Based on National Agriculture Statistic Services (NASS), alfalfa, hay, barley, and spring wheat are grown in the Flint TPA. The distribution of crops and management practices were simulated in the model using information from the local NRCS office, discussion with the Technical Advisory Group, discussion with the local county extension agent, NASS data, and the National Land Cover Dataset (NLCD). Simulated management practices including amount and timing of fertilizer application, crop irrigation schedule and rates, and harvesting practices/schedule. Specific values for management practices were adjusted between the southern half (south of Maxville) and northern half (north of Maxville) of the watershed to account for the variation of local practices as dictated by climatic variations in the watershed.

5.5.3.4 Urban

Septic

Septic systems, even when operating as designed, can contribute nutrients to surface water through subsurface pathways. A simple model, the Method for Estimating Attenuation of Nutrients from Septic Systems (MEANSS), was used to incorporate the previously mentioned variables and provide coarse estimates of the nitrate and TP loads to each waterbody (see **Appendix F**).

The number of septic systems in the watershed was estimated based on land uses and cadastral data. The daily load from each septic system was based on literature values and conservative assumptions used during permitting for subdivisions in Montana (Montana Department of Environmental Quality, 2009b). Because a complete system failure is typically addressed very quickly and no site-specific data were available, it was assumed that all septic systems are working properly (i.e., 0% failure rate). Without any reliable data it was assumed that all septic tanks are conventional systems consisting of a septic tank and drainfield. Conservative assumptions were used for the load estimates of nitrate and TP to surface waters (i.e., low nutrient removal efficiency).

Key assumptions for this method are as follows:

- All septic systems in a watershed are conventional
- The loading rate before attenuation for nitrate from conventional systems is 30.5 lbs/yr
- The loading rate before attenuation for phosphorus from conventional systems is 6.44 lbs/yr
- Load reductions are dependent on soil type and distance from surface water as described in **Appendix F**.

The typical loading rate to streams was estimated using MEANSS and then added to the model as daily point sources. These point sources were calculated independently for each sub-basin based on the number of septic tanks assigned to the specific sub-basin.

Because this modeling exercise assumes a 0% failure rate, for a TMDL to be achieved it is assumed that any failing septic systems would be identified and repaired. This method estimates the load from septic systems as the wastewater enters a stream. It does not account for uptake that occurs once the nutrients enter a stream (Ensign and Doyle, 2006; Valett et al., 2002).

The MEANSS model incorporates many assumptions and as a result there is uncertainty in the loading estimates. It is meant to develop coarse estimates of nutrient loading from septic systems in the Flint TPA. As part of the implementation of a watershed restoration plan (**Section 7-1**), more refined models or site-specific water quality studies could be used to reduce uncertainty in estimates of nutrient loading from septic systems.

Residential Development

Developed areas contribute nutrients to the watershed by runoff from impervious surfaces, deposition by machines/automobiles, application of fertilizers, and increased irrigation on lawns. Although developed areas often have the highest nutrient loading rates, developed areas make up a very small percentage of the overall Flint watershed area. Developed urban areas are simulated in the watershed model using impervious area estimates based on three levels of development density (impervious area affects runoff rates and nutrient loadings), irrigation amounts, and fertilizer use.

Point Sources

In addition to nonpoint sources, nutrients can be discharged to streams in the Flint TPA from several point sources (i.e., distinct, identifiable sources, such as pipes feeding directly into a waterbody). Point sources include the Philipsburg WWTP and various stormwater and groundwater discharges. As of June 24, 2013, there were 10 active permitted discharges in the Flint TPA (**Table 5-16**). See **Appendix G** for a synopsis of point sources in the Flint TPA at the time of the SWAT model start.

Table 5-16. Permitted Discharges in the Flint Total Maximum Daily Load Planning Area

NPDES ID	Facility Name	Latitude	Longitude	Permit Type	Expiration	Discharge To	Project Size
MTB014812	LS Jensen MDOT Camp Creek 318	46.33908	-113.31144	Turbidity Related to Construction Activity 318 Authorization	5/29/13 – Administration continued	Flint Creek Drainage (Camp Creek)	
MTR104474	MDOT - STPP HSIP 19-1(48)Georgetown Philipsburg	46.21278	-113.27583	MPDES Storm Water - Construction Activity General Permit	12/31/2017	Georgetown Lake and Various	Greater than 5 acres
MTX000002	Contact Mining Company	46.31333	-113.29194	MGWPCS - Individual Permit	7/31/2015	Groundwater (Douglas Creek)	

Table 5-16. Permitted Discharges in the Flint Total Maximum Daily Load Planning Area

NPDES ID	Facility Name	Latitude	Longitude	Permit Type	Expiration	Discharge To	Project Size
MTX000002	Contact Mining Company	46.31556	-113.28889	MGWPCS - Individual Permit	7/31/2015	Groundwater (Douglas Creek)	
MTR104706	Northwestern Energy - Philipsburg 100 KV Substation	46.32400	-113.29150	MPDES Storm Water - Construction Activity General Permit	12/31/2017	Douglas Creek	1-5 acres
MT0031500	Town of Philipsburg WWTP	46.34889	-113.31944	NPDES Individual Permit	7/31/2012 – Administration continued	Flint Creek	
MTR000521	Asarco Black pine Mine	46.44002	-113.35839	MPDES Storm Water - Industrial Activity	1/31/2018	Flint Creek Drainage (Smart Creek, South Fork Lower Willow Creek)	
MTR000521	Asarco Black Pine Mine	46.44046	-113.35839	MPDES Storm Water - Industrial Activity	1/31/2018	Flint Creek Drainage (Smart Creek, South Fork Lower Willow Creek)	
MTR000521	Asarco Black Pine Mine	46.44421	-113.37997	MPDES Storm Water - Industrial Activity	1/31/2018	Flint Creek Drainage (Smart Creek, South Fork Lower Willow Creek)	
MTX000134	Sugar Loaf Wool Carding Mill	46.57017	-113.27100	MGWPCS - Individual Permit	7/31/2015	Groundwater (Lower Willow Creek)	

Of the permits listed in **Table 5-16**, only the Philipsburg WWTP lagoon system directly discharges nutrients to a nutrient-impaired waterbody, Flint Creek. The discharge from the WWTP into Flint Creek was simulated in the model by using measured monthly wastewater effluent flow data collected by the city of Philipsburg since 2000 and measured monthly effluent quality data collected since 2006 as required in the city's MPDES discharge permit. When monthly values for effluent and nutrient concentrations were available those were included as direct point source discharges to the stream in sub-basin 30. For months without measured data, the annual averages of the years with applicable data were used.

5.5.4 Approach to Total Maximum Daily Load (TMDL) Development, Allocations, Wasteload Allocations, and Current Loading

5.5.4.1 TMDL Equation

TMDL calculations for nitrate, TN, and TP are based on the following formula:

Equation 1: TMDL = (X) (Y) (5.4)

TMDL= Total Maximum Daily Load in lbs/day
*X = water quality target (***Table 5-2***)*
Y = streamflow in cubic feet per second
5.4 = conversion factor

Note that the TMDL is not static, as flow increases the allowable (TMDL) load increases as shown by the total phosphorus example in **Figure 5-2**.

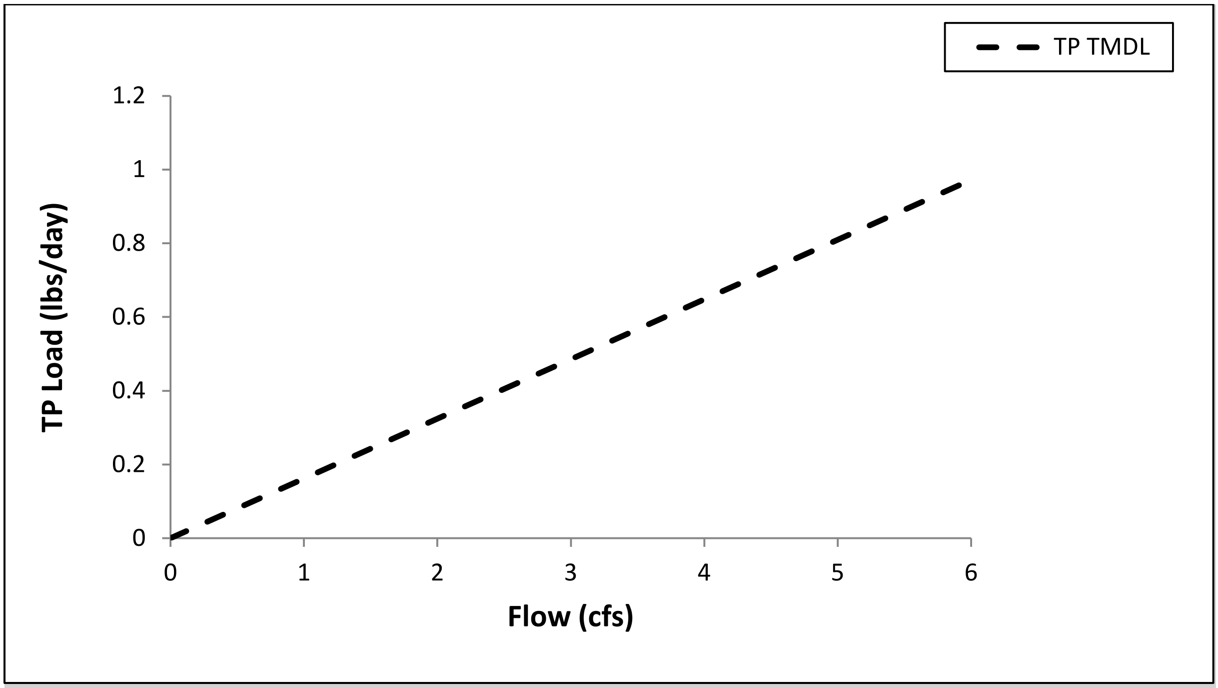

Figure 5-2. Example Total Maximum Daily Load for Total Phosphorus from 0 to 6 cfs

5.5.4.2 Approach to TMDL Source Allocations

As discussed in **Section 4.0**, the nitrate, TN, and TP TMDLs for applicable impaired waterbodies consists of the sum of load allocations to individual source categories (**Tables 5-17 and 5-18**). For Barnes, Douglas, and Smart creeks and Princeton Gulch, the TMDL allocations are composited into a single load allocation to all nonpoint sources, including natural background sources (**Equation 2**). This is done because all sources are nonpoint. Allocations for the two Flint Creek segments will consist of a composited load allocation for all nonpoint sources, including natural background sources and a wasteload to the Philipsburg WWTP (**Equation 3**). In the absence of an explicit margin of safety (MOS), the TMDLs for nitrate, TN, and TP in each waterbody are equal to the sum of the individual loads as follows:

Equation 2: TMDL = LA

LA = Composite Load Allocation to all nonpoint sources including natural background sources

Equation 3: TMDL = LA + WLA

LA = Composite Load Allocation to all nonpoint sources including natural background sources
WLA = Wasteload Allocation to the Philipsburg WWTP (for the two Flint Creek segments only)

Table 5-17. Nitrate and Total Nitrogen Load Allocation Source Categories and Descriptions for the Flint Total Maximum Daily Load Planning Area

Source Category	Load Allocation Descriptions
Natural Background	• soils and local geology • natural vegetative decay • wet and dry airborne deposition • wild animal waste • natural biochemical processes that contribute nitrogen to nearby water bodies
Septic	• human waste
Non-permitted Sources (Livestock, Agriculture, Timber Harvest, and/or Mining)	• domestic animal waste • fertilizer • loss of riparian and wetland vegetation along streambanks • limited nutrient uptake due to loss of overstory • cyanide breakdown from leaching • runoff from exposed rock containing natural background nitrate • residual chemicals left over from mining practices
WLA (Permitted Sources)	• human waste • residual chemicals from manufacturing processes

Table 5-18. Total Phosphorus Load Allocation Source Categories and Descriptions for the Flint Total Maximum Daily Load Planning Area

Source Category	Load Allocation Descriptions
Natural Background	• soils and local geology • natural vegetative decay • wet and dry airborne deposition • wild animal waste • natural biochemical processes that contribute phosphorus to nearby water bodies
Septic	• human waste
Non-permitted Sources (Livestock, Agriculture, Timber Harvest, and/or Mining)	• domestic animal waste • fertilizer • loss of riparian and wetland vegetation along streambanks • limited nutrient uptake due to loss of overstory • runoff from exposed rock containing natural background phosphorus
WLA (Permitted Sources)	• human waste • residual chemicals for manufacturing processes

5.5.4.3 Approach to Philipsburg Wastewater Treatment Plan Wasteload Allocation

Per Montana State rule (ARM 17.30.637(2)), no wastes may be discharged such that the wastes, either alone or in combination with other wastes, will violate, or can reasonably be expected to violate, any of the standards. For a WWTP and other permitted dischargers, this means that a discharge concentration must be less than or equal to an applicable numeric water quality standard if the reach immediately upstream where the discharge occurs is already exceeding the standard. If the reach immediately upstream of the WWTP discharge is determined to be unimpaired for TN and/or TP, the WLA will be modified based on a mass-balance approach if there is sufficient assimilative capacity in the receiving water. In either case, the development of the WLAs is consistent with the reasonable assurance approach defined within Section 4.4.

The TMDL target values provide a numeric translation of the applicable narrative standard found in ARM 17.30.637(1)(e). The draft numeric nutrient criteria provide the basis for the TMDL targets. The reach of Flint Creek immediately upstream of the Philipsburg WWTP discharge is impaired for TP, but not TN based on application of DEQ's nutrient assessment methodology (Suplee and Sada de Suplee, 2011). To ensure the Philipsburg WWTP discharge does not cause or contribute to a violation of water quality standards, the wasteload allocations (WLAs) for TP are based on a discharge concentration equal to the nutrient target concentration multiplied by the WWTP discharge flow during the summer growing season. Therefore, the resulting nutrient WLA for TP is based on the following equation:

Equation 4: WLA_{TP} = (X) (Y) (5.4)

WLA_{TP} = *Total Phosphorus Wasteload Allocation in lbs/day*
X = water quality target for Flint Creek from Georgetown Lake outlet to the ecoregion 17ak boundary (0.072 mg/L; **Table 5-2***)*
Y = WWTP discharge in cubic feet per second
5.4 = conversion factor

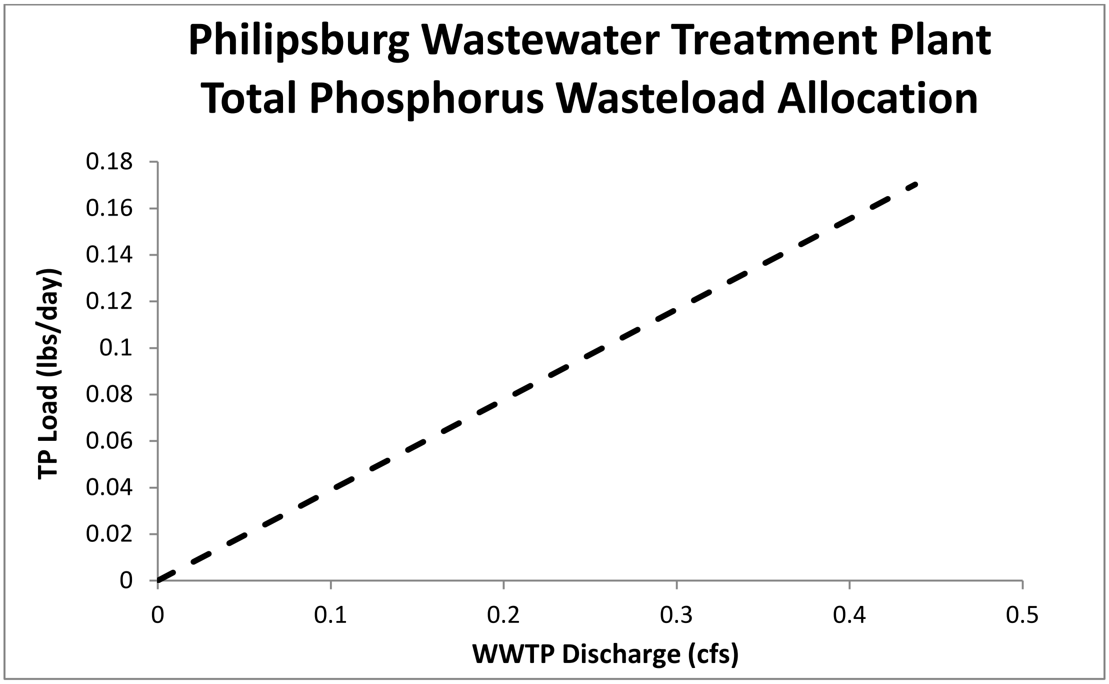

Figure 5-3. Wasteload Allocation for Total Phosphorus from the Philipsburg Wastewater Treatment Plant

The line representing the WLA is shown over the range of discharges from the WWTP during the summer growing season from August 2007 to September 2012.

Note that the WLA is not static, as flow increases the WLA increases as shown by the total phosphorus example in **Figure 5-3**.

For the purpose of setting MPDES discharge permit conditions, **Equation 4** is always satisfied if the discharge concentration is equal to or less than the target concentration of 0.072 mg/L. Therefore, the permit WLA can be satisfied by applying a concentration-based requirement on the discharge of 0.072 mg/L as opposed to establishing a load. If a concentration-based approach is not used for MPDES permit integration, then the WLA should be based on the target concentration multiplied by the existing WWTP discharge flow (as opposed to the design flow). Using a concentration-based approach does not result in a load cap and can be used to simplify MPDES permit development.

For **Equation 4**, the target concentration is lower than current limits of technology for treatment of wastewater effluent, which will require staged implementation of the WLA as discussed later in this section.

During the summer growing season (August 2007 – September 2012), the TN load from the WWTP ranged from 0.2 to 22.5 lbs/day with an average of 6.6 lbs/day. Flint Creek from Georgetown Lake to confluence with Boulder Creek is meeting the targets for TN; therefore no WLA is necessary for that segment. The segment of Flint Creek from Boulder Creek to mouth is impaired by TN and does require a TN WLA. Because the WWTP is not contributing to TN impairment in the upstream segment, and it is a relatively small percentage of the overall TN load (**Sections 5.6.3.2** and **5.6.4.2**), the TN WLA for Flint Creek from Boulder Creek to mouth is based on the WWTP continuing current operating conditions with the goal of achieving an average summer growing season load of 6.6 lbs/day.

Mixing Zone Allowance

If water quality in Flint Creek in the reach immediately upstream of the Philipsburg WWTP discharge location improves to where the TP water quality target or adopted numeric nutrient standard is met, then the TP WLA may be modified as assimilative capacity has been created in the receiving water. This increase would be based on a mass-balance calculation that ensures that water quality standards and/or TMDL targets are met at the end of the mixing zone during July 1 through September 30 under 14Q5 flow conditions. For a given stream, 14Q5 refers to the 14 day low flow with a recurrence interval of 5 years.

A mixing zone would be calculated the same regardless of whether or not numeric nutrient standards are adopted into rule. The 75th percentile of the available upstream water quality data will be used to determine assimilative capacity of TN and TP.

If it is determined that there is assimilative capacity for TP at the WWTP, the TP example WLAs (**Tables 5-23**, **5-24**, and **5-26**) for the two Flint Creek segments will need to be adjusted.

Staged Implementation of Nutrient Wasteload Allocations

The TMDL target for TP represents a concentration below the current limits of treatment technology. MPDES permits provide a regulatory mechanism for implementing the TMDL via the variance process, once nutrient standards are adopted into rule, to address affordability issues and concerns about the limits of treatment technology. The variance (75-5-313 Montana Code Annotated (MCA)) allows Montana to implement numeric nutrient criteria in a staged manner thus allowing enough time to address all point and nonpoint sources of nutrient pollution and allow for advancements in treatment technology and associated affordability.

The TP WLAs for the Philipsburg WWTP defined in this document allow staged implementation consistent with the variance process. There are two staged implementation scenarios based on whether numeric nutrient standards are adopted at the time the MPDES permit is renewed:

Scenario 1: Numeric Nutrient Standards Adopted into Rule
When the town of Philipsburg renews its MPDES permit, it can apply for a variance as part of a staged implementation approach for the TP WLAs defined in **Sections 5.6.3.3** and **5.6.4.3**. The variance will be implemented as defined within Montana State Law (75-5-313, MCA) and the rule as adopted. The town of Philipsburg will have 20 years from the time they receive the variance to meet the numeric nutrient standards. The MPDES permit for the Philipsburg WWTP is currently in the renewal process.

Scenario 2: Numeric Nutrient Standards Not Adopted into Rule
Consistent with the requirements of the proposed variance process, the town of Philipsburg will have 20 years from the time at which EPA approves this document to meet the TP WLAs defined in **Sections 5.6.3.3** and **5.6.4.3**.

Staged implementation will no longer be necessary once 1) the WWTP is able to meet the WLA values defined by **Equation 4** (i.e., discharge concentrations less than or equal to the targets in **Table 5-2**), or 2) Flint Creek gains assimilative capacity and the WWTP meets the mixing zone allowance requirements for TP treatment (defined above).

5.5.4.4 Total Existing Load

To provide an example estimate of the total existing loading, the following equation will be used:

Equation 5: Total Existing Load = (X) (Y) (5.4)

X = measured concentration in mg/L (associated with the median reduction for measured loads that exceed the TMDL or with the median measured load if none exceed the TMDL)
Y = streamflow in cubic feet per second (associated with the median reduction for measured loads that exceed the TMDL or with the median measured load if none exceed the TMDL)
5.4 = conversion factor

In the case of Flint Creek and the Philipsburg WWTP, the long-term (August 2007–September 2012) average discharge from the Philipsburg WWTP during the summer growing season is 0.10 million gallons per day (0.16 cfs). The average concentration for TN is 7.0 mg/L and TP is 3.3 mg/L over the same time period. The average nutrient load (calculated using matching monthly discharge and concentration data) from the WWTP to Flint Creek is approximately 6.6 lbs/day TN and 2.7 lbs/day TP. These average load values serve as the example existing loads from the WWTP and are separated from the example nonpoint source existing loads for the two Flint Creek segments. In addition, the average TN load from the WWTP (6.6 lbs/day) is used in **Section 5.6.4.3** as an example TN WLA in the example TN TMDL for the Flint Creek (Boulder Creek to mouth) segment.

Similar to **Equation 3** and based on the example existing wasteload values described in the previous paragraph, the example existing composite load (i.e., the combined load allocation for all nonpoint sources) for the Flint Creek segments can be calculated as follows:

Equation 6:

Existing Composite Load = Total Existing Load – Existing WWTP Load

5.5.5 Reductions

Graphs portraying the load reductions necessary to meet the nutrients targets are shown for each waterbody segment requiring (a) TMDL(s) in **Section 5.6**. These reductions were calculated using all nutrient data points that had an associated flow. **Equation 7** was used to calculate all load reductions:

Equation 7:

*Load Reduction = ((Measured Load – TMDL) / Measured Load)*100*
*Measured Load = measured nutrient concentration in mg/L*measured flow in cfs*5.4*
*TMDL = target concentration in mg/L*measured flow in cfs*5.4*

Calculated load reduction values greater than zero indicate that the TMDL is being exceeded and reductions are necessary. Calculated load reduction values less than or equal to zero are meeting the TMDL and no reductions are needed.

In cases where there was measured nutrients data but no flow, the points are not shown on the graphs but reductions are described for the values greater than the respective targets. **Equation 8** was used to calculate reductions based on concentration values:

Equation 8:

Concentration Reduction = ((Measured Concentration in mg/L – Target Concentration in mg/L) / Measured Concentration in mg/L)*100

As with calculating the load reductions, concentration reduction values greater than zero indicate that the TMDL is being exceeded and reductions are necessary.

5.5.6 Best Management Practice Scenario Development

BMP scenario development was completed by incorporating several best management practices on different land uses from the calibrated existing condition model. The results of each BMP scenario are then compared to the existing condition model to determine the change in loads from the land uses that were modified. Several scenarios were modeled to estimate nutrient loading reductions associated with various BMPs. Scenarios were focused on sources that tend to be the most significant for nutrients, and included improvements in management practices that are commonly recommended and applicable to the specific land uses in this watershed.

The scenarios are intended to simulate common BMPs but are not prescriptive, and should not be interpreted as exact reductions that are expected with the specified BMP. Rather, they are provided to show approximate reductions available and to show the relative effectiveness compared to other BMPs. This approach allows land managers to preferentially implement those BMPs that will have the greatest impact.

Scenarios modeled for this project include fertilizer reduction, improved grazing, stream channel livestock exclusion, riparian protection, and wastewater treatment improvement. Fertilizer reduction consists of two scenarios: 1) where 30% less fertilizer is applied to agricultural fields and urban lawns and 2) where 60% less fertilizer is applied. The grazing improvement scenario involves grazing livestock such that the conditions of both summer and winter grazed lands are improved. The stream channel livestock exclusion scenario involves removing livestock from adjacent to the stream and distributing them evenly over the remaining grazed area, thus preventing direct input of nutrients from livestock to the stream. The riparian protection scenario consists of the stream channel livestock exclusion scenario with the addition of improvements in the condition of riparian areas through the use of filter strips. The Philipsburg WWTP improvement scenario was only applied to TP loading as Flint Creek (Georgetown Lake to the confluence with Boulder Creek) is not impaired by either TN or nitrate. This scenario involves reducing the average TP concentration from the WWTP from 3.3 mg/L to the summer growing season target of 0.072 mg/L. Additional information regarding the BMP scenarios can be found in **Appendix E**.

5.6 SOURCE ASSESSMENTS, TOTAL MAXIMUM DAILY LOADS (TMDLS), ALLOCATIONS, REDUCTIONS, AND BEST MANAGEMENT PRACTICE SCENARIOS FOR EACH STREAM

The below sections describe the most significant natural, non-permitted, and permitted sources of nutrients in more detail, establish TMDLs and load allocations to specific source categories, provide nutrient loading estimates for nonpoint, and permitted point source categories to nutrient-impaired stream segments, estimate reductions necessary to meet water quality targets, and provide reduction estimates for various best management practice scenarios for the following streams:

- Barnes Creek
- Douglas Creek
- Flint Creek (Georgetown Lake to confluence with Boulder Creek)
- Flint Creek (Boulder Creek to mouth)
- Princeton Gulch
- Smart Creek

The existing loads are used to estimate load reductions by comparing them to the allowable (TMDL) load and computing a required percent reduction to meet the TMDL. These load reduction estimates can be complicated by nutrient uptake within the stream. Nitrate, TN, and/or TP target exceedances, or the extent by which they exceed a target, can be masked by nutrient uptake.

The results of the SWAT source assessment for the smaller impaired streams (Barnes Creek, Douglas Creek, Smart Creek and Princeton Gulch) may underestimate some of the loads from minor land uses within that sub-basin. As described in more detail in **Section 5.5.3**, minor agricultural and livestock land uses within each sub-basin may have combined with other predominant land uses to reduce the size of the model and reduce computational time. However, on the larger scale of the entire watershed this simplification of land uses is minor and does not have any noticeable effect on the source assessment in the two impaired sections of Flint Creek.

The source assessments for each impaired stream segment are broken into six categories: agriculture; livestock-other, livestock adjacent to stream, urban, septics, Philipsburg Wastewater Treatment Plant, and natural background. Livestock is broken into two categories to distinguish the impacts from direct waste discharge into streams from the more indirect sources of runoff and infiltration. Wastewater impacts are divided into two categories to distinguish the septic nonpoint sources from the point source discharge from Philipsburg. Additional urban impacts from impervious surface runoff and lawn maintenance impacts are included in the urban category.

5.6.1 Barnes Creek

5.6.1.1 Assessment of Water Quality Results

The source assessment for Barnes Creek consists of an evaluation of TN and TP concentrations and exceedances of chlorophyll-*a* within the impaired segment of Barnes Creek. This is followed by the quantification of the most significant human caused sources of nutrients as indicated by the SWAT model for the Flint watershed.

DEQ collected water quality samples from Barnes Creek during the growing season over the time period of 2004-2009 (**Section 5.4.3.1**, **Table 5-3**). **Figure 5-4** presents summary statistics for TN concentrations at sampling sites in Barnes Creek. With the exception of one sample at the site closest to the mouth, TN values in this segment were always greater than the target of 0.30 mg/L. In general, there is a decline in TN values when moving in the downstream direction. There was no TN data for sites C0BARNC01 and C0BARN02.

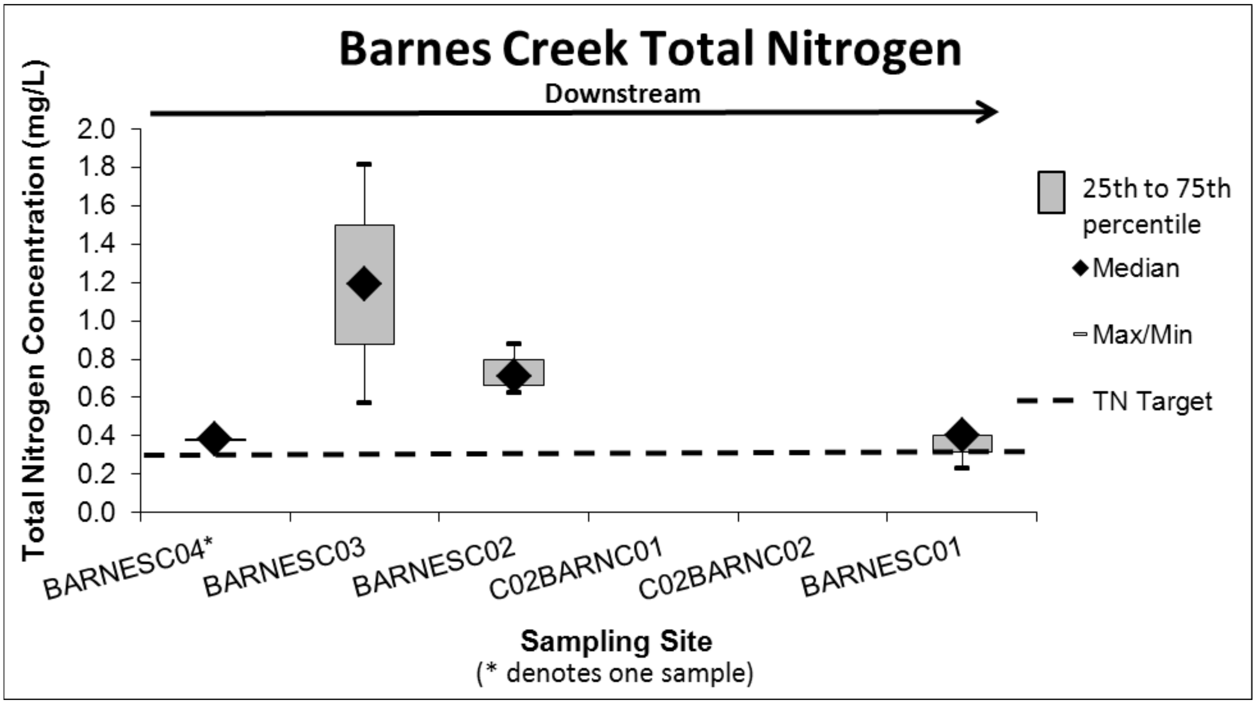

Figure 5-4. Total Nitrogen Box Plots for Barnes Creek

Figure 5-5 presents summary statistics for TP concentrations at sampling sites in Barnes Creek. TP values in this segment were always greater than the target of 0.03 mg/L at all sites. In general, there is a decrease in TP values when moving in the downstream direction.

