Flint Nutrients TMDLs and Water Quality Improvement Plan

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Steve Bullock, Governor
Tracy Stone-Manning, Director DEQ

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Prepared by:
Water Quality Planning Bureau
Watershed Management Section

Contributors:
Water Quality Planning Bureau
Watershed Management Section
Paul Kusnierz, Nutrient Project Manager and Project Coordinator

Information Management and Technical Services Section
Eric Regensburger, Project Modeler

Montana Department of Environmental Quality
Water Quality Planning Bureau
1520 E. Sixth Avenue
P.O. Box 200901
Helena, MT 59620-0901

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Various versions of sections or components of this document were presented or sent to stakeholders for review and input. The involvement of all reviewers led to improvements in this document and is greatly appreciated. Stakeholders include landowners, livestock and agriculture producers, private businesses, and local, state, and federal agency personnel and represent interests from the US Forest Service, Natural Resources Conservation Service, Granite County, the city of Philipsburg, Montana Fish, Wildlife & Parks, among others.

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 = ΣWLA + ΣLA, 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.

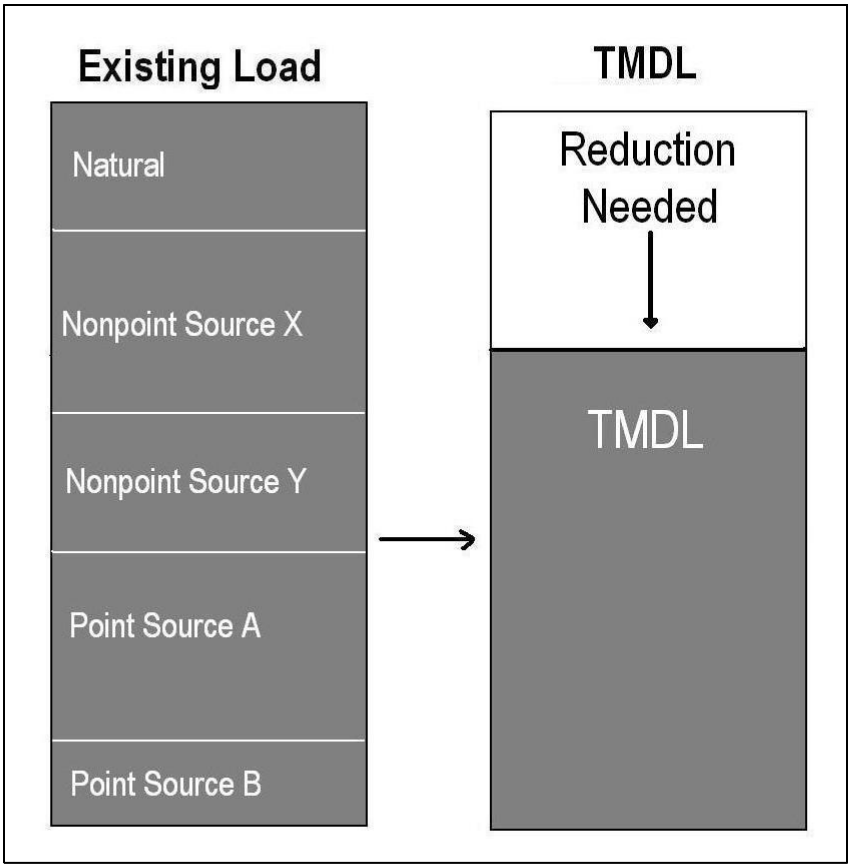

Figure 4-1. Schematic Example of Total Maximum Daily Load Development

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.

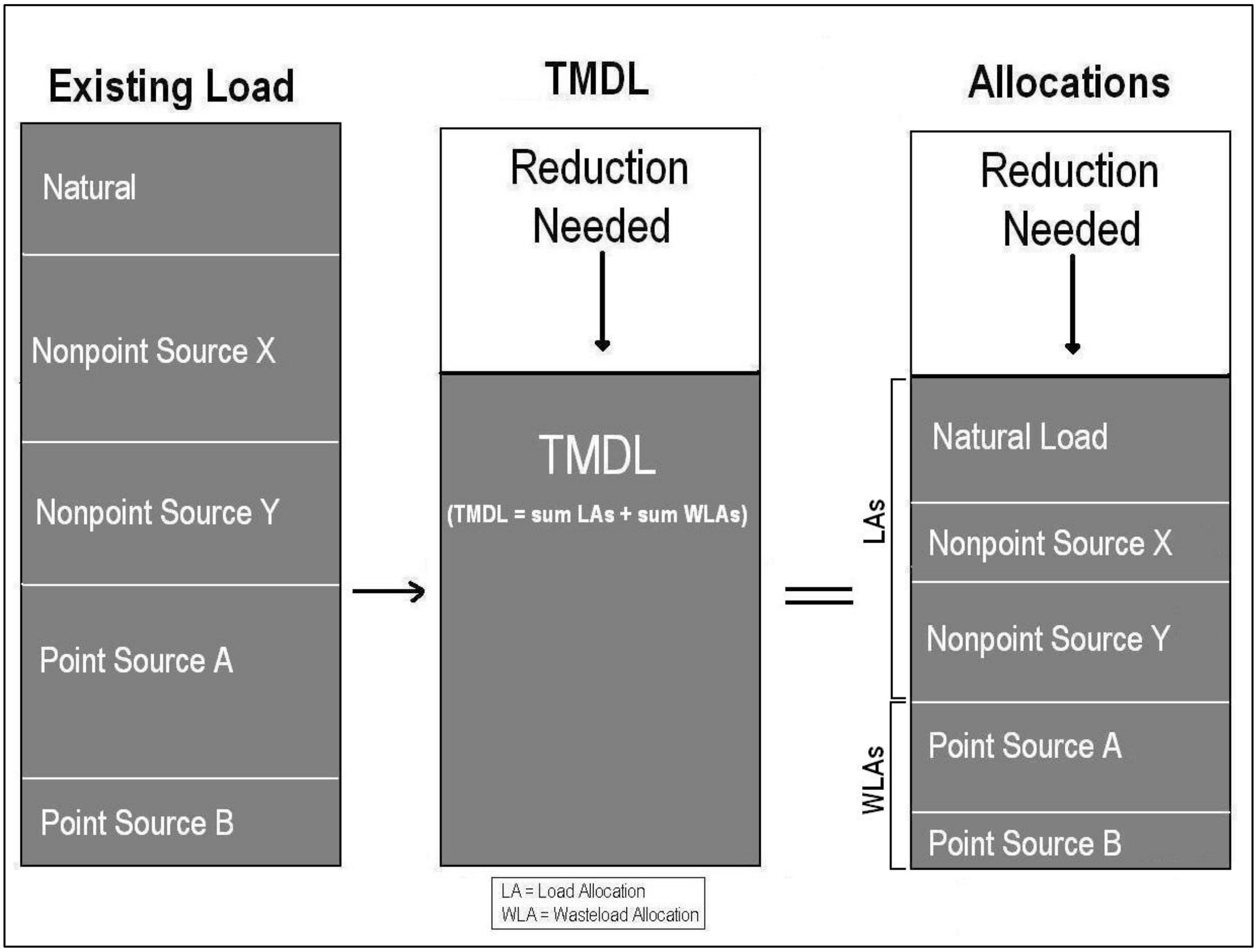

Figure 4-2. Schematic Diagram of a Total Maximum Daily Load and its Allocations

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.

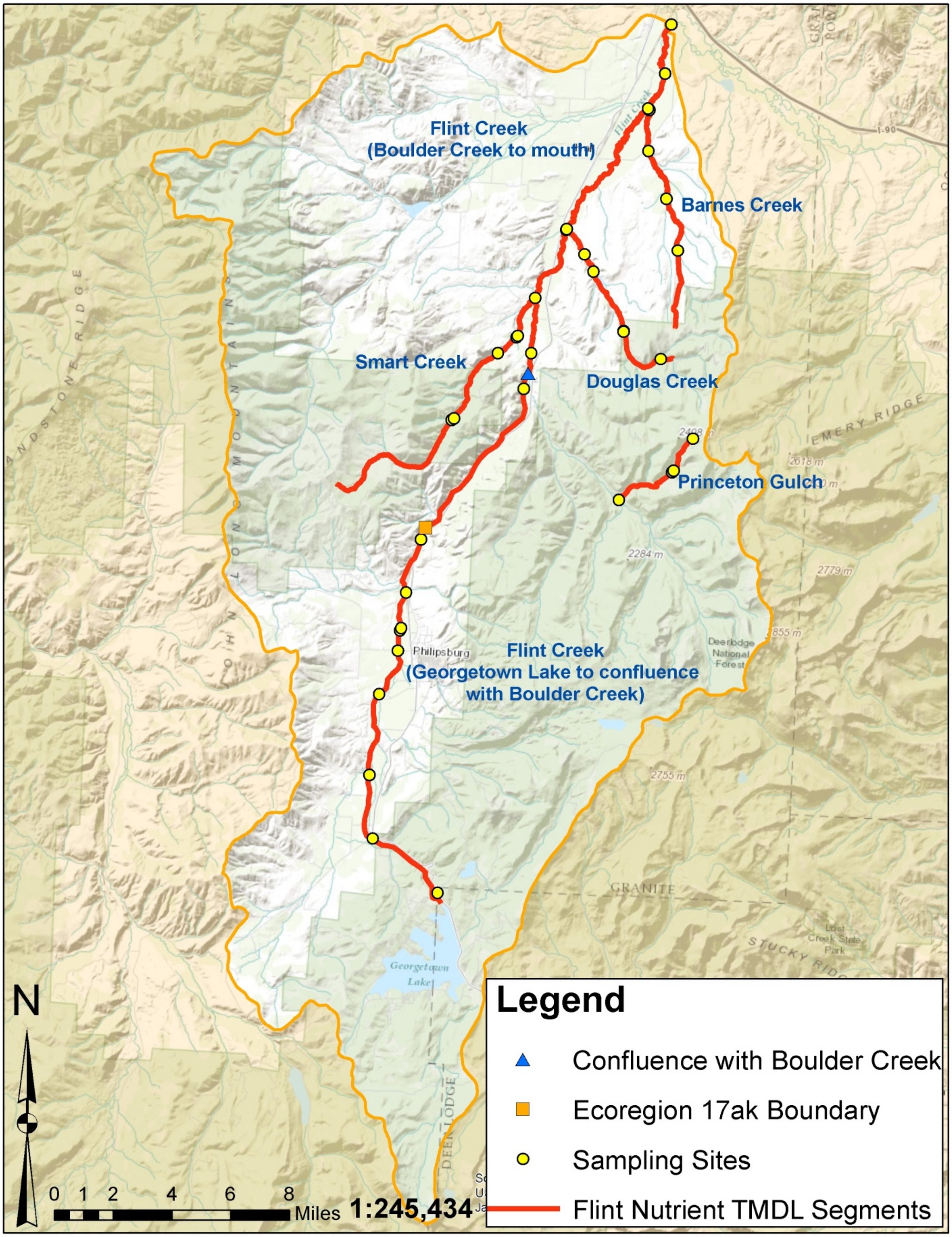

Figure 5-1. Nutrient Impaired Streams in the Flint Total Maximum Daily Load Planning Area and Associated Sampling Locations

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 not 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

<table>
<tr><th>Nutrient Parameter</th><th>Sample Size</th><th>Target Value (mg/l)</th><th>Target Exceedances</th><th>Binomial Test Result</th><th>T-test Result</th><th>Chl-a Test Result</th><th>AFDM Test Result</th><th>Macro Test Result</th><th>TMDL Required ?</th></tr>
<tr><td>Nitrate</td><td>11</td><td>0.100</td><td>7</td><td>FAIL</td><td>FAIL</td><td rowspan="3">FAIL</td><td rowspan="3">NA</td><td rowspan="3">FAIL</td><td>YES</td></tr>
<tr><td>TN</td><td>9</td><td>0.300</td><td>8</td><td>FAIL</td><td>FAIL</td><td>YES</td></tr>
<tr><td>TP</td><td>11</td><td>0.030</td><td>11</td><td>FAIL</td><td>FAIL</td><td>YES</td></tr>
</table>

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/m²	2007-2008	11	8	535	71
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 5-8. 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			NO
TN	19	0.500/ 0.300	0	PASS	PASS	FAIL	NA	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/m^2 with three exceeding the target of 125 mg/m^2. 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/m^2	2007-2009	10	< 0.28	297	94
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 5-10. 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**.

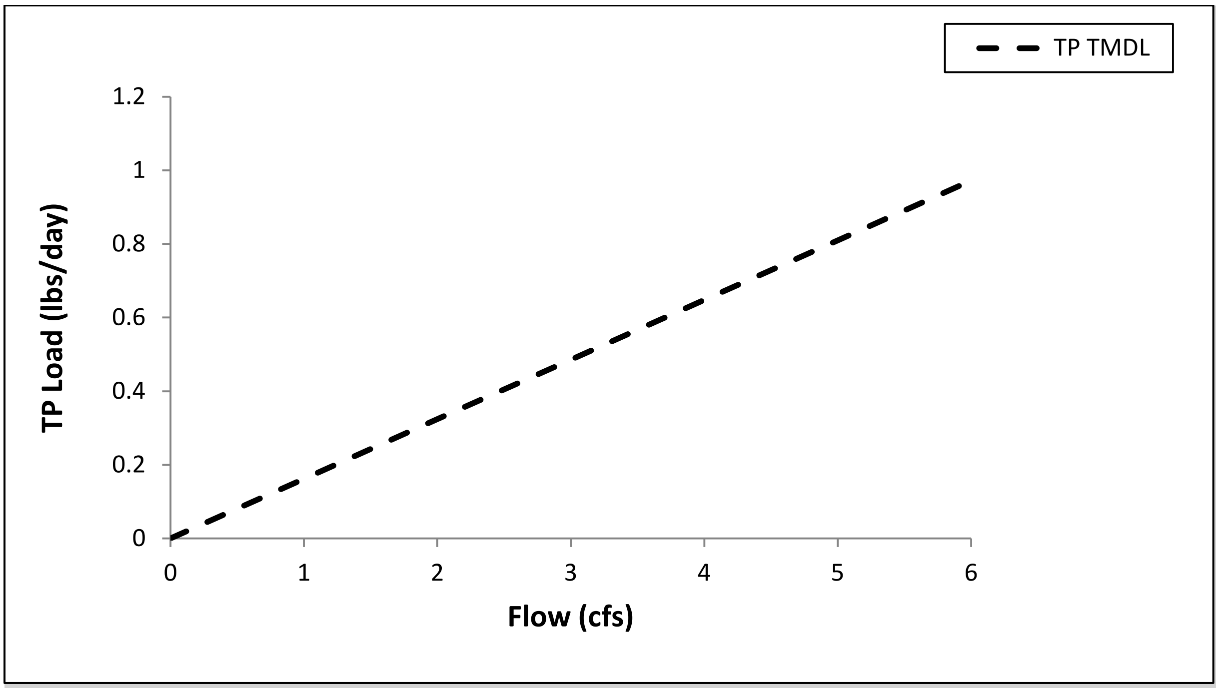

Figure 5-2. Example Total Maximum Daily Load for Total Phosphorus from 0 to 6 cfs

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

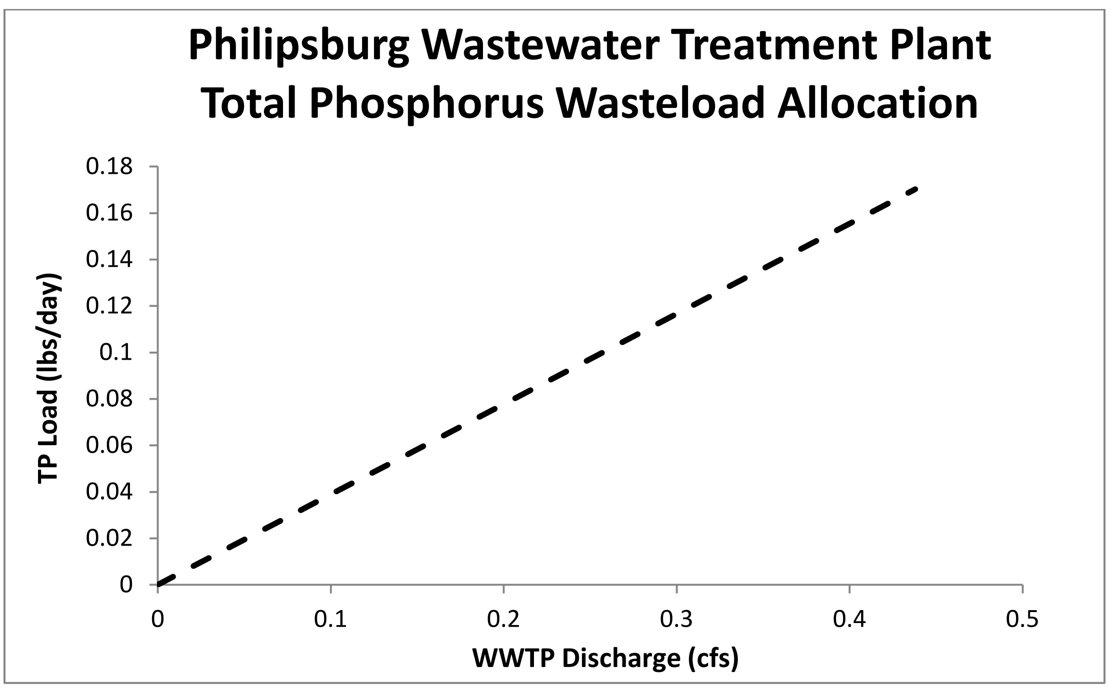

Figure 5-3. Wasteload Allocation for Total Phosphorus from the Philipsburg Wastewater Treatment Plant

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.

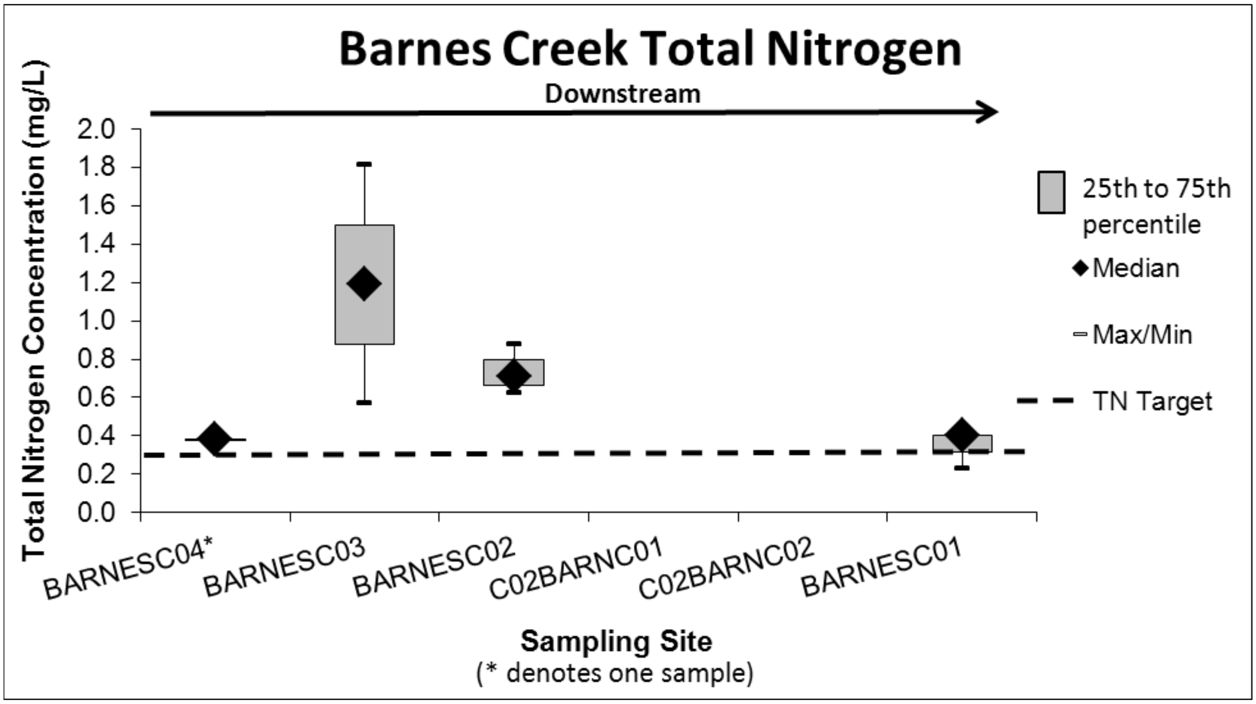

Figure 5-4. Total Nitrogen Box Plots for Barnes Creek

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.

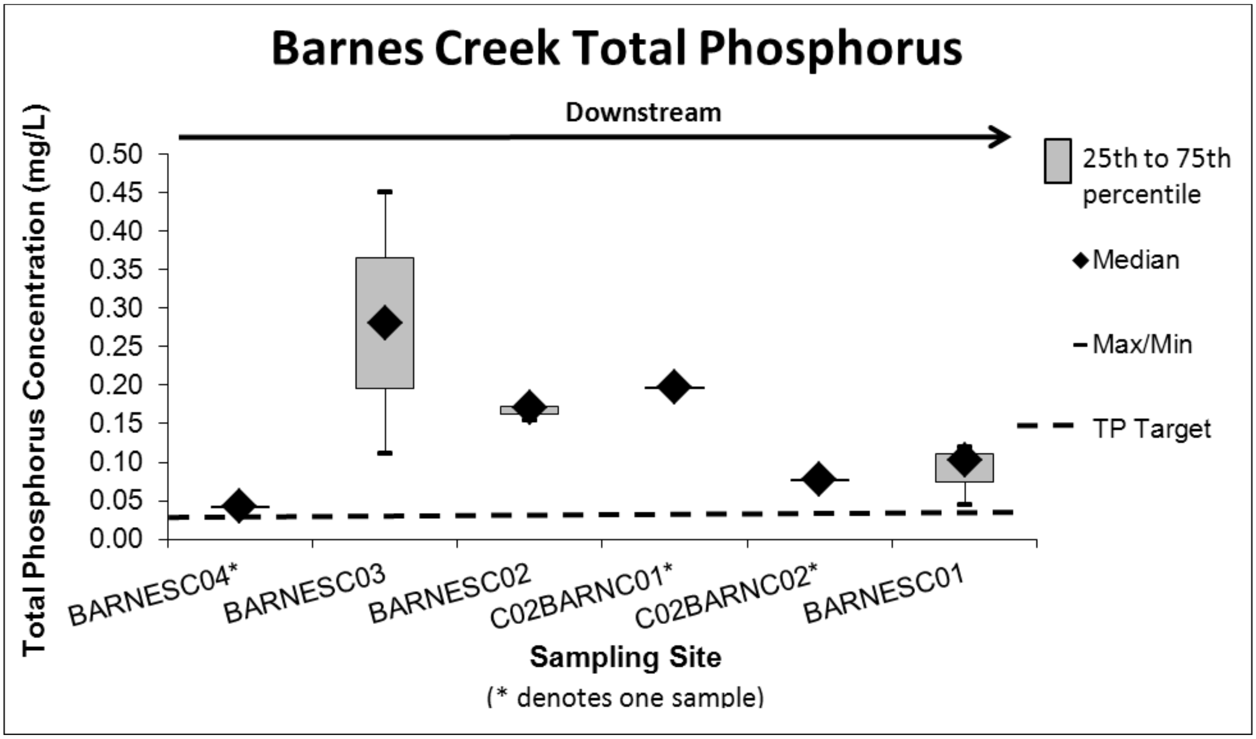

Figure 5-5. Total Phosphorus Box Plots for Barnes Creek

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.

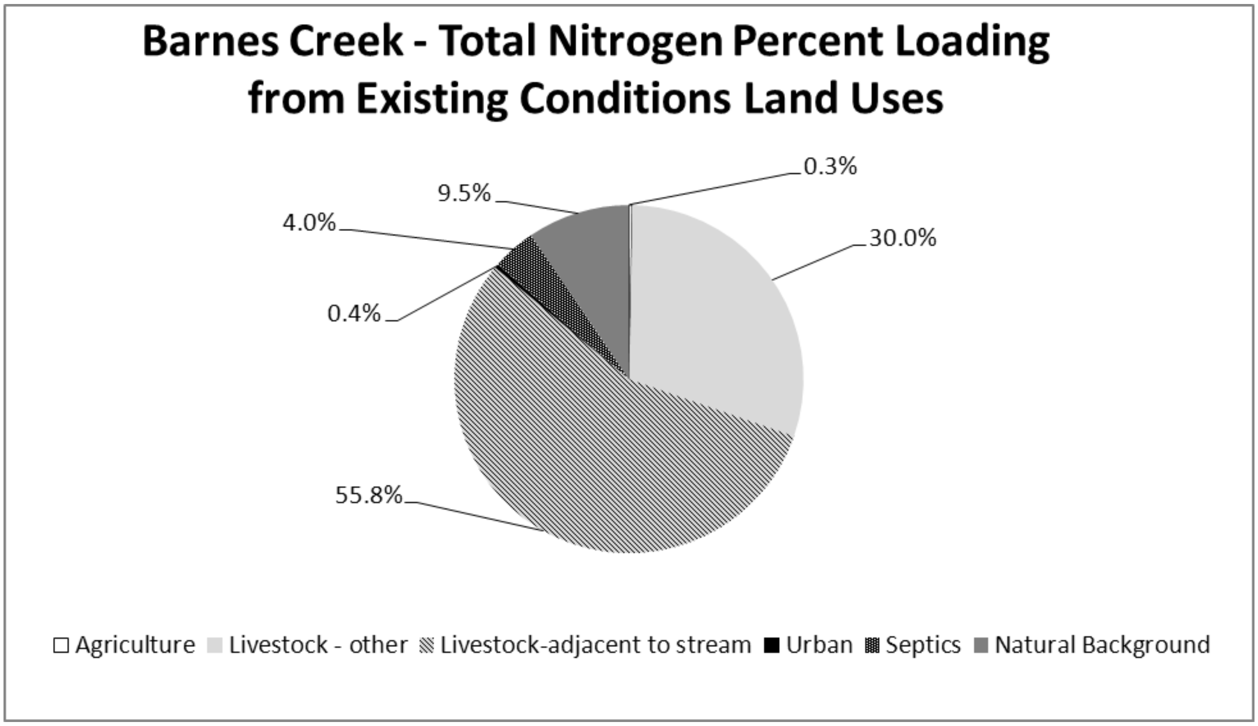

Figure 5-6. Percent Contribution of Total Nitrogen Sources to Barnes Creek during the Summer Growing Season

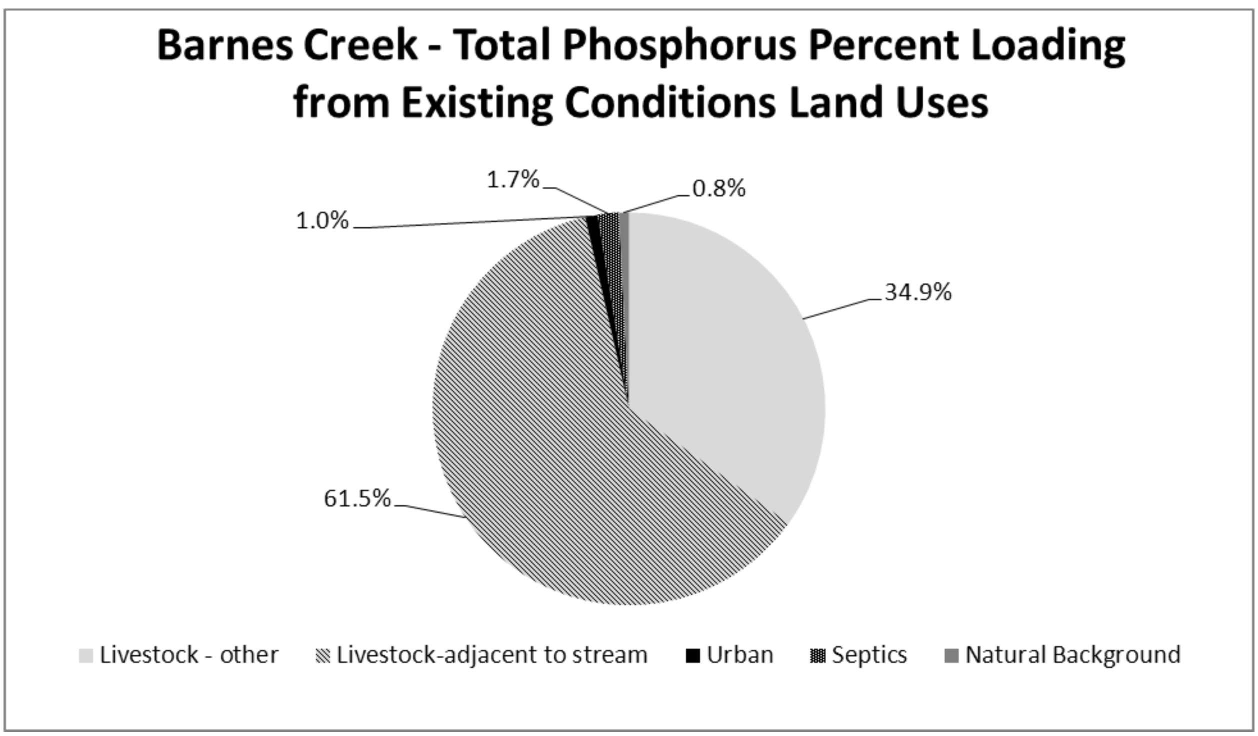

Figure 5-7. Percent Contribution of Total Phosphorus Sources to Barnes Creek during the Summer Growing Season

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%.

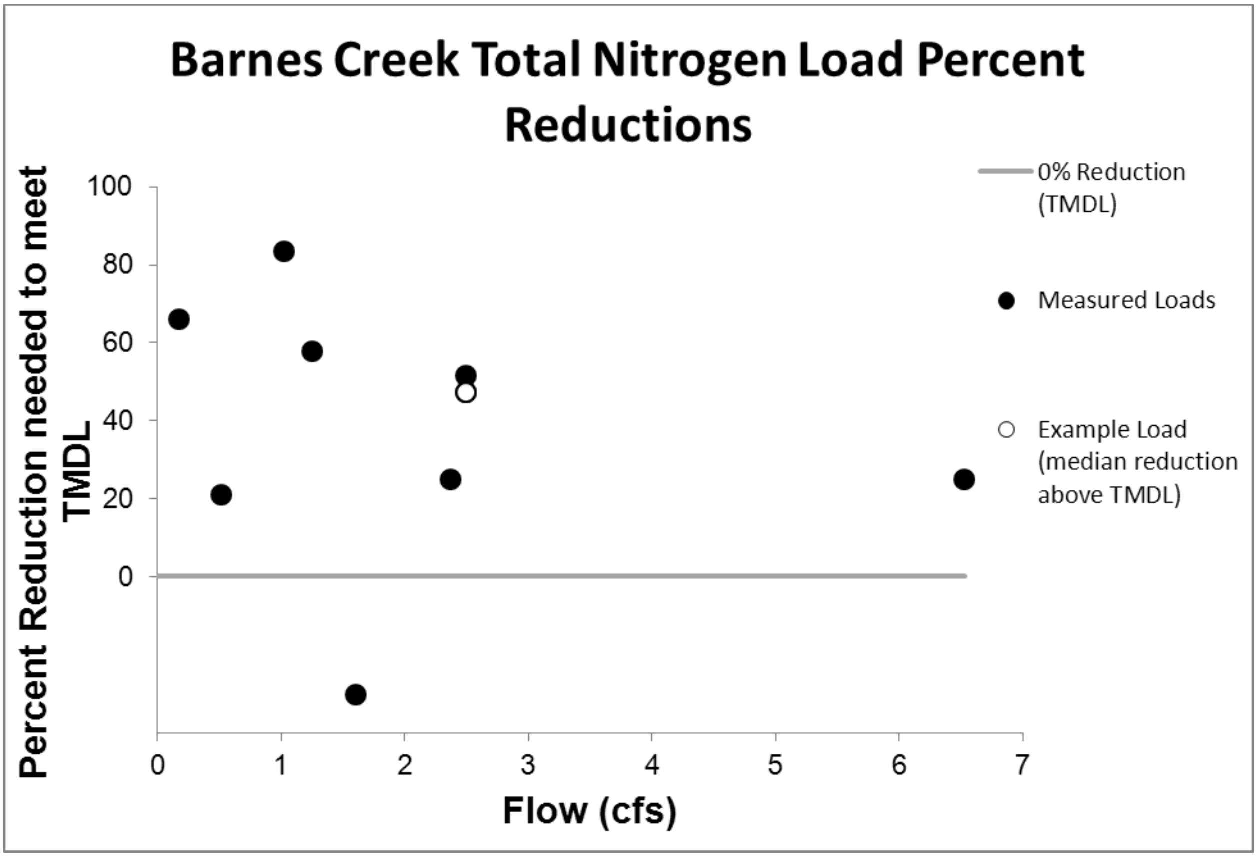

Figure 5-8. Measured Total Nitrogen Loads Percent Reductions for Barnes Creek
All points on or below the gray line are meeting the TMDL. The example existing load from **Table 5-19** is represented by the hollow circle.

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.

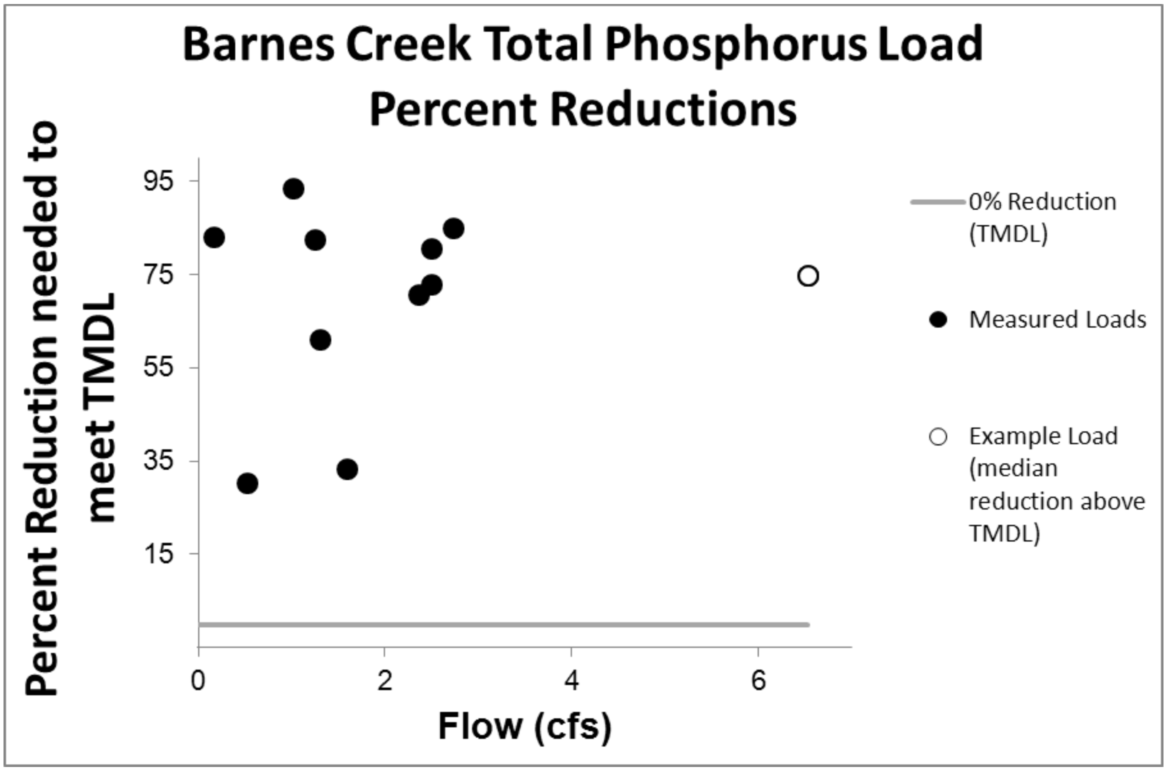

Figure 5-9. Measured Total Phosphorus Loads Percent Reductions for Barnes Creek
All points on or below the gray line are meeting the TMDL. The example existing load from **Table 5-20** is represented by the hollow circle.

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.

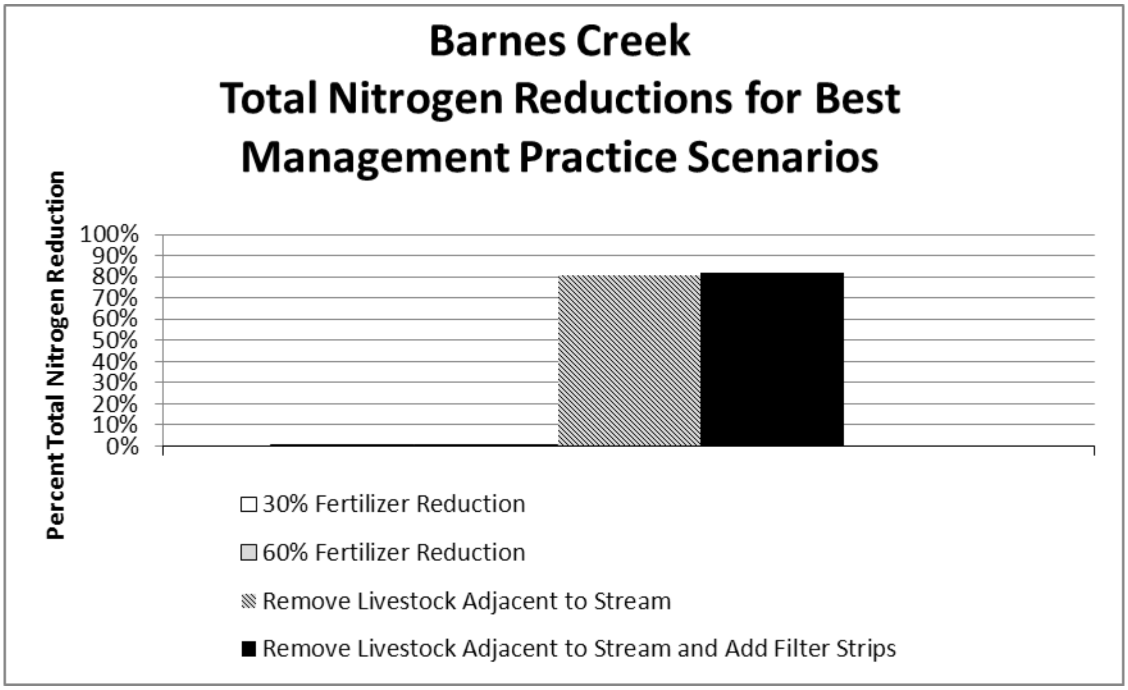

Figure 5-10. Total Nitrogen Best Management Practice Scenarios for Barnes Creek during the Summer Growing Season

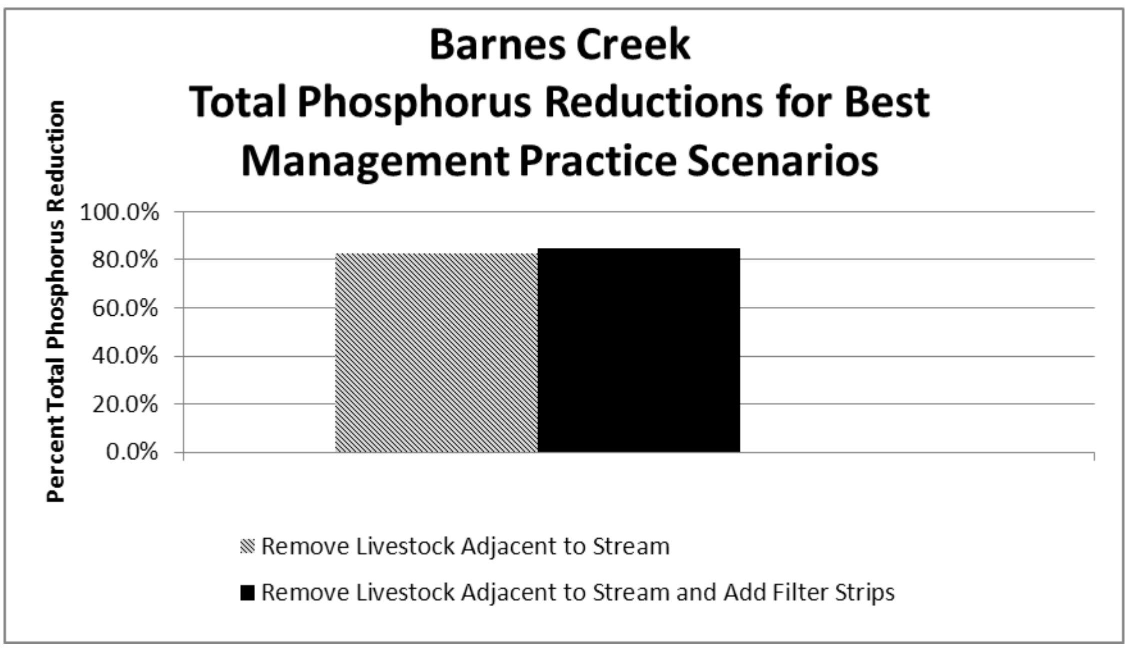

Figure 5-11. Total Phosphorus Best Management Practice Scenarios for Barnes Creek during the Summer Growing Season

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.

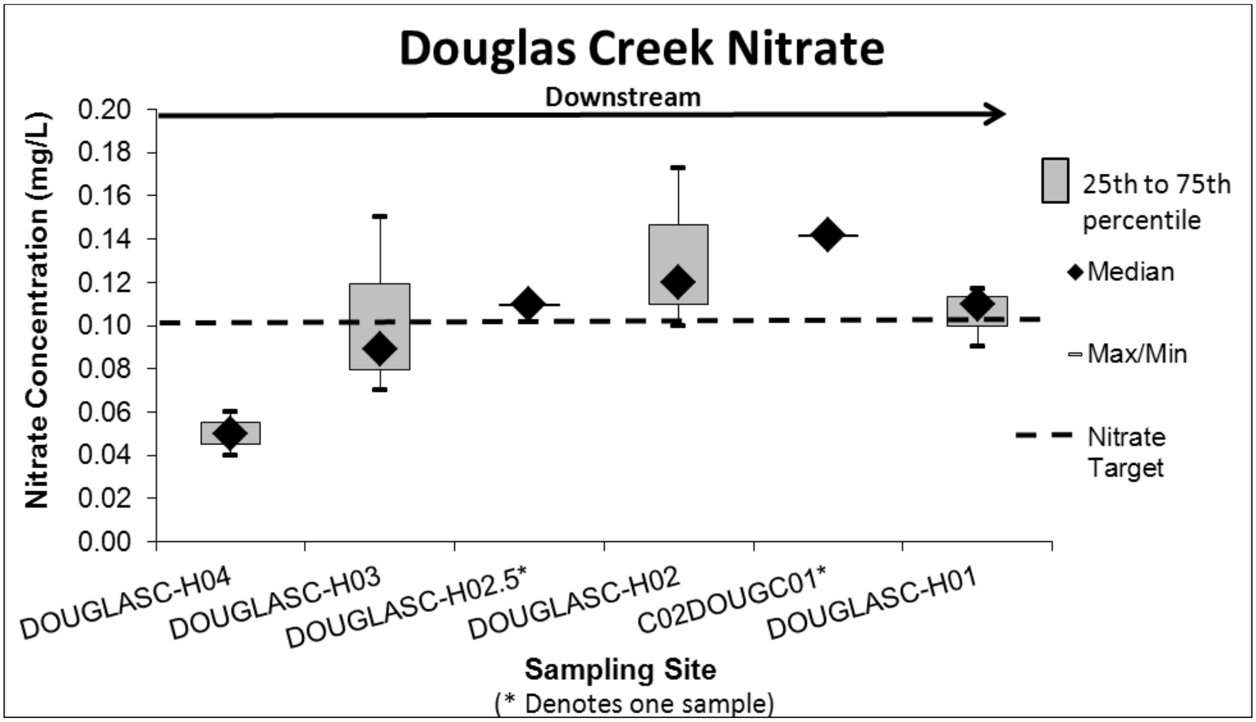

Figure 5-12. Nitrate Box Plots for Douglas Creek

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.

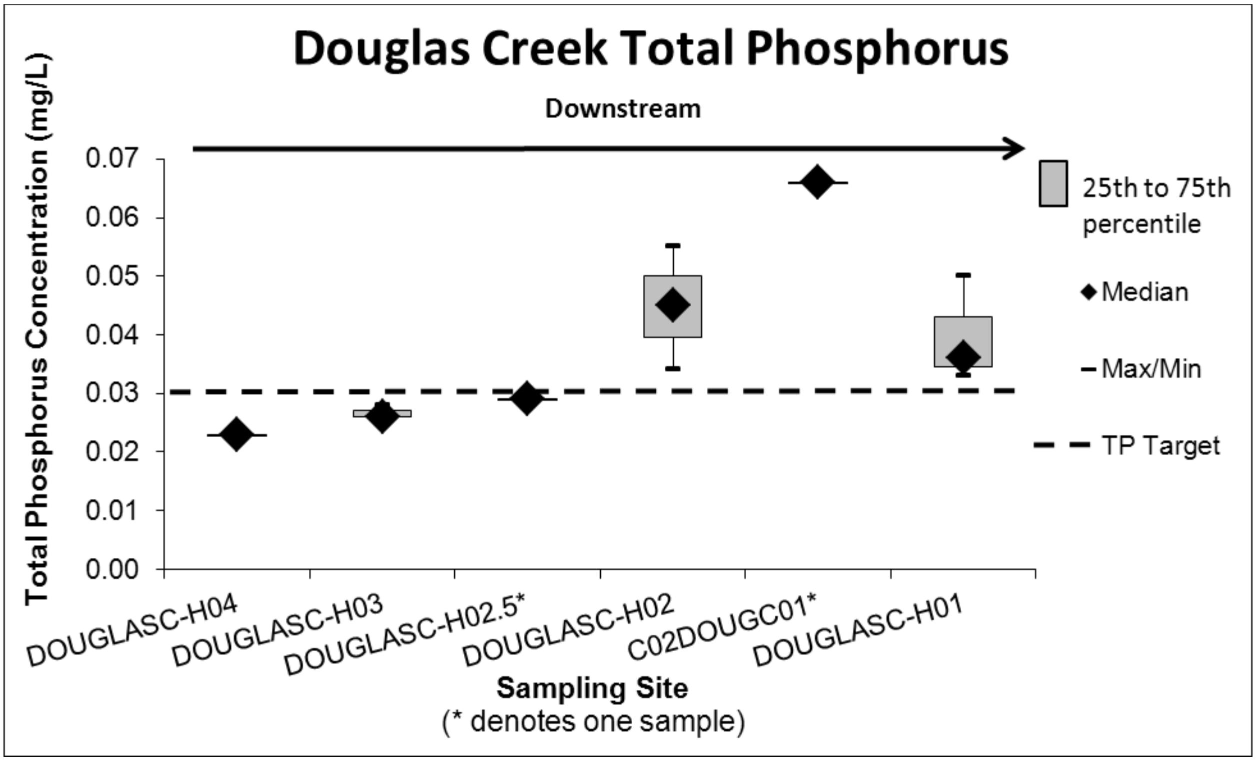

Figure 5-13. Total Phosphorus Box Plots for Douglas Creek

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.

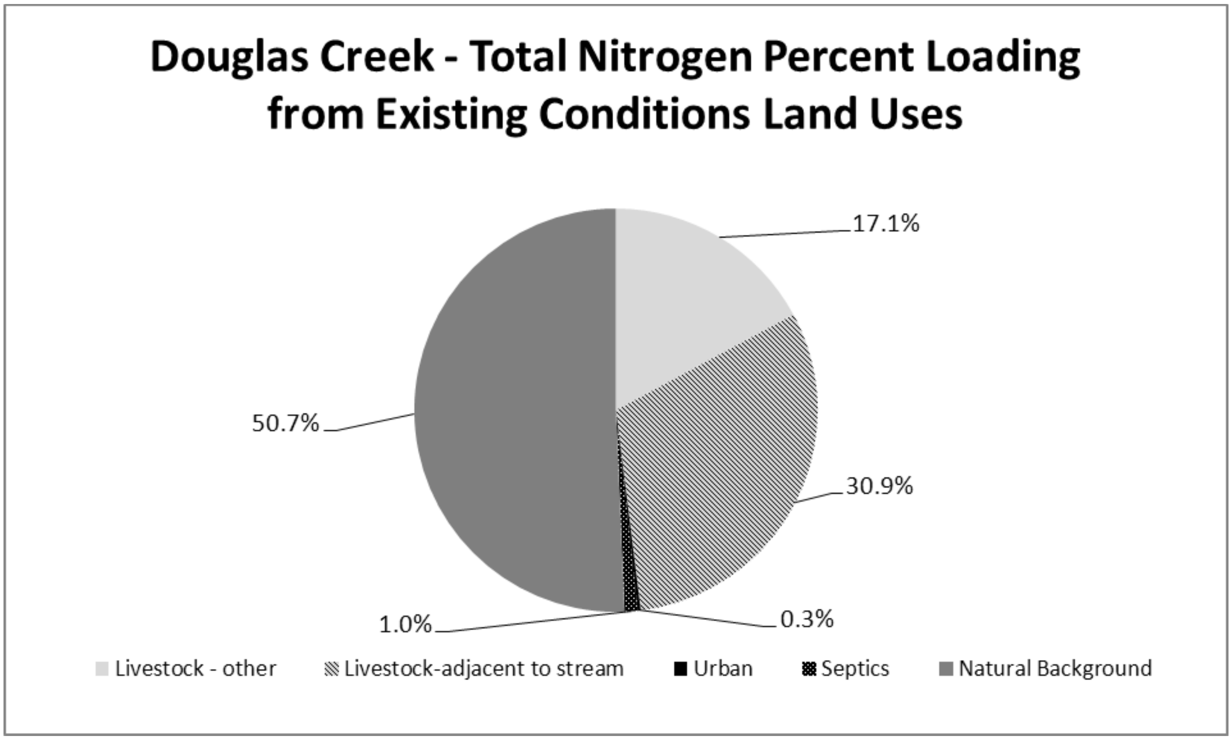

Figure 5-14. Percent Contribution of Total Nitrogen Sources to Douglas Creek during the Summer Growing Season

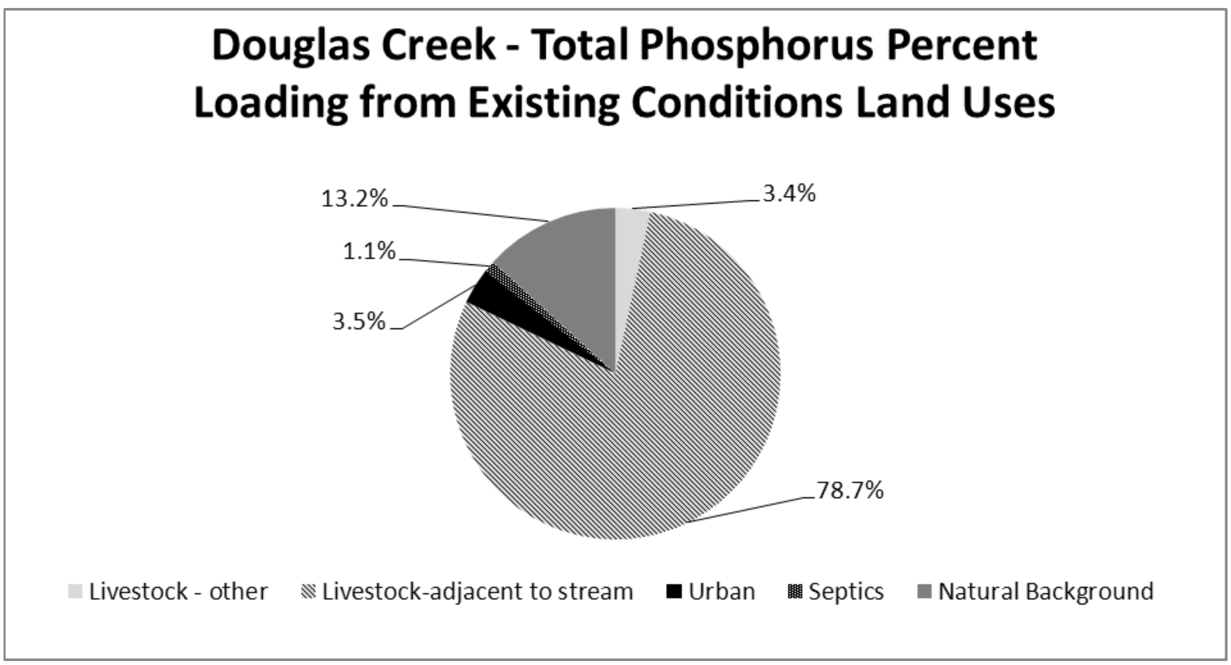

Figure 5-15. Percent Contribution of Total Phosphorus Sources to Douglas Creek during the Summer Growing Season

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%.

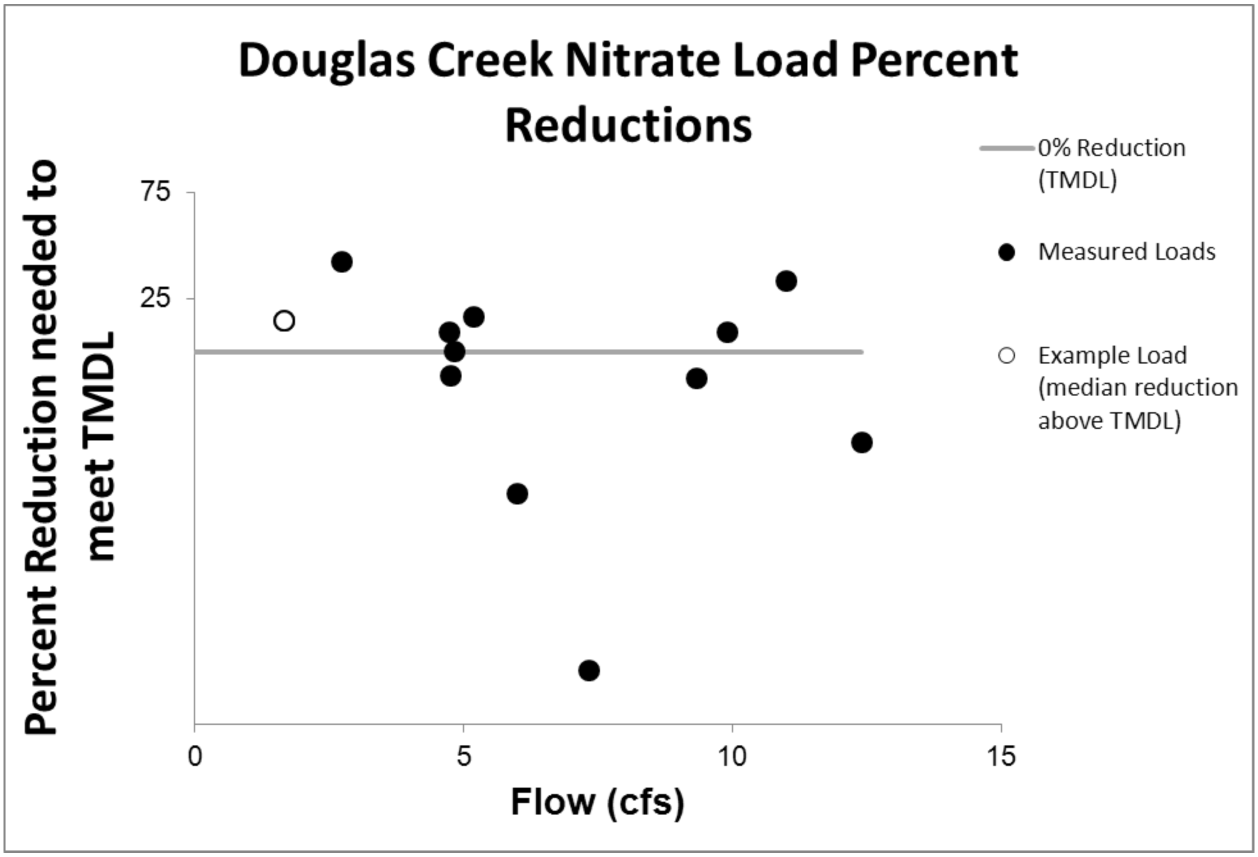

Figure 5-16. Measured Nitrate Loads Percent Reductions for Douglas Creek
All points on or below the gray line are meeting the TMDL. The example existing load from **Table 5-21** is represented by the hollow circle. Concentration data with no associated flow are not represented in this figure.

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%.

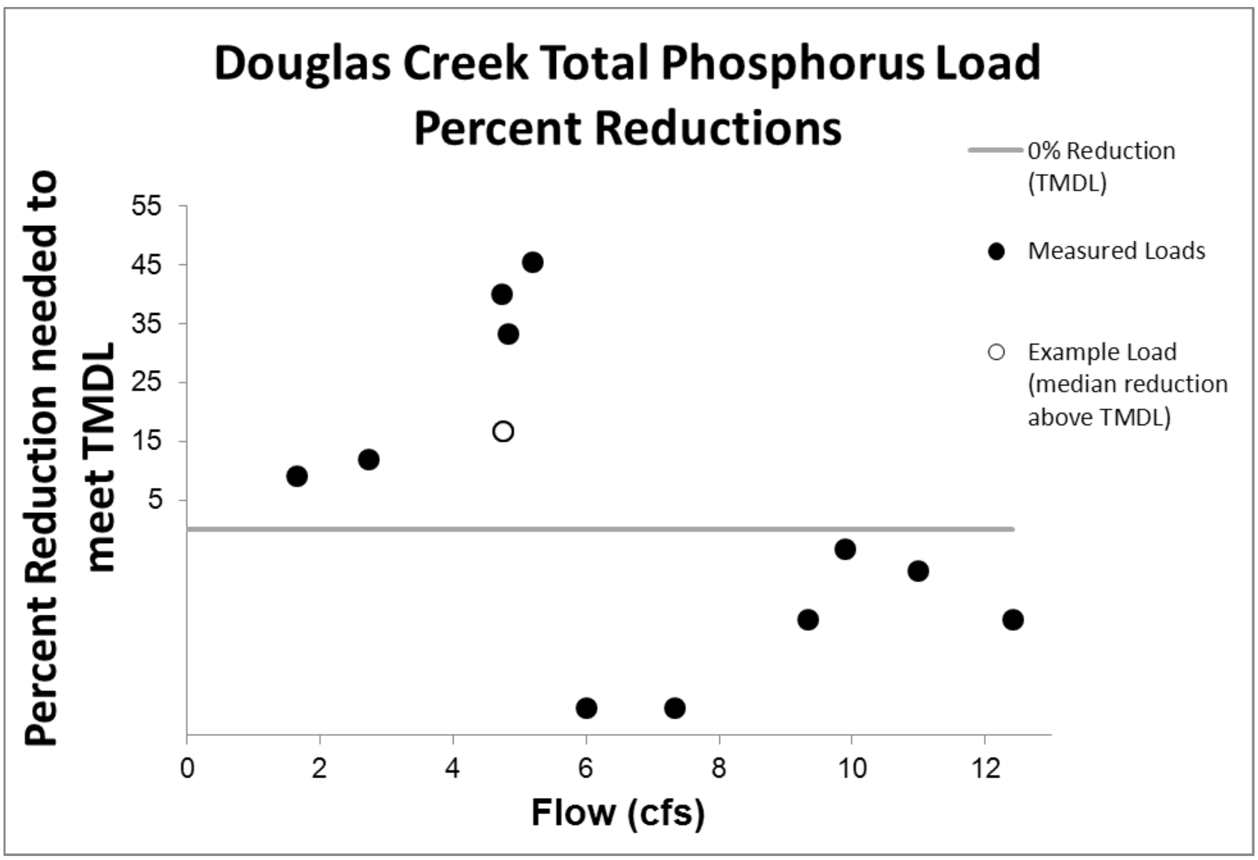

Figure 5-17. Measured Total Phosphorus Loads Percent Reductions for Douglas Creek

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%.

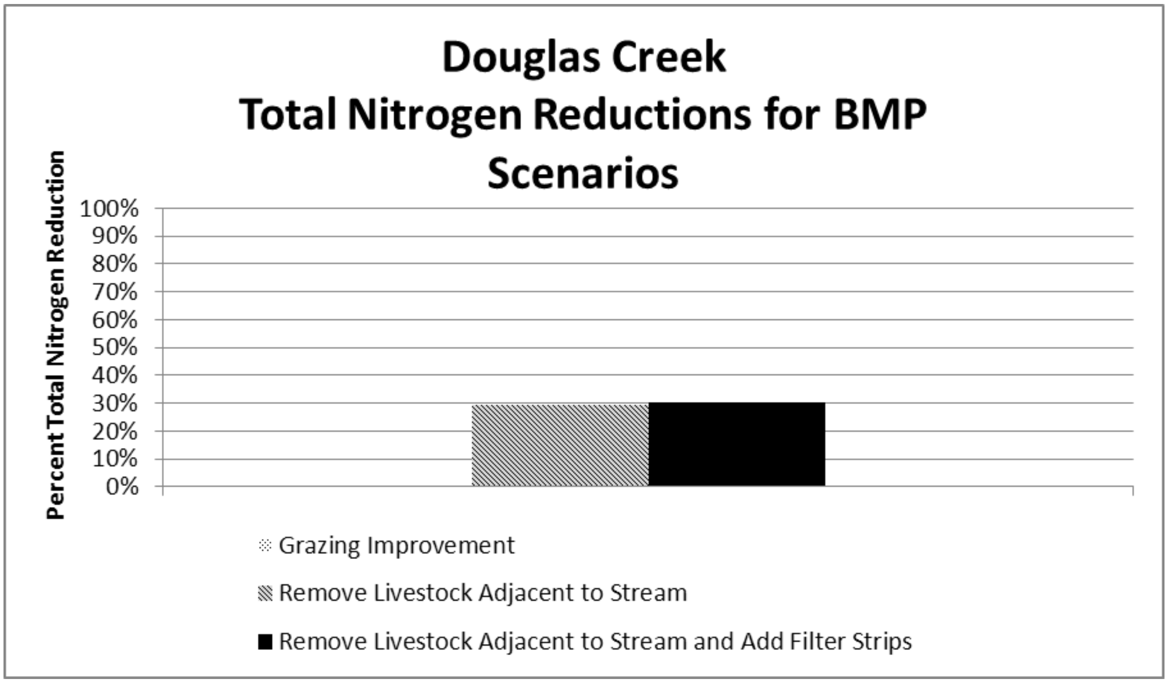

Figure 5-18. Total Nitrogen Best Management Practice Scenarios for Douglas Creek during the Summer Growing Season

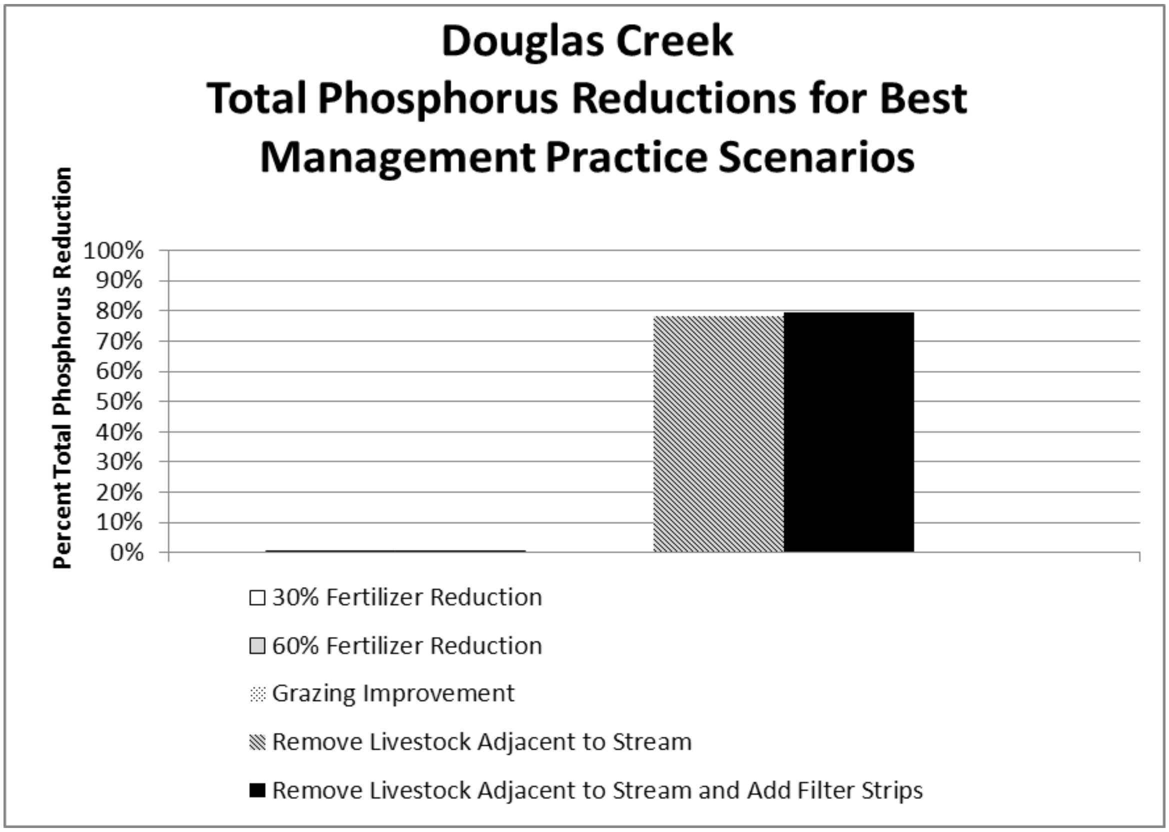

Figure 5-19. Total Phosphorus Best Management Practice Scenarios for Douglas Creek during the Summer Growing Season

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**.

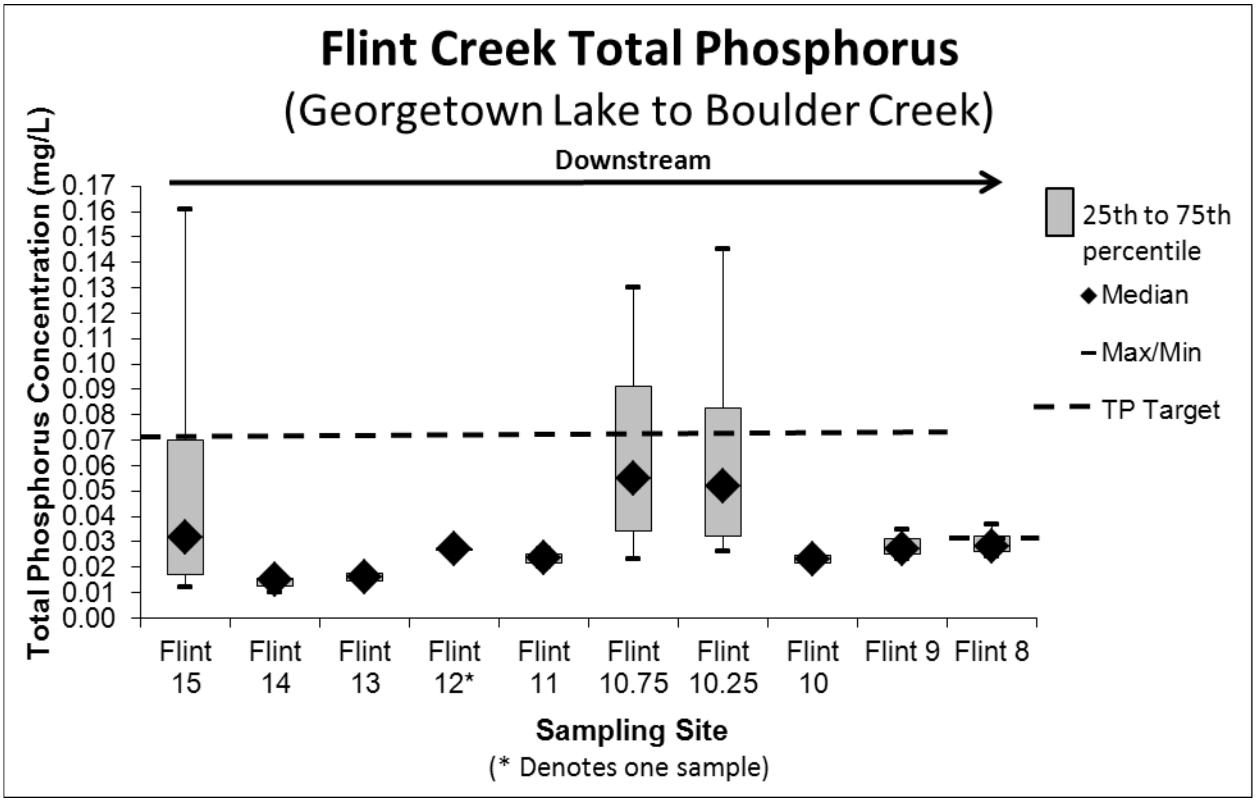

Figure 5-20. Total Phosphorus Box Plots for Flint Creek (Georgetown Lake to confluence with Boulder Creek)

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.

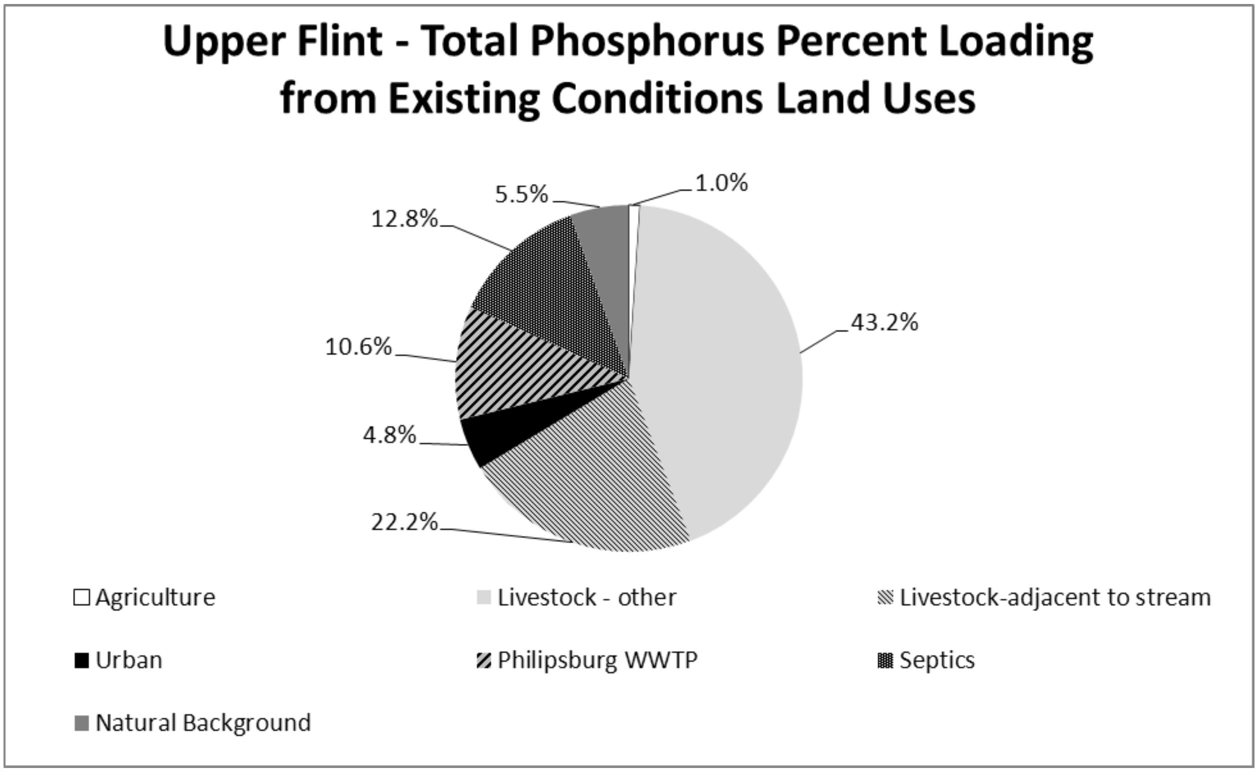

Figure 5-21. Percent Contribution of Total Phosphorus Sources to Flint Creek (Georgetown Lake to Boulder Creek) during the Summer Growing Season

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):

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

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:

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

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

$$LA + 0.06\ lb/day = 25.61\ lbs/day$$

Therefore:

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

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.

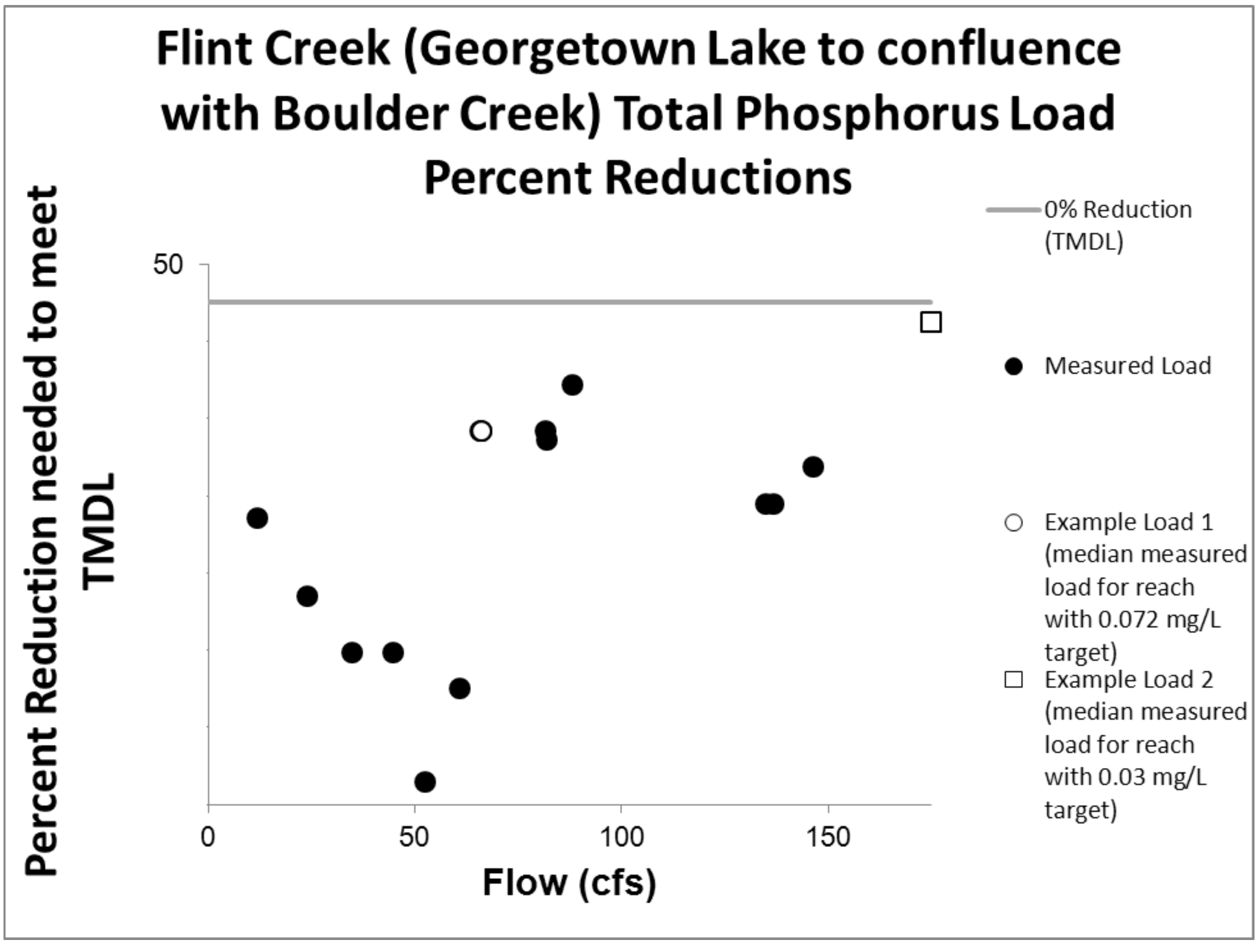

Figure 5-22. Total Phosphorus Percent Reductions for Measured Total Phosphorus Loads from Flint Creek (Georgetown Lake to confluence with Boulder Creek)

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%.