Site BARNESC03 had the highest measured TN and TP values for this segment. Aerial imagery and a tour of the watershed may be performed to determine the specific source(s) of these high nutrients values and whether the application of BMPs is feasible.

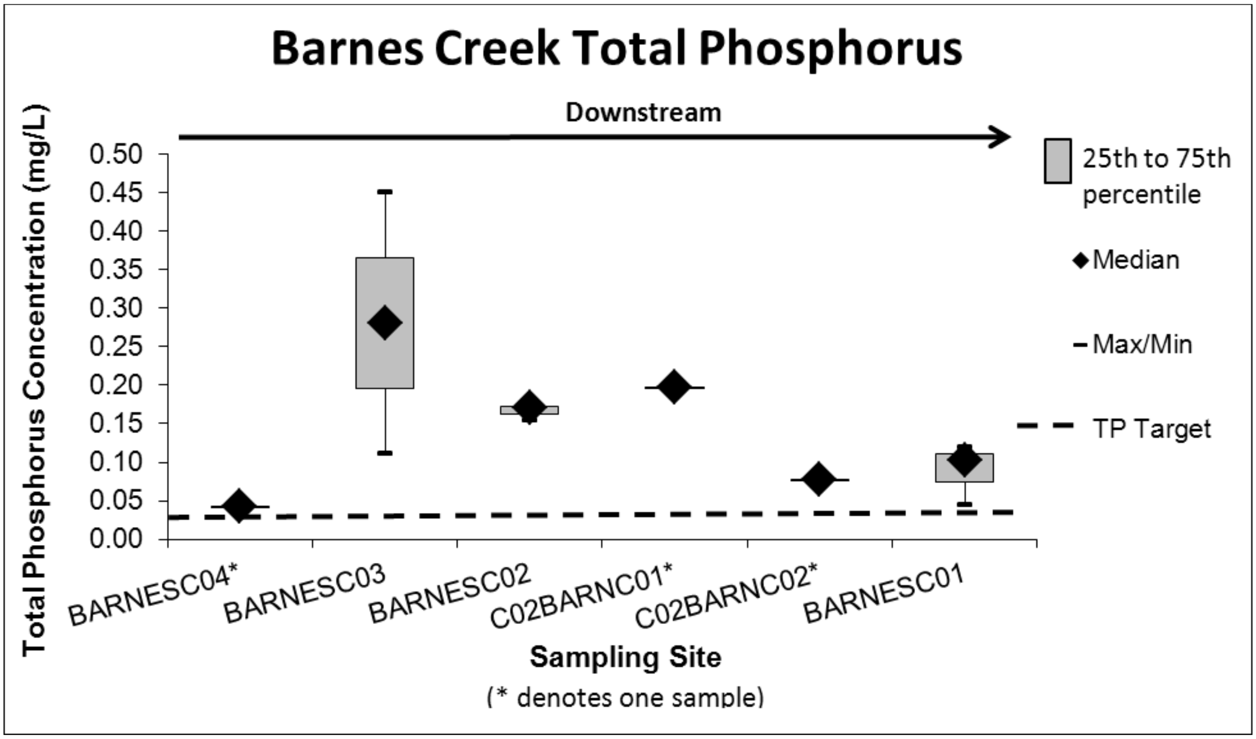

Figure 5-5. Total Phosphorus Box Plots for Barnes Creek

Two exceedances of the chlorophyll-*a* target of 125 mg/m² occurred in Barnes Creek. They occurred at BARNESC02 and BARNESC01 in September, 2007.

5.6.1.2 Assessment of Loading by Source Categories

The SWAT model results indicate that livestock adjacent to the stream is the greatest contributor of nitrogen to Barnes Creek during the summer growing season (**Figure 5-6**), making up more than half of the total load. This is followed by livestock-other, natural background, and then septics. Agriculture and urban each contribute less than 0.5% nitrogen to Barnes Creek.

Livestock adjacent to the stream is also the greatest contributor of phosphorus to Barnes Creek during the summer growing season (**Figure 5-7**), being more than 60% of the total load. This is followed by livestock-other, septics, and urban. Natural background contributes less than 1% and agriculture does not contribute a significant amount of phosphorus to Barnes Creek.

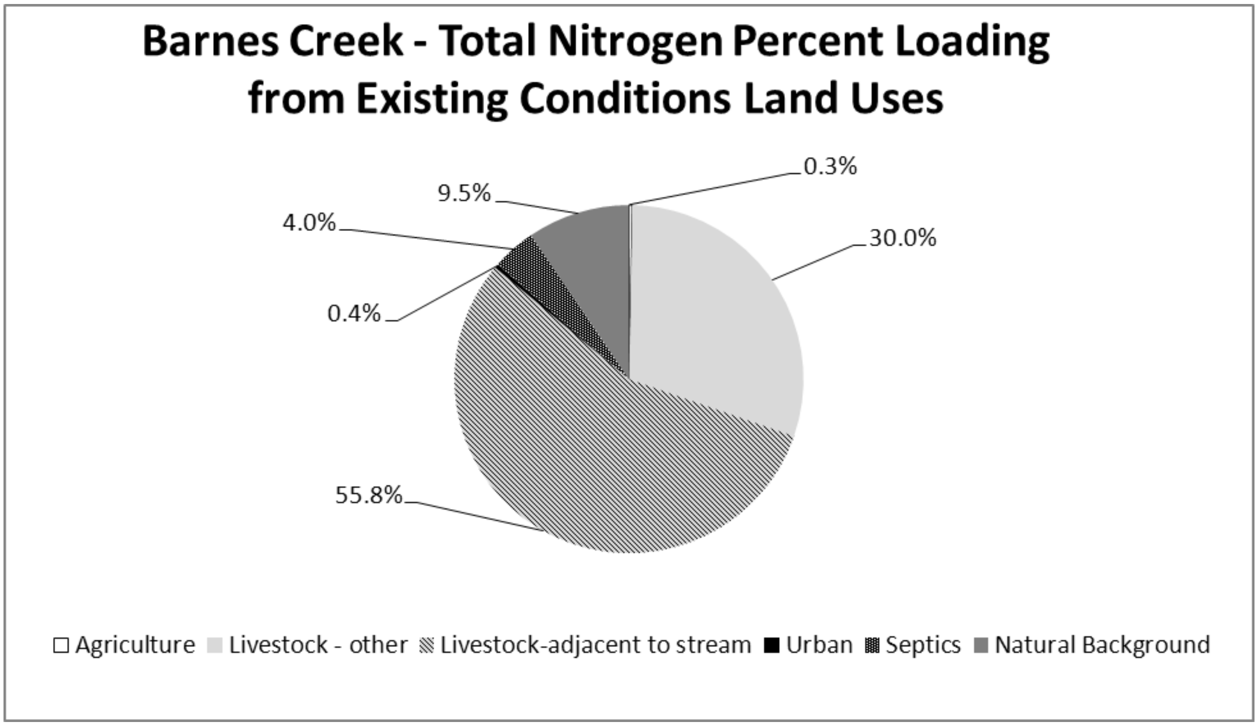

Figure 5-6. Percent Contribution of Total Nitrogen Sources to Barnes Creek during the Summer Growing Season

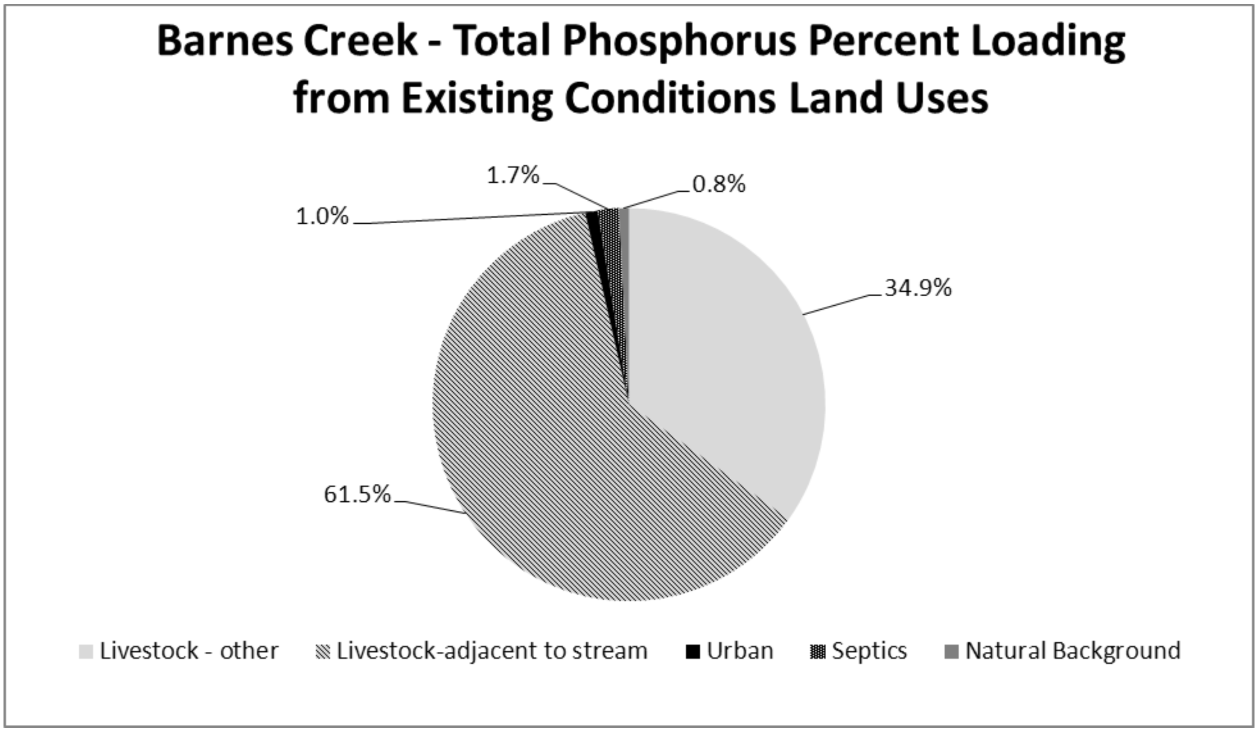

Figure 5-7. Percent Contribution of Total Phosphorus Sources to Barnes Creek during the Summer Growing Season

5.6.1.3 Total Nitrogen (TN) Total Maximum Daily Load (TMDL), Allocations, Current Loading, and Reductions

The TMDL for TN is based on **Equation 1** and the TMDL composite load allocation is based on **Equation 2**. The value of the TN TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TN TMDL for Barnes Creek uses **Equation 1** and the flow associated with the median reduction for measured loads that exceed the TN TMDL from all sites during 2007-2009 sampling (2.5 cfs):

***TMDL* = (0.30 mg/L) (2.5 cfs) (5.4) = 4.1 lbs/day**

Equation 2 is the basis for the example composite load allocation for TN. To continue with the example at a flow of 2.5 cfs, this allocation is as follows:

***LA* = 4.1 lbs/day**

An example total existing load is calculated as follows using **Equation 5** and the flow and concentration associated with the median reduction for measured loads that exceed the TMDL for TN in Barnes Creek from 2007-2009:

***Total Existing Load* = (0.57 mg/L) (2.5 cfs) (5.4) = 7.7 lbs/day**

The example TN TMDL, load allocation, and current loading are summarized in **Table 5-19**. Because the existing load is greater than the TMDL, a reduction is necessary to meet the water quality target for TN. This TMDL along with the TMDL for TP serve to address the chlorophyll-*a* impairment for Barnes Creek. By reducing nutrient loads in Barnes Creek, it is expected that algae growth and thus chlorophyll-*a* levels will be reduced. The source assessment for the Barnes Creek watershed indicates that livestock sources contribute the most human-caused TN loading; load reductions should focus on limiting and controlling TN loading from these sources. Meeting load allocations for Barnes Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 7.0**.

Table 5-19. Barnes Creek Total Nitrogen Example Total Maximum Daily Load, Load Allocation, and Current Loading

Source Category	Allocation & TMDL (lbs/day)[1]	Existing Load (lbs/day)[1]
Composite Load	4.1	7.7

[1] *Based on a growing season flow of 2.5 cfs*

Figure 5-8 shows the percent reductions for TN loads measured in Barnes Creek from 2007-2009. TN reductions are required from the smallest to the largest measured flows. Only one of the measured loads was less than or equal to the TMDL. Loads greater than the TMDL require reductions ranging from 21% to 83%.

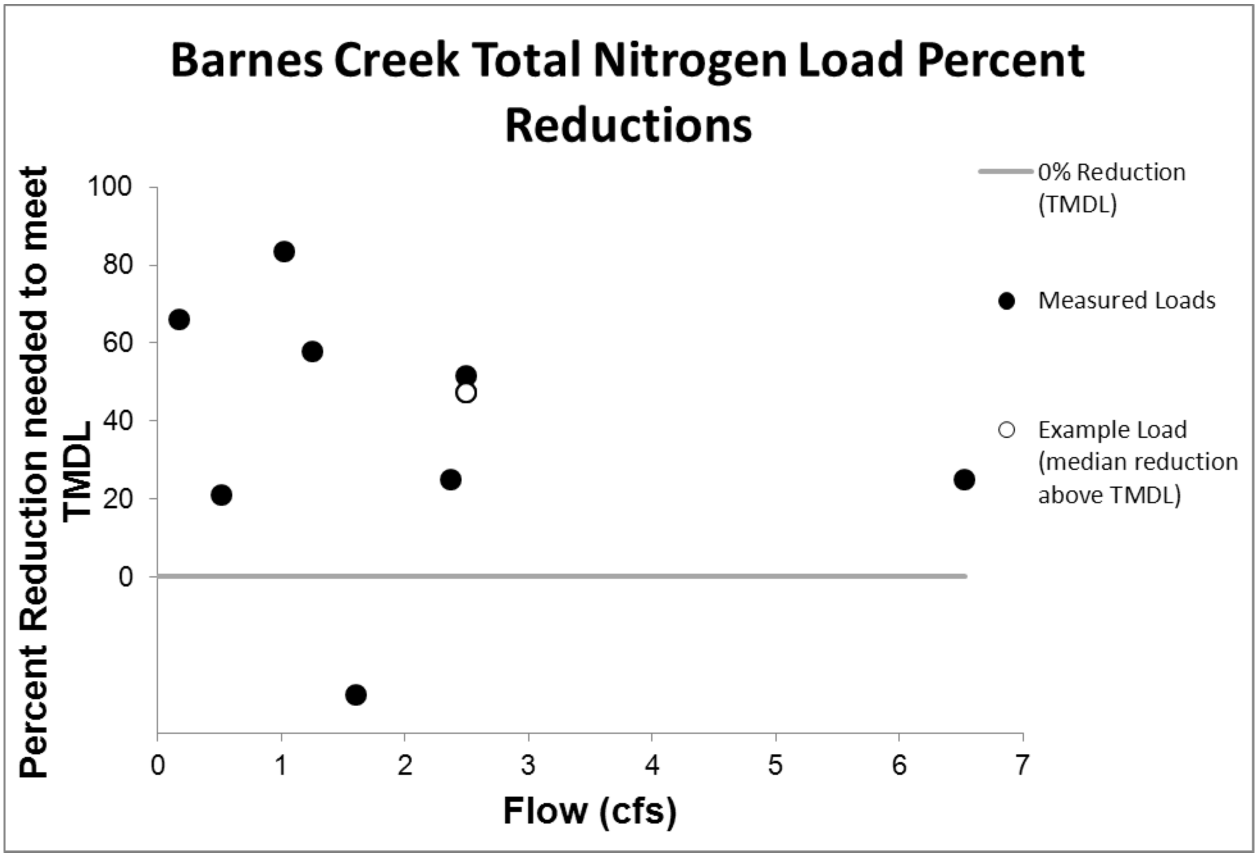

Figure 5-8. Measured Total Nitrogen Loads Percent Reductions for Barnes Creek

All points on or below the gray line are meeting the TMDL. The example existing load from **Table 5-19** is represented by the hollow circle.

5.6.1.4 Nitrate TMDL Surrogate

Because nitrate is a component of TN, and because the loading sources and methods to reduce loading sources of nitrate and TN are essentially the same, the above TMDL for TN provides a surrogate TMDL for nitrate in Barnes Creek. Seven of the 11 nitrate values measured from Barnes Creek were above the target of 0.10 mg/L (**Tables 5-3** and **5-4**). As a result, existing nitrate loading requires reductions consistent with the TN TMDL and the composite load allocation for nitrate would apply to the same source categories as the TN composite load allocation.

5.6.1.5 Total Phosphorus TMDL, Allocations, Current Loading, and Reductions

The TMDL for TP is based on **Equation 1** and the TMDL allocation is based on **Equation 2**. The value of the TP TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TP TMDL for Barnes Creek uses **Equation 1** and the flow associated with the median reduction for measured loads that exceed the TP TMDL from all sites during 2004-2009 sampling (6.53 cfs):

***TMDL* = (0.03 mg/L) (6.53 cfs) (5.4) = 1.1 lbs/day**

Equation 2 is the basis for the example composite load allocation for TP. To continue with the example at a flow of 6.53 cfs, this allocation is as follows:

***LA* = 1.1 lbs/day**

An example total existing load is calculated as follows using **Equation 5** and the flow and concentration associated with the median reduction for measured loads that exceed the TMDL for TP in Barnes Creek from 2004-2009:

***Total Existing Load* = (0.119 mg/L) (6.53 cfs) (5.4) = 4.2 lbs/day**

The example TP TMDL, load allocation, and current loading are summarized in **Table 5-20**. Because the existing load is greater than the TMDL, a reduction is necessary to meet the water quality target for TP. This TMDL along with the TMDL for TN serve to address the chlorophyll-*a* impairment for Barnes Creek. By reducing nutrient loads in Barnes Creek, it is expected that algae growth and thus chlorophyll-*a* levels will be reduced. The source assessment for the Barnes Creek watershed indicates that livestock sources contribute the most human-caused TP loading; load reductions should focus on limiting and controlling TP loading from these sources. Meeting load allocations for Barnes Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 7.0**.

Table 5-20. Barnes Creek Total Phosphorus Example Total Maximum Daily Load, Load Allocation, and Current Loading

Source Category	Allocation & TMDL (lbs/day)[1]	Existing Load (lbs/day)[1]
Composite Load	1.1	4.2

[1] *Based on a growing season flow of 6.53 cfs*

Figure 5-9 shows the percent reductions for TP loads measured in Barnes Creek from 2004-2009. TP reductions are required from the smallest to the largest measured flows. None of the measured loads were less than or equal to the TMDL. Loads require reductions ranging from 30% to 93% to meet the TMDL.

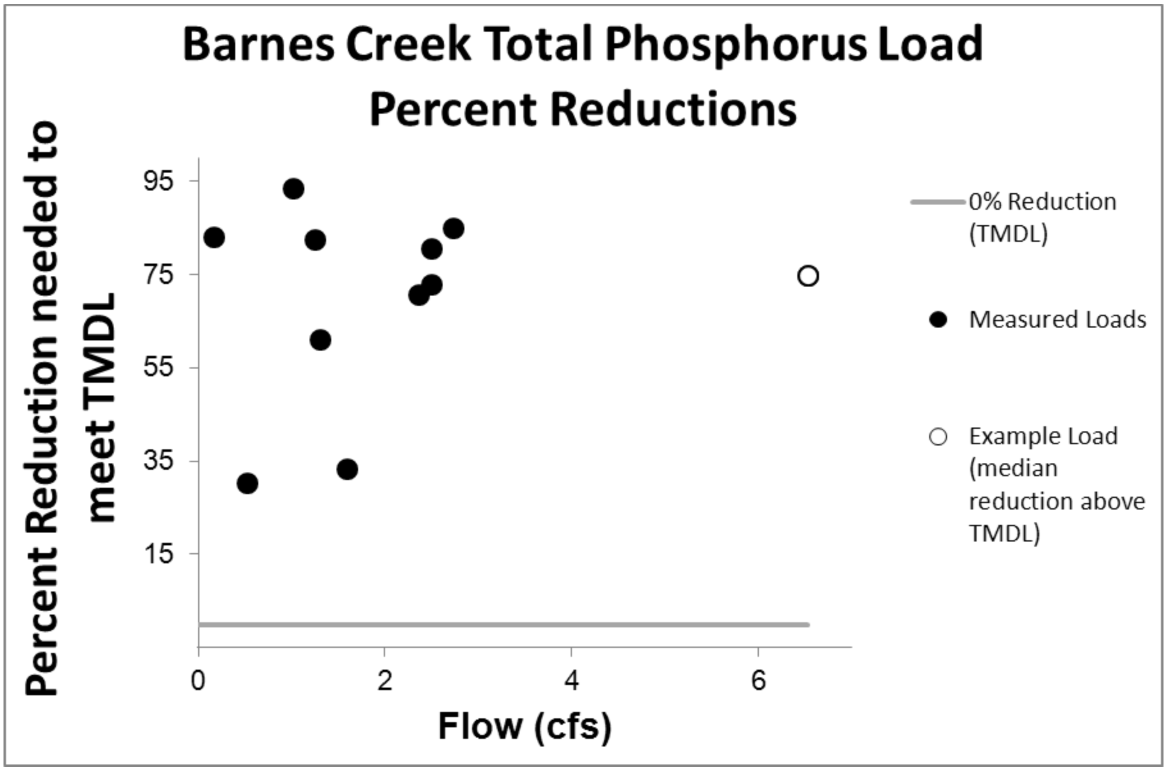

Figure 5-9. Measured Total Phosphorus Loads Percent Reductions for Barnes Creek
All points on or below the gray line are meeting the TMDL. The example existing load from **Table 5-20** is represented by the hollow circle.

5.6.1.4 Best Management Practice Scenarios

Removing cattle from areas adjacent to Barnes Creek results in reductions of about 81% for TN and 82% for TP (**Figures 5-10** and **5-11**). Adding filter strips in addition to removing cattle from areas adjacent to the stream reduces TN about an additional 1% and TP about an additional 2%. Both fertilizer reduction scenarios result in less than a 0.5% reduction of TN and no significant reduction of TP. Grazing improvement does not reduce either TN or TP significantly.

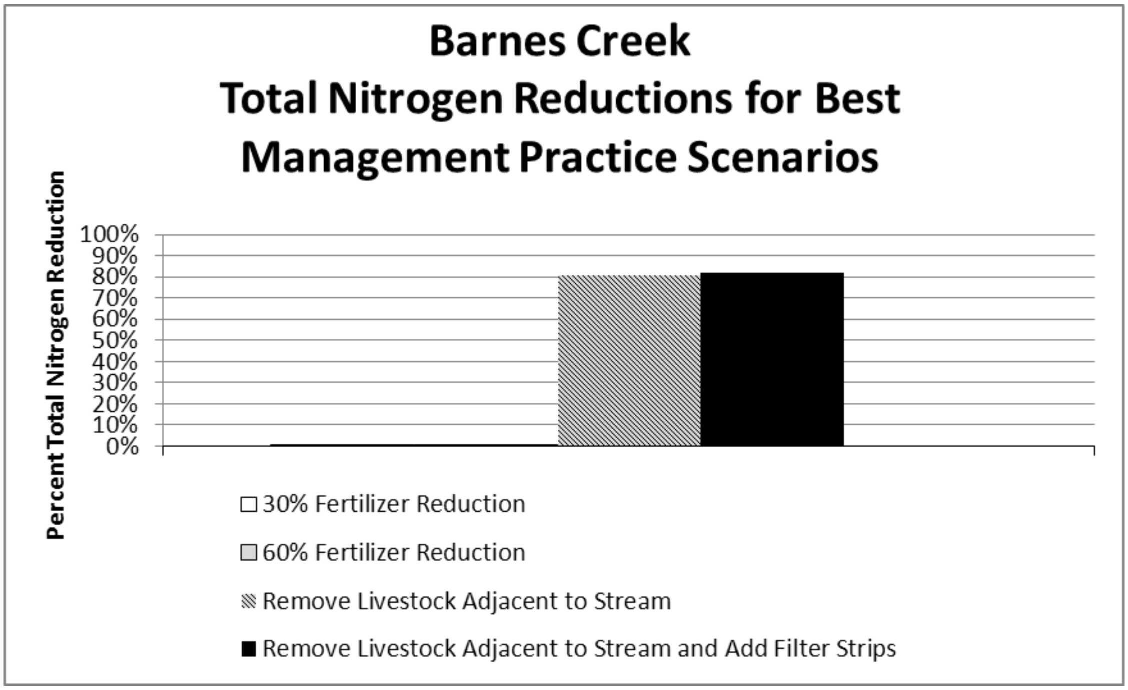

Figure 5-10. Total Nitrogen Best Management Practice Scenarios for Barnes Creek during the Summer Growing Season

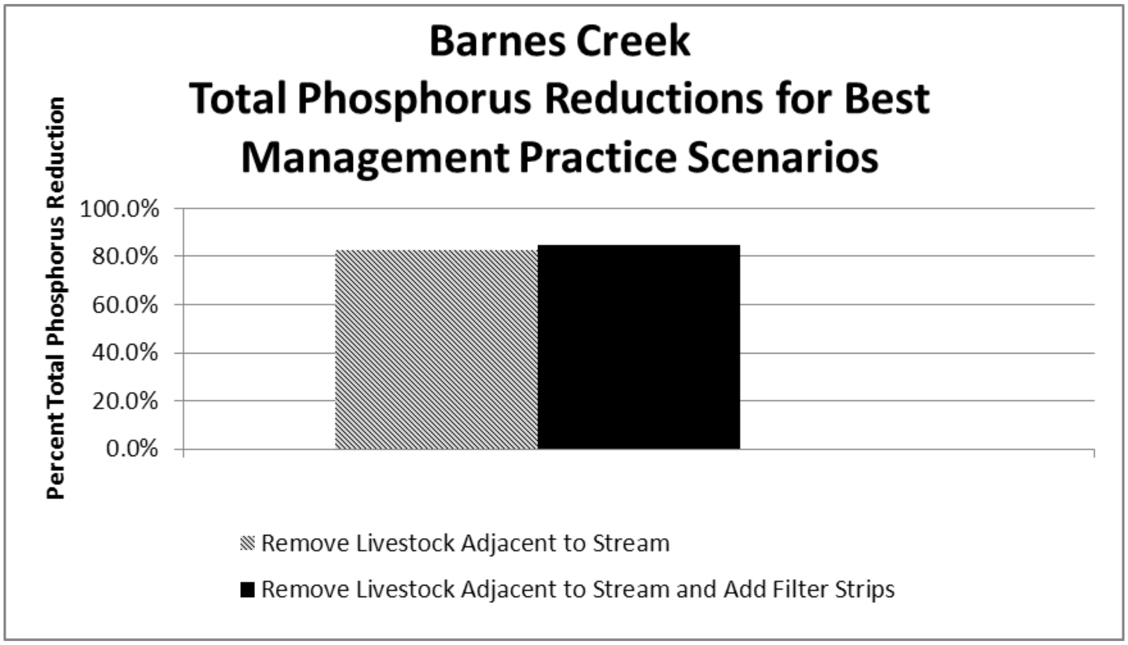

Figure 5-11. Total Phosphorus Best Management Practice Scenarios for Barnes Creek during the Summer Growing Season

5.6.2 Douglas Creek

5.6.2.1 Assessment of Water Quality Results

The source assessment for Douglas Creek consists of an evaluation of nitrate and TP concentrations and exceedances of chlorophyll-*a*. This is followed by the quantification of the most significant human caused sources of nutrients as indicated by the SWAT model for the Flint watershed.

DEQ collected water quality samples from Douglas Creek during the growing season over the time period of 2007-2009 (**Section 5.4.3.2, Table 5-5**). **Figure 5-12** presents summary statistics for nitrate concentrations at sampling sites in Douglas Creek. The most upstream site was the only site that did not have at least one nitrate value greater than the target of 0.10 mg/L. There is a slight trend toward higher nitrate values when moving in the downstream direction.

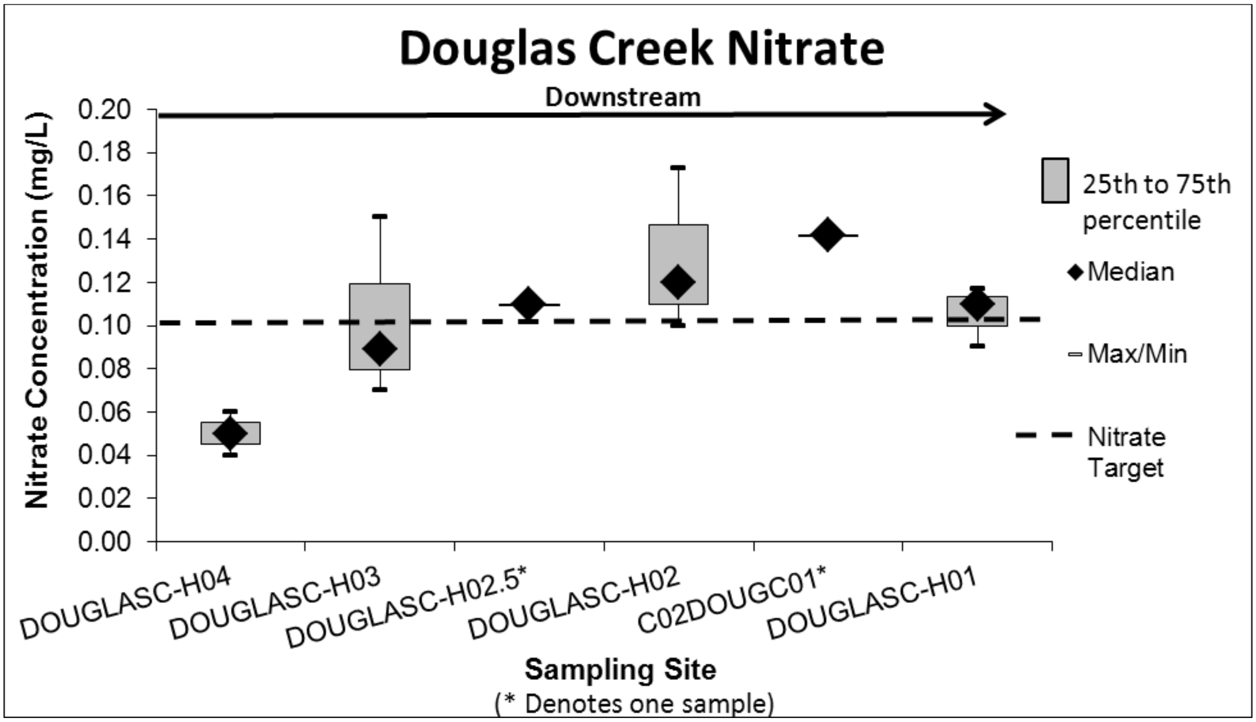

Figure 5-12. Nitrate Box Plots for Douglas Creek

Figure 5-13 presents summary statistics for TP concentrations at sampling sites in Douglas Creek. TP values in this segment were always less than the target of 0.03 mg/L at the upper three sites and always greater than the target at the lower three sites. There is a trend toward higher TP values when moving in the downstream direction.

Sites DOUGLASC-H02, C02DOUGC01, DOUGLASC-H01 tended to have the highest measured nitrate and TP values for this segment. Aerial imagery and a tour of the watershed may be performed to determine the specific source(s) of these high nutrients values and whether the application of BMPs is feasible.

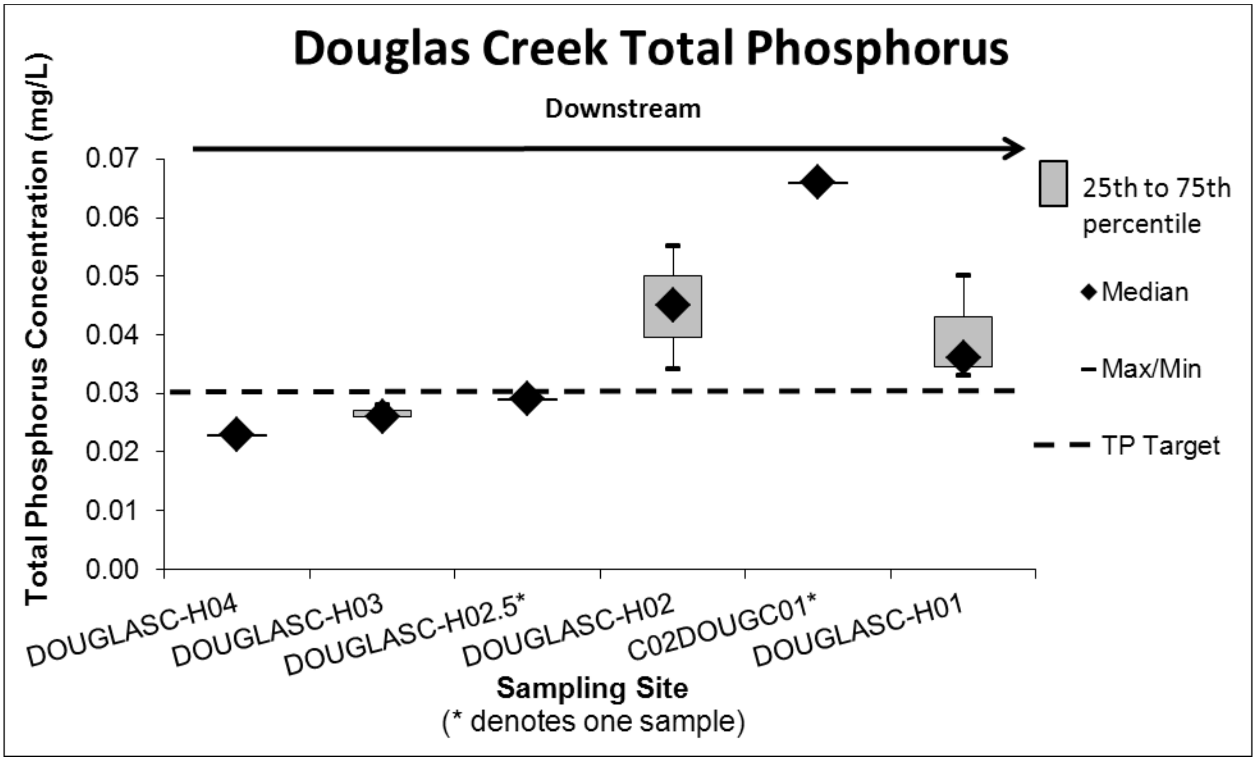

Figure 5-13. Total Phosphorus Box Plots for Douglas Creek

Two exceedances of the chlorophyll-*a* target of 125 mg/m² occurred in Douglas Creek. They occurred at DOUGLASC-H02 and DOUGLASC-H01 in August, 2007.

5.6.2.2 Assessment of Loading by Source Categories

The SWAT model results indicate that natural background is the greatest contributor of nitrogen to Douglas Creek during the summer growing season (**Figure 5-14**), making up more than half of the total load. This is followed by livestock adjacent to the stream, livestock-other, and then septics. Urban contributes less than 0.5% and agriculture does not contribute a significant amount of nitrogen to Douglas Creek.

Livestock adjacent to the stream is the greatest contributor of phosphorus to Douglas Creek during the summer growing season (**Figure 5-15**), being more than 75% of the total load. This is followed by natural background, urban, and then livestock-other. Septics contribute just over 1% and agriculture does not contribute a significant amount of phosphorus to Douglas Creek.

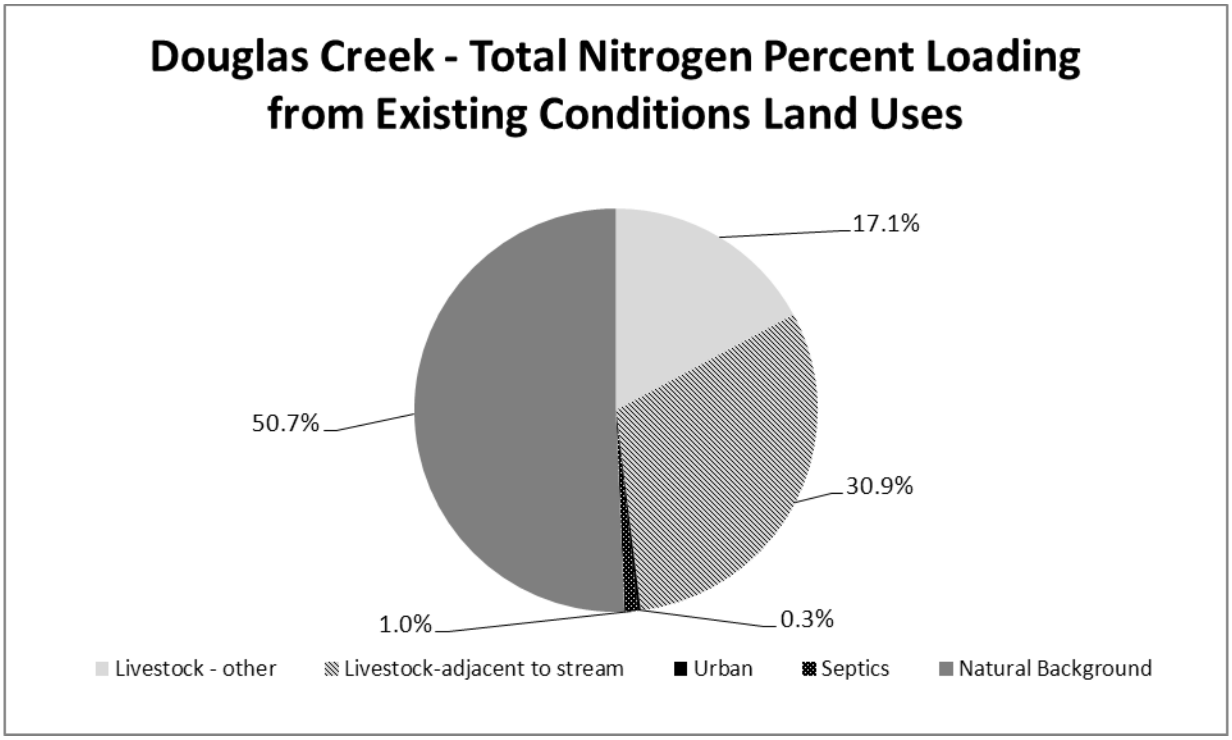

Figure 5-14. Percent Contribution of Total Nitrogen Sources to Douglas Creek during the Summer Growing Season

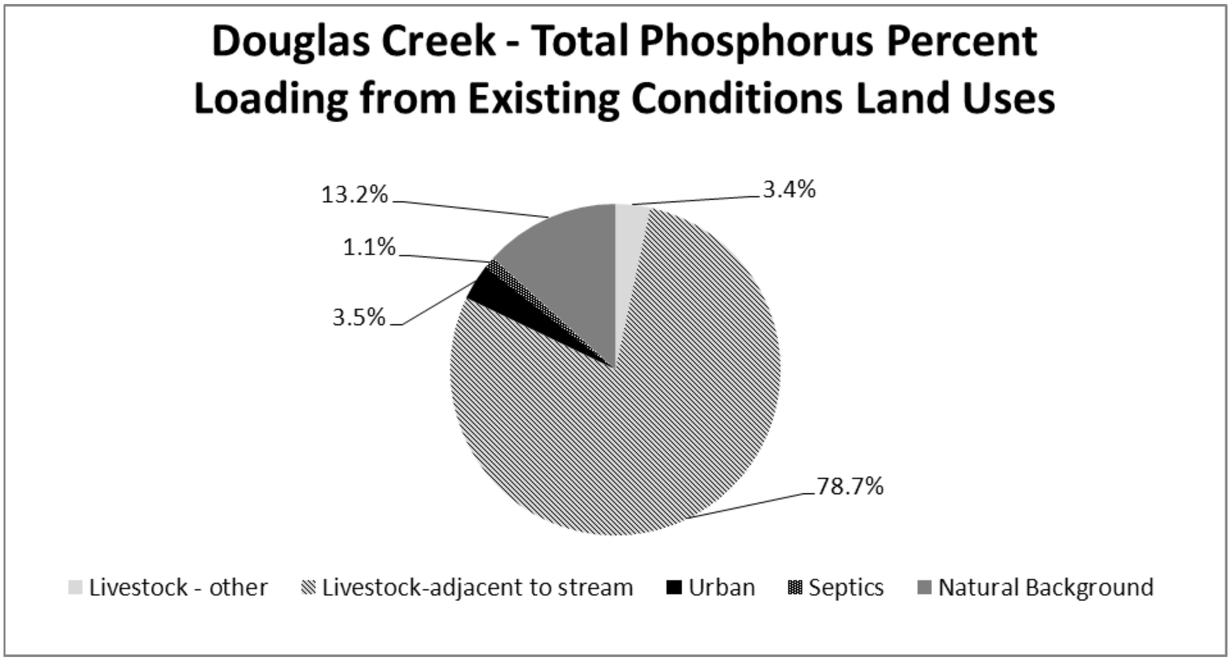

Figure 5-15. Percent Contribution of Total Phosphorus Sources to Douglas Creek during the Summer Growing Season

5.6.2.3 Nitrate TMDL, Allocations, Current Loading, and Reductions

The TMDL for nitrate is based on **Equation 1** and the TMDL allocation is based on **Equation 2**. The value of the nitrate TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example nitrate TMDL for Douglas Creek uses **Equation 1** and the flow associated with the median reduction for measured loads that exceed the nitrate TMDL from all sites during 2007-2009 sampling (1.65 cfs):

***TMDL* = (0.1 mg/L) (1.65 cfs) (5.4) = 0.9 lb/day**

Equation 2 is the basis for the example composite load allocation for nitrate. To continue with the example at a flow of 1.65 cfs, this allocation is as follows:

***LA* = 0.9 lb/day**

An example total existing load is calculated as follows using **Equation 5** and the flow and concentration associated with the median reduction for measured loads that exceed the nitrate TMDL in Douglas Creek from 2007-2009:

***Total Existing Load* = (0.117 mg/L) (1.65 cfs) (5.4) = 1.0 lb/day**

The example nitrate TMDL, load allocation, and current loading are summarized in **Table 5-21**. Because the existing load is greater than the TMDL, a reduction is necessary to meet the water quality target for nitrate. Although the source assessment for the Douglas Creek watershed indicates that natural background sources are contributing the most TN loading overall, livestock sources contribute the most human-caused TN loading; load reductions should focus on limiting and controlling nitrate loading from these human-caused sources. Meeting load allocations for Douglas Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 7.0**.

Table 5-21. Douglas Creek Nitrate Example Total Maximum Daily Load, Load Allocation, and Current Loading

Concentration data with no associated flow are not represented in this table.

Source Category	Allocation & TMDL (lbs/day)[1]	Existing Load (lbs/day)[1]
Composite Load	0.9	1.0

[1] *Based on a growing season flow of 1.65 cfs*

Figure 5-16 shows the percent reductions for nitrate loads measured in Douglass Creek from 2007-2009. Nitrate reductions are required from the smallest to the largest measured flows. Six of the measured loads were less than or equal to the TMDL. Loads greater than the TMDL require reductions ranging from 9% to 42%.

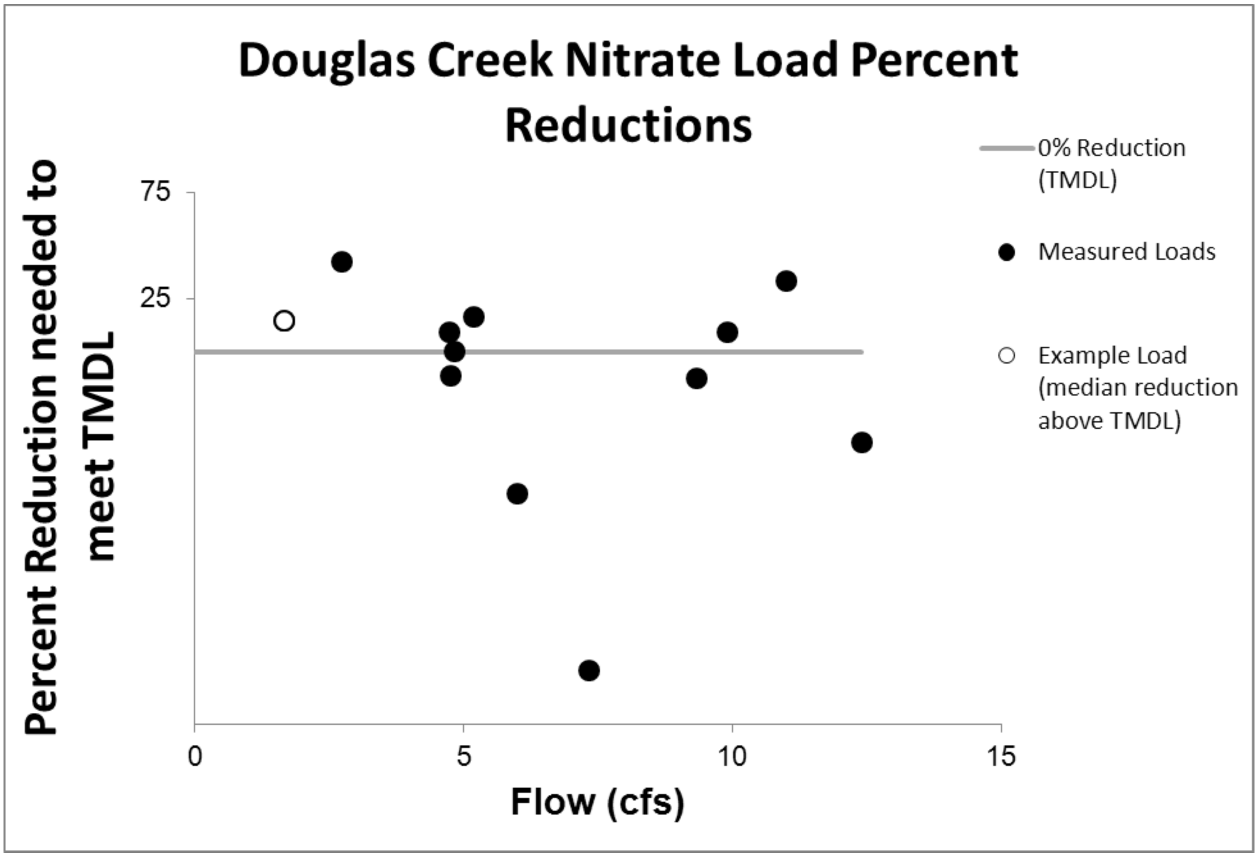

Figure 5-16. Measured Nitrate Loads Percent Reductions for Douglas Creek
All points on or below the gray line are meeting the TMDL. The example existing load from **Table 5-21** is represented by the hollow circle. Concentration data with no associated flow are not represented in this figure.

5.6.2.4 Total Phosphorus TMDL, Allocations, Current Loading, and Reductions

The TMDL for TP is based on **Equation 1** and the TMDL allocation is based on **Equation 2**. The value of the TP TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TP TMDL for Douglas Creek uses **Equation 5** and the flow associated with the median reduction for measured loads that exceed the TP TMDL from all sites during 2007-2009 sampling (4.76 cfs):

TMDL **= (0.03 mg/L) (4.76 cfs) (5.4) = 0.8 lb/day**

Equation 2 is the basis for the example composite load allocation for TP. To continue with the example at a flow of 4.76 cfs, this allocation is as follows:

LA **= 0.8 lb/day**

An example total existing load is calculated as follows using **Equation 5** and the flow and concentration associated with the median reduction for measured loads that exceed the TP TMDL in Douglas Creek from 2007-2009:

Total Existing Load **= (0.036 mg/L) (4.76 cfs) (5.4) = 0.9 lb/day**

The example TP TMDL, load allocation, and current loading are summarized in **Table 5-22**. Because the existing load is greater than the TMDL, a reduction is necessary to meet the water quality target for TP. The source assessment for the Douglas Creek watershed indicates that livestock sources contribute the most human-caused phosphorus loading; load reductions should focus on limiting and controlling TP loading from these sources. Meeting load allocations for Douglas Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 7.0**.

Table 5-22. Douglas Creek Total Phosphorus Example Total Maximum Daily Load, Load Allocation, and Current Loading

Concentration data with no associated flow are not represented in this table.

Source Category	Allocation & TMDL (lbs/day)[1]	Existing Load (lbs/day)[1]
Composite Load	0.8	0.9

[1] *Based on a growing season flow of 4.76 cfs*

Figure 5-17 shows the percent reductions for TP loads measured in Douglas Creek from 2007-2009. TP reductions are required for all loads measured at less than 6 cfs. Six of the measured loads were less than or equal to the TMDL. Loads greater than the TMDL require reductions ranging from 9% to 45%. One TP concentration value (0.066 mg/L; represented in **Figure 5-13**) that exceeded the target did not have an associated flow and therefore a load could not be calculated. The percent reduction of this concentration was 55%.

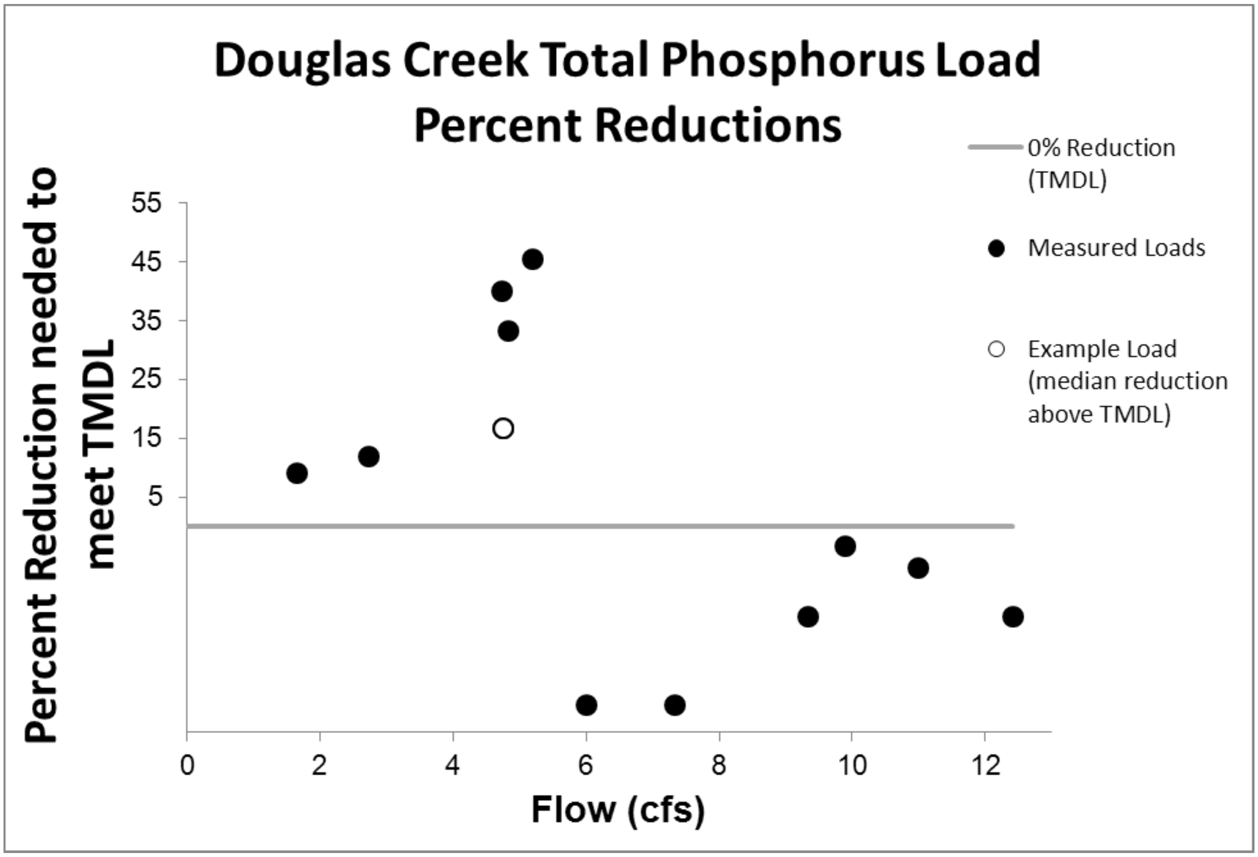

Figure 5-17. Measured Total Phosphorus Loads Percent Reductions for Douglas Creek

All points on or below the gray line are meeting the TMDL. The example existing load from **Table 5-22** is represented by the hollow circle. Concentration data with no associated flow are not represented in this figure.

5.6.2.4 Best Management Practice Scenarios

Removing cattle from areas adjacent to Douglas Creek results in reductions of about 29% for TN and 78% for TP (**Figures 5-18** and **5-19**). Adding filter strips in addition to removing cattle from areas adjacent to the stream reduces both TN and TP about an additional 1%. Both fertilizer BMP scenarios result in less than 0.5% reduction of TP and no significant reduction of TN. Grazing improvement reduces both TN and TP less than 0.5%.

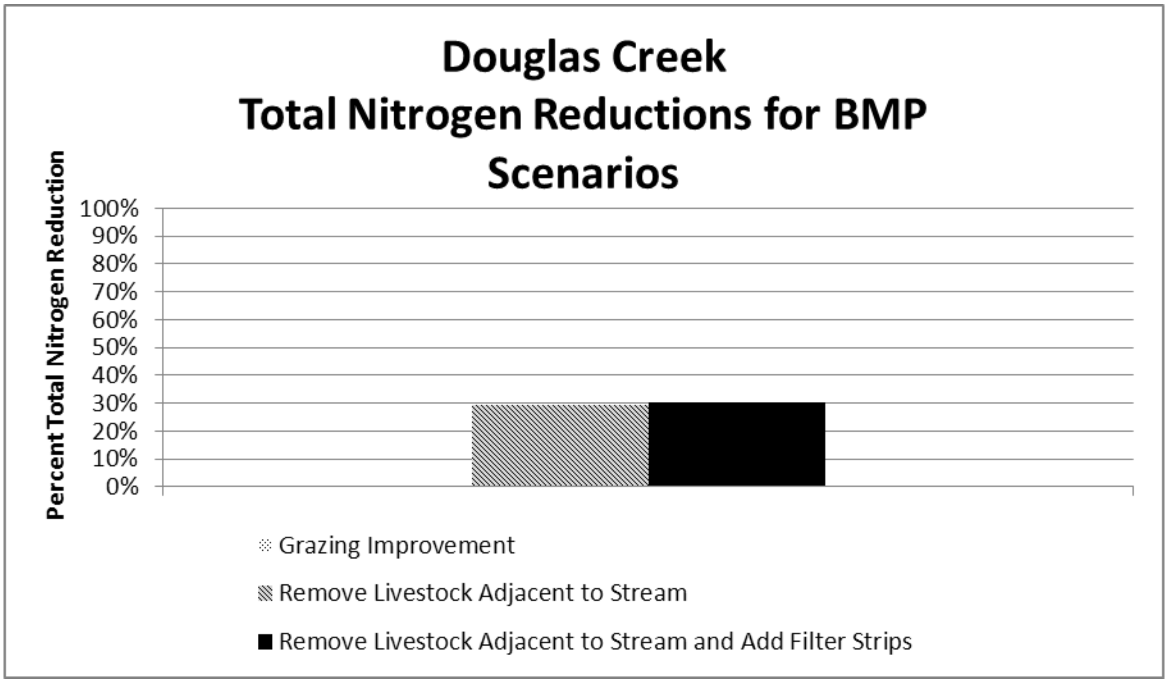

Figure 5-18. Total Nitrogen Best Management Practice Scenarios for Douglas Creek during the Summer Growing Season

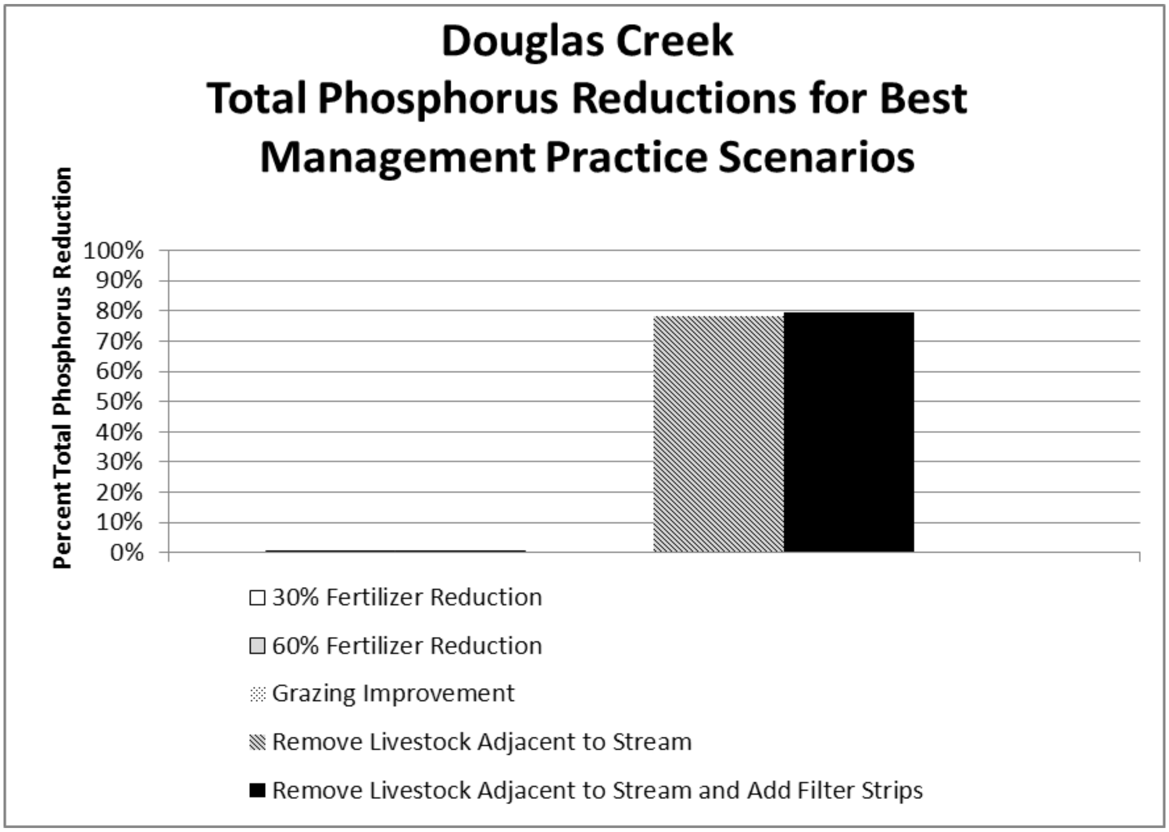

Figure 5-19. Total Phosphorus Best Management Practice Scenarios for Douglas Creek during the Summer Growing Season

5.6.3 Flint Creek (Georgetown Lake to Confluence with Boulder Creek)

5.6.3.1 Assessment of Water Quality Results

The source assessment for Flint Creek (Georgetown Lake to confluence with Boulder Creek) consists of an evaluation of TP concentrations and exceedances of chlorophyll-*a*. This is followed by the quantification of the most significant human caused sources of nutrients as indicated by the SWAT model for the Flint watershed.

DEQ collected water quality samples from this segment of Flint Creek during the growing season over the time period of 2005-2009 (**Section 5.4.3.3, Table 5-7**). **Figure 5-20** presents summary statistics for TP concentrations at sampling sites in Flint Creek (Georgetown Lake to confluence with Boulder Creek). TP values at sites in this segment were generally less than the targets of 0.072 mg/L and 0.030 mg/L (at Flint 8). Exceptions to this were at the sites Flint 15 (directly below Georgetown Lake), Flint 10.75 and Flint 10.25 (which are located directly above and below the Philipsburg WWTP discharge respectively), and Flint 8. Overall, TP values are generally stable when moving in the downstream direction.

The data shown in **Figure 5-20** show that TP values directly above (Flint 10.75) and directly below (Flint 10.25) the WWTP are similar. At the historical loading rates of TP from the WWTP, the WWTP should have a significant impact on instream TP concentrations, and one would expect that the values downstream of the WWTP would be greater than those upstream. There are three potential explanations for the lack of measureable impacts: 1) the WWTP lagoons are leaking nutrients into the stream upstream from the discharge point and sampling site Flint 10.75 was not far enough upstream to escape this influence, 2) soluble forms of phosphorus from the WWTP are being taken up by aquatic organisms locally and thus TP measurements do not capture the actual effects of the phosphorus inputs from the WWTP, and 3) the values at the upstream site are elevated due to nonpoint sources. To determine which of these explanations is correct will require additional sampling of nutrients, chlorophyll-*a*, and AFDM. If additional sampling occurs and it is determined that there is assimilative capacity for TP at this location on Flint Creek, the TP example WLAs (**Tables 5-23**, **5-24**, and **5-26**) for the two Flint Creek segments will need to be adjusted as per the discussion in **Section 5.5.4.3**.