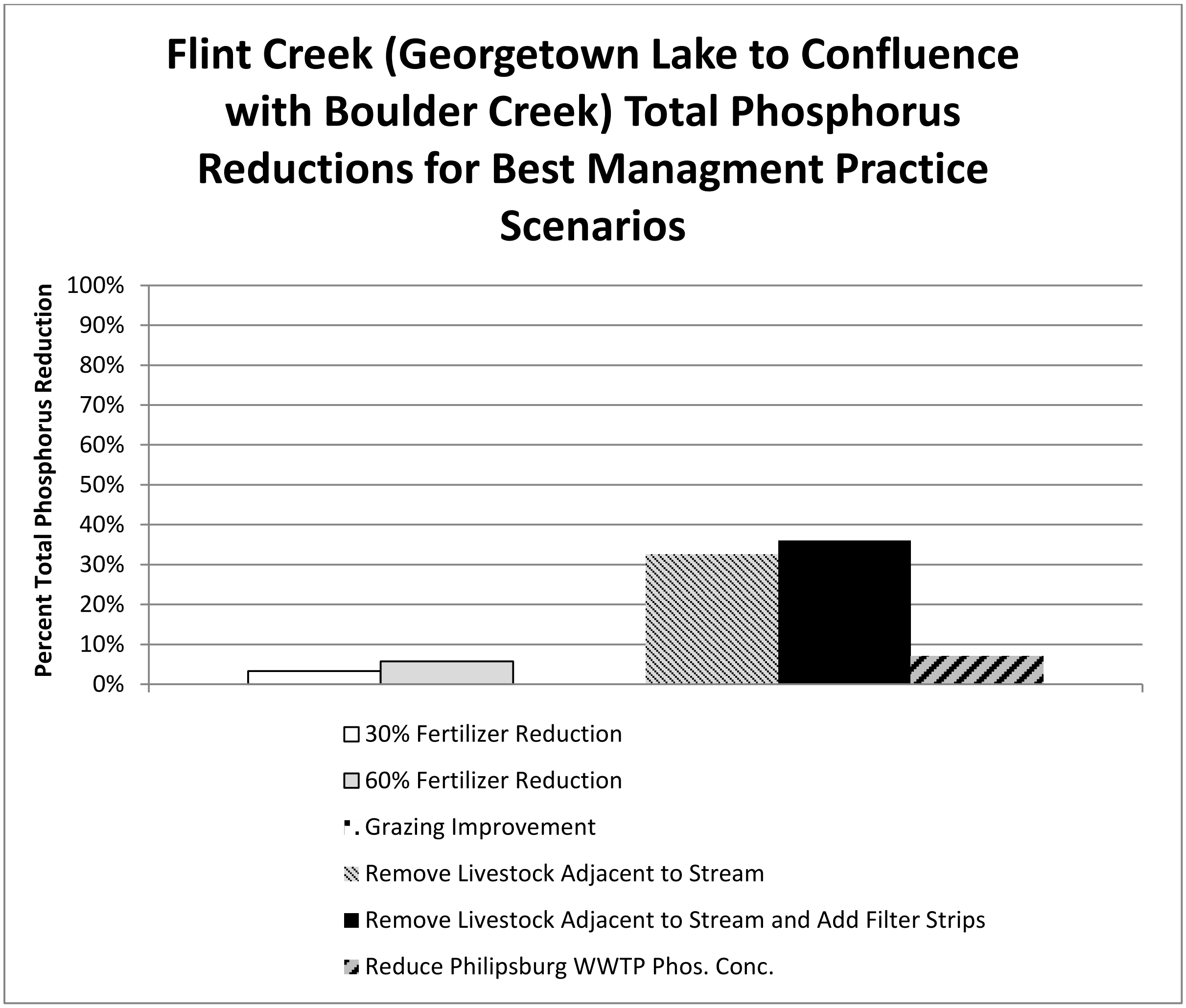

Figure 5-23. Total Phosphorus BMP Scenarios for Flint Creek (Georgetown Lake to confluence with Boulder Creek) during the Summer Growing Season

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.

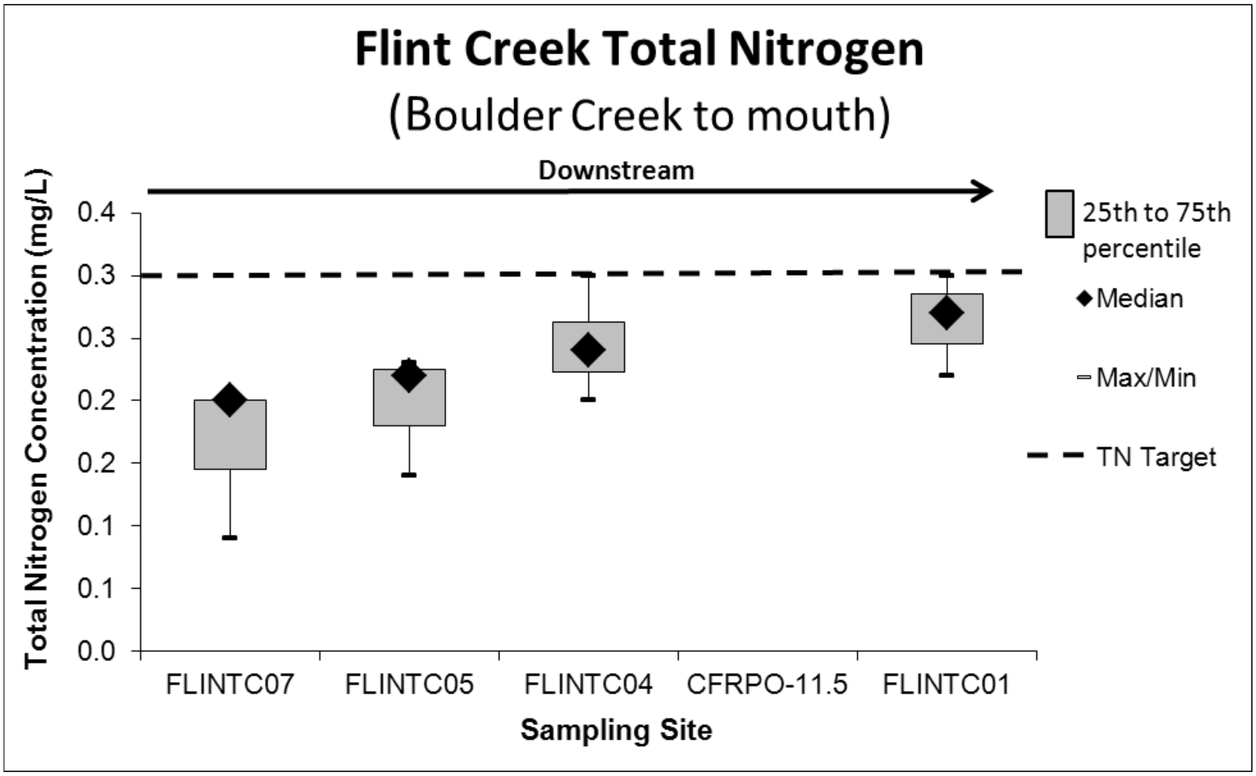

Figure 5-24. Total Nitrogen Box Plots for Flint Creek (Boulder Creek to mouth)

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.

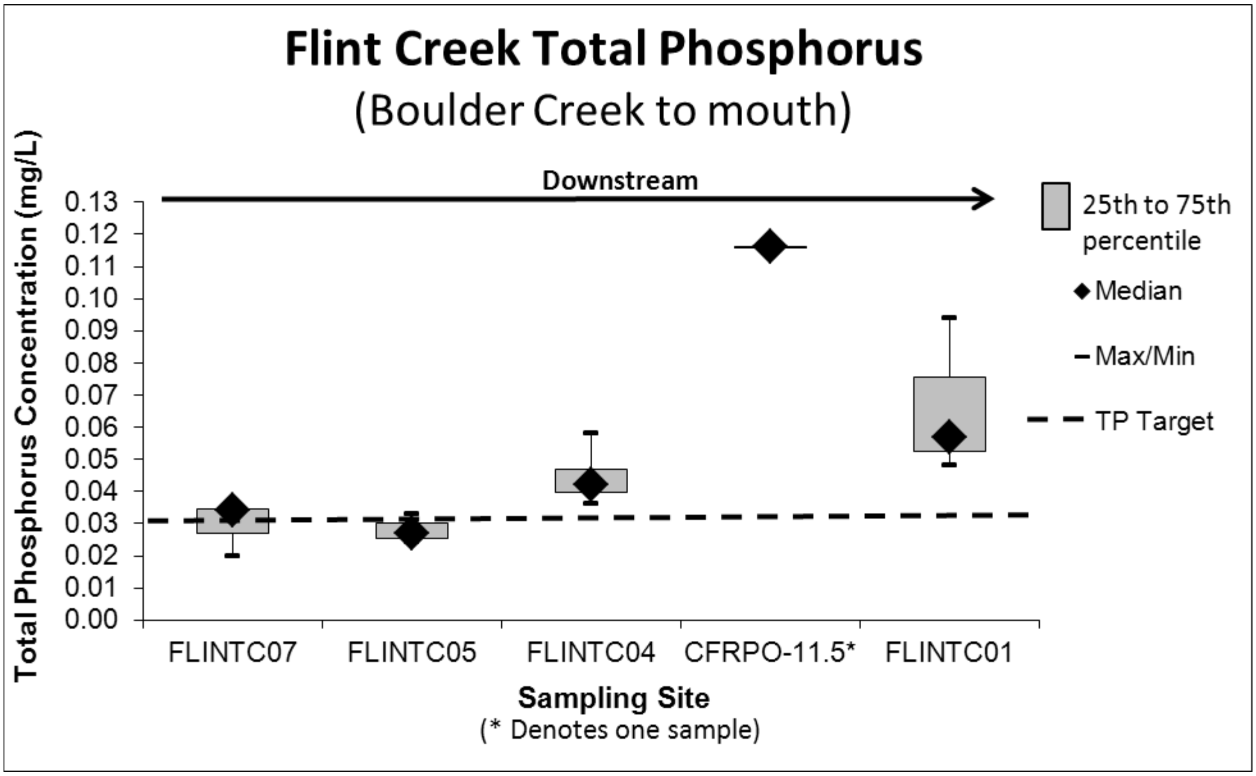

Figure 5-25. Total Phosphorus Box Plots for Flint Creek (Boulder Creek to mouth)

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.

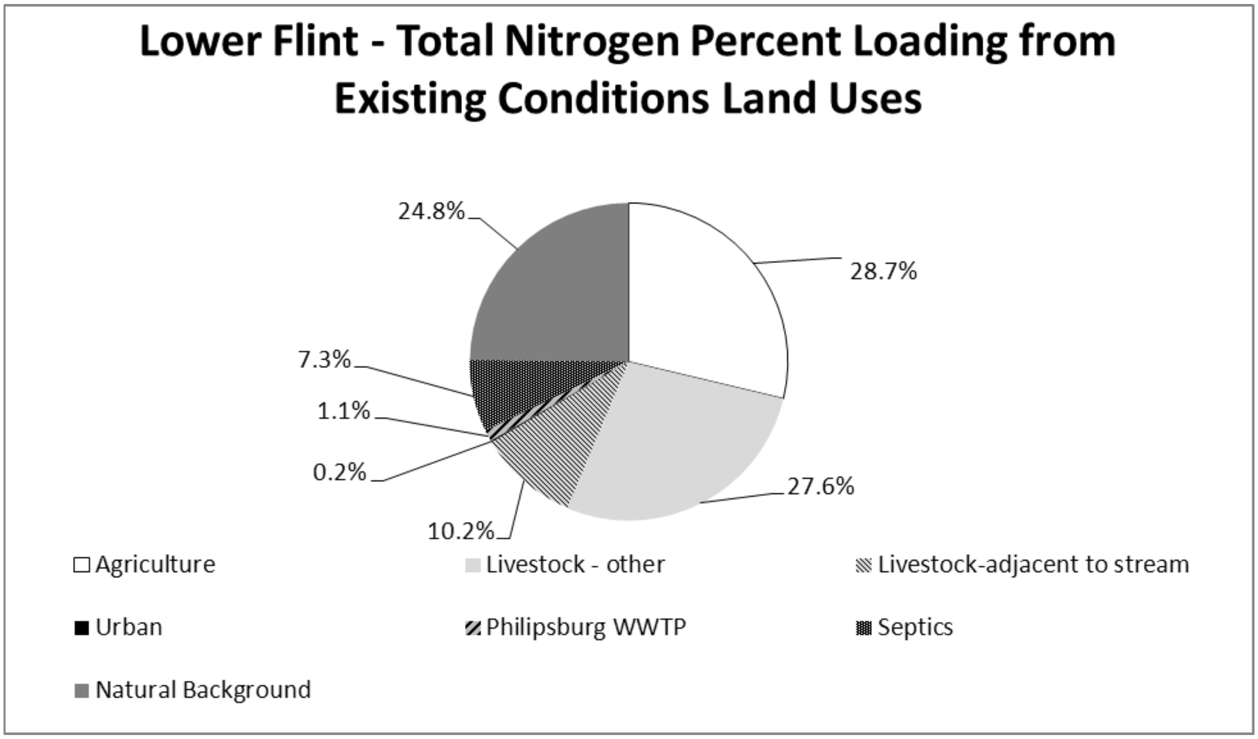

Figure 5-26. Percent Contribution of Total Nitrogen Sources to Flint Creek (Boulder Creek to mouth) during the Summer Growing Season

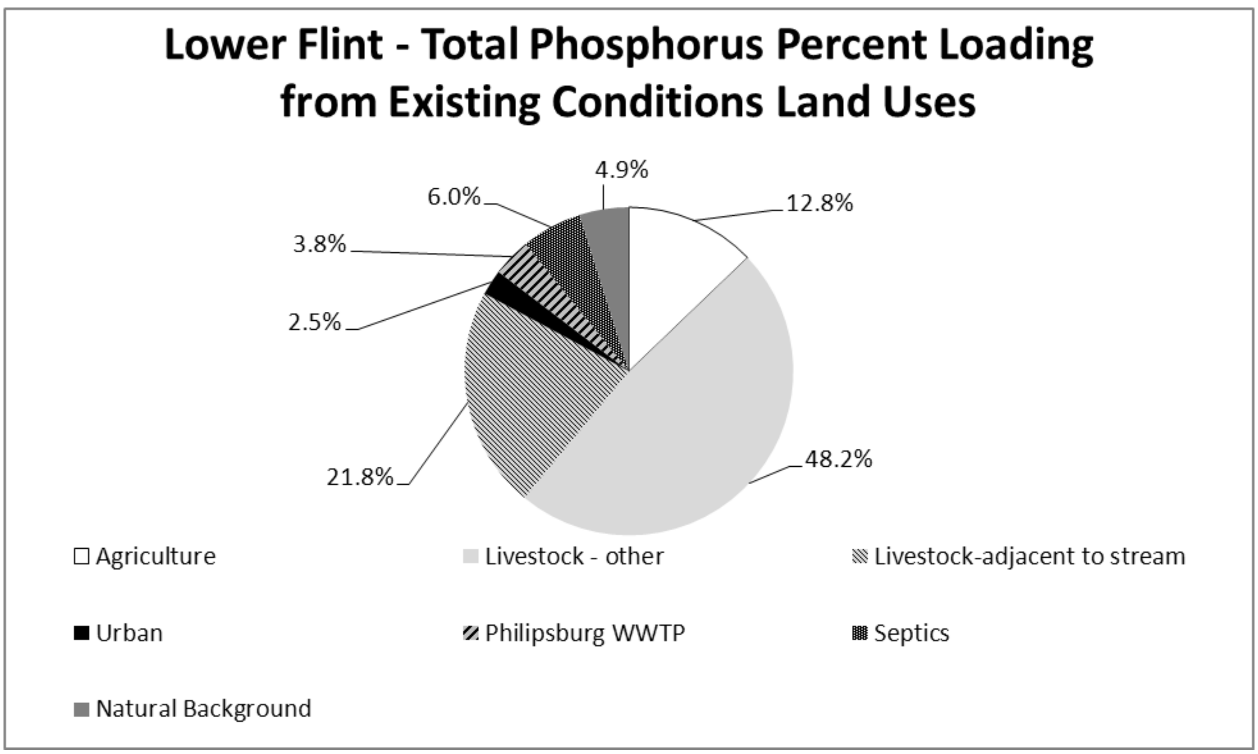

Figure 5-27. Percent Contribution of Total Phosphorus Sources to Flint Creek (Boulder Creek to mouth) during the Summer Growing Season

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.

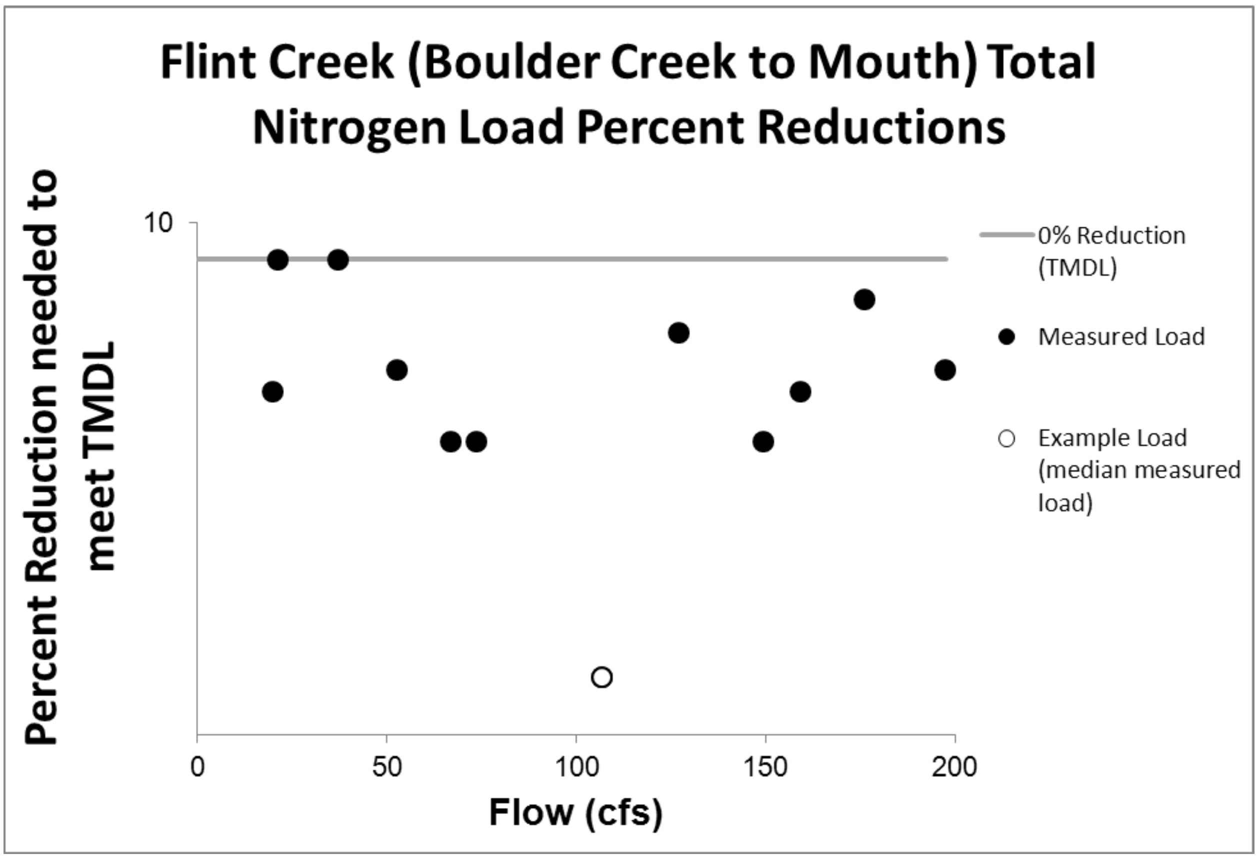

Figure 5-28. Measured Total Nitrogen Loads Percent Reductions for Flint Creek (Boulder Creek to mouth)
All points on or below the gray line are meeting the TMDL. The example existing load from **Table 5-25** is represented by the hollow circle.

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%.

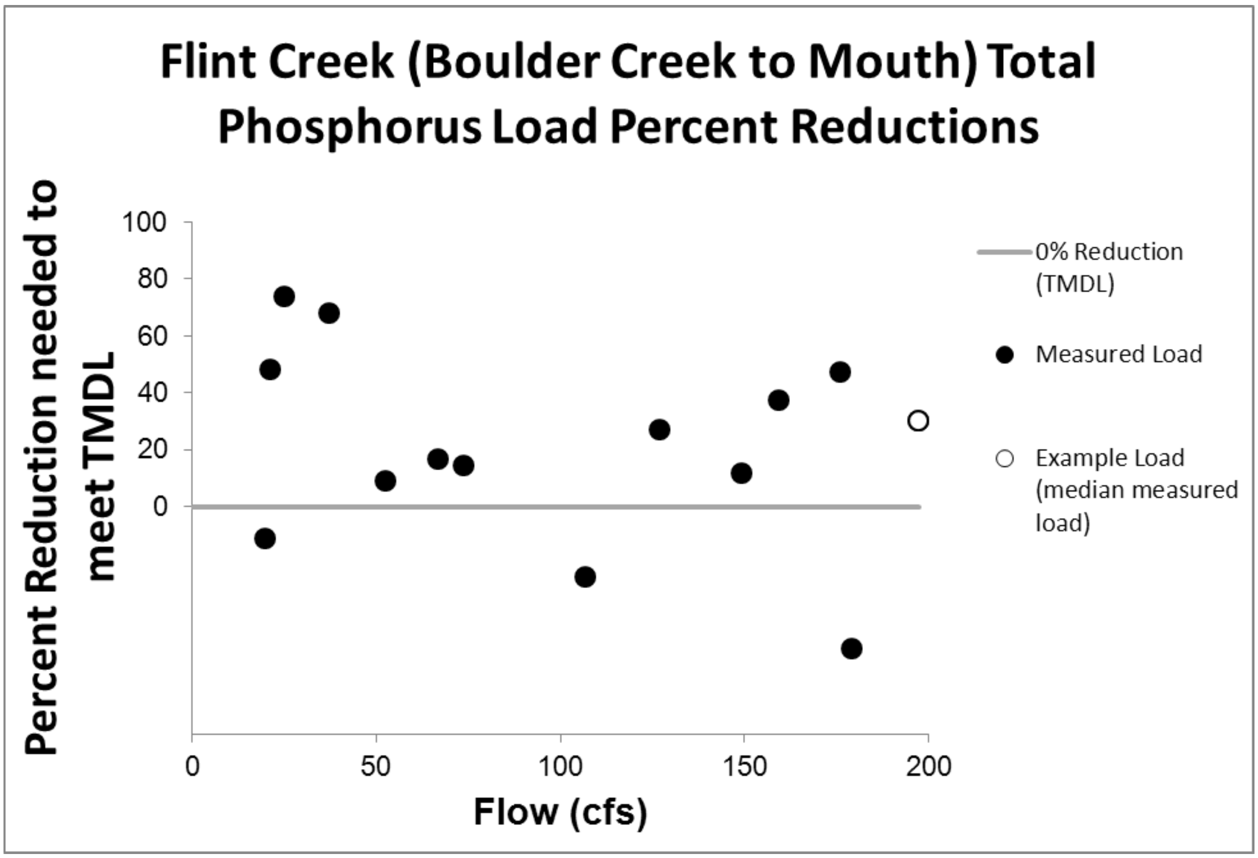

Figure 5-29. Measured Total Phosphorus Loads Percent Reductions for Flint Creek (Boulder Creek to mouth)
All points on or below the gray line are meeting the TMDL. The example existing load from **Table 5-26** is represented by the hollow circle.

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%.

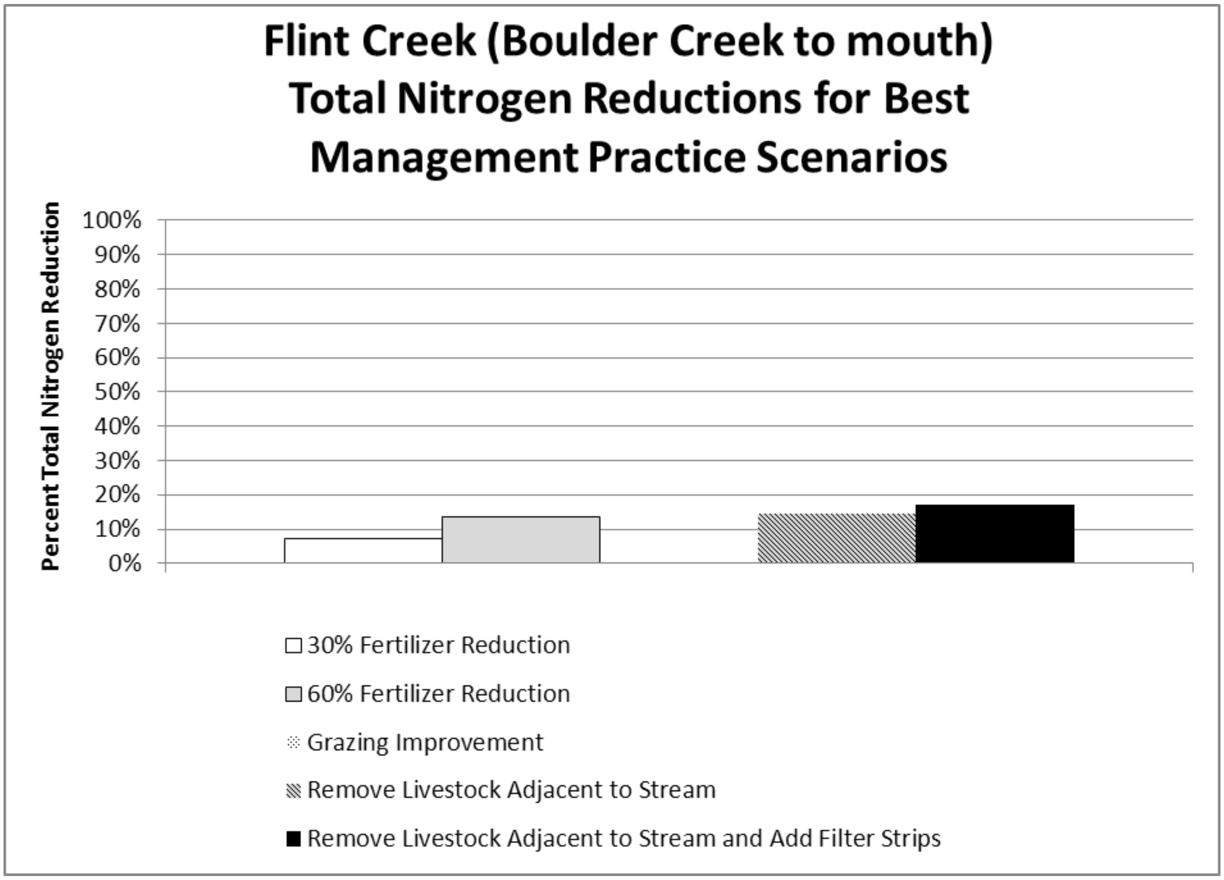

Figure 5-30. Total Nitrogen Best Management Practice Scenarios for Flint Creek (Boulder Creek to mouth) during the Summer Growing Season

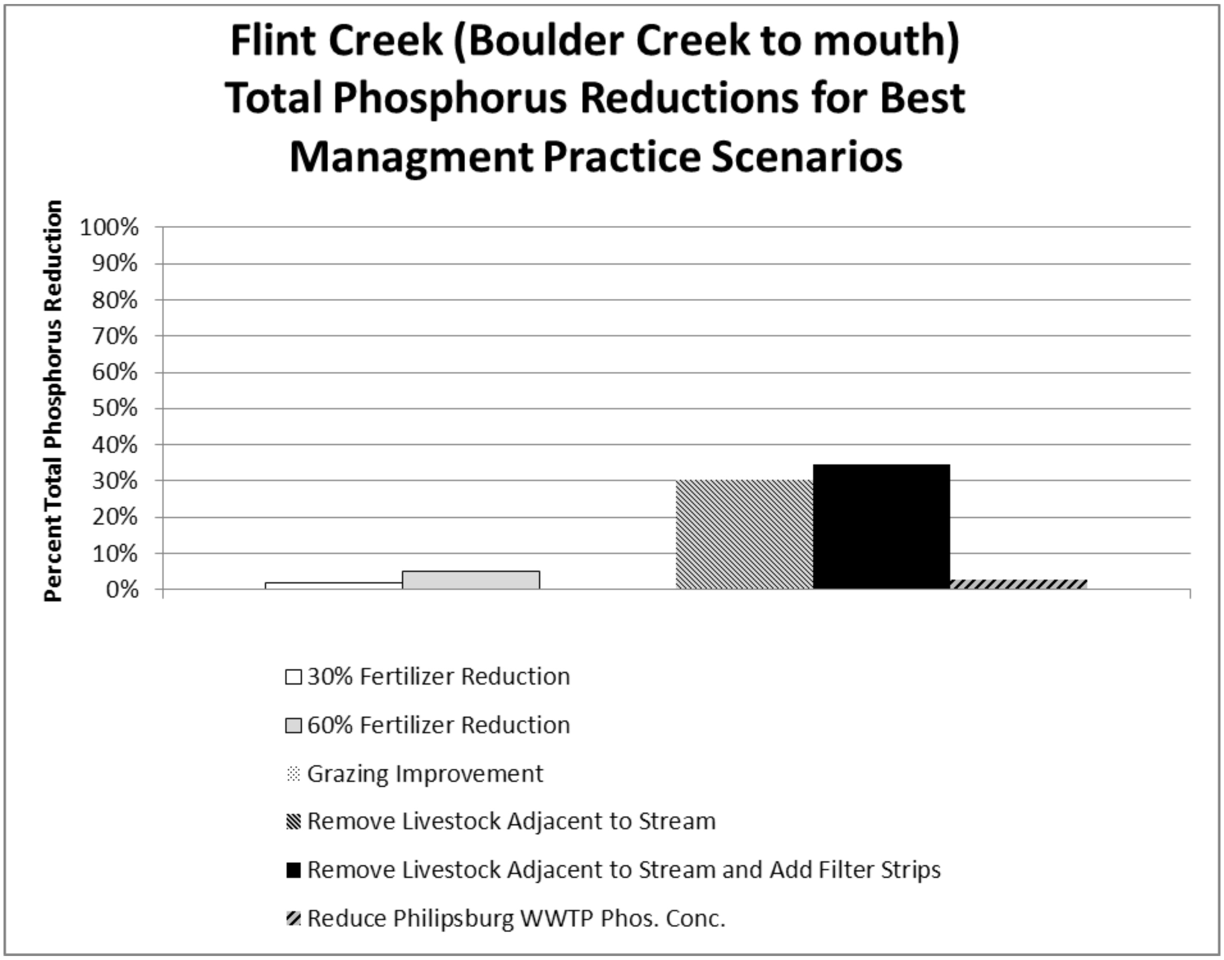

Figure 5-31. Total Phosphorus Best Management Practice Scenarios for Flint Creek (Boulder Creek to mouth) during the Summer Growing Season

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.

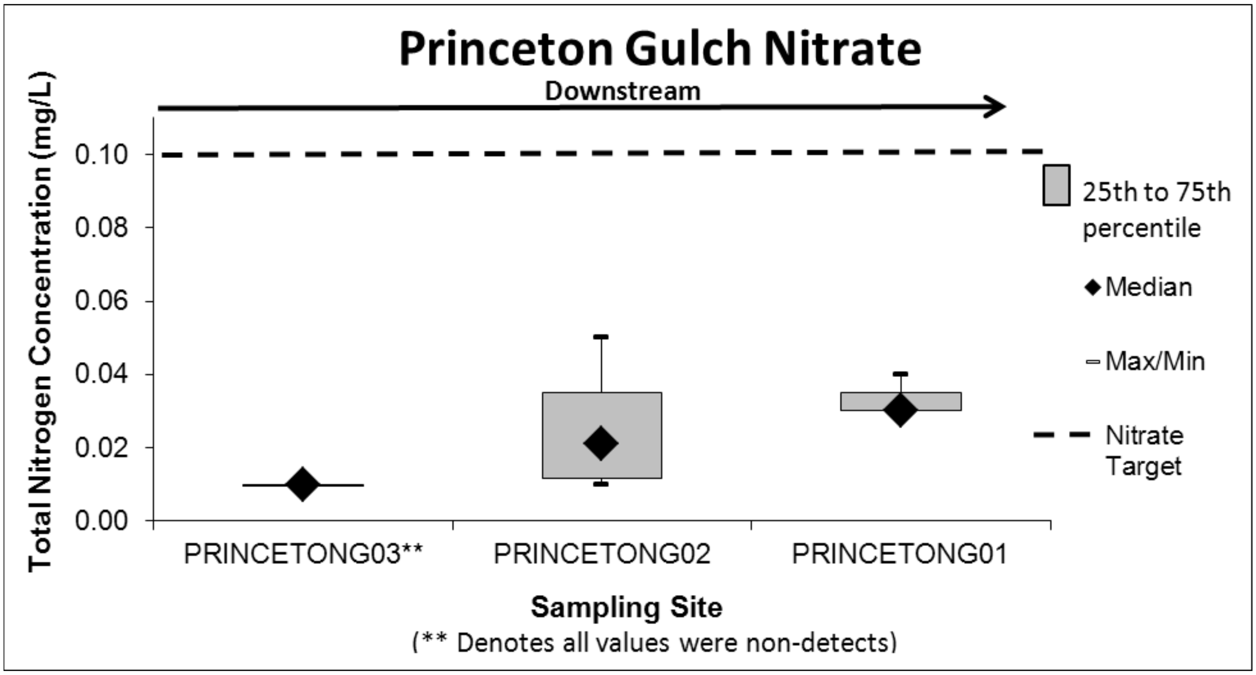

Figure 5-32. Nitrate Box Plots for Princeton Gulch

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.

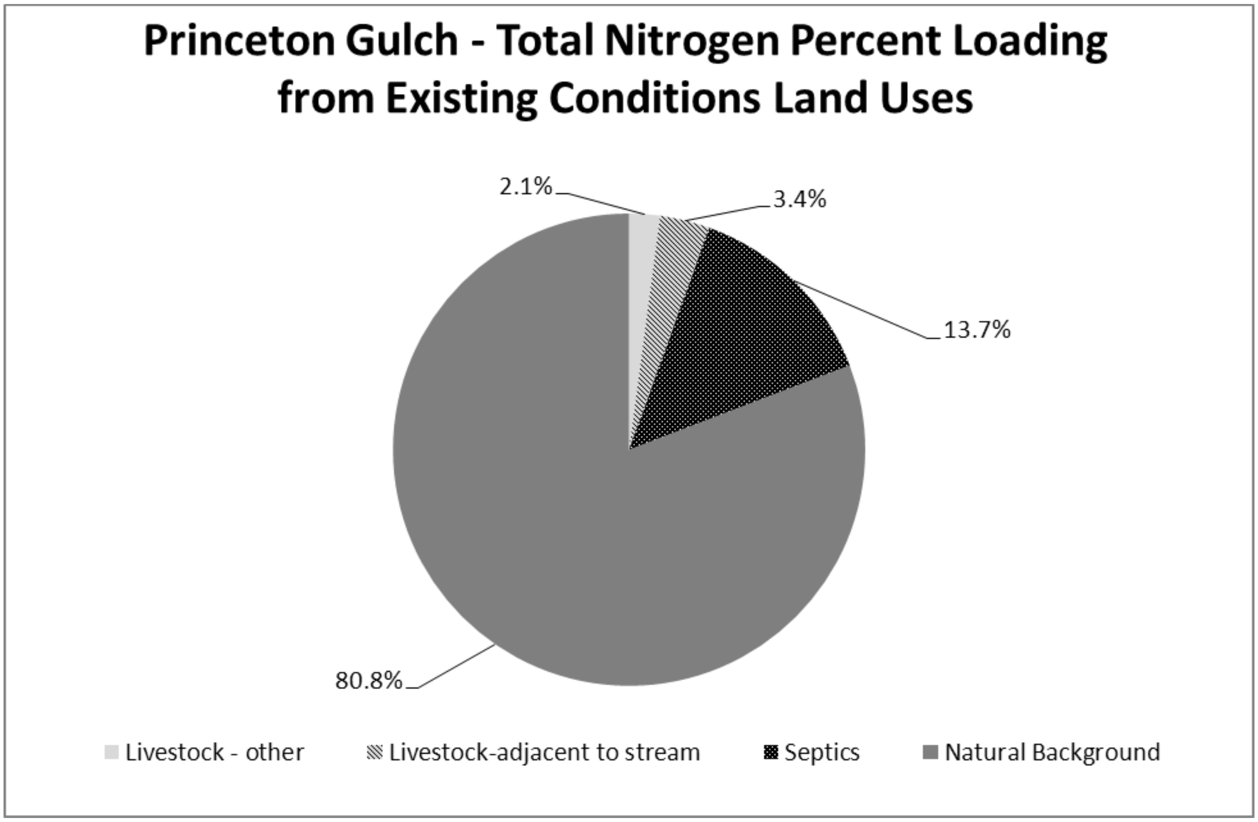

Figure 5-33. Percent Contribution of Total Nitrogen Sources to Princeton Gulch during the Summer Growing Season

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.

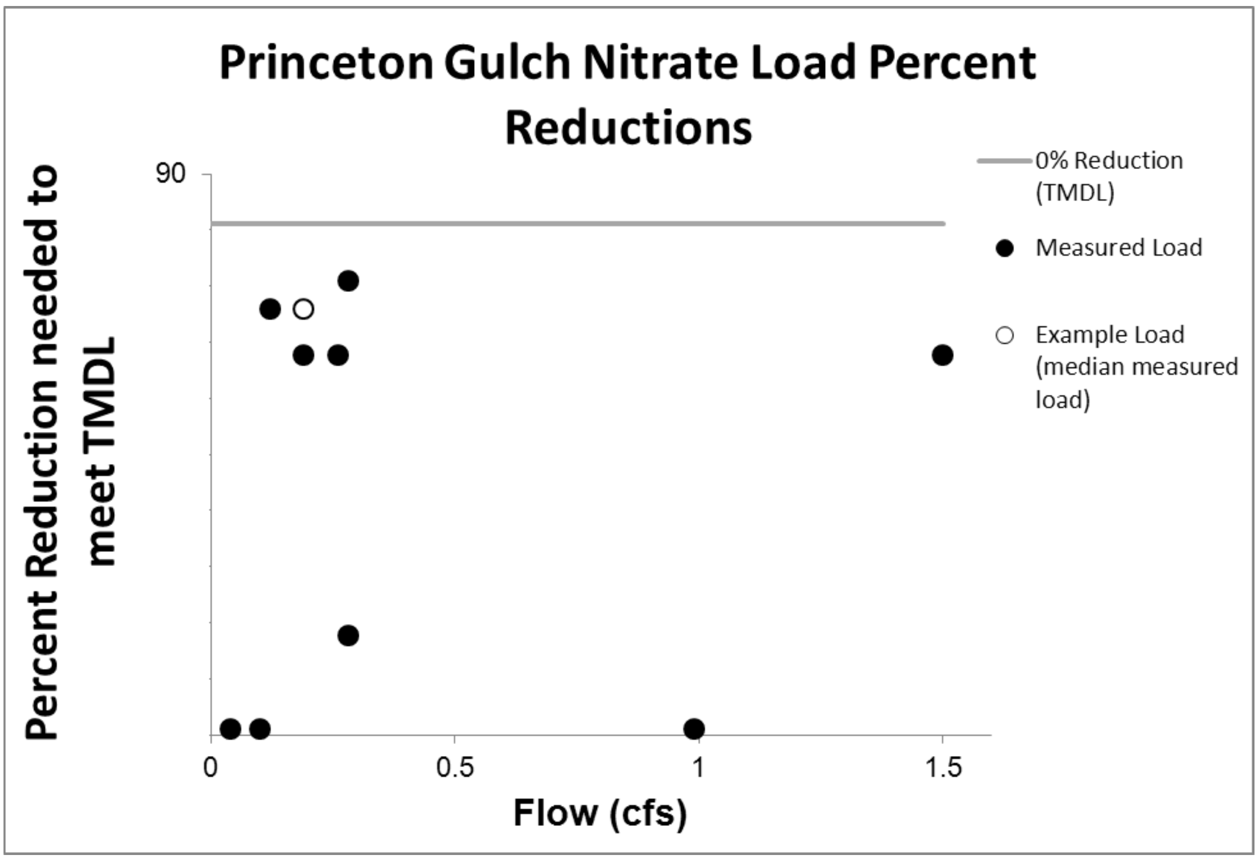

Figure 5-34. Measured Nitrate Loads Percent Reductions for Princeton Gulch
All points on or below the gray line are meeting the TMDL. The example existing load from **Table 5-27** is represented by the hollow circle.

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.

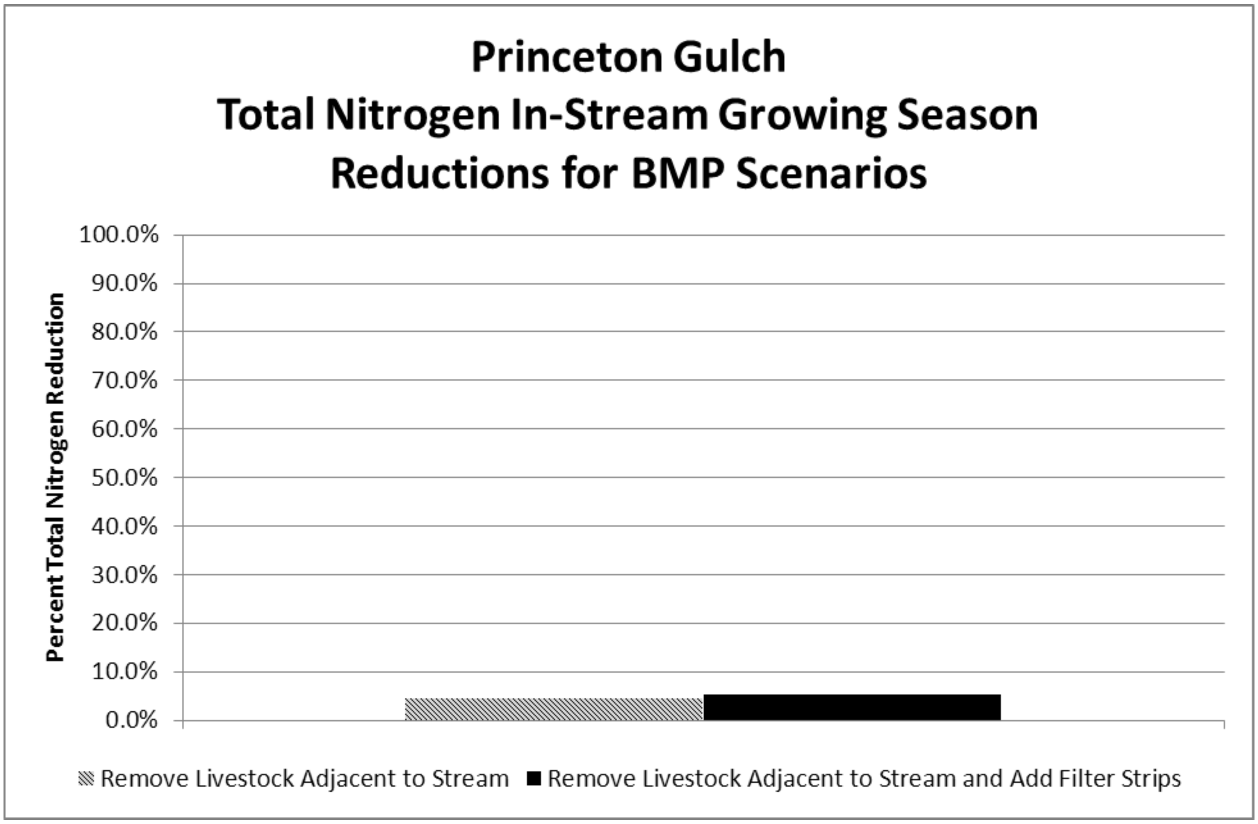

Figure 5-35. Total Nitrogen BMP Scenarios for Princeton during the Summer Growing Season

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.

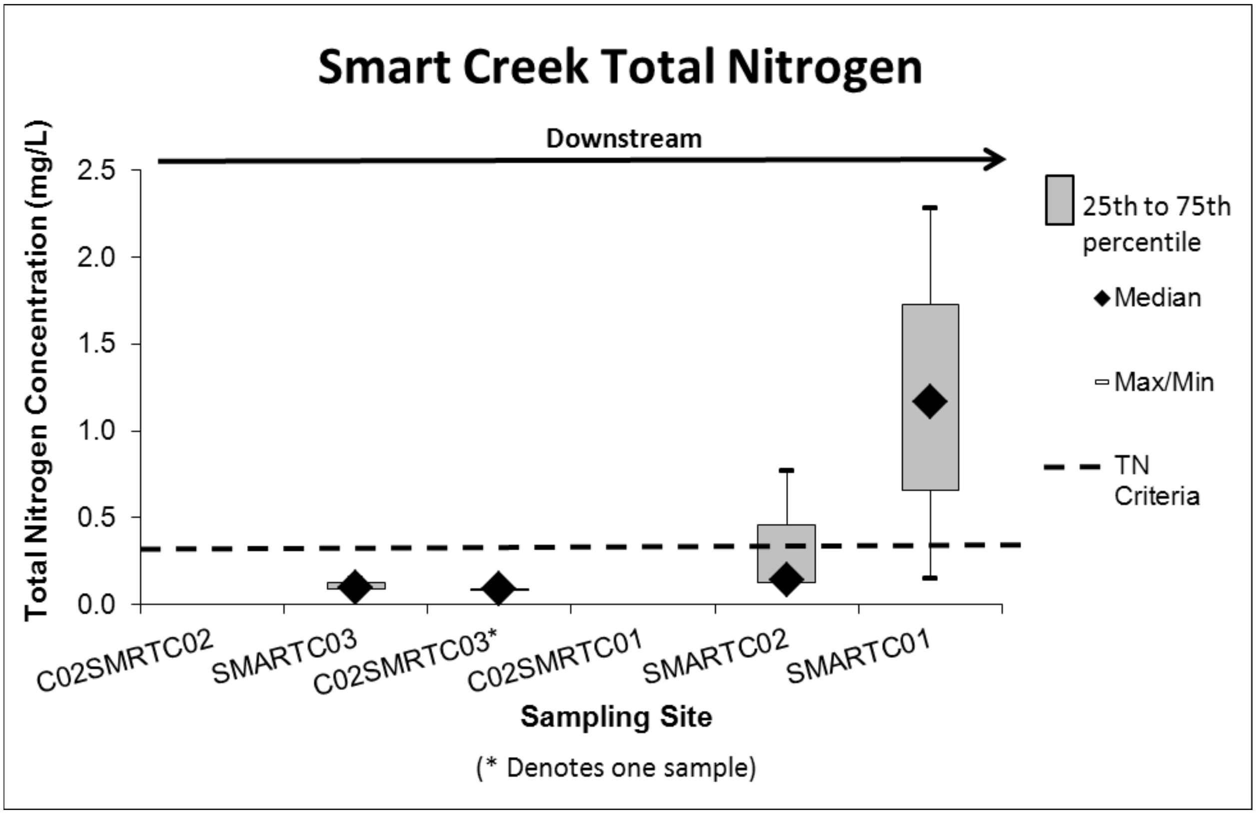

Figure 5-36. Total Nitrogen Box Plots for Smart Creek

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.

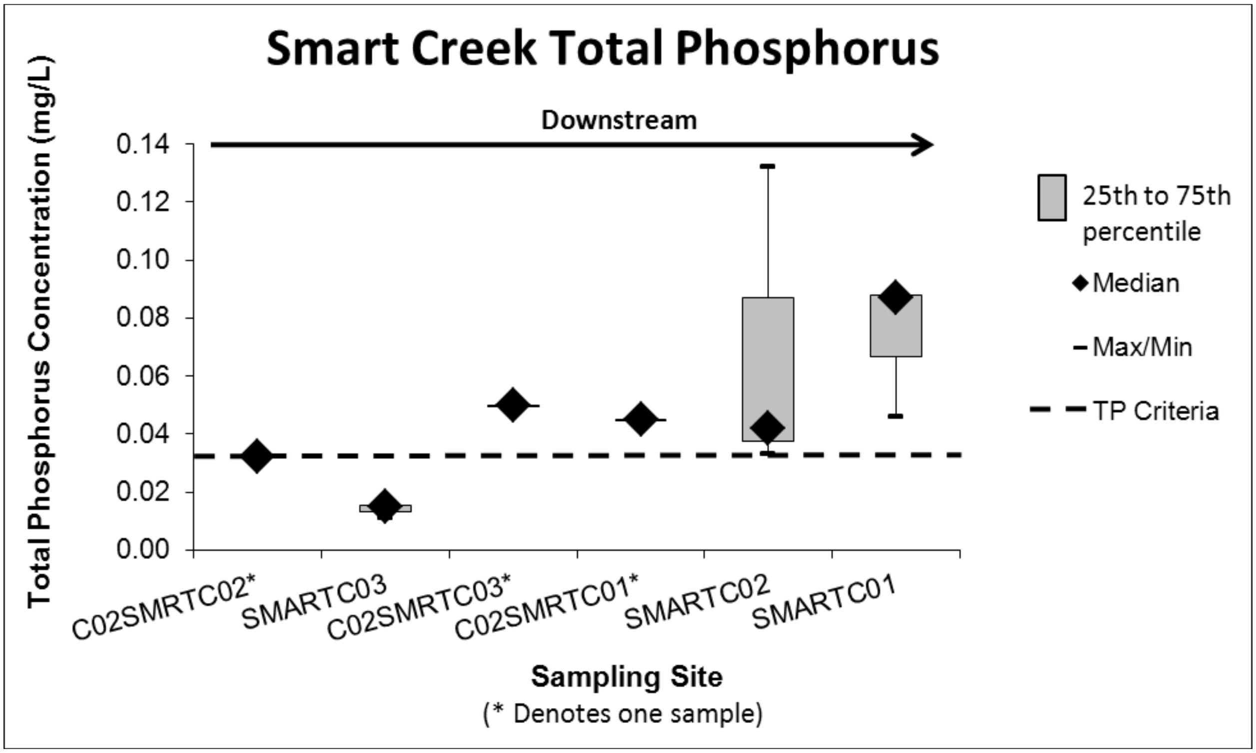

Figure 5-37. Total Phosphorus Box Plots for Smart Creek

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.

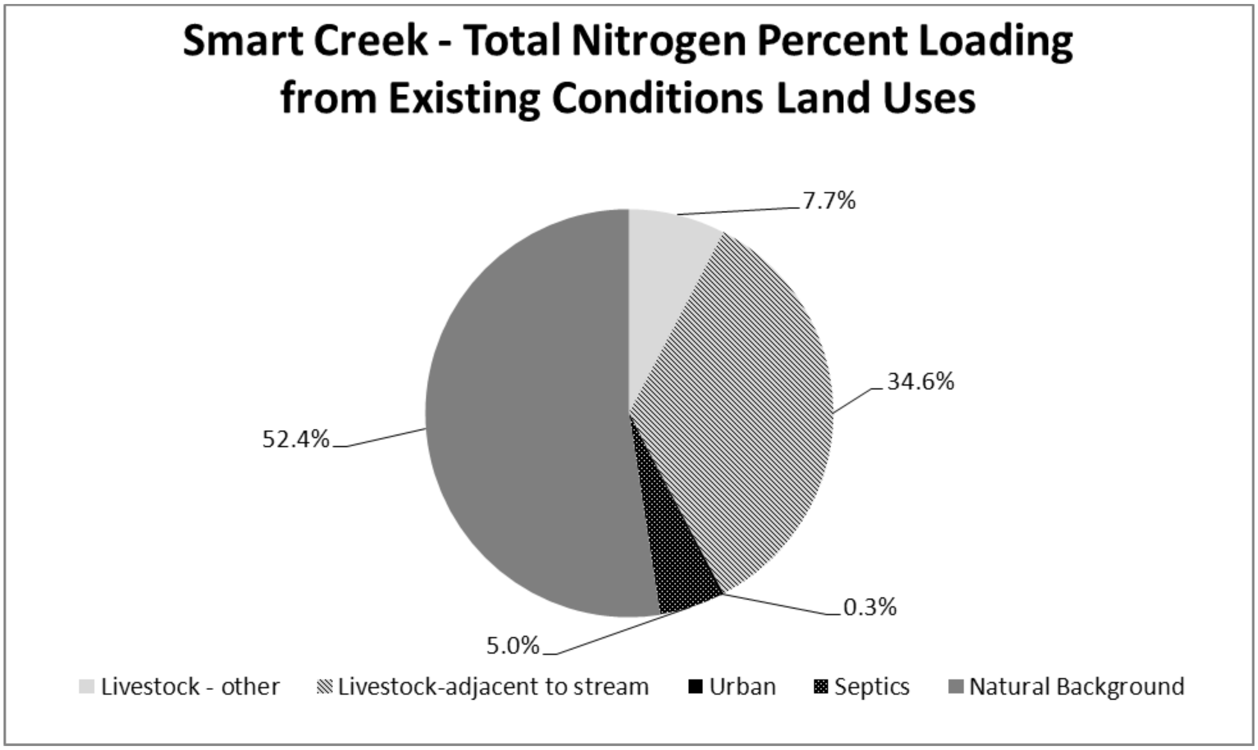

Figure 5-38. Percent Contribution of Total Nitrogen Sources to Smart Creek during the Summer Growing Season

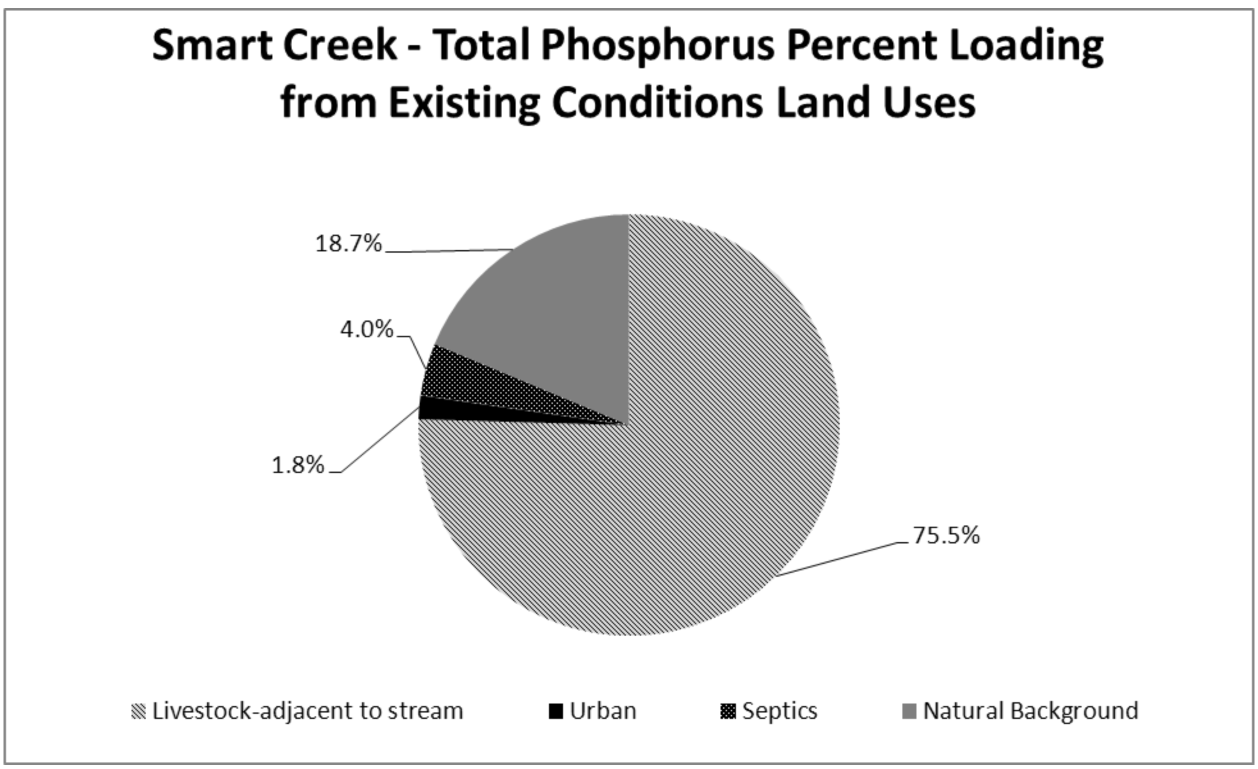

Figure 5-39. Percent Contribution of Total Phosphorus Sources to Smart Creek during the Summer Growing Season

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**.

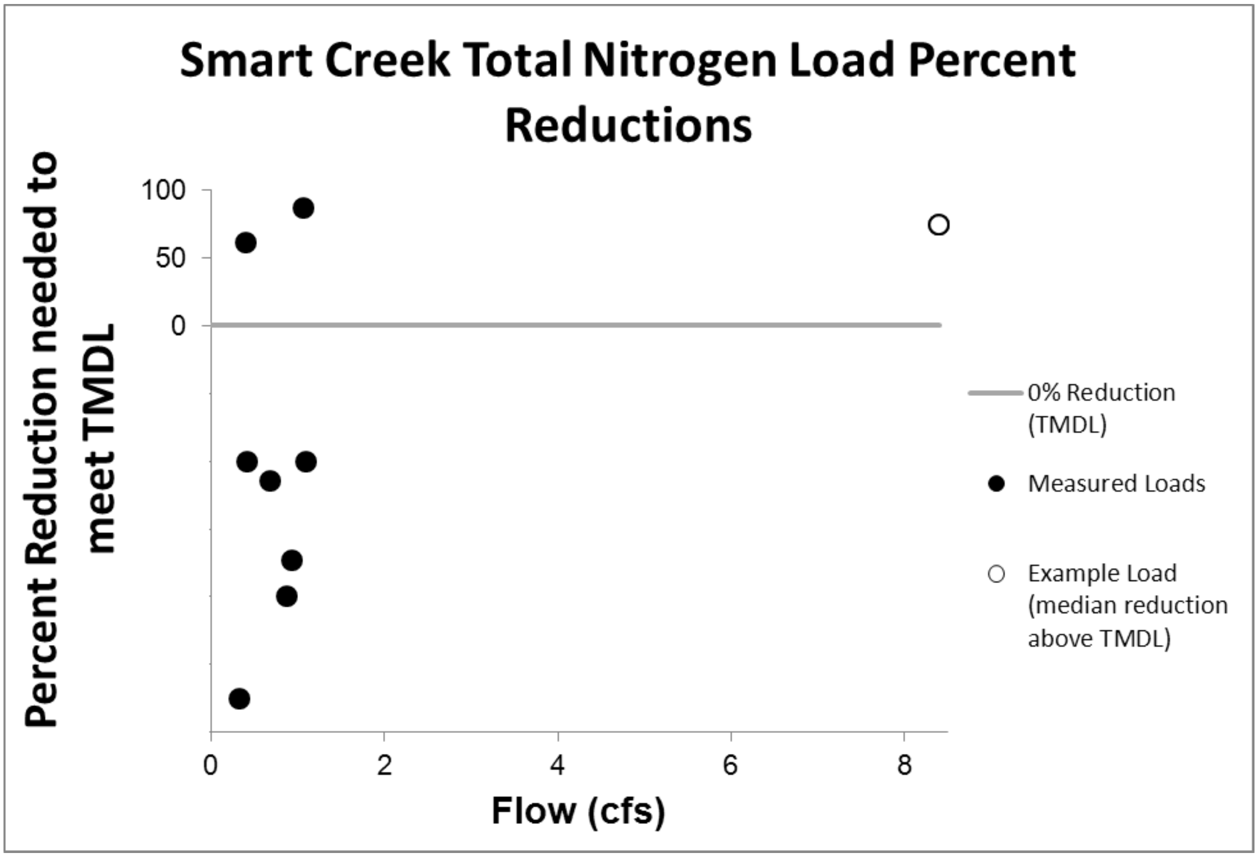

Figure 5-40. Measured Total Nitrogen Loads Percent Reductions for Smart Creek
All points on or below the gray line are meeting the TMDL. The example existing load from **Table 5-28** is represented by the hollow circle. Concentration data with no associated flow are not represented in this figure.

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.

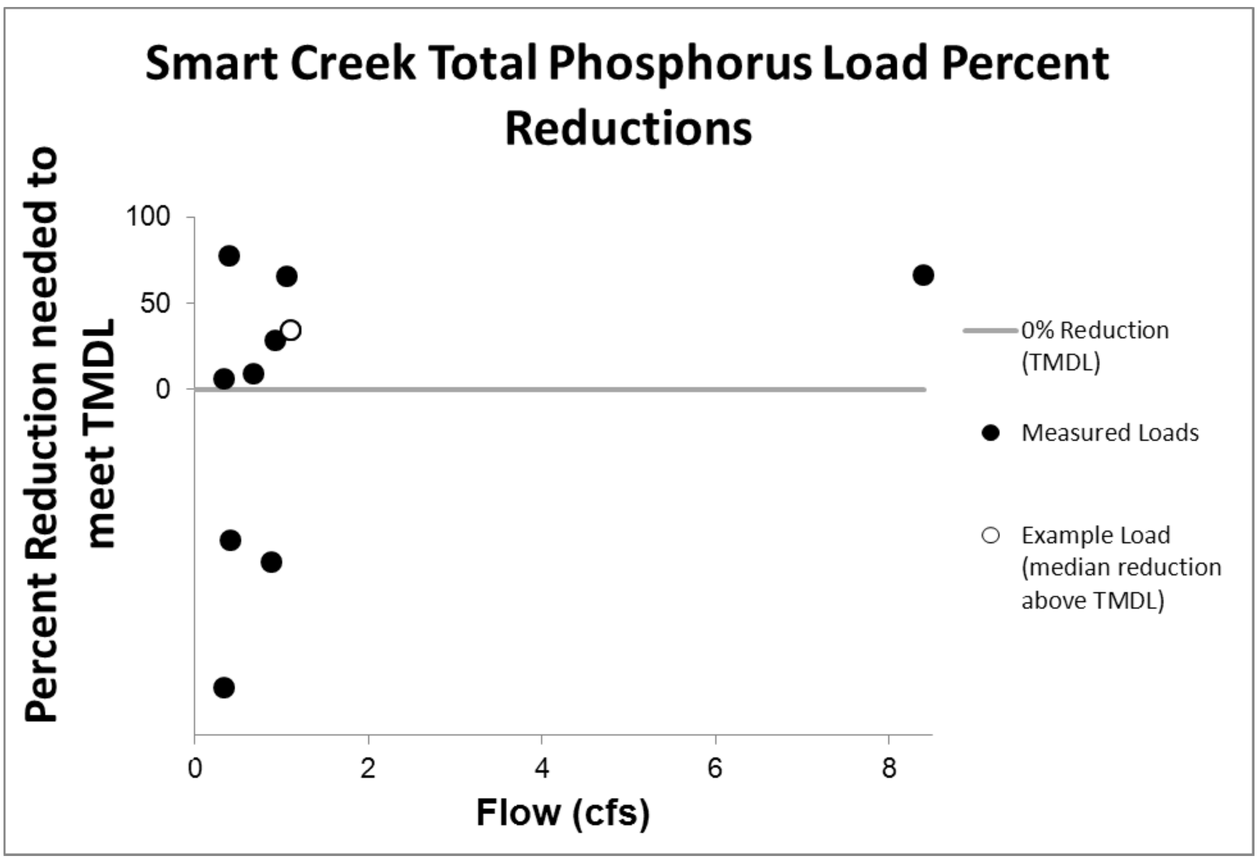

Figure 5-41. Measured Total Phosphorus Loads Percent Reductions for Smart Creek

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%.