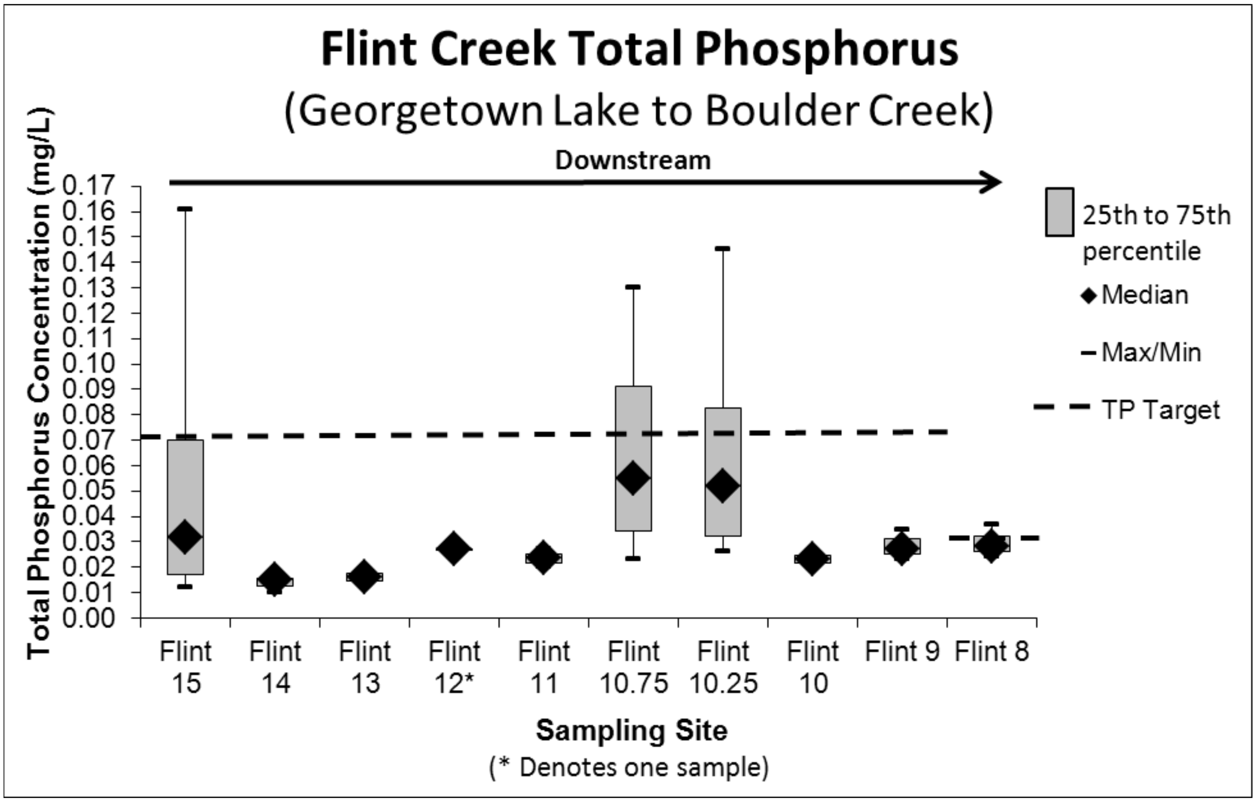

Figure 5-20. Total Phosphorus Box Plots for Flint Creek (Georgetown Lake to confluence with Boulder Creek)

Three exceedances of the chlorophyll-*a* target of 150 mg/m² occurred in this segment of Flint Creek. They occurred at Flint 14, Flint 12, and Flint 09 in August, 2007.

5.6.3.2 Assessment of Loading by Source Categories

The SWAT model results indicate that livestock-other is the greatest contributor of phosphorus to Flint Creek (Georgetown Lake to confluence with Boulder Creek) during the summer growing season (**Figure 5-21**), contributing more than 40% of the total load. This is followed by livestock adjacent to the stream, septics, the Phillipsburg Wastewater Treatment Plant, and then natural background. Urban and agriculture are the smallest contributors of phosphorus to this segment at 4.8% and 1% respectively.

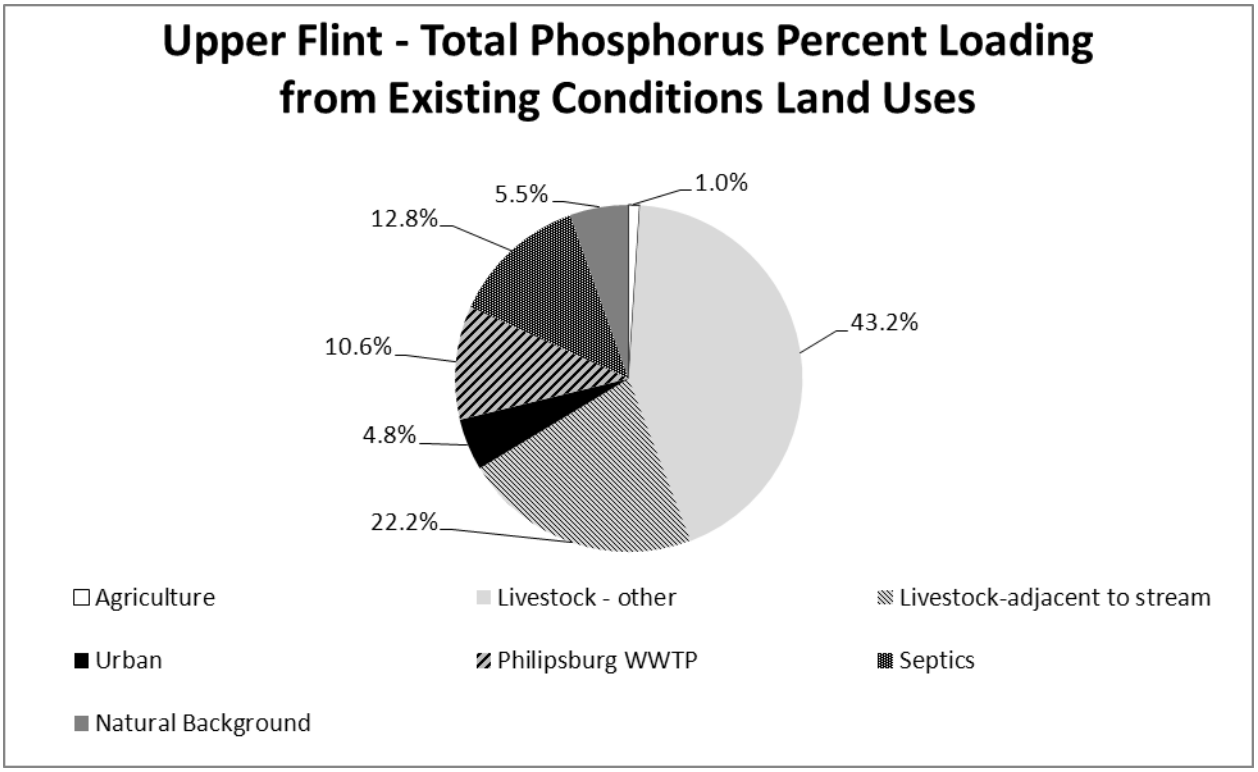

Figure 5-21. Percent Contribution of Total Phosphorus Sources to Flint Creek (Georgetown Lake to Boulder Creek) during the Summer Growing Season

5.6.3.3 Total Phosphorus TMDLs, Allocations, Current Loading, and Reductions

TMDL Example 1 (Flint Creek from Georgetown Lake to ecoregion 17ak boundary; **Figure 5-1**) for TP is based on **Equation 1** and the TMDL allocation and wasteload allocation are based on **Equation 3**. The value of TP TMDL Example 1 is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TP TMDL uses **Equation 1** with the flow associated with the median measured load from all sites during 2005-2009 sampling (65.87 cfs):

$$TMDL = (0.072\ \text{mg/L})\ (65.87\ \text{cfs})\ (5.4) = 25.61\ \text{lbs/day}$$

The TP WLA for the Philipsburg WWTP is calculated using **Equation 4**, and is shown in **Figure 5-3**. For TMDL Example 1, an example TP WLA at 0.16 cfs (average summer growing season discharge from the WWTP from August 2007 to September 2012) can be calculated:

$$WLA_{TP} = (0.072\ \text{mg/L})\ (0.16\ \text{cfs})\ (5.4) = 0.06\ \text{lb/day}$$

Equation 3 is the basis for calculating the example composite load allocation once the Philipsburg WWTP wasteload allocation and TMDL for TP are known:

$$LA + 0.06\ \text{lb/day} = 25.61\ \text{lbs/day}$$

Therefore:

$$LA = 25.61\ \text{lbs/day} - 0.06\ \text{lb/day} = 25.55\ \text{lbs/day}$$

An example total existing load is calculated as follows using **Equation 5** and the flow and concentration associated with the median measured load for TP in Flint Creek (Georgetown Lake to ecoregion 17ak boundary) from 2007-2009:

Total Existing Load = (0.027 mg/L) (65.87 cfs) (5.4) = 9.6 lbs/day

Equation 6 is the basis for calculating the existing composite load. The example existing WWTP TP load is 2.7 lbs/day as described in **Section 5.5.4.4**:

Existing Composite Load = 9.6 lbs/day – 2.7 lbs/day = 6.9 lbs/day

Table 5-23 contains the results for TP TMDL, load allocations, wasteload allocations, and current loading Example 1. Although the example existing load in **Table 5-23** is less than the TMDL, TP reductions are necessary based on concentration data collected with no associated flow (**Figure 5-20**). Any time concentration exceeds a target, the corresponding load, if flow is measured, exceeds the TMDL since the TMDL equation is based on concentration multiplied by the flow. As mentioned in **Section 5.6.3.1**, if it is determined that Flint Creek at the WWTP has assimilative capacity for TP, the wasteload allocation to the WWTP in the example TMDL (**Table 5-23**) will need to be adjusted accordingly.

Table 5-23. Flint Creek (Georgetown Lake to ecoregion 17ak boundary) Total Phosphorus Total Maximum Daily Load, Load Allocations, Wasteload Allocation, and Current Loading Example 1

Concentration data with no associated flow are not represented in this table.

Source Category	Allocation & TMDL (lbs/day)	Existing Load (lbs/day)
Composite Load	25.55	6.9
Wasteload (Philipsburg WWTP)	0.06[1]	2.7[3]
	TMDL = 25.61[2]	**Total = 9.6[2]**

[1] *Based on summer growing season flow of 0.16 cfs from the Philipsburg WWTP 2007-2012*

[2] *Based on a growing season flow of 65.87 cfs*

[3] *Average load based on summer growing season data from the Philipsburg WWTP 2007-2012*

TMDL Example 2 Flint Creek (ecoregion 17ak boundary to confluence with Boulder Creek; **Figure 5-1**) for TP is based on **Equation 1** and the TMDL allocation and wasteload allocation are based on **Equation 3**. The value of TP TMDL Example 2 is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TP TMDL uses **Equation 1** with the flow associated with the only measured load from this section during 2005-2009 sampling (174.84 cfs):

***TMDL* = (0.03 mg/L) (174.84 cfs) (5.4) = 28.32 lbs/day**

The TP WLA for the Philipsburg WWTP is calculated using **Equation 4**, and is shown in **Figure 5-3**. For TMDL Example 1, an example TP WLA at 0.16 cfs (average summer growing season discharge from the WWTP from August 2007 – September 2012) can be calculated:

WLA_{TP} = (0.072 mg/L) (0.16 cfs) (5.4) = 0.06 lbs/day

Equation 3 is the basis for the example composite load allocation and example Philipsburg WWTP wasteload allocation for TP. To continue with the example at a flow of 174.84 cfs, this allocation is as follows:

***LA + 0.06 lb/day* = 28.32 lbs/day**

Therefore:

***LA* = 28.32 lbs/day - 0.06 lb/day = 28.26 lbs/day**

An example total existing load is calculated as follows using **Equation 5** and the flow and concentration associated with the median measured load for TP in Flint Creek (17ak boundary to confluence with Boulder Creek) from 2007-2009:

Total Existing Load = (0.024 mg/L) (174.84 cfs) (5.4) = 22.66 lbs/day

Equation 6 is the basis for calculating the existing composite load. The example existing WWTP TP load is 2.7 lbs/day as described in **Section 5.5.4.4**:

Existing Composite Load = 22.66 – 2.7 = 19.96 lbs/day

Table 5-24 contains the results for TP TMDL, load allocations, and current loading Example 2. Although the example existing load in **Table 5-24** is less than the TMDL, TP reductions are necessary based on concentration data collected with no associated flow (**Figure 5-20**). Any time concentration exceeds a target, the corresponding load, if flow is measured, exceeds the TMDL since the TMDL equation is based on concentration multiplied by the flow. As mentioned in **Section 5.6.3.1**, if it is determined that Flint Creek at the WWTP has assimilative capacity for TP, the TP wasteload allocation to the WWTP in the example TMDL (**Table 5-24**)will need to be adjusted accordingly.

Table 5-24. Flint Creek (ecoregion 17ak boundary to confluence with Boulder Creek) Total Phosphorus Total Maximum Daily Load, Load Allocations, Wasteload Allocation, and Current Loading Example 2
Concentration data with no associated flow are not represented in this table.

Source Category	Allocation & TMDL (lbs/day)	Existing Load (lbs/day)
Composite Load	28.26	19.96
Wasteload (Philipsburg WWTP)	0.06[1]	2.7[3]
	TMDL = 28.32[2]	**Total = 22.66[2]**

[1] *Based on summer growing season flow of 0.16 cfs from the Philipsburg WWTP 2007-2012*
[2] *Based on a growing season flow of 174.84 cfs*
[3] *Average load based on summer growing season data from the Philipsburg WWTP 2007-2012*

Although none of the measured loads was greater than the TMDLs for this waterbody segment, and thus the example existing loads in **Tables 5-23** and **5-24** are less than the respective TMDLs, the concentration data (with no associated flow) for Upper Flint indicates that there are times when the TP targets are exceeded and reductions are necessary. The concentration data shows that 15 of 58 TP samples exceeded the target concentration (0.072 mg/L) in the Georgetown Lake to ecoregion 17ak boundary reach and one of three TP samples exceeded the target concentration (0.03 mg/L) in the ecoregion 17ak boundary to confluence with Boulder Creek reach. Reductions to TP loading will be necessary to achieve the targets and thus the TMDLs for each reach. The source assessment for the Flint

Creek (Georgetown Lake to confluence with Boulder Creek) watershed indicates that livestock sources contribute the most human-caused TP loading; load reductions should focus on limiting and controlling TP loading from these sources. In addition, reductions in the loading of TP from the WWTP will contribute to lower TP values in this segment. Meeting load allocations for Flint Creek in this waterbody segment may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 7.0**.

Figure 5-22 shows the percent reductions for TP loads measured in Flint Creek (Georgetown Lake to confluence with Boulder Creek) from 2005-2009. All of the measured loads were less than or equal to the TMDL. Although TP reductions are not required for any of the measured loads, concentrations were measured for TP (without an associated flow). These samples are represented in **Figure 5-20**. Reductions for these concentrations range from 1% to 55%. In addition chlorophyll-*a* samples were collected that exceeded targets giving further indication that TP load reduction is needed.

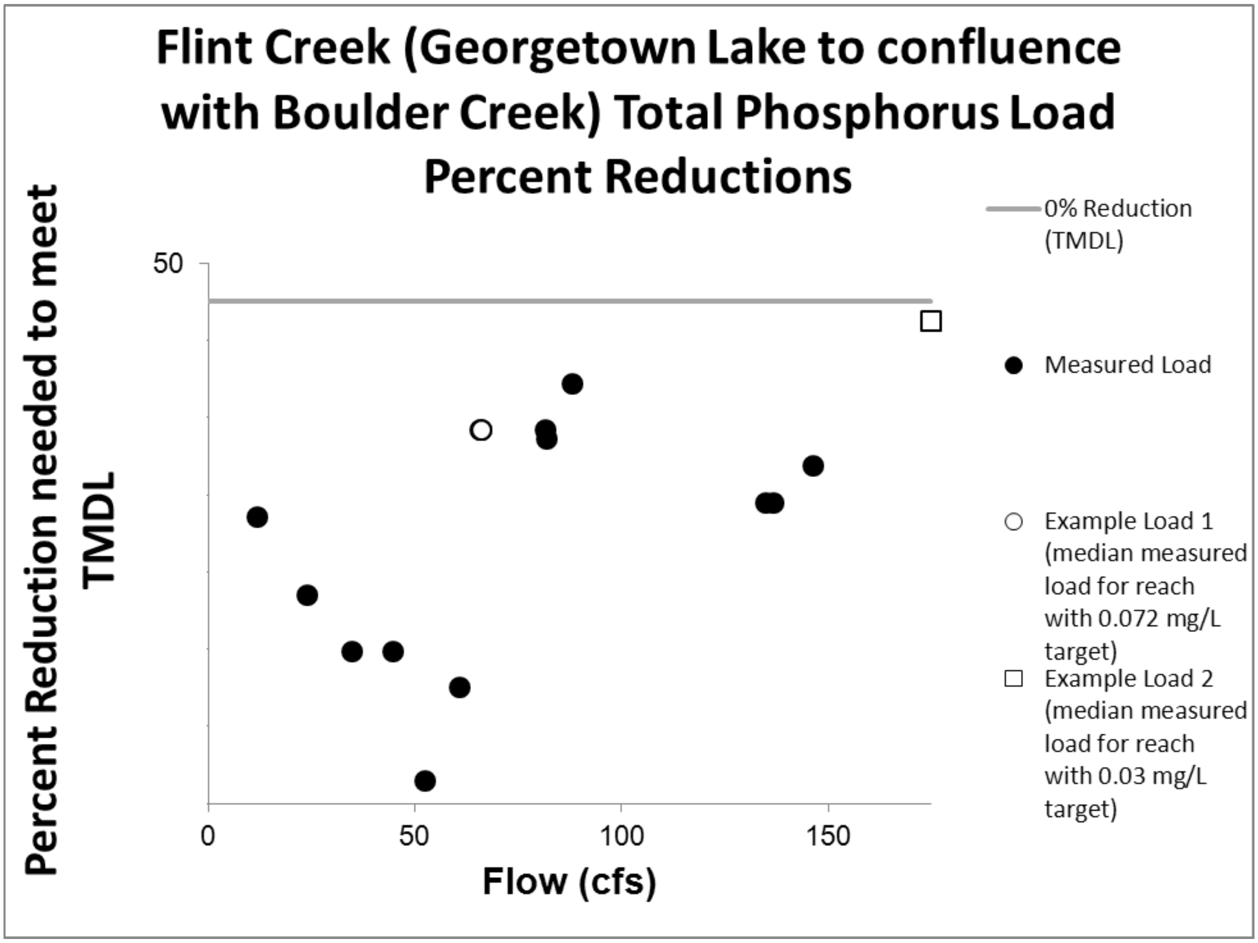

Figure 5-22. Total Phosphorus Percent Reductions for Measured Total Phosphorus Loads from Flint Creek (Georgetown Lake to confluence with Boulder Creek)

All points on or below the gray line are meeting the TMDL. The example existing loads from **Tables 5-23** and **5-24** are represented by the hollow symbols. Concentration data with no associated flow are not represented in this figure.

5.6.3.4 Best Management Practices Scenarios

Removing cattle from areas adjacent to Flint Creek (Georgetown Lake to confluence with Boulder Creek) results in a reduction of about 33% for TP (**Figure 5-23**). Adding filter strips in addition to removing cattle from areas adjacent to the stream reduces TP about an additional 3%. Reducing the concentration of phosphorus discharged from the Philipsburg WWTP from current levels to the target of 0.072 mg/L results in about a 7% reduction to the summer growing season load. The 30% fertilizer reduction BMP scenario results in about a 3% reduction of TP while the 60% fertilizer reduction BMP scenario results in about a 5.5% reduction. Grazing improvement reduces TP less than 0.5%.

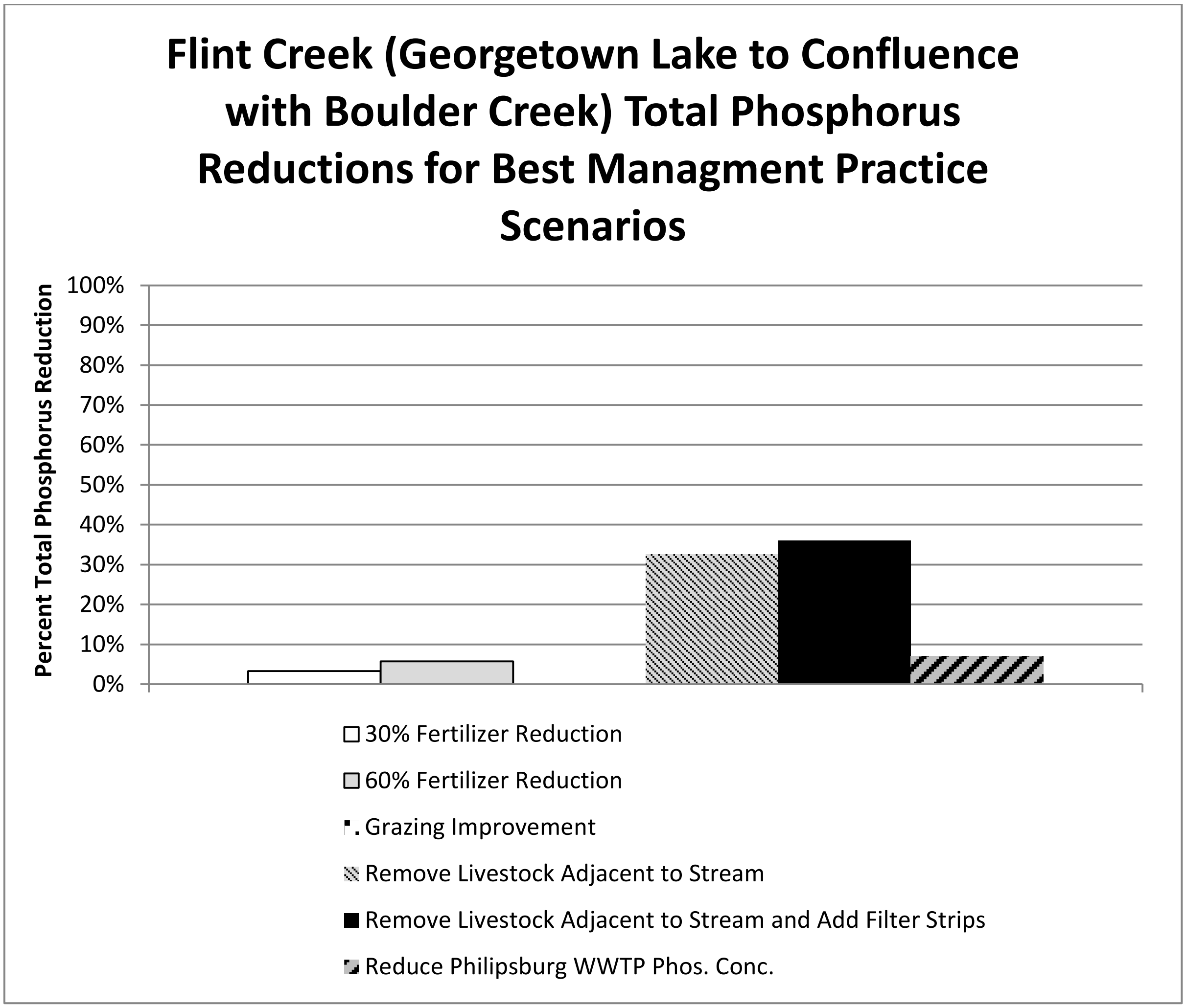

Figure 5-23. Total Phosphorus BMP Scenarios for Flint Creek (Georgetown Lake to confluence with Boulder Creek) during the Summer Growing Season

5.6.4 Flint Creek (Boulder Creek to mouth)

5.6.4.1 Assessment of Water Quality Results

The source assessment for Flint Creek (Boulder Creek to mouth) consists of an evaluation of TN and TP concentrations and exceedances of chlorophyll-*a*. This is followed by the quantification of the most significant human caused sources of nutrients as indicated by the SWAT model for the Flint watershed.

DEQ collected water quality samples from Flint Creek (Boulder Creek to mouth) during the growing season over the time period of 2002-2012 (**Section 5.4.3.4, Table 5-9**). **Figure 5-24** presents summary statistics for TN concentrations at sampling sites in this segment of Flint Creek. TN values in this segment were always less than or equal to the target of 0.30 mg/L. There is an increasing trend in TN in the downstream direction. No TN data was collected from site CFRPO-11.5.

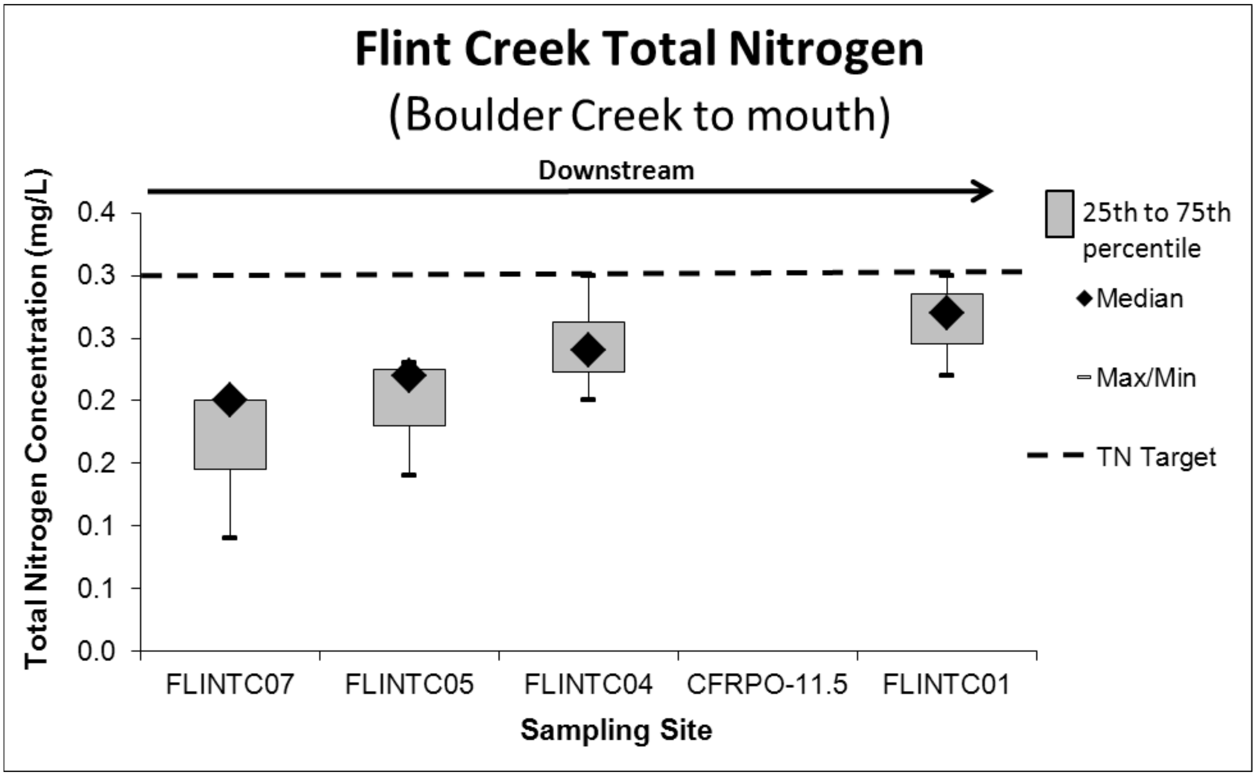

Figure 5-24. Total Nitrogen Box Plots for Flint Creek (Boulder Creek to mouth)

Figure 5-25 presents summary statistics for TP concentrations at sampling sites in Flint Creek (Boulder Creek to mouth). TP values in this segment were nearly always above the target of 0.03 mg/L. At the three lowermost sites, all TP values were greater than the target. There is an increasing trend in TP in the downstream direction.

Only one sample (for TP) was collected at site CFRPO-11.5 but it had the highest measured value for this segment. Sampling for TP and TN should occur at this site to verify whether or not it tends to have the greatest nutrient values for the segment. If it does, aerial imagery and a tour of the watershed may be performed to determine the specific source(s) of these high nutrients values and whether the application of BMPs is feasible.

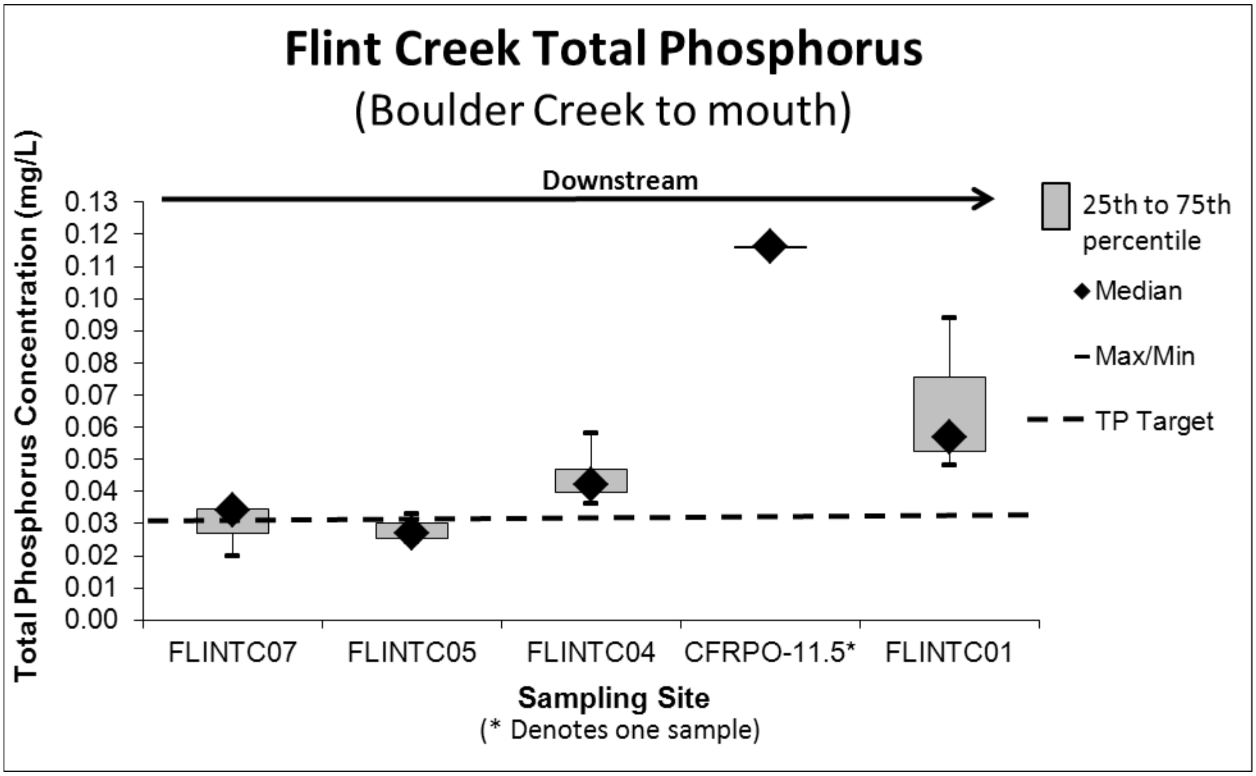

Figure 5-25. Total Phosphorus Box Plots for Flint Creek (Boulder Creek to mouth)

Three exceedances of the chlorophyll-*a* target of 125 mg/m² occurred in this segment of Flint Creek. They occurred at FLINTC05 in August, 2007, FLINTC04 in September, 2007, and FLINTC01 in August, 2009.

5.6.4.2 Assessment of Loading by Source Categories

The source assessment of Flint Creek (Boulder Creek to mouth) includes the entire Flint Creek watershed even though the TMDLs are specifically for the section downstream of Boulder Creek. The SWAT model results indicate that livestock (both groups combined) is the greatest contributor of nitrogen to Flint Creek (Boulder Creek to mouth) during the summer growing season (**Figure 5-26**), making up more than 37% of the total load. This is followed by agriculture, natural background, then livestock adjacent to the stream, and then septics. The Philipsburg Wastewater Treatment Plant contributes just over 1% and urban contributes less than 0.5% nitrogen to this segment of Flint Creek.

The livestock-other source is the greatest contributor of phosphorus to Flint Creek (Boulder Creek to mouth) during the summer growing season (**Figure 5-27**), being nearly half of the total load. This is followed by livestock-adjacent to the stream, agriculture, septics, and then natural background. The Philipsburg Wastewater Treatment Plan contributes less than 4% and urban contributes less than 3% phosphorus to this segment of Flint Creek.

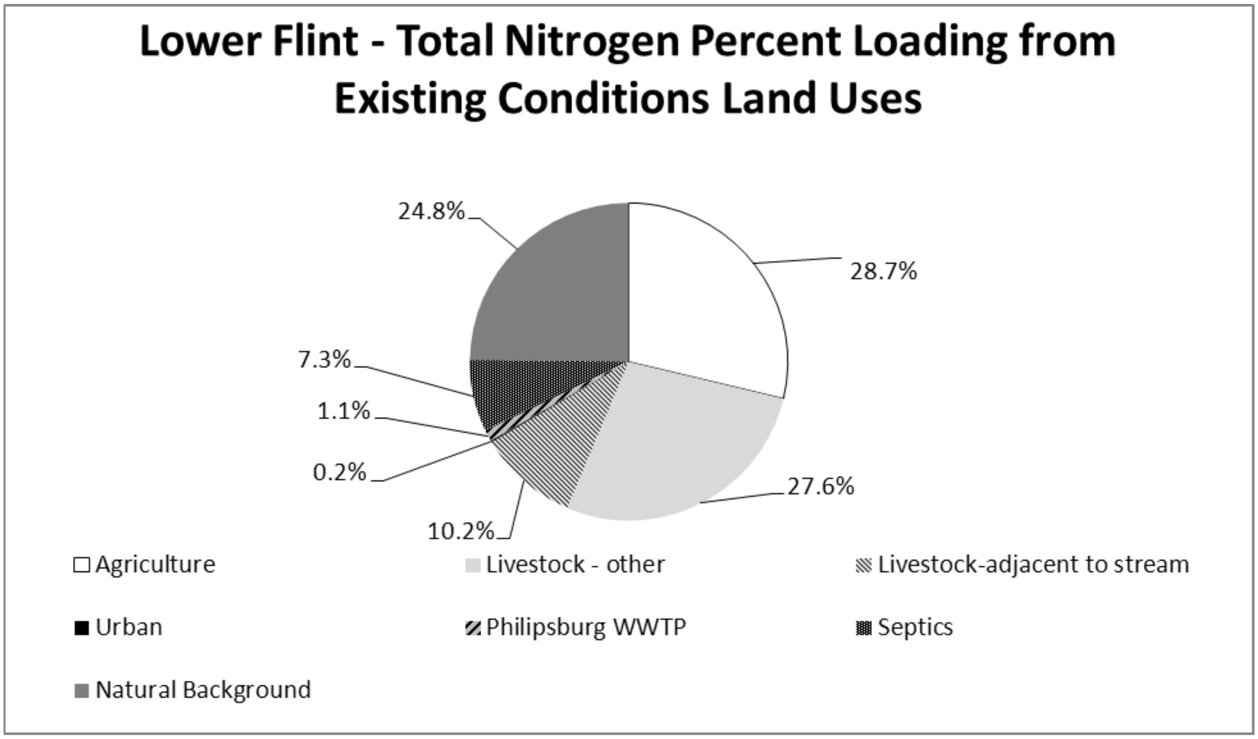

Figure 5-26. Percent Contribution of Total Nitrogen Sources to Flint Creek (Boulder Creek to mouth) during the Summer Growing Season

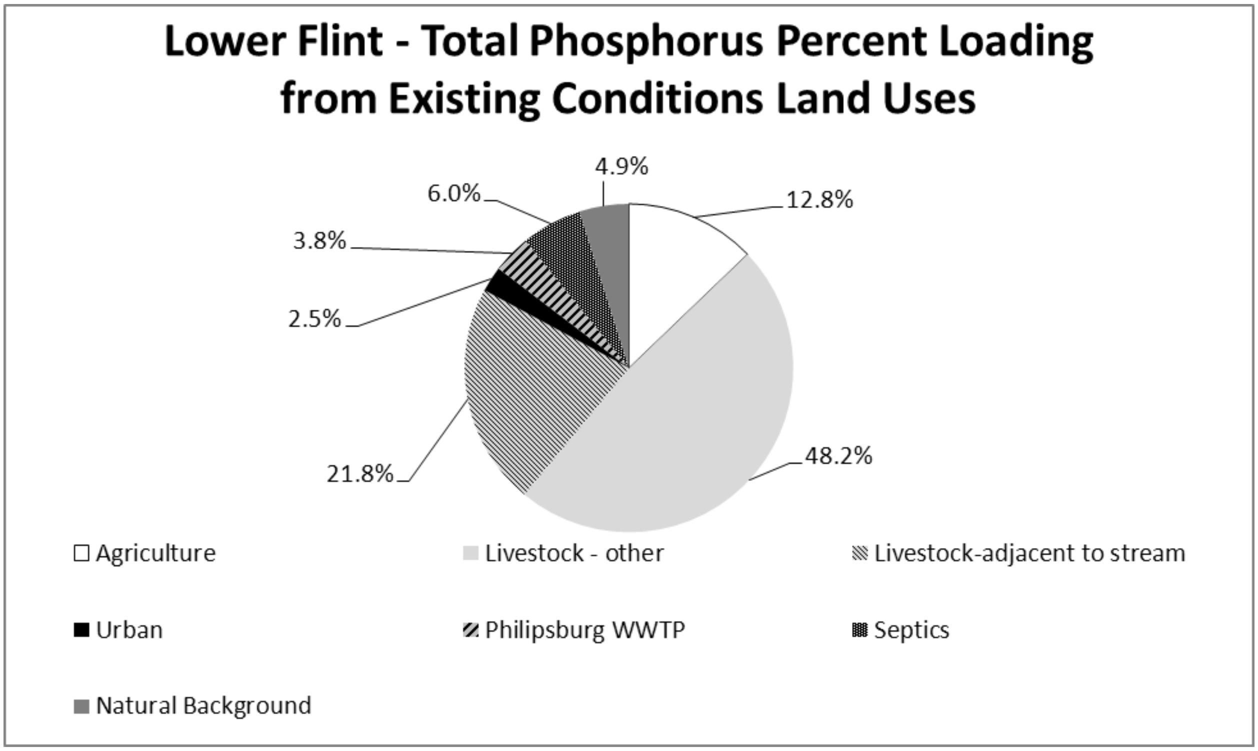

Figure 5-27. Percent Contribution of Total Phosphorus Sources to Flint Creek (Boulder Creek to mouth) during the Summer Growing Season

5.6.4.3 Total Nitrogen Total Maximum Daily Load, Allocations, Current Loading, and Reductions

The TMDL for TN is based on **Equation 1** and the TMDL allocation and wasteload allocation are based on **Equation 3**. The value of the TN TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TN TMDL for Flint Creek (Boulder Creek to mouth) uses **Equation 1** and the flow associated with the median measured load from all sites during 2007-2009 sampling (106.64 cfs):

TMDL **= (0.30 mg/L) (106.64 cfs) (5.4) = 172.8 lbs/day**

Equation 3 is the basis for the example composite load allocation and example Philipsburg WWTP wasteload allocation for TN. The example wasteload allocation used to approximate the current operating conditions of the WWTP with regards to TN is 6.6 lbs/day (described in **Section 5.5.4.4**).

To continue with the example at a flow of 106.64 cfs, this example is as follows:

LA + 6.6 lbs/day **= 172.8 lbs/day**

Therefore:

LA **= 172.8 lbs/day – 6.6 lb/day = 166.2 lbs/day**

An example total existing load is calculated as follows using **Equation 5** and the flow and concentration associated with the median measured load for TN in Flint Creek (Boulder Creek to mouth) from 2002-2009:

Total Existing Load = (0.14 mg/L) (106.64 cfs) (5.4) = 80.6 lbs/day

Equation 6 is the basis for calculating the example existing composite load. The example existing WWTP TN load is 6.6 lbs/day as described in **Section 5.5.4.4**:

Existing Composite Load = 80.6 – 6.6 = 74.0 lbs/day

Table 5-25 contains the results for the example TN TMDL, load allocation, WLA, and current loading. Because the existing load is less than the TMDL, no reduction is necessary to meet the water quality target for TN. This is not surprising given the lack of TN target exceedances. If it were not for the complications of nutrient uptake, one could conclude that TN is not a problem. Nevertheless, the potential for TN target exceedances masked by nutrient uptake makes it difficult to accurately estimate load reduction requirements for most nutrient TMDLs. This segment of Flint Creek is also impaired by TP. Data shown in **Table 5-26** and **Figure 5-29** indicate that TP reductions will be necessary to meet the TP TMDL. Because the main sources of TN and TP (livestock and agriculture), in this segment are the same (**Figures 5-26** and **5-27**), reducing sources of TP will also reduce TN loading.

Table 5-25. Flint Creek (Boulder Creek to mouth) Total Nitrogen Example Total Maximum Daily Load, Load Allocations, and Current Loading

Source Category	Allocation & TMDL (lbs/day)	Existing Load (lbs/day)
Composite Load	166.2	74.0
Wasteload (Philipsburg WWTP)	6.6[1]	6.6[1]
	TMDL = 172.8[2]	**Total = 80.6[2]**

[1] Average load based on summer growing season data from the Philipsburg WWTP 2007-2012

[2] Based on a growing season flow of 106.64 cfs

Figure 5-28 shows the percent reductions for TN loads measured in Flint Creek (Boulder Creek to mouth) from 2007-2009. All of the measured loads were less than or equal to the TMDL. Although TN reductions are not required for any of the measured loads, excessive algal growth has been measured for this segment, indicating that some of the TN is being consumed. The actions taken to reduce TP in this segment are expected to also reduce TN and as a result decrease the likelihood of excessive algal growth and harm to aquatic life and contact recreation.

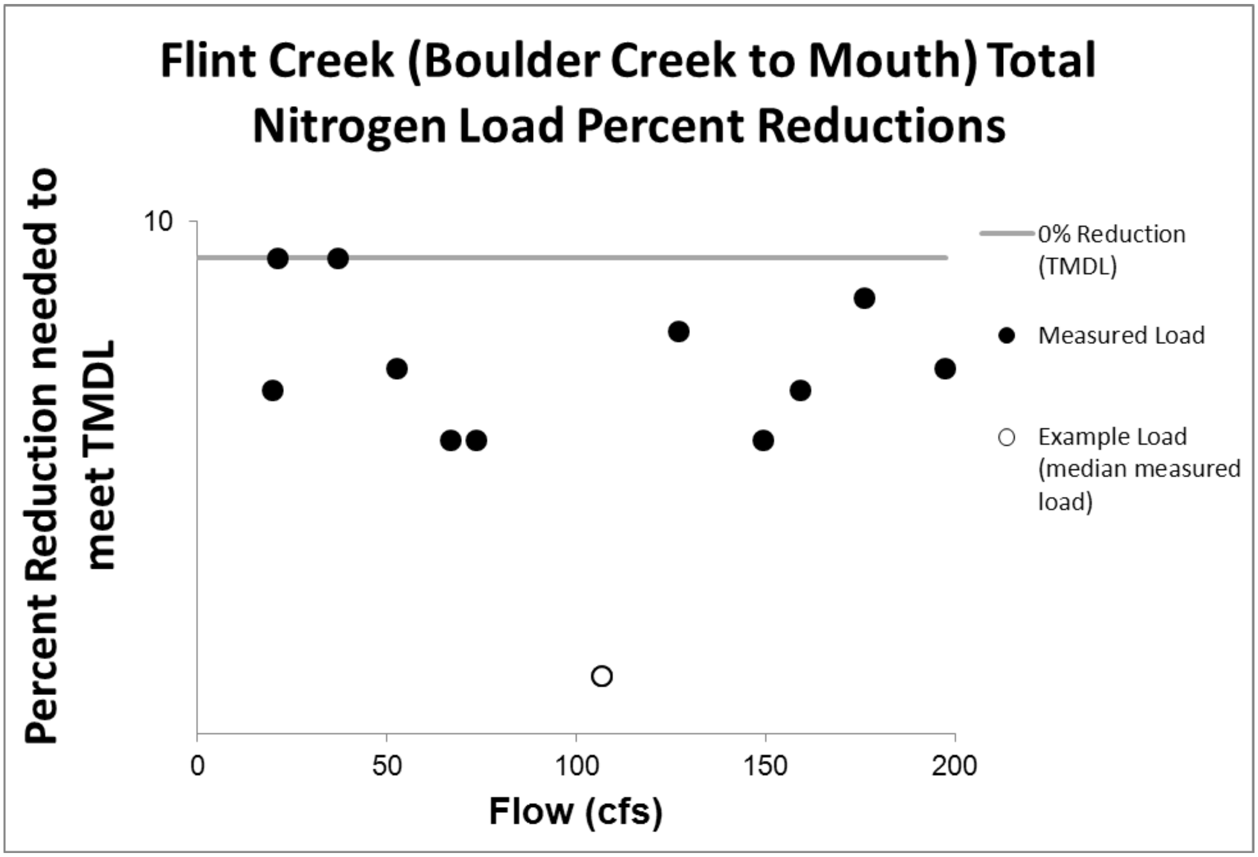

Figure 5-28. Measured Total Nitrogen Loads Percent Reductions for Flint Creek (Boulder Creek to mouth)

All points on or below the gray line are meeting the TMDL. The example existing load from **Table 5-25** is represented by the hollow circle.

5.6.4.4 Total Phosphorus TMDL, Allocations, Current Loading, and Reductions

The TMDL for TP is based on **Equation 1** and the TMDL allocation and wasteload allocation are based on **Equation 3**. The value of the TP TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TP TMDL for Flint Creek (Boulder Creek to mouth) uses **Equation 1** and the flow associated with the median reduction for measured loads that exceed the TP TMDL from all sites during 2002-2009 sampling (197.3 cfs):

***TMDL* = (0.03 mg/L) (197.3 cfs) (5.4) = 31.96 lbs/day**

The TP WLA for the Philipsburg WWTP is calculated using **Equation 4**, and is shown in **Figure 5-3**. For TMDL Example 1, an example TP WLA at 0.16 cfs (average summer growing season discharge from the WWTP from August 2007 – September 2012) can be calculated:

WLA_{TP} = (0.072 mg/L) (0.16 cfs) (5.4) = 0.06 lbs/day

Equation 3 is the basis for the example composite load allocation and example Philipsburg WWTP wasteload allocation for TP. To continue with the example at a flow of 197.3 cfs, this allocation is as follows:

***LA + 0.06 lb/day* = 31.96 lbs/day**

Therefore:

***LA* = 31.96 lbs/day - 0.06 lb/day = 31.90 lbs/day**

An example total existing load is calculated as follows using **Equation 5** and the flow and concentration associated with the median reduction for measured loads that exceed the TP TMDL from all sites within the segment during 2002-2009 sampling:

Total Existing Load = (0.043 mg/L) (197.3 cfs) (5.4) = 45.81 lbs/day

Equation 6 is the basis for calculating the example existing composite load. The example existing WWTP TP load is 2.7 lbs/day as described in **Section 5.5.4.4**:

Existing Composite Load = 45.81 lbs/day – 2.7 lbs/day = 43.11 lbs/day

Table 5-26 contains the results for the example TP TMDL, load allocations, wasteload allocation, and current loading. As mentioned in **Section 5.6.3.1**, if it is determined that Flint Creek at the WWTP has assimilative capacity for TP, the wasteload allocation to the WWTP in the example TMDL (**Table 5-26**) will need to be adjusted accordingly.

Because the existing load is greater than the TMDL, a reduction is necessary to meet the water quality target for TP. The source assessment for the Flint Creek (Boulder Creek to mouth) watershed indicates that livestock sources contribute the most human-caused TP loading; load reductions should focus on limiting and controlling TP loading from these sources. In addition, reductions in the loading of TP from agriculture and the WWTP will contribute to lower TP values in this segment. Meeting load allocations for this segment of Flint Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 7.0**.

Table 5-26. Flint Creek (Boulder Creek to mouth) Total Phosphorus Example Total Maximum Daily Load, Load Allocations, and Current Loading

Source Category	Allocation & TMDL (lbs/day)	Existing Load (lbs/day)
Composite Load	31.90	43.11
Wasteload (Philipsburg WWTP)	0.06[1]	2.7[3]
	TMDL = 31.96[2]	**Total = 45.81[2]**

[1] *Based on summer growing season flow of 0.16 cfs from the Philipsburg WWTP 2007-2012*
[2] *Based on a growing season flow of 197.3 cfs*
[3] *Average load based on summer growing season data from the Philipsburg WWTP 2007-2012*

Figure 5-29 shows the percent reductions for TP loads measured in Flint Creek (Boulder Creek to mouth) from 2002-2009. TP reductions are required from the smallest to the largest measured flows. Three of the measured loads were less than or equal to the TMDL. Loads greater than the TMDL require reductions ranging from 9% to 74%.

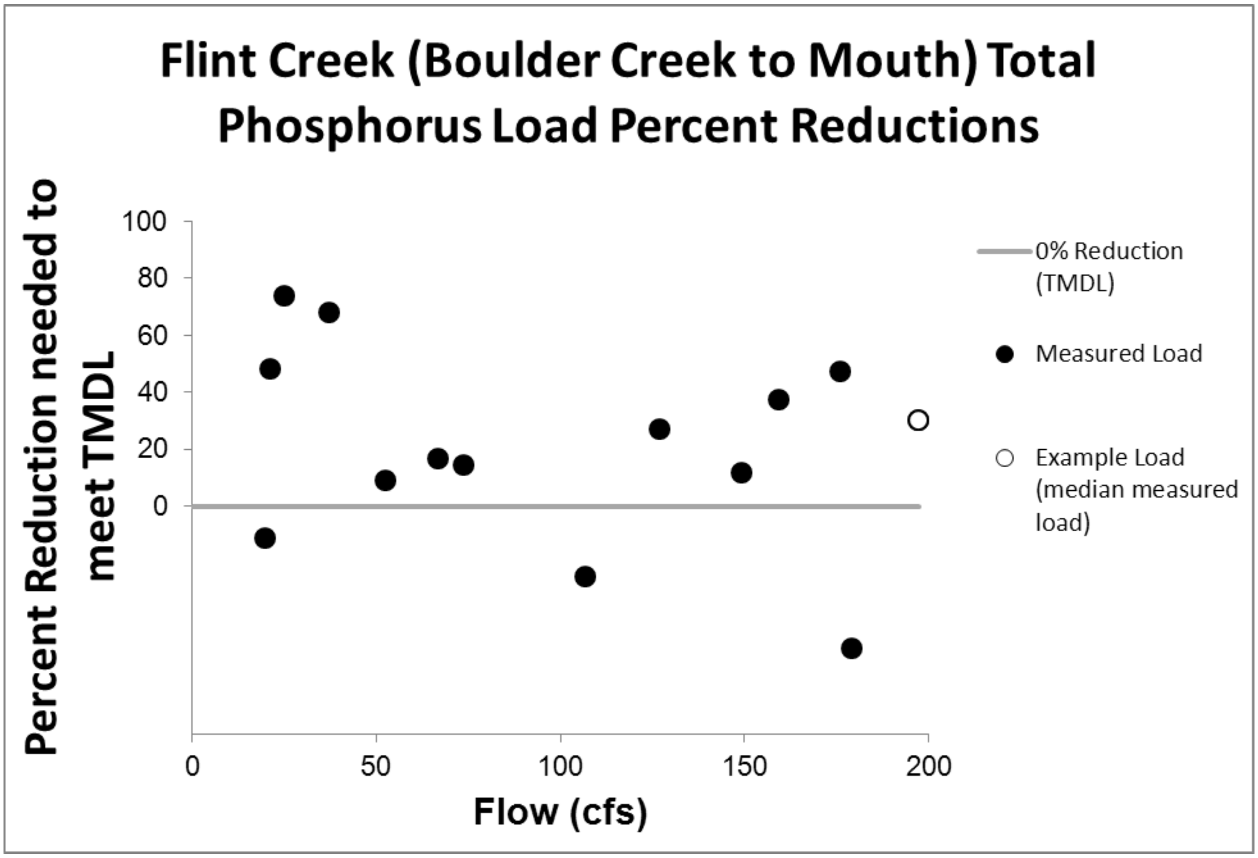

Figure 5-29. Measured Total Phosphorus Loads Percent Reductions for Flint Creek (Boulder Creek to mouth)

All points on or below the gray line are meeting the TMDL. The example existing load from **Table 5-26** is represented by the hollow circle.

5.6.4.4 Best Management Practice Scenarios

Removing cattle from areas adjacent to Flint Creek (Boulder Creek to mouth) results in reductions of about 14% for TN and 31% for TP (**Figures 5-30** and **5-31**). Adding filter strips in addition to removing cattle from areas adjacent to the stream reduces TN about an additional 2% and TP about an additional 4%. Because TN concentrations in the upstream segment of Flint Creek are meeting the targets and no reduction from the Philipsburg WWTP is needed, we did not run a scenario for this segment of Flint Creek (Boulder Creek to mouth) where TN being discharged from the WWTP is reduced. Reducing the concentration of phosphorus discharged from the Philipsburg WWTP from current levels to the criteria of 0.072 mg/L results in about a 3% reduction to the summer growing season load. The 30% fertilizer reduction BMP scenario results in about a 7% reduction of TN and about a 2% reduction of TP while the 60% fertilizer reduction BMP scenario results in about a 14% reduction of TN and about a 5% reduction of TP. Grazing improvement reduces both less than 0.5%.

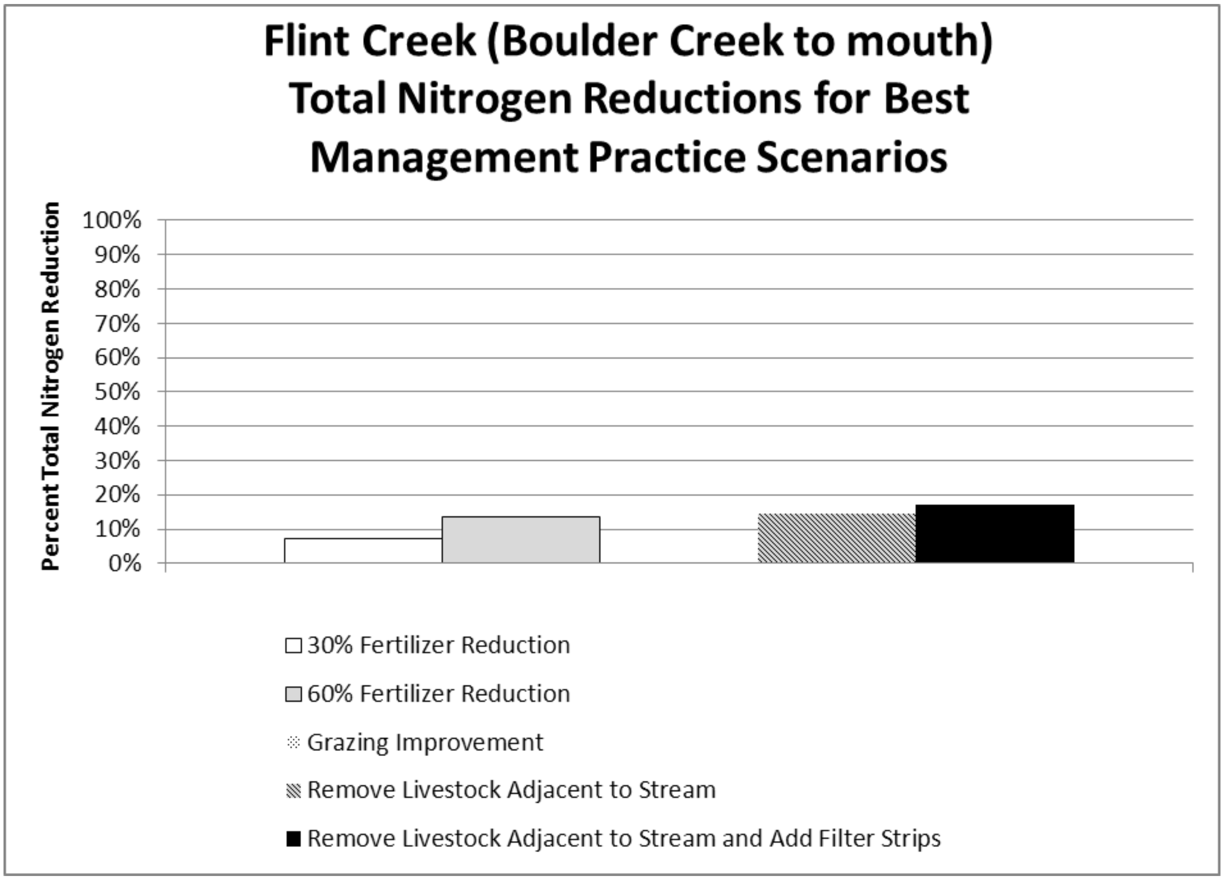

Figure 5-30. Total Nitrogen Best Management Practice Scenarios for Flint Creek (Boulder Creek to mouth) during the Summer Growing Season

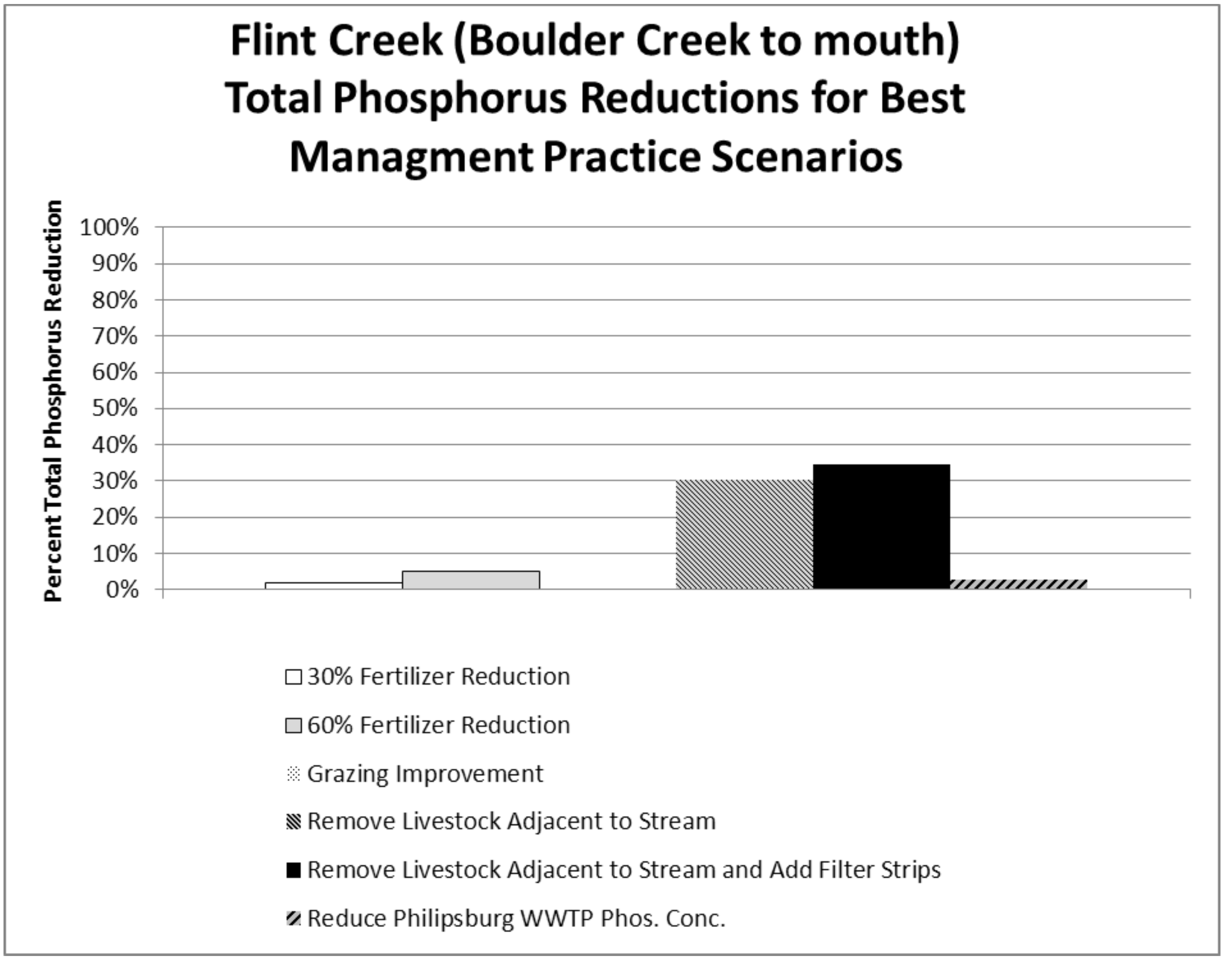

Figure 5-31. Total Phosphorus Best Management Practice Scenarios for Flint Creek (Boulder Creek to mouth) during the Summer Growing Season

5.6.5 Princeton Gulch

5.6.5.1 Assessment of Water Quality Results

The source assessment for Princeton Gulch consists of an evaluation of nitrate concentrations and exceedances of chlorophyll-*a*. This is followed by the quantification of the most significant human caused sources of nutrients as indicated by the SWAT model for the Flint watershed.