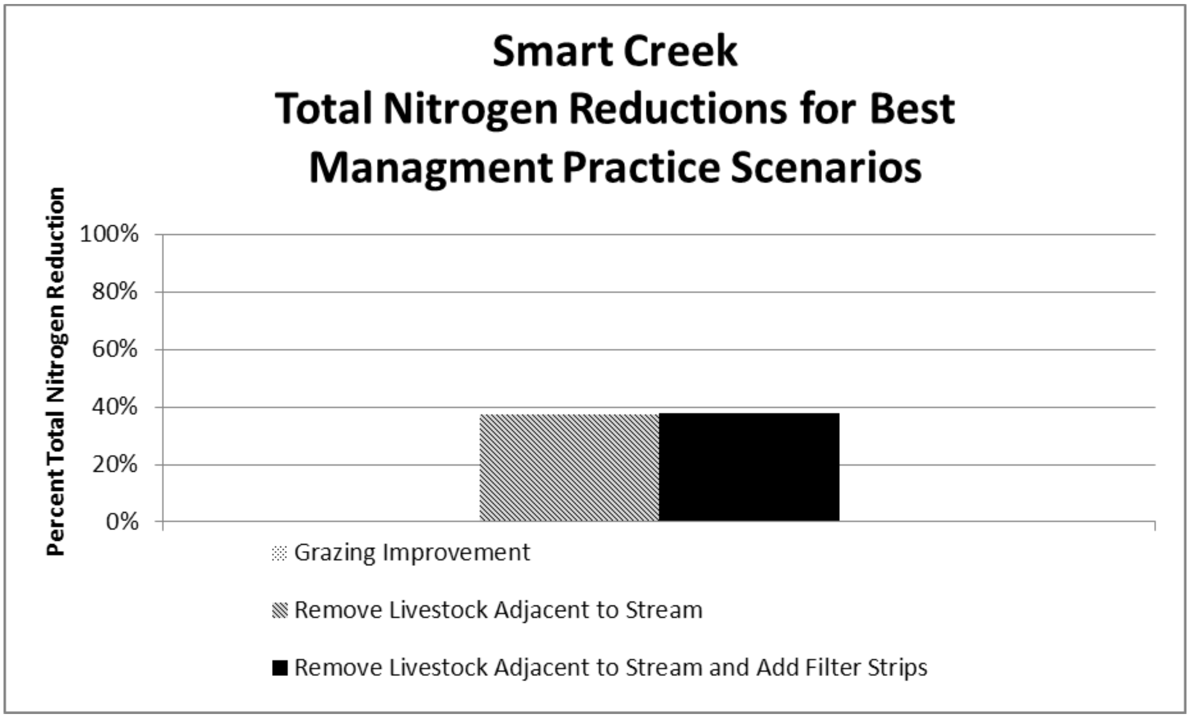

Figure 5-42. Total Nitrogen Best Management Practice Scenarios for Smart Creek during the Summer Growing Season

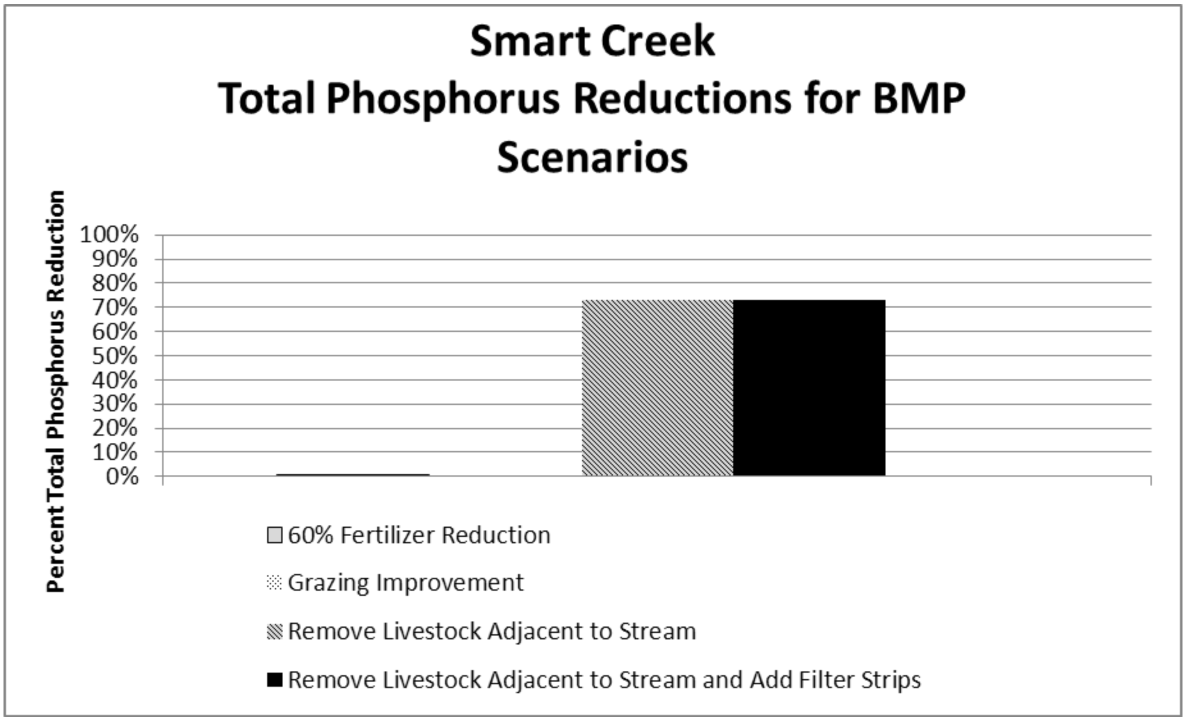

Figure 5-43. Total Phosphorus BMP Scenarios for Smart Creek during the Summer Growing Season

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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APPENDIX A – TABLE OF IMPAIRED WATERBODIES, THEIR IMPAIRED USES, AND IMPAIRMENT STATUS ON THE 2012 WATER QUALITY INTEGRATED REPORT

Table A-1. Status of Waterbody Impairments in the Flint TPA based on the 2012 Integrated Report

Waterbody and Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impairment Cause Status*
Barnes Creek, from headwaters to mouth (Flint Creek)	MT76E003_070	Nitrogen (Total)	Nutrients	TN TMDL in this document
		Nitrate/Nitrite (Nitrite + Nitrate)	Nutrients	Addressed by TN TMDL in this document
		Phosphorus (Total)	Nutrients	TP TMDL in this document
		Chlorophyll-*a*	Not Applicable; Nonpollutant	Addressed by TN and TP TMDLs in this document
		Iron	Metals	Iron TMDL contained in a previous document (2012)
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in a previous document (2012)
Boulder Creek, headwaters to mouth (Flint Creek)	MT76E003_060	Arsenic	Metals	Arsenic TMDL contained in a previous document (2012)
		Lead	Metals	Lead TMDL contained in a previous document (2012)
		Mercury	Metals	Mercury TMDL contained in a previous document (2012)
		Physical substrate habitat alterations	Not Applicable; Nonpollutant	Addressed via recommendations in **Sections 7**, **8**, and **9** of a previous document (2012)
		Zinc	Metals	Zinc TMDL contained in a previous document (2012)
Camp Creek, headwaters to terminus, T7N R14W S25	MT76E003_130	Alteration in streamside or littoral vegetative covers	Not Applicable; Nonpollutant	Addressed via recommendations in **Sections 7**, **8**, and **9** of a previous document (2012)
		Arsenic	Metals	Arsenic TMDL contained in a previous document (2012)
		Copper	Metals	Copper TMDL contained in a previous document (2012)
		Fish-Passage Barrier	Not Applicable; Nonpollutant	Addressed via recommendations in **Sections 7**, **8**, and **9** of a previous document (2012)
		Lead	Metals	Lead TMDL contained in a previous document (2012)
		Zinc	Metals	Zinc TMDL contained in a previous document (2012)

Table A-1. Status of Waterbody Impairments in the Flint TPA based on the 2012 Integrated Report

Waterbody and Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impairment Cause Status*
Douglas Creek, confluence of Middle and South forks to mouth (Flint Creek), T9N R13W S10	MT76E003_020	Nitrogen, Nitrate	Nutrients	Nitrate TMDL in this document
		Physical substrate habitat alterations	Not Applicable; Nonpollutant	Addressed via recommendations in **Sections 7**, **8**, and **9** of a previous document (2012)
Douglas Creek, headwaters to where stream ends, T7N R14W S25	MT76E003_100	Arsenic	Metals	Arsenic TMDL contained in a previous document (2012)
		Cadmium	Metals	Cadmium TMDL contained in a previous document (2012)
		Copper	Metals	Copper TMDL contained in a previous document (2012)
		Iron	Metals	Iron TMDL contained in a previous document (2012)
		Lead	Metals	Lead TMDL contained in a previous document (2012)
		Mercury	Metals	Mercury TMDL contained in a previous document (2012)
		Physical substrate habitat alterations	Not Applicable; Nonpollutant	Addressed via Sediment TMDL contained in a previous document (2012)
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in a previous document (2012)
		Zinc	Metals	Zinc TMDL contained in a previous document (2012)

Table A-1. Status of Waterbody Impairments in the Flint TPA based on the 2012 Integrated Report

Waterbody and Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impairment Cause Status*
Flint Creek, Georgetown Lake to confluence with Boulder Creek	MT76E003_011	Alteration in streamside or littoral vegetative covers	Not Applicable; Nonpollutant	Addressed via Sediment TMDL contained in a previous document (2012)
		Antimony	Metals	Not impaired based on updated assessment
		Arsenic	Metals	Arsenic TMDL contained in a previous document (2012)
		Cadmium	Metals	Not impaired based on updated assessment
		Copper	Metals	Copper TMDL contained in a previous document (2012)
		Lead	Metals	Lead TMDL contained in a previous document (2012)
		Low flow alterations	Not Applicable; Nonpollutant	Partially addressed via recommendations in **Sections 7**, **8**, and **9** of a previous document (2012)
		Mercury	Metals	Mercury TMDL contained in a previous document (2012)
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in a previous document (2012)
Flint Creek, Boulder Creek to mouth (Clark Fork River)	MT76E003_012	Nitrogen (Total)	Nutrients	TN TMDL in this document
		Phosphorus (Total)	Nutrients	TP TMDL in this document
		Alteration in streamside or littoral vegetative covers	Not Applicable; Nonpollutant	Addressed via Sediment TMDL contained in a previous document (2012)
		Arsenic	Metals	Arsenic TMDL contained in a previous document (2012)
		Cadmium	Metals	No TMDL developed; updated 303(d) listing status pending
		Copper	Metals	Copper TMDL contained in a previous document (2012)
		Iron	Metals	Iron TMDL contained in a previous document (2012)
		Lead	Metals	Lead TMDL contained in a previous document (2012)
		Turbidity	Sediment	Addressed via Sediment TMDL contained in a previous document (2012)

Table A-1. Status of Waterbody Impairments in the Flint TPA based on the 2012 Integrated Report

Waterbody and Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impairment Cause Status*
Fred Burr Creek, Fred Burr Lake to mouth (Flint Creek)	MT76E003_040	Alteration in streamside or littoral vegetative covers	Not Applicable; Nonpollutant	Addressed via recommendations in **Sections 7**, **8**, and **9** of a previous document (2012)
		Arsenic	Metals	Arsenic TMDL contained in a previous document (2012)
		Lead	Metals	Lead TMDL contained in a previous document (2012)
		Mercury	Metals	Mercury TMDL contained in a previous document (2012)
North Fork Douglas Creek, headwaters to mouth (Middle Fork Douglas Creek)	MT76E003_030	Alteration in streamside or littoral vegetative covers	Not Applicable; Nonpollutant	Addressed via recommendations in **Sections 7**, **8**, and **9** of a previous document (2012)
		Arsenic	Metals	Not impaired based on updated assessment
		Cadmium	Metals	Cadmium TMDL contained in a previous document (2012)
		Copper	Metals	Copper TMDL contained in a previous document (2012)
		Sulfates	Metals	Not impaired based on updated assessment
		Zinc	Metals	Zinc TMDL contained in a previous document (2012)
Princeton Gulch, headwaters to mouth (Boulder Creek)	MT76E003_090	Nitrates	Nutrients	Nitrate TMDL in this document
		Physical substrate habitat alterations	Not Applicable; Nonpollutant	Addressed via recommendations in **Sections 7**, **8**, and **9** of a previous document (2012)
Smart Creek, headwaters to mouth (Flint Creek), T9N R13W S21	MT76E003_110	Phosphorus (Total)	Nutrients	TP TMDL in this document
		Alteration in streamside or littoral vegetative covers	Not Applicable; Nonpollutant	Addressed via Sediment TMDL contained in a previous document (2012)
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in a previous document (2012)
South Fork Lower Willow Creek, headwaters to mouth (Lower Willow Creek Reservoir)	MT76E003_050	Copper	Metals	Copper TMDL contained in a previous document (2012)
		Lead	Metals	Lead TMDL contained in a previous document (2012)
		Mercury	Metals	Mercury TMDL contained in a previous document (2012)

* TN = Total Nitrogen, TP = Total Phosphorus, Nitrate = Nitrates = Nitrogen, Nitrate = NO_2+NO_3 = Nitrite + Nitrate

APPENDIX B – WATERSHED DESCRIPTION FIGURES

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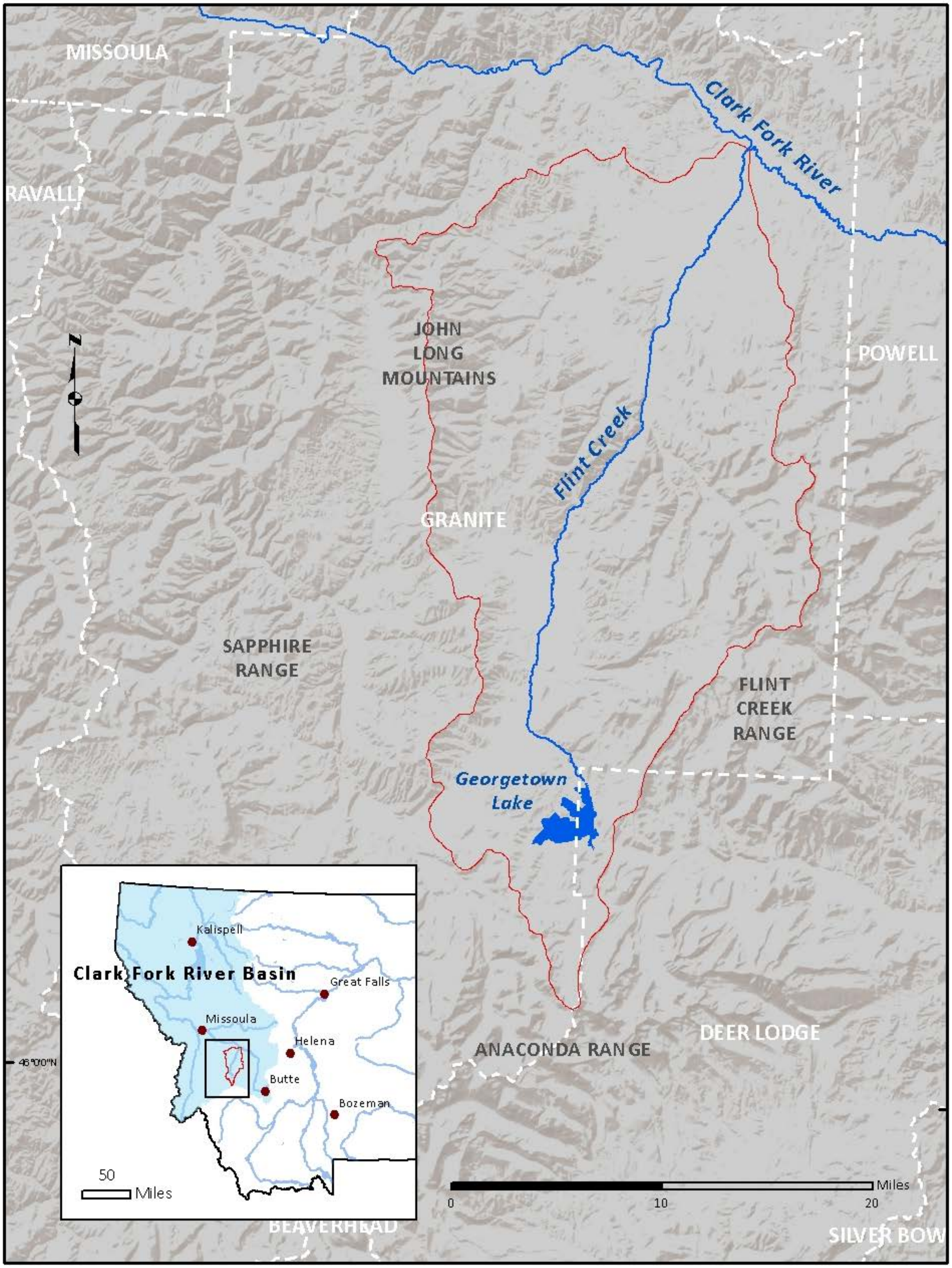
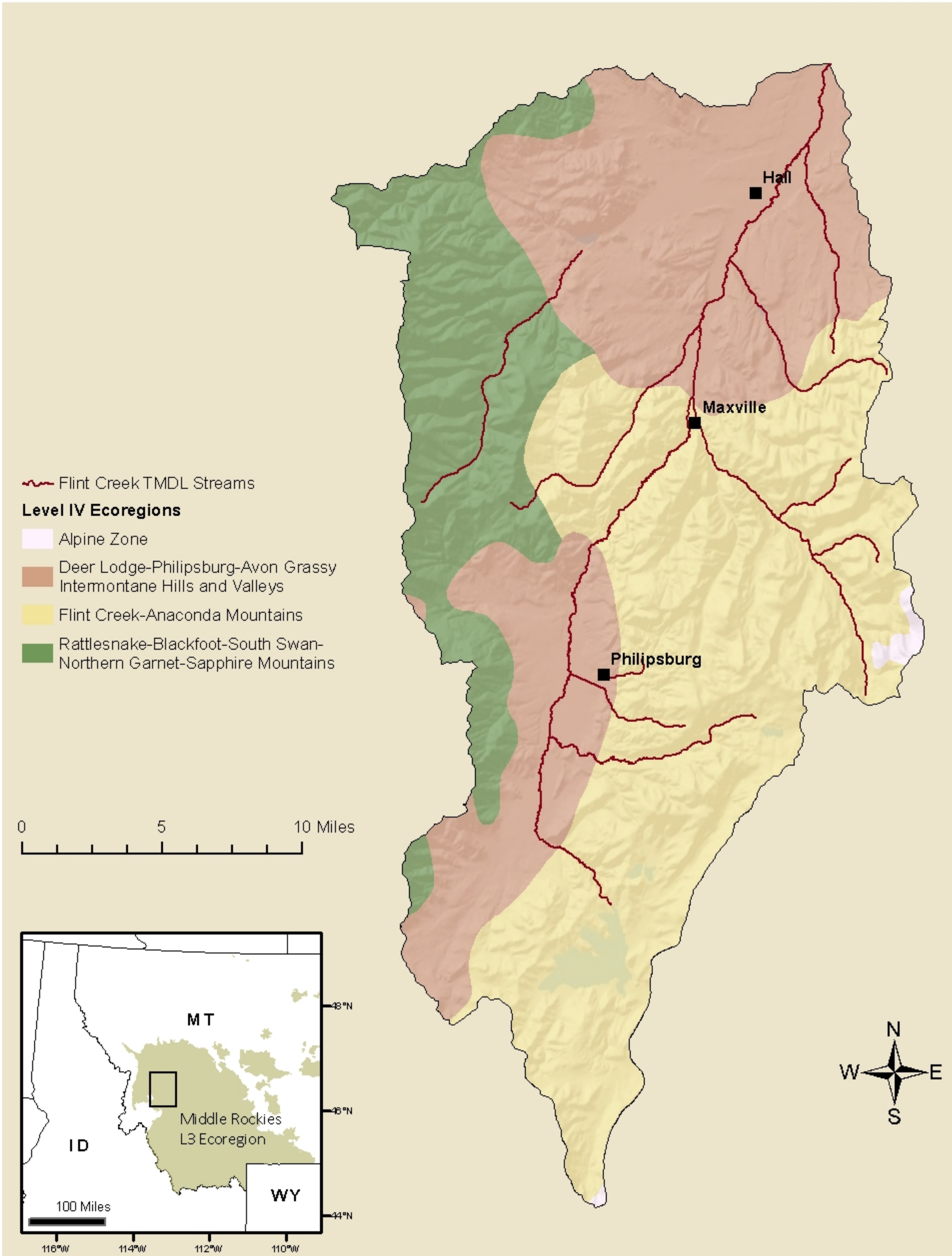


Figure B-1. Location of the Flint TMDL Planning Area



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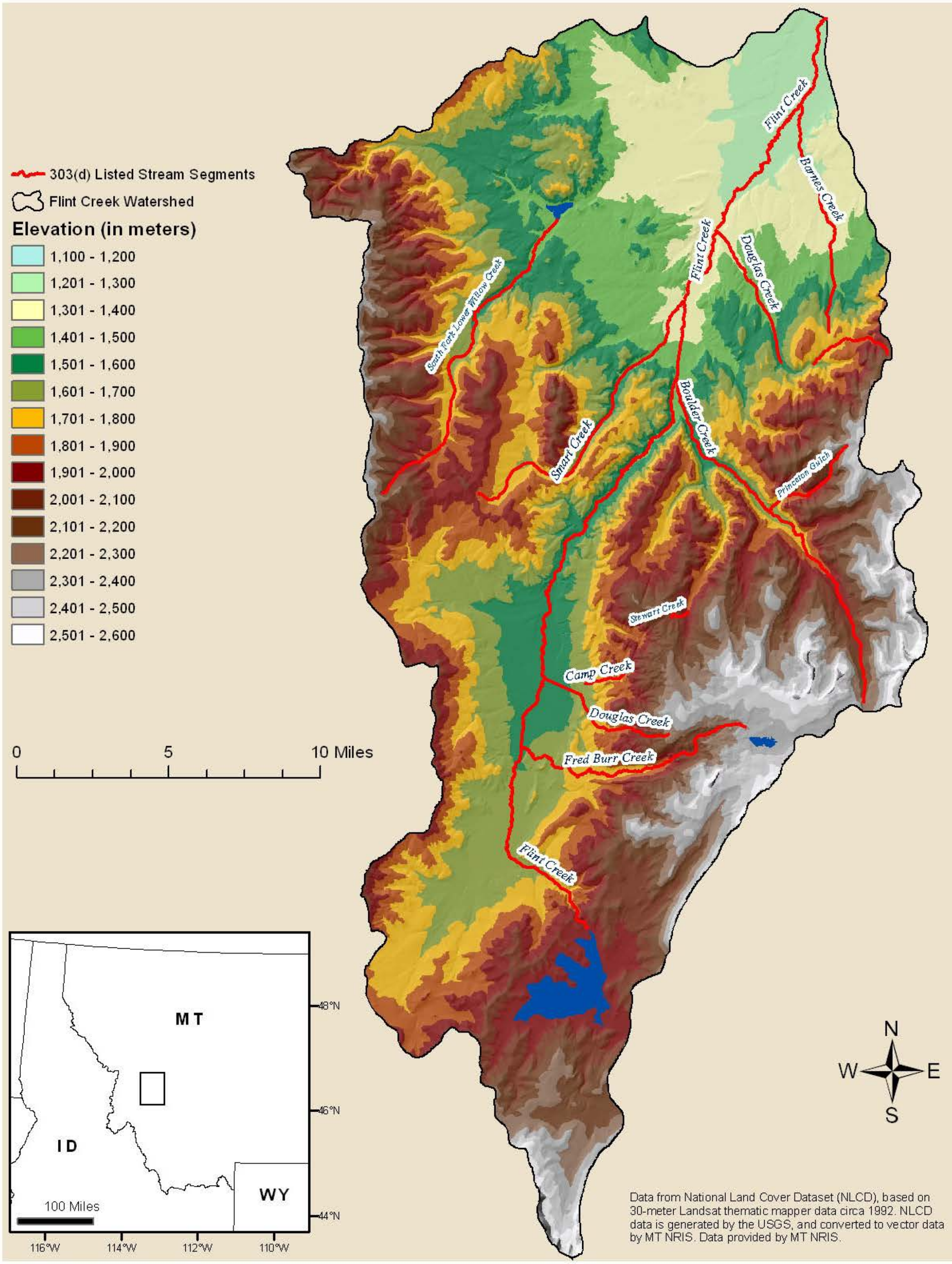

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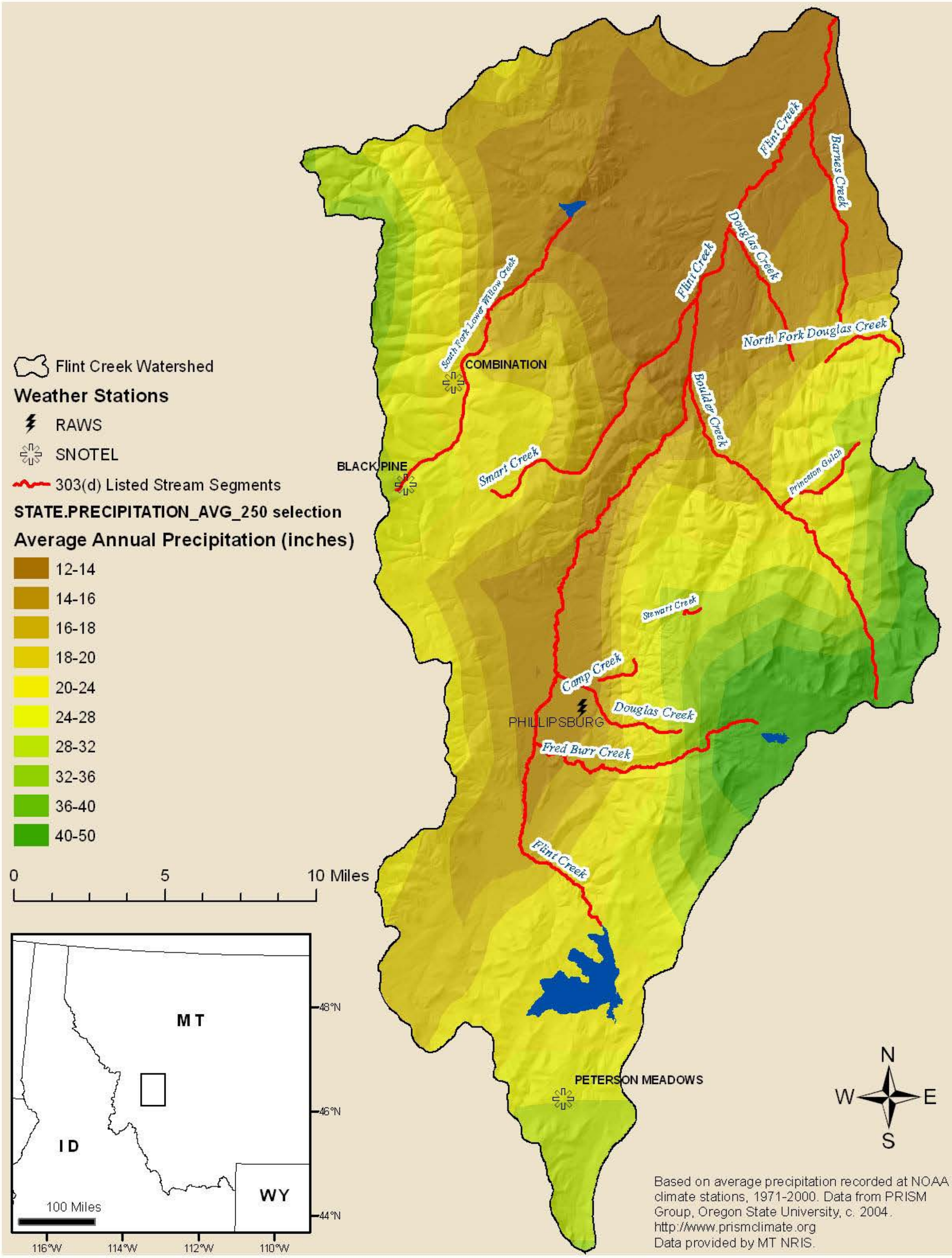

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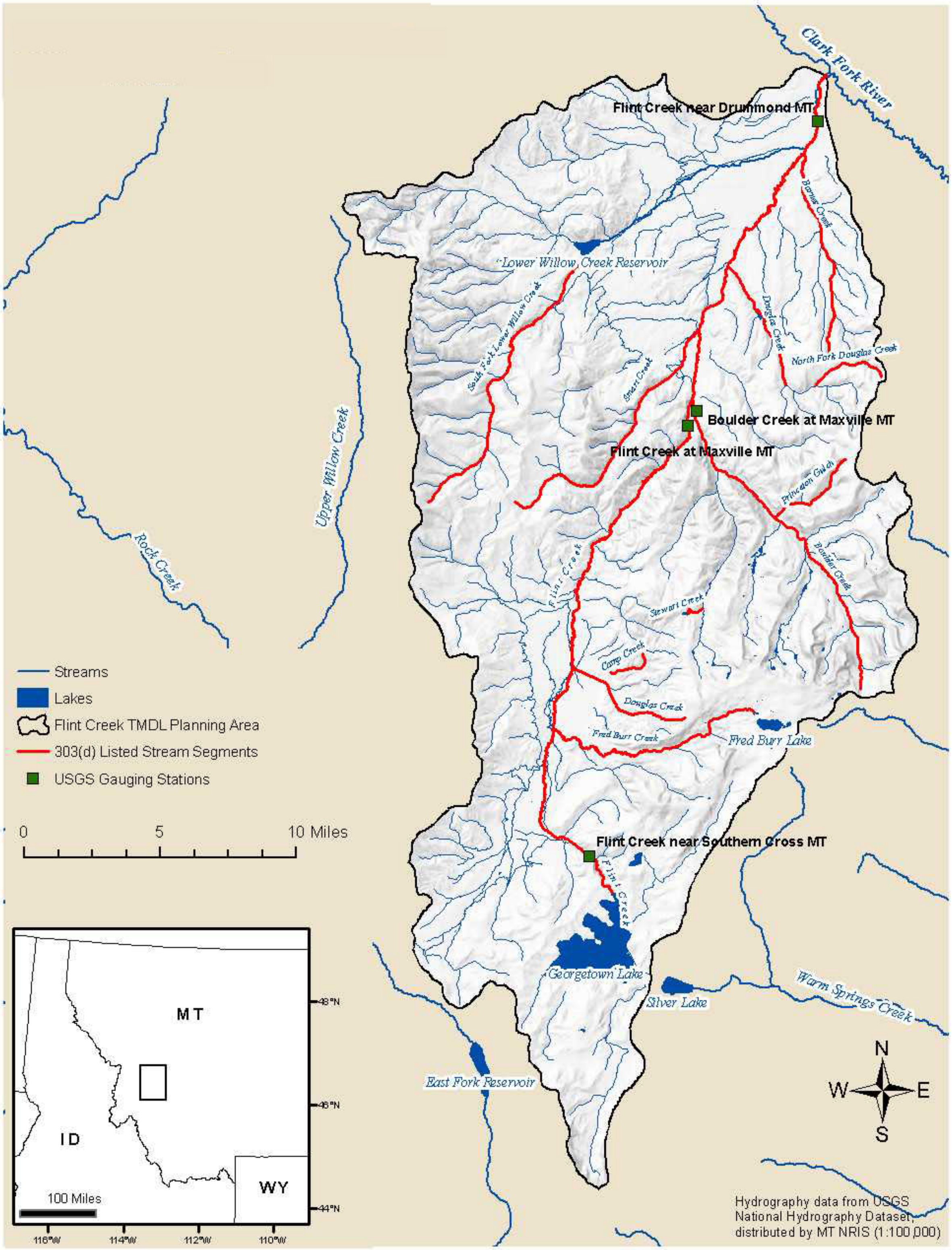

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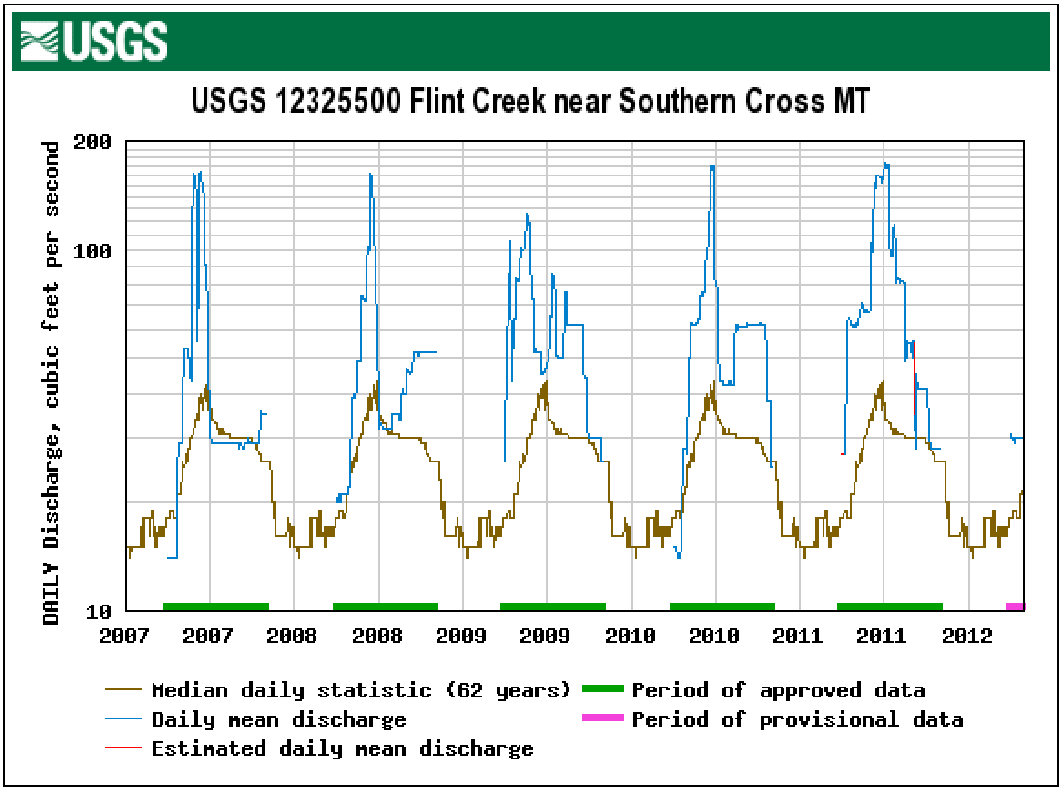
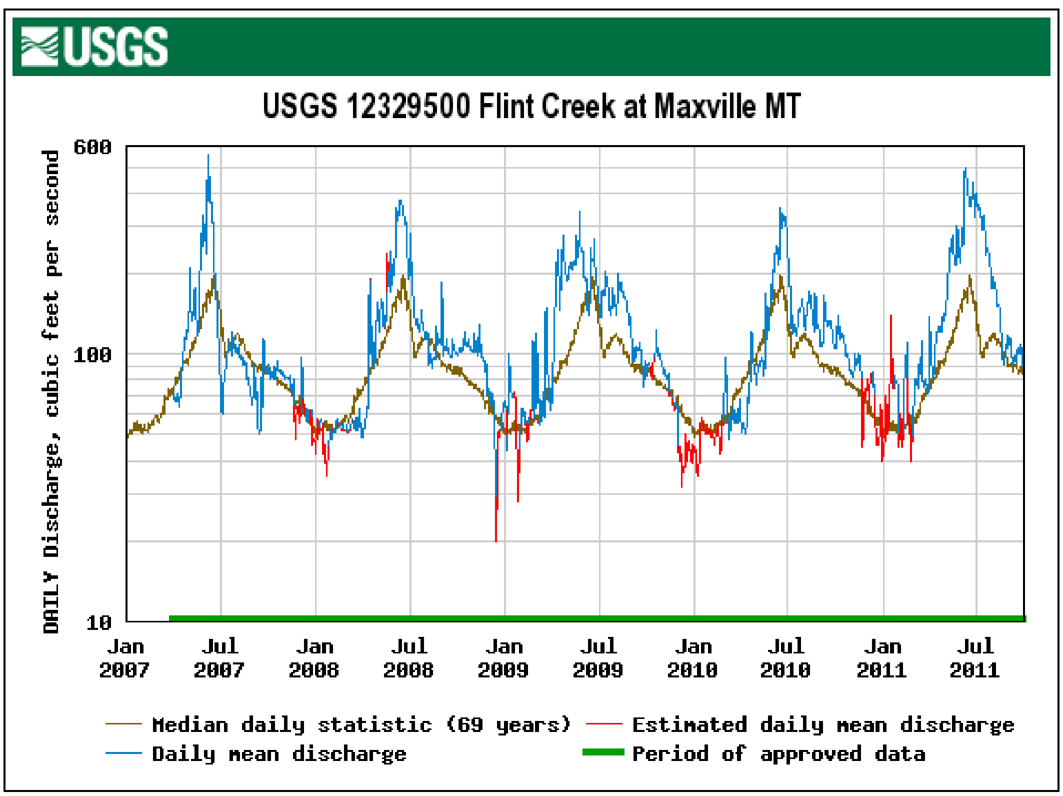


Figure B-6. Streamflow Data - Flint Creek near Southern Cross, MT



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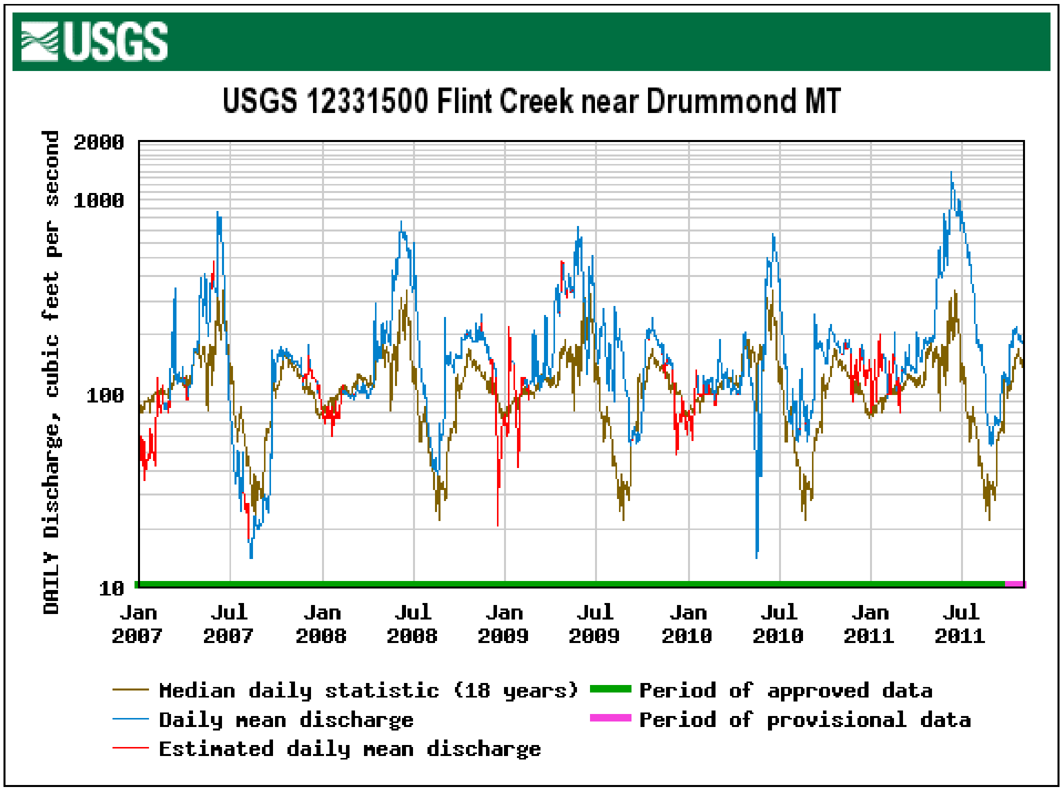

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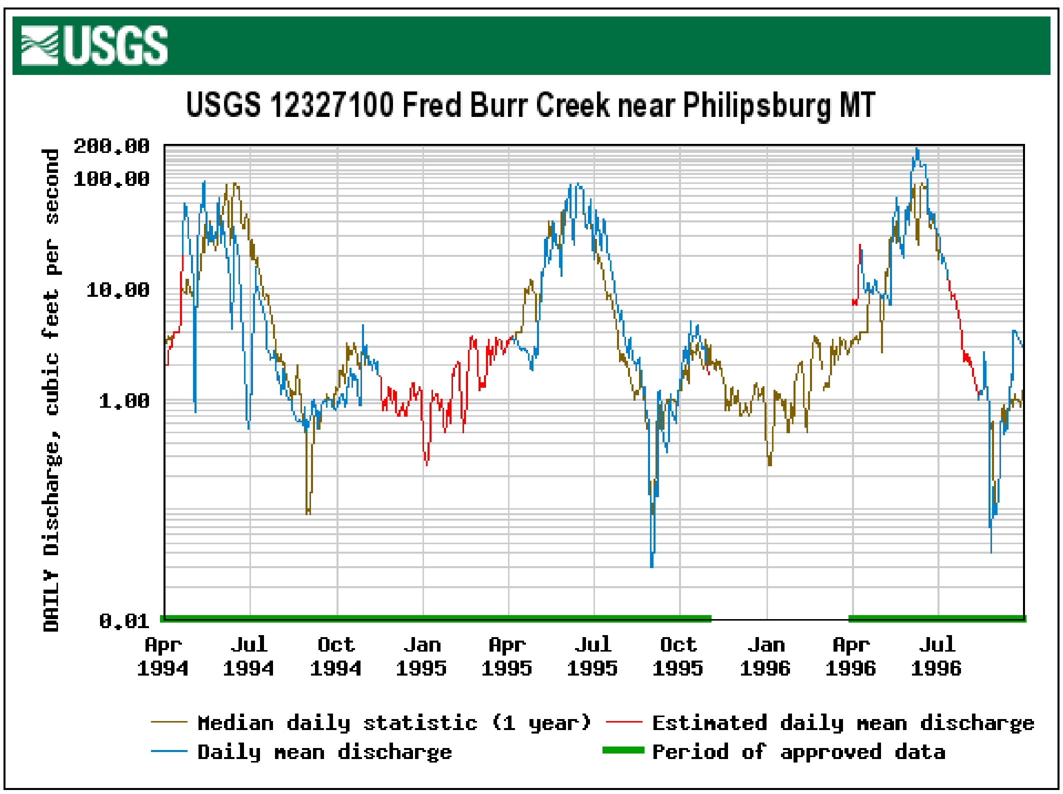

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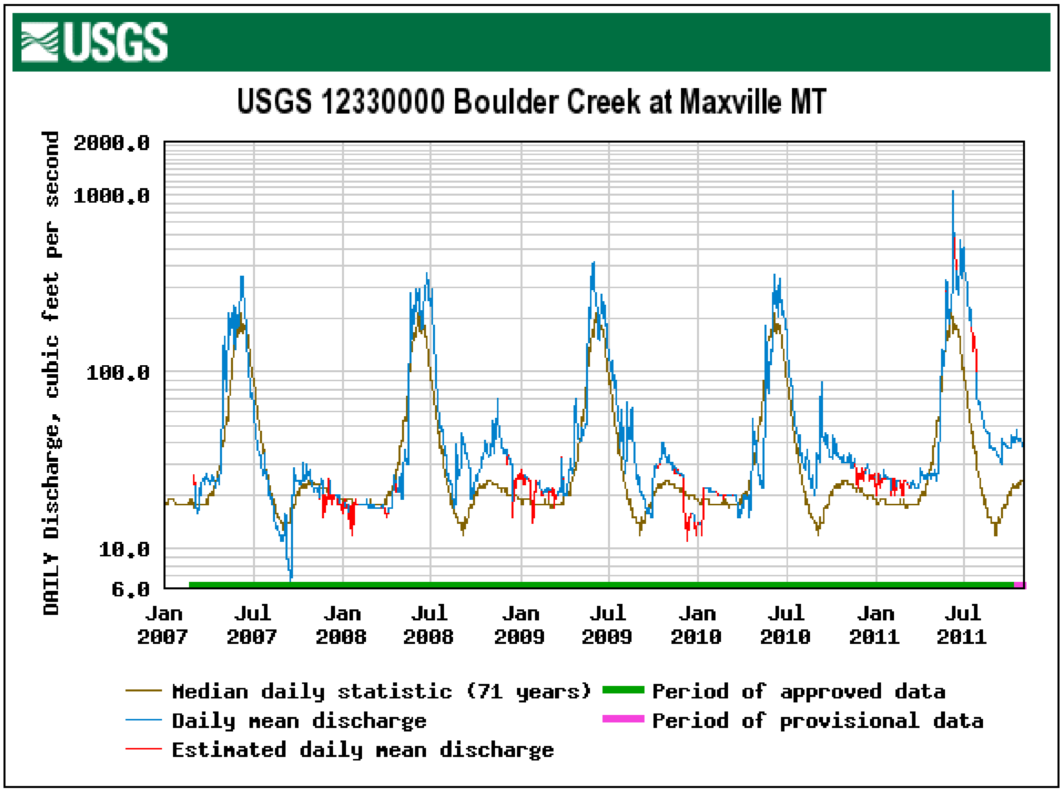

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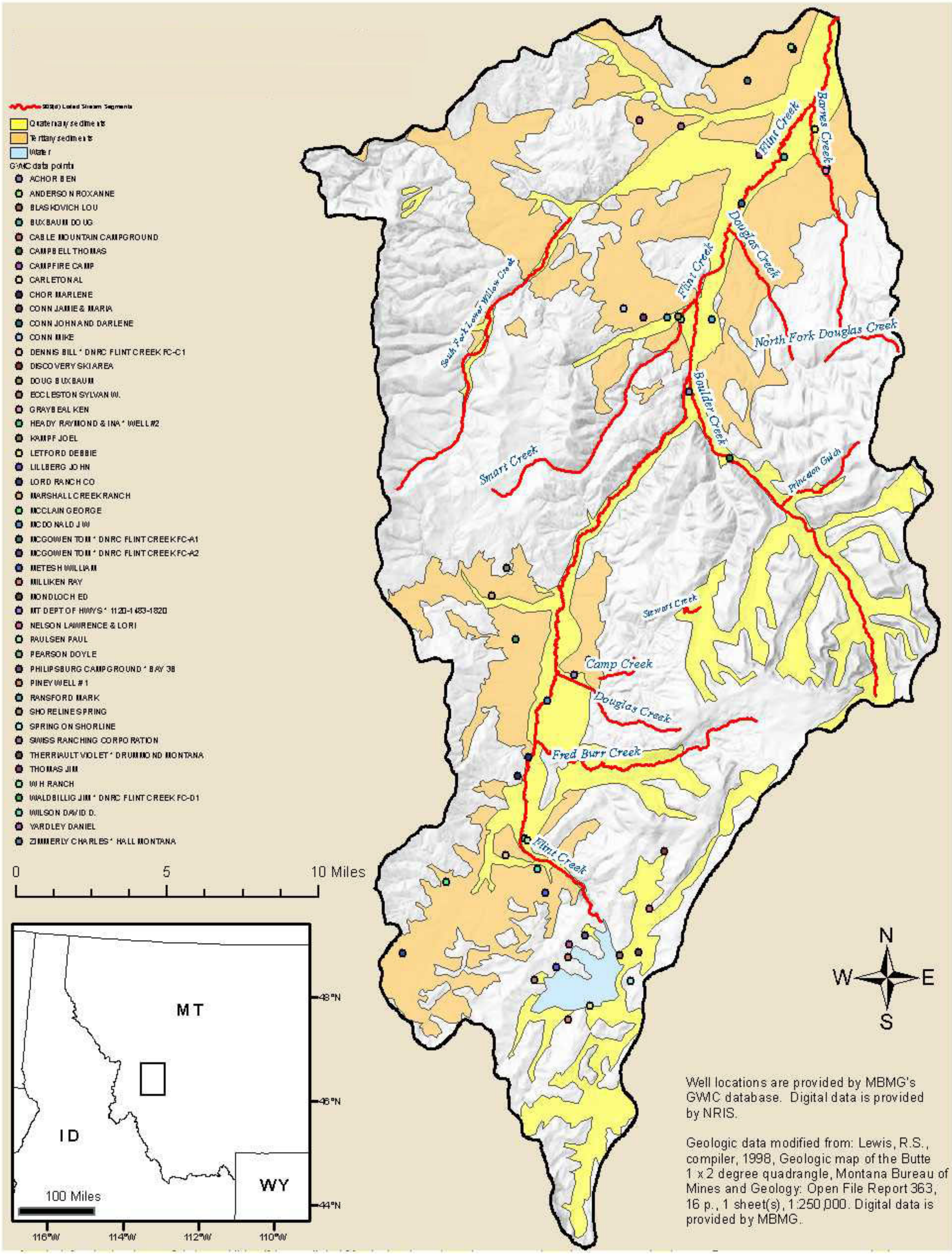

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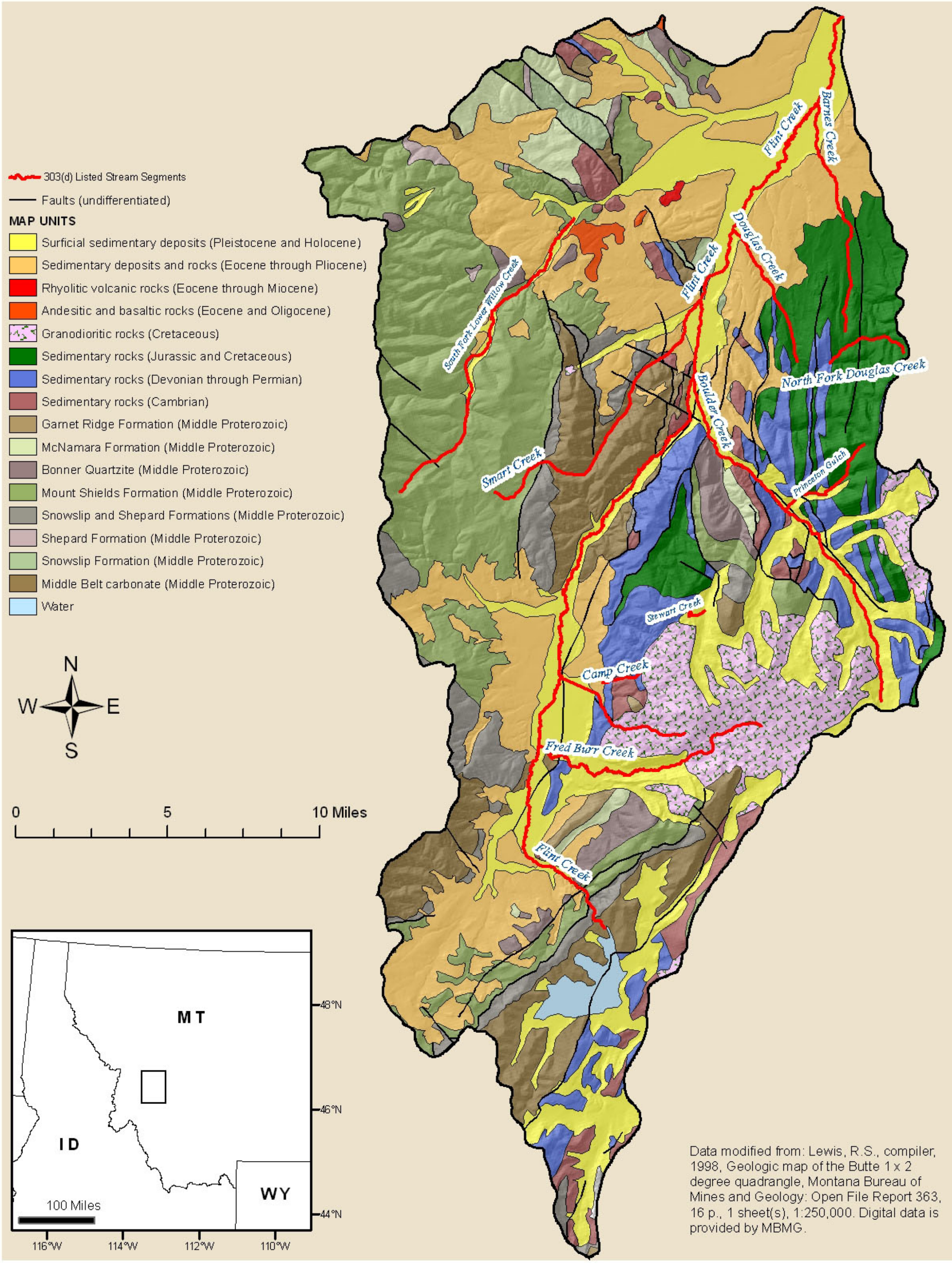

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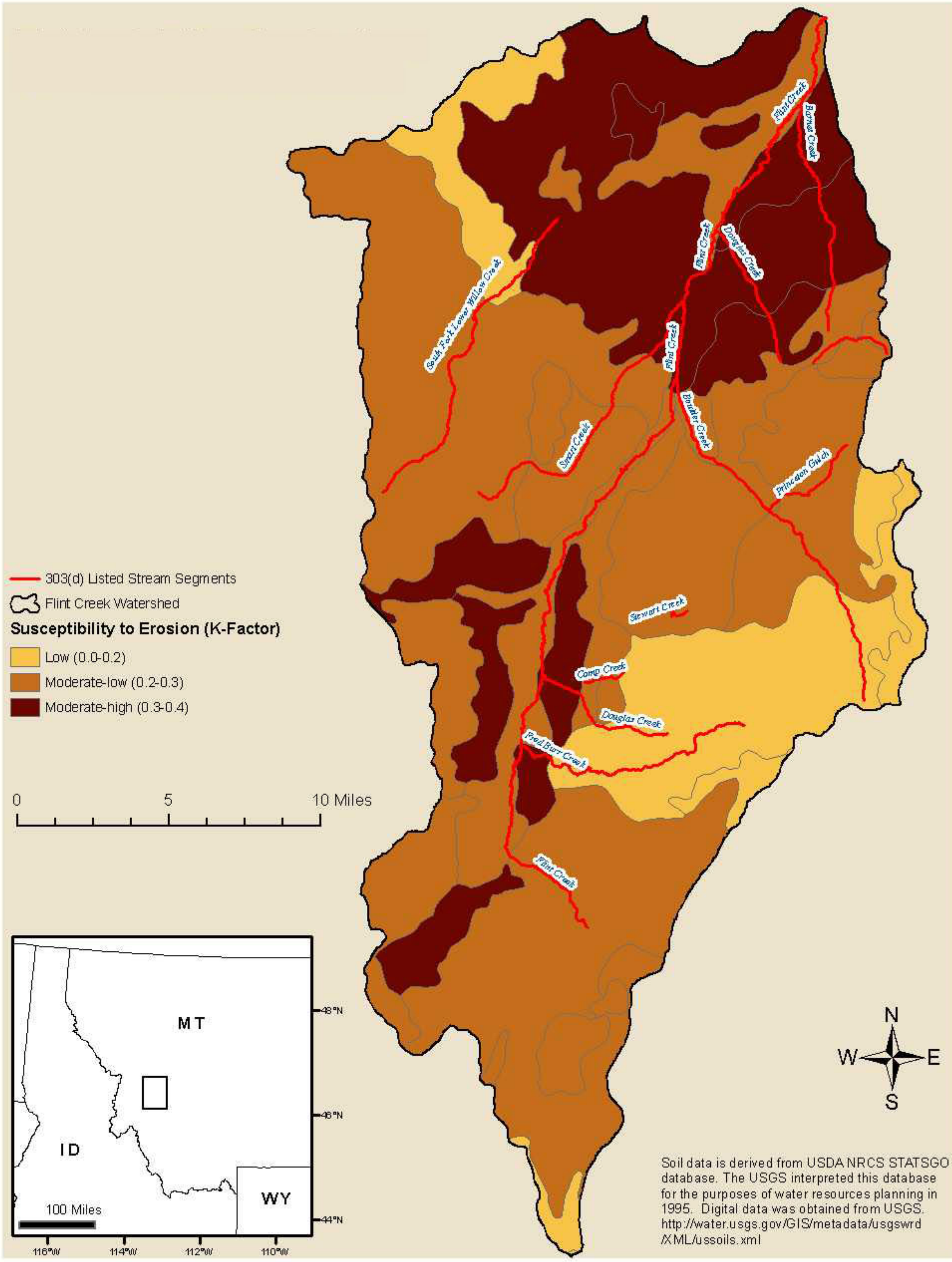

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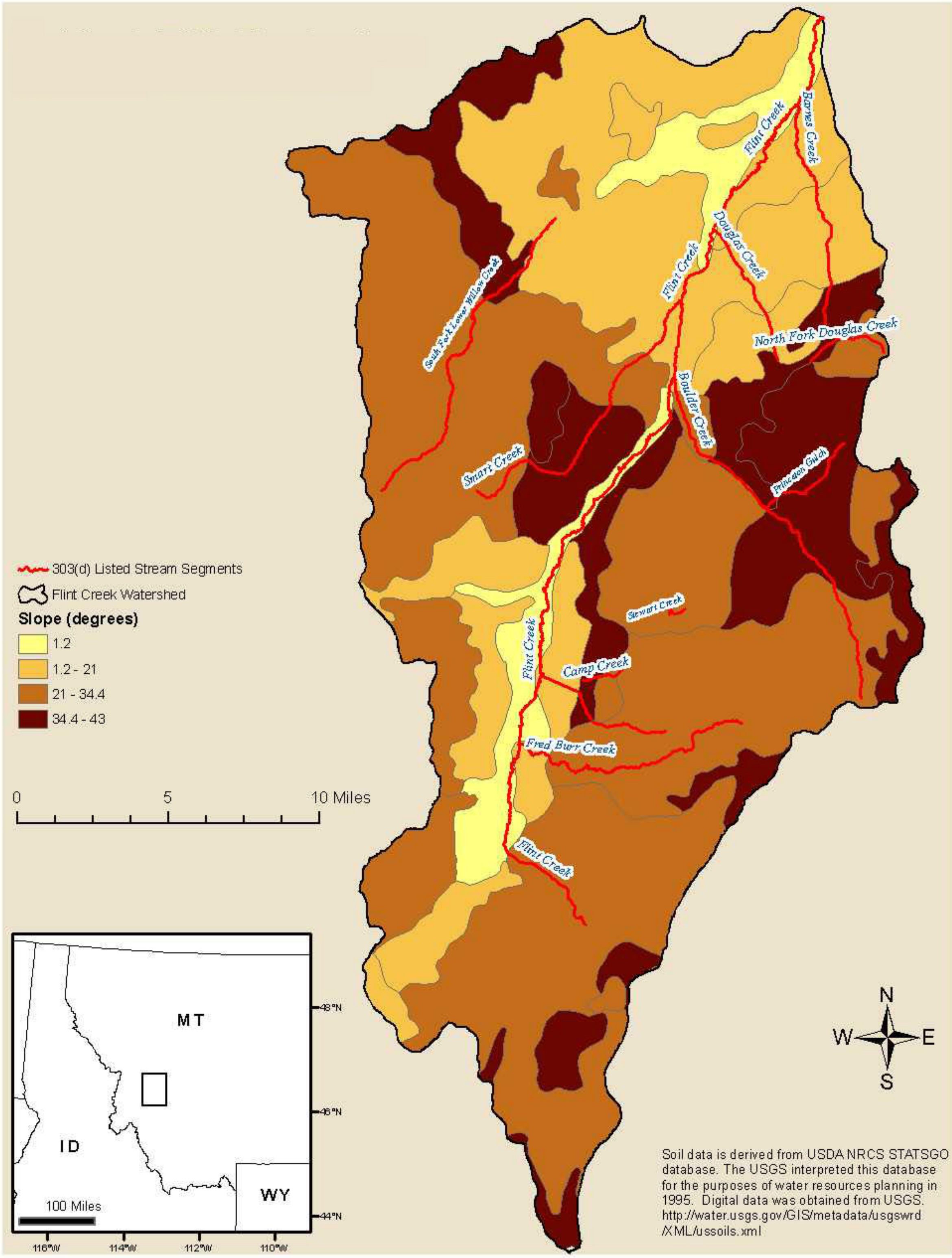

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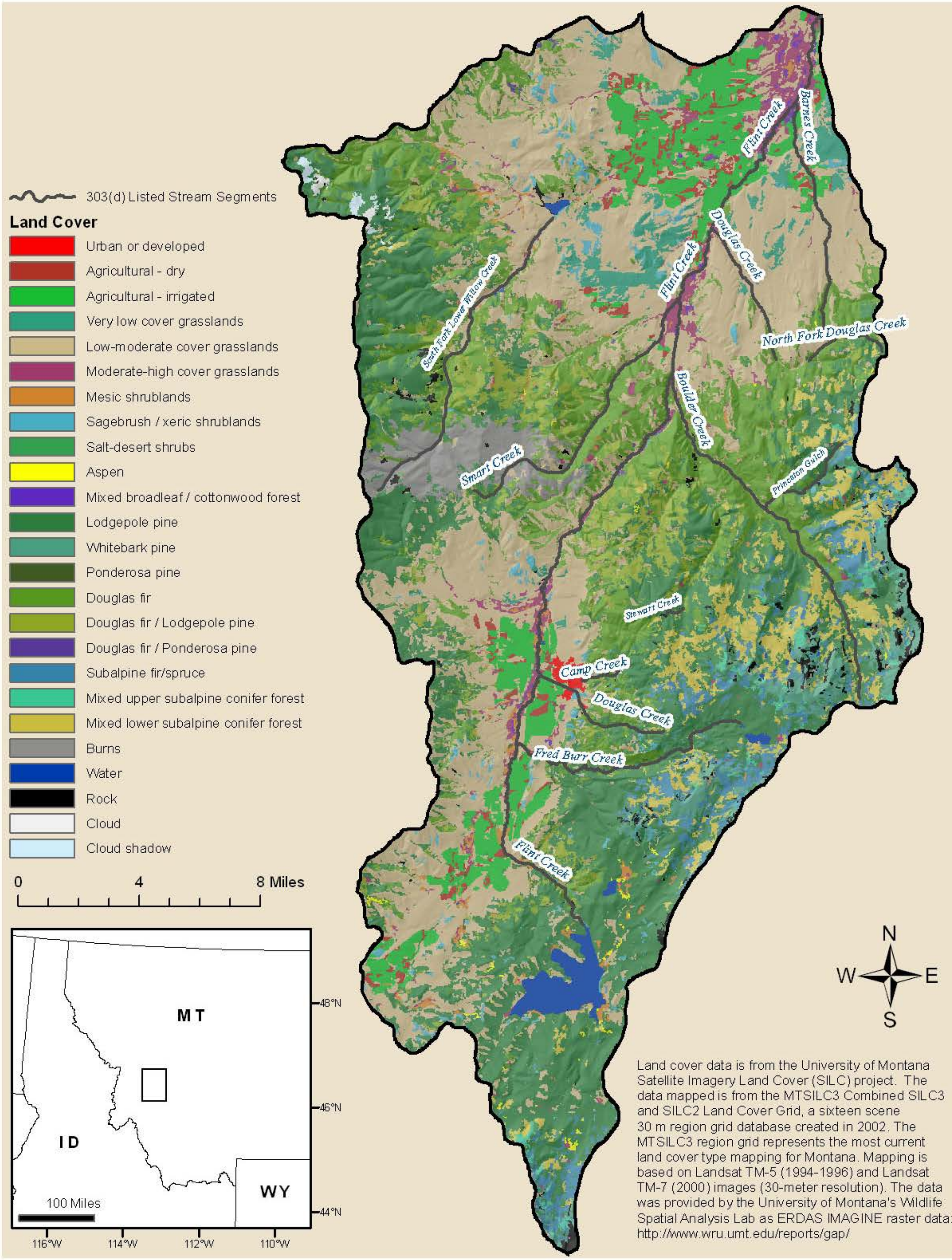

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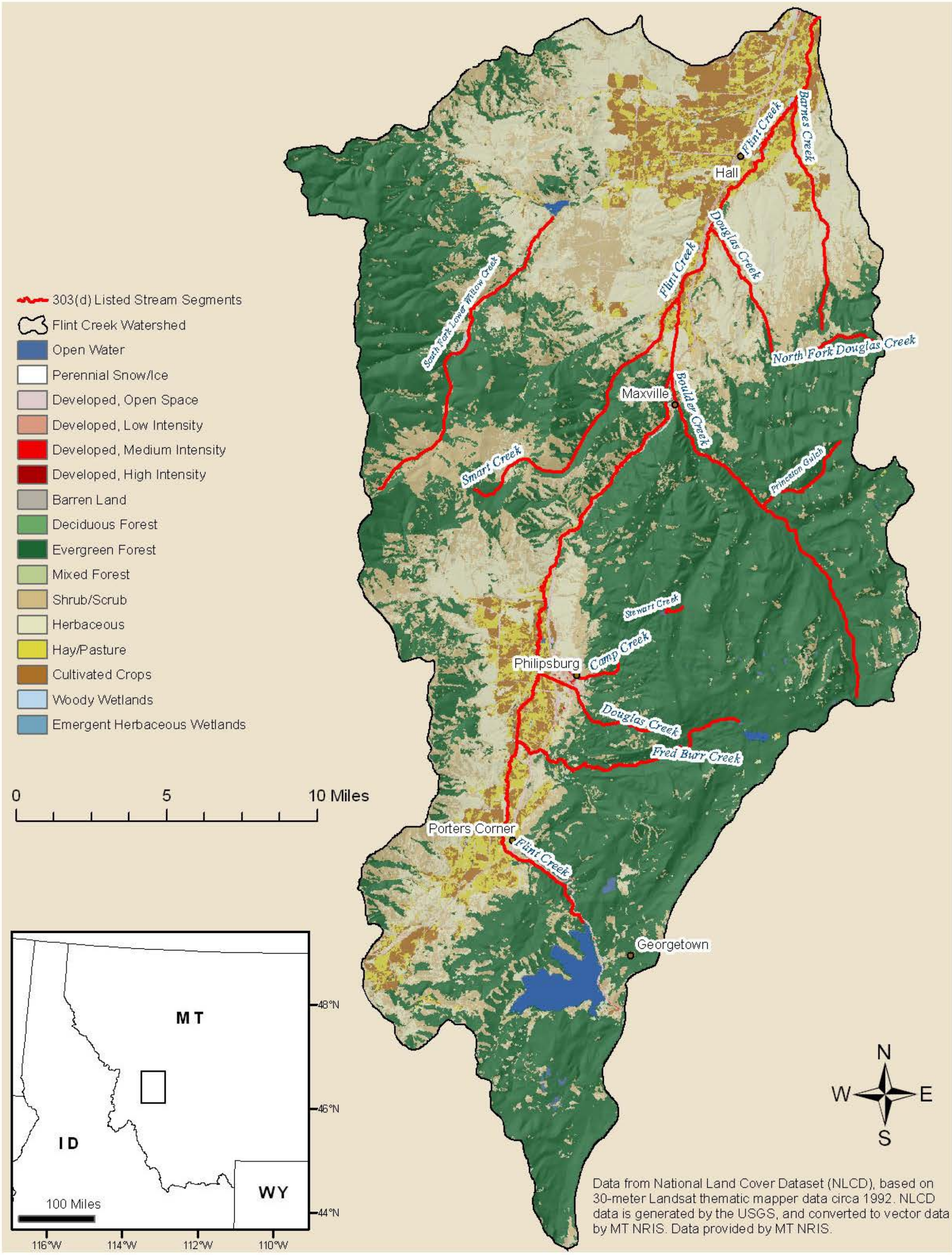

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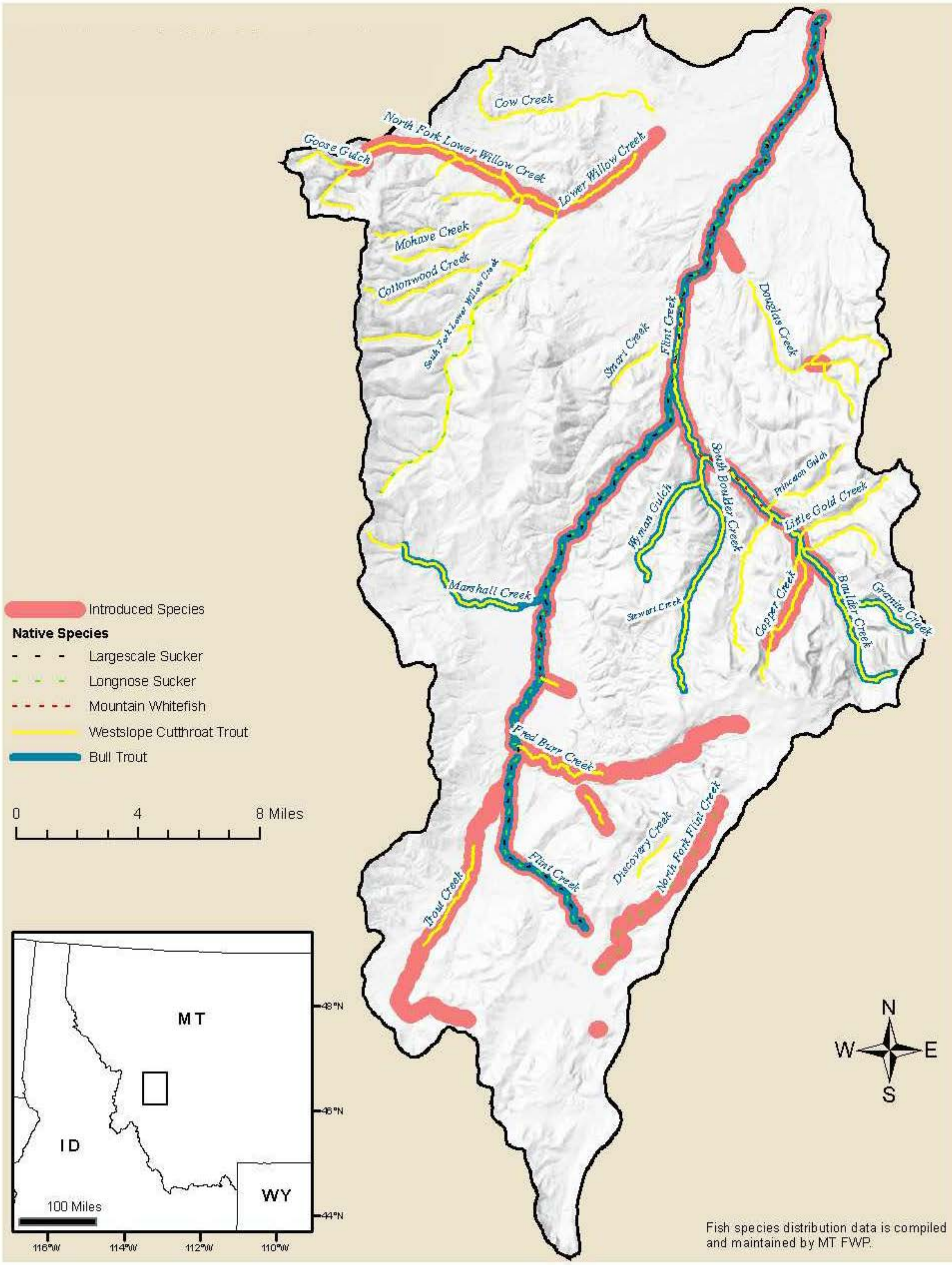

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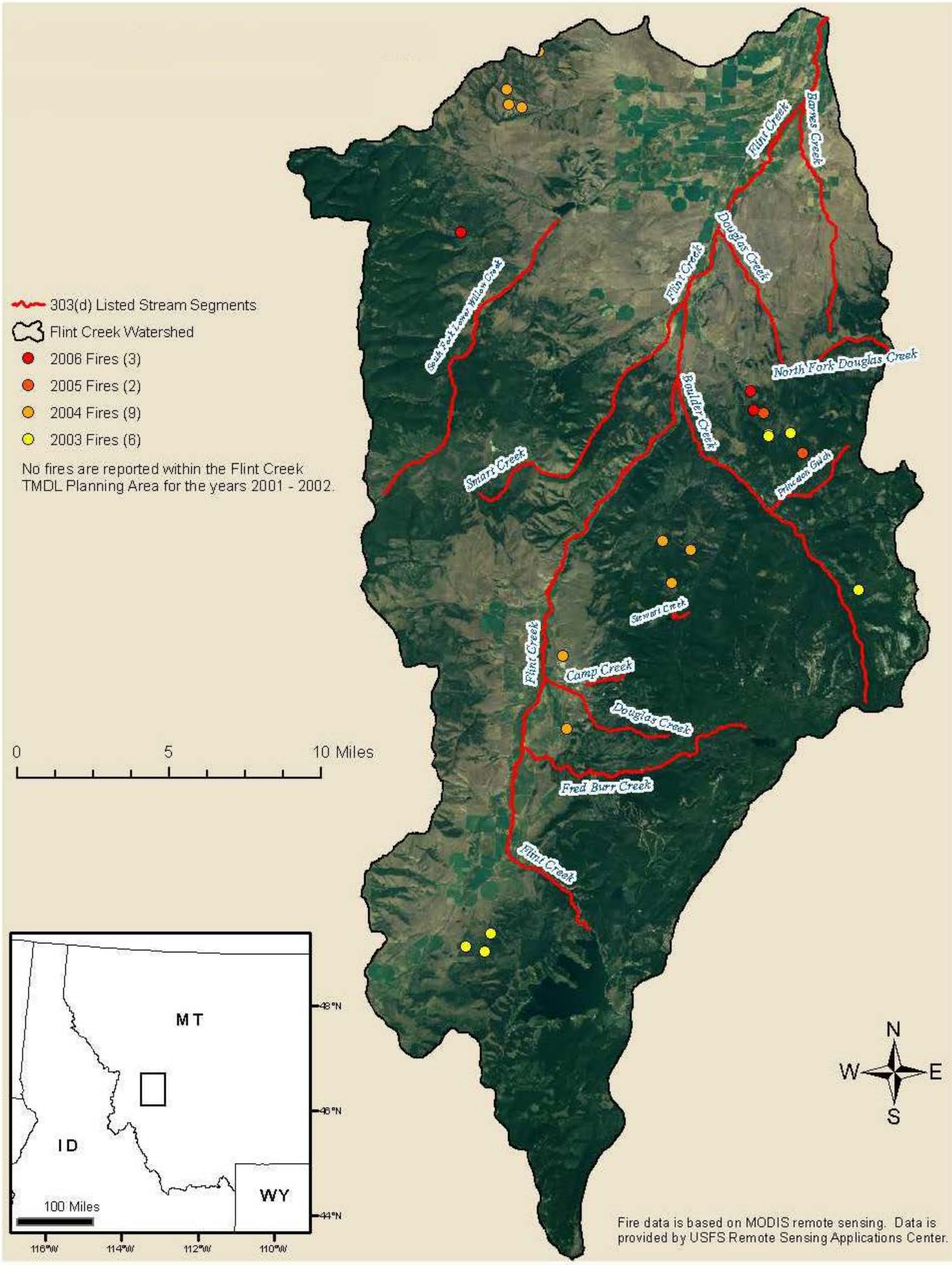

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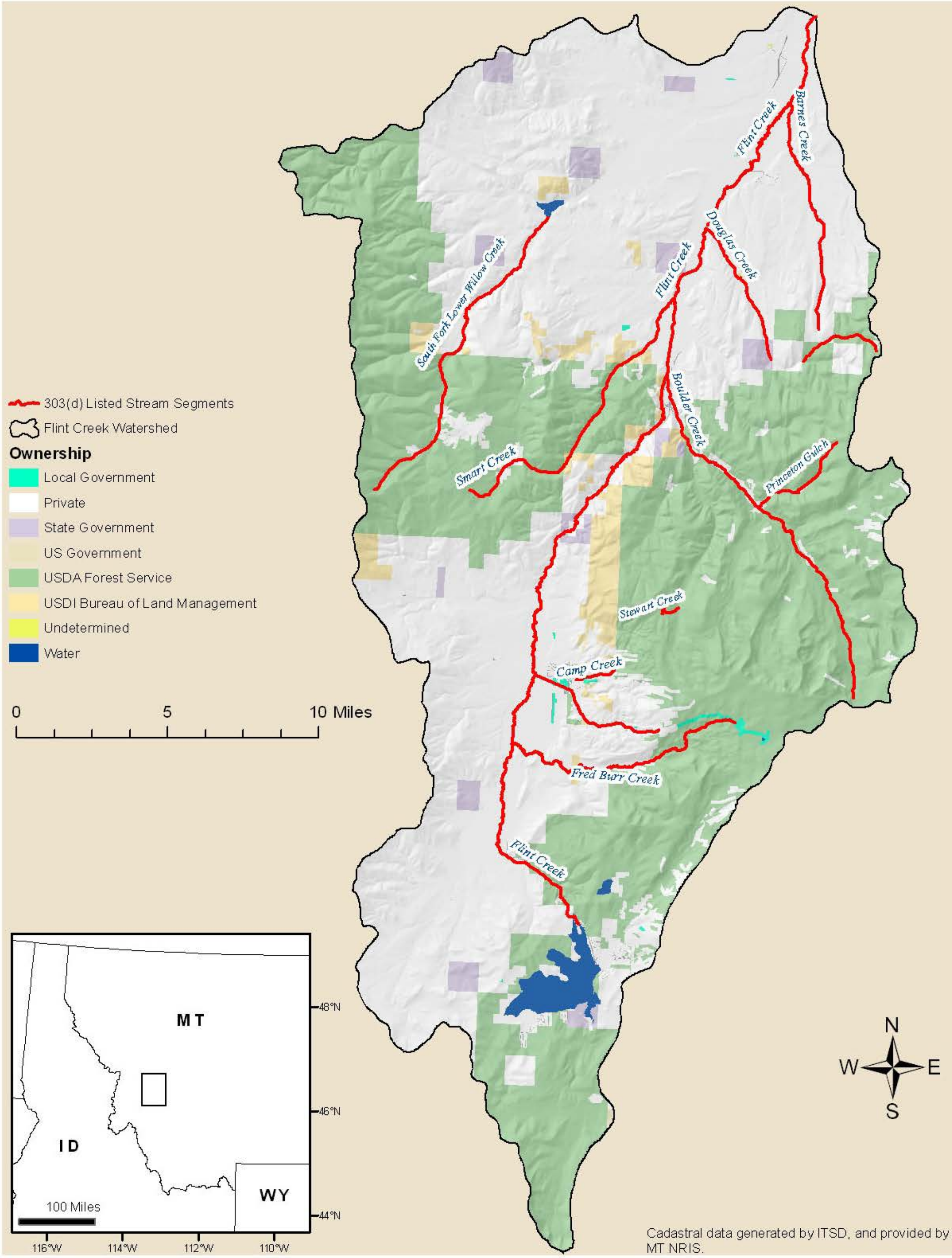

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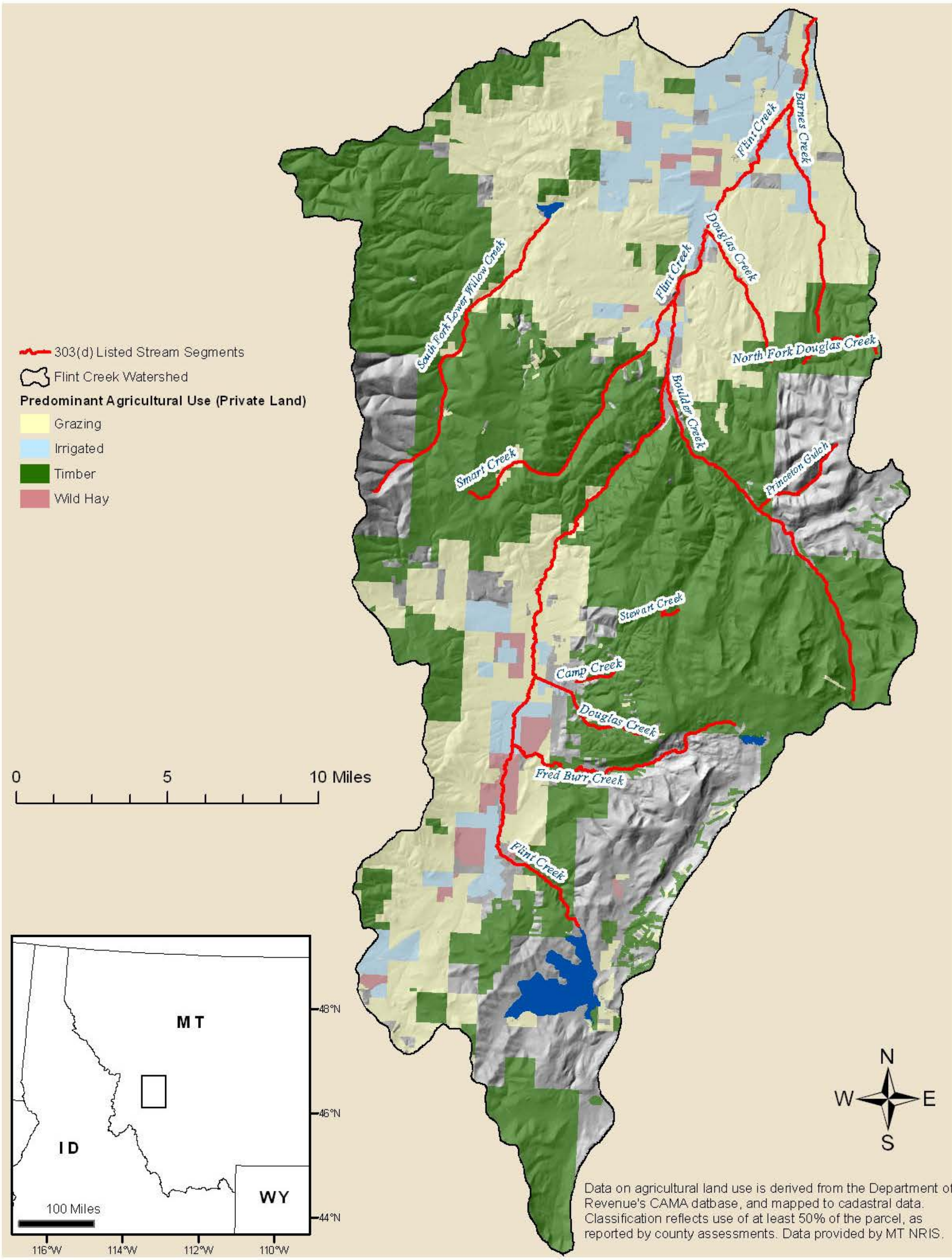

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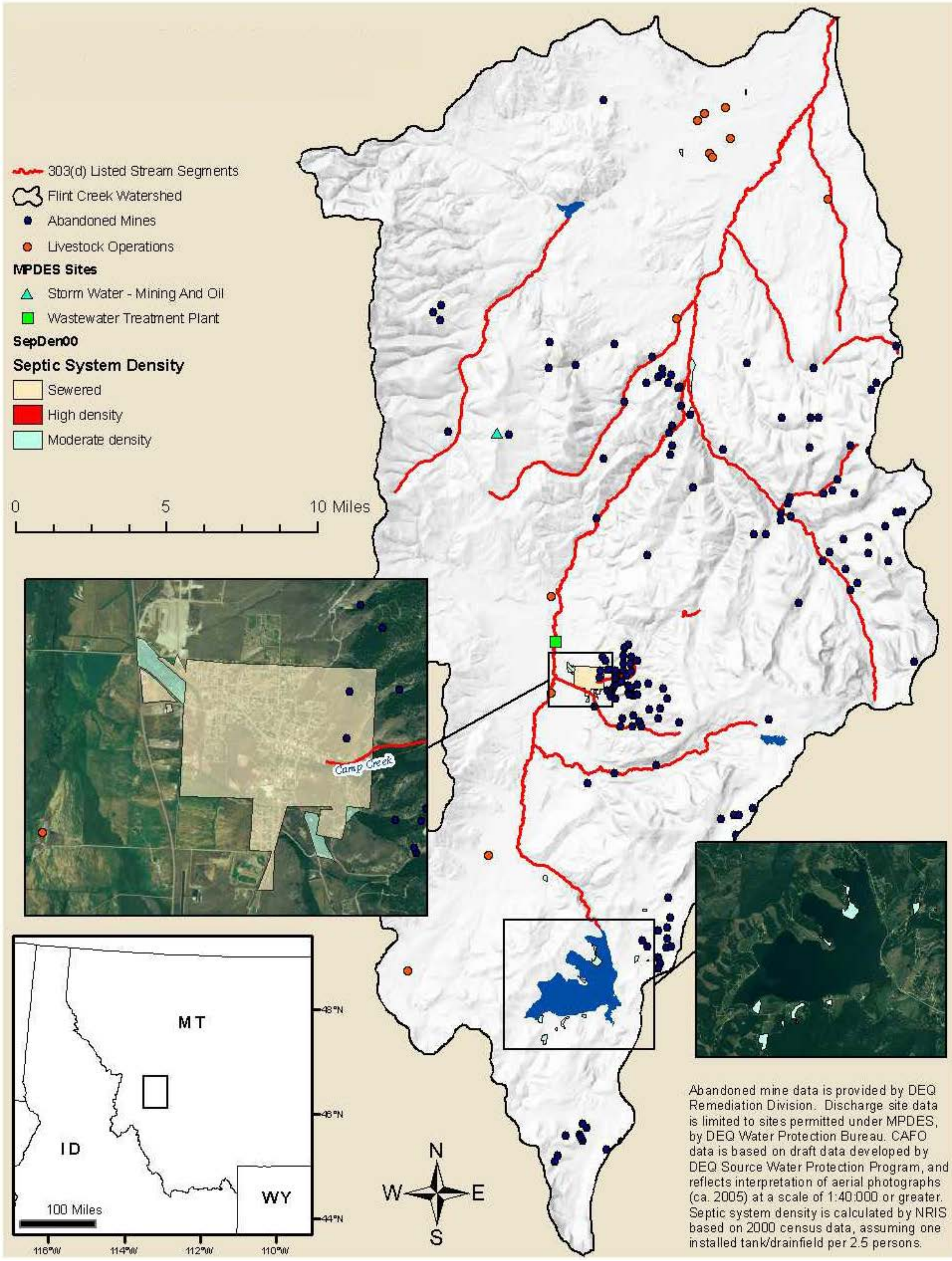

Figure B-21. Discharges

APPENDIX C – FISH SPECIES, SURFACE WATER NUTRIENTS, CHLOROPHYLL-*A*, MACROINVERTEBRATES AND PHILIPSBURG WASTEWATER TREATMENT PLANT DATA

LIST OF TABLES

Table C-1. Fish Species Present in the Flint TPA

Waterbody	Species	Abundance	Origin
Boulder Creek	Bull Trout	Rare	Native
	Mountain Whitefish	Rare	Native
	Westslope Cutthroat Trout	Rare	Native
	Brook Trout	Rare	Introduced
	Brown Trout	Common	Introduced
Colter Gulch	Westslope Cutthroat Trout	Unknown	Unknown
	Brook Trout	Unknown	Introduced
Copper Creek	Bull Trout	Rare	Native
	Westslope Cutthroat Trout	Rare	Native
	Brook Trout	Abundant	Introduced
Cottonwood Creek	Westslope Cutthroat Trout	Rare	Native
Cow Creek	Westslope Cutthroat Trout	Rare	Native
Discovery Creek	Westslope Cutthroat Trout	Rare	Native
Douglas Creek	Westslope Cutthroat Trout	Unknown	Unknown
	Westslope Cutthroat Trout	Rare	Native
	Westslope Cutthroat Trout	Rare	Native
	Brook Trout	Rare	Introduced
	Brown Trout	Common	Introduced
	Brown Trout	Unknown	Introduced
Flint Creek	Bull Trout	Rare	Native
	Largescale Sucker	Common	Native
	Longnose Sucker	Common	Native
	Mountain Whitefish	Abundant	Native
	Westslope Cutthroat Trout	Rare	Native
	Brook Trout	Abundant	Introduced
	Rainbow Trout	Abundant	Introduced
Fred Burr Creek	Bull Trout	Rare	Native
	Westslope Cutthroat Trout	Rare	Native
	Brown Trout	Unknown	Introduced
	Rainbow Trout	Unknown	Introduced
Goose Gulch	Westslope Cutthroat Trout	Rare	Native
Granite Creek	Bull Trout	Rare	Native
	Westslope Cutthroat Trout	Rare	Native
Little Gold Creek	Westslope Cutthroat Trout	Rare	Native
Lower Willow Creek	Westslope Cutthroat Trout	Rare	Native
	Brook Trout	Rare	Introduced
Marshall Creek	Bull Trout	Rare	Native
	Westslope Cutthroat Trout	Rare	Native
McLean Creek	Westslope Cutthroat Trout	Rare	Native
Middle Fork Douglas Creek	Westslope Cutthroat Trout	Rare	Native
	Brook Trout	Unknown	Introduced
Mohave Creek	Westslope Cutthroat Trout	Rare	Native
North Fork Douglas Creek	Westslope Cutthroat Trout	Rare	Native
North Fork Flint Creek	Longnose Sucker	Rare	Native
	Brook Trout	Common	Introduced
	Kokanee	Rare	Introduced
	Rainbow Trout	Rare	Introduced

Table C-1. Fish Species Present in the Flint TPA

Waterbody	Species	Abundance	Origin
North Fork Lower Willow Creek	Westslope Cutthroat Trout	Rare	Native
	Brook Trout	Rare	Introduced
Princeton Gulch	Westslope Cutthroat Trout	Rare	Native
Royal Gold Creek	Westslope Cutthroat Trout	Rare	Native
Senia Creek	Westslope Cutthroat Trout	Rare	Native
Smart Creek	Westslope Cutthroat Trout	Unknown	Native
South Boulder Creek	Bull Trout	Rare	Native
	Westslope Cutthroat Trout	Rare	Native
	Brook Trout	Unknown	Introduced
South Fork Douglas Creek	Westslope Cutthroat Trout	Rare	Native
South Fork Lower Willow Creek	Longnose Sucker	Unknown	Native
	Westslope Cutthroat Trout	Rare	Native
Spring Creek	Westslope Cutthroat Trout	Rare	Native
Stuart Mill Creek	Brook Trout	Abundant	Introduced
	Brown Trout	Unknown	Introduced
	Kokanee	Abundant	Introduced
	Rainbow Trout	Unknown	Introduced
Swamp Gulch Creek	Westslope Cutthroat Trout	Rare	Native
Trout Creek	Westslope Cutthroat Trout	Rare	Native
	Brook Trout	Unknown	Introduced
	Brown Trout	Unknown	Introduced
West Fork Lower Willow Creek	Westslope Cutthroat Trout	Rare	Native
Wyman Gulch	Bull Trout	Rare	Native
	Westslope Cutthroat Trout	Rare	Native

Table C-2. Recent Surface Water Nutrients and Flow Data for the Flint TPA

Waterbody Name	Site ID	Collection Date	Latitude	Longitude	Flow (cfs)	Total N per Sulfate Method (mg/L)	NO_{2+3} Combined (mg/L)	Total P (mg/L)
Barnes Creek	BARNESC01	9/4/2008	46.61124	-113.16065	1.6	0.23	-0.01	0.045
Barnes Creek	BARNESC01	9/5/2007	46.61124	-113.16065	2.37	0.4	0.018	0.102
Barnes Creek	BARNESC01	8/26/2009	46.61124	-113.16065	6.53	0.4	0.12	0.119
Barnes Creek	BARNESC02	8/25/2009	46.59060	-113.15941	2.5	0.62	0.22	0.154
Barnes Creek	BARNESC02	9/4/2007	46.59060	-113.15941	1.25	0.71	0.224	0.17
Barnes Creek	BARNESC02	8/19/2008	46.59060	-113.15941	0.17	0.88	0.2	0.176
Barnes Creek	BARNESC03	8/25/2009	46.56760	-113.14510	2.5	0.57	0.3	0.11
Barnes Creek	BARNESC03	8/19/2008	46.56760	-113.14510	1.02	1.81	0.22	0.45
Barnes Creek	BARNESC04	8/19/2008	46.54210	-113.13510	0.52	0.38	0.09	0.043
Barnes Creek	C02BARNC01	7/15/2004	46.59065	-113.15937	2.74	-	0.24	0.198
Barnes Creek	C02BARNC02	7/16/2004	46.61089	-113.16017	1.31	-	0.08	0.077
Douglas Creek	C02DOUGC01	7/11/2007	46.53820	-113.20180	-	0.17	0.142	0.066
Douglas Creek	DOUGLASC-H01	8/31/2007	46.54995	-113.21549	1.65	0.29	0.117	0.033
Douglas Creek	DOUGLASC-H01	8/25/2009	46.54995	-113.21549	4.76	0.16	0.09	0.036
Douglas Creek	DOUGLASC-H01	8/14/2008	46.54995	-113.21549	4.73	0.22	0.11	0.05
Douglas Creek	DOUGLASC-H02	8/31/2007	46.52990	-113.19452	2.73	0.26	0.173	0.034
Douglas Creek	DOUGLASC-H02	8/14/2008	46.52990	-113.19452	4.84	0.28	0.1	0.045
Douglas Creek	DOUGLASC-H02	8/25/2009	46.52990	-113.19452	5.2	0.21	0.12	0.055
Douglas Creek	DOUGLASC-H02.5	8/25/2009	46.50130	-113.17120	9.9	0.11	0.11	0.029
Douglas Creek	DOUGLASC-H03	8/14/2008	46.50103	-113.17114	12.41	0.13	0.07	0.026
Douglas Creek	DOUGLASC-H03	8/30/2007	46.50103	-113.17114	9.34	0.16	0.089	0.026
Douglas Creek	DOUGLASC-H03	8/25/2009	46.50103	-113.17114	11	0.11	0.15	0.028
Douglas Creek	DOUGLASC-H04	8/14/2008	46.48830	-113.14390	7.33	0.12	0.04	0.023
Douglas Creek	DOUGLASC-H04	8/25/2009	46.48830	-113.14390	6	-0.05	0.06	0.023
Flint Creek	CFRPO-11.5	8/19/2002	46.62920	-113.15000	25	-	0.01	0.116
Flint Creek	Flint_10.25	7/20/2005	46.34981	-113.31946	-	-	-	0.026
Flint Creek	Flint_10.25	7/15/2008	46.34981	-113.31946	-	-	-	0.027
Flint Creek	Flint_10.25	9/16/2008	46.34981	-113.31946	-	-	-	0.028
Flint Creek	Flint_10.25	9/15/2009	46.34981	-113.31946	-	-	-	0.032
Flint Creek	Flint_10.25	8/18/2009	46.34981	-113.31946	-	-	-	0.033
Flint Creek	Flint_10.25	9/14/2005	46.34981	-113.31946	-	-	-	0.038
Flint Creek	Flint_10.25	8/12/2008	46.34981	-113.31946	-	-	-	0.038

Table C-2. Recent Surface Water Nutrients and Flow Data for the Flint TPA

Waterbody Name	Site ID	Collection Date	Latitude	Longitude	Flow (cfs)	Total N per Sulfate Method (mg/L)	NO_2+_3 Combined (mg/L)	Total P (mg/L)
Flint Creek	Flint_10.25	7/14/2009	46.34981	-113.31946	-	-	-	0.052
Flint Creek	Flint_10.25	7/19/2006	46.34981	-113.31946	-	-	-	0.068
Flint Creek	Flint_10.25	8/17/2005	46.34981	-113.31946	-	-	-	0.069
Flint Creek	Flint_10.25	9/13/2006	46.34981	-113.31946	-	-	-	0.0756
Flint Creek	Flint_10.25	8/15/2007	46.34981	-113.31946	-	-	-	0.09
Flint Creek	Flint_10.25	8/16/2006	46.34981	-113.31946	-	-	-	0.108
Flint Creek	Flint_10.25	7/18/2007	46.34981	-113.31946	-	-	-	0.126
Flint Creek	Flint_10.25	9/19/2007	46.34981	-113.31946	-	-	-	0.145
Flint Creek	Flint_10.75	9/16/2008	46.34869	-113.32018	-	-	-	0.023
Flint Creek	Flint_10.75	7/15/2008	46.34869	-113.32018	-	-	-	0.024
Flint Creek	Flint_10.75	9/15/2009	46.34869	-113.32018	-	-	-	0.03
Flint Creek	Flint_10.75	8/18/2009	46.34869	-113.32018	-	-	-	0.032
Flint Creek	Flint_10.75	8/12/2008	46.34869	-113.32018	-	-	-	0.037
Flint Creek	Flint_10.75	7/20/2005	46.34869	-113.32018	-	-	-	0.038
Flint Creek	Flint_10.75	9/14/2005	46.34869	-113.32018	-	-	-	0.053
Flint Creek	Flint_10.75	7/14/2009	46.34869	-113.32018	-	-	-	0.055
Flint Creek	Flint_10.75	8/17/2005	46.34869	-113.32018	-	-	-	0.061
Flint Creek	Flint_10.75	8/16/2006	46.34869	-113.32018	-	-	-	0.079
Flint Creek	Flint_10.75	7/19/2006	46.34869	-113.32018	-	-	-	0.085
Flint Creek	Flint_10.75	9/13/2006	46.34869	-113.32018	-	-	-	0.098
Flint Creek	Flint_10.75	9/19/2007	46.34869	-113.32018	-	-	-	0.105
Flint Creek	Flint_10.75	7/18/2007	46.34869	-113.32018	-	-	-	0.12
Flint Creek	Flint_10.75	8/15/2007	46.34869	-113.32018	-	-	-	0.13
Flint Creek	Flint_15	9/16/2008	46.22140	-113.28810	-	-	-	0.012
Flint Creek	Flint_15	9/15/2009	46.22140	-113.28810	-	-	-	0.014
Flint Creek	Flint_15	7/14/2009	46.22140	-113.28810	-	-	-	0.017
Flint Creek	Flint_15	8/18/2009	46.22140	-113.28810	-	-	-	0.018
Flint Creek	Flint_15	7/15/2008	46.22140	-113.28810	-	-	-	0.021
Flint Creek	Flint_15	8/12/2008	46.22140	-113.28810	-	-	-	0.028
Flint Creek	Flint_15	8/17/2005	46.22140	-113.28810	-	-	-	0.032
Flint Creek	Flint_15	9/14/2005	46.22140	-113.28810	-	-	-	0.039
Flint Creek	Flint_15	7/20/2005	46.22140	-113.28810	-	-	-	0.046

Table C-2. Recent Surface Water Nutrients and Flow Data for the Flint TPA

Waterbody Name	Site ID	Collection Date	Latitude	Longitude	Flow (cfs)	Total N per Sulfate Method (mg/L)	NO_2+$_3$ Combined (mg/L)	Total P (mg/L)
Flint Creek	Flint_15	7/19/2006	46.22140	-113.28810	-	-	-	0.061
Flint Creek	Flint_15	9/13/2006	46.22140	-113.28810	-	-	-	0.0699
Flint Creek	Flint_15	8/15/2007	46.22140	-113.28810	-	-	-	0.073
Flint Creek	Flint_15	8/16/2006	46.22140	-113.28810	-	-	-	0.084
Flint Creek	Flint_15	9/19/2007	46.22140	-113.28810	-	-	-	0.121
Flint Creek	Flint_15	7/18/2007	46.22140	-113.28810	-	-	-	0.161
Flint Creek	FLINTC01	8/25/2009	46.65334	-113.14740	159.05	0.22	0.03	0.048
Flint Creek	FLINTC01	9/5/2008	46.65334	-113.14740	175.9	0.27	0.03	0.057
Flint Creek	FLINTC01	9/3/2007	46.65334	-113.14740	36.98	0.3	0.005	0.094
Flint Creek	FLINTC04	8/26/2009	46.61159	-113.16109	66.77	0.2	0.05	0.036
Flint Creek	FLINTC04	9/4/2008	46.61159	-113.16109	126.8	0.25	0.03	0.041
Flint Creek	FLINTC04	7/10/2008	46.61159	-113.16109	197.3	0.23	-0.01	0.043
Flint Creek	FLINTC04	9/5/2007	46.61159	-113.16109	21.28	0.3	0.03	0.058
Flint Creek	FLINTC05	8/25/2009	46.55023	-113.21521	106.64	0.14	0.01	0.024
Flint Creek	FLINTC05	8/31/2007	46.55023	-113.21521	19.71	0.22	0.082	0.027
Flint Creek	FLINTC05	8/14/2008	46.55023	-113.21521	52.55	0.23	0.09	0.033
Flint Creek	FLINTC07	8/25/2009	46.48835	-113.23619	179	0.09	0.02	0.02
Flint Creek	FLINTC07	9/3/2008	46.48835	-113.23619	149.3	0.2	0.03	0.034
Flint Creek	FLINTC07	9/4/2007	46.48835	-113.23619	73.66	0.2	0.007	0.035
Flint Creek	FLINTC08	8/19/2009	46.47060	-113.24037	174.84	0.19	-0.01	0.024
Flint Creek	FLINTC08	8/28/2007	46.47060	-113.24037	-	0.19	-0.005	0.028
Flint Creek	FLINTC08	9/4/2008	46.47060	-113.24037	-	0.23	0.05	0.037
Flint Creek	FLINTC09	8/25/2009	46.39398	-113.30857	146.25	0.15	-0.01	0.023
Flint Creek	FLINTC09	8/26/2007	46.39398	-113.30857	66.17	0.21	0.02	0.027
Flint Creek	FLINTC09	8/13/2008	46.39398	-113.30857	88.16	0.27	0.01	0.035
Flint Creek	FLINTC10	8/25/2009	46.36751	-113.31714	136.74	0.13	-0.01	0.02
Flint Creek	FLINTC10	8/13/2008	46.36751	-113.31714	81.89	0.22	0.01	0.026
Flint Creek	FLINTC10	9/4/2007	46.36751	-113.31714	60	-	0.026	-
Flint Creek	FLINTC11	8/25/2009	46.33860	-113.32110	134.94	0.11	-0.05	0.02
Flint Creek	FLINTC11	8/13/2008	46.33860	-113.32110	81.44	0.22	0.02	0.027
Flint Creek	FLINTC11	8/24/2007	46.33860	-113.32110	59.78	-	0.04	-
Flint Creek	FLINTC12	8/21/2007	46.31686	-113.33273	65.87	0.21	0.071	0.027

Table C-2. Recent Surface Water Nutrients and Flow Data for the Flint TPA

Waterbody Name	Site ID	Collection Date	Latitude	Longitude	Flow (cfs)	Total N per Sulfate Method (mg/L)	$NO_{2}+_{3}$ Combined (mg/L)	Total P (mg/L)
Flint Creek	FLINTC13	8/24/2009	46.27680	-113.33700	44.57	0.22	0.04	0.013
Flint Creek	FLINTC13	8/13/2008	46.27680	-113.33700	11.81	0.39	0.12	0.019
Flint Creek	FLINTC14	8/24/2009	46.24550	-113.33242	52.33	0.25	0.08	0.01
Flint Creek	FLINTC14	8/13/2008	46.24550	-113.33242	24.07	0.33	0.15	0.015
Flint Creek	FLINTC14	8/21/2007	46.24550	-113.33242	12.65	0.31	0.133	0.016
Flint Creek	FLINTC15	8/24/2009	46.22021	-113.28443	60.9	0.31	0.09	0.012
Flint Creek	FLINTC15	8/18/2008	46.22021	-113.28443	34.82	0.35	-0.01	0.013
Flint Creek	FLINTC15	8/20/2007	46.22021	-113.28443	32.17	-	0.31	0.022
Princeton Gulch	C02PRNCG01	8/30/2012	46.43290	-113.13203	0.52	-0.05	-	0.011
Princeton Gulch	PRINCETONG01	8/27/2007	46.41806	-113.16892	0.19	0.11	0.04	0.011
Princeton Gulch	PRINCETONG01	8/24/2009	46.41806	-113.16892	0.6	-0.05	0.03	0.021
Princeton Gulch	PRINCETONG01	8/20/2008	46.41806	-113.16892	0.26	0.11	0.03	0.03
Princeton Gulch	PRINCETONG02	8/27/2007	46.43376	-113.13091	0.99	0.035	0.012	0.013
Princeton Gulch	PRINCETONG02	8/24/2009	46.43376	-113.13091	1.5	-0.05	-0.01	0.015
Princeton Gulch	PRINCETONG02	8/20/2008	46.43376	-113.13091	0.12	0.04	0.05	0.022
Princeton Gulch	PRINCETONG02	7/8/2008	46.43376	-113.13091	0.28	0.04	0.03	0.044
Princeton Gulch	PRINCETONG03	8/24/2009	46.44990	-113.11830	0.1	-0.05	-0.01	0.009
Princeton Gulch	PRINCETONG03	7/8/2008	46.44990	-113.11830	0.28	-0.01	-0.01	0.01
Princeton Gulch	PRINCETONG03	8/20/2008	46.44990	-113.11830	0.04	-0.01	-0.01	0.058
Smart Creek	C02SMRTC01	8/18/2005	46.49563	-113.24726	-	-	-0.01	0.045
Smart Creek	C02SMRTC02	8/17/2005	46.45355	-113.29070	0.34	-	-0.01	0.032
Smart Creek	C02SMRTC03	7/11/2007	46.48760	-113.26000	-	0.09	0.049	0.05
Smart Creek	SMARTC01	8/21/2008	46.51548	-113.23550	1.1	0.15	-0.01	0.046
Smart Creek	SMARTC01	9/4/2007	46.51548	-113.23550	1.06	2.28	2	0.087
Smart Creek	SMARTC01	8/26/2009	46.51548	-113.23550	8.4	1.17	0.97	0.089
Smart Creek	SMARTC02	8/20/2009	46.49645	-113.24658	0.68	0.14	0.02	0.033
Smart Creek	SMARTC02	8/22/2008	46.49645	-113.24658	0.93	0.11	-0.01	0.042
Smart Creek	SMARTC02	8/29/2007	46.49645	-113.24658	0.4	0.77	0.021	0.132
Smart Creek	SMARTC03	8/29/2007	46.45434	-113.28931	0.33	0.08	-0.005	0.011
Smart Creek	SMARTC03	8/21/2008	46.45434	-113.28931	0.88	0.1	-0.01	0.015
Smart Creek	SMARTC03	8/20/2009	46.45434	-113.28931	0.41	0.15	0.02	0.016

Table C-3. Recent Algal Measure Data for the Flint TPA

Waterbody Name	Site ID	Collection Date	Latitude	Longitude	Algal Measure	Result Value	Result Unit
Barnes Creek	BARNESC01	9/5/2007	46.61124	-113.16065	Chlorophyll-*a*, corrected for pheophytin	556	mg/m^2
Barnes Creek	BARNESC02	9/4/2007	46.59060	-113.15941	Chlorophyll-*a*, corrected for pheophytin	721	mg/m^2
Barnes Creek	BARNESC02	8/19/2008	46.59060	-113.15941	Chlorophyll-*a*, corrected for pheophytin	4	mg/m^2
Barnes Creek	BARNESC03	8/19/2008	46.56760	-113.14510	Chlorophyll-*a*, corrected for pheophytin	3	mg/m^2
Barnes Creek	BARNESC04	8/19/2008	46.54210	-113.13510	Chlorophyll-*a*, corrected for pheophytin	3	mg/m^2
Douglas Creek	C02DOUGC01	7/11/2007	46.53820	-113.20180	Chlorophyll-*a*, corrected for pheophytin	34.7	mg/m^2
Douglas Creek	DOUGLASC-H01	8/31/2007	46.54995	-113.21549	Chlorophyll-*a*, corrected for pheophytin	281	mg/m^2
Douglas Creek	DOUGLASC-H01	8/14/2008	46.54995	-113.21549	Chlorophyll-*a*, corrected for pheophytin	19	mg/m^2
Douglas Creek	DOUGLASC-H02	8/31/2007	46.52990	-113.19452	Chlorophyll-*a*, corrected for pheophytin	354	mg/m^2
Douglas Creek	DOUGLASC-H02	8/15/2008	46.52990	-113.19452	Chlorophyll-*a*, corrected for pheophytin	17	mg/m^2
Douglas Creek	DOUGLASC-H03	8/30/2007	46.50103	-113.17114	Chlorophyll-*a*, corrected for pheophytin	29	mg/m^2
Douglas Creek	DOUGLASC-H03	8/15/2008	46.50103	-113.17114	Chlorophyll-*a*, corrected for pheophytin	5	mg/m^2
Douglas Creek	DOUGLASC-H04	8/14/2008	46.48830	-113.14390	Chlorophyll-*a*, corrected for pheophytin	8	mg/m^2
Flint Creek	FLINTC01	9/3/2007	46.65334	-113.14740	Chlorophyll-*a*, corrected for pheophytin	56	mg/m^2
Flint Creek	FLINTC01	9/11/2008	46.65334	-113.14740	Chlorophyll-*a*, corrected for pheophytin	97	mg/m^2
Flint Creek	FLINTC01	8/25/2009	46.65334	-113.14740	Chlorophyll-*a*, corrected for pheophytin	297	mg/m^2
Flint Creek	FLINTC04	9/5/2007	46.61159	-113.16109	Chlorophyll-*a*, corrected for pheophytin	135	mg/m^2
Flint Creek	FLINTC04	9/4/2008	46.61159	-113.16109	Chlorophyll-*a*, corrected for pheophytin	91	mg/m^2
Flint Creek	FLINTC04	8/26/2009	46.61159	-113.16109	Chlorophyll-*a*, corrected for pheophytin	-0.28	mg/m^3
Flint Creek	FLINTC05	8/31/2007	46.55023	-113.21521	Chlorophyll-*a*, corrected for pheophytin	158	mg/m^2
Flint Creek	FLINTC05	8/14/2008	46.55023	-113.21521	Chlorophyll-*a*, corrected for pheophytin	38	mg/m^2
Flint Creek	FLINTC07	9/4/2007	46.48835	-113.23619	Chlorophyll-*a*, corrected for pheophytin	106	mg/m^2
Flint Creek	FLINTC07	9/3/2008	46.48835	-113.23619	Chlorophyll-*a*, corrected for pheophytin	66	mg/m^2
Flint Creek	FLINTC09	8/26/2007	46.39398	-113.30857	Chlorophyll-*a*, corrected for pheophytin	157	mg/m^2
Flint Creek	FLINTC09	8/20/2008	46.39398	-113.30857	Chlorophyll-*a*, corrected for pheophytin	12	mg/m^2
Flint Creek	FLINTC10	9/4/2008	46.36751	-113.31714	Chlorophyll-*a*, corrected for pheophytin	99	mg/m^2
Flint Creek	FLINTC11	8/24/2007	46.33860	-113.32110	Chlorophyll-*a*, corrected for pheophytin	110	mg/m^2
Flint Creek	FLINTC11	8/27/2008	46.33860	-113.32110	Chlorophyll-*a*, corrected for pheophytin	54	mg/m^2
Flint Creek	FLINTC12	8/21/2007	46.31686	-113.33273	Chlorophyll-*a*, corrected for pheophytin	535	mg/m^2
Flint Creek	FLINTC13	8/26/2008	46.27680	-113.33700	Chlorophyll-*a*, corrected for pheophytin	71	mg/m^2
Flint Creek	FLINTC14	8/21/2007	46.24550	-113.33242	Chlorophyll-*a*, corrected for pheophytin	483	mg/m^2
Flint Creek	FLINTC14	8/26/2008	46.24550	-113.33242	Chlorophyll-*a*, corrected for pheophytin	42	mg/m^2

Table C-3. Recent Algal Measure Data for the Flint TPA

Waterbody Name	Site ID	Collection Date	Latitude	Longitude	Algal Measure	Result Value	Result Unit
Flint Creek	FLINTC15	8/20/2007	46.22021	-113.28443	Chlorophyll-*a*, corrected for pheophytin	34	mg/m^2
Flint Creek	FLINTC15	8/18/2008	46.22021	-113.28443	Chlorophyll-*a*, corrected for pheophytin	8	mg/m^2
Princeton Gulch	PRINCETONG01	8/27/2007	46.41806	-113.16892	Chlorophyll-*a*, corrected for pheophytin	626	mg/m^2
Princeton Gulch	PRINCETONG01	8/20/2008	46.41806	-113.16892	Chlorophyll-*a*, corrected for pheophytin	4	mg/m^2
Princeton Gulch	PRINCETONG01	8/24/2009	46.41806	-113.16892	Chlorophyll-*a*, corrected for pheophytin	382	mg/m^2
Princeton Gulch	PRINCETONG02	8/27/2007	46.43376	-113.13091	Chlorophyll-*a*, corrected for pheophytin	40	mg/m^2
Princeton Gulch	PRINCETONG02	8/20/2008	46.43376	-113.13091	Chlorophyll-*a*, corrected for pheophytin	4	mg/m^2
Princeton Gulch	PRINCETONG03	8/20/2008	46.44990	-113.11830	Chlorophyll-*a*, corrected for pheophytin	3	mg/m^2
Smart Creek	C02SMRTC03	7/11/2007	46.48760	-113.26000	Chlorophyll-*a*, corrected for pheophytin	4.1	mg/m^2
Smart Creek	SMARTC02	8/29/2007	46.49645	-113.24658	Chlorophyll-*a*, corrected for pheophytin	153	mg/m^2
Smart Creek	SMARTC03	8/29/2007	46.45434	-113.28931	Chlorophyll-*a*, corrected for pheophytin	60	mg/m^2
Smart Creek	SMARTC03	8/21/2008	46.45434	-113.28931	Chlorophyll-*a*, corrected for pheophytin	21	mg/m^2

Table C-4. Recent Macroinvertebrate Data for the Flint TPA

Waterbody Name	Site ID	Collection Date	Latitude	Longitude	HBI Score
Barnes Creek	C02BARNC01	7/15/2004	46.59065	-113.15937	5.04
Barnes Creek	C02BARNC02	7/16/2004	46.61089	-113.16017	6.37
Smart Creek	C02SMRTC01	8/18/2005	46.49563	-113.24726	5.20
Smart Creek	C02SMRTC02	8/17/2005	46.45355	-113.29070	3.63
Smart Creek	C02SMRTC03	8/29/2011	46.48805	-113.25986	3.57

Table C-5. Nutrients and Flow Data from Philipsburg Wastewater Treatment Plant Discharge Monitoring Reports

Date	Effluent Rate (gal/day)	Nitrate+ Nitrite (as N) (mg/L)	Total Ammonia (as N) (mg/L)	Total Kjeldahl Nitrogen (as N) (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
Jan-00	87,000	No Data	No Data	No Data	No Data	No Data
Feb-00	120,000	No Data	No Data	No Data	No Data	No Data
Mar-00	109,000	No Data	No Data	No Data	No Data	No Data
Apr-00	77,000	No Data	No Data	No Data	No Data	No Data
May-00	77,000	No Data	No Data	No Data	No Data	No Data
Jun-00	144,000	No Data	No Data	No Data	No Data	No Data
Jul-00	68,000	No Data	No Data	No Data	No Data	No Data
Aug-00	59,000	No Data	No Data	No Data	No Data	No Data
Sep-00	59,000	No Data	No Data	No Data	No Data	No Data
Oct-00	68,000	No Data	No Data	No Data	No Data	No Data
Nov-00	68,000	No Data	No Data	No Data	No Data	No Data
Dec-00	68,000	No Data	No Data	No Data	No Data	No Data
Jan-01	120,000	No Data	No Data	No Data	No Data	No Data
Feb-01	169,000	No Data	No Data	No Data	No Data	No Data
Mar-01	169,000	No Data	No Data	No Data	No Data	No Data
Apr-01	98,000	No Data	No Data	No Data	No Data	No Data
May-01	59,000	No Data	No Data	No Data	No Data	No Data
Jun-01	98,000	No Data	No Data	No Data	No Data	No Data
Jul-01	68,000	No Data	No Data	No Data	No Data	No Data
Aug-01	34,000	No Data	No Data	No Data	No Data	No Data
Sep-01	68,000	No Data	No Data	No Data	No Data	No Data
Oct-01	59,000	No Data	No Data	No Data	No Data	No Data
Nov-01	68,000	No Data	No Data	No Data	No Data	No Data
Dec-01	87,000	No Data	No Data	No Data	No Data	No Data
Jan-02	98,000	No Data	No Data	No Data	No Data	No Data
Feb-02	87,000	No Data	No Data	No Data	No Data	No Data
Mar-02	77,000	No Data	No Data	No Data	No Data	No Data
Apr-02	68,000	No Data	No Data	No Data	No Data	No Data
May-02	59,000	No Data	No Data	No Data	No Data	No Data
Jun-02	144,000	No Data	No Data	No Data	No Data	No Data
Jul-02	59,000	No Data	No Data	No Data	No Data	No Data
Aug-02	42,000	No Data	No Data	No Data	No Data	No Data
Sep-02	50,000	No Data	No Data	No Data	No Data	No Data
Oct-02	50,000	No Data	No Data	No Data	No Data	No Data
Nov-02	59,000	No Data	No Data	No Data	No Data	No Data
Dec-02	77,000	No Data	No Data	No Data	No Data	No Data
Jan-03	77,000	No Data	No Data	No Data	No Data	No Data
Feb-03	77,000	No Data	No Data	No Data	No Data	No Data
Mar-03	109,000	No Data	No Data	No Data	No Data	No Data
Apr-03	87,000	No Data	No Data	No Data	No Data	No Data
May-03	98,000	No Data	No Data	No Data	No Data	No Data
Jun-03	77,000	No Data	No Data	No Data	No Data	No Data
Jul-03	50,000	No Data	No Data	No Data	No Data	No Data
Aug-03	34,000	No Data	No Data	No Data	No Data	No Data
Sep-03	59,000	No Data	No Data	No Data	No Data	No Data

Table C-5. Nutrients and Flow Data from Philipsburg Wastewater Treatment Plant Discharge Monitoring Reports

Date	Effluent Rate (gal/day)	Nitrate+ Nitrite (as N) (mg/L)	Total Ammonia (as N) (mg/L)	Total Kjeldahl Nitrogen (as N) (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
Oct-03	77,000	No Data	No Data	No Data	No Data	No Data
Nov-03	109,000	No Data	No Data	No Data	No Data	No Data
Dec-03	59,000	No Data	No Data	No Data	No Data	No Data
Jan-04	68,000	No Data	No Data	No Data	No Data	No Data
Feb-04	98,000	No Data	No Data	No Data	No Data	No Data
Mar-04	156,000	No Data	No Data	No Data	No Data	No Data
Apr-04	59,000	No Data	No Data	No Data	No Data	No Data
May-04	156,000	No Data	No Data	No Data	No Data	No Data
Jun-04	87,000	No Data	No Data	No Data	No Data	No Data
Jul-04	42,000	No Data	No Data	No Data	No Data	No Data
Aug-04	50,000	No Data	No Data	No Data	No Data	No Data
Sep-04	87,000	No Data	No Data	No Data	No Data	No Data
Oct-04	59,000	No Data	No Data	No Data	No Data	No Data
Nov-04	N/A	No Data	No Data	No Data	No Data	No Data
Dec-04	N/A	No Data	No Data	No Data	No Data	No Data
Jan-05	N/A	No Data	No Data	No Data	No Data	No Data
Feb-05	N/A	No Data	No Data	No Data	No Data	No Data
Mar-05	N/A	No Data	No Data	No Data	No Data	No Data
Apr-05	N/A	No Data	No Data	No Data	No Data	No Data
May-05	N/A	No Data	No Data	No Data	No Data	No Data
Jun-05	N/A	No Data	No Data	No Data	No Data	No Data
Jul-05	N/A	No Data	No Data	No Data	No Data	No Data
Aug-05	N/A	No Data	No Data	No Data	No Data	No Data
Sep-05	N/A	No Data	No Data	No Data	No Data	No Data
Oct-05	N/A	No Data	No Data	No Data	No Data	No Data
Nov-05	N/A	No Data	No Data	No Data	No Data	No Data
Dec-05	N/A	No Data	No Data	No Data	No Data	No Data
Jan-06	N/A	No Data	No Data	No Data	No Data	No Data
Feb-06	N/A	No Data	No Data	No Data	No Data	No Data
Mar-06	N/A	No Data	No Data	No Data	No Data	No Data
Apr-06	N/A	No Data	No Data	No Data	No Data	No Data
May-06	N/A	No Data	No Data	No Data	No Data	No Data
Jun-06	N/A	No Data	No Data	No Data	No Data	No Data
Jul-06	N/A	No Data	No Data	No Data	No Data	No Data
Aug-06	N/A	No Data	No Data	No Data	No Data	No Data
Sep-06	N/A	No Data	No Data	No Data	No Data	No Data
Oct-06	N/A	No Data	No Data	No Data	No Data	No Data
Nov-06	144,000	No Data	No Data	No Data	No Data	No Data
Dec-06	132,000	No Data	No Data	No Data	No Data	No Data
Jan-07	109,000	No Data	No Data	No Data	No Data	No Data
Feb-07	68,000	No Data	No Data	No Data	No Data	No Data
Mar-07	87,000	No Data	No Data	No Data	No Data	No Data
Apr-07	87,000	No Data	No Data	No Data	No Data	No Data
May-07	156,000	No Data	No Data	No Data	No Data	No Data
Jun-07	182,000	No Data	No Data	No Data	No Data	No Data

Table C-5. Nutrients and Flow Data from Philipsburg Wastewater Treatment Plant Discharge Monitoring Reports

Date	Effluent Rate (gal/day)	Nitrate+ Nitrite (as N) (mg/L)	Total Ammonia (as N) (mg/L)	Total Kjeldahl Nitrogen (as N) (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
Jul-07	34,000	No Data	No Data	No Data	No Data	No Data
Aug-07	50,000	0.16	5.16	5.74	5.90	2.20
Sep-07	87,000	0.062	5.23	6.96	6.97	3.02
Oct-07	98,000	0.084	10.4	11.9	11.98	2.74
Nov-07	120,000	0.154	10.8	8.16	8.31	0.74
Dec-07	109,000	0.174	8.93	11.6	11.77	2.19
Jan-08	77,000	0.06	0.08	15	15.06	2.91
Feb-08	68,000	<0.01	9.71	19.5	19.50	3.50
Mar-08	87,000	0.02	17.5	23.8	23.82	2.93
Apr-08	98,000	0.575	10.2	15	15.58	19.10
May-08	87,000	0.186	5.74	12.6	12.79	2.84
Jun-08	196,000	0.095	2.75	9.82	9.92	9.73
Jul-08	87,000	<0.01	0.5	2.03	2.03	3.77
Aug-08	59,000	0.148	2.32	2.11	2.26	9.61
Sep-08	132,000	0.173	6.99	7.53	7.70	10.60
Oct-08	98,000	0.55	2.18	4.1	4.65	1.94
Nov-08	120,000	0.746	4.8	7.42	8.17	1.24
Dec-08	120,000	0.077	6.52	6.48	6.56	1.67
Jan-09	87,000	0.017	10.2	14.5	14.52	3.28
Feb-09	87,000	0.048	9.3	10.3	10.35	4.68
Mar-09	68,000	0.054	6.88	14.9	14.95	2.26
Apr-09	50,000	0.332	6.41	13.3	13.63	2.29
May-09	50,000	0.397	0.63	5.63	6.03	1.87
Jun-09	120,000	0.013	6.07	8.84	8.85	2.62
Jul-09	68,000	0.012	9.42	14.7	14.71	3.32
Aug-09	27,000	0.091	1.09	6.18	6.27	2.28
Sep-09	59,000	0.304	1.67	5.77	6.07	2.82
Oct-09	120,000	0.179	5.31	7.81	7.99	3.06
Nov-09	34,000	0.79	2.9	6.79	7.58	1.87
Dec-09	34,000	0.297	3.78	6.25	6.55	3.03
Jan-10	27,000	0.653	2.21	7.62	8.27	3.00
Feb-10	42,000	0.003	10.4	17.6	17.60	4.34
Mar-10	27,000	0.004	11.3	23.6	23.60	3.81
Apr-10	14,000	0.219	5.9	12.2	12.42	2.20
May-10	15,000	0.27	1.17	4.52	4.79	1.99
Jun-10	120,000	0.198	5.68	9.88	10.10	3.58
Jul-10	50,000	0.149	9.09	12.5	12.65	3.51
Aug-10	59,000	0.46	1.57	7.25	7.71	1.50
Sep-10	68,000	0.332	1.09	2.97	3.30	1.73
Oct-10	90,000	0.204	0.9	2.51	2.71	2.38
Nov-10	70,000	0.131	0.48	2.28	2.41	1.90
Dec-10	70,000	0.003	2	10.1	10.1	2.50
Jan-11	70,000	0.003	7.01	10.2	10.2	2.22
Feb-11	70,000	0.003	5.08	5.99	5.99	2.11
Mar-11	50,000	0.017	12.3	14.3	14.32	2.58

Table C-5. Nutrients and Flow Data from Philipsburg Wastewater Treatment Plant Discharge Monitoring Reports

Date	Effluent Rate (gal/day)	Nitrate+ Nitrite (as N) (mg/L)	Total Ammonia (as N) (mg/L)	Total Kjeldahl Nitrogen (as N) (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
Apr-11	40,000	0.086	8.57	9.4	9.49	2.24
May-11	120,000	0.241	1.22	4.25	4.49	1.89
Jun-11	310,000	0.016	5.96	9.01	9.03	2.05
Jul-11	280,000	0.324	4.83	6.06	6.38	2.25
Aug-11	10,000	0.135	0.927	1.73	1.87	1.06
Sep-11	130,000	0.04	0.413	1.81	1.85	1.93
Oct-11	100,000	0.04	2.39	4.59	4.63	2.17
Nov-11	80,000	0.022	5.78	7.36	7.39	2.59
Dec-11	90,000	0.12	6.85	9.51	9.63	2.71
Jan-12	90,000	0.008	11.3	13.5	13.51	3.22
Feb-12	90,000	0.097	11	19.3	19.4	2.83
Mar-12	90,000	0.012	8.06	12.9	20.97	2.02
Apr-12	40,000	<0.01	4.08	5.29	5.29	3.73
May-12	50,000	0.089	0.469	2.45	3.81	1.45
Jun-12	470,000	0.68	0.826	3.11	3.94	2.13
Jul-12	210,000	<0.01	2.88	10	12.88	0.82
Aug-12	120,000	0.007	4.38	8.95	13.34	2.58
Sep-12	270,000	0.277	1.37	3.09	7.14	2.40

N/A – Measured effluent rate unreliable during this month

APPENDIX D – REGULATORY FRAMEWORK AND REFERENCE CONDITION APPROACH

This appendix presents details about applicable Montana Water Quality Standards (WQS) and the general and statistical methods used for development of reference conditions.

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ACRONYMS

Acronym	Definition
ARM	Administrative Rules of Montana
BER	Board of Environmental Review (Montana)
CWA	Clean Water Act
DEQ	Department of Environmental Quality (Montana)
EPA	Environmental Protection Agency (U.S.)
MCA	Montana Code Annotated
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TPA	TMDL Planning Area
TSS	Total Suspended Solids
UAA	Use Attainability Analysis
WQA	Water Quality Act
WQS	Water Quality Standards

D1.0 TOTAL MAXIMUM DAILY LOAD DEVELOPMENT REQUIREMENTS

Section 303(d) of the federal Clean Water Act (CWA) and the Montana Water Quality Act (WQA) (Section 75-5-703) requires development of total maximum daily loads (TMDL) for impaired waterbodies that do not meet Montana Water Quality Standards (WQS). Although waterbodies can become impaired from nonpollutant (e.g., low flow alterations and habitat degradation) and pollutants (e.g., nutrients, sediment, metals, pathogens, and temperature), the CWA and Montana state law (75-5-703) require TMDL development only for impaired waters with pollutant causes. Section 303(d) also requires states to submit a list of impaired waterbodies to the U.S. Environmental Protection Agency (EPA) every two years. Prior to 2004, EPA and the Montana Department of Environmental Quality (DEQ) referred to this list simply as the 303(d) list.

Since 2004, EPA has requested that states combine the 303(d) list with the 305(b) report containing an assessment of Montana's water quality and its water quality programs. EPA refers to this new combined 303(d)/305(b) report as the Integrated Water Quality Report. The 303(d) list also includes identification of the probable cause(s) of the water quality impairment (e.g., pollutants such as metals, nutrients, sediment, pathogens or temperature), and the suspected source(s) of the pollutants of concern (e.g., various land-use activities). State law (Montana Code Annotated [MCA] 75-5-702) identifies that a sufficient credible data methodology for determining the impairment status of each waterbody is used for consistency. The impairment status determination methodology is described in Section 4.0 of Montana's Water Quality Integrated Report (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012).

Under Montana state law, an "impaired waterbody" is defined as a waterbody or stream segment for which sufficient credible data show that the waterbody or stream segment is failing to achieve compliance with applicable WQS (Montana WQA; Section 75-5-103(11)). A "threatened waterbody" is defined as a waterbody or stream segment for which sufficient credible data and calculated increases in loads show that the waterbody or stream segment is fully supporting its designated uses, but threatened for a particular designated use because of either (a) proposed sources that are not subject to pollution prevention or control actions required by a discharge permit, the nondegradation provisions, or reasonable land, soil, and water conservation practices or (b) documented adverse pollution trends (Montana WQA; Section 75-5-103(31)). State law and Section 303(d) of the CWA require states to develop all necessary TMDLs for impaired or threatened waterbodies. There are no threatened waterbodies within the Flint TMDL Planning Area (TPA).

A TMDL is a pollutant budget for a waterbody identifying the maximum amount of the pollutant that a waterbody can assimilate without causing applicable WQS to be exceeded (violated). TMDLs are often expressed in terms of an amount, or load, of a particular pollutant (expressed in units of mass per time such as pounds per day). TMDLs must account for loads/impacts from point and nonpoint sources in addition to natural background sources and must incorporate a margin of safety and consider influences of seasonality on analysis and compliance with WQS. **Section 4.0** of the main document provides a description of the components of a TMDL.

To satisfy the federal CWA and Montana state law, TMDLs are developed for each waterbody-pollutant combination identified on Montana's 303(d) list of impaired or threatened waters, and are often presented within the context of a water quality restoration or protection plan. State law (Administrative Rules of Montana [ARM] 75-5-703(8)) also directs DEQ to "…support a voluntary program of reasonable land, soil, and water conservation practices to achieve compliance with water quality standards for nonpoint source activities for waterbodies that are subject to a TMDL…" This is an important directive that is reflected in the overall TMDL development and implementation strategy within this plan. It is important to note that water quality protection measures are not considered voluntary where such measures are already a requirement under existing federal, state, or local regulations.

D2.0 Applicable Water Quality Standards

WQS include the uses designated for a waterbody, the legally enforceable standards that ensure that the uses are supported, and a nondegradation policy that protects the high quality of a waterbody. The ultimate goal of this total maximum daily load document, once implemented, is to ensure that all designated beneficial uses are fully supported and all WQS are met. WQS form the basis for the targets described in **Section D2.1**. Nutrients pollutants are addressed in this framework water quality improvement plan. This section provides a summary of the applicable WQS for nutrients.

D2.1 Classification and Beneficial Uses

Classification is the assignment (designation) of a single or group of uses to a waterbody based on the potential of the waterbody to support those uses. Designated uses or beneficial uses are simple narrative descriptions of water quality expectations or water quality goals. There are a variety of "uses" of state waters including growth and propagation of fish and associated aquatic life; drinking water; agriculture; industrial supply; and recreation and wildlife. The Montana WQA directs the Board of Environmental Review (BER) (i.e., the state) to establish a classification system for all waters of the state that includes their present (when the Act was originally written) and future most beneficial uses (ARM 17.30.607-616) and to adopt standards to protect those uses (ARM 17.30.620-670).

Montana, unlike many other states, uses a watershed-based classification system, with some specific exceptions. As a result, *all* waters of the state are classified and have designated uses and supporting standards. All classifications have multiple uses and in only one case (A-Closed) is a specific use (drinking water) given preference over the other designated uses. Some waters may not actually be used for a specific designated use, for example as a public drinking water supply; however, the quality of that waterbody must be maintained suitable for that designated use. When natural conditions limit or preclude a designated use, permitted point source discharges or nonpoint source activities or pollutant discharges must not make the natural conditions worse.

Modification of classifications or standards that would lower a water's classification or a standard (i.e., B-1 to a B-3), or removal of a designated use because of natural conditions, can only occur if the water was originally misclassified. All such modifications must be approved by the BER, and are undertaken via a Use Attainability Analysis (UAA) that must meet EPA requirements (40 Code of Federal Regulations 131.10(g), (h) and (j)). The UAA and findings presented to the BER during rulemaking must prove that the modification is correct and all existing uses are supported. An existing use cannot be removed or made less stringent.

All nutrients impaired streams within the Flint TPA are classified as B-1. Descriptions of Montana's surface water classifications and designated beneficial uses are presented in **Table D2-1**.

Table D2-1. Montana Surface Water Classifications and Designated Beneficial Uses

Classification	Designated Uses
A-CLOSED CLASSIFICATION:	Waters classified A-Closed are to be maintained suitable for drinking, culinary and food processing purposes after simple disinfection
A-1 CLASSIFICATION:	Waters classified A-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment for removal of naturally present impurities. A-1 waters must be maintained suitable for bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B-1 CLASSIFICATION:	Waters classified B-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B-2 CLASSIFICATION:	Waters classified B-2 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B-3 CLASSIFICATION:	Waters classified B-3 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of nonsalmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-1 CLASSIFICATION:	Waters classified C-1 are to be maintained suitable for bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-2 CLASSIFICATION:	Waters classified C-2 are to be maintained suitable for bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-3 CLASSIFICATION:	Waters classified C-3 are to be maintained suitable for bathing, swimming and recreation; growth and propagation of nonsalmonid fishes and associated aquatic life, waterfowl and furbearers. The quality of these waters is naturally marginal for drinking, culinary and food processing purposes, agriculture and industrial water supply.
I CLASSIFICATION:	The goal of the State of Montana is to have these waters fully support the following uses: drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

D2.2 STANDARDS

In addition to the use classifications described above, Montana's WQS include numeric and narrative criteria as well as a nondegradation policy.

Numeric Standards

Numeric surface WQS have been developed for many parameters to protect human health and aquatic life. These standards are in the Department Circular DEQ-7 (Montana Department of Environmental Quality, 2012). The numeric human health standards have been developed for parameters determined to be toxic, carcinogenic, or harmful and have been established at levels to be protective of long-term (i.e., lifelong) exposures as well as through direct contact such as swimming.

The numeric aquatic life standards include chronic and acute values that are based on extensive laboratory studies including a wide variety of potentially affected species, a variety of life stages and durations of exposure. Chronic aquatic life standards are protective of long-term exposure to a parameter. The protection afforded by the chronic standards includes detrimental effects to reproduction, early life stage survival and growth rates. In most cases the chronic standard is more stringent than the corresponding acute standard. Acute aquatic life standards are protective of short-term exposures to a parameter and are not to be exceeded.

Narrative Standards
Narrative standards have been developed for substances or conditions for which sufficient information does not exist to develop specific numeric standards. The term "Narrative Standards" commonly refers to the General Prohibitions in ARM 17.30.637 and other descriptive portions of the surface WQS. The General Prohibitions are also called the "free from" standards; that is, the surface waters of the state must be free from substances attributable to discharges, including thermal pollution, that impair the beneficial uses of a waterbody. Uses may be impaired by toxic or harmful conditions (from one or a combination of parameters) or conditions that produce undesirable aquatic life. Undesirable aquatic life includes bacteria, fungi, and algae.

The standards applicable to the list of pollutants addressed in the Flint TPA are summarized below. In addition to the standards below, the beneficial-use support standard for B-1 streams, as defined above, can apply to other conditions, often linked to nonpollutants, limiting aquatic life. These other conditions can include effects from chlorophyll-*a*, dewatering/flow alterations, and effects from habitat modifications.

Nondegradation Policy
High quality waters are afforded an additional level of protection by the nondegradation policy as stated in statute (75-5-303 MCA) and administrative rules (ARM 17.30.701 et seq.). Changes in water quality must be "non-significant", or an authorization to degrade must be granted by DEQ. However, under no circumstance may standards be exceeded. It is important to note that waters that meet or are of better quality than a standard are high quality for that parameter, and nondegradation policies apply to new or increased discharges to that waterbody.

D2.2.1 Nutrient Standards

The narrative standards applicable to nutrients in Montana are contained in the General Prohibitions of the surface WQS (ARM 17.30.637 et seq.). The prohibition against the creation of "*conditions which produce undesirable aquatic life*" is generally the most relevant to nutrients. Undesirable aquatic life includes bacteria, fungi, and algae. Montana has recently developed draft nutrient criteria for total nitrogen (TN) and total phosphorus (TP) based on the level III ecoregion in which a stream is located (Suplee and Watson, 2013). In addition, Suplee et al. (2007), developed a target for nitrate (also known as nitrate+nitrite nitrogen or NO_2+NO_3) for the Middle Rockies Level III Ecoregion that provides an appropriate numeric translation of the applicable narrative nutrient water quality standard. For the Middle Rockies Level III Ecoregion and Flint Creek (Georgetown Lake outlet to 17ak boundary), draft water quality criteria for TN and TP and the target for nitrate are presented in **Table D2-2**. This target and the proposed criteria are growing season, or summer, values applied from July 1st through September 30th. Additionally, numeric human health standards exist for nitrogen (**Table D2-3**), but the narrative standard is most applicable to nutrients as the concentration in most waterbodies in Montana is well below the human health standard and the nutrients contribute to undesirable aquatic life at much lower concentrations than the human health standard.

Table D2-2. Nitrate Target and Proposed Numeric Nutrient and Criteria for the Middle Rockies Ecoregion and Flint Creek (Georgetown Lake outlet to 17ak boundary)

Parameter	Middle Rockies Ecoregion Criteria/Target	Flint Creek, from Georgetown Lake outlet to the ecoregion 17ak boundary [1]
Nitrate (Nitrate+Nitrite) [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

[1] Values are only applicable to the specific portion of Flint Creek
[2] From Suplee et al., 2008
[3] From Suplee and Watson, 2012

Table D2-3. Human Health Standards for Nitrogen for the State of Montana

Parameter	Human Health Standard (µL)[1]
Nitrate as Nitrogen (NO_3-N)	10,000
Nitrite as Nitrogen (NO_2-N)	1,000
Nitrate plus Nitrite as N	10,000

[1] Maximum Allowable Concentration

D3.0 Reference Conditions

D3.1 Reference Condition Concept as Described in Montana's 2012 Water Quality Integrated Report

A number of Montana's narrative water standards require that water quality be compared to "naturally occurring," conditions. The state of Montana has defined naturally occurring as "conditions or materials present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil and water conservations practices have been applied" (ARM 17.30.602[19]). The ARM then define reasonable land, soil and water conservation practices as those that, in essence, completely protect all beneficial water uses (ARM 17.30.602[24]). Thus, human activities in a watershed are an integral component of the landscape, as long as those activities do not negatively impact the various beneficial uses of the water (drinking, recreation, fisheries, etc.). DEQ uses the reference condition concept to evaluate the difference between current water quality conditions and naturally occurring conditions.

The reference condition concept asserts that for any group of waterbodies there are relatively undisturbed examples that represent the natural biological, physical, and chemical integrity of a region. These examples, or reference sites, reflect a waterbody's greatest potential for water quality given historic land-use activities (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012) . All classes of waters are subject to the provision that there can be no increase above naturally occurring concentrations of sediment and settleable solids, oils, or floating solids sufficient to create a nuisance or render the water harmful, detrimental, or injurious. Since naturally occurring concentrations depend on site-specific factors, DEQ applies the reference condition concept and reference sites to assess compliance with such narrative standards.

Waterbodies used to determine reference condition are not necessarily pristine or perfectly suited to giving the best possible support to all possible beneficial uses. Reference condition also does not reflect an effort to turn the clock back to conditions that may have existed before human settlement, but is intended to accommodate natural variations in biological communities, water chemistry, etc. due to climate, bedrock, soils, hydrology, and other natural physiochemical differences. The intention is to differentiate between natural conditions and widespread or significant alterations of biology, chemistry, or hydrogeomorphology due to human activity. Therefore, reference conditions should reflect minimum impacts from human activities. It attempts to identify the potential condition that could be attained (given historical land use) by the application of reasonable land, soil, and water conservation practices. DEQ realizes that pre-settlement water quality conditions usually are not attainable.

Comparison of conditions in a waterbody to reference waterbody conditions must be made during similar season and/or hydrologic conditions for both waters. For example, the Total Suspended Solids (TSS) of a stream at base flow during the summer should not be compared to the TSS of reference condition that would occur during a runoff event in the spring. In addition, a comparison should not be made to the lowest or highest TSS values of a reference site, which represent the outer boundaries of reference conditions.

The following methods may be used to determine reference conditions:

Primary Approach
Comparing conditions in a waterbody to baseline data from minimally impaired waterbodies that are in a nearby watershed or in the same region having similar geology, hydrology, morphology, and/or riparian habitat.

Evaluating historical data relating to condition of the waterbody in the past.

Comparing conditions in a waterbody to conditions in another portion of the same waterbody, such as an unimpaired segment of the same stream.

Secondary Approach
Reviewing literature (e.g., a review of studies of fish populations, etc., that were conducted on similar waterbodies that are least impaired.

Seeking expert opinion (e.g., expert opinion from a regional fisheries biologist who has a good understanding of the waterbody's fisheries health or potential).

Applying quantitative modeling (e.g., applying sediment transport models to determine how much sediment is entering a stream based on land-use information, etc.).

DEQ uses the primary approach for determining reference condition if adequate regional reference data are available and uses the secondary approach to estimate reference condition when there is no regional data. DEQ often uses more than one approach to determine reference condition, especially when regional reference condition data are sparse or nonexistent.

D4.0 References

Montana Department of Environmental Quality. 2012. 2012 Circular DEQ-7. Helena, MT: Montana Department of Environmental Quality. http://deq.mt.gov/wqinfo/Circulars.mcpx. Accessed 1/15/2013.

Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau. 2012. Montana 2012 Final Water Quality Integrated Report. Helena, MT: Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau. WQPBIMTSR-004f.

Suplee, Michael W., Arun Varghese, and Joshua Cleland. 2007. Developing Nutrient Criteria for Streams: An Evaluation of the Frequency Distribution Method. *Journal of the American Water Resources Association.* 43(2): 453-472.

Suplee, Michael W. and Vicki Watson. 2013. Scientific and Technical Basis of the Numeric Nutrient Criteria for Montana's Wadeable Streams and Rivers—Update 1. Helena, MT: Montana Department of Environmental Quality.

APPENDIX E – FLINT CREEK WATERSHED NUTRIENT ASSESSMENT

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ACRONYMS

Acronym	Definition
AMSL	Above Mean Sea Level
BMP	Best Management Practices
BOD	Biochemical Oxygen Demand
DEQ	Department of Environmental Quality (Montana)
DNRC	Department of Natural Resources & Conservation (Montana)
FERC	Federal Energy Regulation Commission
GIS	Geographic Information System
GPS	Global Positioning System
GWIC	Groundwater Information Center
HRU	Hydrologic Response Units
MGWPCS	Montana Ground Water Pollution Control System
MPDES	Montana Pollutant Discharge Elimination System
msl	mean sea level
NHD	National Hydrography Dataset
NLCD	National Land Cover Dataset
NRCS	National Resources Conservation Service
SNOTEL	SNOw TELemetry
SWAT	Soil & Water Assessment Tool
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
USFS	United States Forest Service
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation

E1.0 INTRODUCTION

The Flint Creek watershed is located in southwestern Montana within the Clark Fork River watershed (**Figure E1-1**). Flint Creek and four tributaries are characterized as "water quality-limited" (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b) from nutrients impairments (**Table E1-1** and **Figure E1-2**). To satisfy the Montana Water Quality Act and the Federal Clean Water Act requirements, Total Maximum Daily Loads (TMDLs) must be developed for these waterbodies so they can support beneficial uses. The Montana Department of Environmental Quality (DEQ) has determined that a modeling approach is the most effective way to identify existing nonpoint source loads in the watershed, and to complete equitable allocations between those sources as part of the TMDL. Therefore, a Soil & Water Assessment Tool (SWAT) model has been prepared to estimate watershed-scale loadings of nutrients, and to calculate associated fate and transport in the stream channel network. DEQ used the SWAT for this project. The model period chosen was October 1, 1989 through September 30, 2010. This time period was chosen to coincide with available water quality datasets, and to provide a sufficiently long modeling time that incorporates enough natural climatic variability to better predict future hydrology under several management scenarios.

The results of the SWAT model are used for several TMDL planning purposes including: (1) evaluating baseline conditions in the watershed; (2) partitioning pollutant loadings between nonpoint sources; (3) allocating nutrients for TMDL development; (4) formulating water quality restoration plans; and (5) prescribing management and land-use scenario changes to meet TMDL objectives.

Table E1-1. Nutrients Water Quality Limited Stream Segments in the Flint Creek Watershed

Waterbody Name	Reach Segment	Reach Length (mi)	TMDL Developed[1]
Flint Creek (upper)[2]	MT76E003_011	28.1	TP
Flint Creek (lower)[3]	MT76E003_012	16.9	TN/TP
Douglas Creek (lower)	MT76E003_020	7.1	Nitrate /TP
Barnes Creek	MT76E003_070	8.9	Nitrate/TN/TP
Princeton Gulch	MT76E003_090	3.9	Nitrate
Smart Creek	MT76E003_110	11.6	TN/TP

[1] TN = Total Nitrogen, TP = Total Phosphorus
[2] Flint Creek (upper) extends from Georgetown Lake to confluence with Boulder Creek
[3] Flint Creek (lower) extends from confluence with Boulder Creek to the mouth at Clark Fork River

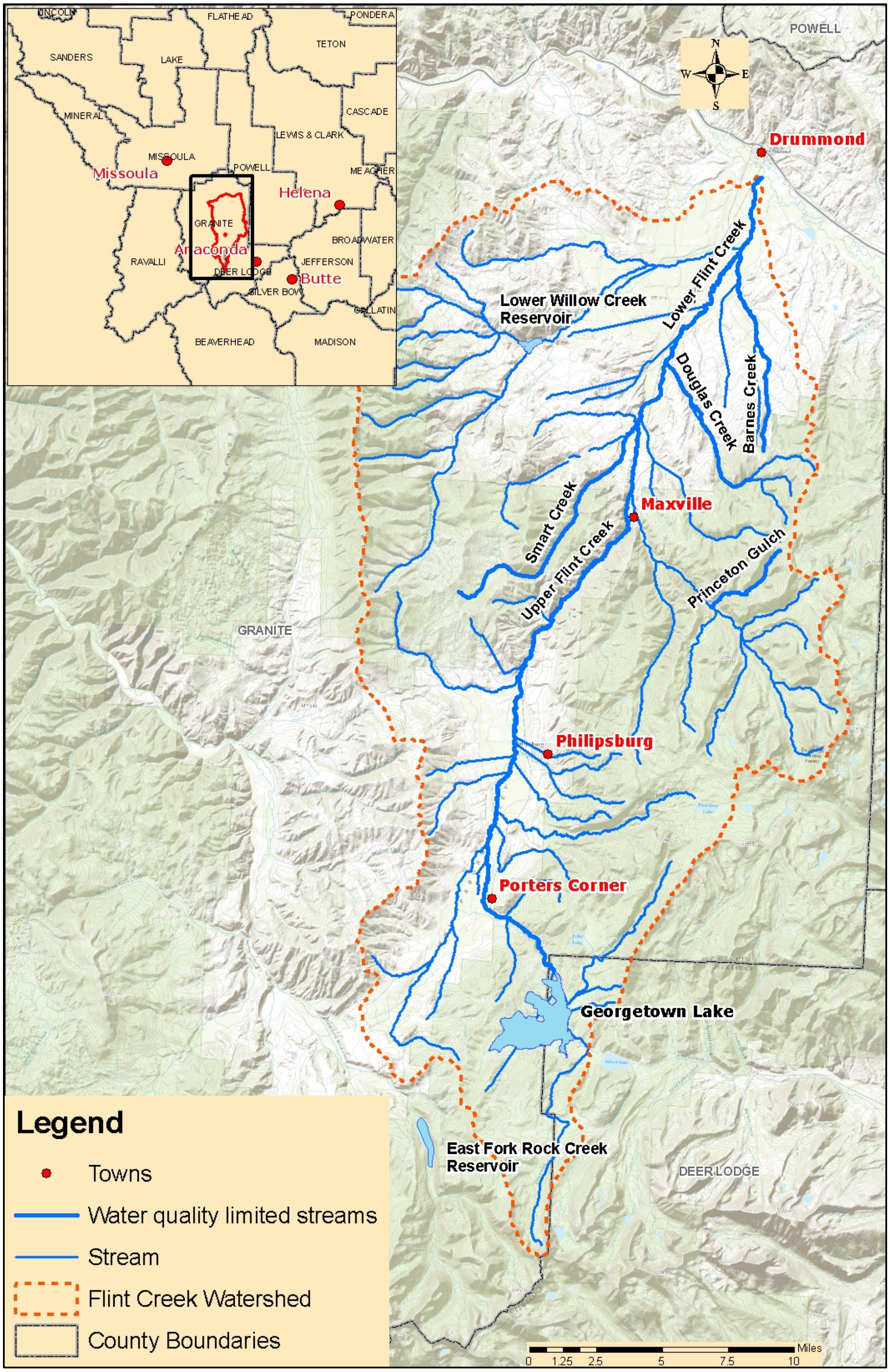

Figure E1-1. Location of the Flint Creek Watershed with 2010 Nutrient Water Quality Limited Stream Segments

Figure E1-2. The Flint Creek Watershed with 2012 Water Quality Limited Streams (303(d) Streams) Listed for Nutrients Impairments

E1.1 PRIOR STUDIES

There have been several prior studies specific to the Flint Creek watershed, all of which were reviewed for development of this model. These include:

- Georgetown Lake Clean Lakes Project (Garrett and Kahoe, 1984)
- Flint Creek Project Federal Energy Regulation Commission (FERC) No. 1473 Draft: Application to Surrender License (Montana Power Company, 1987)
- Flint Creek Return Flow Study (Voeller and Waren, 1997)
- Flint Creek Planning Area Watershed Characterization Report (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Source Water Protection Program, 2007)
- Flint Creek Watershed Sediment Assessment: Upland Sediment Assessment and Modeling and BMP Effectiveness and Percent Reduction Potential (Water & Environmental Technologies, 2010)
- Flint Creek TMDL Planning Area Nutrient Source Review - Task 1: Discrete Source Characterization (Houston Engineering, 2011a)
- Flint Creek TMDL Planning Area Nutrient Source Review - Task 2: Non-Discrete Source Characterization (Houston Engineering, 2011b)
- Flint Creek TMDL Planning Area – Unpaved Roads Assessment: Sediment Load Estimates and Potential Reductions (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2011)
- 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)

E1.2 NUTRIENTS CRITERIA IN MONTANA

Montana is currently governed by narrative nutrients criteria that requires surface waters to be free from municipal, industrial, and agricultural discharges that produce undesirable aquatic life [Administrative Rules of Montana 17.30.637(1)(e)]. Because narrative criteria are somewhat problematic for TMDL analysis, draft numeric criteria were used instead (Suplee et al., 2008; Suplee and Watson, 2013). Those applicable for the Flint Creek Watershed TMDL (e.g., the Middle Rockies Ecoregion) are shown in **Table E1-2** and **Figure E1-2**. These draft criteria are used as the target concentrations in management scenarios discussed in **Section E6.0**. DEQ anticipates these interim criteria will become final at or near their current concentrations by 2013. These criteria are applicable during the summer growing season which is defined as July 1 through September 30.

Table E1-2. Interim Nutrients Numeric Criteria (July 1–Sept 30) for the Flint Creek Watershed
(Suplee and Watson, 2013)

Constituent	Watershed Concentration[1]	Upper Flint Creek Concentration[2]
Total Nitrogen (TN)	≤ 0.30 mg/L	≤ 0.50 mg/L
Nitrate	≤ 0.10 mg/L	≤ 0.10 mg/L
Total Phosphorus (TP)	≤ 0.03 mg/L	≤ 0.072 mg/L

[1] Concentrations apply everywhere in the watershed except for Upper Flint Creek
[2] Upper Flint Creek for purposes of the water quality standards extends from the outlet of Georgetown Lake (the Flint Creek dam) to the northern end of the Philipsburg valley approximately 4.2 miles north of the town of Philipsburg (see **Figure E1-2**)

E2.0 DATA COMPILATION AND ASSESSMENT

A variety of climatic, hydraulic, water quality, land-use, and geospatial data was reviewed and evaluated to populate the SWAT model with site-specific information. The details are described below.

E2.1 WATERSHED DESCRIPTION

The Flint Creek watershed is located in southwestern Montana. It stretches from the continental divide south of Georgetown Lake to just south of Drummond (**Figure E1-1**). The watershed covers approximately 314,000 acres, and the continental divide runs along the southern tip. Flint Creek originates below Georgetown Lake and runs for 45 miles towards its confluence with the Clark Fork River near Drummond. Elevations in the watershed range from approximately 3,960 feet above mean sea level (AMSL) in the valley near Drummond to 9,848 feet AMSL at Mount Tiny along the southern boundary of the watershed.

The hydrology in the watershed is partially controlled via Flint Creek dam (which created Georgetown Lake in the late 1800s) and an inter-basin water transfer from the East Fork Rock Creek Reservoir. Management of the Flint Creek dam and East Fork Rock Creek Reservoir changes the natural hydrologic cycle in Flint Creek. Effects of the dam are visible in the United States Geological Survey (USGS) stream gage (Flint Creek near Southern Cross) that is less than 2 miles below the dam. Although less obvious than the upper USGS stream gage, effects of both the dam and the East Fork Rock Creek Reservoir are visible in the two stream gages on the lower Flint Creek at Maxville and near Drummond.

The Flint Creek dam was initially built for power generation, additional uses for irrigation and recreation evolved over time. For approximately the last 20 years it has not been used for power generation, but Granite County, the current dam owner, is preparing to begin power generation sometime in the near future. Part of the Federal Energy Regulatory Commission license (Federal Energy Regulating Commission, 2010) that controls operation of the dam includes several discharge requirements including a minimum flow of 30 cubic feet per second (cfs) from May 15 to September 15, and a minimum flow of 10 cfs at other times of the year to comply with an existing water rights decree. Some of the other requirements are maintaining the lake level within certain ranges, and capping maximum flows at 100 cfs except in times of emergencies. Discharge rates from the dam are not available, but the USGS gage located below the dam is used in the model to determine the hydrology in this upper portion of the watershed, and is described in **Section E2.5.5**.

The East Fork Rock Creek Reservoir is located in the Rock Creek watershed, which is near the southwest border of the Flint Creek watershed. Water is diverted into the Flint Creek watershed from the reservoir for irrigation use via a canal. The data and methods used to determine the amount of water diverted into the watershed from the East Fork Rock Creek Reservoir are described in **Section E2.5.5**.

A second dam that has only minor effects to the watershed hydrology is the Willow Creek dam located in the northern portion of the watershed. The data and methods used to determine the amount of water discharged from the Willow Creek dam are described in **Section E2.5.5**.

E2.2 CLIMATE

Climate in the Flint Creek watershed is inter-montane with distinct seasonality. Valleys tend to be moderately arid while mountainous regions are moderately wet. Annual average precipitation is estimated to range from under 12 inches near Drummond to over 40 inches in the mountains along the east side of the watershed (**Figure E2-1**). Seven weather stations were used in the SWAT model based on their distance to each sub-basin to distribute precipitation events across the watershed (**Table E2-1**). The eighth site in **Table E2-1**, Warm Springs SNOw TELemetry (or SNOTEL), located immediately east of the watershed may overestimate snowfall for its elevation as prevailing winds tend to deposit more snow east of topographic divides, therefore it was not used for estimating precipitation in the watershed. The maximum snow water equivalent generally occurs in April or May every year and comprises 47 to 60% of the total annual precipitation at four of the five the SNOTEL sites; at the Combination site, the snow water equivalent only comprises 24% of the total annual precipitation. The large amount of water contained as snow in the higher elevations creates a strong control on the stream hydrology, and will be discussed in **Section E2.3**

Maximum and minimum daily temperature values from all eight stations in **Table E2-1** were used to estimate daily temperatures across the watershed.