DEQ collected water quality samples from Princeton Gulch during the growing season over the time period of 2007-2012 (**Section 5.4.3.5, Table 5-11**). **Figure 5-32** presents summary statistics for nitrate concentrations at sampling sites in Princeton Gulch. Nitrate values in Princeton Gulch were always less than the target of 0.10 mg/L. There is a slight trend toward higher nitrate values when moving in the downstream direction.

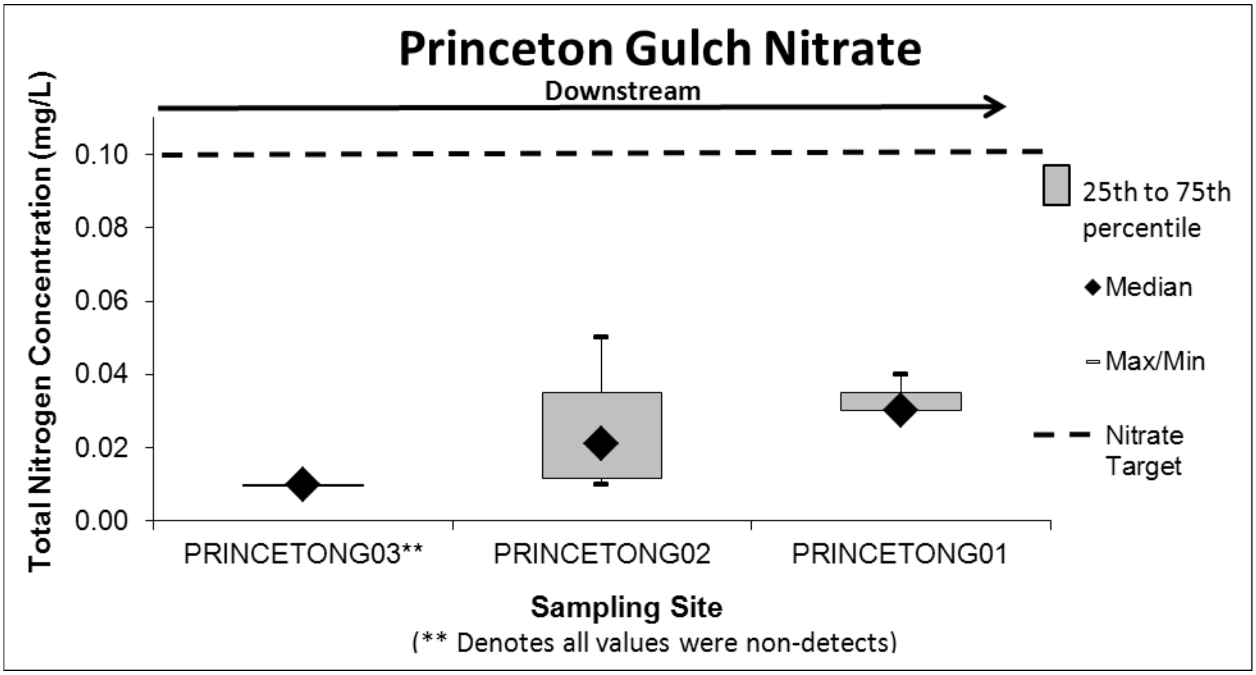

Figure 5-32. Nitrate Box Plots for Princeton Gulch

Two exceedances of the chlorophyll-*a* target of 125 mg/m² occurred in Princeton Gulch. They both occurred at PRINCETONG01; one occurred in August, 2007 and the other in August, 2009.

5.6.5.2 Assessment of Loading by Source Categories

The SWAT model results indicate that natural background is the greatest contributor of nitrogen to Princeton Gulch during the summer growing season (**Figure 5-33**), making up more than 80% of the total load. This is followed by septics and livestock adjacent to the stream. Livestock-other contributes just over 2% of nitrogen to Princeton Gulch. Neither agriculture nor urban contribute a significant amount of nitrogen to Princeton Gulch.

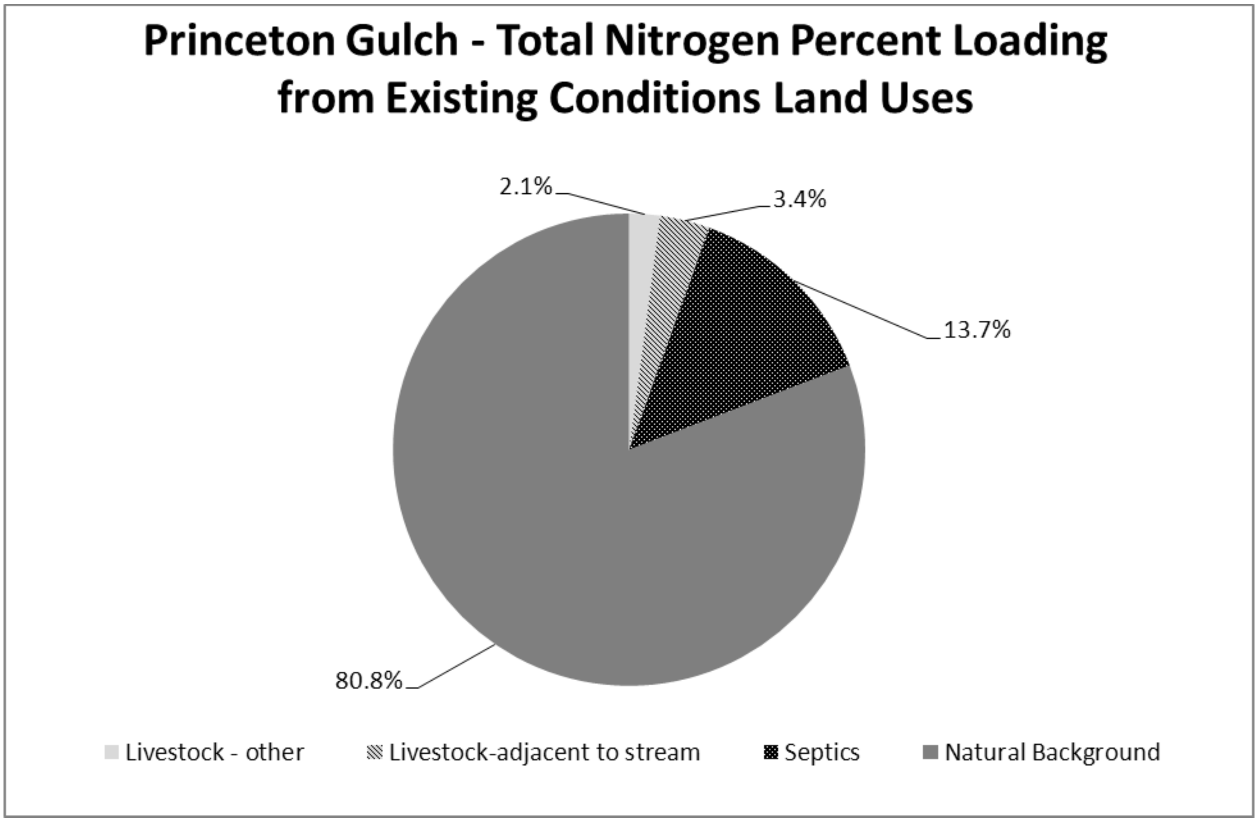

Figure 5-33. Percent Contribution of Total Nitrogen Sources to Princeton Gulch during the Summer Growing Season

5.6.5.3 Nitrate TMDL, Allocations, Current Loading, and Reductions

The TMDL for nitrate is based on **Equation 1** and the TMDL composite load allocation is based on **Equation 2**. The value of the nitrate TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example nitrate TMDL for Princeton Gulch uses **Equation 1** and the flow associated with the median measured load from all sites during 2007-2012 sampling (0.19 cfs):

TMDL **= (0.1 mg/L) (0.19 cfs) (5.4) = 0.10 lb/day**

Equation 2 is the basis for the example composite load allocation for nitrate. To continue with the example at a flow of 0.19 cfs, this allocation is as follows:

LA **= 0.10 lb/day**

An example total existing load is calculated as follows using **Equation 5** and the flow and concentration associated with the median measured load for nitrate in Princeton Gulch 2007-2012:

Total Existing Load **= (0.04 mg/L) (0.19 cfs) (5.4) = 0.04 lb/day**

The example nitrate TMDL, load allocation, and current loading are summarized in **Table 5-27**. Note that the existing load is less than the TMDL, suggesting that a reduction is unnecessary, consistent with the lack of nitrate target exceedances. If it were not for the complications of nutrient uptake, one could conclude that nitrate is not a problem. Nevertheless, the potential for nitrate target exceedances masked by nutrient uptake makes it difficult to accurately estimate load reduction requirements for most nutrient TMDLs. There is an abandoned mine (Thursday Friday Mine) in the headwaters of Princeton Gulch that may have historically been a source of nitrate. It is possible that the excessive algal growth observed in Princeton Gulch is the result of this nitrate cycling through the system. Additional monitoring of Princeton Gulch may help determine if the high algae concentrations observed in 2007 and 2009 were isolated incidences resulting from past mining practices or the result of excessive nitrate from current sources.

Table 5-27. Princeton Gulch Nitrate Example Total Maximum Daily Load, Load Allocations, and Current Loading

Source Category	Allocation & TMDL (lb/day)[1]	Existing Load (lb/day)[1]
Composite Load	0.1	0.04

[1] *Based on a growing season flow of 0.19 cfs*

Figure 5-34 shows the percent reductions for nitrate loads measured in Princeton Gulch from 2007-2012. All of the measured loads were less than the TMDL. Although nitrate reductions are not required for any of the measured loads, excessive algal growth has been measured for this segment. Determining the cause of the algal growth absent nitrate values exceeding the target warrants further study.

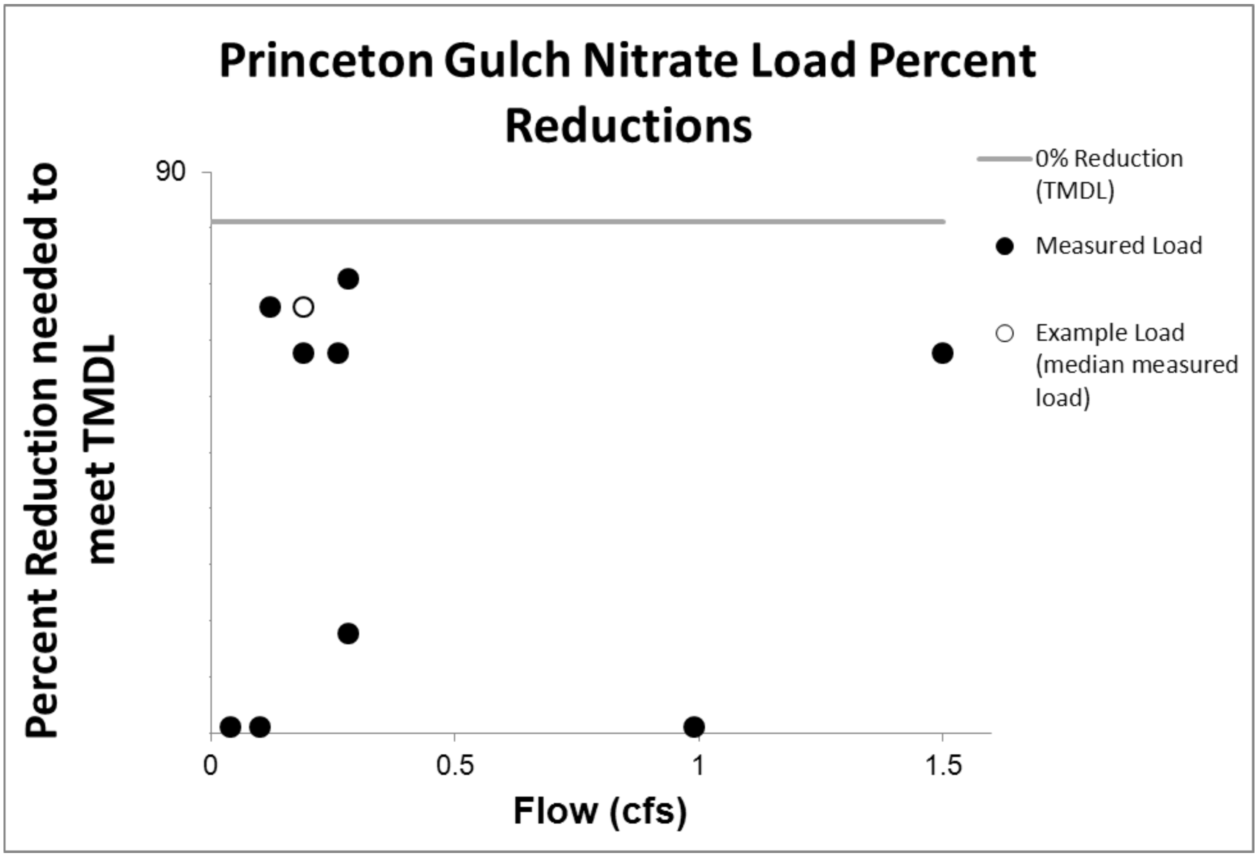

Figure 5-34. Measured Nitrate Loads Percent Reductions for Princeton Gulch

All points on or below the gray line are meeting the TMDL. The example existing load from **Table 5-27** is represented by the hollow circle.

5.6.5.4 Best Management Practice Scenarios

Removing cattle from areas adjacent to Princeton Gulch results in a reduction of about 4% for TN (**Figure 5-35**). Adding filter strips in addition to removing cattle from areas adjacent to the stream reduces TN about an additional 1%. None of the other scenarios result in significant TN reductions.

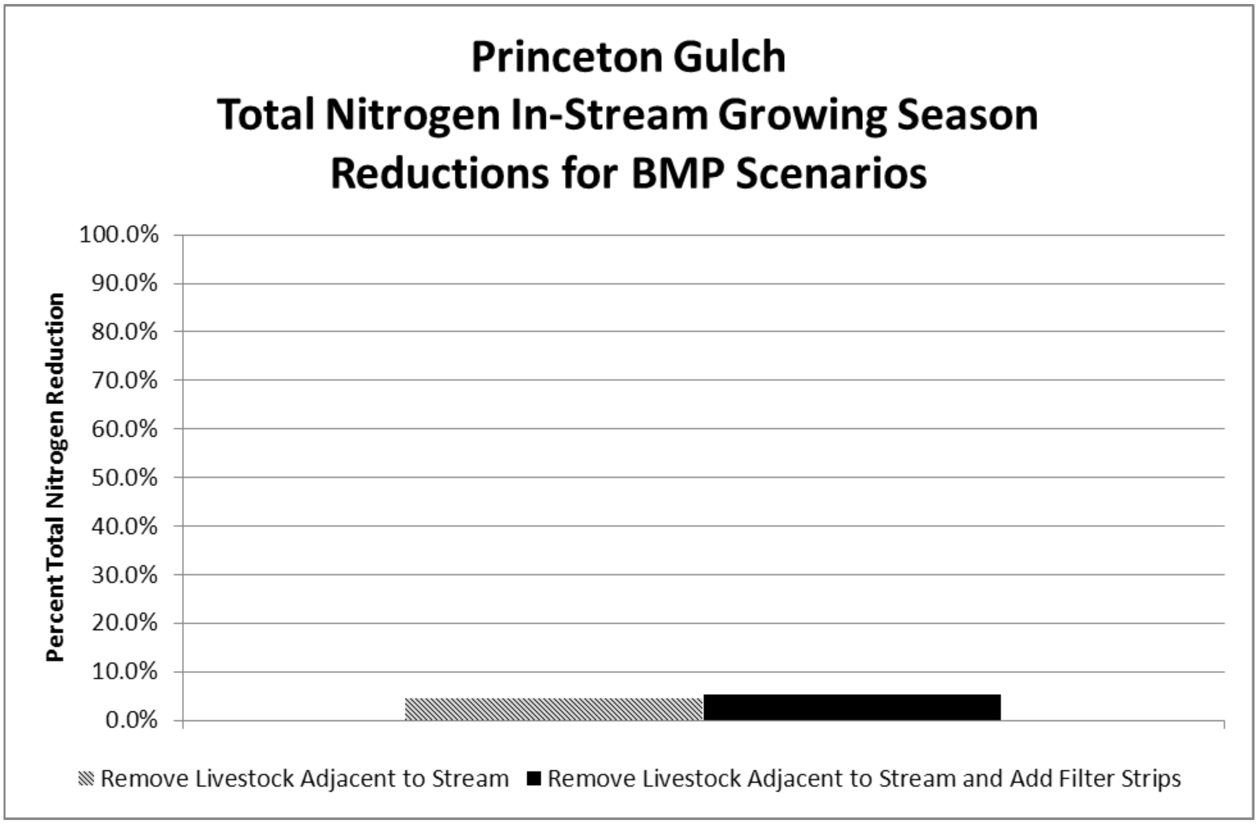

Figure 5-35. Total Nitrogen BMP Scenarios for Princeton during the Summer Growing Season

5.6.6 Smart Creek

5.6.4.1 Assessment of Water Quality Results

The source assessment for Smart Creek consists of an evaluation of TN and TP concentrations and exceedances of chlorophyll-*a*. This is followed by the quantification of the most significant human caused sources of nutrients as indicated by the SWAT model for the Flint watershed.

DEQ collected water quality samples from Smart Creek during the growing season over the time period of 2005-2009 (**Section 5.4.3.6, Table 5-13**). **Figure 5-36** presents summary statistics for TN concentrations at sampling sites in Smart Creek. TN values at the upper two sites with data always had values less than the target of 0.30 mg/L. Both of the two lowermost sites had values greater than the target. There is an increasing trend and increased variability in TN values when moving in the downstream direction. No TN data was collected from sites C02SMRTC02 and C02SMRTC01.

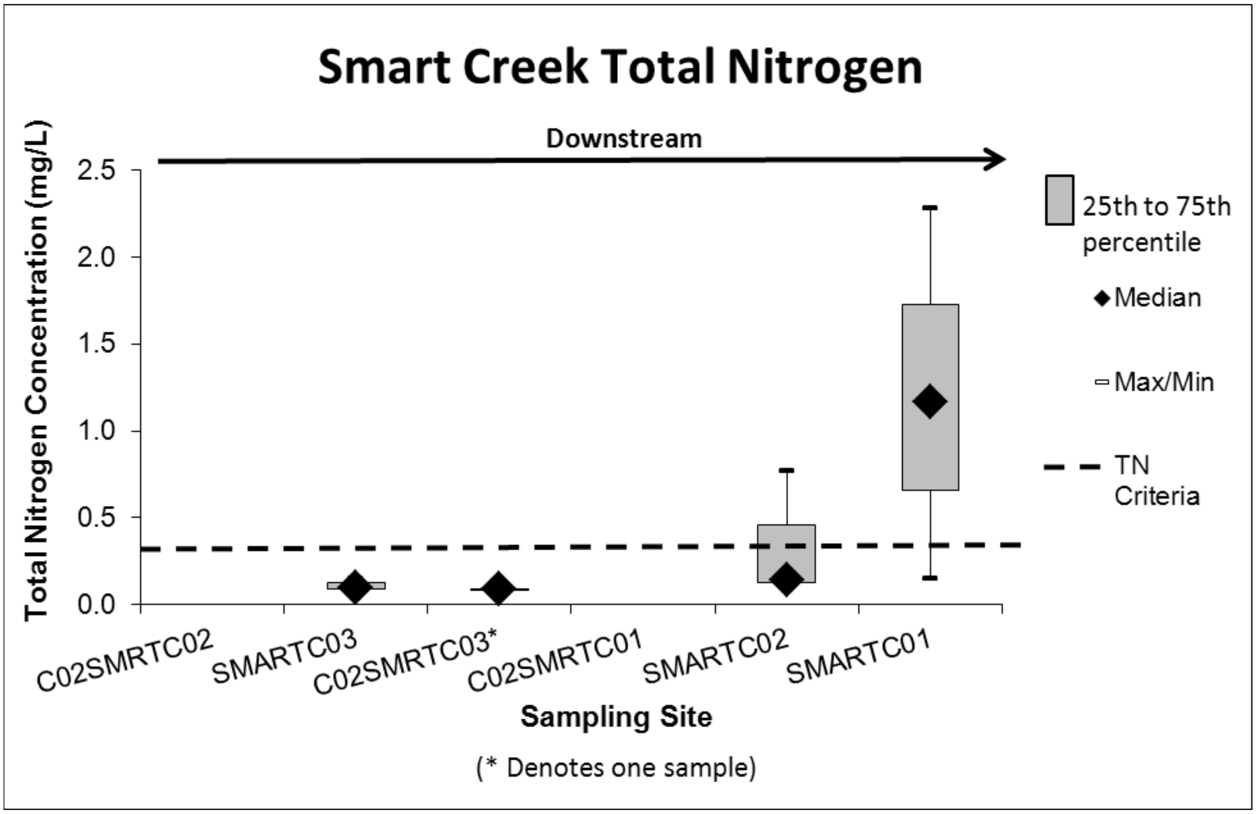

Figure 5-36. Total Nitrogen Box Plots for Smart Creek

Figure 5-37 presents summary statistics for TP concentrations at sampling sites in Smart Creek. SMARTC03 was the only site with TP values less than the target of 0.03 mg/L. At the four lowermost sites, all TP values were greater than the target. There is an increasing trend in TP in the downstream direction.

Sites SMARTC02 and SMARTC01 tended to have the highest measured TN and TP values for this segment. Aerial imagery and a tour of the watershed may be performed to determine the specific source(s) of these high nutrients values and whether the application of BMPs is feasible.

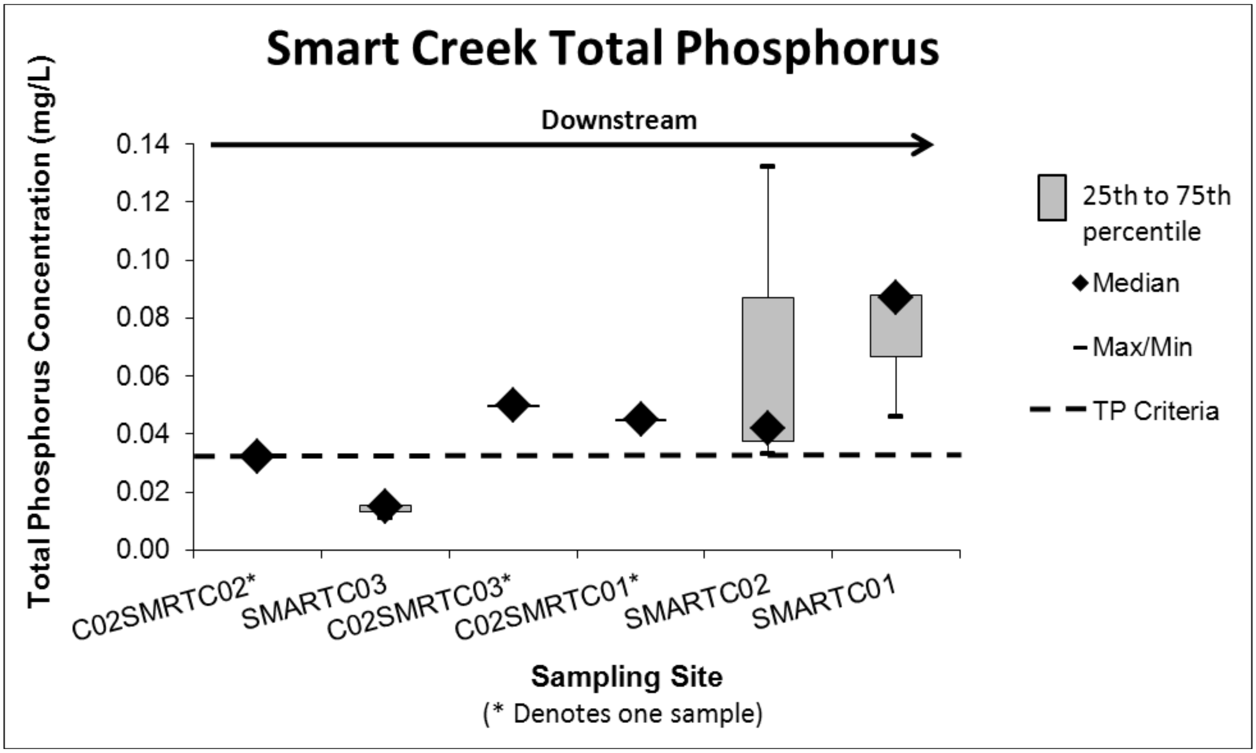

Figure 5-37. Total Phosphorus Box Plots for Smart Creek

One exceedance of the chlorophyll-*a* target of 125 mg/m² occurred in Smart Creek. It occurred at C02SMRTC01 in August, 2005.

5.6.4.2 Assessment of Loading by Source Categories

The SWAT model results indicate that natural background is the greatest contributor of nitrogen to Smart Creek during the summer growing season (**Figure 5-38**), making up more than half of the total load. This is followed by livestock adjacent to the stream, livestock-other, and then septics. Urban contributes less than 0.5% and agriculture does not contribute a significant amount of nitrogen to Smart Creek.

Livestock adjacent to the stream is the greatest contributor of phosphorus to Smart Creek during the summer growing season (**Figure 5-39**), being more than 75% of the total load. This is followed by natural background and septics. Urban contributes less than 0.5% and neither agriculture nor livestock-other contribute a significant amount of phosphorus to Smart Creek.

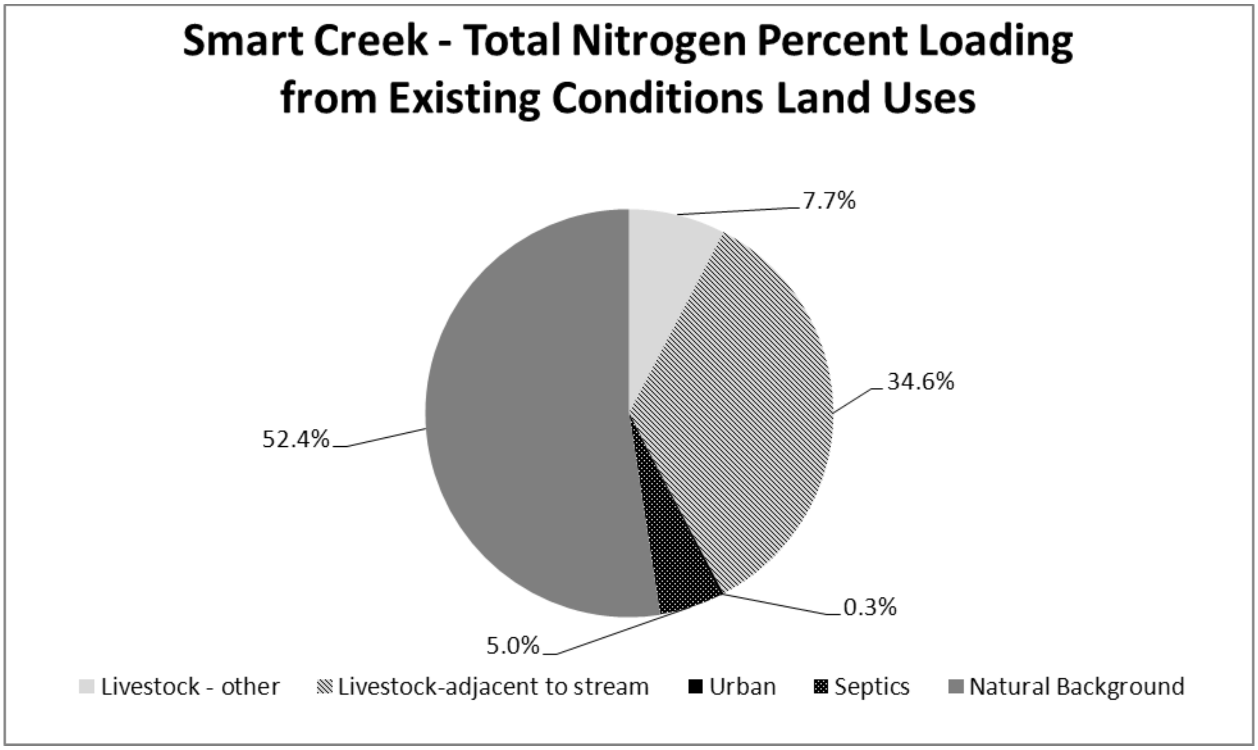

Figure 5-38. Percent Contribution of Total Nitrogen Sources to Smart Creek during the Summer Growing Season

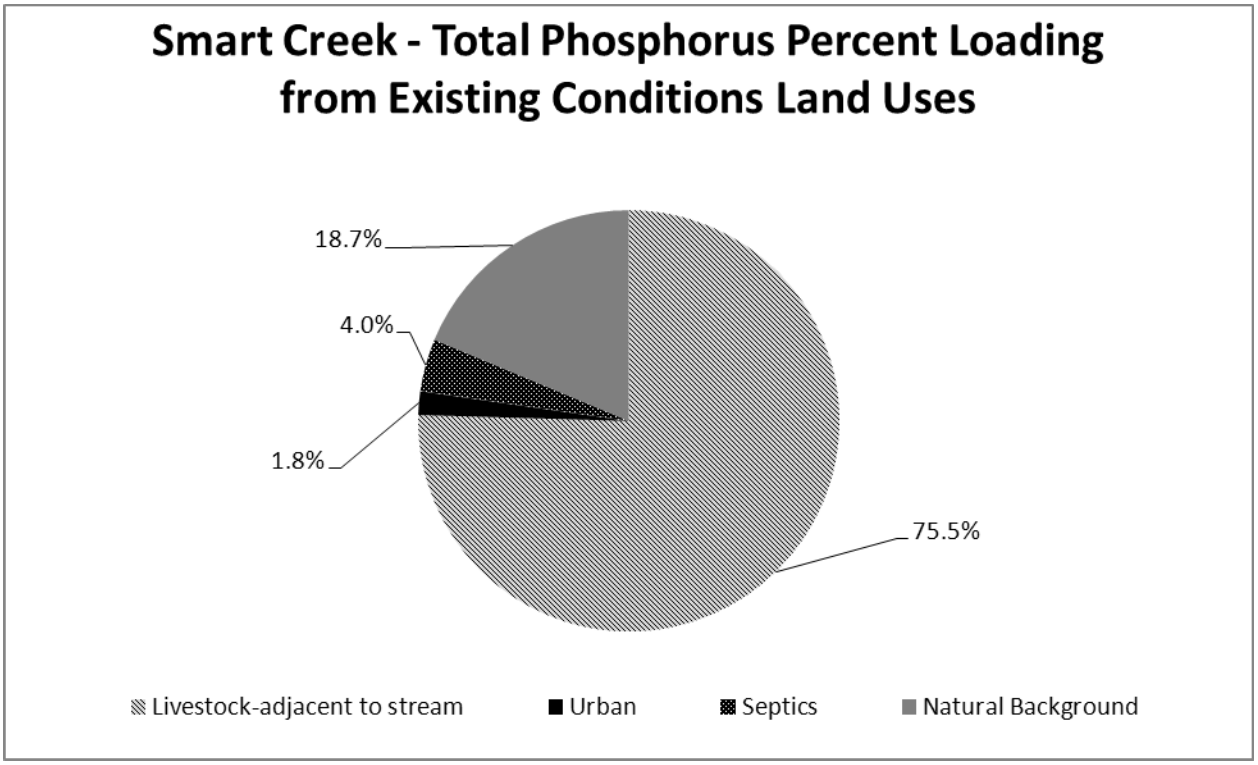

Figure 5-39. Percent Contribution of Total Phosphorus Sources to Smart Creek during the Summer Growing Season

5.6.4.3 Total Nitrogen Total Maximum Daily Load, Allocations, Current Loading, and Reductions

The TMDL for TN is based on **Equation 1** and the TMDL composite load allocation is based on **Equation 2**. The value of the TN TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TN TMDL for Smart Creek uses **Equation 1** and the flow associated the median reduction for measured loads that exceed the TN TMDL from all sites during 2007-2009 sampling (8.4 cfs):

TMDL **= (0.30 mg/L) (8.4 cfs) (5.4) = 13.6 lbs/day**

Equation 2 is the basis for the example composite load allocation for TN. To continue with the example at a flow of 8.4 cfs, this allocation is as follows:

LA **= 13.6 lbs/day**

An example total existing load is calculated as follows using **Equation 5** and the flow and concentration associated with the median reduction for measured loads that exceed the TN TMDL in Smart Creek 2007-2009:

Total Existing Load **= (1.17 mg/L) (8.4 cfs) (5.4) = 53.1 lbs/day**

The example TN TMDL, load allocation, and current loading are summarized in **Table 5-28**. Because the existing load is greater than the TMDL, a reduction is necessary to meet the water quality target for TN. The source assessment for the Smart Creek watershed indicates that while natural sources contribute the most TN overall, livestock sources contribute the most human-caused TN loading; load reductions should focus on limiting and controlling TN loading from these sources. Meeting load allocations for Smart Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 7.0**.