Table E2-1. Weather Station Data Used in the Flint Creek SWAT Model

Location	Station Type	Elevation (ft AMSL)	Average Annual Precipitation (in)	Average Annual Max Temp (F)	Average Annual Min Temp (F)	Avg. Max Snow Water Equiv. (in)
Time Period			**1989–2010**	**1989–2010**	**1989–2010**	**1971–2000**
Barker Lakes	SNOTEL[(1)]	8,248	34.4	44.2	25.2	16.2
Black Pine	SNOTEL[(1)]	7,212	25.5	46.6	29.9	12.8
Combination	SNOTEL[(1)]	5,601	20.5	52.0	28.6	4.9
Peterson Meadows	SNOTEL[(1)]	7,199	24.3	47.7	24.5	11.4
Warm Springs	SNOTEL[(1)]	7,799	41.0	44.6	25.2	24.2
Drummond Aviation	NCDC[(2)]	4,000	11.7	58.1	28.0	No data
Georgetown Lake	NCDC[(2)]	6,470	16.5	49.6	27.9	No data
Philipsburg Ranger Station	NCDC[(2)]	5,269	15.7	55.9	28.0	No data

(1) SNOTEL is a network of sensors operated by the Natural Resources Conservation Service to collect and disseminate mountain snowpack and climate data
(2) NCDC is the National Climatic Data Center, which collects and disseminates climate data

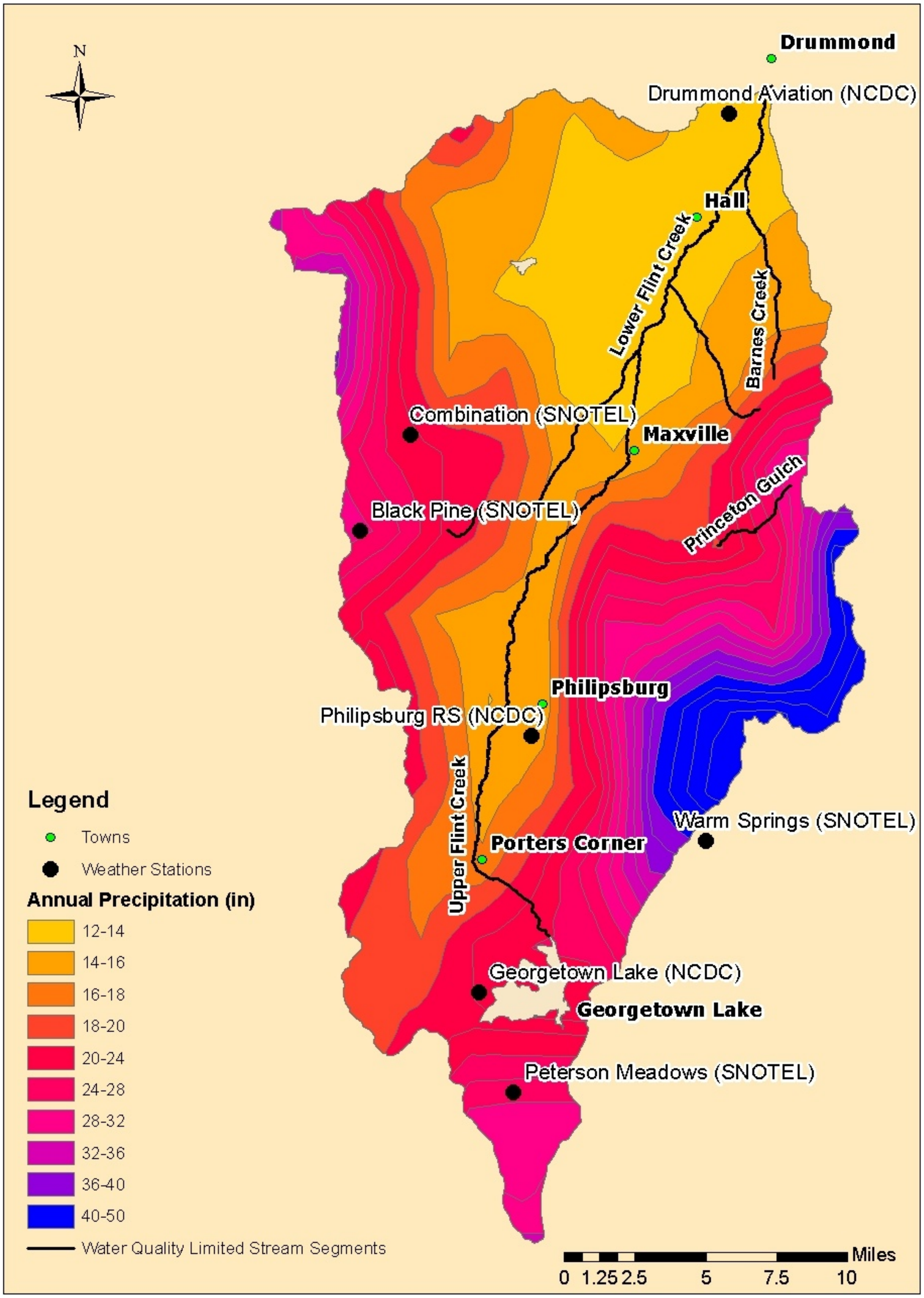

Figure E2-1. Precipitation Distribution and Location of Weather Stations Used in the Flint Creek SWAT Model

Daily wind speed, solar radiation, and relative humidity were obtained from various sources inside the watershed where available, and outside the watershed when there were no data available inside the watershed. Solar data were collected inside the watershed from Drummond Aviation (National Solar Radiation database) and from Philipsburg [Remote Automatic Weather Stations database]. Missing records in the solar radiation data were filled in through regression with two stations outside the basin, the Missoula Airport [Northern Research Station database] and Deer Lodge (AgriMet database). Humidity data were collected from the Philipsburg Remote Automatic Weather Stations site. Missing records in the humidity data were filled in through regression with the Missoula Airport Northern Research Station site and the Deer Lodge AgriMet site. Wind data were collected from the Philipsburg Remote Automatic Weather Stations site. Long periods of missing wind records (1989 through 2000 data were not available) could not be filled through regression with other stations (Missoula Airport or Deer Lodge) as the coefficient of determination (r^2) was very low between the sites. Therefore, a daily average of the 2001–2010 wind data from the Philipsburg site was used to populate the model from 1989 through 2000.

E2.3 Streamflow Hydrology

There are four active USGS streamflow gaging stations in the Flint Creek watershed with sufficient datasets within the modeling period (**Table E2-2** and see **Figure E1-2**). There have been several other short-term gaging stations in the watershed monitored by the USGS and the Montana Department of Natural Resources & Conservation (DNRC) (Voeller and Waren, 1997), but those stations did not have sufficient data for use in calibrating the model.

Table E2-2. USGS Streamflow Gaging Station Information (McCarthy et al., 2004)

USGS Station Name	Period of Record	Drainage Area (sq. miles)	Mean Annual Flow (cfs)	Mean High Monthly Flow for June (cfs)	Mean Low Monthly Flow (cfs) [month]
Flint Creek near Drummond	1990–present	490	125	280	49 [Aug]
Boulder Creek at Maxville	1939–present	71.3	45	174	18 [Feb/Mar/Sept]
Flint Creek at Maxville	1941–present	208	97	188	54 [Jan]
Flint Creek near Southern Cross	1940–1998 and 2000–present	52.6	30	57	19 [Jan]

The typical hydrograph for this type of snowmelt-controlled watershed consists of spring snowmelt runoff beginning in mid to late March (or April for higher elevation basins), peaking in June and then declining rapidly in July and August towards base flow. However, due to dams, diversions, irrigation withdrawals, and irrigation return flows only one of the USGS gages in this watershed (Boulder Creek at Maxville) has a typical hydrograph (**Figure E2-2**). The Flint Creek near Drummond gage shows the effects of irrigation withdrawals in late summer which causes the annual low flows at this gage to occur in late summer rather than in winter. At the same gage the streamflows rise from late summer through mid-October due to irrigation return flows and the reduction of irrigation. This atypical hydrograph pattern due to irrigation withdrawals and returns has been described in other Montana valleys (Kendy and Bredehoeft, 2006). The Flint Creek at Maxville gage shows a slightly more typical hydrograph, but still shows effects of upstream irrigation return flows with an earlier than anticipated flattening of the hydrograph slope during the irrigation season. The Flint Creek at Southern Cross gage shows a late-summer rising hydrograph, similar to the Flint Creek at Maxville gage, most likely due to increased dam releases. The Flint Creek at Southern Cross gage is controlled by releases from Flint Creek dam with only a small spring time peak as the dam has minimum (30 cfs) and maximum (100 cfs) discharge limitations during the summer growing season as described earlier. The SWAT model was less accurate predicting streamflow at gages heavily influenced by human activities, as discussed in **Section E4.4**. These less accurate predictions are primarily due to a lack of available information regarding irrigation schedules, irrigation diversions, and difficulty estimating return flow rates in the groundwater.

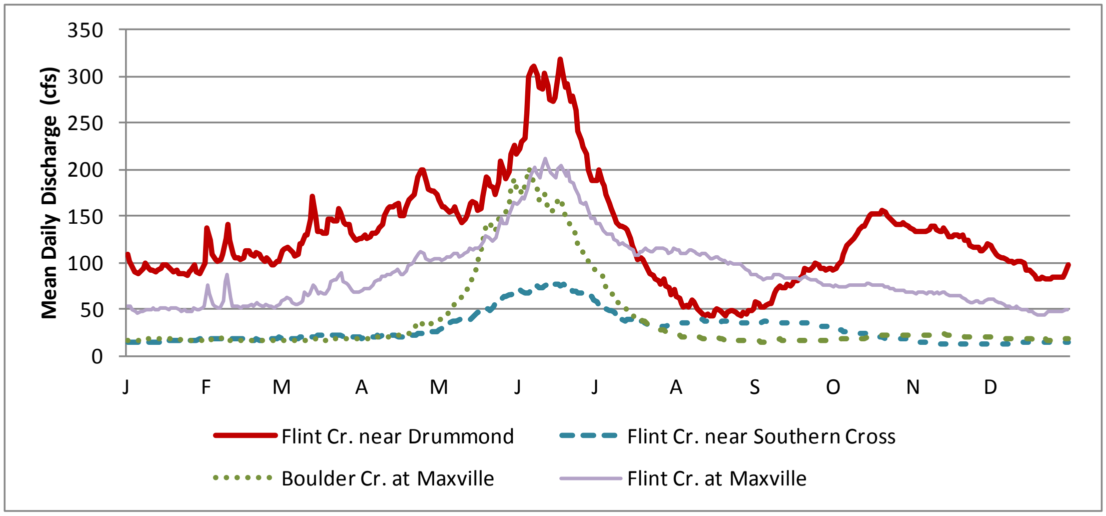

Figure E2-2. Average Annual Streamflow Hydrographs at USGS Gages (1990–2010)

The Flint Creek watershed lies within the Upper Clark Fork basin that is closed to new surface water rights appropriations (with a few limited exceptions) per a legislative closure on April 14, 1995 (Montana Department of Natural Resources and Conservation, 2003). The closure is due to over-appropriation as there is not always sufficient water in the watershed to satisfy every water right. There are approximately 1,400 recorded surface water diversions in the basin; only two of the largest ones have available data associated with them and are the only ones specifically accounted for in the model with location-specific diversions to a canal. However, based on DNRC mapped irrigation units (Buck, 1959) the SWAT model is able to indirectly account for diversions by withdrawing water from the representative stream within the sub-basin that the irrigated area is in. In some cases, a diversion for irrigation may be located in an upstream sub-basin, which could create a minor error in simulated streamflow if a hydrology calibration point is located between the actual diversion and the sub-basin that the irrigated land is located. A detailed discussion of how irrigation was simulated in the model is included in **Section E2.5.1.1**.

E2.4 Water Quality

Streamflow and water quality data are required components for sediment and nutrients model calibration. Those available to DEQ in 2011 were used in the modeling process. Data were reviewed with particular focus on recent data (1990 through 2010) for model construction and development. These data are considered most relevant as they are coincident with the land cover that will be used for the model (the 2001 National Land Cover Dataset [NLCD]). Key data included the following:

- Flow
- Sediment
- Nutrients
    - o Total Phosphorus (TP)
    - o Total Nitrogen (TN)

- Nitrate+Nitrite (NO_3+NO_2)

Instream data for model calibration were acquired from several sources including the USGS, Philipsburg Department of Public Works, Tri-State Water Quality Council, the University of Montana, Missoula Valley Local Water Quality District, Craig Stafford, and the DEQ. Other than streamflow at the four USGS gages, data collection was sporadic in the watershed. The longest and most regular water quality data were collected monthly at three sites on Flint Creek from July 2005 through October 2009 by the Philipsburg Department of Public Works (**Table E2-3**).

Table E2-3. Available Data for Calibration and Validation of SWAT Model in the Flint Creek Watershed

Location [Model Sub-Basin]	Parameter	Period of Record	Sampling Frequency	Number of Samples
USGS gage – Flint Creek near Drummond [2]	Flow Sediment Nutrients Nutrients	1990–1991 1985–2004 1990–1991 1998–2002	Daily Seasonal Monthly Monthly Seasonal Monthly	4,201 139 23 38
USGS gage – Boulder Creek at Maxville [19]	Flow Sediment Nutrients	1939–2010 2007–2009 2007–2009	Daily Seasonal Intermittent Seasonal Intermittent	4,901 5 5
USGS gage – Flint Creek at Maxville [24]	Flow Sediment Nutrients	1941–2010 1991–92/2007–08 2007–2009	Daily Intermittent Seasonal Intermittent	4,870 15 5
Flint Creek above and below Philipsburg Wastewater Discharge [32]	Sediment Nutrients	2007–2009 2005–2009	Seasonal Intermittent Monthly	5 59
USGS gage – Flint Creek near Southern Cross [38]	Flow Sediment Nutrients	1940–2010 2007–2009 2005–2009	Daily/Seasonal Daily Seasonal Intermittent Monthly	5,725 5 52
North Fork Flint Creek [40]	Sediment Nutrients	2009–2010 2009–2010	Monthly Monthly	15 15
Seven sites on Flint Creek [multiple]	Sediment Nutrients	2007–2009 2007–2009	Seasonal Intermittent Seasonal Intermittent	4–5 4–5
Barnes Ck; Boulder Ck; Douglass Cr; Lower Willow Cr; Princeton Gulch; Smart Cr; Trout Cr [multiple]	Sediment Nutrients	2007–2009 2007–2009	Seasonal Intermittent Seasonal Intermittent	4–5 4–5

The calibration point nearest the mouth of Flint Creek (Flint Creek near Drummond) is approximately 1.7 miles upstream from the mouth of Flint Creek. The mouth of Flint Creek only has 6 months of daily streamflow measurements and five water quality samples, so the upstream site with better data was used as the final downstream calibration point in the model. However, the model boundary does extend completely to the mouth of Flint Creek.

Where the sampling frequency is described as seasonal, the samples collection times are predominately during the summer season or the late spring/early fall seasons. Much of the nutrients and sediment data was collected during the summer which is the time of year that nutrients have a greater effect on water quality.

Numerous additional sites on Flint Creek and its tributaries have water quality data, but the amount of data at those sites was typically five dates or less over 1- to 3-year periods and was determined to not be sufficient for numerical calibration as is described in **Sections E4.6** and **E4.7**.

Groundwater monitoring was not conducted for the TMDL development. However, the SWAT model requires the user to specify a background groundwater phosphorus concentration. The concentration used in the model, 0.01 mg/L, is based on groundwater well data from the Montana Bureau of Mines and Geology well database, the Groundwater Information Center (GWIC). That database contained orthophosphorus sample data from 54 wells. Forty-eight of those wells reported orthophosphorus concentrations below the detection limit, which ranged from 0.05 to 0.25 mg/L. Assuming that all those samples below the detection limit are equal to zero, the average of all 54 wells is 0.01 mg/L. Therefore, the groundwater phosphorus concentration in the model was set at 0.01 mg/L. Although background phosphorus levels vary from region to region this value for background phosphorus is consistent with other published values. One study showed the average background orthophosphorus (also referred to as mineral phosphorus) at 0.02 mg/L in 47 wells across the country in undeveloped areas (Fuhrer et al., 1999). A local study in the Kalispell area sampled 10 residential wells and 4 monitoring wells that showed mean Total Phosphorus (TP) and orthophosphorus concentrations were 0.008 and 0.003 mg/L, respectively (Tappenbeck and Ellis, 2010).

E2.5 LAND USE

Land uses in the model were based on the NLCD 2001 dataset (**Table E2-4**) but were modified where necessary. Estimations of land uses and land-use practices are described in the following sub-sections, and are also summarized for easier reference in **Attachment EA**.

Eighty-seven percent of the watershed is categorized as either forest or rangeland. Another 10% is categorized as agriculture and livestock uses. The remaining 3% is categorized as water/wetlands and developed. The Hay/Pasture acreage is primarily comprised of alfalfa and alfalfa-hay mixes. The land listed as cultivated crop was significantly overestimated in the NLCD data; this was corrected in the SWAT model delineation and is discussed in the next section. Developed lands, particularly medium and high density, are increased in the final SWAT discretization land-use percentages due to the high growth rates near Georgetown Lake that were not captured in the 2001 NLCD. Each of the major land uses with temporal changes that may have occurred naturally or by human activity over the course of the modeling period is discussed in **Sections E2.5.1** through **E2.5.5**.

Table E2-4. Land Uses within the Flint Creek Watershed (2001 NLCD)

NLCD Land Use	Area (acres)	Watershed Area (%)
Cultivated Crops	16,422	5.23
Hay/Pasture	14,949	4.76
Evergreen Forest	166,921	53.12
Shrub/Scrub [Range - Brush]	53,575	17.05
Herbaceous [Range - Grass]	53,085	16.89
Deciduous Forest	16	0.01
Developed - Low Density/Open Space	4,209	1.34
Developed - Medium Density	53	0.02
Developed - High Density	5	<0.01
Open Water	3,353	1.07
Wetlands	1,516	0.48
Barren Land	118	0.04
Totals	**314,224**	**100.0%**

E2.5.1 Agriculture

Two datasets, the 2001 NLCD and the National Agricultural Statistics Service, were used to establish an estimate of typical crop production in the watershed. An average of the available National Agricultural Statistics Service Cropland Data Layer data from 2003 to 2009 was used in the analysis [**Attachment EB**]. The 2003–2009 National Agricultural Statistics Service data are published on a county basis, but because the Flint Creek watershed contains over 95% of the agricultural lands in Granite County (2001 NLCD), using the county values was determined to be an acceptable approximation. Over 96% of the crops in the watershed are hay, alfalfa and pasture, the remaining amount is used for spring wheat and barley. The amount of hay, alfalfa, pasture and other row crops was estimated from the 2001 NLCD and National Agricultural Statistics Service data to differentiate these land uses in SWAT because the irrigation, fertilizer and harvesting needs for each of those crops can be different. The 2001 NLCD lists 31,371 acres of crops/hay-alfalfa/pasture but does not distinguish which fraction of the crops code (AGRR) is alfalfa. The National Agricultural Statistics Service 2003–2009 database does differentiate alfalfa and hay, it lists 15,857 acres of hay and 9,000 acres of alfalfa. Accounting for the differences in the NLCD and National Agricultural Statistics Service datasets, and due to the methods SWAT uses to partition the watershed into land uses (referred to as Hydrologic Response Units [HRUs]) based on land use, soil type, and slope, the final land-use areas in the SWAT model are provided in **Table E2-5** and **Figure E2-3**. The HRUs are described in more detail in **Section E3.5**.

Table E2-5. SWAT Land Uses within the Flint Creek Watershed

SWAT Land Use	Area (acres)	Watershed Area (%)
Alfalfa	9,958	3.17
Hay	15,031	4.78
Pasture	4,473	1.42
Spring Wheat	479	0.15
Spring Barley	479	0.15
Forest – Evergreen	169,184	53.82
Range – Brush	54,039	17.19
Range – Grass	52,851	16.81
Residential – Low Density	3,761	1.20
Residential – Medium Density	775	0.25
Residential – High Density	21	0.02
Water	2,966	0.94
Wetlands	306	0.10
Totals	**314,323**	**100.0%**

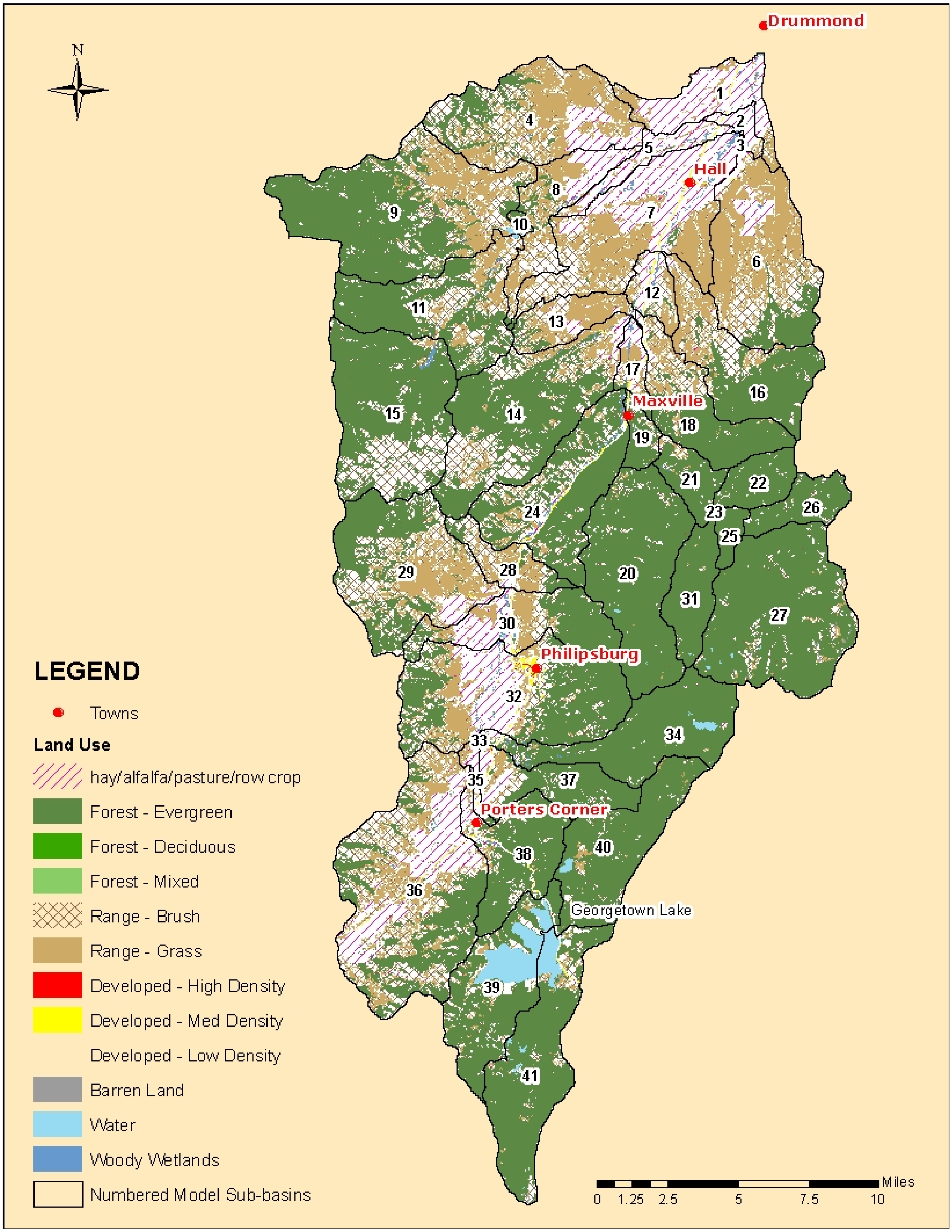

Figure E2-3. SWAT Land Use

Crop harvesting can vary year to year based on climatic factors. However, without detailed data on those variations the agriculture practices for planting, irrigating, fertilizing, and harvesting were set for the same date every year. Due to the higher elevation and shorter growing season, the irrigated land in the Philipsburg valley only gets a single hay/alfalfa cutting(Montana State University County Extension Agent, Lucas, Dan, personal communication 4/23/2013), which is set at July 4 in the model. The Drummond-Hall valley gets two alfalfa/hay cuttings, which are set at July 4 and September 30 in the model. Barley and spring wheat are harvested once annually on September 15 and 30 in the Philipsburg and Drummond-Hall valleys, respectively. For purposes of discussing crops and irrigation (see **Figure E2-3**), the Philipsburg valley is the agricultural area that begins approximately 5 miles south of the town of Maxville and extends to the southwest corner of the watershed, and the Drummond-Hall valley is the agricultural area immediately north of Maxville that extends to Drummond.

E2.5.1.1 Irrigation

The irrigation needs were primarily based on a report (Voeller and Waren, 1997) that indicated flood irrigation accounts for approximately 60–90% of the irrigation and sprinkler accounts for the remainder of irrigation in the watershed. Irrigation efficiency is the percent of water applied to crops that is actually used by the crop, it does not include applied water that flows past the root zone and enters the groundwater and/or surface water; the USGS (U.S. Geological Survey, 2000) estimates flood irrigation is about 50% efficient and sprinkler is about 90% efficient. From these values a watershed average irrigation efficiency of 58% was estimated for use in the SWAT model. However, to better match the measured streamflow trends at the USGS gages, and particularly higher than predicted streamflows in the fall and winter partially due to irrigation return flows, the efficiency was changed to 50% in the final SWAT simulations. The reported annual consumptive use of irrigation water (Voeller and Waren, 1997) averaged between 1.5 and 1.75 acre-feet per acre in the Drummond-Hall area (1.7 acre-feet per acre was used in the SWAT model), and averaged 0.75 acre-feet per acre in the Philipsburg area (0.74 acre-feet per acre was used in the SWAT model). Without specific irrigation rates for different crops, the same irrigation rate was used for hay, alfalfa, pasture, spring wheat and barley. The difference in irrigation rates and schedules (described below) for the two primary agricultural areas in the watershed (Philipsburg area and Drummond-Hall area) is primarily due to the higher elevations and colder temperatures in the Philipsburg area.

The irrigation season for the Drummond-Hall area was estimated to occur from May 1 through September 15 of each year (except for hay and pasture, where irrigation began on June 1 to allow for spring grazing on those lands). The start and end dates of the irrigation season were based on information from four sources and are summarized in **Table E2-6**:

- Using the 1990–2010 average of the USGS Flint Creek gage near Drummond, a distinct drop in streamflow occurs around May 1 and a distinct rise occurs approximately between September 1 and October 1 (see **Figure E2-2**);
- Data from the Allendale Ditch (**Figure E2-4a**) show it was flowing in mid-May or late May in 1994, 1995 and 1996 (Voeller and Waren, 1997). That report shows that it went dry between September 29 and October 25 in 1994, and went dry between September 26 and October 19 in 1995;
- A DNRC groundwater monitoring well (GWIC Id M:154595) with daily water level measurements since 2000 that is located approximately 4,000 feet downgradient from the Allendale Ditch, has a steeply rising hydrograph due to irrigation starting in late May or early June, and then a steeply falling hydrograph in late September or early October. Other wells monitored by DNRC (Voeller and Waren, 1997) during 1996 and 1997 showed similar trends. Due to the lag-time for

the canal water or irrigation water to effect the well, it is assumed irrigation begins and ends sometime before water level changes in the well; and

- A discussion between DEQ employees and the Willow Creek Reservoir manager on May 19, 2011 indicated that the Allendale Ditch is flowing in early May most years for flood irrigation which typically begins earlier than sprinkler irrigation due to freezing issues.

The irrigation season for the Philipsburg area was estimated to occur from June 1 through August 30 of each year. The start and end dates of the irrigation season were based on information from three sources:

- Using the 1990–2010 average of the USGS Flint Creek gage at Maxville, a subtle rise in streamflow occurs near September 1 (see **Figure E2-2**). This trend is not as distinct as the trends described above for the lower gage on Flint Creek, because this gage is several miles below the irrigated areas around Philipsburg and other influences are likely muting the effects from irrigation practices;
- Data from the Marshall Canal diversion (**Figure E2-4b**), which diverts some of the water supplied by the East Fork Rock Creek Reservoir diversion (Voeller and Waren, 1997), show it started flowing between May 17 and May 25 in 1994, and started flowing sometime before June 8 in 1995. That report shows that it went dry between September 15 and 29 in 1994, and went dry sometime between August 30 and September 27 in 1995; and
- Data from the East Fork Rock Creek Reservoir Diversion (Norberg Matthew, personal communication, 5/2011), show that for the 8 years with available data between 2000 and 2010 the median date that the diversion began was on May 24 and the median date that the diversion stopped was on September 17.

Table E2-6. Summary of Irrigation Information

Crop Type	Start Date	End Date	Irrigation Rate (feet/season)	Harvest Dates
DRUMMOND-HALL AREA				
Alfalfa	May 1	September 15	1.7	July 4, Sept 30
Hay	June 1	September 15	1.7	July 4, Sept. 30
Pasture	June 1	September 15	1.7	Not Applicable
Barley/Spring Wheat	May 1	September 15	1.7	September 30
PHILIPSBURG AREA				
Hay/Alfalfa	June 1	August 30	0.74	July 4
Pasture	June 1	August 30	0.74	Not Applicable
Barley/Spring Wheat	June 1	August 30	0.74	September 15

There are three irrigation diversions in the watershed that are accounted for in the SWAT model, the East Fork Rock Creek Reservoir, Marshall Canal and the Allendale Ditch (**Figures E2-4a** and **E2-4b**). The East Fork Rock Creek Reservoir water is diverted from the adjacent Rock Creek watershed into Trout Creek (sub-basin 36 in the SWAT model). Daily discharge rates for that water transfer were available for 2000, 2002–2004, and 2007–2010 from the monitoring point called East Fork Rock Creek Main Canal below Head Gate (#76E 2000) and provided by DNRC. Measured flows (Voeller and Waren, 1997) indicate that approximately only about 76% of the water diverted at this station actually makes it into the Flint Creek basin due to conveyance losses – those losses were accounted for in the SWAT model. Some of the water from the East Fork Rock Creek Reservoir is diverted into the Marshall Canal (in model sub-basin 36), where it is used to irrigate lands on the west side of Philipsburg valley before entering Flint Creek via Marshall Creek downstream of Philipsburg. The other diversion is at the Allendale Ditch (in model sub-basin 12) that diverts water from Flint Creek to irrigate lands on the west side of the

Drummond-Hall valley. Both the Marshall Canal and Allendale Ditch have a limited number of instantaneous flow measurements (Voeller and Waren, 1997) but are not sufficient to extrapolate over the model period. The volume of water moved into these two diversions is estimated by determining the amount of land that is irrigated from the diversion based on DNRC water rights maps (Buck, 1959) and described below.

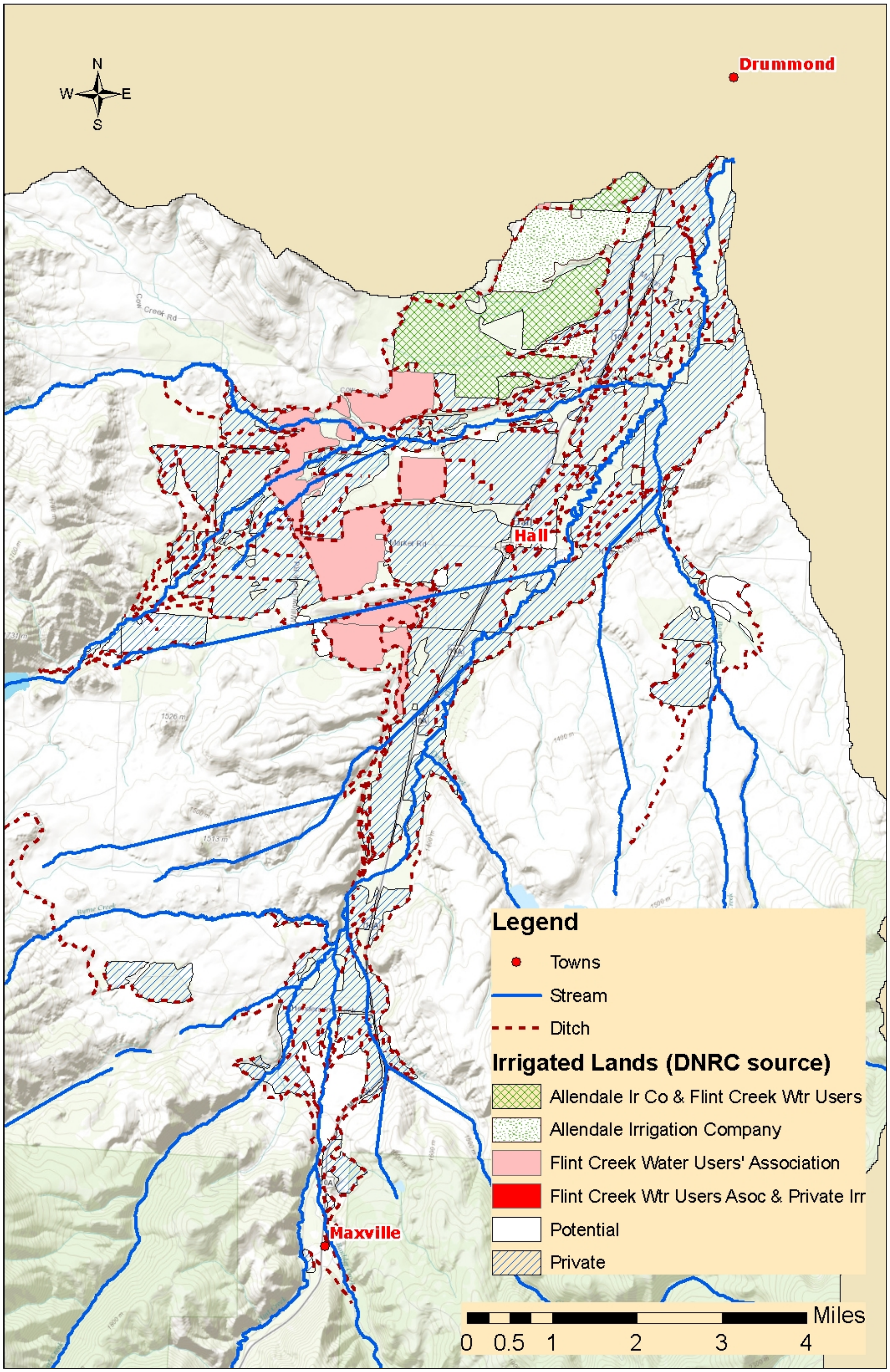

Figure E2-4a. Irrigation Canals, Diversions, and Dams in the Northern Flint Creek Watershed

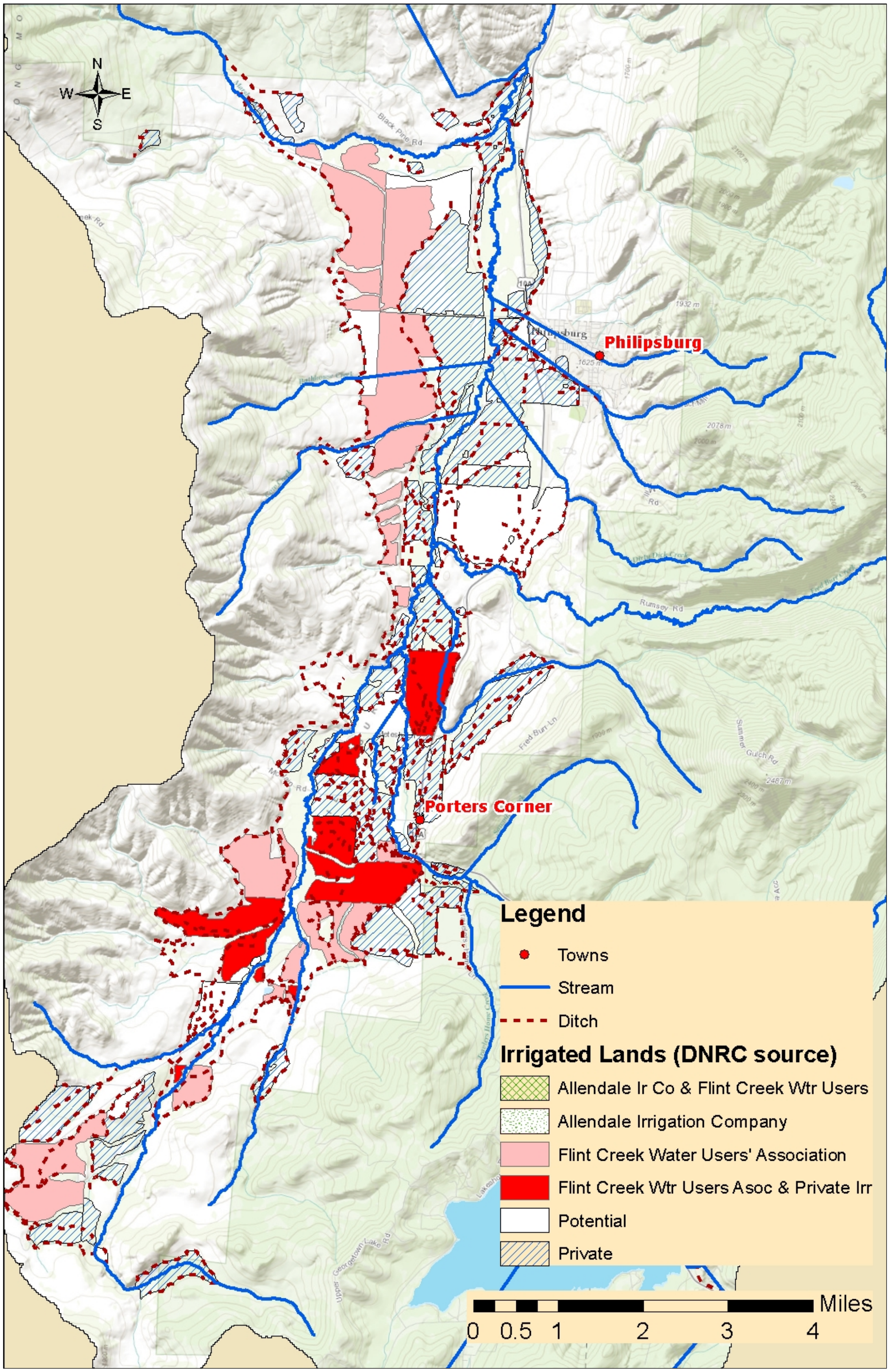

Figure E2-4b. Irrigation Canals, Diversions, and Dams in the Southern Flint Creek Watershed

Using the 16 dates of flow measurement between 1994 and 1996 at the Allendale Ditch Head Gate (Voeller and Waren, 1997), the average flow rate was 67.8 cfs when there was water in the ditch. Using the 1.7 acre-feet per acre value of consumptive use described above, the annual irrigation need from the Allendale Ditch was only 29.7 cfs (based on the estimated acreage of irrigated land served by the ditch from DNRC records (Buck, 1959)) (see **Figure E2-4a**). Because the irrigation needs of 29.7 cfs are less than half of the average measured values, and to account for the 0.5 irrigation efficiency (which indicates twice the water that the crops will consume must be diverted to account for irrigation inefficiency), the diversion amount and irrigation use was doubled to 59.4 cfs at this diversion, which roughly approximates the average measured diversion of 67.8 cfs.

Similarly for the Marshall Canal diversion, the 13 dates of flow measurement between 1994 and 1996 at the Allendale Canal (Voeller and Waren, 1997) showed an average flow rate of 30 cfs when there was water in the canal. Using the 0.74 acre-feet per acre value of consumptive use described above, the annual irrigation need from the Marshall Canal was only 5.9 cfs (based on estimated acreage of irrigated land served by the canal from DNRC records (Buck, 1959)) (see **Figure E2-4b**). Because the irrigation needs of 5.9 cfs are 20% of the average measured values, and to account for the 0.5 irrigation efficiency, the diversion amount and irrigation use was also doubled to 11.8 cfs at this diversion. At 11.8 cfs there is still a significant discrepancy from the measured diversions of 30 cfs, the cause for this discrepancy is uncertain but could be related to issues such as high rates of ditch losses to groundwater, additional irrigated lands not accounted for in the DNRC database, or higher irrigation rates than were estimated (Voeller and Waren, 1997).

A minimum flow was specified for each stream reach (each sub-basin has one stream reach) in the model to avoid dewatering streams. If the stream reached this value in the SWAT simulation it would not remove additional water for irrigation until the flow exceeded the pre-set minimum value. For larger streams (Flint Creek, Boulder Creek, Trout Creek, and Lower Willow Creek) the minimum value was set at 3.5 cfs. The USGS gages on Flint Creek and Boulder Creek showed that measured flow rates fell below 3.5 cfs on only a few dates at the gage near Drummond during the modeling period. For all other stream reaches the minimum value was set at 1.0 cfs. These minimum flow rates did limit some irrigation particularly in the late summer.

E2.5.1.2 Fertilizer

Local fertilizing application rates were unavailable from suppliers due to privacy concerns (Houston Engineering, 2011b). Therefore, typical crop-specific fertilizer rates for nitrogen, phosphorus and potassium were based upon a Montana State University Extension Service publication titled “Fertilizer Guidelines for Montana Crops” (Jacobsen et al., 2005). Fertilizer was used on alfalfa, spring wheat and barley. The alfalfa rates recommended in Jacobsen et al. (2005) were reduced in half based on communication with the Technical Advisory Group that indicated roughly half of the land owners use fertilizer on alfalfa fields (this was simulated in the model by reducing fertilizer use in half on all alfalfa fields rather than removing fertilizer from half of the alfalfa acreage in the watershed). Hay and pasture land uses were assigned winter grazing periods and fertilized through animal waste.

Fertilizer rates for alfalfa were based on estimated average soil conditions for phosphorus, and an estimated yield of 1 ton/acre (Houston Engineering, 2011b) for a 60/40 mix of alfalfa/grass. Fertilizer rates for Barley and Spring Wheat were based on average yields in Granite County based on National Agricultural Statistics Service Quick Stats (Houston Engineering, 2011b), and Montana fertilizer guidelines (Jacobsen et al., 2005). All fertilizer was applied on June 3 of each year as based on communication with the Technical Advisory Group. Fertilizer application rates are summarized in **Table E2-7**.

Table E2-7. Annual Fertilizer Rates in Flint Creek Watershed

Crop Type	Nitrogen load (lb/acre)	Phosphorus load (lb/acre)	Potassium load (lb/acre)
Alfalfa/Hay (60/40)[1]	5	20	20
Barley	90	0	0
Spring Wheat	247	35	0

(1) The rates used are half of the values suggested in Jacobsen (2005) to account for landowners that do not use fertilizer in the watershed

E2.5.2 Grazing

National Agricultural Statistics Service statistics show an average of 17,350 beef cattle in Granite County between 1980 and 2010. Through personal conversation, the National Resources Conservation Service (NRCS) estimates 65–75% of those are in the Flint Creek basin (Houston Engineering, 2011b), therefore a value of 12,000 was used in the SWAT model. There are also approximately 650 lamb/sheep in the watershed, primarily located in the Smart Creek drainage based on a 2011 site visit. Because grazing information for sheep was not available through the Montana State University extension service and there are relatively few sheep in the watershed, the 650 sheep were incorporated into the cattle values by estimating that an adult sheep is about 1/10 the weight (Kott, 2005) of a typical 1,400 lb beef cattle. The Environmental Protection Agency Spreadsheet Tool for the Estimation of Pollutant Load uses a similar ratio for Total Nitrogen (TN) and TP production for sheep as compared to cattle (Michigan Department of Environmental Quality, 1999). Therefore, the 650 sheep are equivalent to 65 beef cattle and are added to the 12,000 value discussed previously for a total value of 12,065.

Grazing was assumed to occur only in lands classified as range land (either grass range or brush range), which largely occurs on private land in the watershed. The United States Forest Service (USFS) has 15 grazing allotments in the watershed, but they are mostly in evergreen forest and except for one allotment located west of Maxville in range land are not suitable for grazing (Houston Engineering, 2011b). The USFS grazing allotment located west of Maxville (in sub-basins 14 and 15) does contain about 5,000 acres of range land and was used for summer grazing land in the SWAT model. All other land classified as range land that is located on USFS property (approximately 12,350 acres) was not included in the grazing acreage. The majority of summer grazing (about 95% of the total grazing area) was therefore located on privately owned range land. Privately owned evergreen forest areas, which account for approximately 37,000 acres in the watershed, were not included in the grazing area to remain consistent with the lack of grazing on government owned evergreen forest. Using those assumptions the total available summer grazing land for the 12,065 cattle is approximately 94,500 acres. To better represent grazing rotations the amount of grazing was varied between rangeland HRUs by allowing more grazing on lands that grow more vegetation (as based on biomass estimations in the model). Grazing lands were thus divided into 4 categories: no grazing, low grazing, moderate grazing and heavy grazing. Moderately grazed HRUs had 2 times as much grazing as low grazing HRUs, and heavily grazed HRUs had 3 times as much grazing as low grazing HRUs. Rangeland HRUs with no grazing only comprised 300 acres which reduced the total summer grazing area to approximately 94,200 acres. This tiered system provided more consistent rates of rangeland biomass growth in the watershed and attempted to simulate good grazing rotation practices. Over a 5 month grazing season (June 1 through October 31), that is approximately 1.6 acres/animal-unit-month. For reference, according to a Montana State University Extension Service publication (Lacey and Taylor, 2005) the range of acres/animal-unit-month is between 0.6 and 50 in Montana. During the winter months, it is assumed that the cattle feed on the hay (15,031 acres) and pasture (4,473 acres) lands in the watershed (Houston Engineering, 2011b). Based on discussions with the Technical Advisory Group winter grazing used existing field vegetation in November and May, and used feed transported into the grazing areas from December through April.

A 1,400 lb cow/calf pair eats approximately 35 pounds per day (dry weight) (Paterson, 2009). In this watershed the average cow/calf pair is roughly 1,200 lbs (based on communication with the Technical Advisory Group). Daily trampling was estimated equal to their consumption based on recommended SWAT values and previous studies (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011). Based on NRCS (Natural Resources Conservation Service, 2008) a 1,000 lb beef cow produces 125 lb/day of manure, 88% of that is water weight, which provides a dry weight of 15 lb/day/cow. Converting that to a 1,200 lb cow/calf pair provides a dry weight manure of 18 lb/day/cow. That manure is applied across the summer and winter grazing ranges for all 12,065 livestock in the watershed, for a watershed-wide summer load of 2.3 lb/acre/day and a winter load of 11.1 lb/acre/day. The nutrients composition of the dry manure used in the model was based on NRCS (Natural Resources Conservation Service, 2008) that estimates it contains 2.8% nitrogen and 0.66% phosphorus. SWAT allows the manure applied to break down, percolate into the subsurface, or runoff towards streams. In addition, to simulate the time that livestock spend in the local streams 1% of the livestock waste is applied directly into the surface waters (Sheffield et al., 1997).

E2.5.3 Urban Land Use and Septic Systems

Urban density was initially based on the 2001 NLCD. However, the 2001 NLCD did not capture some of the significant growth of single family homes in the area surrounding Georgetown Lake in the 1990s and 2000s. To account for that growth, the land use surrounding Georgetown Lake was updated using visual inspection of 2009 air photos. The land-use update was only conducted once during the model period because there is insufficient information available to warrant a more frequent land-use update. The update was included halfway through the modeling period, January 1, 2000. This date is also approximately halfway through the increase in development rates that began in the early 1990s and ended in the late 2000s. Updating the urban land use to correctly identify areas of low, medium or high density is reflected in the SWAT model with increased percentages of impervious ground as the residential (i.e., urban) density increases.

To simulate typical residential land use, the model includes information for irrigation, cutting and disposal of grass for urban development. To determine the amount of land used for lawns, the number of septic systems for the watershed in 2009 was estimated at 1,613 from a county Geographic Information System (GIS) layer described below; based on the population in Philipsburg of 825 and an average household of 2.2 persons/home an additional 370 lawns were included. This provided approximately 2,000 lawns to include in the model. Without any available statistics, the average size of the lawn was estimated as ¼ acre (roughly 10,000 square feet) for a total lawn area in the watershed of 500 acres. Irrigation from groundwater was applied automatically by SWAT based on the soil moisture content, 10% of the irrigation water was assumed to runoff. Grass was harvested on the same seven dates every year (June 1, June 15, July 1, July 15, August 1, September 1, and October 1), and each harvest removed 50% of the grass. Fertilizer application was estimated from recommended application rates (Rosen et al., 2006) and from commercial lawn fertilizer bags. It was assumed that only half of the 2,000 lawns use commercial fertilizer, which provided 250 fertilized acres. Current fertilizer recommendations (Rosen et al., 2006) and commercial fertilizers do not use significant amounts of phosphorus, therefore only nitrogen was added to the lawns. The application rate on the 250 acres was set at 71.6 lb/ac/yr, for a total watershed application of 17,900 lb/yr.

For the purposes of estimating septic system locations a 2009 GIS layer created for Granite and Deer Lodge counties to assist emergency responders was used. The GIS layer was reduced to those parcels described as an apartment, cabin, house, or mobile home. A septic system was assigned to each of those parcels except for parcels served by the city of Philipsburg as determined from the city's sewer system map. Based on the GIS layer there were approximately 1,613 septic systems in the watershed in 2009, approximately half of those (875) are located in the immediate vicinity of Georgetown Lake and the other half spread around the rest of the watershed (**Figure E2-5**).

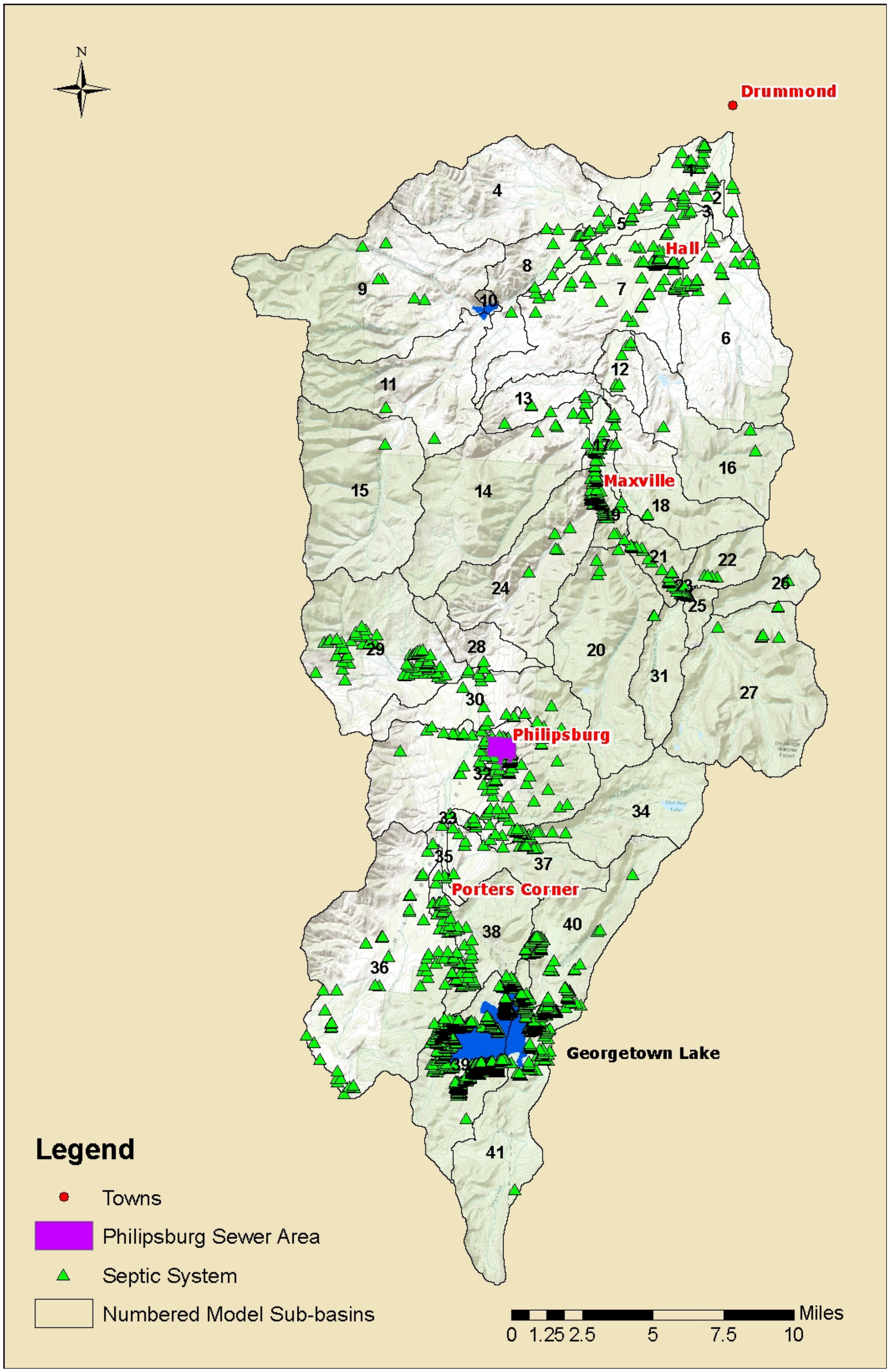

Figure E2-5. Approximate Septic System Location (2009)

The septic density land use designation in SWAT does not add a nitrogen or phosphorus load to the watershed that is specific to septic discharges (it only changes the runoff characteristics of the land by increasing impervious area with increased development density). Specific loading of nutrients from septic systems must be completed with a separate septic module within SWAT or via an external calculation that is then added to the model via a point source at the upstream end of the reach in each sub-basin. The latter option was used for this watershed. Using the locations of septic systems from the GIS layer, the nitrogen and phosphorus loading to surface waters from the 1,613 septic systems was estimated using a simple spreadsheet method as described in **Appendix F**. The number of septic systems in **Appendix F** is slightly different than described here due to minor differences in the watershed boundary delineated by SWAT versus the GIS information originally supplied with the 2009 county septic layer.

To account for the increase of septic systems in the vicinity of Georgetown Lake during the model simulation period, the point source loadings from septic systems were updated on an annual basis during the modeling period. Between 1990 and 1999, the number of septic system permits issued in the Flint Creek watershed was approximately 202 (Granite County Sanitarian, Lanes, Chad, personal communication 2013). Between 2000 and 2010, the rate of septic permits issued remained similar to the previous 10 years at 188 (Granite County Sanitarian, Lanes, Chad, personal communication 2013). A septic permit is issued when a new septic system is installed, and thus is an accurate measure of the increase of development. Because the rate of development in the watershed below Georgetown Lake has been relatively stagnant (as seen in the constant or slightly declining population in Philipsburg – see **Section E2.7.1** for additional detail), all of the increased development is assumed to occur in the vicinity of Georgetown Lake. Based on the 2009 estimate of 875 septic systems near Georgetown Lake and the 390 septic permits issued during the model period, the number of septic systems in the Georgetown Lake area was increased annually at a constant rate from 485 (875 minus 390) in 1990 to 875 in 2010, or 19.5 systems per year.

Each septic system was assumed to be a conventional system that produces an average of 200 gallons per day with a nitrate concentration of 50 mg/L and a mineral phosphorus concentration of 10.6 mg/L (U.S. Environmental Protection Agency, 2002; Montana Department of Environmental Quality, 2009) (see **Appendix F** for additional details). Those concentrations equate to loading values of 0.0836 lb/day and 0.0176 lbs/day/system for nitrate and mineral phosphorus, respectively. While there are some level 2 systems (septic systems that reduce nitrogen concentrations) in the county, it is a small percentage of the septic systems and without any available database to determine how many level 2 systems exist they were not accounted for in the SWAT model. For reference, the nitrate and mineral phosphorus loads applied as point sources from septic systems in 2000 after the attenuation rates calculated in **Appendix F** are incorporated are provided in **Table E2-8**.

Table E2-8. Nitrate and Mineral Phosphorus Loading Rates from Septic Systems in 2000

Sub-Basin	Nitrate Load (lbs/day)	Mineral Phos. Load (lbs/day)	Sub-Basin	Nitrate Load (lbs/day)	Mineral Phos. Load (lbs/day)	Sub-Basin	Nitrate Load (lbs/day)	Mineral Phos. Load (lbs/day)
1	1.053	0.093	15	0.030	0.003	29	1.835	0.161
2	0.180	0.016	16	0.090	0.008	30	0.481	0.042
3	0.000	0.000	17	0.572	0.050	31	0.000	0.000
4	0.120	0.011	18	0.241	0.021	32	3.640	0.320
5	0.451	0.040	19	1.594	0.140	33	0.000	0.000

Table E2-8. Nitrate and Mineral Phosphorus Loading Rates from Septic Systems in 2000

Sub-Basin	Nitrate Load (lbs/day)	Mineral Phos. Load (lbs/day)	Sub-Basin	Nitrate Load (lbs/day)	Mineral Phos. Load (lbs/day)	Sub-Basin	Nitrate Load (lbs/day)	Mineral Phos. Load (lbs/day)
6	0.572	0.050	20	0.180	0.016	34	0.963	0.085
7	2.557	0.225	21	0.692	0.061	35	0.120	0.011
8	0.421	0.037	22	0.150	0.013	36	1.745	0.154
9	0.180	0.016	23	0.211	0.019	37	0.451	0.040
10	0.000	0.000	24	0.602	0.053	38	1.745	0.154
11	0.060	0.005	25	0.211	0.019	39	14.605	1.285
12	0.211	0.019	26	0.060	0.005	40	2.009	0.177
13	0.090	0.008	27	0.271	0.024	41	4.442	0.391
14	0.361	0.032	28	0.060	0.005			

E2.5.4 Fires/Timber Harvest/Beetle Kill

More than 87% of the model area is classified as forest or rangeland (see **Figure E2-3**). Timber harvest, fire, and beetle kill effects were examined to determine whether temporal land-use changes should be incorporated into the SWAT model. Locations discussed are shown on **Figure E2-6**.

Fire effects were researched via discussion with USFS personnel (Houston Engineering, 2011b). Between 1985 and 2009 there was only one significant wildfire on USFS land which was in 1988. The fire consumed 8,200 acres near the headwaters of the Smart Creek drainage on the west side of the watershed in sub-basins 14 and 15. The high density of roads in this area suggest it was likely also harvested for timber pre or post fire. This area was accounted for in the 2001 NLCD as a rangeland-brush land use instead of forest as it would have been before the fire. Since 1994, the DNRC database showed several small fires that were all less than 15 acres in size. The smaller wildfires are minor and were not accounted for in the watershed discretization. Additional information is available on the DNRC website (Montana Department of Natural Resources and Conservation,2012).

Timber harvests were incorporated as land-use updates in the SWAT model. Harvested areas were identified through visual interpretation of the air photos that are available from 1990 through the present, which included 1990, 1991, 1995, 2003, 2005, and 2009. Three areas were identified. The first area is in sub-basin 29 and covers approximately 1,300 acres; it appears to have been harvested between 1995 and 2001. The 2001 NLCD classified it as rangeland-brush as a result of the logging, it was modified to be forest from 1989 through 1997 and then set to rangeland-brush for the remainder of the model period. The second area is in sub-basin 16 and covers approximately 640 acres; it appears to have been harvested between 2003 and 2005. The 2001 NLCD classified it as forest; therefore the land use was changed in the SWAT model in 2004 from forest to rangeland-brush to match the land-use classification for harvested areas. The third area is in sub-basins 9 and 11 and covers approximately 1,500 acres, it was harvested before 1990, but in the 1995 air photo the effects are still visible. By 2001, the effects were low enough that the NLCD classified the area as forest. The land use for this area was changed to rangeland-brush from 1989 through 1999 and then reverted back to forest in 2000.

The scope of mountain pine beetle effects was examined using information from the USFS (U.S. Department of Agriculture, Forest Service,2013) includes maps based on aerial surveys showing the location and number of affected trees. Based on those maps there are tens of thousands of forested acres in the watershed that have been affected by beetle kill. However, the effects of beetle kill on the hydrology of the watershed are not clear at this time. Therefore, the SWAT model was not altered to account for the beetle kill effects, if any had occurred during the modeling period. This may be an area to re-assess in the model in the future if additional information and studies about the effects of beetle kill on hydrology and/or nutrient migration become available.

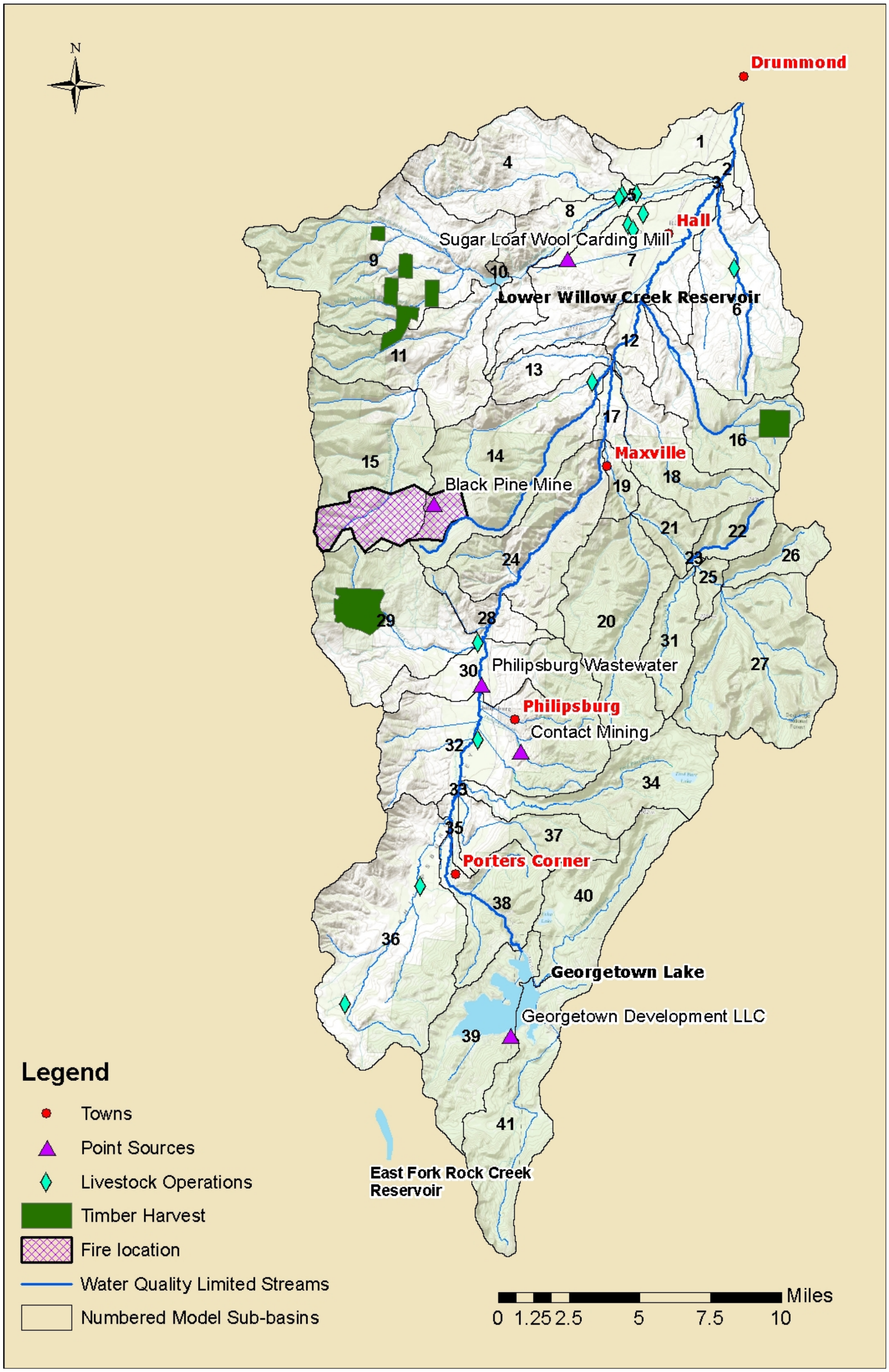

Figure E2-6. Timber Harvest, Fire, Livestock Confinement, and Point Source Locations

E2.5.5 Water/Wetlands/Reservoirs

In addition to the main and tributary stream channels that route the water through the watershed, SWAT also incorporates four different types of impoundments: ponds, wetlands, depressions/potholes, and reservoirs. Reservoirs are located on the main channel network and receive water from all sub-basins upstream of the waterbody. Ponds, wetlands, and depressions/potholes are located within a sub-basin off of the main channel and only receive runoff from a portion of the sub-basin in which they are located. As simulated in SWAT, no distinction is made between naturally occurring and man-made waterbodies. Daily calculations of surface area, precipitation, evaporation, and seepage are completed in SWAT based on user-provided information on the reservoir outflow or storage-operational curves. Ponds, wetlands, or depressions/potholes were not included in the model, but three reservoirs were included. The three reservoirs include Georgetown Lake (sub-basin 39), Lower Willow Creek Reservoir (sub-basin 10), and the East Fork Rock Creek Reservoir (sub-basin 36) (see **Figure E2-6**).

The history of the Flint Creek dam which created Georgetown Lake was described previously in **Section E2.1**. The lake area is 2,900 acre, and the lake volume at full pool is approximately 31,000 acre-feet (Garrett and Kahoe, 1984). Full pool is estimated as the noncontrolled spillway at 6,429.5 feet above mean sea level (msl) (Montana Power Company, 1987). Discharges from the dam are controlled by the dam operator, and are not directly related to reservoir water elevation (Stafford and Ahl, 2011). Records of dam releases are not available; therefore the amount of water released from the dam was based on the daily readings from the USGS gage station (Flint Creek near Southern Cross) located approximately 9,400 feet downstream of the dam. Because there is only one unnamed small stream (its drainage area is approximately 1.3 square miles) that enters Flint Creek between the dam and that USGS gage station, the USGS streamflow values should be representative of the dam releases from Georgetown Lake. Daily year-round flow data collection at the USGS gage has been reduced since 2004 to daily collection from April 1 to October 31 of each year. The missing winter data in that time period were based on the average daily flow for each day from November 1 through March 31 measured at the gage between 1990 and 2003 (**Attachment EC**).

Information for the Lower Willow Creek Reservoir was obtained from the Granite Conservation District (Houston Engineering, 2011b). It was constructed in 1962 with a maximum capacity of 6,230 acre-feet and a normal storage of 4,800 acre-feet. Average monthly discharge data when the dam releases water for irrigation (April through October) are only available from 1965 through 1983. Normal operation of the dam has not changed over its life span, therefore the monthly averages of the historic data were used as the daily discharge during the model period (**Attachment EC**). From November through March there are no releases from the dam, but normal runoff is directed through the reservoir in sub-basin 10.

The East Fork Rock Creek Reservoir is located in the adjacent Rock Creek watershed. It transfers water into the Flint Creek watershed via siphon into Trout Creek to meet water rights obligations for irrigation. Because the reservoir is outside the watershed it is treated as a point source of water in the SWAT model. The DNRC monitors the flow from the reservoir – daily data for water diverted into the Flint Creek watershed were available for 8 years of the model period (2000, 2002–2004, and 2007–2010). For the years without data, the median daily value for each of the years with data was used to estimate the daily diversion values (**Attachment EC**). The median was used instead of the average because there were only eight or fewer values (the diversion started and stopped on different dates each year so some dates had less than eight discharge volumes) for each date; with so few data points one anomalously low or high value could skew the extrapolated value.

E2.6 Roads

Sediment runoff from unpaved roads contributes sediment to surface water and was estimated based on the Water Erosion Prediction Project model (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2011). That project divided the Flint Creek watershed into 13 sub-watersheds and estimated sediment loads for each sub-watershed. The sediment loads in each of the 13 sub-watersheds were divided proportionally by the miles of gravel or native material roads within each of the 41 sub-basins in the SWAT model (paved roads were not included in determining the sediment loads). Those sediment loads were added as a constant daily point source load to each sub-basin (**Table E2-9**). Although there may be some seasonal variation in sediment loading from streams there was not enough information to vary the sediment loading seasonally. Additional details on methods used to measure and extrapolate the sediment loads are available in the report (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2011).

Although paved roads may contribute some sediment loading (from traction sand in winter months, for example), the comparative load to unpaved roads is small and not significant on the watershed scale.

Table E2-9. Sediment Loading Rates from Roads

Sub-Basin	Sediment Load (lbs/day)	Sub-Basin	Sediment Load (lbs/day)	Sub-Basin	Sediment Load (lbs/day)
1	7.50	15	19.84	29	25.35
2	2.65	16	39.24	30	12.13
3	0.00	17	1.10	31	4.19
4	15.65	18	10.36	32	33.73
5	3.53	19	2.87	33	0.44
6	15.65	20	18.08	34	5.95
7	18.30	21	5.51	35	1.10
8	5.29	22	5.51	36	20.94
9	31.31	23	0.66	37	7.94
10	0.22	24	23.59	38	17.64
11	10.80	25	2.87	39	16.98
12	0.00	26	5.29	40	18.08
13	6.61	27	13.01	41	13.67
14	69.67	28	0.00		

E2.7 Point Sources

There are several permitted discharges in Flint Creek watershed (**Figure E2-6**). Most are intermittent with no predictable discharge or too small to be included in the model, except for the wastewater discharge from the city of Philipsburg. Each discharge is described below. There can be a few construction stormwater permits active at any time in the watershed; due to the lack of monitoring typically required for such activities and their transient nature they were not included in the SWAT model. The description and identification numbers for these permitted discharges may have changed since the model was initially parameterized in 2010, the permits described may have lapsed, been re-issued with different conditions, or new permits may have been issued in the interim. The model inputs were maintained under the conditions that existed in 2010.

E2.7.1 City of Philipsburg Wastewater Discharge

Discharge from the Philipsburg wastewater treatment plant was simulated as a point source to Flint Creek in sub-basin 30 of the SWAT model. Flow and water quality data were not available for the entire modeling period, therefore, some interpolation and extrapolation of the data that have been collected were used to estimate the monthly constituent loadings from the wastewater treatment plant as described below. Based on the available wastewater treatment plant effluent data monthly loads of sediment, organic nitrogen, nitrate, ammonia, organic nitrogen, organic phosphorus, and orthophosphorus were included in the loads applied to Flint Creek from the wastewater treatment plant.

The city of Philipsburg's wastewater treatment plant was constructed in 1961, it was upgraded in the early 1990s, and the city is currently evaluating plans for further upgrades. Treatment is via a 2-cell facultative lagoon with continuous discharge into Flint Creek near the northwest corner of the treatment lagoons. It currently operates under a Montana Pollutant Discharge Elimination System (MPDES) permit (MT0031500) with a permitted design flow of 160,000 gallons per day. As required in the MPDES permit the effluent flow rate has been measured since 2000. TN and TP have been measured in the effluent since 2005. Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS) have been measured in the effluent since 2007. For periods when effluent quality data and flow rates were not available, values from the discharge monitoring reports submitted to the DEQ were used to estimate average monthly flow and loadings. Effluent dissolved oxygen has not been measured in the past therefore the concentration was estimated at 2.0 mg/L. However, since July 2012, the MPDES permit has required dissolved oxygen monitoring. The current estimate of 2.0 mg/L can be adjusted in the future if necessary based on the data collected. Effluent rate data from November 2004 through October 2006 showed the flow nearly doubling for that time period without any known increase in population or usage. The rapid increase and then decrease in flow is likely due to one or a combination of two events: the first event was the replacement of a corroded outflow flume in November 2004 which may have resulted in incorrect manual readings from the new flume; the second event was a broken sewer line (repaired in December 2006) that was allowing water from Camp Creek to enter the wastewater collection system (Houston Engineering, 2011a). For this time period of uncertain flow rate records, average values of wastewater treatment plant loading from other years with data were used. The population of Philipsburg has ranged from 925 in 1990 to 914 in 2000 to 825 in 2010. There were no noticeable changes in measured effluent rates for the period of available data in the MPDES file (2000 through 2010); therefore the extrapolated effluent and loading rates between 1989 and 2000 were not adjusted for the population change.

The city of Philipsburg is under an Administrative Order on Consent to improve treatment of TSS and BOD by October 2013. That improvement has not been completed yet; therefore the historic TSS and BOD loading rates have been used in the SWAT model.

E2.7.2 Black Pine Mine Stormwater Discharge

The Black Pine Mine has sporadic stormwater discharges to an outfall in the Smart Creek drainage and is covered under MPDES permit MTR300080. This outfall is into a detention basin that allows the stormwater to discharge into the groundwater rather than flowing directly into the nearest surface water. Due to the sporadic nature of the discharge and the dissipating effects of the detention basin, a point source discharge was not included in the SWAT model.

E2.7.3 Sugar Loaf Wool Carding Mill

This discharge is a small industrial discharge near the town of Hall via a drainfield to groundwater for a wool processing facility. It is covered under Montana Ground Water Pollution Control System (MGWPCS) permit MTX000134. There have only been four effluent samples collected for nitrate and Total Kjeldahl Nitrogen analysis. Due to the lack of information and small volume of discharge from this facility to groundwater (less than a single family home septic system) it was not included as a separate point source in the SWAT model.

E2.7.4 Contact Mining

This discharge is for process water of an ore processing facility located near Philipsburg under MGWPCS permit MTX000002. The discharge is to two settling ponds where solids are allowed to settle out and then the water is recycled for additional ore processing. The permit is for the potential discharge to groundwater. The single monitoring well downgradient of the settling ponds has never had groundwater in it, and therefore effects to groundwater, if any, have not been documented. The current permit includes requirements to install new monitoring wells to better define the amount of discharge that may be occurring from the settling ponds. Because there is no documentation of the amount or concentration of discharges to groundwater, this facility was not included as a point source in the SWAT model.

E2.7.5 Georgetown Development LLC

This discharge is for domestic wastewater from a subdivision on the south side of Georgetown Lake under MGWPCS permit MTX000201. This system began discharging wastewater in late 2011 after the model period ended, and therefore was not included as a point source in the model.

E2.7.6 Livestock Operations

Analysis of aerial photos and GIS information show there are approximately 12 areas of animal confinement in the watershed (Houston Engineering, 2011b), four of which may be located near streams. Whether these sites are actually Concentrated Animal Feeding Operations or Animal Feeding Operations by definition was not determined as part of this project. A few of the sites were observed during a DEQ watershed site visit in 2011, and did appear to have areas denuded of vegetation due to livestock activities, but it could not be determined whether they had direct connection to surface waters. These areas were maintained as pasture in the SWAT model. Future studies may want to reconsider this based on the best available data. The effect of livestock confinements on nutrients and sediment loading can be significant. These facilities may act as point sources discharging directly to streams, and can potentially contribute to nutrients and sediment loading.

E3.0 Model Development

For this SWAT model, which includes numerous land owners, the specific land management practices (e.g., irrigation schedules, irrigation types, fertilizer application, grazing rotations, urban management, etc.) used by each land owner could not logistically be replicated. Therefore, the best information available from published literature and local knowledge was used to develop typical land management practices that are incorporated uniformly across the watershed. For example, the timing and amount of fertilizer may vary between different land owners, but the model uses a single average fertilizer application rate and date for each type of crop that is fertilized. This homogenization does limit the models ability to accurately predict field scale loading estimates, but the model results are well suited to predicting how changes in management practices across the watershed will affect nutrients loadings to surface waters, which is the ultimate goal of developing the SWAT model.

E3.1 SWAT Model Description

DEQ selected the SWAT model for modeling the Flint Creek watershed. The SWAT model and its ArcView Extension (ArcSWAT) were developed, and are actively supported, by the U.S. Department of Agriculture Agricultural Research Service. SWAT is a public domain watershed-scale hydrologic and water quality model developed to quantify the effect of land management practices in large watersheds. It is a deterministic, distributed parameter continuous simulation basin-scale model. SWAT partitions the watershed into a number of sub-basins. Each sub-basin has a single climatic dataset based on the average elevation of the sub-basin; for example, the snowfall value for a specific date is the same for each HRU in the sub-basin and is based on the nearest climate station and the average elevation of that sub-basin. The sub-basins are distributed in the context that they are linked with other sub-basins through the stream channel network. Each sub-basin is further partitioned (i.e., discretized) into HRUs that are lumped into unique soil, land cover, and slope combinations. These HRUs form the fundamental computational unit of the model.

The advantages of SWAT include:

- It is physically based and uses readily available data;
- It is computationally efficient, computers are able to complete the simulation calculations within a reasonable amount of time;
- It incorporates comprehensive processes by using mathematical equations to represent flow, fate, and transport and other physical, chemical, and biological interactions;
- It can be used to study long-term effects and to simulate management scenarios; and
- It has globally validated model code, as both the model and its code are publicly available for free and widely used.

Disadvantages of SWAT are primarily related to simplifying assumptions to reduce computational time and include:

- The impacts of HRUs on the stream reach within a sub-basin are only based on their total size, not on their location within each sub-basin;
- While it does include groundwater routing, the routines used are not designed to adequately characterize complex groundwater systems; and
- As a watershed-scale model it cannot be used to predict field-scale water quality changes.

Pollutant yields, water balance, surface runoff, sediment yield, and management practices are computed at the HRU level, and then are aggregated for subsequent routing through the stream channel system. SWAT simulates streamflow, sedimentation, and water quality parameters including nutrients. Six general compartments are incorporated into the model to describe the flux of water through the landscape. These include: (1) snow accumulation and melt, (2) surface runoff, (3) unsaturated zone processes/evapotranspiration, (4) lateral subsurface flow, (5) shallow groundwater flow, and (6) deep aquifer flow. Hydrologic computations are completed using a modified version of the curve number (United States Department of Agriculture, 1986) where daily curve number is adjusted according to the previous day's soil water content (Arnold et al., 2011; Neitsch et al., 2011). Sediment yield in SWAT is simulated using the Modified Universal Soil Loss Equation (Williams and Berndt, 1977), where erosion and delivery are calculated as a function of peak runoff rate and volume, soil erodibility, slope steepness and length, cover factor, and supporting practice factor. In particular, the slope steepness and length, and the cover management factor (Universal Soil Loss Equation (USLE) C factor) are important because they are largely based on specific field-level conditions, and therefore are more accurate with user input. Channel sediment routing is based on the unique sediment transport characteristics of the individual routing reach and the upstream continuum of sediment from other sub-basins and channel reaches. Sediment is routed through the stream channel considering deposition and degradation processes and using a simplified equation based on stream power (Bagnold, 1977). For each stream reach on each day, either bank deposition or bank erosion occurs to maintain the sediment load in the stream at the maximum amount of sediment that the calculated stream power can sustain. The theory and the algorithms that control many of the processes in SWAT are provided in the model documentation (Neitsch et al., 2011).

SWAT simulates the transfers and internal cycling of the major forms of nitrogen and phosphorus. The model monitors two pools of inorganic and three pools of organic forms of nitrogen. SWAT also monitors three pools of inorganic and three pools of organic forms of phosphorus. SWAT incorporates instream nutrient dynamics using kinetic routines from QUAL2E, an instream water quality model (Brown and Barnwell, Jr., 1987). Details regarding model development are described by Arnold et al. (1993). SWAT documentation consists of theoretical documentation, input and output documentation, and user's manual (Arnold et al., 2011; Neitsch et al., 2011; Winchell et al., 2010).

E3.2 MODEL INPUT

ArcSWAT and SWAT Editor (both Version 2009.93.5) were used in this modeling effort. This is not the most current version of SWAT but it was the most recent version at the onset of the project, and compatibility problems did not allow the updating of the model version without significant structural modification. Fundamental input data for SWAT are topography, land use, soils, and climatic data. ArcSWAT (with its GIS interface) was used to perform the pre-processing, initial model setup and parameterization. Geographic data sources used for model setup are shown below:

- National Elevation Dataset (NED) – The USGS NED is a 1:24,000 scale high-resolution compilation of elevation data used for watershed delineation, flow accumulation processing, and slope determination (U.S. Geological Survey,2010a).
- National Hydrography Dataset (NHD) – NHD is a 1:24,000 scale vector coverage of stream topology (U.S. Geological Survey,2010b). It was used in definition of the stream and channel network.
- National Land Cover Dataset (NLCD) – The 2001 NLCD is a 21-category land cover classification (30-m grid) available for the conterminous U.S.

- STATSGO Soils – The STATSGO soil map (Natural Resources Conservation Service, 1994) is a 1:250,000 scale generalization of detailed soil survey data that were used to develop soil properties of land cover classes.

E3.3 Simulation Period

The model simulation period was chosen to be coincident with: the most recent land cover; available calibration data for flow, sediment, and nutrients; and climatic datasets with few or no missing values. The period of 1989 through 2010 was chosen to best meet these requirements. The dataset was partitioned into three subsets: 1989–1991 for a model “warm-up” period; 1997–2010 for calibration; and 1992–1996 for validation. Further descriptions and rationales of the three chosen model periods are provided in **Sections E4.1** and **E4.5**.

E3.4 Watershed Delineation

Sub-watershed discretization was performed to capture 6th code Hydrologic Unit Code boundaries for the watershed, and also to capture specific sub-watersheds with water quality-limited stream segments within the model. This resulted in a delineation of 41 total sub-watersheds (referred to as sub-basins) for the Flint Creek watershed (**Figure E3-1**). Sub-basin sizes ranged from 0.02 square miles to over 34 square miles (**Table E3-1**).

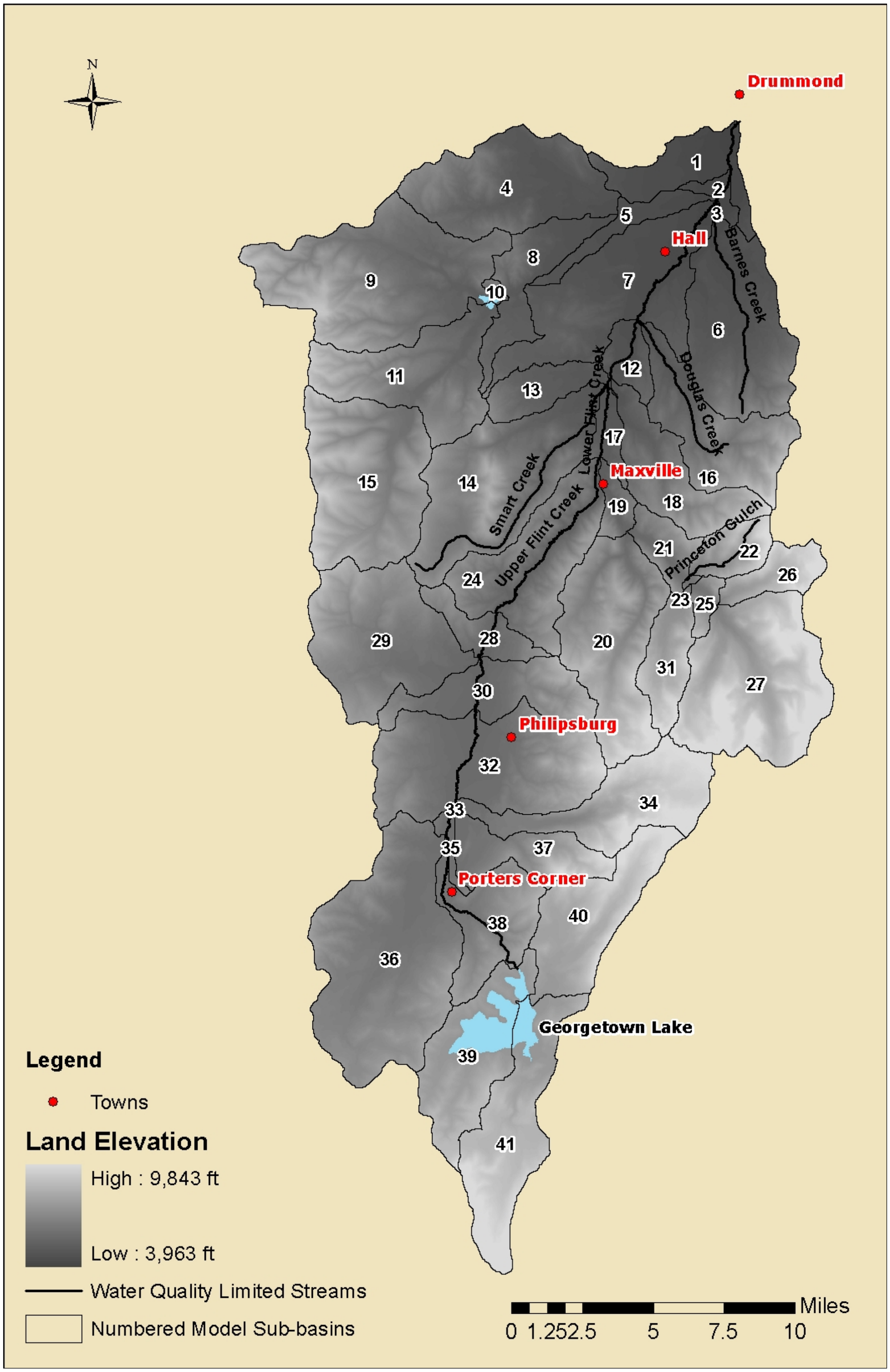

Figure E3-1. Sub-Basins within the Flint Creek Watershed

Table E3-1. SWAT Sub-Basin Information for Flint Creek Watershed

Sub-Basin	Area (square miles)	% Watershed Area	Average Elevation (feet above msl)	Comment
1	8.38	1.71	4,202	
2	1.46	0.3	4,094	USGS flow gage
3	0.02	0.004	4,065	
4	20.04	4.08	4,958	
5	3.98	0.81	4,303	
6	20.74	4.22	4,750	
7	23.09	4.7	4,505	
8	8.75	1.78	4,830	
9	30.25	6.16	5,824	
10	0.47	0.1	5,096	Lower Willow Cr. Reservoir
11	17.11	3.48	5,809	
12	3.55	0.72	4,578	
13	5.47	1.11	4,953	
14	24.30	4.95	5,664	
15	23.24	4.73	6,463	
16	14.61	2.97	5,705	
17	2.58	0.53	4,739	
18	11.58	2.36	5,796	
19	2.39	0.49	5,348	USGS flow gage
20	20.74	4.22	6,577	
21	4.15	0.85	5,853	
22	4.49	0.91	6,938	
23	0.17	0.03	5,558	
24	17.50	3.56	5,627	USGS flow gage
25	1.72	0.35	6,247	
26	4.68	0.95	7,348	
27	25.35	5.16	7,482	
28	4.84	0.98	5,579	
29	21.73	4.43	5,933	
30	11.58	2.36	5,787	Philipsburg wastewater source
31	6.55	1.33	6,995	
32	26.42	5.38	5,837	
33	0.14	0.03	5,243	
34	15.36	3.13	7,234	
35	1.13	0.23	5,375	
36	34.71	7.07	5,847	East Fork Reservoir Diversion
37	8.50	1.73	6,304	
38	11.30	2.3	6,081	USGS flow gage
39	15.33	3.12	6,646	Georgetown Lake
40	14.46	2.95	7,226	
41	18.20	3.71	7,252	
Totals	**491.06**			

E3.5 HYDROLOGIC RESPONSE UNITS

Sub-basins were further divided into homogeneous landscape units, HRUs, which have unique soil, land cover, and slope combinations. HRUs have no spatial context within each sub-basin, meaning that the model does not account for the location of the HRU within the sub-basin or the spatial relation between multiple HRUs. In practical terms, all loadings of water, sediment, and nutrients from each HRU are added directly to the stream reach at the upstream end of the sub-basin without allowing movement of water, sediment, and nutrients between any of the other HRUs. A minimum threshold percentage of 2% was specified, meaning that soil, land use, or slope categories totaling less than2% of a sub-basin would be excluded from the HRU definition process (those small areas are then divided proportionally among the other HRUs in the sub-basin). The only exception to the 2% criteria was for low, medium or high residential density land uses, which had no minimum threshold for HRU delineation to maintain their effects to the watershed regardless of the area covered. The minimum threshold designation reduces the number of HRUs in the model and greatly reduces computational time without sacrificing accuracy. This process resulted in 1,505 HRUs delineated within the watershed. Management files for each HRU were written based on an understanding and estimation of activities that were occurring within the watershed which included: (1) cattle grazing on pasture, hay, and rangeland; (2) agricultural irrigation, fertilizing, harvesting; and (3) urban irrigation, fertilizing and grass cutting.

E3.6 Climatic Patterns

Climate data were obtained from a total of eight weather stations within or adjacent to the watershed, as described in **Section E2.2**. Because precipitation and air temperature vary with elevation, elevation bands were used to better simulate orographic effects for each sub-basin that had more than 100 meters of topographic relief. Elevation bands are used to determine a more accurate weighted average elevation for each sub-basin to provide a better climatic data; the bands are not used to calculate variation of climatic parameters within a sub-basin. Bands were generated from the SWAT topographic report and climatic information from the most proximal meteorological station was lapsed according to the elevation of the assigned climate station and each band. Lapse rates were determined based on seven climate stations for precipitation and eight climate stations for temperature (**Figure E3-2** and **Figure E3-3**, respectively). Precipitation and temperature lapse rates were calculated as 4.85 in/1,000 ft (r^2=0.84) and -3.6 ˚F/1000ft (r^2=0.97), respectively, which is similar to that reported in other Montana watersheds (Flynn and Van Liew, 2010; Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011). One of the precipitation stations, Warm Springs, was removed because it was likely overestimating precipitation as it is on the leeward side of the mountains (and thus collects additional wind-driven snow), it was significantly skewed from the regression curve of the other seven stations, and it was creating significantly higher runoff from the Flint Creek Range than was observed in the USGS gage at the mouth of Boulder Creek (Boulder Creek drains much of the high elevations portions of the Flint Creek Range and is thus a good location to check the accuracy of the snowmelt parameters in the model). To define which precipitation station is assigned to a particular sub-basin, SWAT identifies the closest defined meteorological station by its proximity to the centroid of the sub-basin. The station chosen by SWAT was then modified in some cases to match lower and higher elevation sub-basins to weather stations of similar elevations. Both temperature and precipitation information are then read from that station.

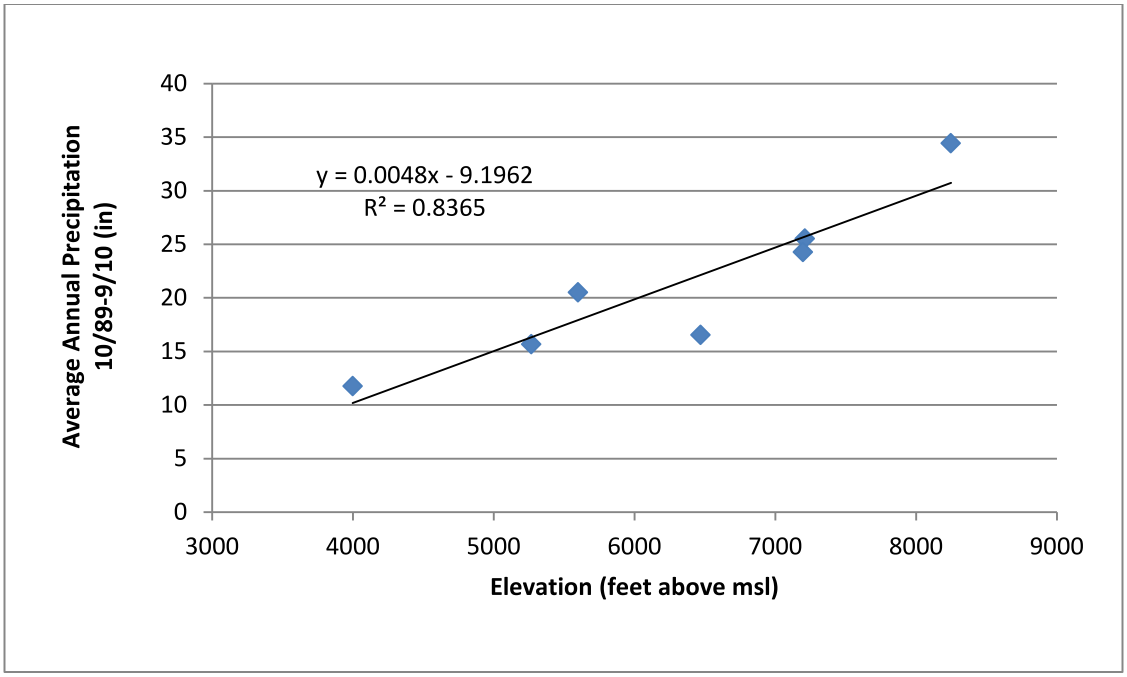

Figure E3-2. Precipitation Lapse Rate Used in the Flint Creek SWAT Model

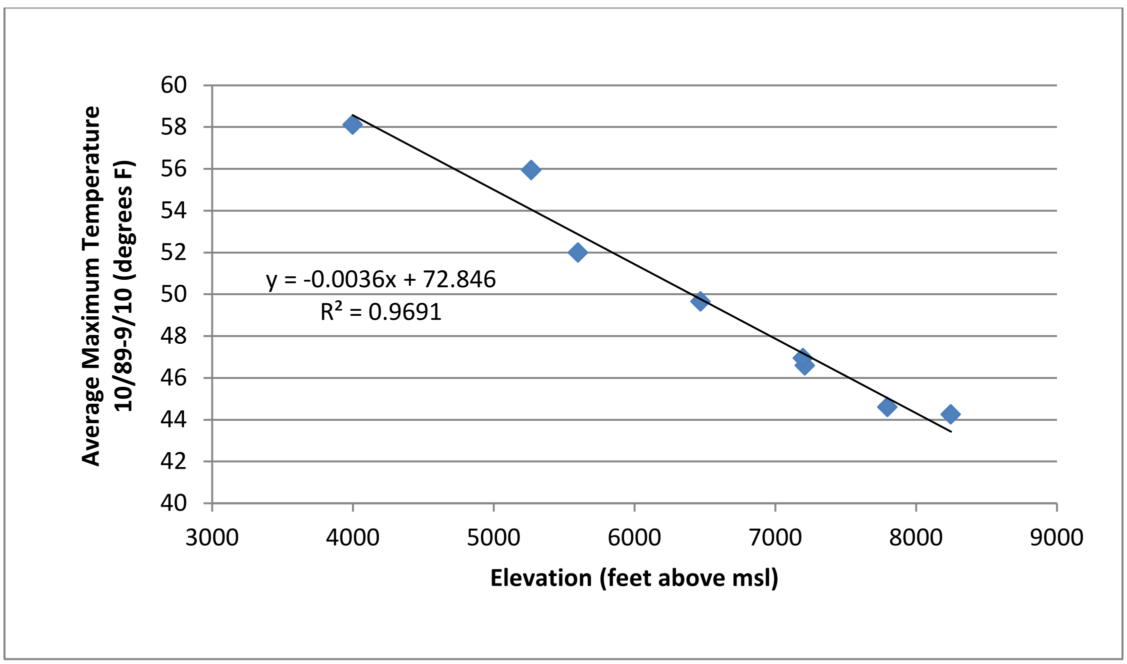

Figure E3-3. Temperature Lapse Rate Used in the Flint Creek SWAT Model

E3.7 Routing Geometry

The SWAT model automatically calculates channel dimensions for the main channel and tributaries based on drainage area regression statistics. One study has shown that the SWAT regression is not accurate for mountainous regions (Flynn and Van Liew, 2010). Field channel measurements were taken by the DEQ (Water & Environmental Technologies, 2010) and the USGS (Lawlor, 2004) for 20 stream reaches within the watershed, these values were used to define the channel geometry for the sub-basin they were collected in. Comparing the sub-basins with measured data versus that calculated by SWAT shows that SWAT consistently over-predicted both the bankfull channel width and the width-to-depth ratio. To correct the errors in sub-basins without direct measurements, a regression was created between the 20 sub-basins with measured data and the corresponding sub-basin values calculated in SWAT that regression was then used to extrapolate the channel morphology for the remaining 21 sub-basins. The regressed values were then used in the SWAT model in place of the SWAT calculated values.

Manning's n values (between 0.026 and 0.053) typical of natural stream systems were used (Federal Highway Administration, 2008) in place of the SWAT default values. Slightly higher values (increased roughness) were used for the tributaries than for the main channels. Manning's n values were varied slightly between sub-basins based on the width/depth ratio for that sub-basin reach. All routing coefficients can be found in **Attachment EC**.

E3.8 EVAPOTRANSPIRATION

Evapotranspiration is the combined loss of water from ground surface evaporation and by transpiration from plants, while the potential evapotranspiration rate describes how fast water vapor would be lost from a densely vegetated plant-soil system if soil water content was continuously maintained at an optimal level. In SWAT, three options exist for estimating potential evapotranspiration rate and subsequently evapotranspiration: the Penman-Monteith method (Monteith, 1965), the Priestly-Taylor method (Priestly and Taylor, 1972), and the Hargreaves method (Hargreaves and Samani, 1985). Measured potential evapotranspiration rate values can also be used if measurements are available. **Table E3-2** shows the data requirements of the three potential evapotranspiration rate methods listed from the method requiring the most to least data for the calculation. The Penman-Monteith method was used for this watershed.

Table E3-2. Data Requirements for SWAT-Available Potential Evapotranspiration Methods

Method	Air Temperature	Wind Speed	Relative Humidity	Solar Radiation
Penman-Monteith	Input	Input	Input	Input
Priestly-Taylor	Input	Not used	Input	Input
Hargreaves	Input	Not used	Not used	Not used

E4.0 MODEL CALIBRATION

Model calibration was completed numerically with commonly used error statistics, and qualitatively using graphical methods to visually compare the results when numerical evaluation was not appropriate. Three calibration sites were used, Flint Creek near Drummond, Flint Creek at Maxville and Boulder Creek at Maxville. The criteria and results are described in this section.

E4.1 SIMULATION PERIOD AND BOUNDARY CONDITIONS

The simulation was performed from 1989 through 2010. 1989 through 1991 was used as a "warm-up" period to allow some of the initialized variables to reach a steady-state. This lowers the reliance on initial values and initial value estimation procedures, as these parameters have several years in which to reach a steady-state. The model was then calibrated on the period 1997–2010, and validated on the period 1992–1996. Model calibration refers to the process of adjusting model parameters to obtain a fit to observed data. It is advantageous for the calibration period to include years of high and low flows, which are met with the chosen calibration period. Once the model adequately reproduces observed values, it is then run with another dataset from a different time period to re-test (validate) the performance of the model.

The annual daily mean streamflow at the Flint Creek near Drummond USGS gage shows that the modeled period was characterized by a wide range of both high and low flow years (**Figure E4-1**). For a scale of reference in **Figure E4-1**, the mean annual flow characterized by the "0" value on the y-axis is 125 cfs. While it is always ideal to have a representative time period, low flow periods are generally more reactive to nutrients stresses than high flow periods because low flow conditions often occur in the late summer when stream temperatures are warm. Warm water temperatures, slower flowing streams, and shallower water depths are all favorable conditions for algal growth and the resulting negative impacts to stream aesthetics and aquatic habitat. Because TMDLs must consider seasonality and the most critical time period for each pollutant, it is advantageous to have at least a portion of the simulation period with low flow water years which was achieved in the chosen model period.

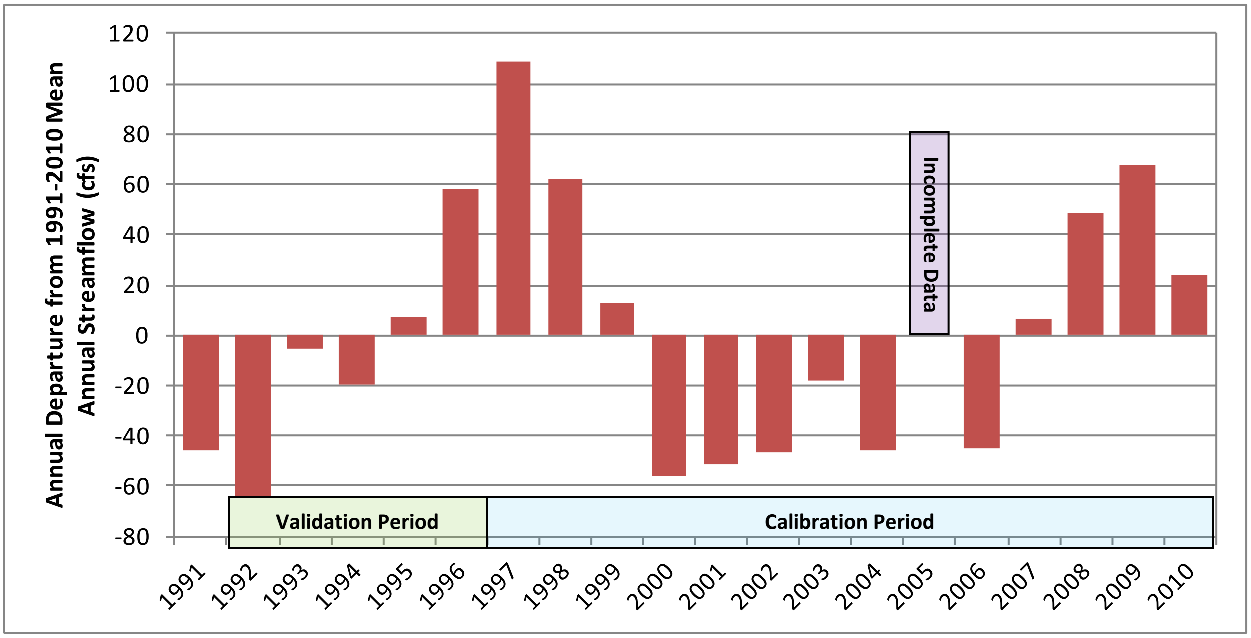

Figure E4-1. Departure from Mean Annual Streamflow for Flint Creek near Drummond USGS Gage

Boundary conditions are mostly geographic for this modeling effort (**Figure E4-2**). There is one intra-basin transfer of water as described previously from the East Fork Rock Creek Reservoir. There is also some water that exits the watershed directly into the Clark Fork River separate from the water in Flint Creek (Voeller and Waren, 1997). That water flows out through Lorranson Creek west of Flint Creek, and is likely due to the Allendale Canal diversion (Voeller and Waren, 1997). Based on 22 measurements by DNRC in 1994 through 1996 and 6 months of daily monitoring by the USGS in 1995, the flow in Lorransen Creek varies from less than 1 cfs up to 15 cfs.

E4.2 Water Budget

The overall output water budget is shown in **Table E4-1**. This is from the standard output file in SWAT (output.std) and shows the annual average water budget for the modeling period. Although this data is not used for the calibration, it does provide a check on the overall water budget values. The ratio of surface runoff to precipitation and evapotranspiration to precipitation are similar to those observed in other modeling efforts in western Montana (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011) and in other semi-arid climates (Tateishi and Ahn, 1996).

Table E4-1. Average Annual Water Budget Values (from the SWAT output.std File)

Parameter	Value (in/year)	Percentage of Precipitation (%)
PRECIPITATION	19.7	-
SNOWFALL	11.0	55.9%
SNOWMELT	10.1	51.1%
SUBLIMATION	1.1	5.6%
SURFACE RUNOFF FLOW	0.8	4.1%
LATERAL SOIL FLOW	2.1	10.9%
DEEP AQUIFER RECHARGE	1.5	7.7%
TOTAL AQUIFER RECHARGE	6.1	30.9%
EVAPOTRANSPIRATION	13.4	68.3%

E4.3 Evaluation Criterion

Two model performance statistics were used to assess monthly and daily predictions of the SWAT model. The first is relative error, which is a measure of the average tendency of simulations to be larger or smaller than an observed value. Relative error is defined as the deviation between simulated ($Y_{i,sim}$) and observed ($X_{i,obs}$) values, where optimal relative error is 0.0, and positive and negative values reflect bias toward over- or under-estimation of measured values, respectively. Van Liew et al. (2005) suggested relative error values <±20% are "good," while more strict guidelines have been suggested elsewhere. For the purpose of this project, due to the high amount of irrigation effects, which were difficult to simulate, relative error < ±20% was considered to be sufficient for model calibration. Relative error is calculated as:

Table E4-2. SWAT Calibration Parameters

Parameter	Description	Calibrated Value[1]	Range of Values Tested in Calibration[1]	SWAT Suggested Range[1]	Units
SFTMP	Snowfall temperature	5.0	(-1)–5	(-5)–5	°C
SMTMP	Snowmelt base temperature	2.5	1–4	(-5)–5	°C
SMFMX	Melt factor for snow on June 21	3	1–5	0–10	mmH_2O/°C-day
SMFMN	Melt factor for snow on December 21	2	0.5–3	0–10	mmH_2O/°C-day
SNOCOVMX	Minimum water that corresponds to 100% snow cover	100	40–100	0–500	mm H_2O
SNO50COV	Fraction of snow volume that corresponds to 50% cover	0.1	0.1–0.8	0–1	Dimensionless
TIMP	Snowpack lag factor	0.01	0.01–0.2	0–1	Dimensionless
SURLAG	Surface runoff lag time	1	0.05–4	1–24	Days
SPCON	Linear parameter for sediment re-entrainment	0.0001	0.0001–0.001	0.0001–0.01	Dimensionless
SPEXP	Exponent parameter for sediment re-entrainment	2.2	1–2.2	1–2	Dimensionless
ESCO	Soil evaporation compensation factor	0.95	0.1–0.95	0–1	Dimensionless
EPCO	Plant water uptake compensation factor	1	0.4–1	0–1	Dimensionless
SLOPE	HRU slope steepness	0.006–0.71	NA	0–1	m/m
SLSUBBSN	Average slope length	9–121	9–121	0–90	m
GW_DELAY	Delay time for aquifer recharge	250	30–250	0–500	Days
ALPHA_BF	Base flow recession constant	0.4	0.1–0.9	0–1	Days
GW_REVAP	Revap coefficient	0.2	0.1–0.2	0.002–0.2	Dimensionless
REVAPMN	Threshold depth for "revap" to occur	100	100–250	0–1,000	mm
GWQMN	Threshold depth for return flow to occur	100	100–1,000	0–1,000	mm
RCHRG_DP	Deep aquifer percolation fraction	0.25	0.05–0.25	0–1	Fraction
CH_K(2)	Effective hydraulic conductivity of main channel	64, 640	1–640	0–1,000	mm/hr
CH_COV1	Channel erodibility factor	0.6	0.25 – 0.6	0–1	Dimensionless
CH_COV2	Channel cover factor	0.50	0.25 – 0.5	0–1	Dimensionless
CN	Curve Number	25–92	25–92	25–92	Dimensionless
USLE_C	cover management factor	0.001–0,03	0.001–0.03	0.001–0.5	Dimensionless

(1) Multiple values or range of values indicates multiple values used for different sub-basins, HRUs, crop types, or soil types

There are four USGS streamflow gages in the watershed with sufficient data for calibration (**Figure E4-2**) and three were used for calibration: Flint Creek at Maxville; Boulder Creek at Maxville; Flint Creek near Drummond. The fourth gage (Flint Creek near Southern Cross) was not used because of its proximity to the upstream Flint Creek Dam at Georgetown Lake; the streamflow data from this gage were used in the model as the daily discharge from the dam as there are insufficient records of direct dam releases. The most downstream gage, Flint Creek near Drummond, is 1.7 miles above the confluence of Flint Creek and the Clark Fork River. The flows in Flint Creek at its confluence with the Clark Fork River are generally larger than at the upstream USGS gage due to groundwater inflows. From April 26 through November 8, 1995, daily flow measurements were collected at the mouth of Flint Creek. During that time period, the average flow at the mouth was 9.3 cfs higher than measured at the Flint Creek near Drummond gage.

The runoff contribution area to the uppermost calibration point in the SWAT model, Flint Creek at Maxville gage, includes the southern two-thirds of the watershed including various land uses from un-altered forested and range land, human-altered irrigated and grazed land, and a large reservoir (**Figure E4-2**). The next calibration point is the Boulder Creek at Maxville gage. The runoff contribution area to this gage is primarily unaltered range and forest land and a large portion of this sub-watershed is comprised of high elevation terrain. This gage is located above the mouth of Boulder Creek; Boulder Creek enters Flint Creek immediately below the Flint Creek at Maxville gage. The final calibration point, Flint Creek near Drummond gage, combines the flow from the previous two gages and collects runoff from un-altered forested and range land in addition to human-altered irrigated and grazed land.

The Boulder Creek at Maxville USGS gage is used as a comparison to other gages in the watershed (see **Figure E4-2**) because the sub-basins that drain to the Boulder Creek gage have little irrigation influences. Without significant irrigation effects, the Boulder Creek hydrograph has a smoother and more natural shape than the two other calibration points that have significant irrigation influences.

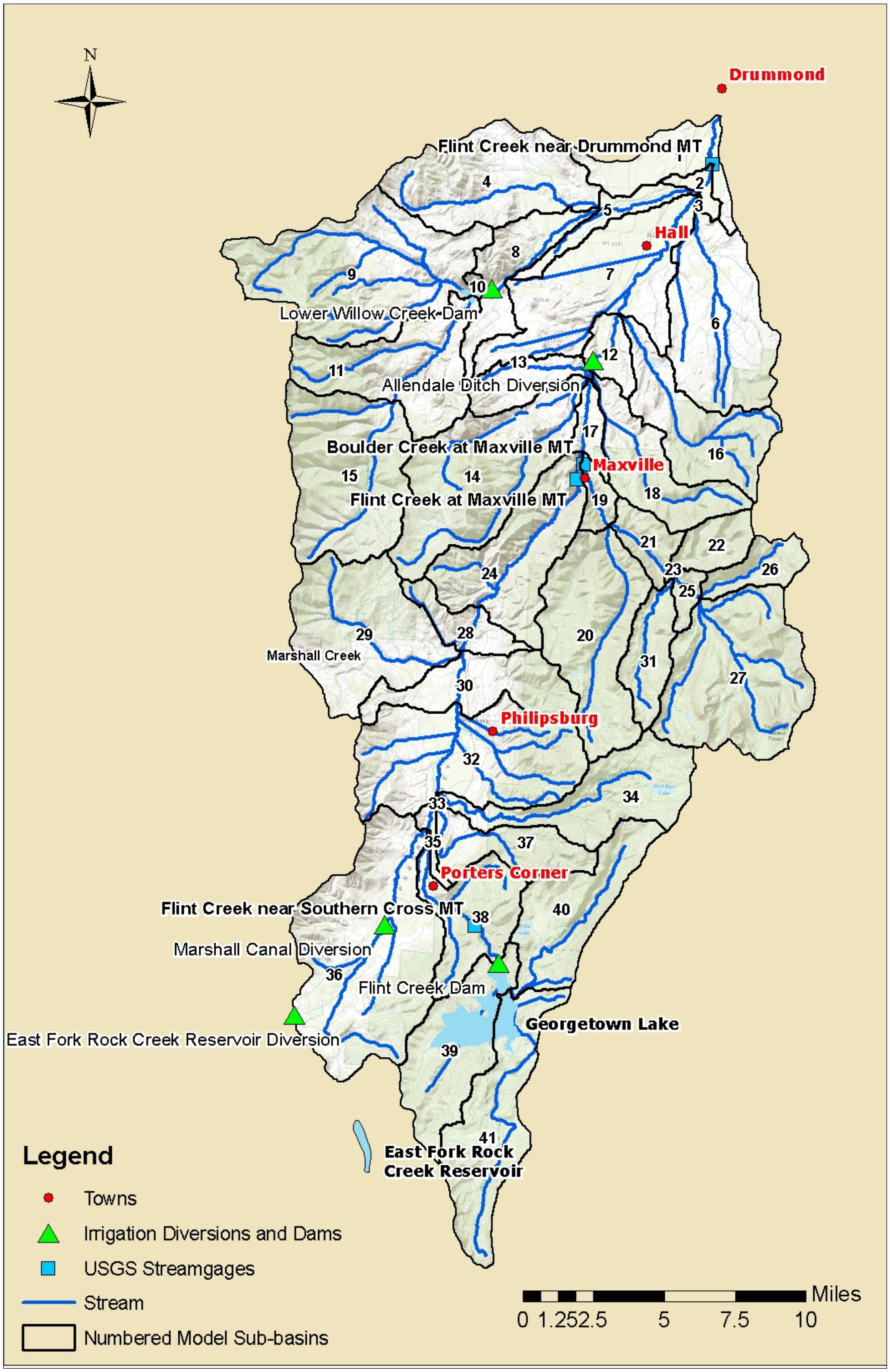

Figure E4-2. Hydrology Gages and Irrigation Diversions in the Flint Creek Watershed

Error statistics were substantially better for the Boulder Creek at Maxville site compared with the two sites located on Flint Creek (see **Table E4-3**). This is likely due to the amount of water diverted and irrigation associated with Flint Creek that is not present in the sub-watersheds contributing to Boulder Creek. Despite the complexity of human-caused influences in the Flint Creek watershed both error criteria were met annually for the three calibration sites. Error statistics are also presented for the growing season (July 1 through September 30) as that is the time when nutrients create the most significant effects on surface waters. During the growing season the relative error criteria were also met for all three stations, but the Nash-Sutcliffe coefficient of efficiency criteria were not met for both Flint Creek stations. Those error criteria at the Flint Creek sites would likely improve significantly with more accurate diversion timing and flow volumes.

Table E4-3. Daily Calibration Metrics (1997–2010)

USGS Gage	Time Period[1]	Measured Mean Total Volume (acre-feet)	Simulated Mean Total Volume (acre-feet)	Relative Error (%)	Nash-Sutcliffe Error
Flint Creek at Maxville	Annual	910,538	859,982	-5.6	0.44
	Growing Season	269,323	243,546	-9.6	-0.02
Boulder Cr. at Maxville	Annual	423,919	472,300	11.4	0.71
	Growing Season	77,512	82,265	6.1	0.56
Flint Cr. near Drummond	Annual	1,124,856	1,052,820	-6.4	0.41
	Growing Season	183,747	170,610	-7.2	0.35

(1) Growing season time period is July 1 through September 30

E4.4.1 Flint Creek at Maxville Streamflow Calibration

The average of the calibrated daily flows from 1997 to 2010 at the bottom of the SWAT model sub-basin 24 are compared to the average of the measured flows for the Flint Creek at Maxville USGS gage in **Figure E4-3**. Average daily flows over the time period are used here rather than the running hydrograph over the 14 years of the calibration period as trends are easier to discern and discuss. The complete 19 year hydrographs (including both the calibration and validation time periods) are provided in **Attachment ED**.

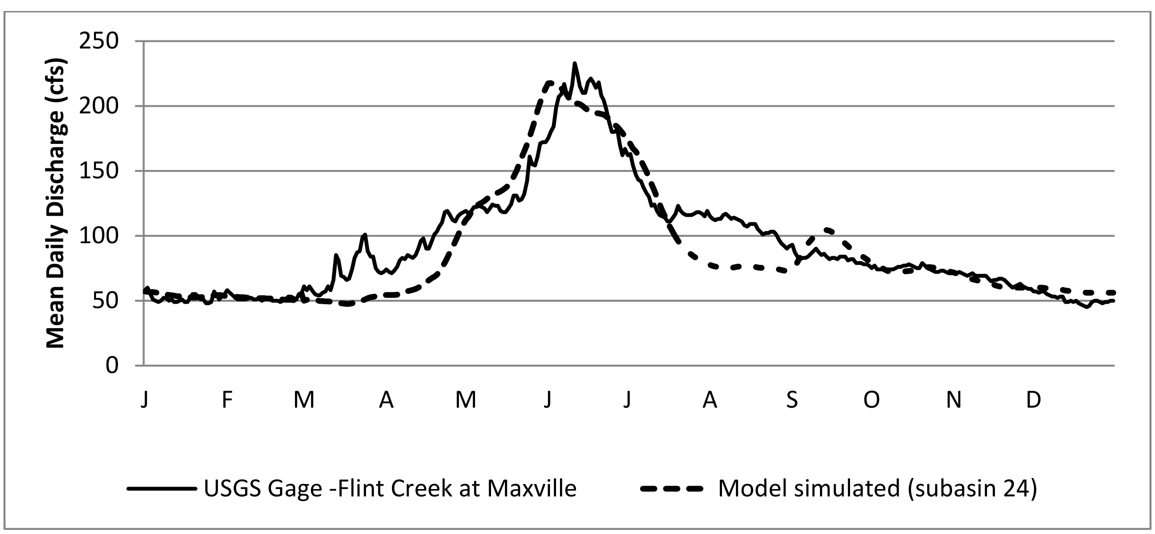

Figure E4-3. Mean Measured (1997–2010) and Mean Simulated (1997–2010) Daily Hydrology for the Flint Creek at Maxville USGS Gage

The annual water balance was well within the +/-20% relative error criteria at -5.6% (meaning the simulated values under-predict the measured values), the growing season relative error (July through September) was also acceptable at -9.7% (**Table E4-3**). The Nash-Sutcliffe coefficient of efficiency values were acceptable during the annual period (0.44) but were unacceptable during the growing season (-0.02). The poor Nash-Sutcliffe coefficient of efficiency for the growing season is primarily due to an unnatural flattening of the measured hydrograph that begins around mid-July and lasts into early August (**Figure E4-3**). The term “unnatural” is used as in comparison to a stream gage that drains primarily unaltered land such as the Boulder Creek at Maxville gage. The hydrograph flattening is likely due to irrigation return flows from the early season flood irrigating that occurs in the Philipsburg area, and is not being accurately re-created in the model. Rather, the SWAT model predicts the hydrograph rise from return flow to occur in September when irrigation diminishes in the valley. A DNRC study (Voeller and Waren, 1997) noted that return flows occur quicker in this area of the watershed than in other sections and attributed that mainly to two causes. The first is a shallow water table that has limited capacity to store irrigation water, and the second is a shallow clay layer seen in one well that may create nearly direct runoff conditions for excess irrigation water in some parts of this area. Attempts to re-create this early return flow trend by modifying groundwater parameters that control the rate of groundwater movement to stream reaches (ALPHA_BF, GW_DELAY and GWQMN) were not successful. The earlier than expected rise in the hydrograph does not appear to be a function of reduced irrigation diversions after the early July alfalfa and hay cutting because according to limited 1994–1996 flow measurements (Voeller and Waren, 1997) from the Marshall Canal diversion, the diversions do not appear to be reduced in late July or August as compared to June or early July values. Although, there is only one cutting of hay/alfalfa in this area around early July, the irrigators continue to irrigate those fields after the first cutting to promote healthy vegetation for the following year (Montana State University County Extension Agent, Lucas, Dan, personal communication 4/23/2013). Additional evidence that irrigation continues through the end of summer is supported by limited 1994–1996 flow measurements (Voeller and Waren, 1997) at the mouth of Marshall Creek (which drains the water remaining in the Marshall Canal after it flows through the irrigated areas) below Philipsburg which does not show any noticeable increase in flows after the harvest in early July.

During the modeling period there has been some conversion of flood irrigated land to sprinkler irrigation which may have slowly altered the hydrograph between 1989 and 2010, but this change in irrigation practice is not discernible in the hydrograph (**Attachment ED**).

Other portions of the annual curve have noticeable differences between the simulated and measured streamflows (**Figure E4-3**). The simulated annual peak occurs slightly earlier than the measured peak which is primarily related to spring snowmelt parameters used in the model (specifically SMTMP and TIMP, see **Table E4-2**). These controlling factors are defined on a watershed basis and cannot be specified on a sub-basin or HRU level in the SWAT model. Therefore, those parameters were set at values that on average worked best for all three calibration points. Those parameters could be varied to provide a better match to the annual peak at this calibration site, but that would decrease the correlation at the other calibration sites.

During the calibration process the simulated streamflow at this location was consistently lower than the measured streamflows. This difference was particularly noticeable during base flow periods in the fall and winter when the difference was consistently around 15 cfs. This consistent under-estimation indicated that a constant source unrelated to more transient climate and irrigation effects may not have been accounted for in the model. Water seepage into the groundwater from Georgetown Lake was the most obvious unaccounted groundwater source. SWAT allows the user to specify the seepage rate from a reservoir to maintain the correct water levels in the reservoir but then that water is lost from the system – it does not go into groundwater. Therefore, the leakage from Georgetown Lake had to be added to the system as a point source in a lower sub-basin (sub-basin 38 was used). Using existing lake morphology data and reasonable values from published hydraulic conductivity tables, an average constant seepage rate that matched the 15 cfs discussed above was calculated. The data used included an estimated average area of Georgetown Lake at its normal level, 2,122 acres (Stafford and Ahl, 2011), and an estimate of lake bottom sediments hydraulic conductivity of 0.01 ft/day. The hydraulic conductivity of the lake bottom sediments was used to estimate the long-term lake infiltration rate (Bouwer, 2002). Because there is no site-specific information available (Stafford and Ahl, 2011), the hydraulic conductivity of the lake sediments was estimated from near the middle of the range of silty materials (Freeze and Cherry, 1979). The additional 15 cfs slightly improved the Nash-Sutcliffe coefficient of efficiency for the Flint Creek at Maxville gage, and also provided an improved visual match between simulated and measured values.

The growing season values were more difficult to calibrate due to higher variability in natural effects (e.g., evapotranspiration, plant uptake, and precipitation events), and human-caused effects (e.g., irrigation, water diversions, return flows, etc.). Also, due to low summer flows, a small difference in simulated versus observed flows can create a large difference in the error metrics. Additionally, the year-to-year variability of irrigation practices makes it difficult to simulate accurately. In high runoff years irrigators use more water, and in low years they use less. This trend is difficult to capture in the management files because most diversion volumes are not available. While the model does limit irrigation when streamflows get too low, it still cannot provide an exact replication of actual landowner practices year to year. Growing season flow calibration involved manipulation of groundwater and lateral flow parameters to increase base flow accuracy in the SWAT model. Parameters in the groundwater module, ALPHA_BF, GWQMIN, and GW_DELAY (see **Table E4-2**), which can control the movement of groundwater, were adjusted to better calibrate to the irrigation related trends in the hydrograph. One source of error may have been the diversions from the East Fork Rock Creek Reservoir, but the error metrics for years with measured diversion rates were not better than those years with extrapolated diversion rates. Better calibration might be achieved with a detailed groundwater model of the watershed but one does not exist for this watershed.

The poor metrics for the growing season versus the annual results indicate that the information supplied to the SWAT model is not as accurate in characterizing certain parameters during the growing season months. To determine possible causes for the poor growing season metrics the results from this calibration point, which has human-caused influences, was compared to another calibration point (Boulder Creek at Maxville) that has little active human-caused influences. Based on the good annual and growing season metrics observed at the Boulder Creek calibration point, the poor results at the Flint Creek at Maxville site are determined to be due human-caused stressors (rather than errors in climatic parameterization) that are not being adequately quantified in the SWAT model. Those stressors could be related to irrigation practices, or irrigation diversions. One possible explanation is that there have been water calls by senior water rights holders on junior water rights in the watershed during the modeling period that have not been included in the model. Information on whether specific water calls occurred during the modeling period are not available, but if some did occur it would have most likely been during the western Montana drought in the late 1990s and early 2000s (Montana State University County Extension Agent, Lucas, Dan, personal communication 4/23/2013). Those drought years are apparent in the USGS hydrographs (**Attachment ED**). If widespread water calls had occurred it could have a significant effect on streamflows for specific years that the SWAT model could not accurately simulate. As mentioned previously, quick irrigation return flows into Flint Creek that the model did not replicate may also be causing the differences between measured and simulated water levels.

E4.4.2 Boulder Creek at Maxvillle Streamflow Calibration

The average of the calibrated daily flows from 1997 to 2010 at the bottom of sub-basin 19 are compared to the average of the measured flows for the Boulder Creek at Maxville USGS gage in **Figure E4-4**. Average daily flows over the time period are used here rather than the running hydrograph over the 14 years of the calibration period as trends are easier to discern and discuss. The complete 19 year hydrographs (including both the calibration and validation time periods) are provided in **Attachment ED**.

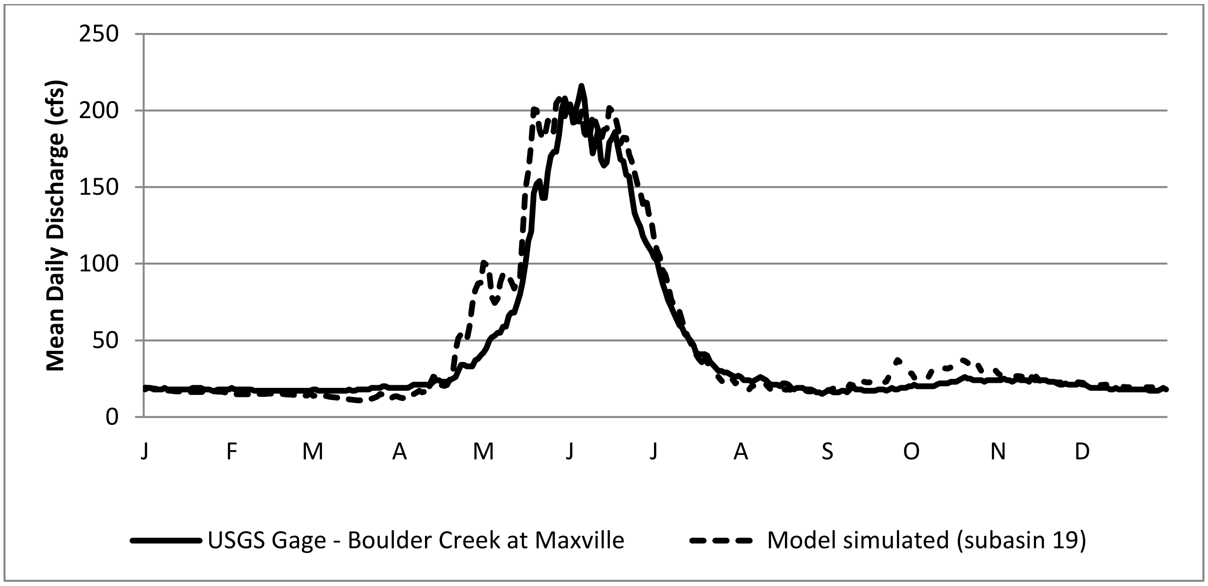

Figure E4-4. Mean Measured (1997–2010) and Mean Simulated (1997–2010) Daily Hydrology for the Boulder Creek at Maxville USGS Gage

The annual water balance was good and within the +/-20% relative error criteria at 11.4% (simulated values over-predict), the growing season (July through September) was better at 6.1% (**Table E4-3**). The Nash-Sutcliffe coefficient of efficiency values were good during both the annual period (0.71) and during the growing season (0.56). Of the three calibration points, this gage is the one that has very little active irrigation effects or other current human-caused effects, and subsequently has the best calibration statistics of the three. The only noticeable differences between simulated and measured are during the spring runoff period from early April to mid-June. This difference could have been reduced by modifying some of the snowmelt parameters such as SMTMP and TIMP (see **Table E4-2**), however, that would have created greater differences in the two other streamflow calibration points as those values are defined on a watershed basis and cannot be specified on a sub-basin or HRU level in the SWAT model. The SMTMP and TIMP parameters were set at values that provided the best overall fit to all three gages. This gage drains primarily high elevation mountainous terrain, which could partially account for the different spring runoff characteristics compared to the other gages that include more variable land uses.

Another feature in the simulated hydrograph is a short term fluctuation and flattening of the curve in early May. This gage drains sub-basins that are nearly entirely comprised of rangeland and forest that have their growing season set to begin on May 1 of each year in the SWAT model. The fluctuation shows the onset of plant water uptake in the SWAT model on that date.

E4.4.3 Flint Creek near Drummond Streamflow Calibration

The average of the calibrated daily flows from 1997 to 2010 at the bottom of the SWAT model sub-basin 2 are compared to the average of the measured flows for the Flint Creek near Drummond USGS gage in **Figure E4-5**. Average daily flows over the time period are used here rather than the running hydrograph over the 14 years of the calibration period as trends are easier to discern and discuss. The complete 19 year hydrographs (including both the calibration and validation time periods) are provided in **Attachment ED**.

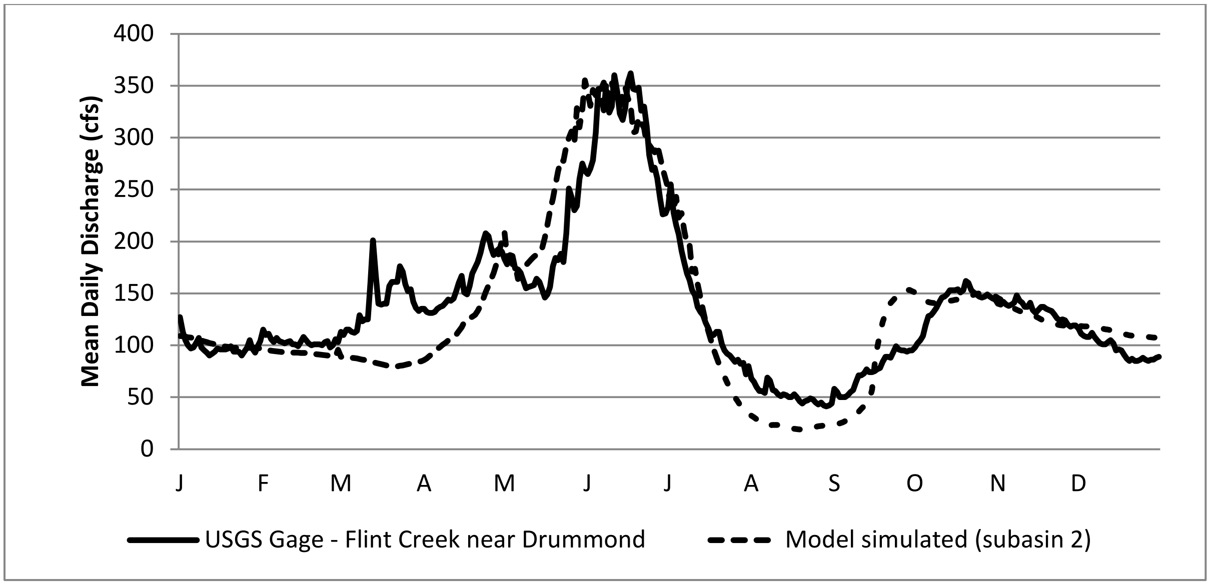

Figure E4-5. Mean Measured (1997–2010) and Mean Simulated (1997–2010) Daily Hydrology for the Flint Creek near Drummond USGS Gage

The annual water balance was good and within the +/-20% relative error criteria at -6.4% (simulated values under-predict), the growing season (July through September) was also good at -7.2% (**Table E4-3**). The Nash-Sutcliffe coefficient of efficiency values were acceptable during the annual period (0.41) and lower during the irrigation season (0.35) but still acceptable given the difficulties matching irrigation effects. This gage includes the combined flow of the other two gages; it is below the Allendale canal diversion and several other irrigation diversions. The average daily streamflow at the Flint Creek near Drummond gage is less than the combined flow of the other two upper gages from early May to early October due to irrigation diversions and possibly groundwater seepage (see **Figure E2-2**). For the remainder of the year, the streamflow at this gage is greater than the combined flow of the other two gages.

The mean simulated streamflow is consistently higher than the mean measured streamflow (see **Figure E4-5**) during the spring and early summer months by up to 50 cfs. Part of this discrepancy may be due to outflows from the watershed via groundwater, irrigation ditches, and springs that are modeled in SWAT as exiting the watershed in Flint Creek. Those types of outflows were reported to combine for an additional 35 cfs during the summer months and 20 cfs for the remainder of the year (Voeller and Waren, 1997).

Both the measured and simulated hydrographs show an unnatural and pronounced decrease in flow in early May as the spring runoff is beginning due to the onset of irrigation diversions. The simulated hydrograph provides a good match to the measured values early in the growing season but in September there are significant differences between the two. The measured hydrograph shows an unnatural and steady rise in the hydrograph from late August through mid-October. This rise is most likely due to a combination of early season irrigation return flows and the gradual decrease in irrigation diversions as the growing season ends. The SWAT model mimics this rise, although at a much faster rate than is observed. This portion of the hydrograph could not be simulated better because there was no information available as to when each diversion is turned off at the end of the growing season. Without specific knowledge of how each landowner reduces or turns off irrigation diversions, the irrigation season was ended on a specific date every year in the SWAT model. Another reason for the poor match is that the measured hydrograph in **Figure E4-5** is using mean values and the gradual rise of the USGS gage hydrograph is an average of 14 years which, in this case, smooths out the actual rapid rise in streamflow that is seen at the end of each individual irrigation season. The annual more rapid rise is evident in the 19 year running hydrograph (**Attachment ED**). Therefore, the model results have a better year-to-year match to the late growing season shape of the measured hydrograph than is depicted in **Figure E4-5**.

E4.4.4 Hydrology Calibration Summary

The growing season metrics are not as good as the annual metrics, which is most likely due to the inability to properly simulate irrigation diversions on a day to day basis. However, based on the good growing season metrics for the Boulder Creek at Maxville gage, the framework of the SWAT model accurately represents the hydrology prior to management diversions. Therefore, with regards to the hydraulics calibration, the model is a valid tool for its intended purpose of estimating changes in nutrients loadings with changing management scenarios.

E4.5 Hydrology Validation

Model validation is the independent process by which a model is tested against “new” data, usually from a different time period than the calibration period. If the calibrated model predicts the validation period, it is considered to be “validated.” A validated model provides more confidence that the model can predict future conditions.

The calibrated model was run for the 5-year validation time period 1/1/1992 through 12/31/1996. The annual validation results were similar to the calibration results (**Table E4-4**). All the relative error values were within the +/- 20% acceptable value, however one of the Nash-Sutcliffe coefficient of efficiency values (for the Flint Creek near Drummond (gage)) was 0.34, slightly below the acceptable value of 0.36. The growing season validation metrics varied in relation to the calibration metrics. For the Boulder Creek at Maxville gage the growing season validation statistics were substantially worse than the growing season calibration statistics (**Table E4-4**). At that gage the SWAT model was accurate in predicting the hydrograph trends during the validation period with a coefficient of determination (r^2) value of 0.84 for the simulated versus measured values; however, streamflow volumes were consistently over-predicted, which provided a large relative error (42.5%) and a low Nash-Sutcliffe coefficient of efficiency (-0.29). Based on measurements at the Boulder Creek at Maxville gage, the 5 years previous to the start of the validation period had cumulative annual streamflows that were 18 to 42% lower than the 1989–2010 average for that gage. The poor growing season metrics for the Boulder Creek at Maxville gage may have been caused by the model not being able to account for the unusually dry conditions that existed prior to the model period causing the model to over predict flows in the earlier years of the model period. In contrast, while the SWAT model over-predicted growing season flows at the Boulder Creek gage, it under-predicted flows at the other two calibration gages (**Table E4-4**). These contradictory errors are possibly due to changes in irrigation diversions, withdrawals and timing related to the drought period prior to and at the start of the validation period. The growing season validation metrics for the Flint Creek at Maxville gage are mixed compared to the calibration metrics – the relative error has increased from -9.6% to -21.7%, but the Nash-Sutcliffe coefficient of efficiency has improved from -0.02 to 0.2.

Table E4-4. Daily Validation Metrics (1992–1996) Compared with Calibration Metrics

USGS Gage	Time Period(1)	Relative Error (%) [calibration period metric]	Nash-Sutcliffe Error [calibration period metric]
Flint Creek at Maxville	Annual	-11.6 [-5.6]	0.36 [0.44]
	Growing Season	-21.7 [-9.6]	0.20 [-0.02]
Boulder Cr. at Maxville	Annual	15.4 [11.4]	0.71 [0.71]
	Growing Season	42.5 [6.1]	-0.29 [0.56]
Flint Cr. near Drummond	Annual	-2.1 [6.4]	0.34 [0.41]
	Growing Season	-14.7 [-7.2]	0.63 [0.35]

(1) Growing season time period is July 1 through September 30

A visual representation of the hydrology validation is provided for each location in **Figures E4-6, E4-7** and **E4-8**, which show the average of the 1992–1996 USGS measured flows as compared to the average of the daily flows from 1992 to 1996 predicted by the SWAT model at each of the three calibration locations. Average daily flows over the time period are used here rather than the running hydrograph over the 5 years of the validation period as trends are easier to discern and discuss. The complete 19 year hydrographs (including both the calibration and validation time periods) are provided in **Attachment ED**.

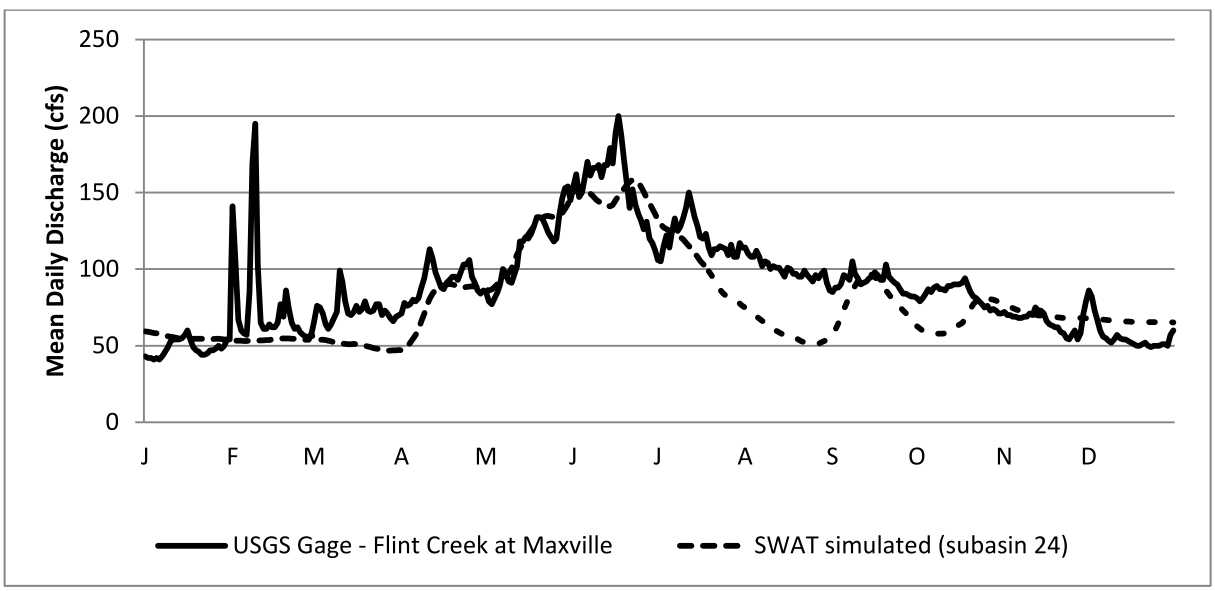

Figure E4-6. Mean Measured (1992–1996) and Mean Simulated (1992–1996) Daily Hydrology for the Flint Creek at Maxville USGS Gage

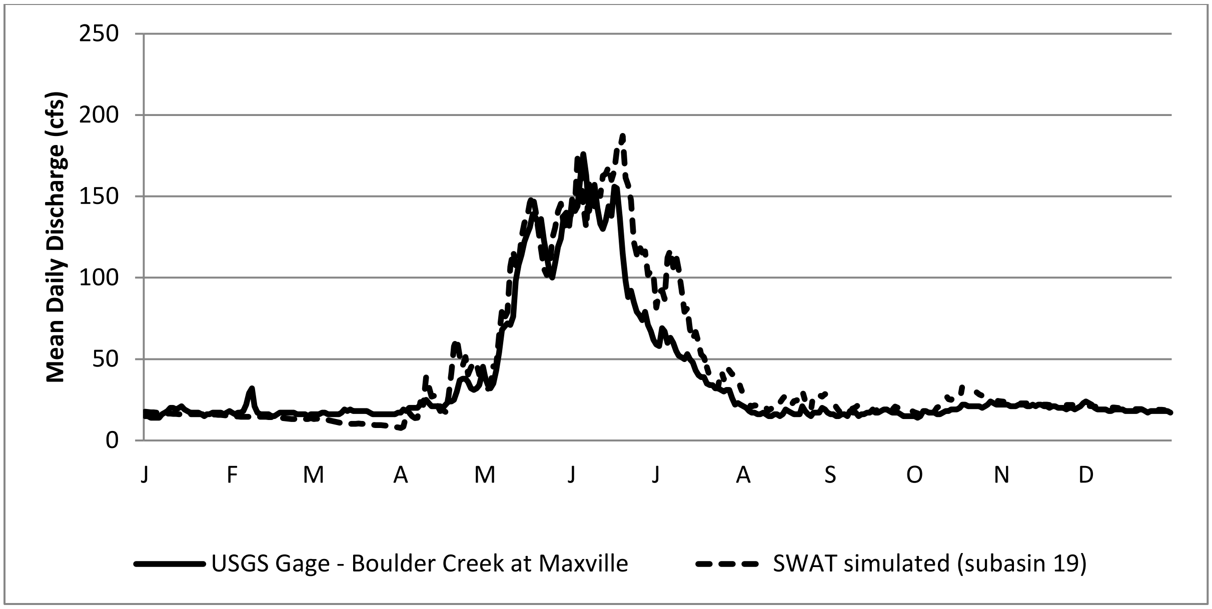

Figure E4-7. Mean Measured (1992–1996) and Mean Simulated (1992–1996) Daily Hydrology for the Boulder Creek at Maxville USGS Gage

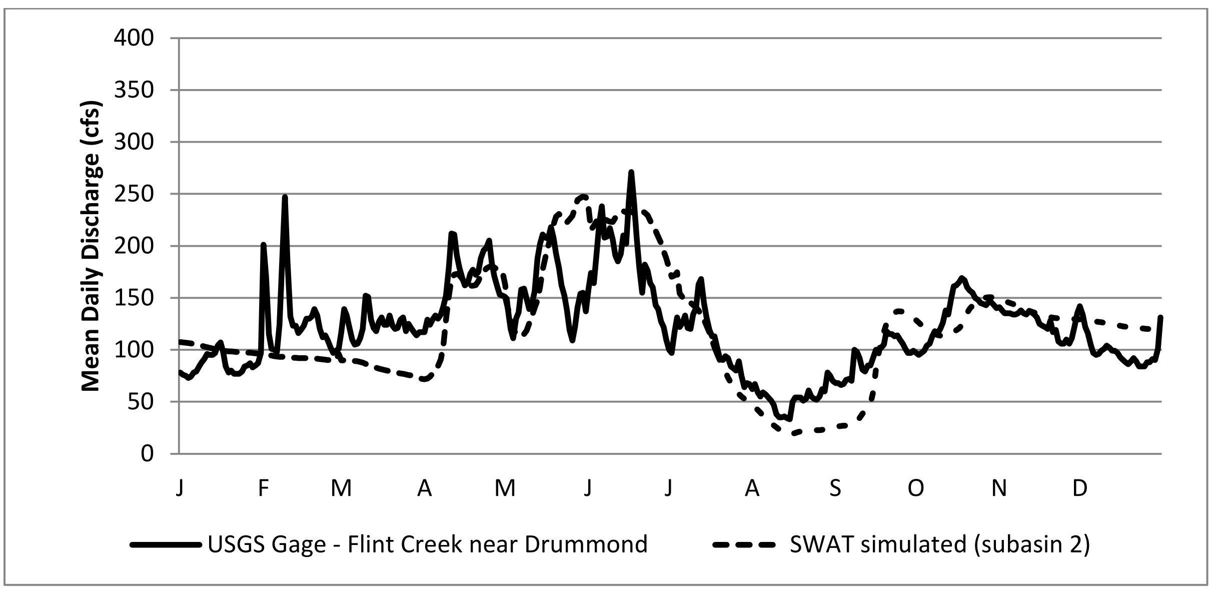

Figure E4-8. Mean Measured (1992–1996) and Mean Simulated (1992–1996) Daily Hydrology for the Flint Creek near Drummond USGS Gage

The validation results demonstrate some of the same inaccuracies as seen with the calibration period, primarily due to lack of specific field-level information on land management practices, and in some cases magnified due to the shorter averaging period. As discussed in the calibration summary, the results are considered acceptable for the intended purpose of the model to compare and choose best management practices (BMPs) for reducing nutrients loadings to streams and ultimately meet instream water quality targets.

E4.6 SEDIMENT CALIBRATION

The SWAT model is not being used to develop a sediment TMDL which was previously completed (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012a). However, because the sediment loading to streams includes delivery of nutrients attached to the sediment, it is necessary to calibrate the sediment prior to calibrating the nutrients loads.

Sediment is delivered to the end of each stream reach (each sub-basin in the SWAT model has one stream reach) by two separate processes – sediment delivery and sediment routing. Sediment delivery is the process by which sediment is washed off of the land surface and carried into the river channel. This happens during runoff events, and is modeled by SWAT using the Modified Universal Soil Loss Equation. Sediment routing within the river channel is a separate process where sediment can either be deposited in the river channel or sediment degradation can cause channel erosion and pick up sediment on its way to the end of the stream reach. The amount of deposition or erosion depends on factors such as the size of sediment particles, stream velocities, and streambank stability.

The Modified Universal Soil Loss Equation includes factors to account for water runoff rates, soil erodibility, cover and management, support practice (e.g., contour tillage, strip-cropping on contour, and terracing), topography, and coarse soil fragment percent. The cover and management factor in the equation is referred to as the Universal Soil Loss Equation (USLE) C (Universal Soil Loss Equation cover and management factor) and is one of the variables in the Modified Universal Soil Loss Equation that can be varied by the model user to reflect local conditions. Due to changes in cover during the growing season (e.g., plant growth, harvest, etc.) the USLE C values are re-calculated by SWAT daily by modifying a user-specified minimum USLE C factor. The default USLE C minimum values recommended in SWAT were used in the model (**Table E4-5)**.

Table E4-5. Minimum USLE C factors

Land Use	Minimum USLE C factor
Forest	0.001
Hay/Pasture	0.003
Range	0.003
Alfalfa	0.01
Spring Wheat	0.03
Barley	0.01
Urban	0.003

Another factor in the Modified Universal Soil Loss Equation is the soil erodibility factor (USLE K) – this value is derived in SWAT using information from the NRCS STATSGO soil database, but is not taken directly from the value listed in STATSGO. The USLE K value used in the SWAT model may therefore vary from the value previously used directly from STATSGO for the previously completed sediment TMDLs (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012a).

Statistical calibration (e.g., the Nash-Sutcliffe coefficient of efficiency method) of the sediment loads was not conducted because sediment data had not been collected on a frequent or regular schedule (see **Table E2-3)** to provide meaningful results using a statistical method. Instead visual matching was conducted for impaired streams with the several data points available for each stream. In addition, an annual sediment load rating curve was employed on the one location that had a longer-term record of sediment measurements, the Flint Creek near Drummond USGS gage that has 97 measurements during the model period. A sediment load rating curve uses the relationship between the days that both sediment concentrations and streamflow measurements are available to predict sediment loads in relation to measured streamflow rates. The USGS gage has daily streamflow rates for most of the model period, which provides the necessary flow data to prepare the load rating curve. The sediment load rating curve was evaluated on a logarithmic scale, and using the available streamflow data from the USGS gage provided an average sediment load of 39,554 lb/day during the modeling period (**Figure E4-9**). The model estimated an average sediment load of 47,619 lb/day at the gage, which is within 20% of the load rating curve estimate. This is an acceptable error given the relatively small number of available sediment measurements. Visual matching of measured versus predicted sediment concentrations for the other impaired streams provided adequate matches (graphs of daily simulated sediment concentrations and measured concentrations are provided in **Attachment EE**). The simulated concentrations in **Appendix E** are daily averages, and thus can vary significantly from the instantaneous measured values because sediment loads can be highly variable within a single day particularly during spring runoff and summer thunderstorms.

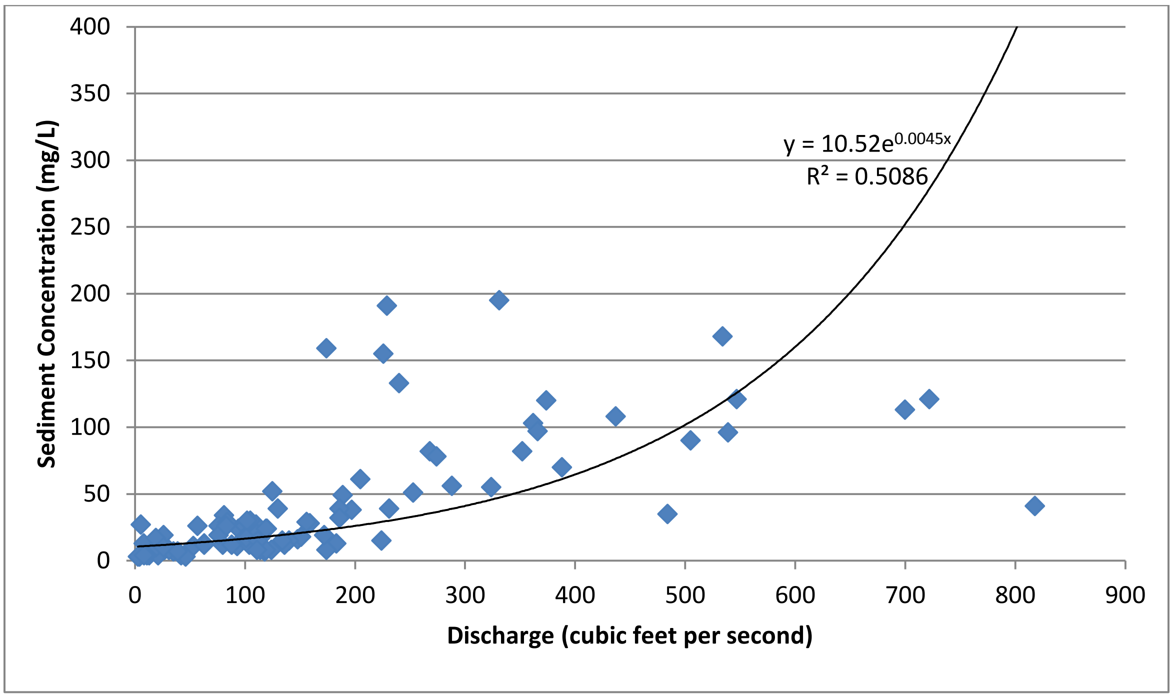

Figure E4-9. Measured Total Suspended Sediment Concentrations (Measured between 1992 and 2004) Versus Measured Discharge at the Flint Creek near Drummond USGS Gage

E4.7 Nutrients Calibration

Nutrients of concern for these TMDLs are TN, TP, and nitrate. TN includes the various forms of nitrogen: organic nitrogen, ammonia, nitrate and nitrite. TP includes orthophosphorus (which is the more soluble form of phosphorus) and organic phosphorus.

Nutrients are similar to sediments in that they are delivered to the river mouth by several separate processes, but there is an additional process in the nutrients modeling – nutrients generation (along with delivery and routing). Nutrients are a dynamic parameter that are constantly being produced and consumed. Nutrients generation is the process by which plants, rain, soils, and management practices (e.g., fertilization, cattle, and development) generate nitrogen and phosphorus in the upland areas. Delivery is the process by which nutrients are washed off of the land surface or leached into the ground and carried into the river channel. This happens both during runoff events and daily processes, and is modeled by SWAT using equations to calculate surface runoff concentrations, movement through the soil, attachment to soil that is carried away in runoff events, lateral unsaturated zone flow, and groundwater flows. Routing within the river channel is a separate process, where interactions with light, nutrients, algae growth and death, and oxygen levels are simulated via an instream nutrients model (QUAL2E) that is included within the SWAT program.

Similar to the sediment calibration, statistical calibration (e.g., the Nash-Sutcliffe coefficient of efficiency method) of the nutrients loads was not conducted because nutrients data had not been collected on a frequent or regular schedule (see **Table E2-3**) to provide meaningful results using a statistical method. The same problems present in the sediment calibration are present in the nutrients calibration, with the addition that nutrients are not only correlated to discharge, but are also strongly correlated to seasons. Soluble nutrients (nitrate, nitrite and ammonia) concentrations tend to drop in the summer when algal growth occurs, and rise as algae dies off in the fall. Therefore, not only was a daily calibration not possible, but a simple regression of all data points (regardless of season) would over-simplify the nutrients concentrations distribution. Instead visual matching was conducted for impaired streams with the available measured instream nutrients concentrations.

The instream nitrogen data used for calibration included TN, nitrate, nitrite and nitrate+nitrite data. The nitrate and nitrite data varied between individual analysis of each species and combined analysis due to the multiple entities collecting samples and the different emphasis for each entity. Because nitrite is not stable in the environment and quickly converts to nitrate, all nitrate-only measurements and the nitrate+nitrite measurements were combined and used in the model calibration as nitrate+nitrite data (this simplifies the analysis and provides more measured data points for calibration). TP is the other parameter that is included in the calibration.