Table 5-28. Smart Creek Total Nitrogen Example Total Maximum Daily Load, Load Allocations, and Current Loading

Concentration data with no associated flow are not represented in this table.

Source Category	Allocation & TMDL (lbs/day)[1]	Existing Load (lbs/day)[1]
Composite Load	13.6	53.1

[1] *Based on a growing season flow of 8.4 cfs*

Figure 5-40 shows the percent reductions for TN loads measured in Smart Creek from 2007-2009. TN reductions are required from the smallest to the largest measured flows. Nine of the measured loads had reductions less than or equal to 0% and thus were meeting the TMDL. The remaining reductions ranged from 61% to 87%. One TN concentration value (without an associated flow) that did not exceed the target could not be converted to a load and is represented in **Figure 5-36**.

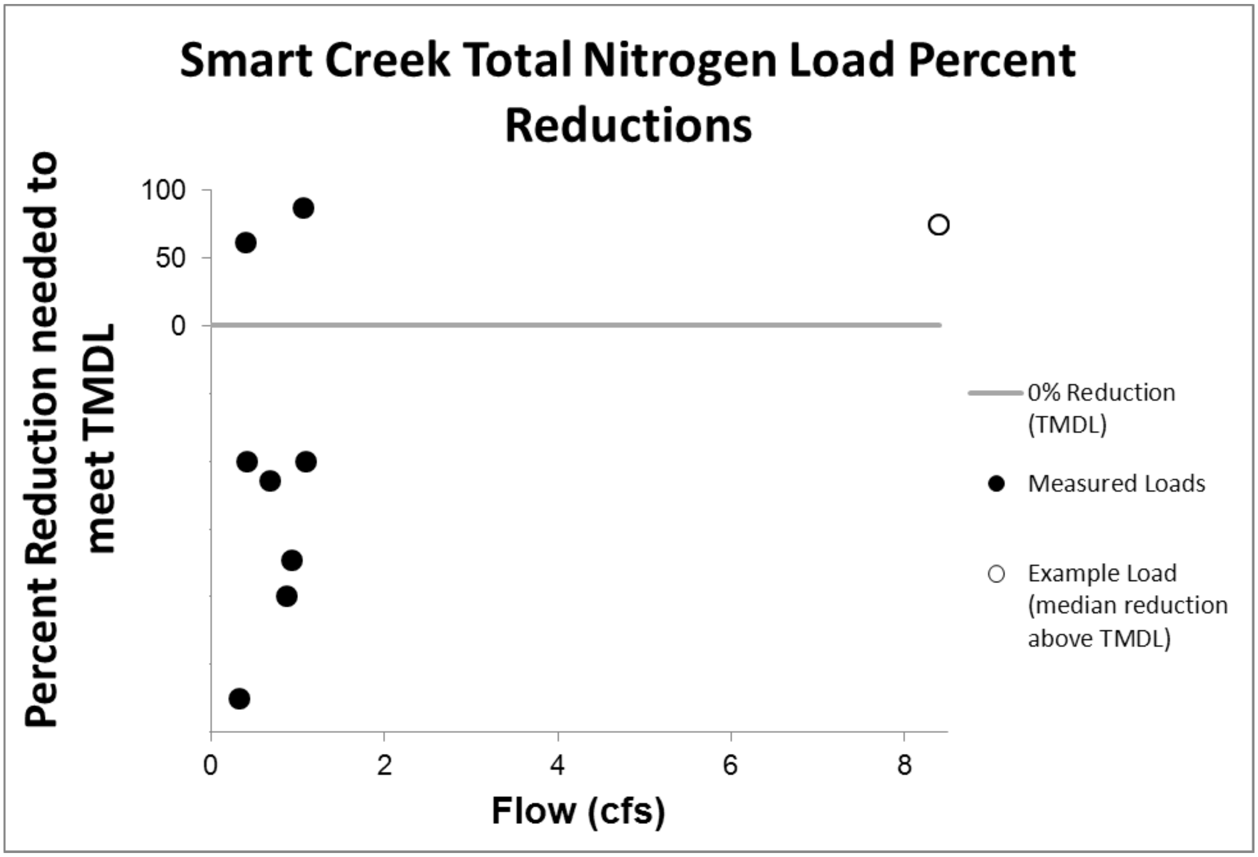

Figure 5-40. Measured Total Nitrogen Loads Percent Reductions for Smart Creek
All points on or below the gray line are meeting the TMDL. The example existing load from **Table 5-28** is represented by the hollow circle. Concentration data with no associated flow are not represented in this figure.

5.6.4.4 Total Phosphorus Total Maximum Daily Load, Allocations, Current Loading, and Reductions

The TMDL for TP is based on **Equation 1** and the TMDL composite load allocation is based on **Equation 2**. The value of the TP TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TP TMDL for Smart Creek uses **Equation 1** and the flow associated the median reduction for measured loads that exceed the TP TMDL from all sites during 2005-2009 sampling (1.1 cfs):

***TMDL* = (0.03 mg/L) (1.1 cfs) (5.4) = 0.2 lb/day**

Equation 2 is the basis for the example composite load allocation for TP. To continue with the example at a flow of 1.1 cfs, this allocation is as follows:

***LA* = 0.2 lb/day**

An example total existing load is calculated as follows using **Equation 5** and the flow and concentration associated with the median reduction for measured loads that exceed the TP TMDL in Smart Creek 2005-2009:

Total Existing Load = (0.046 mg/L) (1.1 cfs) (5.4) = 0.3 lb/day

The example TP TMDL, load allocation, and current loading are summarized in **Table 5-29**. Because the existing load is greater than the TMDL, a reduction is necessary to meet the water quality target for TP. The source assessment for the Smart Creek watershed indicates that livestock sources contribute the most human-caused TP loading; load reductions should focus on limiting and controlling TP loading from these sources. Meeting load allocations for Smart Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 7.0**.

Table 5-29. Smart Creek Total Phosphorus Example Total Maximum Daily Load, Load Allocations, and Current Loading

Concentration data with no associated flow are not represented in this table.

Source Category	Allocation & TMDL (lbs/day)[1]	Existing Load (lbs/day)[1]
Composite Load	0.2	0.3

[1] *Based on a growing season flow of 1.1 cfs*

Figure 5-41 shows the percent reductions for TP loads measured in Smart Creek from 2005-2009. TP reductions are required from the smallest to the largest measured flows. Three of the measured loads were less than or equal to the TMDL and thus were meeting the TMDL. The remaining reductions ranged from 6% to 77%. Two TP concentration values (0.045 mg/L and 0.05 mg/L; represented in **Figure 5-37**) that exceeded the target did not have an associated flow and therefore a load could not be calculated. The percent reductions for these concentrations were 33% and 40% respectively.

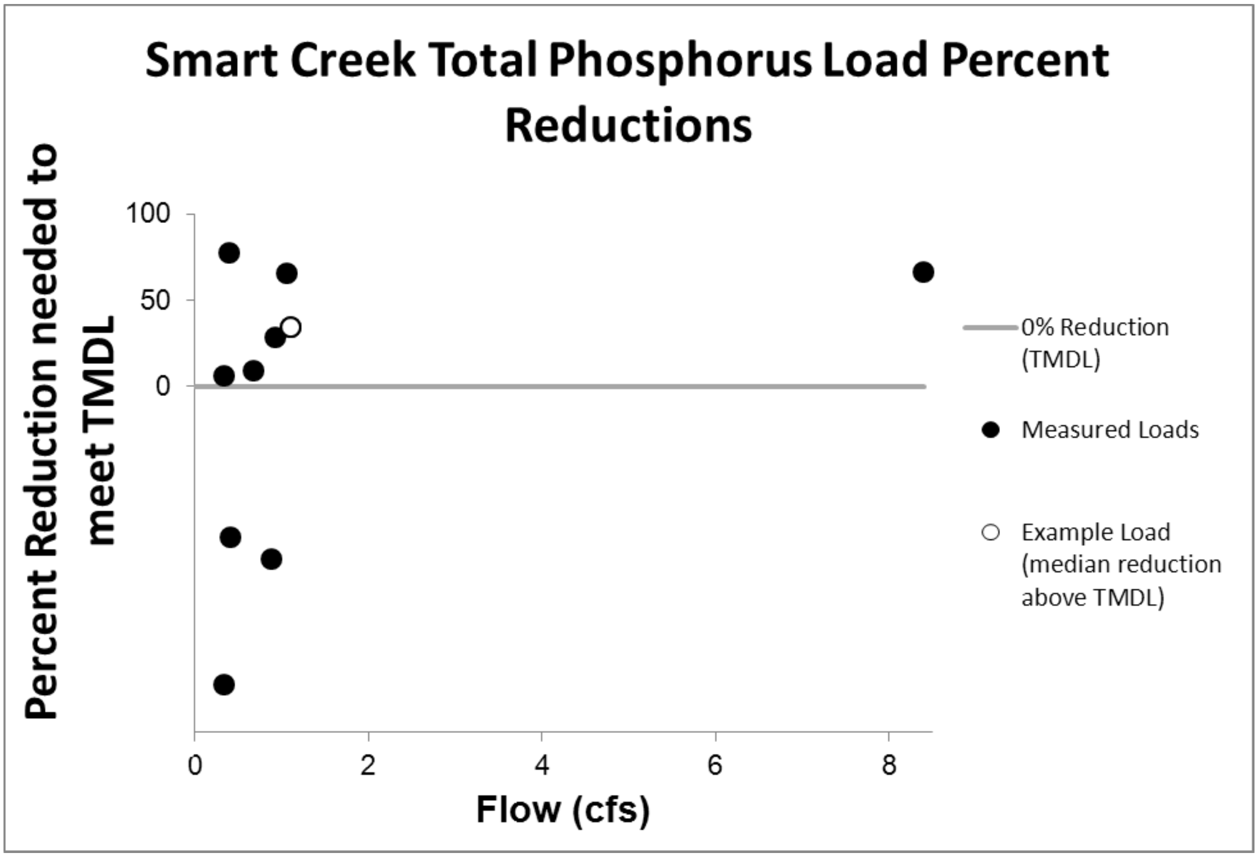

Figure 5-41. Measured Total Phosphorus Loads Percent Reductions for Smart Creek

All points on or below the gray line are meeting the TMDL. The example existing load from **Table 5-29** is represented by the hollow circle. Concentration data with no associated flow are not represented in this figure.

5.6.6.4 Best Management Practice Scenarios

Removing cattle from areas adjacent to Smart Creek results in reductions of about 37% for TN and 73% for TP (**Figures 5-42** and **5-43**). Adding filter strips in addition to removing cattle from areas adjacent to the stream reduces TN about an additional 0.5% and TP about an additional 0.2%. For TN, both fertilizer reduction scenarios result in no significant load reduction. For TP, the 30% fertilizer reduction scenario results in no significant reduction and the 60% fertilizer reduction scenario results in less than a 0.5% reduction. Grazing improvement reduces both TN and TP less than 0.5%.

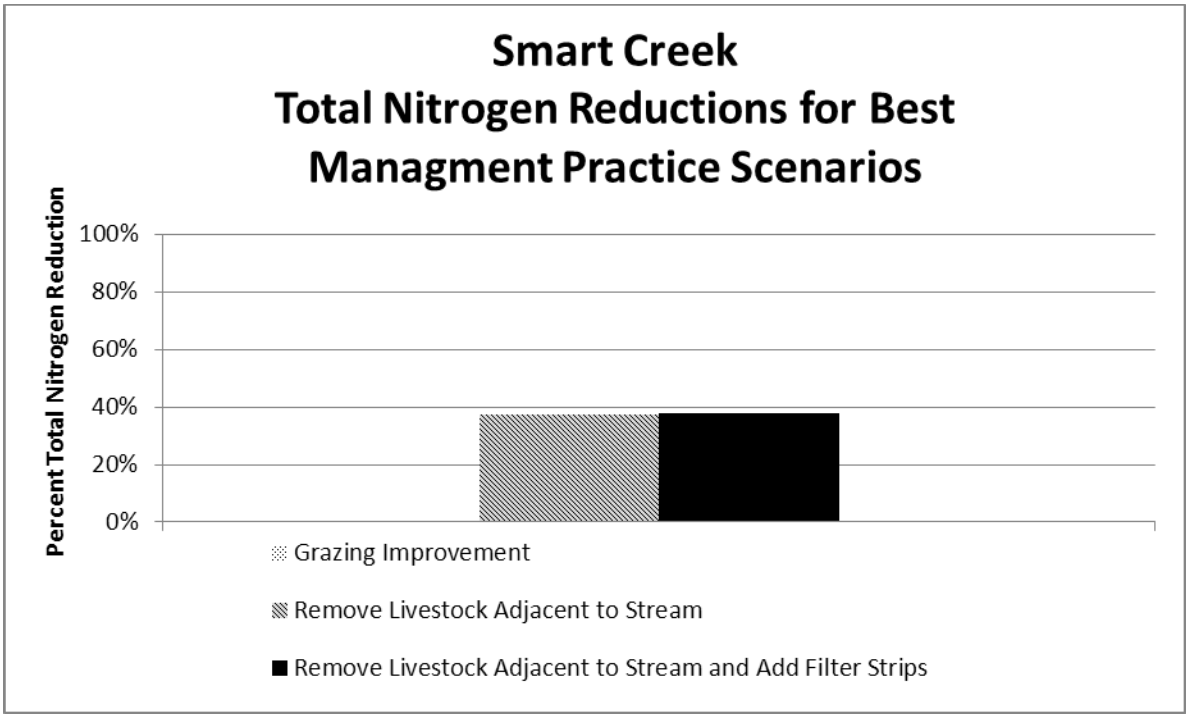

Figure 5-42. Total Nitrogen Best Management Practice Scenarios for Smart Creek during the Summer Growing Season

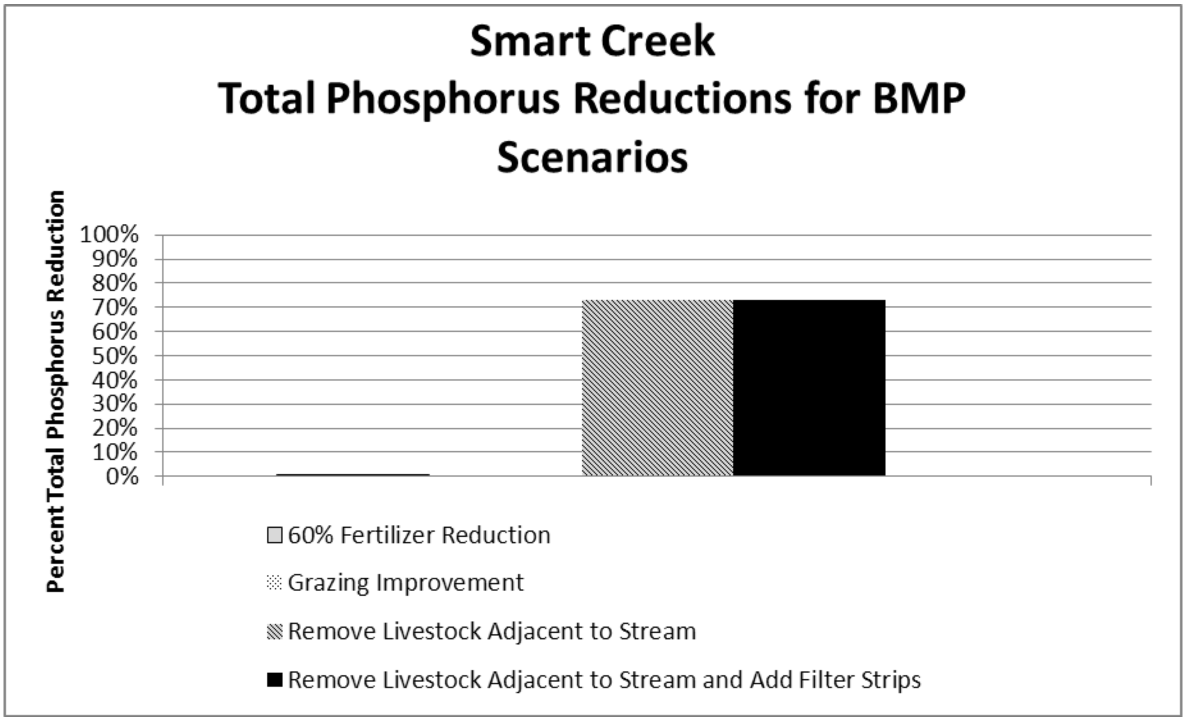

Figure 5-43. Total Phosphorus BMP Scenarios for Smart Creek during the Summer Growing Season

5.7 SEASONALITY AND MARGIN OF SAFETY

TMDL documents must consider the seasonal variability, or seasonality, on water quality impairment conditions, maximum allowable pollutant loads in a stream (TMDLs), and load allocations. TMDL development must also incorporate a margin of safety to account for uncertainties between pollutant sources and the quality of the receiving waterbody, and to ensure (to the degree practicable) that the TMDL components and requirements are sufficiently protective of water quality and beneficial uses. This section describes seasonality and margin of safety in the Flint TPA nutrient TMDL development process.

5.7.1 Seasonality

Addressing seasonal variations is an important and required component of TMDL development and throughout this plan seasonality is an integral consideration. Water quality and particularly nutrients concentrations are recognized to have seasonal cycles. Specific examples of how seasonality has been addressed within this document include:

- Water quality targets and subsequent allocations are applicable for the summer growing season for algae (July 1st – Sept 30th), to coincide with seasonal algal growth targets.
- Nutrient data used to determine compliance with targets and to establish allowable loads was collected during the summer growing season to coincide with applicable nutrient targets.

5.7.2 Margin of Safety

A margin of safety is a required component of TMDL development. The margin of safety accounts for the uncertainty about the pollutant loads and the quality of the receiving water and is intended to protect beneficial uses in the face of this uncertainty. The MOS may be applied implicitly by using conservative assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading (U.S. Environmental Protection Agency, 1999). This plan addresses MOS implicitly in a variety of ways:

- Static nutrient target values (e.g., 0.100 mg/L nitrate, 0.300 mg/L TN, 0.030 mg/L TP) were used to calculate allowable loads (TMDLs). Allowable exceedances of nutrient targets were not incorporated into the calculation of allowable loads, thereby adding a MOS to established allocations.
- Target values were developed to err on the conservative side of protecting beneficial uses.
- By considering seasonality (discussed above) and variability in nutrient loading.
- By using an adaptive management approach to evaluate target attainment and allow for refinement of load allocation, assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development.

5.8 UNCERTAINTY AND ADAPTIVE MANAGEMENT

Uncertainties in the accuracy of field data, nutrient targets, source assessments, loading calculations, and other considerations are inherent when assessing and evaluating environmental variables for TMDL development. However, mitigation and reduction of uncertainties through adaptive management approaches is a key component of ongoing TMDL implementation and evaluation. The process of adaptive management is predicated on the premise that TMDL targets, allocations, and the analyses supporting them are not static, but are processes subject to modification and adjustment as new information and relationships are understood. Uncertainty is inherent in both the water quality-based and model-based modes of assessing nutrient sources and needed reductions. The main sources of uncertainty are summarized below.

Water Quality Conditions

It was assumed that sampling data for each waterbody segment is representative of conditions in each segment. Three of the segments have more than the desired 12 samples but three have fewer samples for at least one nutrient form. Despite this, enough data was collected to perform an assessment for each nutrient form for each of the six waterbody segments. Additionally, there were situations where data for a specific nutrient indicated that values were below targets, but because of previous impairment determinations, exceedances of the chlorophyll-*a* target, and the uncertainty in nutrient limitation and uptake within the streams the impairment determinations were retained. As a result, data for some waterbody segments with a nutrient TMDL indicate that targets are being attained. Future monitoring as discussed in **Section 8.0** should help reduce the uncertainty regarding data representativeness, clarify whether or not nutrient forms that have a TMDL but are meeting targets have a role in causing excess algal growth, improve the understanding of the effectiveness of BMP implementation, and increase the understanding of the loading reductions needed to meet the TMDLs.

It was assumed that background concentrations are less than the target values, and based on sample data upstream of known sources and from segments within the Flint TPA that are not impaired for a given nutrient, this appears to be true. However, it is possible that target values are naturally exceeded during certain times or at certain locations in the watershed. Future monitoring should help reduce uncertainty regarding background nutrients concentrations.

Septic Loading (MEANSS) and Watershed (SWAT) models

Much of the uncertainty associated with the septic loading and SWAT models is related to how well they represent existing conditions. Efforts were made to work with agency representatives familiar with the watershed as well as landowners to make the model inputs as realistic as possible. Assumptions for the SWAT model are provided in **Appendix E** and for the septic loading model in **Appendix F.**

Based on the age of some septic systems within the watershed, there are probably some failing systems, and depending on their proximity or connectivity to surface water, they could be point sources of nutrient loading. However, a completely failing system has obvious symptoms and will be addressed quickly, and a partially failing system will likely result in similar loading as a functioning system, unless it's in close proximity to surface water. This source could be investigated further, particularly in segments with nearby septic systems and elevated nutrient concentrations that cannot be explained by other sources.

Accurately representing the different management practices between landowners and from year to year was the most difficult part of completing an accurate watershed model. For agriculture land uses the differences in irrigation types, irrigation rates/timing, fertilizing practices, and crop rotations could not be tailored to a field-by-field scale, but rather were averaged using best estimate common values over the southern and northern halves of the watershed. For livestock land uses the differences in grazing rotations and winter feeding practices could also not be tailored to a field-by-field scale, but rather were averaged using best estimate common values over the entire watershed. The same averaging scheme was used for lawn care in urban areas. These averaging estimates may produce results that are less accurate on a monthly or annual basis, but over the length of the 22 year model period the results are a good representation of long-term hydrology and nutrient sources within the watershed.

Specific to the segment of Flint Creek from Georgetown Lake to Boulder Creek, there is some additional uncertainty due to the hydrology calibration metrics not meeting the acceptable criteria in the SWAT watershed model (see **Section E.4.4.1** in **Appendix E**). Most likely due to irrigation effects, the watershed model was not able to replicate the growing season measured daily hydrograph within the pre-defined statistical metric. However, the relative percentages of TP loading among the main source categories are still accurate and provide the necessary information to distribute loads between categories and assess the best BMPs to meet water quality targets.

Despite the uncertainty associated with the loading contributions from the various nonpoint sources in the watershed, based on the modeling, literature, and field observations there is a fairly high level of certainty that improvements in land management practices discussed in this document will reduce nutrient loading sufficiently to meet the TMDLs.

6.0 OTHER IDENTIFIED ISSUES OR CONCERNS

6.1 POLLUTANT IMPAIRMENTS

There are many other pollutant impairments in the Flint total maximum daily load (TMDL) Planning Area (TPA) (see **Table A-1** in **Appendix A**). These impairments were addressed in the 2012 TMDL document for the Flint TPA (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012a).

6.2 NON-POLLUTANT IMPAIRMENTS

Water quality issues are not limited simply to those streams where TMDLs are developed. In some cases, streams have not yet been reviewed through the assessment process and do not appear on the 303(d) list. In other cases, streams in the Flint TPA may appear on the 303(d) list but may not always require TMDL development for a pollutant, but do have non-pollutant listings such as "chlorophyll-*a*" that could be linked to a nutrient pollutant. Many non-pollutant causes are habitat issues often associated with sediment, but may be associated with nutrient or temperature, or may be having a deleterious effect on a beneficial use without a clearly defined quantitative measurement or direct linkage to a pollutant to describe that impact. Nevertheless, the issues associated with these streams are still important to consider when working to improve water quality conditions in individual streams, and the Flint TPA as a whole. In some cases, pollutant and non-pollutant causes are listed for waterbody, and the management strategies as incorporated through the TMDL development for the pollutant, inherently address some or all of the non-pollutant listings. Barnes Creek has the only non-pollutant impairment (chlorophyll-*a*) in the Flint TPA that was not addressed by the 2012 TMDL document for the Flint TPA (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012a). This impairment was addressed via Total Nitrogen (TN) and Total Phosphorus (TP) TMDLs (see **Section 5.6.1**). Best Management Practices (BMP) described in **Section 7.0** of this document and those described in **Section 9.3.4.2** of DEQ (2012a) will help address the chlorophyll-*a* listing in Barnes Creek. As BMPs are put into place and nutrient values are reduced, DEQ expects that algal growth will decrease and chlorophyll-*a* values will be reduced as well.

6.1.2 Monitoring and Best Management Practices for Non-Pollutant-Affected Streams

Streams impaired for a non-pollutant as opposed to a pollutant should not be overlooked when developing watershed management plans. Attempts should be made to collect sediment, nutrient, and temperature information where data are minimal and the linkage between probable cause, non-pollutant listing, and effects to the beneficial uses are not well defined. The monitoring and restoration strategies that follow in **Sections 7.0** and **8.0** are presented to address both pollutant and non-pollutant issues for streams in the Flint TPA with TMDLs in this document.

7.0 WATER QUALITY IMPROVEMENT PLAN

While certain land uses and human activities are identified as sources and causes of water quality impairment during total maximum daily load (TMDL) development, the management of these activities is of more concern than the activities themselves. This document does not advocate for the removal of land and water uses to achieve water quality restoration objectives, but instead for making changes to current and future land management practices that will help improve and maintain water quality. This section describes an overall strategy and specific on-the-ground measures designed to restore beneficial water uses and attain nutrients water quality standards in Barnes, Douglas, Flint, and Smart creeks and Princeton Gulch. The strategy includes general measures for reducing loading from each significant identified pollutant source.

7.1 WATER QUALITY RESTORATION OBJECTIVE

The following is the general water quality objective provided in this TMDL document:

- Provide technical guidance for full recovery of aquatic life and contact recreation beneficial uses to all impaired streams within the Flint TMDL Planning Area (TPA) by improving nutrients water quality conditions. This technical guidance is provided by the TMDL components in the document which include:
    - water quality targets,
    - pollutant source assessments, and
    - a restoration and TMDL implementation strategy.

This TMDL document is a step in restoring water quality in the Flint TPA. A watershed restoration plan (WRP) can provide a framework strategy for water quality restoration and monitoring in the Flint TPA, focusing on how to meet conditions that will likely achieve the TMDLs presented in this document, as well as other water quality issues of interest to local communities and stakeholders. WRPs contain detailed adaptive management plans and identify considerations that should be addressed during TMDL implementation. A locally developed WRP will likely provide more detailed information about restoration goals and spatial considerations but may also encompass more broad goals than this framework includes. A WRP would serve as a locally organized “road map” for watershed activities, sequences of projects, prioritizing of projects, and funding sources for achieving local watershed goals, including water quality improvements. The WRP is intended to be a living document that can be revised based on new information related to restoration effectiveness, monitoring results, and stakeholder priorities. The following are the nine minimum elements for the WRP:

- Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan. Sources that need to be controlled should be identified at the significant subcategory level, along with estimates of the extent to which they are present in the watershed (e.g., X number of dairy cattle feedlots needing upgrading, including a rough estimate of the number of cattle per facility; Y acres of row crops needing improved nutrient management or sediment control; or Z linear miles of eroded streambank needing remediation).

- An estimate of the load reductions expected from management measures.

- A description of the nonpoint source management measures that will need to be implemented to achieve load reductions in paragraph 2, and a description of the critical areas in which those measures will be needed to implement this plan.

- Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.

- An information and education component used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented.

- Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.

- A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.

- A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.

- A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item 8 immediately above.

7.2 IMPLEMENTATION OF THE PLAN

The implementation plan discussed in this report is based on an adaptive management approach that includes a monitoring program and feedback loop. Successful implementation requires collaboration among private landowners, land management agencies, and other stakeholders.