The results of the daily simulated TN and TP concentrations versus the measured concentrations for each impaired stream segment and two other model sub-basins with available instream monitoring data are discussed in the following sub-sections. Data from the Flint Creek near Southern Cross were not used because that data in conjunction with data collected from Georgetown Lake were used to inform the model of the water quality being discharged from Georgetown Lake, directly above the monitoring location. Graphs of the data are included in **Attachment EF**. The nitrate+nitrite data were not included in the graphs, it was not as good as the TN calibration most likely due to the complexities of instream nutrients cycling that were not simulated as well as the loading inputs from land uses, but the results of the TN here and in the BMP scenarios discussed later are transferrable to the nitrate+nitrite loadings. In addition to the measured and simulated nutrients concentrations, the graphs in **Attachment EF** include daily precipitation from the nearest and/or most applicable weather station, simulated hydrograph, and the measured hydrograph where available. The time scale on each figure varies, as it only includes the years with instream monitoring data to compare to the simulated concentrations (different stream segments had different sample dates). Concentrations instead of loads are used in the graphs so that inaccuracies in modeled flow values are not superimposed on the nutrients calibration results.

E4.7.1 Flint Creek near Drummond

The Flint Creek near Drummond USGS gage (CFRPO-11.5 in **Figure E4-10**), located at the downstream end of sub-basin 2, has more measured TN and TP data than most of the other locations in the watershed. The simulated TN and TP concentrations show pronounced decreases and increases that correlate with spring runoff and then summer low flows, respectively (**Figure EF-1** in **Attachment EF**). The decreases are due to spring runoff dilution, increases are associated with both less dilution from spring runoff and increased irrigation withdrawals that reduce the amount of water to dilute the nutrients coming from the land surface. The simulated TN concentrations match the expected growing season decrease of soluble nitrogen due to algal growth and uptake in some years, but not every year. The simulated TP concentrations show similar annual trends and matches to the measured data as the TN results.

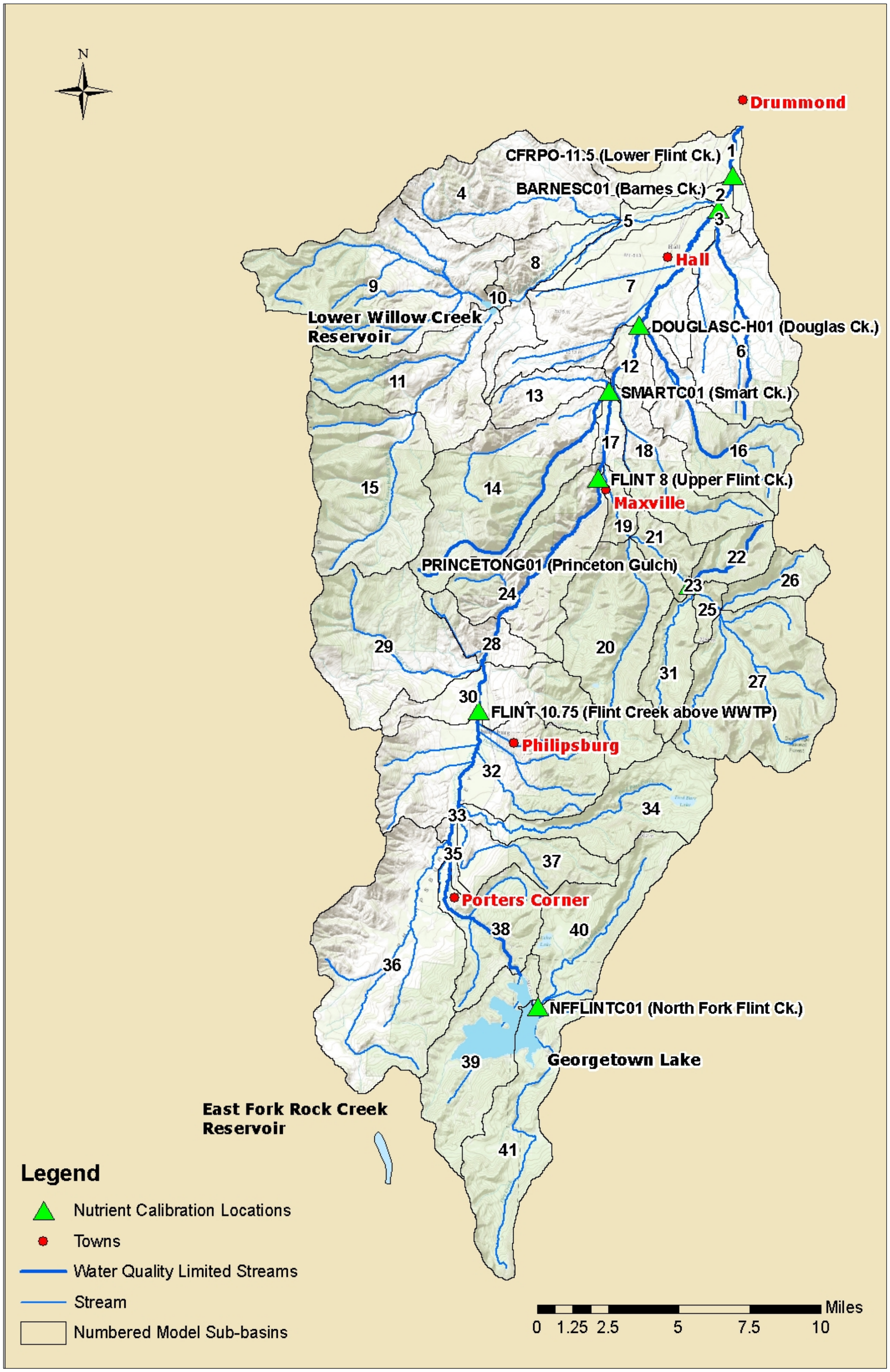

Figure E4-10. Nutrients Calibration Locations Used in the SWAT Model

E4.7.2 Barnes Creek

The mouth of Barnes Creek site (BARNESC01 in **Figure E4-10**), located at the downstream end of sub-basin 6, has five TN and TP measured data points for comparison (**Attachment EF**). The simulated TN and TP concentrations have variable accuracy to the measured data, accurately matching about half of the measured data points and over-estimating the other half. The Barnes Creek sub-basin has a large percentage of range land and thus the water quality is dominated by impacts from that land use. The significant seasonal increase in simulated TP concentrations, shown in **Attachment EF**, is due to the summer grazing of livestock in this basin, particularly from the 1% of livestock that are assumed to deposit waste directly into the stream. These elevated summer simulated concentrations match the measured TP concentrations well in the summers 2007 and 2009, but the simulated concentrations are not as accurate in the summers of 2004 and 2008. The simulated TN concentrations are similar showing a summer increase due to livestock management, with good matches to measured data in the summer of 2009, but not as good in the summers of 2004, 2007, and 2008. Some of the discrepancies between simulated values and measured data may be due to the way livestock were evenly distributed across the watershed, if less livestock are actually grazed in the Barnes Creek sub-basin than is estimated in the model that could cause the over-estimation of concentrations (the number of cattle estimated to graze during the summer in this sub-basin is 1,567). Because the Barnes Creek sub-basin has a large amount of livestock use, it would be a good location for additional high intensity growing season instream monitoring to better calibrate the livestock management assumptions used in the model.

E4.7.3 Smart Creek

The mouth of Smart Creek site (SMARTC01 in **Figure E4-10**), located at the downstream end of sub-basin 14, has five TN and TP measured data points for comparison (**Attachment EF**). The simulated TN and TP concentrations show pronounced increases that correlate with summer low flows. The simulated TN and TP concentrations have good matches to the measured concentrations. Note the pronounced and linear increase of TN and TP concentrations each summer that correlates well with the rapid streamflow decrease during the same time period.

E4.7.4 Douglas Creek

The mouth of Douglas Creek site (DOUGLASC-H01in **Figure E4-10**), located at the downstream end of sub-basin 16, has five TN and TP measured data points for comparison (**Attachment EF**). The simulated TP concentrations show pronounced increases that correlate with summer low flows, the TN concentrations show a similar but less pronounced trend. The simulated TP concentrations have good matches to the measured concentrations, while the simulated TN values tend to over-estimate the measured concentrations. As discussed in Barnes Creek, this discrepancy in TN concentrations may be related to errors in the estimation of the number of livestock grazing in the Douglass Creek sub-basin (the number of cattle estimated to graze during the summer in this sub-basin is 534).

E4.7.5 Princeton Gulch

The mouth of Princeton Gulch site (PRINCETONG01 in **Figure E4-10**), located at the downstream end of sub-basin 22, has five TN and TP measured data points for comparison (**Attachment EF**). The simulated TN and TP concentrations show pronounced increases during the spring runoff period, which is the opposite trend from the other impaired stream segments. This is likely due to the physiography of Princeton Gulch which unlike the other listed stream segments is located in the more mountainous section of the watershed with steep slopes and little human management. Due to steeper slopes, the spring runoff carries much more sediment and nutrients to the stream than in the lower streams, thus contributing to increasing concentrations with increased flows. The simulated TN and TP concentrations have good matches to the measured concentrations.

E4.7.6 Flint Creek at Maxville

The Flint Creek at Maxville USGS gage (FLINT 8 in **Figure E4-10**), located at the downstream end of sub-basin 24, has five TN and TP measured data points for comparison (**Attachment EF**). The simulated TN and TP concentrations have good matches to the measured data, but the accuracy of seasonal variations cannot be determined with the number of available instream measurements. The seasonal range of simulated TN and TP concentrations is less than at the Lower Flint site primarily due to the more consistent hydrograph that doesn't include the large spring runoff from the large Boulder Creek tributary, has less summer diversions than in the Lower Flint, and may have less groundwater losses due to the local geology.

E4.7.7 Flint Creek Above Phillipsburg Wastewater Treatment Plant

Although the Flint Creek at Maxville site is used to determine contributing sources for the Upper Flint Creek impairment and source assessment, this site (FLINT 10.75 in **Figure E4-10**) is included in the model results because it has several years of TN and TP data collected by the city of Philipsburg (**Attachment EF**). The monitoring location is in sub-basin 30 approximately 1,000 feet downstream of sub-basin 32. The data were collected monthly from July 2005 through October 2009 upstream of the city's wastewater discharge (the TN data collected prior to September 2007 are not included in **Attachment EF** because an incorrect sample preservation method was used). With more monitoring data than the Flint Creek at Maxville site, this site provides a check on the model's accuracy for the Upper Flint Creek impaired segment. The simulated TN concentrations from sub-basin 32 show pronounced decreases starting in the spring and lasting through the summer months, which is likely due to dilution from the spring runoff and then instream nutrients uptake during the summer months. Both the TN and TP simulated concentrations show variable correlation to the measured data with some years matching the trends better than others. The simulated TP seems to be consistently lower than the measured TP during winter months. This could indicate that phosphorus concentration estimated for groundwater in the model, 0.01 mg/L, could be low for this section of the watershed.

E4.7.8 North Fork Flint Creek

This site (NFFLINTC01 in **Figure E4-10**) is included because it is in a relatively undisturbed sub-basin that has had 15 instream samples analyzed for TN and TP concentrations between July 2009 and September 2010 and an additional three samples between August 2007 and August 2008 (**Attachment EF**). The data were collected by Craig Stafford of the University of Montana. This site is used as a check on the accuracy of the model's framework in a sub-basin that isn't significantly affected by human management and thus not subject to many of the management practice assumptions used in the model. The calibration to both TN and TP are generally acceptable with simulated concentrations matching many of the peaks in the earlier and later measured data, but less accurate when compared to the measured data in late 2009 and early 2010.

As a relatively undisturbed sub-basin, the North Fork Flint Creek is a good stream to compare the model results to reference streams that have been monitored by the DEQ. The Flint Creek watershed is located in the Middle Rockies Ecoregion, the DEQ has developed draft numeric nutrients standards for this area using reference streams (Suplee and Watson, 2013). For the Middle Rockies Ecoregion, the median TN and TP concentrations of the reference streams were 0.095 and 0.01 mg/L as based on 57 and 61 sites, respectively (Suplee and Watson, 2013). The draft water quality criteria proposed for TN and TP for the

Middle Rockies Ecoregion are 0.300 and 0.030 mg/L, respectively (Suplee and Watson, 2013). During the summer growing season the graph of measured and simulated TN concentrations (**Attachment EF**) for the North Fork Flint Creek show concentrations predominantly below the median reference stream concentration (0.095 mg/L), and all concentrations (except two simulated dates in 2010) below the proposed criteria of 0.300 mg/L. During the summer growing season the graph of measured and simulated TP concentrations (**Attachment EF**) for the North Fork Flint Creek show concentrations predominantly at or below the median reference stream concentration (0.01 mg/L), and all concentrations well below the proposed criteria of 0.0300 mg/L. Comparison of the simulated concentrations for TN and TP to the reference streams concentrations and proposed water quality standards shows that the SWAT model has accurately simulated TN and TP concentrations in the relatively undisturbed North Fork Flint Creek sub-watershed.

E4.7.9 Nutrients Calibration Summary

The lack of long-term, frequent, instream nutrients analyses precludes a definitive statistical analysis of the models nutrients calibration. However a subjective visual analysis indicates an acceptable match to the measured data considering the daily averaging period of the model compared to instantaneous measurements of water quality. The model results are acceptable for use in determining relative impacts of different management scenarios that are designed to reduce nutrients loadings and improve stream water quality. Those scenarios and the impacts to instream water quality are discussed in **Section E6.0**.

E5.0 NATURAL BACKGROUND SCENARIO

This scenario is conducted to estimate the sources and amount of nutrients that would have been entering surface waters prior to any human-related impacts. The conditions that existed without human impacts are referred to as natural background. The nutrients loadings in the natural background scenario are compared to the loadings in the calibrated model for use in the source assessment to determine the amount of nutrients that can be attributed to human impacts. Details of the assumptions used in the natural background scenario and a summary of the results are described in this appendix. A more detailed analysis of the loadings attributed to different land uses are provided in **Section 5** of the main report.

The natural background model scenario was prepared by using the existing condition calibrated model for nutrients, the results of which were discussed in the previous section, and converting all land uses altered by humans back to their estimated condition prior to human intervention. As shown in **Figure E2-3** most human impacted lands are surrounded by range grass land use, therefore the human impacted lands were all converted to range grass land use to approximate natural background conditions. Some developed lands under existing conditions may have been forest or wetlands under natural conditions, but the percentage is likely very small and therefore using range grass instead of those land uses will not create any significant error in the scenario results.

E5.1 NUTRIENTS LAND-USE SOURCE ASSESSMENT

Based on the comparison between the existing conditions and the natural background scenario, the amount of TN and TP loadings attributed to human use and management for the entire Flint Creek watershed are shown in **Figures E5-1** and **E5-2**. The results are broken out by land-use types and show that the sources are substantially different for TN compared with TP. The TN results (**Figure E5-1**) shows livestock and agricultural sources comprise the majority (greater than 65%) of human-caused (anthropogenic) TN, with wastewater contributing a lesser amount, (less than 9%). Natural sources of TN comprise about 25% of the current TN loading in the watershed. The TP results (**Figure E5-2**) shows a different distribution with livestock uses contributing 70% of the load, agriculture and wastewater contribute an additional 25%. Only about 5% of the TP is from natural sources. The higher percent of TP contributed from livestock (as compared to TN) is because TP is often contributed via overland means while TN has a larger contribution through the subsurface because it is more mobile through soils than TP. Livestock impacts from grazing and waste are more concentrated at the land surface (thus a relatively higher amount of TP compared to TN) while agriculture has relatively more impact through the subsurface due to such things as irrigation return flows and fertilizer migration (thus a relatively higher amount of TN compared to TP). More detailed discussion of the source assessment for each impaired stream segment is included in **Section 5** of the report.

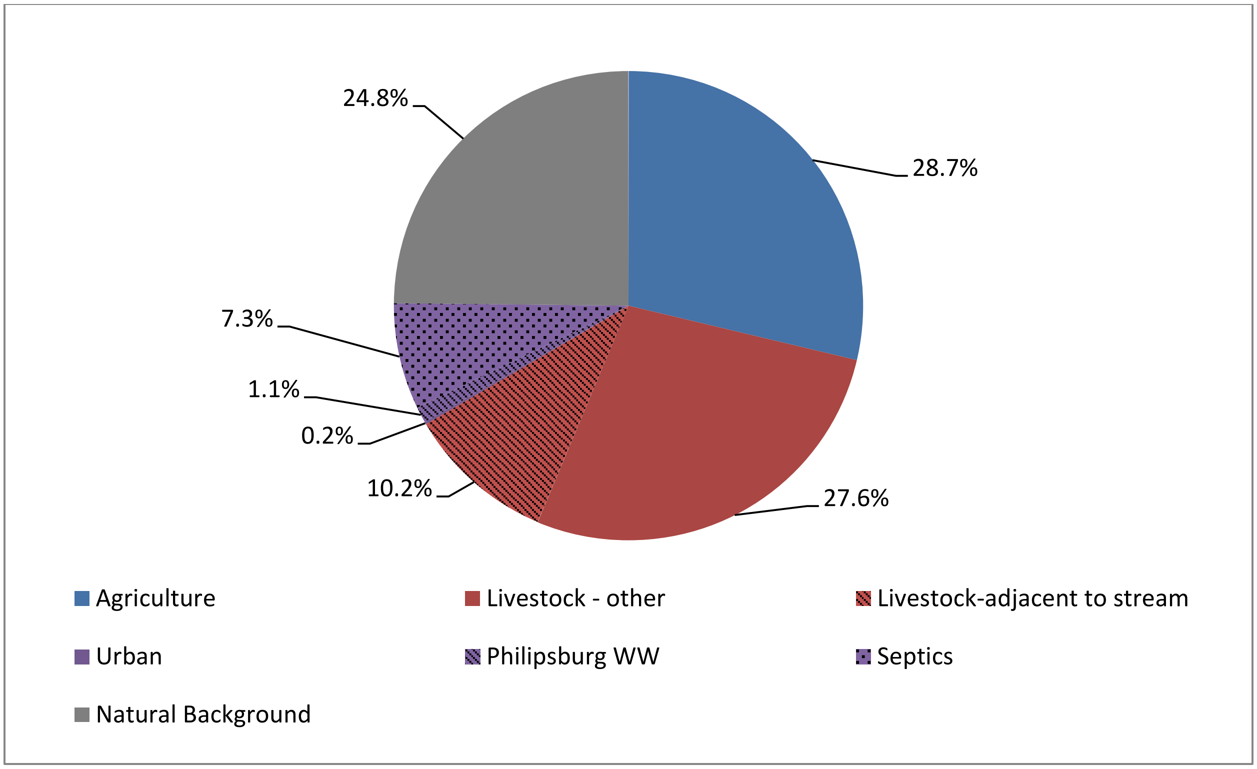

Figure E5-1. Percent of Total Nitrogen Loading during Growing Season from Existing Condition Land Uses for the Flint Creek Watershed

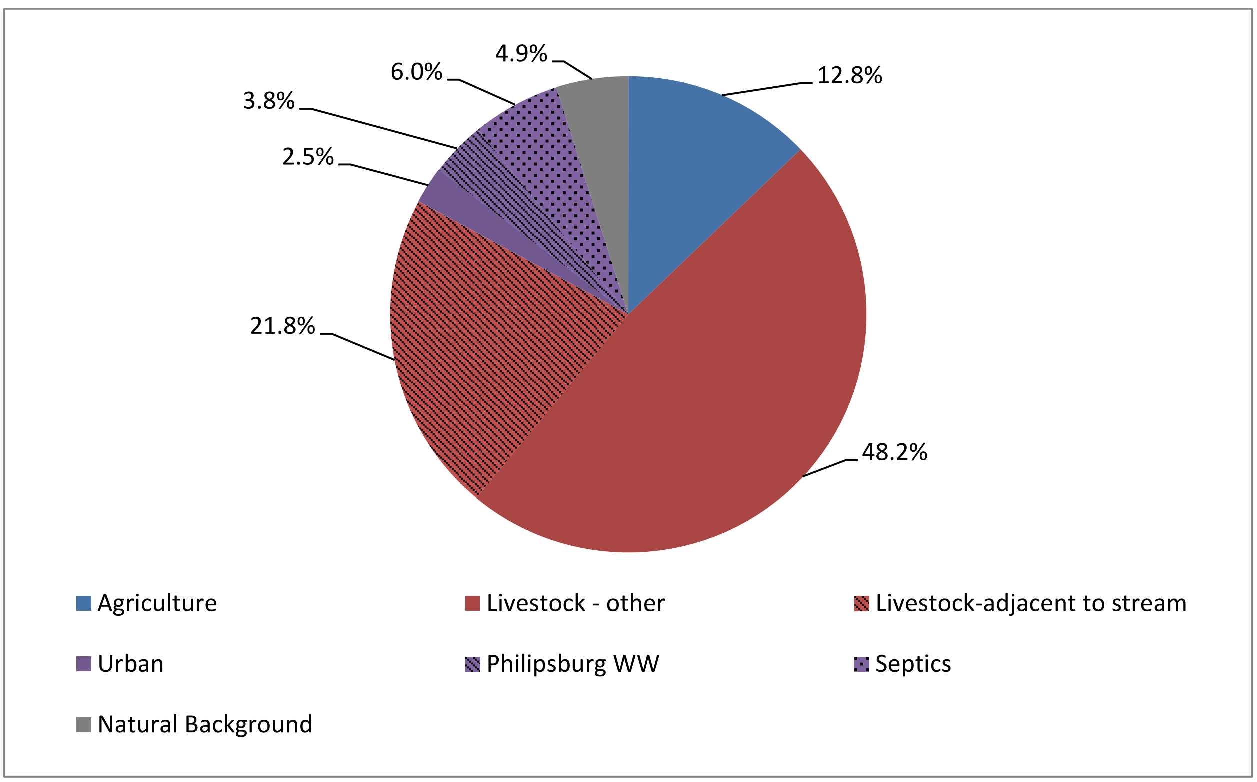

Figure E5-2. Percent of Total Phosphorus Loading during Growing Season from Existing Condition Land Uses for the Flint Creek Watershed

E5.2 Nutrients Location Source Assessment

The source assessment for different land uses discussed in the previous section can be used in conjunction with the spatial distribution of the nutrients sources to provide a more complete source assessment. The results of the SWAT model are too coarse to provide a field-by-field analysis of the nutrients loads within each sub-basin. However, the SWAT model is divided into 41 sub-basins that can be used for a coarser analysis of relative loading rates. This information is useful for identifying sub-basins that are contributing relatively higher amounts of nutrients to the impaired segments of Flint Creek which eventually receives nutrients from all 41 sub-basins. This will allow managers to initially focus on those areas with higher nutrients loadings for specific locations to apply BMPs that will reduce nutrients loadings to Flint Creek.

Figure E5-3 shows a graduated range of TN loading rate by acre from each of the 41 sub-basins. The TN loading rates in **Figure E5-3** are based on contributions from all land uses (i.e., HRUs) and from all point sources (including septic wastewater, municipal wastewater, and livestock waste applied directly into streams). The area is based on the total acreage of each sub-basin. Areas with higher TN loading are generally located in sub-basins with relatively high amounts of agriculture, livestock, or urban development land uses (see **Figure E2-3**).

Figure E5-3 shows that two of the nitrogen impaired stream segments, Smart Creek (impaired for TN) and Princeton Gulch (impaired for nitrate), have relatively low TN loading rates compared to other impaired stream segments. Based on the source assessment the human-related TN loading in the Smart Creek sub-basin is predominantly from livestock activities, and nearly all of its livestock land use is towards the downstream end of the sub-basin (the rangeland in the upper portion of the basin is primarily located on USFS land that is not used for grazing in the model). This is confirmed by the Smart Creek assessment results in **Section E5.6.6** that show low nitrogen concentrations in the upper Smart Creek sampling sites. Because only a relatively small portion of the Smart Creek sub-basin is contributing high nutrients loads, the average nitrogen concentration by acre is relatively small compared to other sub-basins with higher amounts of contributing area. The Princeton Gulch sub-basin has little current development; the sources causing its nitrate impairment may be related to other historical activities such as mining.

The distribution of TP loads in the watershed (**Figure E5-4**) is similar to the TN distributions showing higher loadings from sub-basins with relatively high amounts of agriculture, livestock, or urban development land uses. However, one substantial difference from the TN distributions is in sub-basin 30, where the Philipsburg wastewater treatment plant is located. The ratio of TP in the wastewater discharge compared to other TP sources is higher than the comparable TN ratio, which creates the higher relative loading of TP in sub-basin 30. The relatively lower TP versus TN ratios for land uses are shown in **Figures E5-3** and **E5-4** that show, in general, that TP loadings from human impacts are over 10 times lower than TN loads. The Philipsburg wastewater treatment plant discharges, based on their discharge monitoring reports (see **Table EC-5**), show that the TP loads are only 3.5 times lower than the TN loads.

In Smart Creek the TP loadings show the same comparatively low loading rates as was seen with TN, which is due again to the location of the human-related nutrients sources near the bottom of the Smart Creek sub-basin and confirmed by the assessment results in **Section E5.6.6**.

Figure E5-5 shows the distribution of TN and TP growing season loads in graphical format and apportioned by model sub-basin and by land use. **Figure E5-5** is used to supplement **Figures E5-3** and **E5-4** to show the specific land uses that are contributing to the TN and TP loadings in each sub-basin.

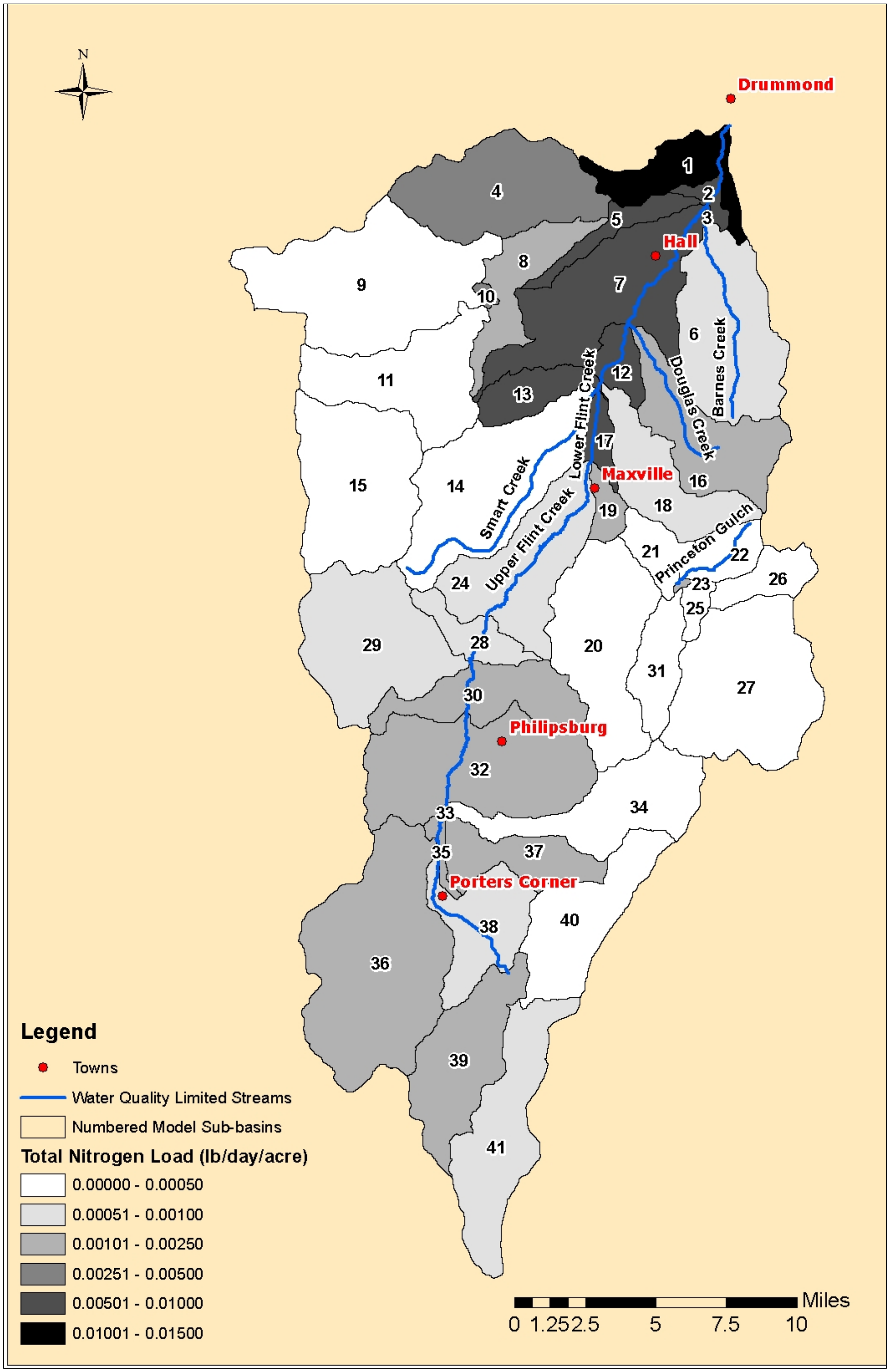

Figure E5-3. Simulated Rates of Human-Related Total Nitrogen Loading under Existing Conditions

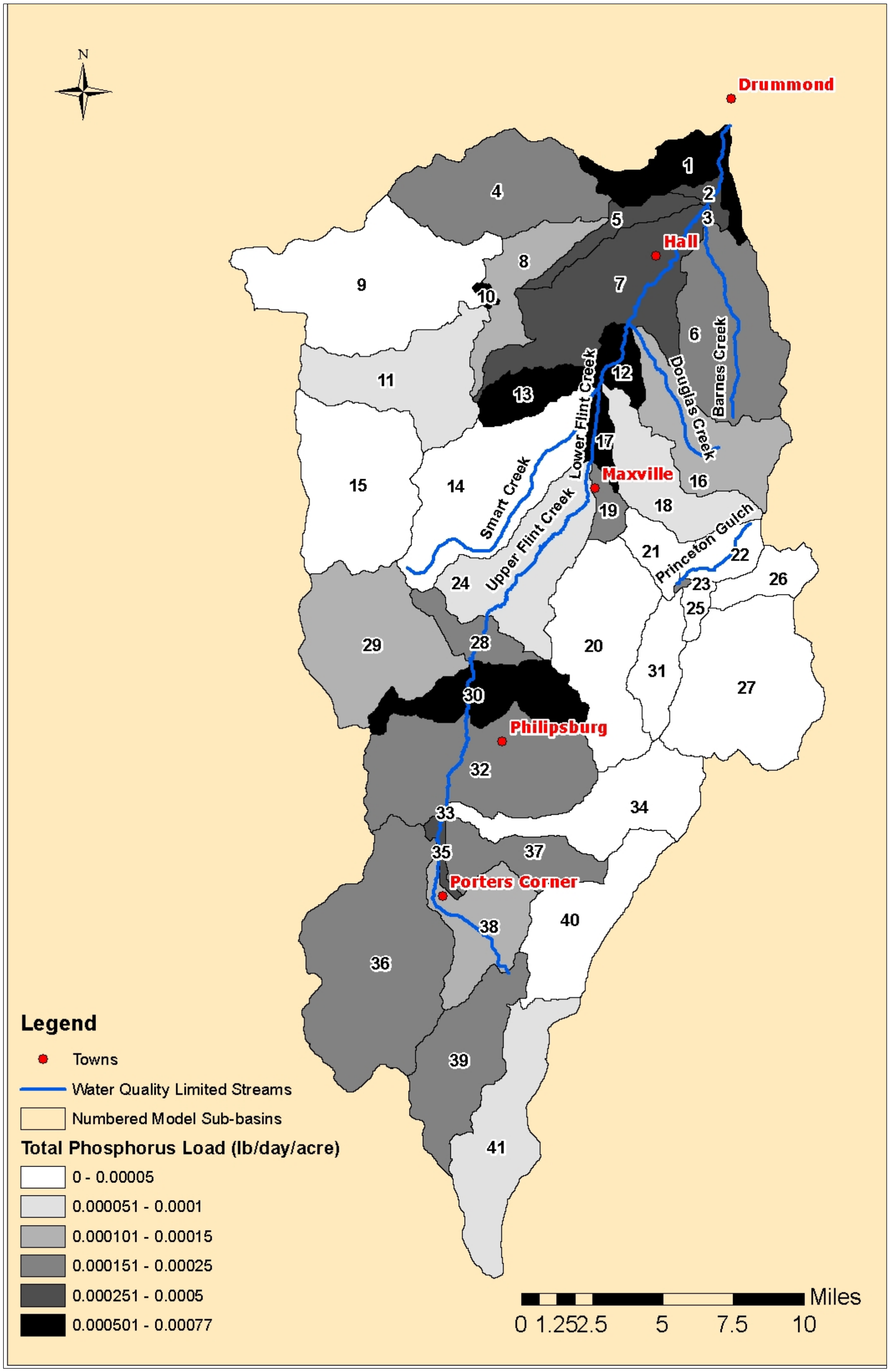

Figure E5-4. Simulated Rates of Human-Related Total Phosphorus Loading under Existing Conditions

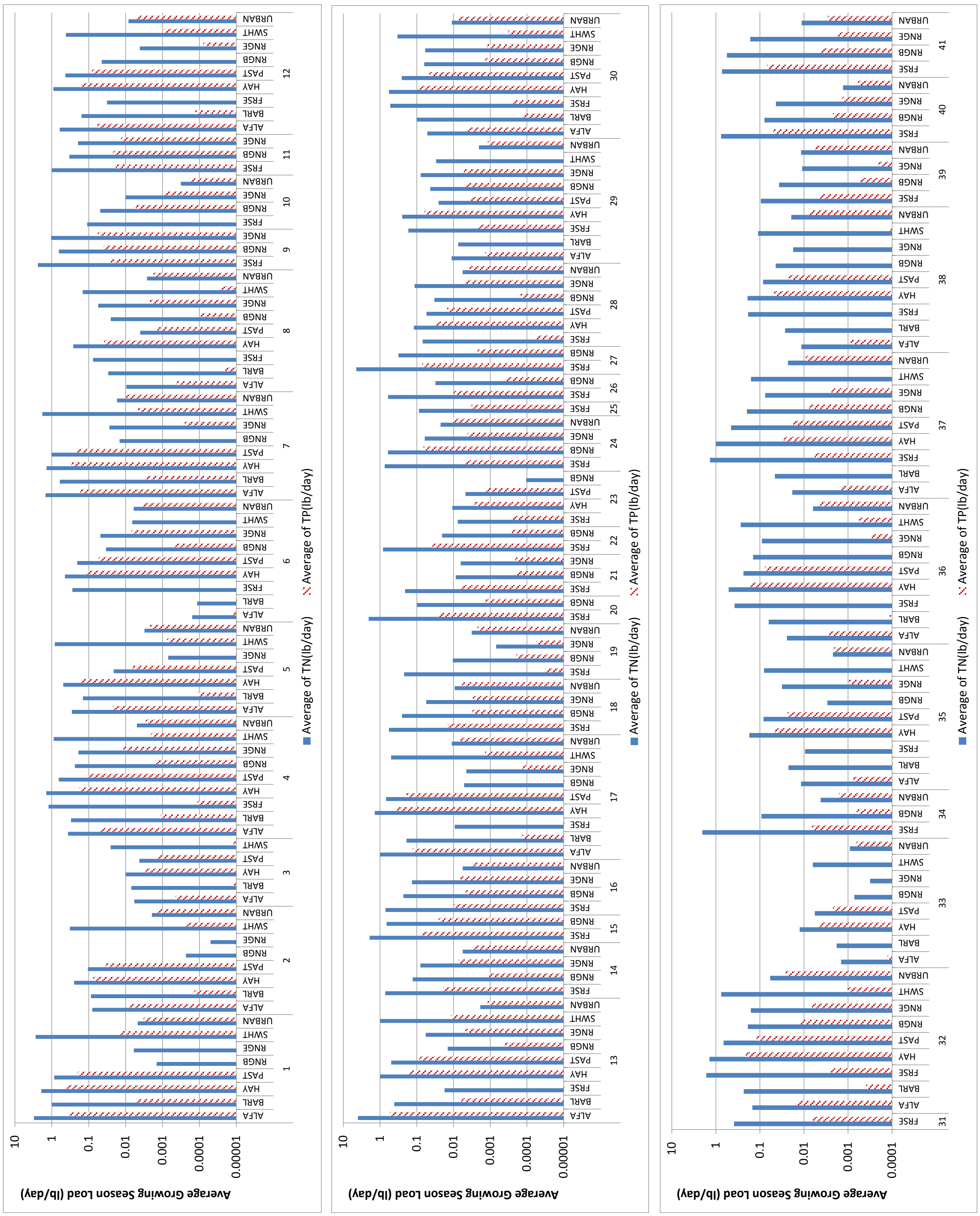

Figure E5-5. Total Nitrogen and Total Phosphorus Growing Season Loading Rates by SWAT Model Sub-Basin and Land Use

(FRSE = Forest; RNGE = Grass Range; RNGB = Brush Range; ALFA = Alfalfa; BARL = Barley; SWHT = Spring Wheat; PAST = Pasture)

E6.0 BEST MANAGEMENT PRACTICES SCENARIOS

Scenario development was completed by incorporating several BMPs 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 nutrients loadings reductions associated with various BMPs, and to identify the BMP combinations most likely to result in TMDL attainment. 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 existing land uses in the 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, the scenarios 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. A comprehensive literature review of common agricultural BMP implementation practices in the United States (Agourids et al., 2005) found that at least one aspect of stream water quality (e.g., chemical, physical, or biological) has improved in watersheds that received one or more of the following measures: livestock exclusion, offstream watering, rotational grazing, supplemental feeding, and buffer strips. As such, DEQ believes that one or more practices could be implemented cost-effectively (e.g., through cost-shares with NRCS) to improve water quality in the watershed.

When reviewing the scenario results it is important to be aware of the fundamental structure of the SWAT program which was previously discussed but is reviewed here in the context of implementing BMPs. The HRU is SWAT's fundamental computational unit, and most parameter modifications affect SWAT at the HRU level. HRUs are portions of the same sub-basin that share similar land uses, soils, and slopes. An HRU can (and typically does) consist of multiple spatial areas that are located within the same sub-basin, but aren't adjacent to each other. However, these nonadjacent areas are lumped into one HRU within that sub-basin as long as they share similar land use, soil, and slope. There is no spatial context to HRUs within each sub-basin – every HRU is assumed to deliver its load directly to the stream in its sub-basin without accounting for the distance of the HRU to the stream (in contrast, sub-basins are spatially correlated to other sub-basins and are routed correctly from one sub-basin to the next). Most BMPs are applied to the HRU, not to the sub-basin or watershed, so applying a BMP to one stretch of river may require applying it to multiple HRUs (and their associated area), and may be somewhat limited in its accuracy (with respect to location or amount of land affected) by the size of affected HRUs in each sub-basin.

The discussion of scenario results focus on the stream segments that are impaired. However, because the entire length of Flint Creek below Georgetown Lake is impaired for TN and/or TP, the BMPs described should be considered in every tributary in the watershed (when they are applicable to the land use) as they all eventually contribute nutrients to Flint Creek.

Scenarios modeled for this project include fertilizer reduction, improved grazing, stream channel livestock exclusion, riparian protection, and wastewater treatment improvement. A summary of TN and TP percent reductions, as compared to the existing conditions, for each BMP scenario by impaired stream segment is provided in the following sub-sections and are summarized in **Figures E6-1** and **E6-2**. A watershed summary of the TN and TP percent reductions, as compared to the existing conditions, for each BMP scenario from different land uses is also provided in **Figures E6-3** and **E6-4**. All reductions discussed are for the summer growing season only, July 1 through September 30, which is when the instream nutrients targets apply.

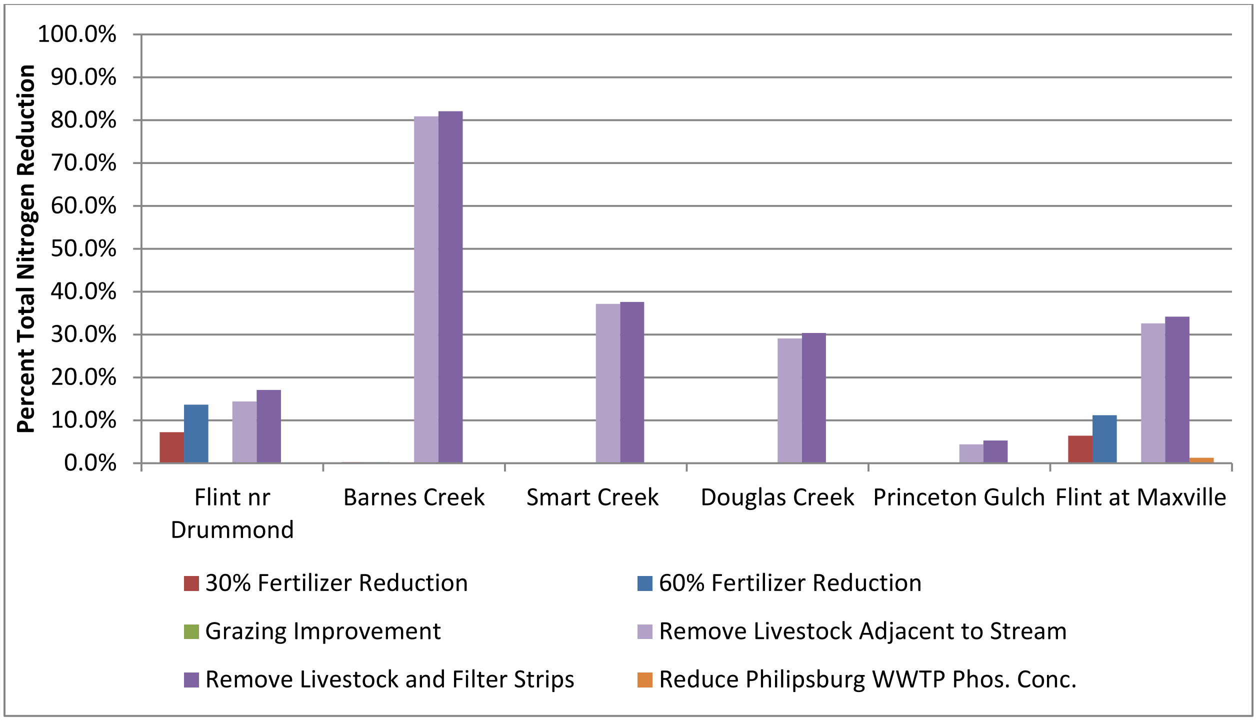

Figure E6-1. Total Nitrogen Instream Reductions from best management practices during the Growing Season for each Impaired Stream as Compared to the Existing Conditions

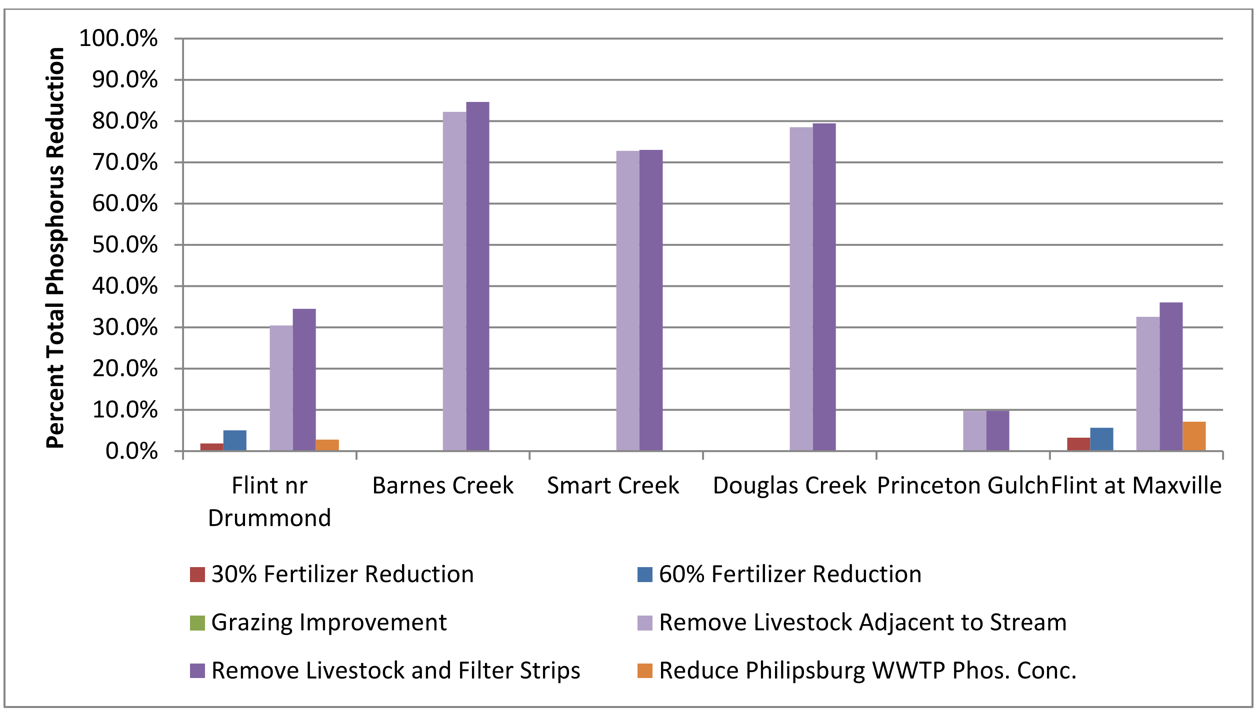

Figure E6-2. Total Phosphorus Instream Reductions from best management practices during the Growing Season for each Impaired Stream as Compared to the Existing Conditions

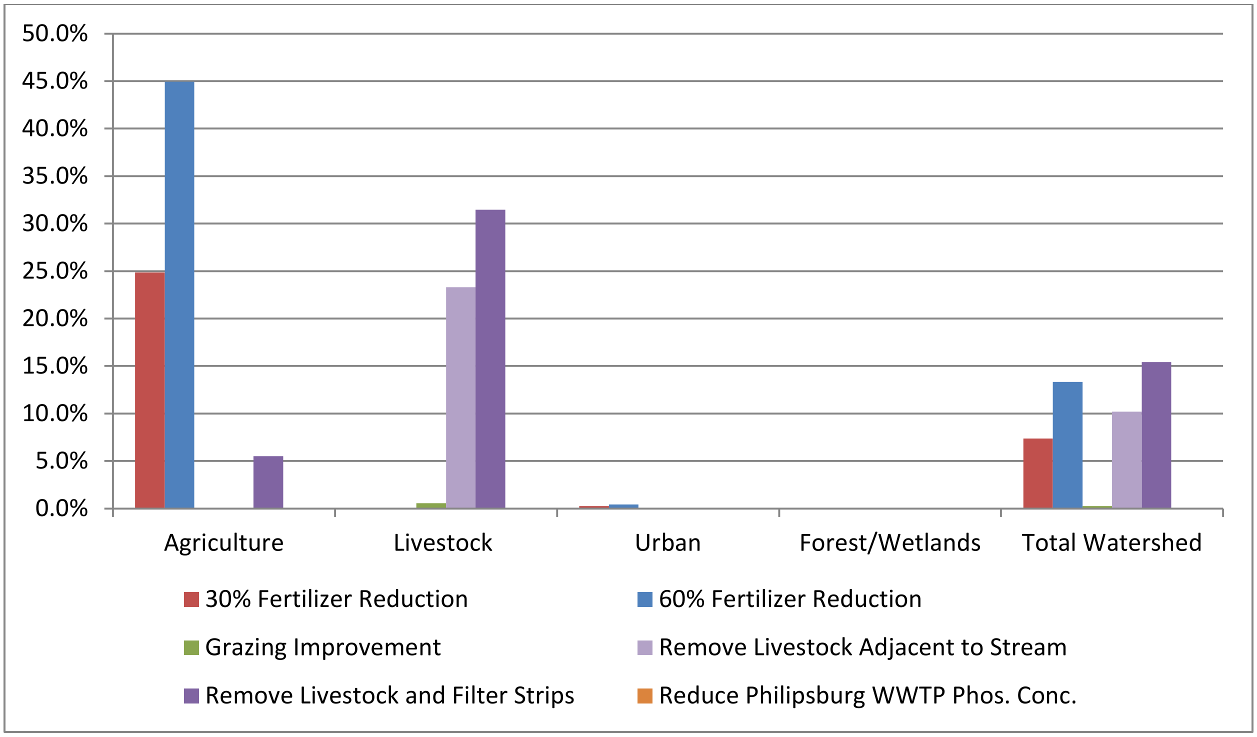

Figure E6-3. Total Nitrogen Land-Use Reductions from best management practices during the Growing Season (July–September) as Compared to the Existing Conditions

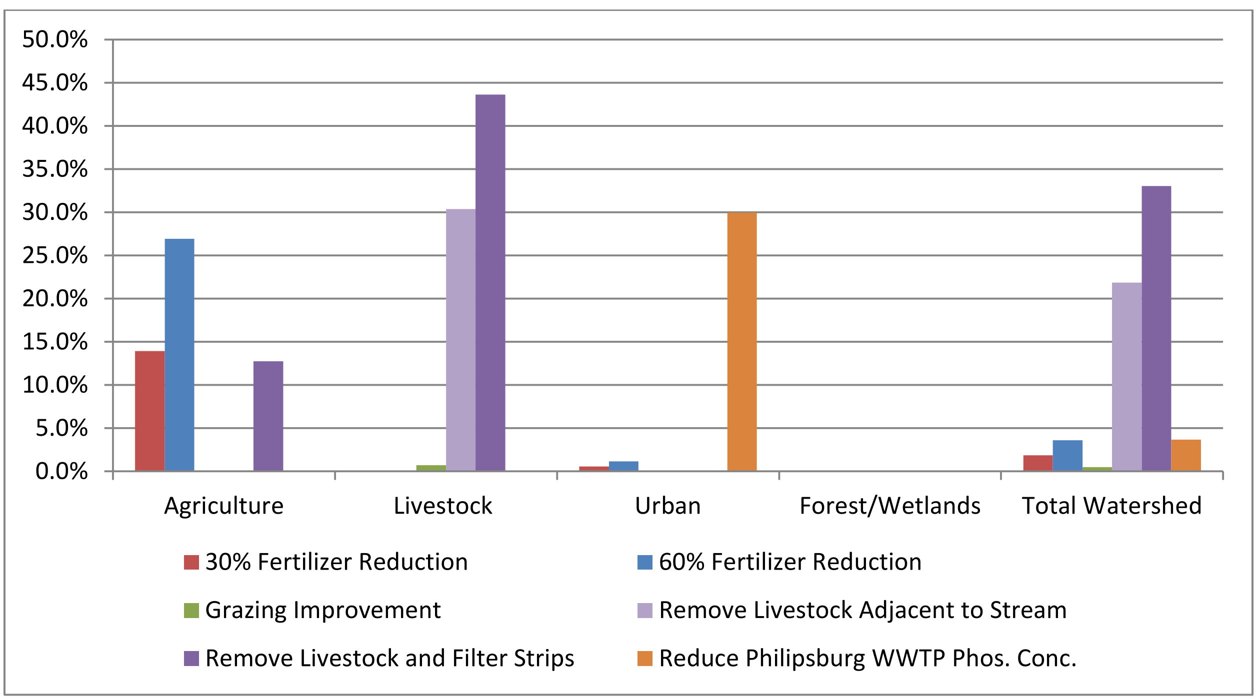

Figure E6-4. Total Phosphorus Land-Use Reductions from best management practices during the Growing Season (July–September) as Compared to the Existing Conditions

E6.1 Existing Conditions

The calibrated model was used to develop the existing conditions from 1992 through 2010. The results of the existing condition model with respect to TN and TP trends was discussed in **Section E4.7**. Each of the following BMP scenarios is compared to the results of the existing condition simulation.

E6.2 Thirty Percent Fertilizer Reduction Scenario

The existing condition simulation applies commercial fertilizer to the alfalfa, spring wheat and barley crops as discussed in **Section E2.5.1.2**. The fertilizer loading rates per acre listed in **Table E2-7** and **Section E2.5.3** were reduced by 30% in this scenario and are shown in **Table E6-1**.

Methods available to reduce fertilizer use include but are not necessarily limited to: 1) conversion to crops that require less supplemental fertilizer; 2) better management of existing organic matter to reduce the amount of supplemental fertilizer used; and 3) increased use of variable rate technology, which uses Global Positioning System (GPS) to apply fertilizer at different rates based on location specific needs rather than applying at a uniform rate across entire fields.

The results of this scenario (**Figures E6-1** through **E6-4**) show negligible to no TN or TP reductions in the four impaired tributaries to Flint Creek (Barnes Creek, Smart Creek, Douglas Creek and Princeton Gulch) as those sub-basins have little or no fertilized crops. The Upper Flint (Flint Creek at Maxville) and Lower Flint (Flint Creek near Drummond) impaired segments responded with TN reductions of 6.4% and 7.2%, respectively; they also responded with TP reductions of 3.3% and 1.9%, respectively. The phosphorus percent reductions are less because phosphorus is less mobile in soil than nitrogen which tends to mute the impacts to surface waters.

Table E6-1. Nitrogen and Phosphorus Fertilizer Loads for Existing Conditions and 30% Fertilizer Reduction Scenario

Crop Type	Watershed Area (acres)	Exist. Condition Annual Nitrogen Load (lb/yr)	Exist. Condition Annual Phosphorus Load (lb/yr)	30% Reduction Annual Nitrogen Load (lb/yr)	30% Reduction Annual Phosphorus Load (lb/yr)
Alfalfa/Hay (60/40)	9,958	49,790	199,160	34,853	139,412
Barley	479	43,110	0	30,177	0
Spring Wheat	479	118,333	16,765	82,819	11,736
Urban grass	250	17,900	0	12,530	0

E6.3 Sixty Percent Fertilizer Reduction Scenario

This scenario is similar to the previous scenario and estimates the impacts of additional fertilizer reductions. The existing condition model applies commercial fertilizer to the alfalfa, spring wheat and barley crops as discussed in **Section E2.5.1.2**. The fertilizer loading rates per acre listed in **Table E2-7** and **Section E2.5.3** were reduced by 60% in this scenario and are shown in **Table E6-2**.

Methods available to reduce fertilizer use include but are not necessarily limited to: 1) conversion to crops that require less supplemental fertilizer; 2) better management of existing organic matter to reduce the amount of supplemental fertilizer used; and 3) increased use of variable rate technology, which uses GPS to apply fertilizer at different rates based on location specific needs rather than applying at a uniform rate across entire fields.

The results of this scenario (**Figures E6-1** through **E6-4**) show negligible to no TN or TP reductions in the four impaired tributaries to Flint Creek (Barnes Creek, Smart Creek, Douglas Creek and Princeton Gulch) as those subasins have little or no fertilized crops. The Upper Flint and Lower Flint impaired segments responded with TN reductions of 11.2% and 13.7%, respectively; they also responded with TP reductions of 5.7% and 5.1%, respectively. The phosphorus percent reductions are less because phosphorus is less mobile in soil than nitrogen which tends to mute the impacts to surface waters.

Table E6-2. Nitrogen and Phosphorus Fertilizer Loads for Existing Conditions and 60% Fertilizer Reduction Scenario

Crop Type	Watershed Area (acres)	Exist. Condition Annual Nitrogen Load (lb/yr)	Exist. Condition Annual Phosphorus Load (lb/yr)	60% Reduction Annual Nitrogen Load (lb/yr)	60% Reduction Annual Phosphorus Load (lb/yr)
Alfalfa/Hay (60/40)	9,958	49,790	199,160	19,916	79,664
Barley	479	43,110	0	17,244	0
Spring Wheat	479	118,333	16,765	47,325	6,706
Urban grass	250	17,900	0	7,160	0

E6.4 Grazing Improvement Scenario

This scenario simulates an improvement in both summer and winter grazed land conditions. Decreased ground cover, due to grazing, influences sedimentation and nutrients processes. No specific practice was specified for this improvement because ground cover can potentially be altered through a number of BMPs including alteration of cattle distribution on the landscape (e.g., water, shade), modification of the grazing time-frame and duration through different rotational practices, or reductions in stock density. To reflect some combination of these changes, modifications were made to the Universal Soil Loss Equation (USLE) C factor in SWAT. Adjustment was made based on several studies in southwestern and central Montana which relate rangeland ground cover response to grazing practices. Bare ground was shown to be 14.9, 18.6, and 6.8% higher on the Beaverhead National Forest near Dillon, Montana, on sites that were heavily, moderately, and lightly grazed respectively, than those with no cattle on them (Evanko and Peterson, 1955). The comparison was made after a 15–18 year exclusion period. Similar results were found in an exclusion study on foothill sheep ranges in Meagher County near White Sulphur Springs, Montana; total cover (e.g., foliage and litter) was 16.7% higher in protected plot as compared to grazed plots after 4 years of exclusion (Vogel and Van Dyne, 1966). Based on those studies a relationship between ground cover and grazing does exist, and a maximum difference between grazed and un-grazed lands is around 10–20%. Therefore, a conservative estimate of a 10% improvement for rangeland USLE C factor, and a 10% improvement in hay/pasture USLE C factor was used in this scenario. This 10% improvement was incorporated by reducing the USLE C factor for range, hay, and pasture from 0.003 to 0.0027 (see original USLE C factors in **Table E4-5**).

The results of this scenario (**Figures E6-1** through **E6-4**) show a less than 1% improvement in all of the impaired stream sub-basins. As these impacts are averages over an entire sub-basin or the watershed, the results should not be interpreted that improved grazing is not a worthwhile practice. On a field scale, rather than a larger sub-basin scale, there may be individual grazing areas that will be improved and result in significant local reductions of nutrients through better grazing practices.

E6.5 Reduce Livestock Stream Access Scenario

The existing conditions scenario included direct discharge of 1% of the waste from livestock into surface waters (Porath et al., 2002; Sheffield et al., 1997) during the summer grazing season, June 1 through October 31. This is designed to simulate the amount of time on average that livestock spend in and directly adjacent to surface waters. This scenario simulates the impacts if direct access to surface waters is restricted across the entire watershed so that livestock do not discharge any waste directly into streams. Although 100% livestock exclusion is not practicable, because the source is a direct source into the streams the results of this scenario can be easily extrapolated to different amounts of exclusion. For example, if direct livestock access is reduced 25%, then the instream loading reductions would be 25% of what is presented for this scenario.

The results indicate a large impact in TN loads to every impaired stream segment except for Princeton Gulch, which has limited grazing land (**Figures E6-1** through **E6-4**). The percent reductions in TN range from 4.4% in Princeton Gulch up to 80.9% in Barnes Creek. The TP percent reductions are similar and range from 9.8% in Princeton Gulch up to 82.2% in Barnes Creek. The amount of improvement in each sub-basin or watershed is primarily dependent on the percent of summer grazing land in each of the sub-basins because summer grazing is distributed relatively evenly across the watershed on land classified as range. As discussed previously, complete livestock exclusion is not likely, but this scenario does illustrate that even a modest reduction in livestock access to surface waters will create substantial improvements to instream water quality. As such, BMPs to reduce livestock access to surface waters are an important tool in improving water quality and meeting target water quality levels.

E6.6 Reduce Livestock Stream Access and Riparian Filter Strips Scenario

This scenario includes the results of the previous scenario and adds riparian filter strips to both grazing lands and agricultural lands. Riparian vegetation in the watershed has been degraded by a variety of factors including historic vegetation removal, grazing, mining, timber harvest, and residential development. Because riparian areas function as important filters for streamflow and overland runoff, this scenario is used to evaluate the effect of improved riparian health on nutrients loads.

The addition of filter strips was the method chosen to simulate riparian improvement in the model. In SWAT, filter strips are applied at the HRU level. Filter strips are basically improved vegetation adjacent to streams that reduce the sediment and nutrients loads in both the overland flow and subsurface flow primarily through physical entrapment and absorption. The filter strip could be considered roughly analogous to a riparian area as they both filter nutrients and sediment from the computed HRU load before delivery to the stream channel. In this scenario, filter strips were applied to areas that tend to be alongside streams or canals (pasture, hay, barley, spring wheat and alfalfa), and areas that are heavily grazed (rangeland). One limitation in modeling this scenario is filter strips are applied to HRUs (and not at a watershed level), their application is somewhat restricted by the division of HRUs within each sub-basin. The SWAT program does not allow for splitting an HRU and giving different characteristics within that HRU, therefore a single HRU within a sub-basin cannot have filter strips designated over a portion of the HRU. For example, if improved riparian areas were supposed to be applied to 50% of a sub-basin, but there were five HRUs each comprising 20% of the sub-basin, then filter strips were applied to either 40% (two HRUs) or 60% (three HRUs) of the sub-basin. For this application in the Flint Creek watershed the HRU limitation didn't alter the targeted percentages of filter strip application substantially on the mainstem Flint Creek impaired segments, but there were some minor differences on the tributary sub-basins.

A coarse riparian habitat assessment was completed for the Flint Creek watershed (Water & Environmental Technologies, 2010) to collect data on riparian area extent, health, and locations. Delineated reaches were given a riparian condition category of good, fair, or poor based on land use adjacent to the stream, riparian vegetation type and density, and the presence or absence of human related activities near the stream corridor. Based on this, the riparian areas along each stream investigated were given ratings (and corresponding percentages) of good, fair, or poor based on the results of the assessment. Due to the coarse nature of the riparian analysis, it was determined that it would not be practical to incorporate the results qualitatively into the model scenario. Instead, the approach used for the scenario was to include a watershed-wide riparian improvement at set percentages for several different land uses.

The filter strip widths were set uniformly at 33 feet (10 meters). A review of studies on riparian buffers (Mayer et al., 2005) showed that buffer widths that have been tested generally vary between 33 feet and 330 feet and that increasing buffer width does increase nitrogen removal although there are diminishing returns as the widths exceed 330 feet. Thirty-three foot buffers were demonstrated to remove up to 61% and 80% of nitrogen using forested and grassland buffers, respectively. Although wider buffers are better, for this scenario a 33 foot width was used because it is shown to be an effective width (Mayer et al., 2005) and logistically is likely to be the best compromise between maintaining existing land uses while still providing a meaningful buffer to nutrients transport. In areas that can support wider buffers from a landscape and land-use perspective, they should certainly be implemented to realize greater nutrients retention. In this scenario the filter strips were implemented on 25% of all hay, pasture, barley, spring wheat and alfalfa land uses, and on 10% of all range land uses. These percentages are different because it was assumed that based on easier access and a much lower amount of acreage, it would be easier to implement filter strips on the hay, pasture, barley, spring wheat and alfalfa lands than it would be on the more remote and larger range lands. These percentages are only approximate targets, but are primarily used for comparative purposes to demonstration the relative effectiveness of this BMP versus other BMP scenarios.

The results of this scenario (**Figures E6-1** through **E6-4**) show moderate instream improvements when combined with the previous livestock stream access scenario. The TN instream loads are reduced between 0.5% and 2.6% on all the impaired stream segments, the TP instream loads are reduced between 0% and 4% on the same stream segments. As with the grazing improvement scenario, these values are sub-basin or watershed averages and individual fields that have poor existing riparian health can realize much greater percent improvements through the use of filter strips.

E6.7 Wastewater Phosphorus Treatment Improvement Scenario

This scenario decreases the amount of phosphorus discharged from the city of Philipsburg wastewater treatment plant. Based on the discharge permit discharge monitoring reports, the average TP concentration discharged from the wastewater treatment plant between August 2007 and September 2012 is 3.3 mg/L. This scenario assumes that the wastewater treatment plant reduces its TP discharge concentration to the instream target TP concentration of 0.072 mg/L (TN reductions for the wastewater treatment plant are not simulated in this scenario because the Upper Flint Creek impaired segment is only impaired for TP, not for any nitrogen species). This reduction may be realized through one or more methods such as improved treatment, wastewater land application during the summer, and continued reduction of phosphorus in household products. For this scenario, it was assumed that the reduced concentration would occur all year, not just during the summer growing season when the instream target concentration applies.

The results (**Figures E6-1** through **E6-4**) show that the impacts of this scenario are greatest in the Upper Flint Creek impaired segment because the wastewater treatment plant is located in the lower section of that impaired stream segment. The TP reduction in that section is 7.1%. TP reduction in the lower Flint segment, 2.8%, is much less due to stream cycling, diversions, and dilution from other sources. Although TN was not reduced from the wastewater treatment plant, the results show a small reduction of TN of 1.2% and 0.1% at the Upper and Lower Flint Creek impaired segments, respectively. The cause of the TN decrease is unknown. However, it is likely related to the instream processing routines in SWAT. Currently, algal assimilation in SWAT is limited to suspended algae which are subject to settling losses from the water column. Provided that the system was P limited, further reduction of P from the SWAT scenario would constrain algal biomasses even more, thus theoretically reducing the N incorporated as internal nutrients and lost through settling. This in turn would increase the TN in the watershed at a ratio equal to the reduced mass of settling and the N:P intracellular stoichiometry ratio which is often assumed to be 7:1 by mass (e.g., Redfield ratio).

E6.8 Best Management Practice Scenario Summary

The results of the scenarios should be reviewed and used in a comparative fashion to determine the best BMPs based on local management practices and land condition. For example, a field that has excellent riparian conditions and very little livestock activity may not need any additional BMPs even if it is in a sub-basin that had significant scenario improvements from filter strips and changes in livestock management. Conversely, another field may have poor riparian vegetation, heavy livestock use and a nearby upgradient fertilized agricultural field, and therefore may benefit significantly from multiple BMPs. Local knowledge and implementation of the most applicable BMPs to each location is the most important factor in improving instream water quality to meet the target values.

Although not included as a scenario, using advanced septic systems that treat TN to lower concentrations for replacement of aging septic systems, would provide only minor additional TN reductions. The advanced treatment systems reduce the TN in half as compared to a conventional septic system, but do not reduce the TP concentrations. Therefore if, for example, the annual failure rate on existing septic systems was 1% (which would be about 16 systems a year in the watershed), the TN source reduction for the entire watershed would be 0.24 lb/day or 0.04% of the total TN load in the watershed. At the estimated 1% failure rate, it would require 25 years to reduce the TN loading in the watershed by 1%.

E7.0 Conclusion and Limitations

Hydrologic modeling was completed on the Flint Creek watershed to identify the contribution of nutrients (TN and TP) sources in six impaired stream segments, and to assess potential BMPs that might improve water quality in those streams. The calibrated model under existing conditions is used to develop the source assessment and determine the reductions necessary to meet water quality targets for impaired stream segments. The BMP scenarios included fertilizer reduction, improved grazing, stream channel livestock exclusion, riparian protection, and wastewater treatment improvement. Through scenario analysis, it was shown that livestock management was the most sensitive management option for reducing nutrients sources to surface water. The key management conclusion is that nutrients loadings will most effectively be reduced by the protection of streams and riparian zones from direct livestock access. Additional but smaller reductions in nutrients loadings can be achieved through reductions in agricultural fertilizer applications, use of riparian filter strips, and reductions in the Philipsburg wastewater treatment plant phosphorus loads. Grazing management improvements can provide limited watershed scale reductions, but may provide more substantial local improvements on fields that are currently not managed well. Upgrading failed septic systems would provide minor decreases to TN loadings only.

This model, like any other, has certain limitations based on the accuracy of the watershed parameterization. Climatic data are always crucial, as precipitation, snowfall, snowmelt, and evapotranspiration are the most important processes for determining hydrology. The climatic data available for the watershed are acceptable, with two weather stations at Drummond and Philipsburg and several SNOTEL sites for snow information. Some of the climatic data such as daily wind speed, solar radiation, and relative humidity were partially available from within the watershed, but significant amounts of data not available during the modeling period had to be extrapolated from Missoula and Deer Lodge. Spatial variation of precipitation and snow events cannot always be accurately simulated due to the local nature of many events compared to the distances between weather stations; this creates some errors in simulating rapid fluctuations of streamflows, but has less of an effect on the longer term fluctuations that the calibrated model replicates acceptably.

Many of the assumptions used in this model are related to land management practices such as irrigation practices and diversions, grazing rotations, fertilizer application, etc. Where possible, information from local sources was used to characterize the management practices, and literature sources were used to estimate other management practices. In either situation, the management practices had to be averaged over the entire watershed as the specific management practices from the multiple land owners in the watershed is not available. Information related to potential nutrients sources from mining was researched, but little information was found to provide any meaningful characterization of mining impacts. What information was found regarding mining impacts indicated they were not substantial sources of nutrients to the watershed. Future work in the watershed could include better characterization of these potential nutrients sources.

The calibrated and validated hydrologic model met most of the pre-determined evaluation criterion metrics, and responded well to climatic inputs. Additionally, the sediment and nutrients calibrations were acceptable. This model is to be used as a relative gage of system response to various management changes, rather than an absolute indicator of nutrients loadings. And in this capacity, in spite of the limitations discussed above, the model met its objectives and is acceptable for the intended use.

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ATTACHMENT EA – IMPORTANT LAND-USE ESTIMATIONS AND ASSUMPTIONS USED IN MODEL DEVELOPMENT

- **Section E2.5.1** - Hay/alfalfa harvesting occurs July 4 in both Philipsburg and Drummond-Hall valleys, and again on September 30 in the Drummond-Hall valley. Spring wheat and barley are harvested on September 15 and 30 in the Philipsburg and Drummond-Hall valleys, respectively.
- **Section E2.5.1.1** - Average irrigation efficiency set at 50%.
- **Section E2.5.1.1** - Annual irrigation set at 1.7 feet in the Drummond-Hall valley from May 1 through September 15 (except for hay and pasture where irrigation begins June 1). Annual irrigation set at 0.74 feet in the Philipsburg valley from June 1 through August 30.
- **Section E2.5.1.1** - Irrigation is curtailed in individual sub-basins when streamflows fall below 3.5 cfs and 1.0 cfs in large streams and small streams, respectively.
- **Section E2.5.1.2** - Fertilizer rates based on generic rates published in Montana State University Extension service publication. Rates for alfalfa were halved based on communication with Technical Advisory Group, that some land owners do not fertilize alfalfa. The final rates used for nitrogen, phosphorus and potassium were 5 lbs/acre, 20 lbs/acre and 20 lbs/acre, respectively
- **Section E2.5.2** - 650 sheep in the valley are assumed equivalent to 65 cattle for purposes of grazing impacts.
- **Section E2.5.2** - Summer grazing (June 1 through October 31) only occurs on privately owned lands classified as range shrub and range brush. Winter grazing (November 1 through May 31) only occurs on lands classified as hay and pasture.
- **Section E2.5.2** - Winter grazing uses existing vegetation in November and May, and supplied feed for December through April.
- **Section E2.5.3** - Distribution and increase of septic systems in the watershed during the modeling period estimated using 2001 NLCD, 2009 county GIS layer, county septic permits, and interpretation of available air photos.
- **Section E2.5.4** - Land uses modified for fires and timber harvest using available air photos and updating land uses to range-brush from forest where appropriate.
- **Section E2.5.5** - Discharge from Georgetown Lake based on USGS gage located 1.3 miles below dam. Discharge from Lower Willow Creek Reservoir extrapolated to model period from 1965 to 1983 measured discharge rates. Discharge from East Fork Rock Creek Reservoir extrapolated from 8 years (2000, 2002–2004, and 2007–2010) of measured discharge rates.
- **Section E2.7.1** - Dissolved oxygen concentration of the City of Philipsburg wastewater treatment plant discharge estimated at 2.0 mg/L.
- **Section E2.7.1** - Extrapolated 2000–2010 measured effluent discharge rates for the City of Philipsburg wastewater treatment plant for use from 1989 through 1999, and excluded 2 years of anomalously high discharge rates between 2004 and 2006.
- **Section E2.7.6** - Identified livestock confinement operations were not accounted for in land-use updates or as point sources.