7.2.1 DEQ and Stakeholder Roles

Successful implementation requires collaboration among private landowners, land management agencies, and other stakeholders. The Montana Department of Environmental Quality (DEQ) does not implement TMDL pollutant reduction projects for nonpoint source activities, but can provide technical and financial assistance for stakeholders interested in improving their water quality. DEQ will work with participants to use the TMDLs as a basis for developing locally-driven WRPs, administering funding specifically to help fund water quality improvement and pollution prevention projects, and identifying other sources of funding.

Because most nonpoint source reductions rely on voluntary measures, it is important that local landowners, watershed organizations, and resource managers continue to work collaboratively with local and state agencies to achieve water quality restoration which will progress toward meeting water TMDL targets and load reductions. Specific stakeholders and agencies that have been, and will likely continue to be vital to restoration efforts include the Granite County Conservation District, Granite Headwaters Watershed Group, Georgetown Lake Association, the Town of Philipsburg, Natural Resources Conservation Service (NRCS), Montana Department of Natural Resources and Conservation (DNRC), Montana Fish Wildlife and Parks (FWP), U.S. Environmental Protection Agency and DEQ. Other organizations and non-profits that may provide assistance through technical expertise, funding, educational outreach, or other means include Montana Water Center, University of Montana Watershed Health Clinic, and Montana State University (MSU) Extension Water Quality Program.

7.2.2 Nutrients Restoration Strategy

The goal of the nutrient restoration strategy is to reduce nutrient input to stream channels by increasing the filtering and uptake capacity of riparian vegetation areas, decreasing the amount of bare ground, and limiting the transport of nutrients from rangeland and cropland. Cropland filter strip extension, vegetative restoration, and long-term filter area maintenance are vital BMPs for achieving nutrient TMDLs in predominantly agricultural watersheds. Grazing systems with the explicit goal of increased post-grazing vegetative ground cover are needed to address the same nutrient loading from rangelands. Grazing prescriptions that enhance the filtering capacity of riparian filter areas offer a second tier of controls on the sediment content of upland runoff. Grazing and pasture management adjustments should consider:

1. The timing and duration of near-stream grazing,
2. The spacing and exposure duration of on-stream watering locations,
3. Provision of off-stream site watering areas to minimize near-stream damage
4. Active reseeding and rest rotation of locally damaged vegetation stands,
5. Improved management of irrigation systems and fertilizer applications, and
6. Incorporation of streamside vegetation buffer to irrigated croplands and confined feeding areas

Seasonal livestock confinement areas have historically been placed near or adjacent to flowing streams. Stream channels were the only available livestock water sources prior to the extension of rural electricity. Although limited in size, their repeated use generates high nutrient concentrations in close proximity to surface waters. Episodic runoff with high nutrient concentrations generates large loads that can settle in pools of intermittent streams and remain bio-available through the growing season. Diversion and routing of confinement runoff to harvestable nutrient uptake areas outside of active water courses are effective controls.

In general, these are sustainable grazing and cropping practices that can reduce nutrient inputs while meeting production goals. The appropriate combination of BMPs will differ according to landowner preferences and equipment but are recommended as components of a comprehensive plan for farm and ranch operators. Sound planning combined with effective conservation BMPs should be sought whenever possible and applied to croplands, pastures and livestock handling facilities. Assistance from resource professionals from various local, state, and federal agencies or non-profit groups is widely available in Montana. The local United States Department of Agriculture (USDA) Service Center and county conservation district offices are geared to offer both planning and implementation assistance.

In addition to the agricultural related BMPs, reducing sediment delivery from roads and eroding streambanks is another component of the nutrient reduction restoration plan. Sediment issues in the Flint TPA were addressed in a 2012 TMDL document (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012a). It is expected that the sediment and temperature related BMPs presented in **Section 9.0** of that plan will also help reduce nutrient loading in Barnes, Flint, and Smart creeks.

7.2.3 Non-Pollutant Restoration Strategy

Although TMDL development is not required for non-pollutant listings, they are frequently linked to pollutants, and addressing non-pollutant sources is an important component of TMDL implementation. There is one nutrient related non-pollutant listing in the Flint TPA (chlorophyll-*a* on Barnes Creek). This impairment will be addressed during implementation of associated TN and TP TMDLs for Barnes Creek. BMPs related to nutrients are discussed below in **Section 7.3**.

7.3 RESTORATION APPROACHES BY SOURCE CATEGORY

For each potential source of human-caused pollutant loads in the Flint A, general management recommendations are outlined below. Livestock grazing is considered to be the major nutrients contributor to the Flint TPA and is given the most in depth consideration and discussion in **Section 5.0**. The other sources described in this section may represent a substantial contribution of nutrients locally or when combined. The effect of different sources can change seasonally and be dependent on the magnitude of storm/high flow events. Therefore, restoration activities within the Flint TPA should focus on all major sources for each pollutant category. Restoration should begin with addressing significant sources where large load reductions can be obtained within each source category. The source assessment results and BMP scenarios in **Sections 5.6.1-5.6.6** provide information that should be used to help determine priorities for each major source type in the watershed.

Applying BMPs for existing activities where they are currently needed is the core of TMDL implementation but only forms a part of the restoration strategy. Also important are efforts to avoid future load increases by implementing appropriate BMPs for new activities and continuing implementation and maintenance of those BMPs currently in place or practice. Restoration might also address current non-pollutant -causing uses and management practices. In some cases, efforts beyond implementing new BMPs may be required to address key pollutant sources. In these cases, BMPs are usually identified as a first effort followed by the determination of whether further restoration activities are necessary to achieve water quality standards. Monitoring is also an important part of the restoration process; recommendations are outlined in **Section 8.0**.

In recognition that noxious weeds are a problem throughout Montana and may be associated with any of the following source categories, noxious weed control should be actively pursued whenever BMPs are being implemented.

7.3.1 Livestock Grazing

A riparian grazing management should be a goal for landowners in the watershed who are not currently using a plan. Private land owners may be assisted by state, county, federal, and local conservation groups to establish and implement appropriate grazing management plans. The goal of riparian grazing management is not to eliminate all grazing in these areas. Nevertheless, in some areas, a more restrictive management strategy may be necessary for a period in order to accelerate re-establishment of a riparian community with the most desirable species composition and structure. Grazing should be managed to provide filtering capacity via adequate groundcover, streambank stability via mature riparian vegetation communities, and shading from mature riparian climax communities.

Grazing management includes the timing and duration of grazing, the development of multi-pasture systems, including riparian pastures, and the development of off-site watering areas. The key strategy of the recommended grazing BMPs is to develop and maintain healthy riparian vegetation and minimize disturbance of the streambank and channel. The primary recommended BMPs for the Flint TPA are providing off-site watering sources, limiting livestock access to streams, providing “water gaps” where livestock access to a stream is necessary, planting woody vegetation along streambanks, and establishing riparian buffers. Although passive restoration via new grazing plans or limited bank revegetation are preferred BMPs, in some instances, bank stabilization may be necessary prior to planting vegetation. Other general grazing management recommendations and BMPs to address grazing sources of pollutants and non-pollutant can be obtained in Appendix A of Montana’s Nonpoint Source (NPS) Management Plan (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b) and in Harmon (1999).

7.3.2 Small Acreages

The number of small acreages is growing rapidly, and many small acreage owners own horses or cattle. Animals grazing on small acreages can lead to overgrazing and a shortage of grass cover, leaving the soil subject to erosion and runoff to surface waters. General BMP recommendations for small acreage lots with animals include creating drylots, developing a rotational grazing system, and maintaining healthy riparian buffers. Small acreage owners should collaborate with MSU Extension Service, NRCS, conservation districts and agriculture organizations to develop management plans for their lots. Further information may be obtained from the Montana Nonpoint Source Management Plan (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b) or by contacting the MSU extension (http://www.msuextension.org/).

7.3.3 Septic

BMPs for septic systems include regular inspection and cleaning and repair of leaking or otherwise malfunctioning systems. As large acreages are subdivided into smaller lots, the number of septic systems in the watershed increases. Plans for development of lands within the Flint TPA should consider the effects of additional septic systems to watersheds and consider ways of minimizing septic impacts to water quality.

7.3.4 Philipsburg Wastewater Treatment Plant

The Philipsburg Wastewater Treatment Plant will be working towards the reduction of total phosphorus as a result of the TMDLs and wasteload allocations in **Sections 5.6.3** and **5.6.4**. Reducing phosphorus from this source will be a part of the overall restoration strategy.

7.3.5 Animal Feeding Operations

Animal feeding operations (AFOs) can pose a number of risks to water quality. To minimize water quality effects from AFOs, the USDA and EPA released the Unified National Strategy for AFOs in 1999 (U.S. Department of Agriculture and U.S. Environmental Protection Agency, 1999). This plan is a written document detailing manure storage and handling systems, surface runoff control measures, mortality management, chemical handling, manure application rates, schedules to meet crop nutrient needs, land management practices, and alternate options for manure disposal. An AFO that meets certain specified criteria is referred to as a Concentrated Animal Feeding Operation (CAFO), and in addition may be required to obtain a Montana Pollution Discharge Elimination System (MPDES) permit as a point source. Montana’s AFO compliance strategy is based on federal law and has voluntary, as well as regulatory components. If voluntary efforts can eliminate discharges to state waters, no direct regulation is necessary through a permit. Operators of AFOs may take advantage of effective, low cost practices to reduce potential runoff to state waters, which additionally increase property values and operation productivity. Properly installed vegetative filter strips, in conjunction with other practices to reduce wasteloads and runoff volume, are very effective at trapping and detaining sediment and reducing transport of nutrients and pathogens to surface waters, with removal rates approaching 90% (U.S. Department of Agriculture and U.S. Environmental Protection Agency, 1999). Other options may include clean water diversions, roof gutters, berms, sediment traps, fencing, structures for temporary manure storage, shaping, and grading. Animal health and productivity also benefit when clean, alternative water sources are installed to prevent contamination of surface water.

Financial and technical assistance (including comprehensive nutrient management plan development) in achieving voluntary AFO and CAFO compliance may be available from conservation districts and NRCS field offices. Voluntary participation may aide in preventing a more rigid regulatory program from being implemented for Montana livestock operators in the future.

Further information may be obtained from the DEQ website at:
http://deq.mt.gov/wqinfo/mpdes/cafo.mcpx

Montana's NPS pollution control strategies for addressing AFOs are summarized in the bullets below:
- Work with producers to prevent NPS pollution from AFOs.
- Promote use of State Revolving Fund for implementing AFO BMPs.
- Collaborate with MSU Extension Service, NRCS, and agriculture organizations in providing resources and training in whole farm planning to farmers, ranchers, conservation districts, watershed groups and resource agencies.
- Encourage inspectors to refer farmers and ranchers with potential nonpoint source discharges to DEQ watershed protection staff for assistance with locating funding sources for BMPs that meet their needs. (This is in addition to funds available through NRCS and the Farm Bill).
- Develop early intervention of education & outreach programs for small farms and ranches that have potential to discharge nonpoint source pollutants from animal management activities. This includes assistance from the DEQ Permitting and Compliance Division, as well as external entities such as DNRC, local watershed groups, conservation districts, and MSU Extension.

7.3.6 Cropland

The major factors involved in decreasing sediment loads are reducing the amount of erodible soil, reducing the rate of runoff, and intercepting eroding soil before it enters waterbodies. The main BMP recommendation for the Flint TPA on cropland is the use of riparian buffers. Buffers reduce the rate of runoff, promote infiltration into the soil (instead of delivering runoff directly to the stream), and intercept sediment. Buffers are most effective when used in conjunction with agricultural BMPs that reduce the availability of erodible soil such as conservation tillage, crop rotation, strip cropping, and precision farming. Buffers along streams should be composed of natural vegetative communities which will also supply shade to reduce instream temperatures. Buffer widths along streams should be at least double the average mature canopy height to assist in providing stream shade. Additional BMPs and details on the suggested BMPs can be obtained from NRCS and in Appendix A of Montana's NPS Management Plan (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b).

7.3.7 Irrigation

Flint Creek is substantially affected by irrigation. Flow alteration and dewatering are commonly considered water quantity rather than water quality issues. However, changes to stream flow can have a profound effect on the ability of a stream to attenuate pollutants, especially nutrients, metals and heat. Flow reduction may increase water temperature, allow pollutants to accumulate in stream channels, reduce available habitat for fish and other aquatic life, and may cause the channel to respond by changing in size, morphology, meander pattern, rate of migration, bed elevation, bed material composition, floodplain morphology, and streamside vegetation if flood flows are reduced (Andrews and Nankervis, 1995; Schmidt and Potyondy, 2004). In addition to the BMPs recommended in Appendix A of Montana's NPS Management Plan (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b), local coordination and planning are especially important for flow management because State law indicates that legally obtained water rights cannot be divested, impaired, or diminished by Montana's water quality law (Montana Code Annotated (MCA) 75-5-705).

7.3.8 Riparian Areas and Floodplains

Riparian areas and floodplains are critical for wildlife habitat, groundwater recharge, reducing the severity of floods and upland and streambank erosion, and filtering pollutants from runoff. Enhancing and protecting riparian areas and floodplains within the watershed should be a priority of TMDL implementation in the Flint TPA.

Initiatives to protect riparian areas and floodplains will help protect property, increase channel stability, and buffer waterbodies from pollutants. However, in areas with a much smaller buffer or where historical vegetation removal and development have shifted the riparian vegetation community and limited its functionality, a tiered approach for restoring stream channels and adjacent riparian vegetation should be considered that prioritizes areas for restoration based on the existing condition and potential for improvement. In non-conifer dominated areas, the restoration goals should focus on restoring natural shrub cover on streambanks. Passive riparian restoration is preferable, but in areas where stream channels are unnaturally unstable or streambanks are eroding excessively, active restoration approaches, such as channel design, woody debris and log vanes, bank sloping, seeding, and shrub planting may be desired to speed up the rate of recovery. Factors influencing appropriate riparian restoration would include the severity of degradation, site-potential for various species, and the availability of local sources as transplant materials. In general, riparian plantings should be designed to promote the establishment of functioning stands of native riparian species. Weed management should also be a dynamic component of managing riparian areas.

The use of riprap or other "hard" approaches is not recommended and is not consistent with water quality protection or implementation of this plan. Although they may be absolutely necessary in some instances, these "hard" approaches generally redirect channel energy and exacerbate erosion in other places. Bank armoring should be limited to areas with a demonstrated infrastructure threat. Where deemed necessary, apply bioengineered bank treatments to induce vegetative reinforcement of the upper bank, reduce stream scouring energy, and provide shading and cover habitat.

7.3.9 Forestry and Timber Harvest

Timber harvest activities should be conducted by all landowners according to Forestry BMPs for Montana (Montana State University Extension Service, 2001) and the Montana Streamside Management Zone (SMZ) Law (77-5-301 through 307 MCA). The Montana Forestry BMPs cover timber harvesting and site preparation, road building including culvert design, harvest design, other harvesting activities, slash treatment and site preparation, winter logging, and hazardous substances. While the SMZ Law is intended to guide commercial timber harvesting activities in streamside areas (i.e., within 50 feet of a waterbody), the riparian protection principles behind the law should be applied to numerous land management activities (i.e., timber harvest for personal use, agriculture, development). Prior to harvesting on private land, landowners or operators are required to notify the Montana DNRC. DNRC is responsible for assisting landowners with BMPs and monitoring their effectiveness. The Montana Logging Association and DNRC offer regular Forestry BMP training sessions for private landowners.

Buffers of about 50 ft can substantially reduce the amount of sediment and nutrients entering a stream (Lakel et al., 2010; Lee et al., 2003). The SMZ Law protects against excessive erosion within 50 ft of a stream and therefore is an appropriate starting point for helping meet nutrient (especially forms bound to sediments) load allocations. Buffers of greater than 50 ft provide additional protection against sediment and nutrients (Wegner, 1999; Mayer et al., 2005). On USFS Lands, Inland Native Fish Strategy (INFISH) Riparian Habitat Conservation Area guidelines provide significant sediment protection as well as protection from elevated thermal loading (i.e., elevated temperature) by providing adequate shade.

In addition to the BMPs identified above, effects that timber harvest may have on yearly streamflow levels, such as peak flow, should be considered. Timber harvest plans should evaluate the potential for cumulative effects on water yield and peak flow increases and implement BMPs to reduce sediment and nutrients loading.

7.3.10 Mining

In general, mining did not seem to be a source of nutrients in the Flint TPA. The one potential exception to this was Princeton Gulch which has an abandoned mine and high chlorophyll-*a* values (see discussion in **Section 5.6.5.3**) but requires further study to determine in nitrate from the mine is causing the high chlorophyll-*a* values.

For an in-depth discussion regarding restoration approaches for mining, see Section 8.5.6 of the 2012 Flint TPA TMDL document (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012a).

7.5 POTENTIAL FUNDING SOURCES

Funding and prioritization of restoration or water quality improvement projects is integral to maintaining restoration activity and monitoring successes and failures. Several government agencies fund watershed or water quality improvement projects. Below is a brief summary of potential funding sources to assist with TMDL implementation.

7.5.1 Section 319 Nonpoint Source Grant Program

Section 319 grant funds are typically used to implement water quality restoration projects that focus on implementing a Watershed Restoration Plan. Individual contracts under the yearly award process typically range from \$10,000 to \$300,000, with a 40% of total project cost match requirement. 319 project funds are awarded to non-profit or governmental entities such as a conservation district, a watershed group, or a county.

7.5.2 Future Fisheries Improvement Program

The Future Fisheries grant program is administered by FWP and offers funding for on-the-ground projects that focus on habitat restoration to benefit wild and native fish. Anyone ranging from a landowner or community-based group to a state or local agency is eligible to apply. Applications are reviewed semiannually in December and June. Projects that may be applicable to the Flint watershed include restoring streambanks, improving fish passage, and restoring/protecting spawning habitats.

7.5.3 Watershed Planning and Assistance Grants

The MT DNRC administers Watershed Planning and Assistance Grants to conservation districts and watershed groups that are sponsored by a conservation district. Funding is capped at $11,000 per project and the application cycle is quarterly. The grant focuses on locally developed watershed planning activities; eligible activities include developing a watershed plan, group coordination costs, data collection, and educational activities.

Numerous other funding opportunities exist for addressing nonpoint source pollution. Additional information regarding funding opportunities is contained in Montana's Nonpoint Source Management Plan (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b) and online at: http://www.epa.gov/nps/funding.html.

7.5.4 Environmental Quality Incentives Program

The Environmental Quality Incentives Program (EQIP) is administered by NRCS and offers financial (i.e., incentive payments and cost-share grants) and technical assistance to farmers and ranchers to help plan and implement conservation practices that improve soil, water, air and other natural resources on their land. The program is based on the concept of balancing agricultural production and forest management with environmental quality, and is also used to help producers meet environmental regulations. EQIP offers contracts with a minimum length of one year after project implementation to a maximum of 10 years.

7.5.5 Resource Indemnity Trust/Reclamation and Development Grants Program

The Resource Indemnity Trust/Reclamation and Development Grants Program (RIT/RDG) is a biennial program administered by MT DNRC that can provide up to $300,000 to address environmental issues. This money can be applied to sites included on the abandoned mine lands priority list, but of low enough priority where cleanup under abandoned mine lands is uncertain. RIT/RDG program funds can also be used for conducting site assessment/ characterization activities such as identifying specific sources of water quality impairment. RIT/RDG projects need to be administered through a local government such as a conservation district, city board, or county.

8.0 MONITORING FOR EFFECTIVENESS

The monitoring framework discussed in this section is an important component of watershed restoration, a requirement of total maximum daily load (TMDL) development under Montana's TMDL law, and the foundation of the adaptive management approach. While targets and allocations are calculated using the best available data, the data are only an estimate of a complex ecological system. The margin of safety is put in place to reflect some of this uncertainty, but other issues only become apparent when restoration strategies are underway. Having a monitoring strategy in place allows for feedback on the effectiveness of restoration activities (whether TMDL targets are being met), if all significant sources have been identified, and whether attainment of TMDL targets is feasible. Data from long-term monitoring programs also provide technical justifications to modify restoration strategies, targets, or allocations where appropriate.

The monitoring framework presented in this section provides a starting point for local land managers, stakeholder groups, and federal and state agencies to develop more detailed and specific planning efforts regarding monitoring needs; it does not assign monitoring responsibility. Funding for future monitoring is uncertain and can vary with economic and political changes. Prioritizing monitoring activities depends on stakeholder priorities for restoration and funding opportunities.

The objectives for future monitoring in the Flint TMDL Planning Area (TPA) include: 1) tracking and monitoring restoration activities and evaluating the effectiveness of individual and cumulative restoration activities, 2) baseline and impairment status monitoring to assess attainment of water quality targets and identify long-term trends in water quality and 3) refining the source assessments. Each of these objectives is discussed below.

8.1 ADAPTIVE MANAGEMENT AND UNCERTAINTY

An adaptive management approach is used to manage resource commitments as well as achieve success in meeting the water quality standards and supporting all beneficial uses. This approach works in cooperation with the monitoring strategy and allows for adjustments to the restoration goals or pollutant targets, TMDLs, and/or allocations, as necessary. These adjustments would take into account new information as it arises.

The adaptive management approach is outlined below:
TMDLs and Allocations: The analysis presented in this document assumes that the load reductions proposed for each of the listed streams will enable the streams to meet target conditions and that meeting target conditions will ensure full support of all beneficial uses. Much of the monitoring proposed in this section of the document is intended to validate this assumption. If it looks like greater reductions in loading or improved performance is necessary to meet targets, then updated TMDL and/or allocations will be developed.

The Soil and Water Assessment Tool (SWAT) model was used to estimate the relative nutrients load contribution of each source type to the impaired streams. The Method for Estimating Attenuation of Nutrients from Septic Systems model (MEANSS) was used to estimate the nutrients loading specifically from septic systems in the Flint watershed; the results from MEANSS were incorporated into SWAT. Both models calculate loading estimates based on specific sets of assumptions described in Appendix E (SWAT) and Appendix F (MEANSS). As with any model there is uncertainty in the accuracy of the values developed. If there is future interest in answering specific questions regarding nutrients loading or in calculating more accurate loading estimates, more detailed models and/or data collection will need to be considered.

Water Quality Status: As new stressors are added to the watershed and additional data are collected, new water quality targets may need to be developed or existing targets/allocations may need to be modified.

8.2 TRACKING AND MONITORING RESTORATION ACTIVITIES AND EFFECTIVENESS

Monitoring should be conducted prior to and after project implementation to help evaluate the effectiveness of specific practices or projects. This approach will help track the recovery of the system and the effects, or lack of effects, from ongoing management activities in the watershed. At a minimum, effectiveness monitoring should address the pollutants that are targeted for each project. Information about specific locations, spatial extent, designs, contacts, and any effectiveness evaluation should be compiled about each project. Information about all restoration projects along with tracking overall extent of BMP implementation should be compiled in one location for the entire watershed.

Loading reductions and BMP effectiveness can be evaluated with water quality samples and comparing them to the targets. In cases where BMPs targeting other probable causes such as sediment are being implemented, BMP effectiveness may be evaluated by documenting the length of streambank repaired and/or taking before and after photos of the project area.

If sufficient implementation progress is made within a watershed, the Montana Department of Environmental Quality (DEQ) will conduct a TMDL Implementation Evaluation (TIE). During this process, DEQ compiles recent data, conducts monitoring (if necessary), may be compare data to water quality targets (typically a subset for sediment), summarizes BMP implementation since TMDL development, and evaluates data to determine if the TMDL is being achieved or if conditions are trending one way or another. If conditions indicate the TMDL is being achieved, the waterbody will be recommended for reassessment and may be removed from the 303(d) list. If conditions indicate the TMDL is not being achieved, according to Montana State Law (75-5-703(9)), the evaluation must determine if:

- The implementation of a new or improved phase of voluntary reasonable land, soil, and water conservation practices is necessary,
- Water quality is improving, but more time is needed for compliance with water quality standards, or
- Revisions to the TMDL are necessary to achieve applicable water quality standards.

8.3 BASELINE AND IMPAIRMENT STATUS MONITORING

In addition to effectiveness monitoring, watershed scale monitoring should be conducted to expand knowledge of existing conditions and to provide data that can be used during the TIE. Although DEQ is the lead agency for conducting impairment status monitoring, other agencies or entities may collect and provide compatible data. Wherever possible, it is recommended that the type of data and methodologies used to collect and analyze the information be consistent with DEQ methodology so as to allow for comparison to TMDL targets and track progress toward meeting TMDL goals. The information in this section provides general guidance for future impairment status monitoring.

8.3.1 Nutrients

Although extensive nutrient data were collected to assist with TMDL development, fewer samples were collected from Princeton Gulch due to access and time constraints during the sampling time period. When watershed scale monitoring is conducted to assist with future impairment determinations, particular attention should be given to collecting additional nutrient data on Flint Creek (Georgetown Lake to confluence with Boulder Creek) and Princeton Gulch. Future sampling should also include algal sampling for chlorophyll-*a* and ash free dry mass. Additionally, macroinvertebrates are part of a second tier assessment if nutrient and/or algae concentrations do not clearly indicate impairment or non-impairment and should be collected. Data collection that includes water quality, algal, and macroinvertebrate samples ensures that all aspects of nutrients and their effects on aquatic life can be evaluated.

8.4 SOURCE ASSESSMENT REFINEMENT

In many cases, the level of detail provided by the source assessments only provides broad source categories that need reduced pollutant loads. Strengthening source assessments for each of the pollutants may include more thorough sampling or field surveys of source categories and are described in this section. To refine source assessment of nutrient impaired waterbodies in the Flint TPA resources could be used to focus on identifying the most significant source areas within each impaired stream's watershed to determine where implementation will be most effective.

8.4.1 Nutrients

The following could help strengthen the source assessment:

- more data to characterize background conditions,
- a better understanding of septic contributions,
- a better understanding of nutrient concentrations in groundwater and spatial variability
- a detailed understanding of fertilization practices within the watershed
- a review of land management practices specific to sub-watersheds of concern to determine where the greatest potential for improvement can occur for the major land use categories,
- additional sampling in streams with less data such as Princeton Gulch to get a better idea of the reductions needed and to identify source areas
- analysis of aerial images and visiting sampling sites with high nutrient values to verify specific sources

9.0 STAKEHOLDER AND PUBLIC PARTICIPATION

Stakeholder and public involvement is a component of total maximum daily load (TMDL) planning supported by the U.S. Environmental Protection Agency's (EPA) guidelines and required by Montana state law (Montana Code Annotated (MCA) 75-5-703, 75-5-704) which directs the Montana Department of Environmental Quality (DEQ) to consult with watershed advisory groups and local conservation districts during the TMDL development process. Technical advisors, stakeholders and interested parties, state and federal agencies, interest groups, and the public were solicited to participate in differing capacities throughout the TMDL development process in the Flint TMDL Planning Area (TPA).

9.1 PARTICIPANTS AND ROLES

Throughout completion of the Flint TPA nutrient TMDLs, DEQ worked with stakeholders to keep them apprised of project status and solicited input from a TMDL advisory group. A description of the participants in the development of the TMDLs in the Flint TPA and their roles is contained below.

Montana Department of Environmental Quality

Montana state law (MCA 75-5-703) directs DEQ to develop all necessary TMDLs. DEQ has provided resources toward completion of these TMDLs in terms of staff, funding, internal planning, data collection, technical assessments, document development, and stakeholder communication and coordination. DEQ has worked with other state and federal agencies to gather data and conduct technical assessments. DEQ has also partnered with watershed organizations to collect data and coordinate local outreach activities for this project.

United States Environmental Protection Agency

EPA is the federal agency responsible for administering and coordinating requirements of the Clean Water Act (CWA). Section 303(d) of the CWA directs states to develop TMDLs (see **Section 1.1**), and EPA has developed guidance and programs to assist states in that regard. EPA has provided funding and technical assistance to Montana's overall TMDL program and is responsible for final TMDL approval. Project management was primarily provided by the EPA Regional Office in Helena, MT.

TMDL Advisory Group

The Flint TPA TMDL Advisory Group consisted of selected resource professionals who possess a familiarity with water quality issues and processes in the Flint TPA, and also representatives of applicable interest groups. All members were solicited to participate in an advisory capacity per Montana state law (75-5-703 and 704). DEQ requested participation from the interest groups defined in MCA 75-5-704 and included local city and county representatives, livestock-oriented and farming-oriented agriculture representatives, conservation groups, watershed groups, state and federal land management agencies, and representatives of recreation and tourism interests. The advisory group also included additional stakeholders and landowners with an interest in maintaining and improving water quality and riparian resources.

Advisory group involvement was voluntary and the level of involvement was at the discretion of the individual members. Members had the opportunity to provide comment and review of technical TMDL assessments and reports and to attend meetings organized by DEQ for the purpose of soliciting feedback on project planning. Typically, draft documents were released to the advisory group for review under a limited timeframe, and their comments were then compiled and evaluated. Final technical decisions regarding document modifications resided with DEQ.

Communications with the group members was typically conducted through e-mail and draft documents were made available through DEQ’s wiki for TMDL projects (http://montanatmdlflathead.pbworks.com). Opportunities for review and comment were provided for participants at varying stages of TMDL development, including opportunity for review of the draft TMDL document prior to the public comment period.

Area Landowners

Since 52% of the planning area is in private ownership, local landowner cooperation in the TMDL process has been critical. Their contribution has included access for stream sampling and field assessments and personal descriptions of seasonal water quality and streamflow characteristics. The DEQ sincerely thanks the planning area landowners for their logistical support and informative participation in impromptu water resource and land management discussions with our field staff and consultants.

9.2 RESPONSE TO PUBLIC COMMENTS

Upon completion of the draft TMDL document, and prior to submittal to EPA, DEQ issues a press release and enters into a public comment period. During this timeframe, the draft TMDL document is made available for general public comment, and DEQ addresses and responds to all formal public comments. This public review period was initiated on November 19, 2013, and ended on December 18, 2013. At a public meeting on December 4, 2013, in Philipsburg, Montana, DEQ provided an overview of the TMDLs for nutrients in the Flint TPA, made copies of the document available to the public, answered questions, and solicited public input and comment on the plan. The announcement for that meeting was distributed among the Watershed Advisory Group; posted on the DEQ webpage; located at the Granite County Conservation District Office, the Philipsburg Public Library, and the Montana State Library; and advertised in the following newspapers: Anaconda Leader, The Philipsburg Mail, The Montana Standard, Helena Independent Record, and Missoulian. There were no public comments received during the public comment period for this document.

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