ATTACHMENT EB – NATIONAL AGRICULTURAL STATISTICS SERVICE

Table EB-1. Crop Types and Acreages for Granite County, 2003–2009(1)

Commodity	Practice	Year	State	County	Planted All Purposes Acres	Harvested Acres	Yield per Acre	Yield Unit	Production	Production Unit	Yield per Net Seeded Acre Bushels	Net Seeded Acres
Wheat, Other Spring	Irrigated (total for crop)	2003	MT	Granite	0	0	ND	Bushel	ND	Bushel	ND	ND
Wheat, Other Spring	Irrigated (total for crop)	2004	MT	Granite	0	0	ND	Bushel	ND	Bushel	ND	ND
Wheat, Other Spring	Irrigated (total for crop)	2005	MT	Granite	0	0	ND	Bushel	ND	Bushel	ND	ND
Wheat, Other Spring	Irrigated (total for crop)	2006	MT	Granite	0	0	ND	Bushel	ND	Bushel	ND	ND
Wheat, Other Spring	Irrigated (total for crop)	2007	MT	Granite	0	0	ND	Bushel	ND	Bushel	ND	ND
Wheat, Other Spring	Irrigated (total for crop)	2008	MT	Granite	1200	1200	70	Bushel	84000	Bushel	ND	ND
Wheat, Other Spring	Irrigated (total for crop)	2009	MT	Granite	1200	1200	75	Bushel	90000	Bushel	ND	ND
Total Average						**343**						
Barley, All	Irrigated (total for crop)	2003	MT	Granite	1000	300	53	Bushel	16000	Bushel	ND	ND
Barley, All	Irrigated (total for crop)	2004	MT	Granite	1000	400	80	Bushel	32000	Bushel	ND	ND
Barley, All	Irrigated (total for crop)	2005	MT	Granite	1400	500	78	Bushel	39000	Bushel	ND	ND
Barley, All	Irrigated (total for crop)	2006	MT	Granite	1300	700	60	Bushel	42000	Bushel	ND	ND
Barley, All	Irrigated (total for crop)	2007	MT	Granite	0	0	ND	Bushel	ND	Bushel	ND	ND
Barley, All	Irrigated (total for crop)	2008	MT	Granite	0	0	ND	Bushel	ND	Bushel	ND	ND
Barley, All	Irrigated (total for crop)	2009	MT	Granite	0	0	ND	Bushel	ND	Bushel	ND	ND
Total Average						**271**						

Table EB-1. Crop Types and Acreages for Granite County, 2003–2009(1)

Commodity	Practice	Year	State	County	Planted All Purposes Acres	Harvested Acres	Yield per Acre	Yield Unit	Production	Production Unit	Yield per Net Seeded Acre Bushels	Net Seeded Acres
Hay, Alfalfa	Irrigated	2003	MT	Granite	9700	9500	2.9	Tons	27100	Tons	ND	ND
Hay, Alfalfa	Irrigated	2004	MT	Granite	10300	10000	3	Tons	29500	Tons	ND	ND
Hay, Alfalfa	Irrigated	2005	MT	Granite	8000	8000	3.1	Tons	24400	Tons	ND	ND
Hay, Alfalfa	Irrigated	2006	MT	Granite	ND	7000	3.3	Tons	23000	Tons	ND	ND
Hay, Alfalfa	Irrigated	2007	MT	Granite	ND	8000	3.3	Tons	26000	Tons	ND	ND
Hay, Alfalfa	Irrigated	2008	MT	Granite	ND	ND	ND	Tons	ND	Tons	ND	ND
Hay, Alfalfa	Irrigated	2009	MT	Granite	ND	ND	ND	Tons	ND	Tons	ND	ND
Hay, Alfalfa	Non- irrigated	2003	MT	Granite	1500	1000	0.8	Tons	800	Tons	ND	ND
Hay, Alfalfa	Non-irrigated	2004	MT	Granite	500	500	2.2	Tons	1100	Tons	ND	ND
Hay, Alfalfa	Non-irrigated	2005	MT	Granite	ND	ND	ND	Tons	ND	Tons	ND	ND
Hay, Alfalfa	Non-irrigated	2006	MT	Granite	ND	500	1	Tons	500	Tons	ND	ND
Hay, Alfalfa	Non-irrigated	2007	MT	Granite	ND	1000	2.6	Tons	2600	Tons	ND	ND
Hay, Alfalfa	Non-irrigated	2008	MT	Granite	ND	ND	ND	Tons	ND	Tons	ND	ND
Hay, Alfalfa	Non-irrigated	2009	MT	Granite	ND	ND	ND	Tons	ND	Tons	ND	ND
Hay, Alfalfa	Total for crop	2003	MT	Granite	11200	10500	2.7	Tons	27900	Tons	ND	ND
Hay, Alfalfa	Total for crop	2004	MT	Granite	10800	10500	2.9	Tons	30600	Tons	ND	ND
Hay, Alfalfa	Total for crop	2005	MT	Granite	8000	8000	3.1	Tons	24400	Tons	ND	ND
Hay, Alfalfa	Total for crop	2006	MT	Granite	ND	7500	3.1	Tons	23500	Tons	ND	ND
Hay, Alfalfa	Total for crop	2007	MT	Granite	ND	9000	3.2	Tons	28600	Tons	ND	ND
Hay, Alfalfa	Total for crop	2008	MT	Granite	ND	9000	3.3	Tons	29500	Tons	ND	ND
Hay, Alfalfa	Total for crop	2009	MT	Granite	ND	8500	2.7	Tons	23000	Tons	ND	ND
Total Average						**9000**						
Hay, All Other	Irrigated	2003	MT	Granite	ND	16000	2	Tons	32500	Tons	ND	ND
Hay, All Other	Irrigated	2004	MT	Granite	ND	19300	2.1	Tons	40500	Tons	ND	ND
Hay, All Other	Irrigated	2005	MT	Granite	ND	28500	2.2	Tons	62200	Tons	ND	ND
Hay, All Other	Irrigated	2006	MT	Granite	ND	13000	1.9	Tons	24700	Tons	ND	ND
Hay, All Other	Irrigated	2007	MT	Granite	ND	14000	2.1	Tons	29400	Tons	ND	ND
Hay, All Other	Irrigated	2008	MT	Granite	ND	ND	ND	Tons	ND	Tons	ND	ND
Hay, All Other	Irrigated	2009	MT	Granite	ND	ND	ND	Tons	ND	Tons	ND	ND
Hay, All Other	Non-irrigated	2003	MT	Granite	ND	ND	ND	Tons	ND	Tons	ND	ND
Hay, All Other	Non-irrigated	2004	MT	Granite	ND	ND	ND	Tons	ND	Tons	ND	ND
Hay, All Other	Non-irrigated	2005	MT	Granite	ND	ND	ND	Tons	ND	Tons	ND	ND

Table EB-1. Crop Types and Acreages for Granite County, 2003–2009(1)

Commodity	Practice	Year	State	County	Planted All Purposes Acres	Harvested Acres	Yield per Acre	Yield Unit	Production	Production Unit	Yield per Net Seeded Acre Bushels	Net Seeded Acres
Hay, All Other	Non-irrigated	2006	MT	Granite	ND	ND	ND	Tons	ND	Tons	ND	ND
Hay, All Other	Non-irrigated	2007	MT	Granite	ND	1000	1.5	Tons	1500	Tons	ND	ND
Hay, All Other	Non-irrigated	2008	MT	Granite	ND	ND	ND	Tons	ND	Tons	ND	ND
Hay, All Other	Non-irrigated	2009	MT	Granite	ND	ND	ND	Tons	ND	Tons	ND	ND
Hay, All Other	Total for crop	2003	MT	Granite	ND	16500	2	Tons	33300	Tons	ND	ND
Hay, All Other	Total for crop	2004	MT	Granite	ND	19500	2.1	Tons	40800	Tons	ND	ND
Hay, All Other	Total for crop	2005	MT	Granite	ND	29000	2.2	Tons	63200	Tons	ND	ND
Hay, All Other	Total for crop	2006	MT	Granite	ND	13000	1.9	Tons	24700	Tons	ND	ND
Hay, All Other	Total for crop	2007	MT	Granite	ND	15000	2.1	Tons	30900	Tons	ND	ND
Hay, All Other	Total for crop	2008	MT	Granite	ND	8000	2	Tons	16000	Tons	ND	ND
Hay, All Other	Total for crop	2009	MT	Granite	ND	10000	2.25	Tons	22500	Tons	ND	ND
Total Average						**15857**						

(1) From National Agriculatural Statistics Services website, http://www.nass.usda.gov/Statistics_by_State/Montana/Publications/cntytoc.htm

ND - No data provided in National Agricultural Statistics Service database

ATTACHMENT EC – MODEL INPUT

Databases and output files are available upon request.

ATTACHMENT ED – SIMULATED VS. MEASURED HYDROGRAPHS

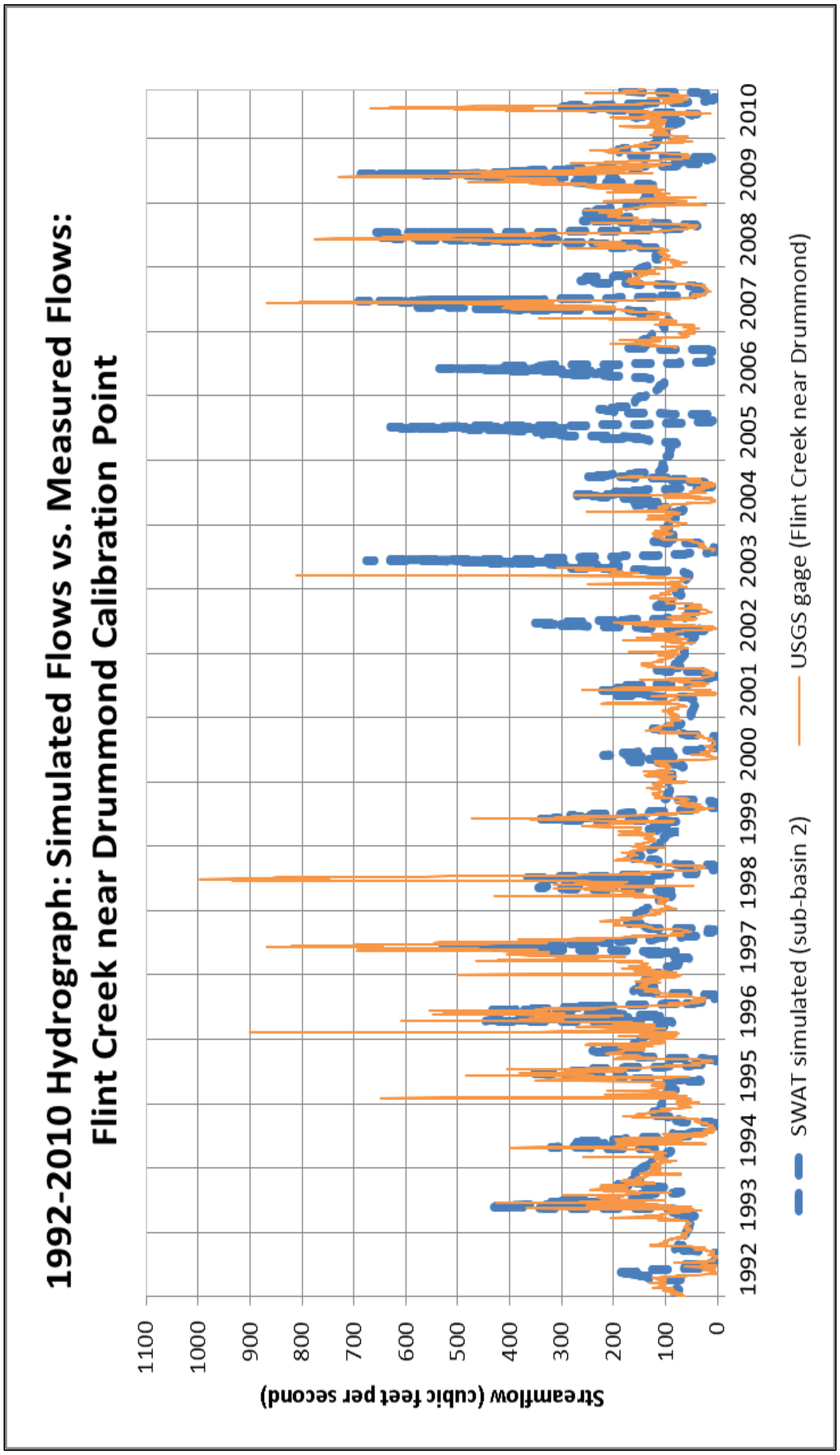


Figure ED-1. 1992-2010 Hydrograph: Simulated Flow vs. Measured Flows: Flint Creek near Drummond Calibration Point

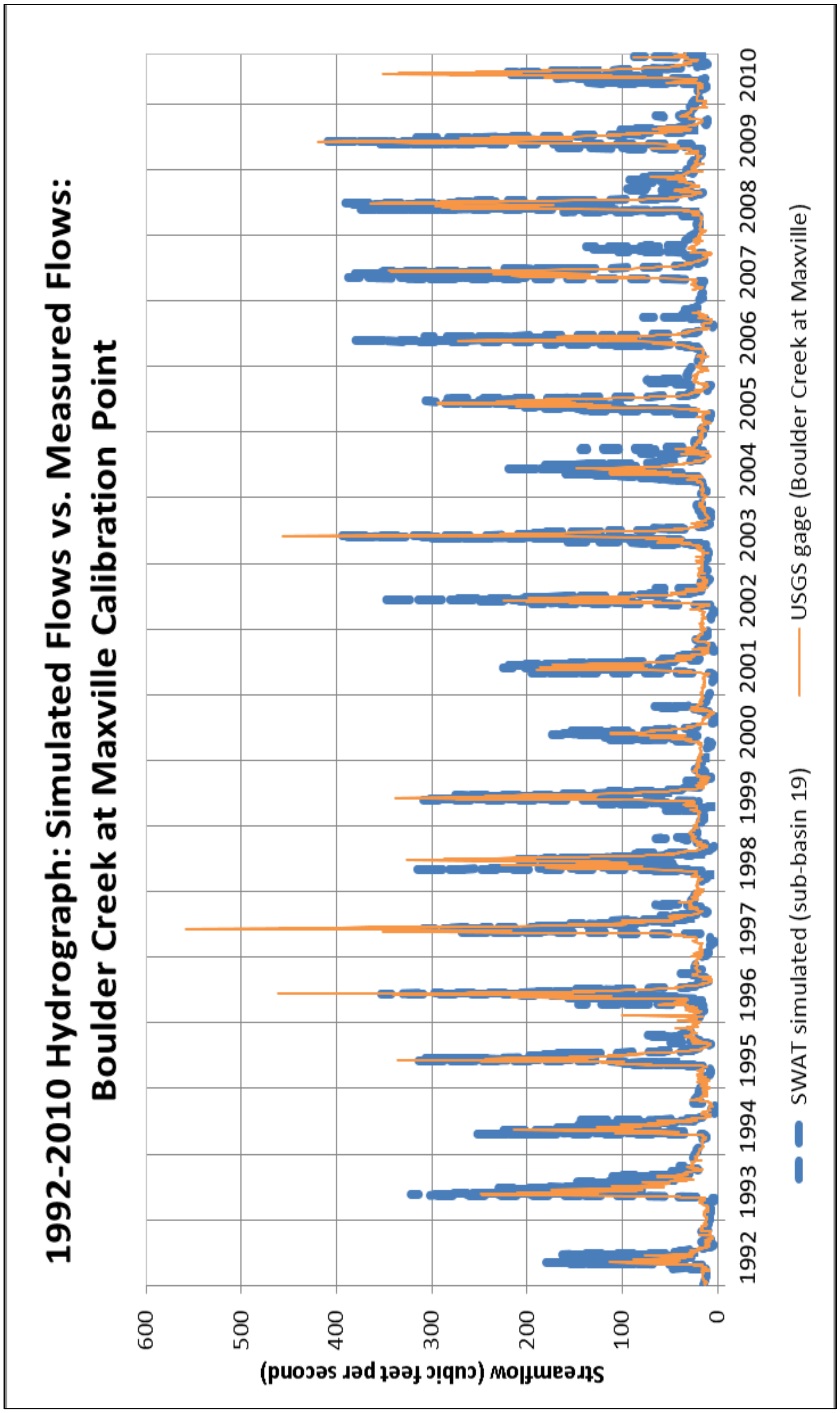


Figure ED-2. 1992-2010 Hydrograph: Simulated Flows vs. Measured Flows: Boulder Creek at Maxville Calibration Point

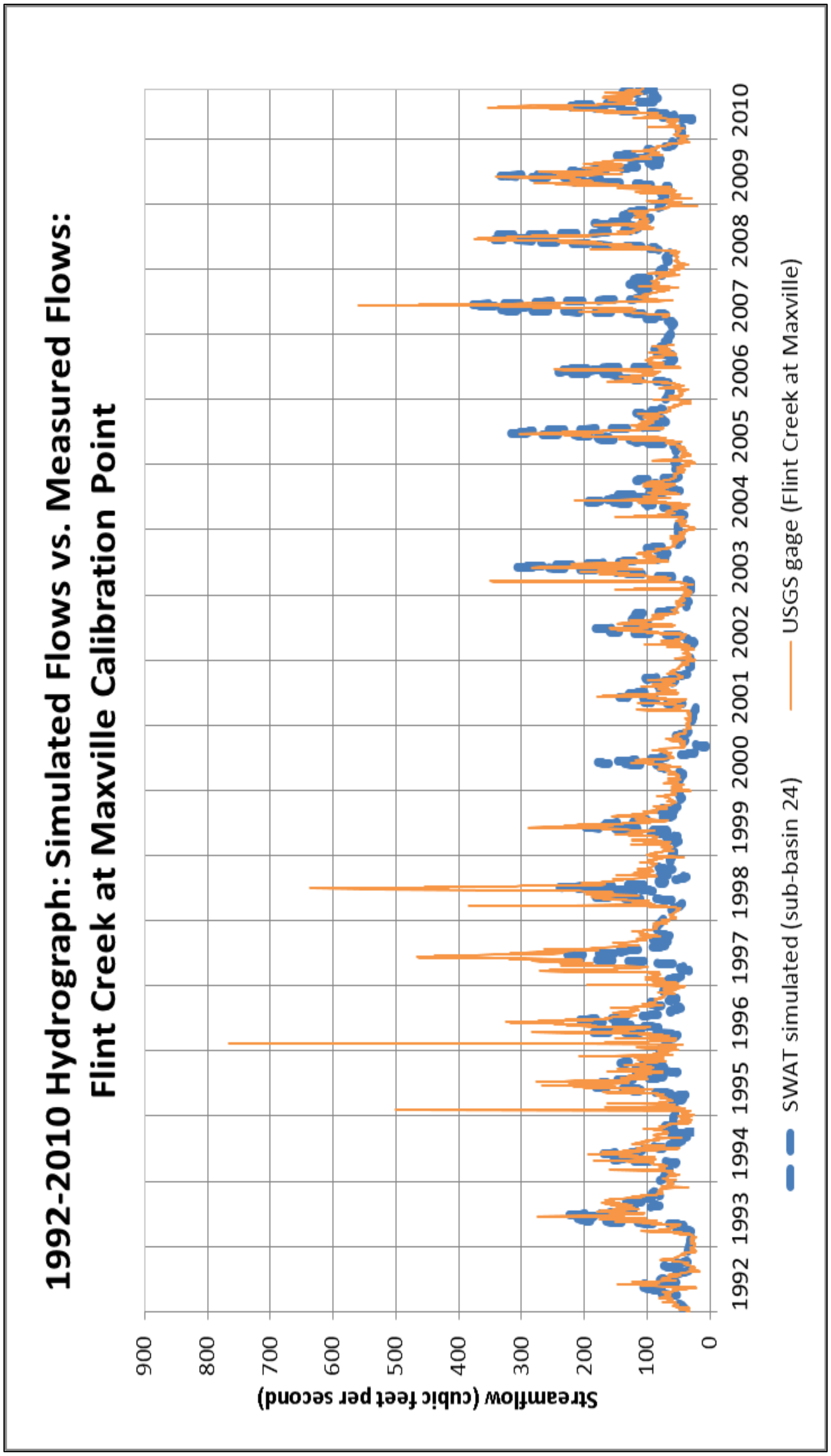


Figure ED-3. 1992-2010 Hydrograph: Simulated Flows vs. Measured Flows: Flint Creek at Maxville Calibration Point

ATTACHMENT EE – SIMULATED VS. MEASURED SEDIMENT CONCENTRATIONS

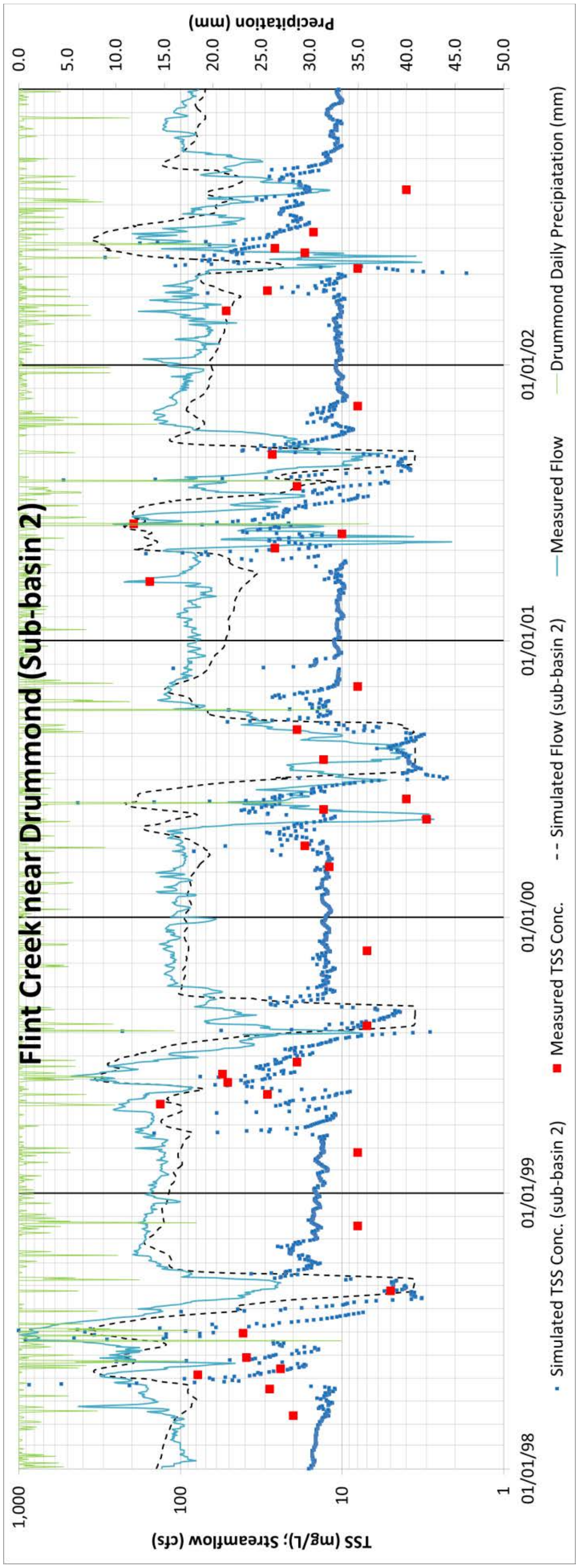


Figure EE-1. Total Suspended Solids for Flint Creek Near Drummond (Sub-basin 2)

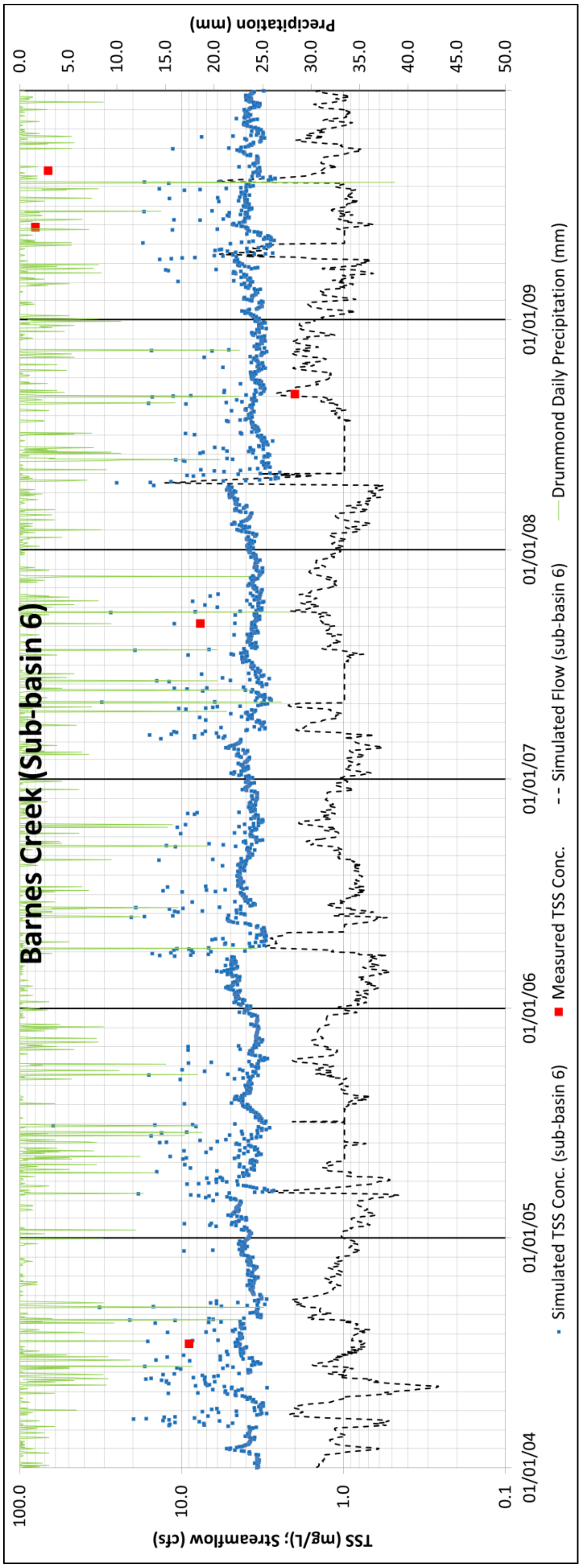


Figure EE-2. Total Suspended Solids for Barnes Creek (Sub-basin 6)

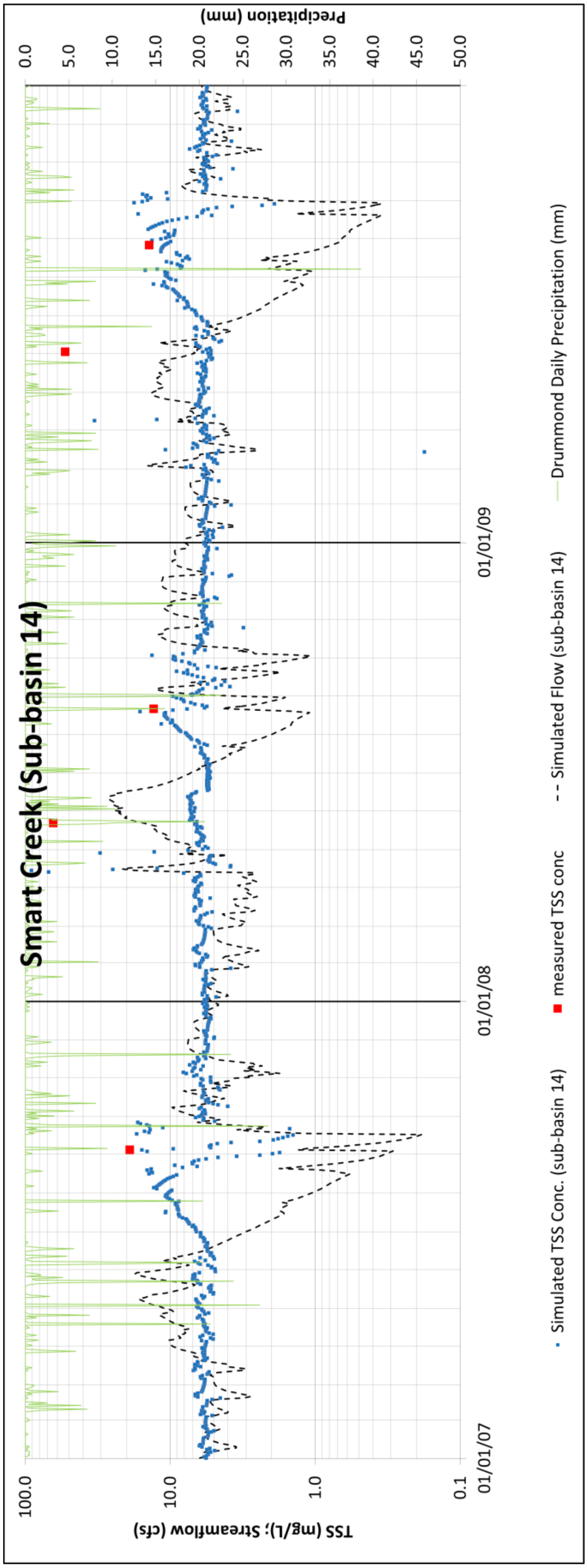


Figure EE-3. Total Suspended Solids for Smart Creek (Sub-basin 14)

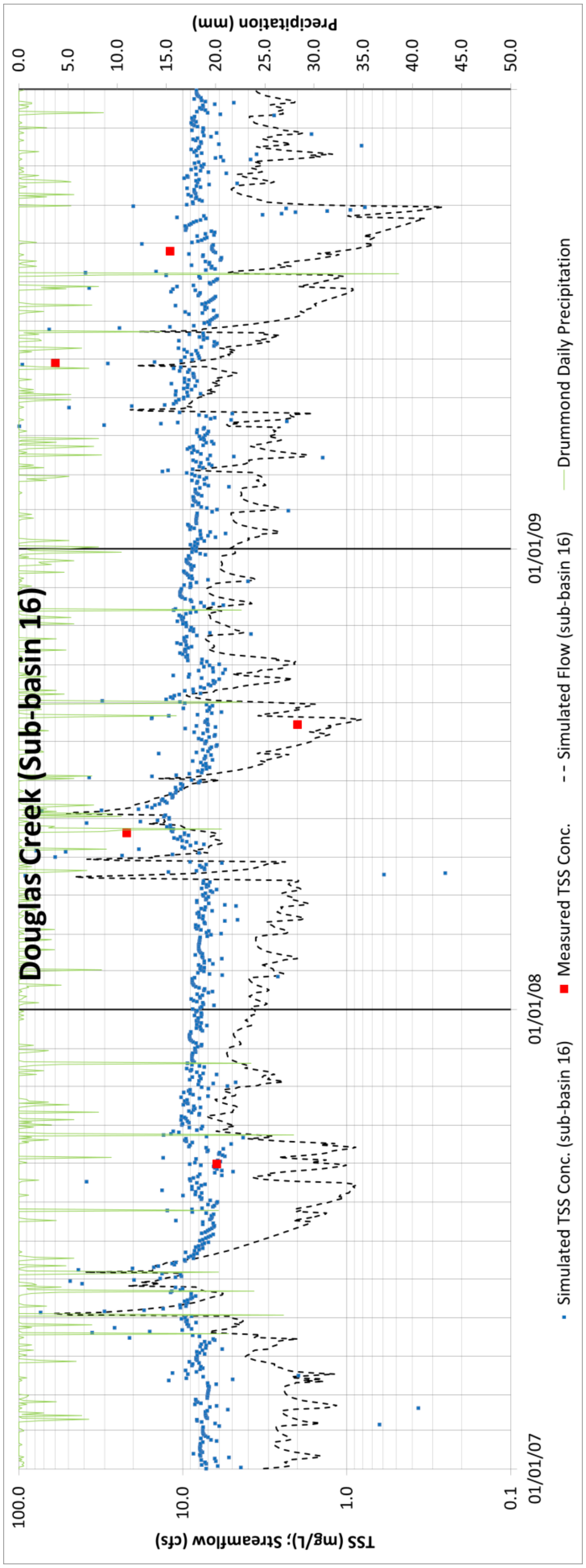


Figure EE-4. Total Suspended Solids for Douglas Creek (Sub-basin 16)

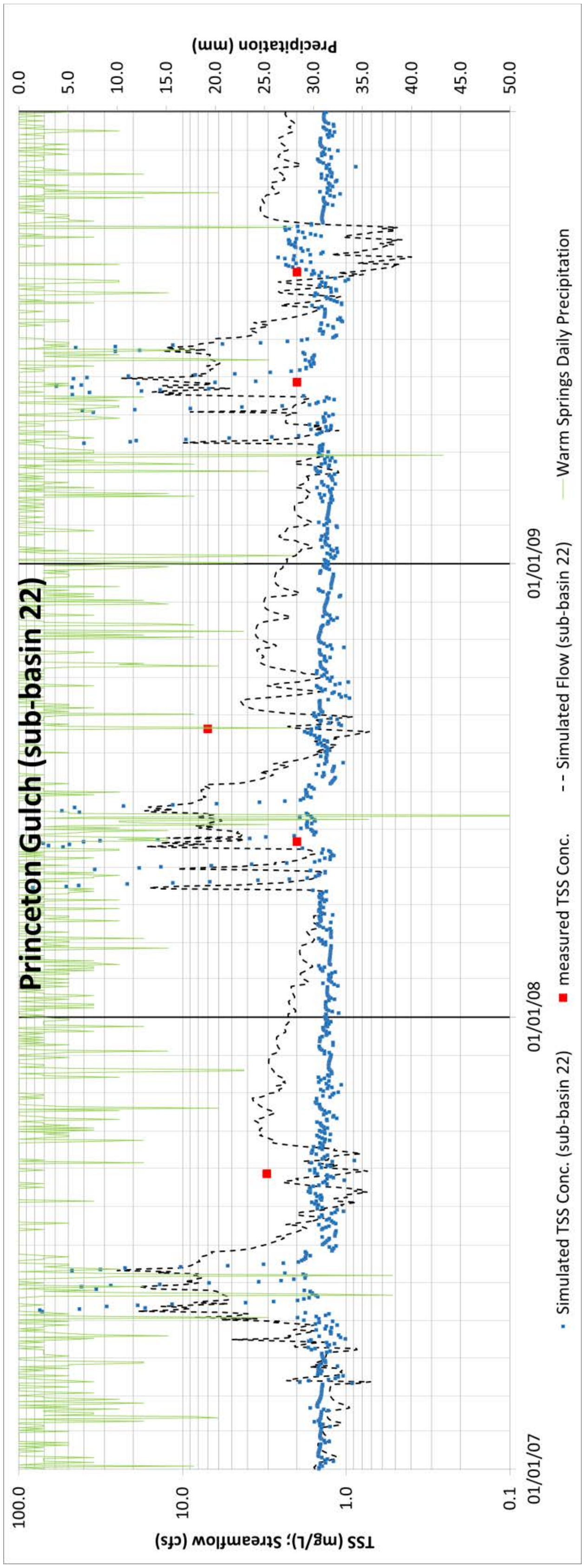


Figure EE-5. Total Suspended Solids for Princeton Gulch (Sub-basin 22)

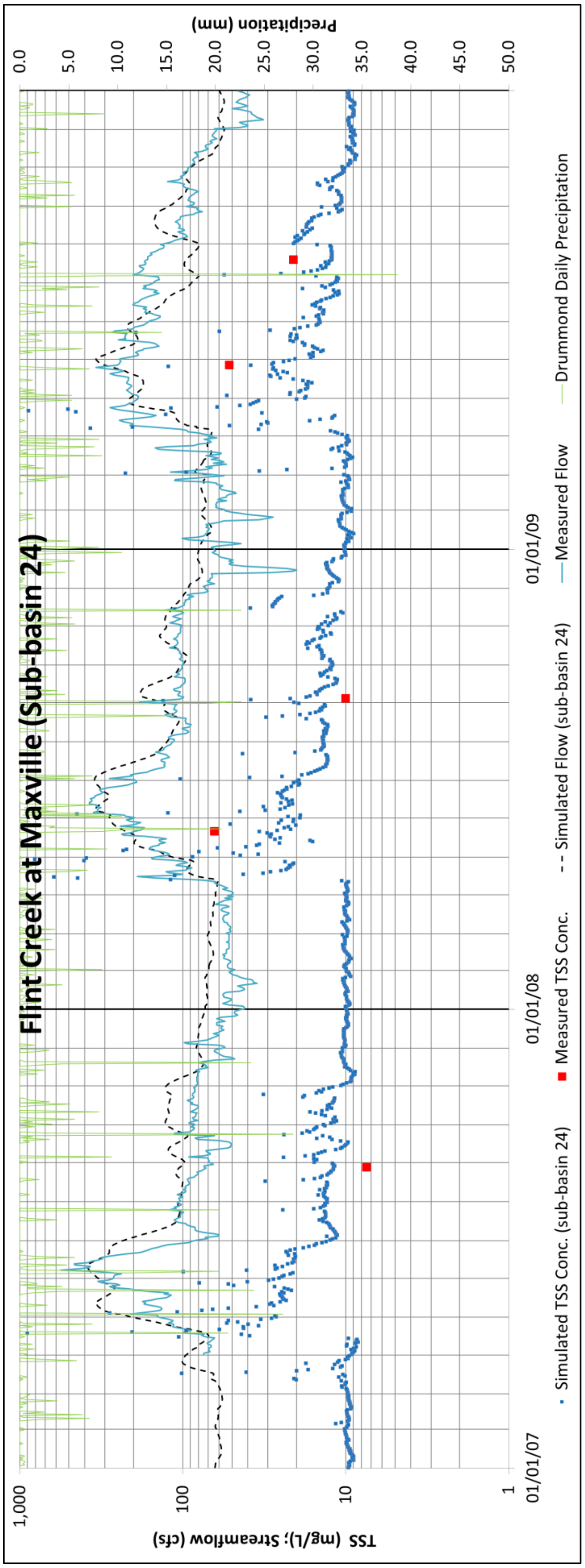


Figure EE-6. Total Suspended Solids for Flint Creek at Maxville (Sub-basin24)

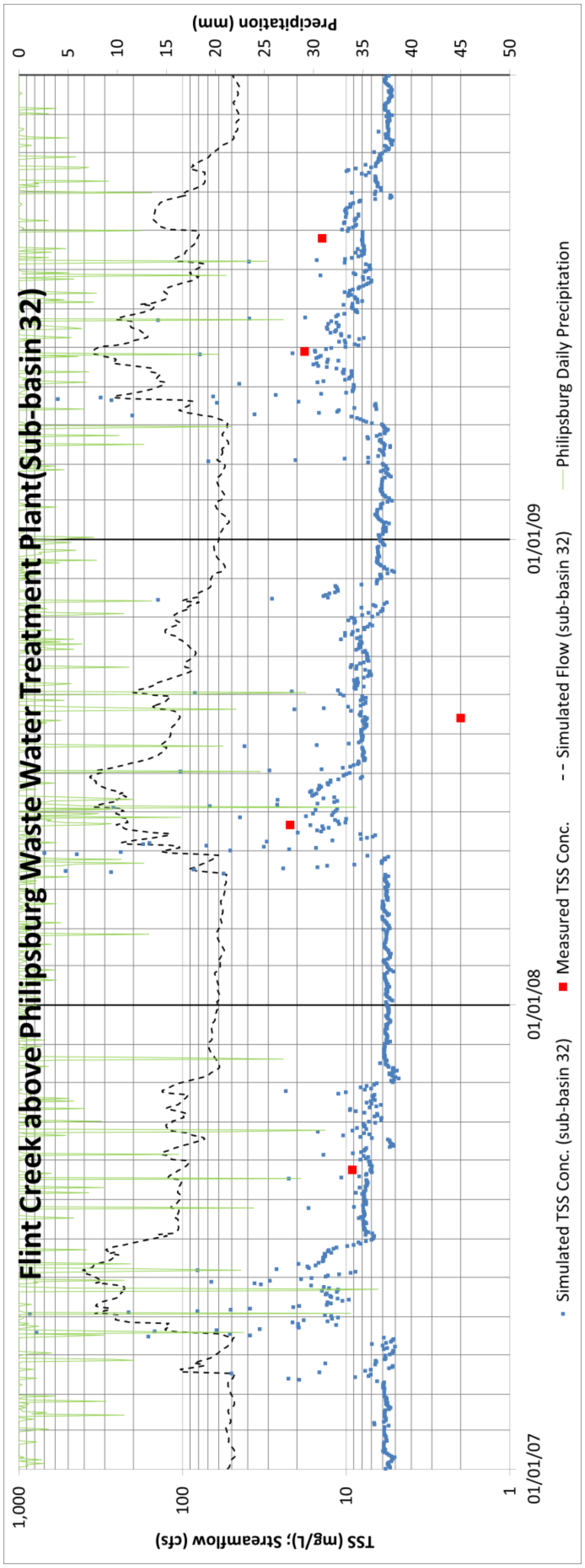


Figure EE-7. Total Suspended Solids for Flint Creek above Philipsburg Wastewater Treatment Plant (Sub-basin 32)

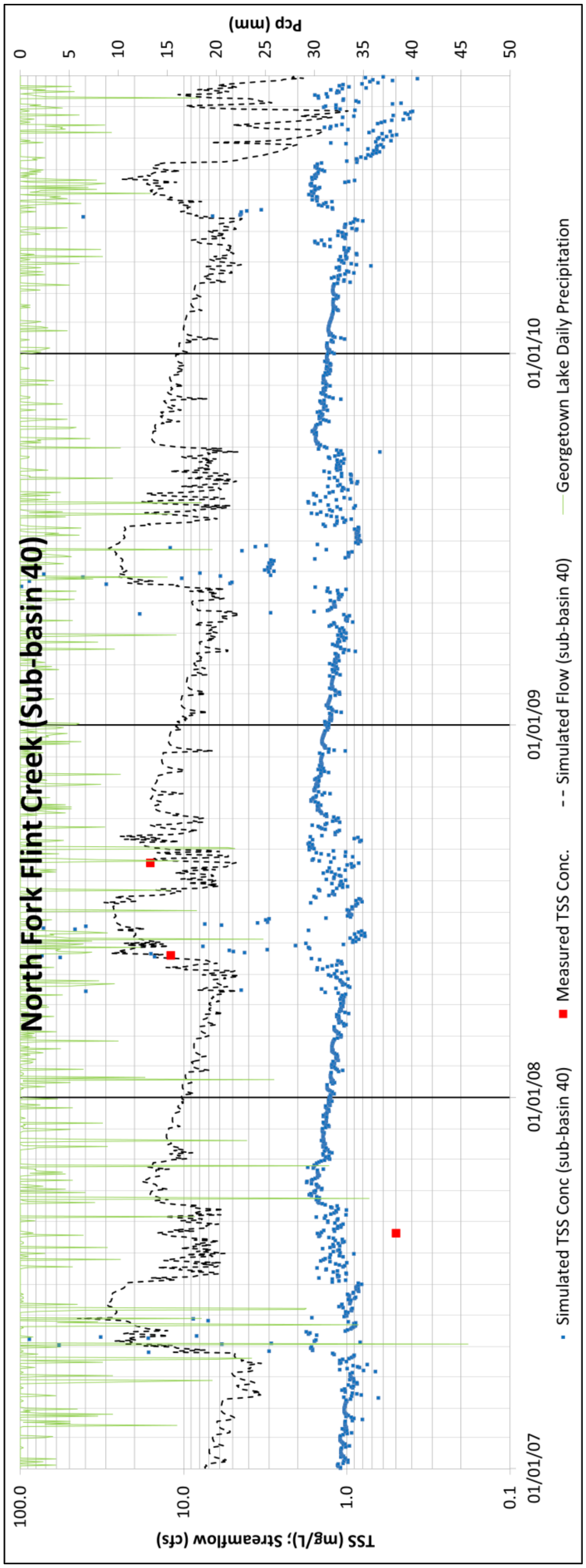
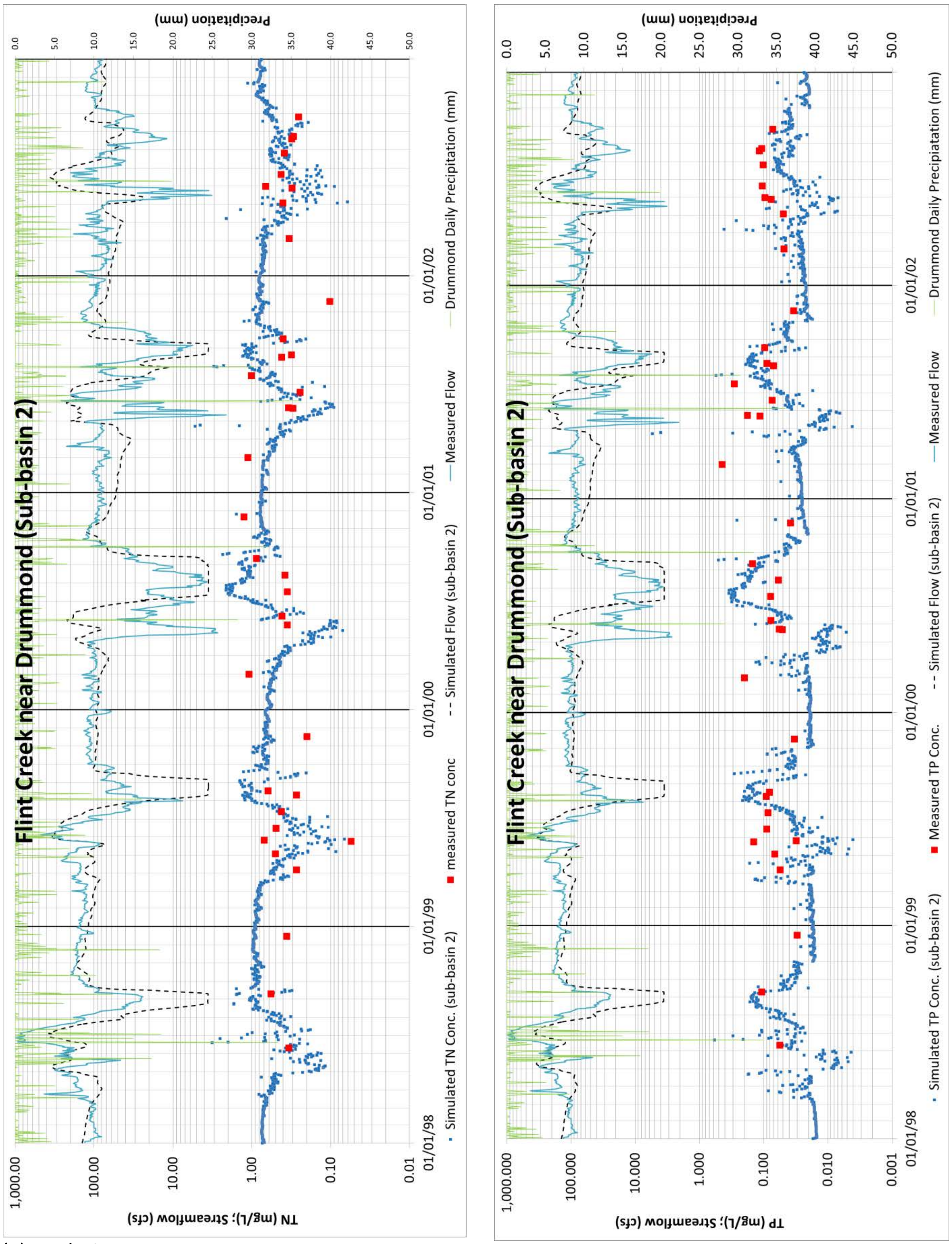


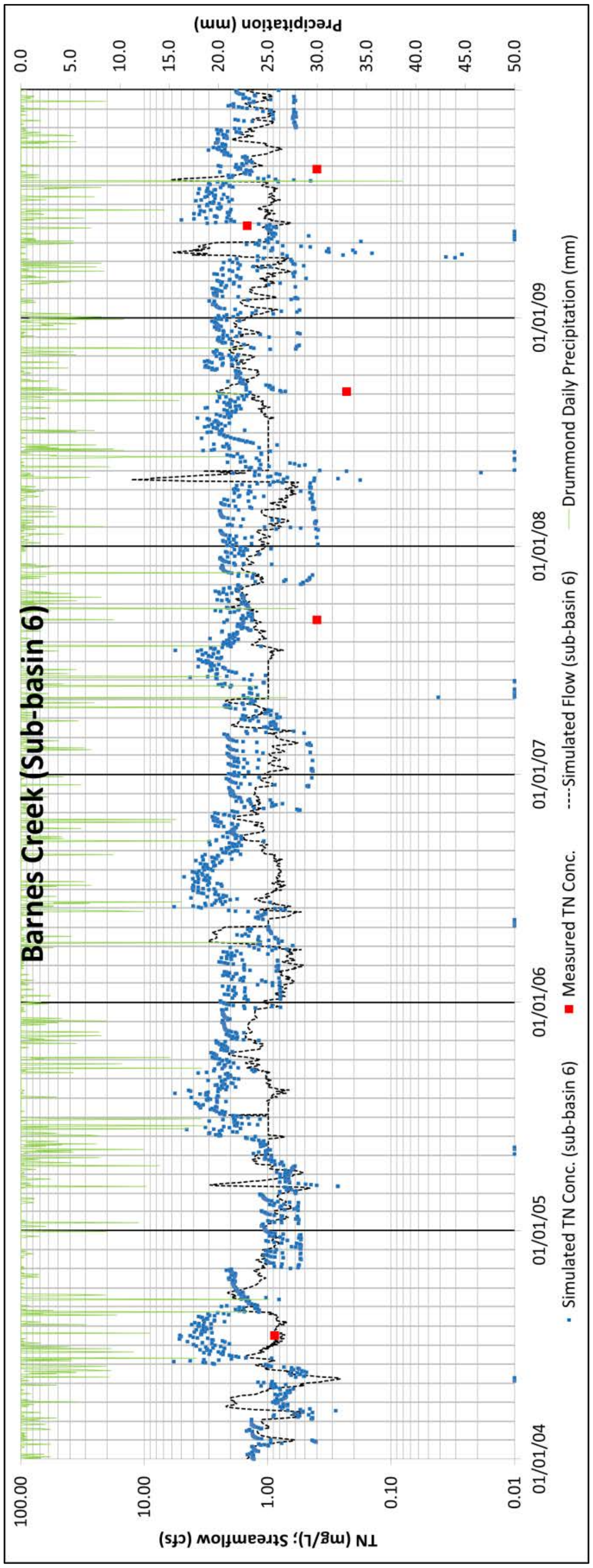
Figure EE-8. Total Suspended Solids for North Fork Flint Creek (Sub-basin 40)

ATTACHMENT EF – SIMULATED VS. MEASURED NUTRIENT CONCENTRATIONS

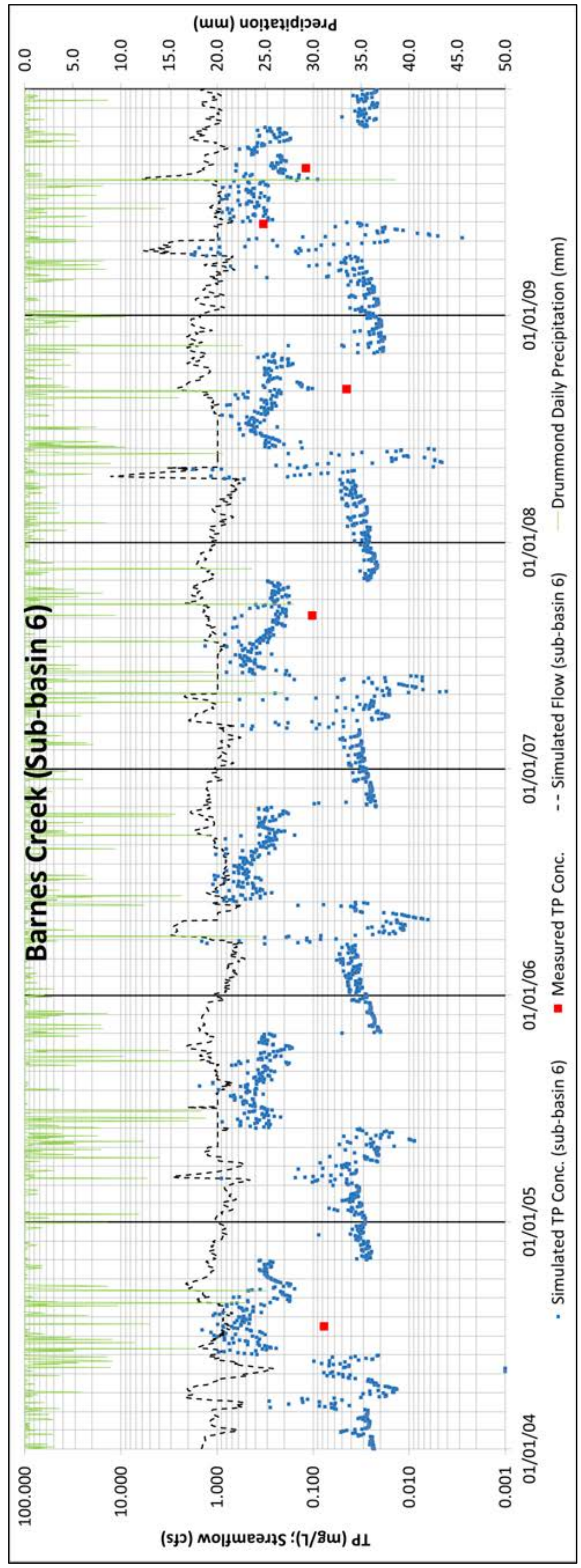


(a)Total Nitrogen (b)Total Phosphorus

Figure EF-1. Nutrients for Flint Creek near Drummond (Sub-basin 2)

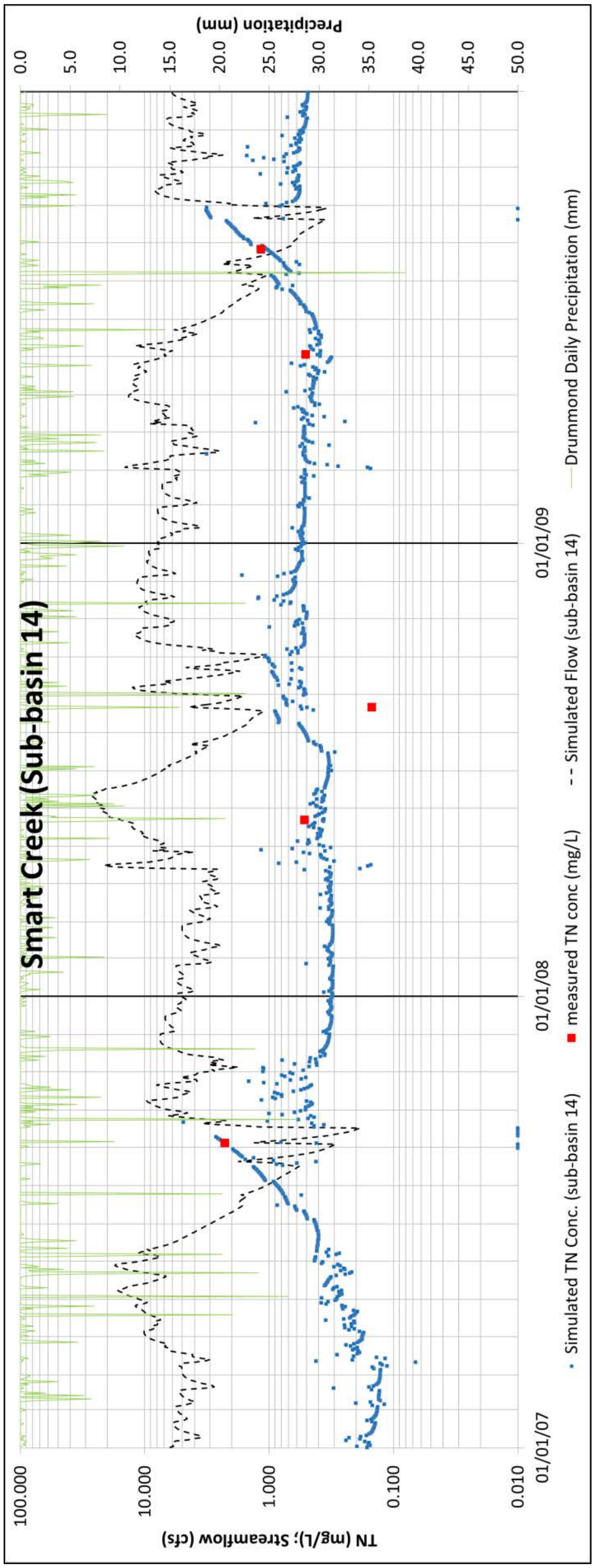


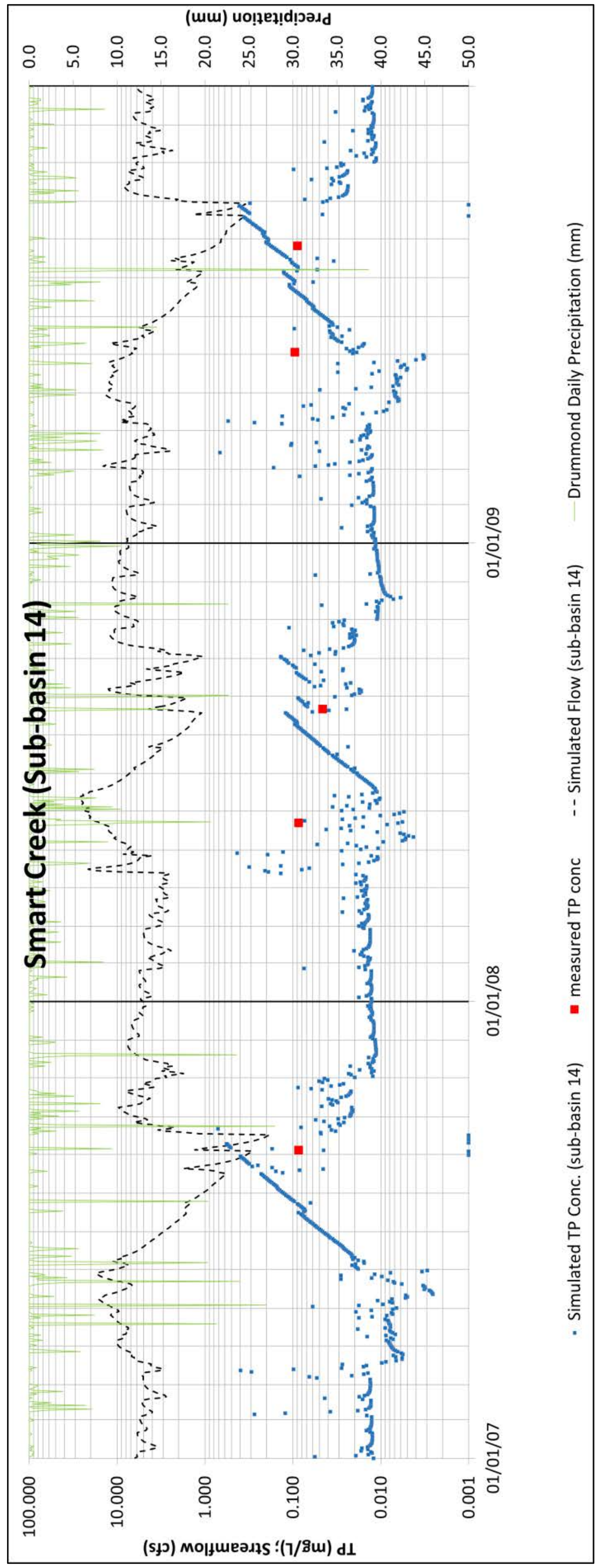
(a) Total Nitrogen



(b) Total Phosphorus

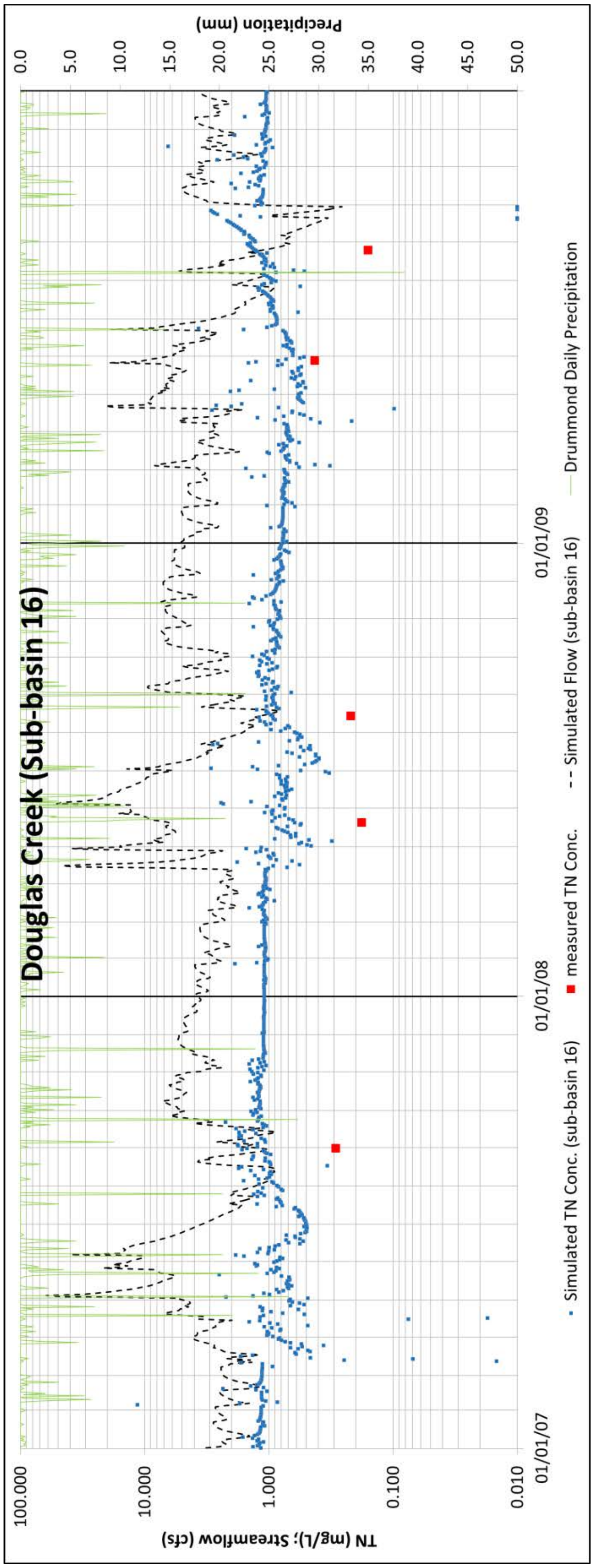
Figure EF-2. Nutrients for Barnes Creek (Sub-basin 6)



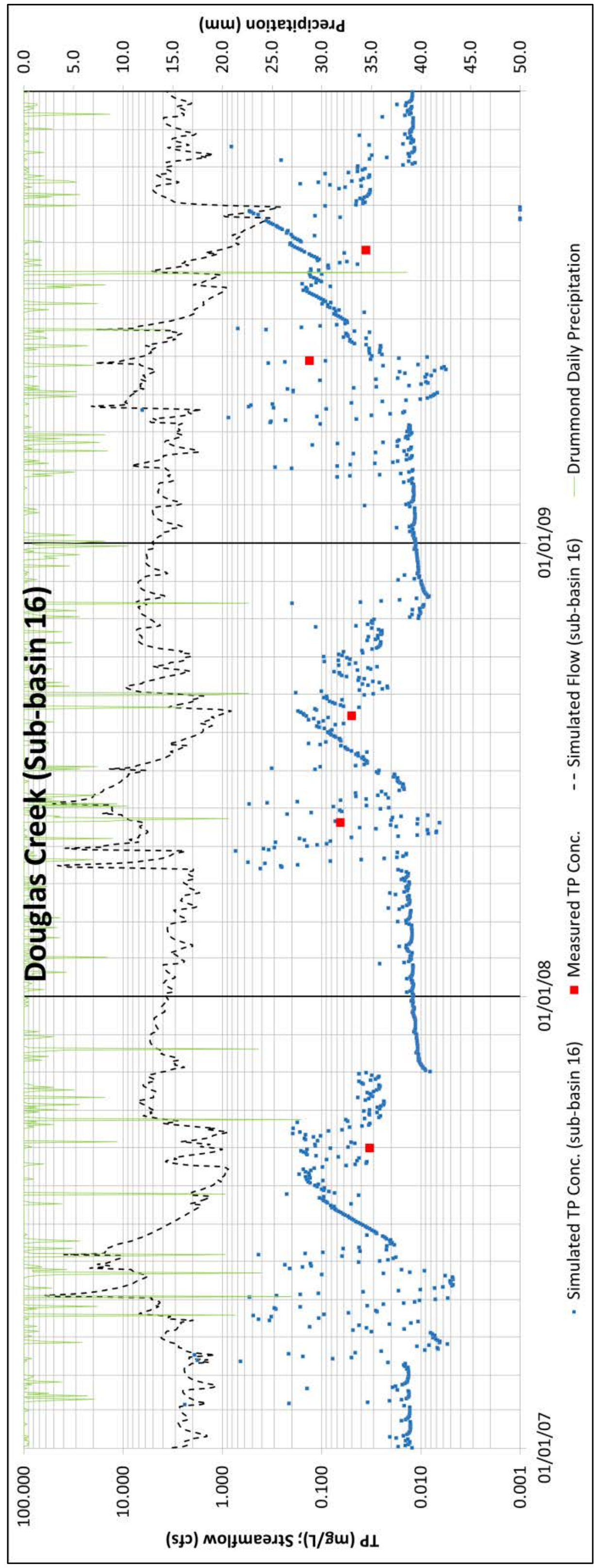


(a) Total Nitrogen (b) Total Phosphorus

Figure EF-3. Nutrients for Smart Creek (Sub-basin 14)

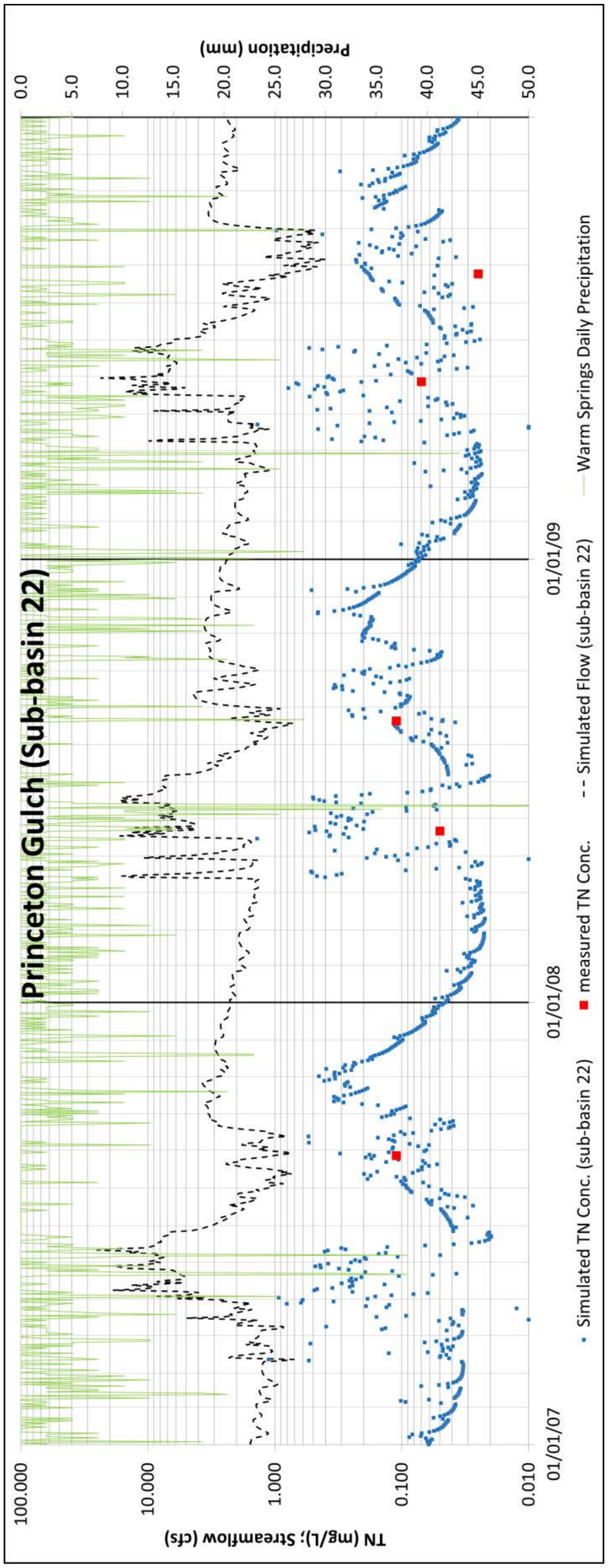


(a) Total Nitrogen

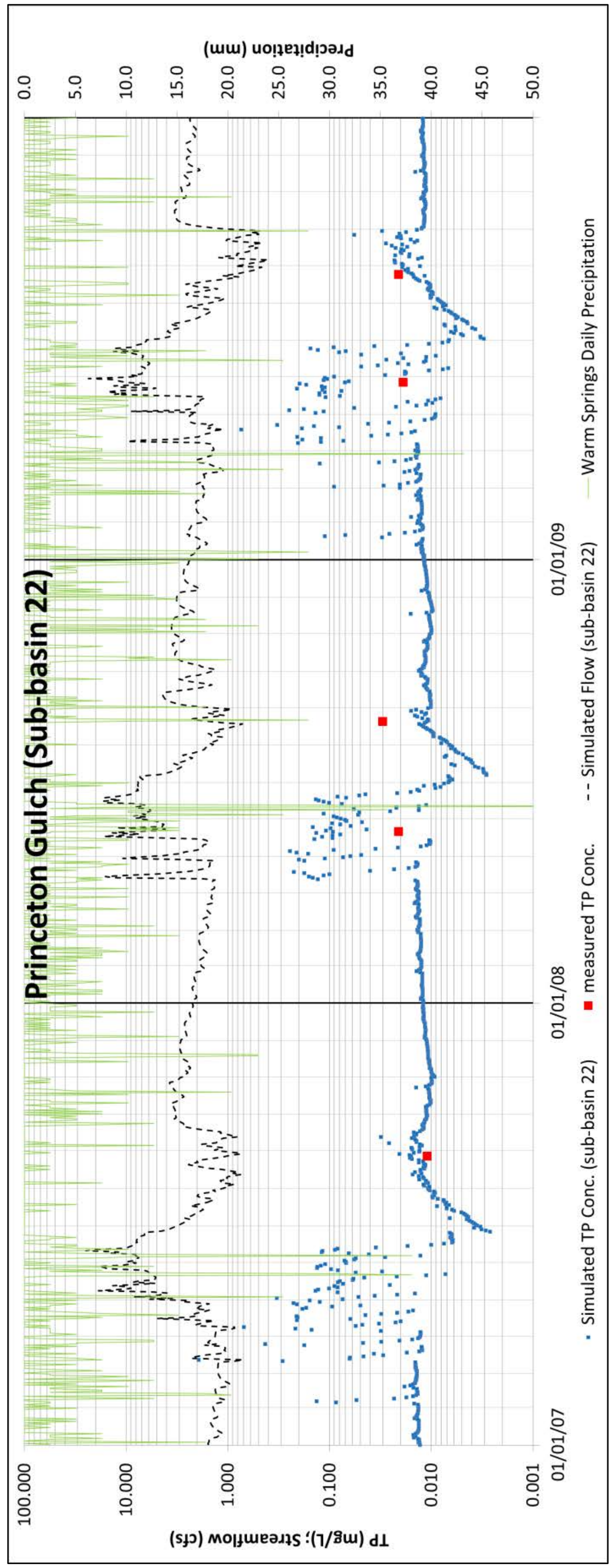


(b) Total Phosphorus

Figure EF-4. Douglas Creek (Sub-basin 16)

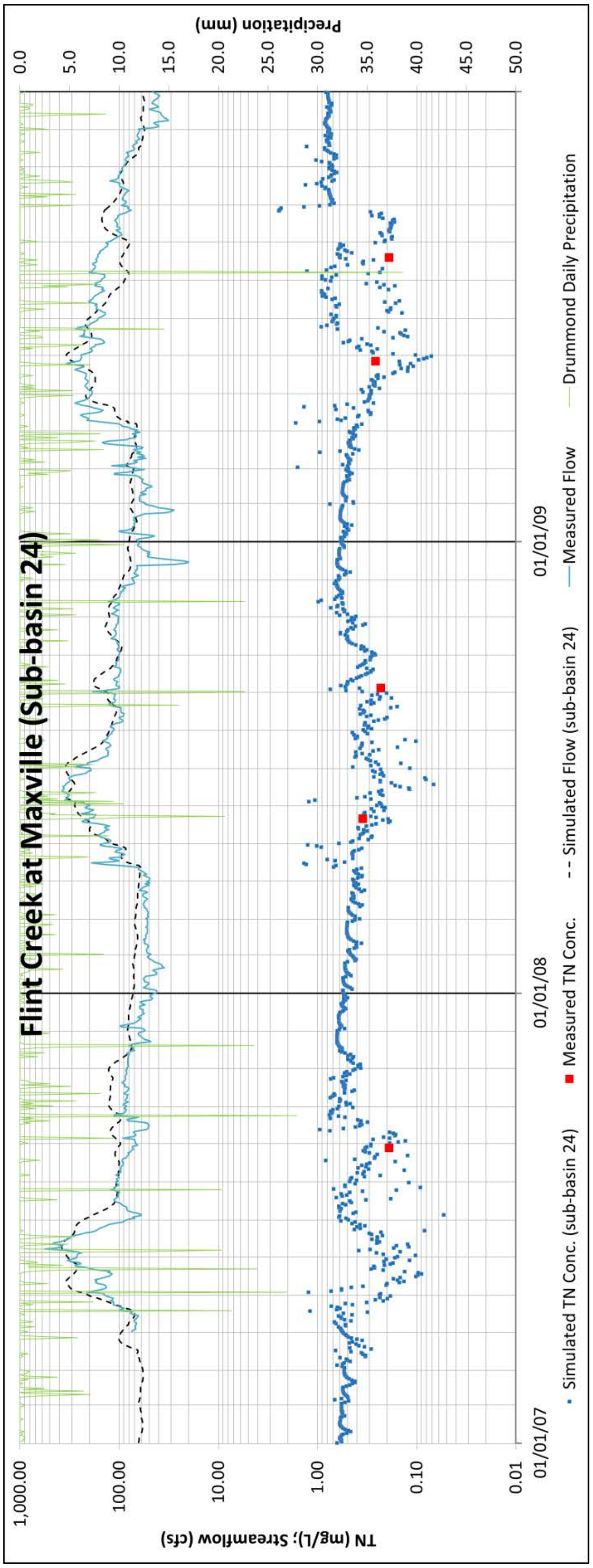


(a)Total Nitrogen

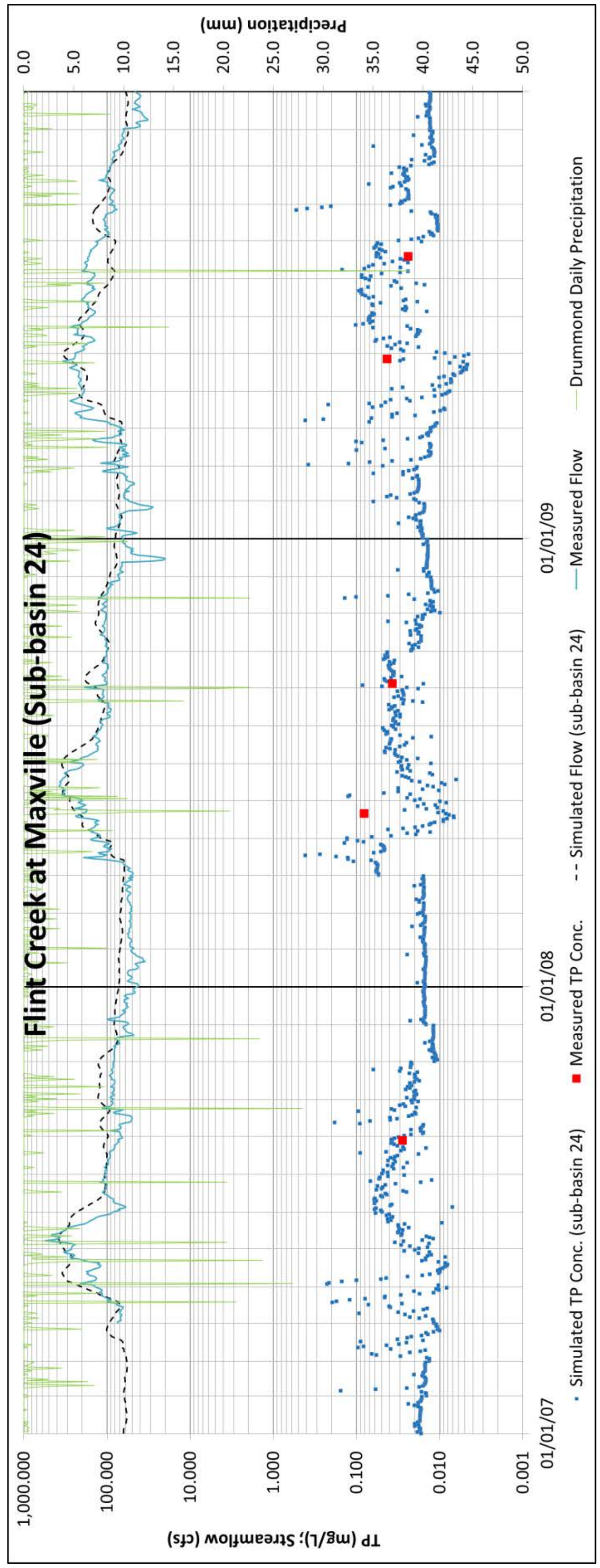


(b) Total Phosphorus

Figure EF-5. Nutrients for Princeton Gulch (Sub-basin 22)

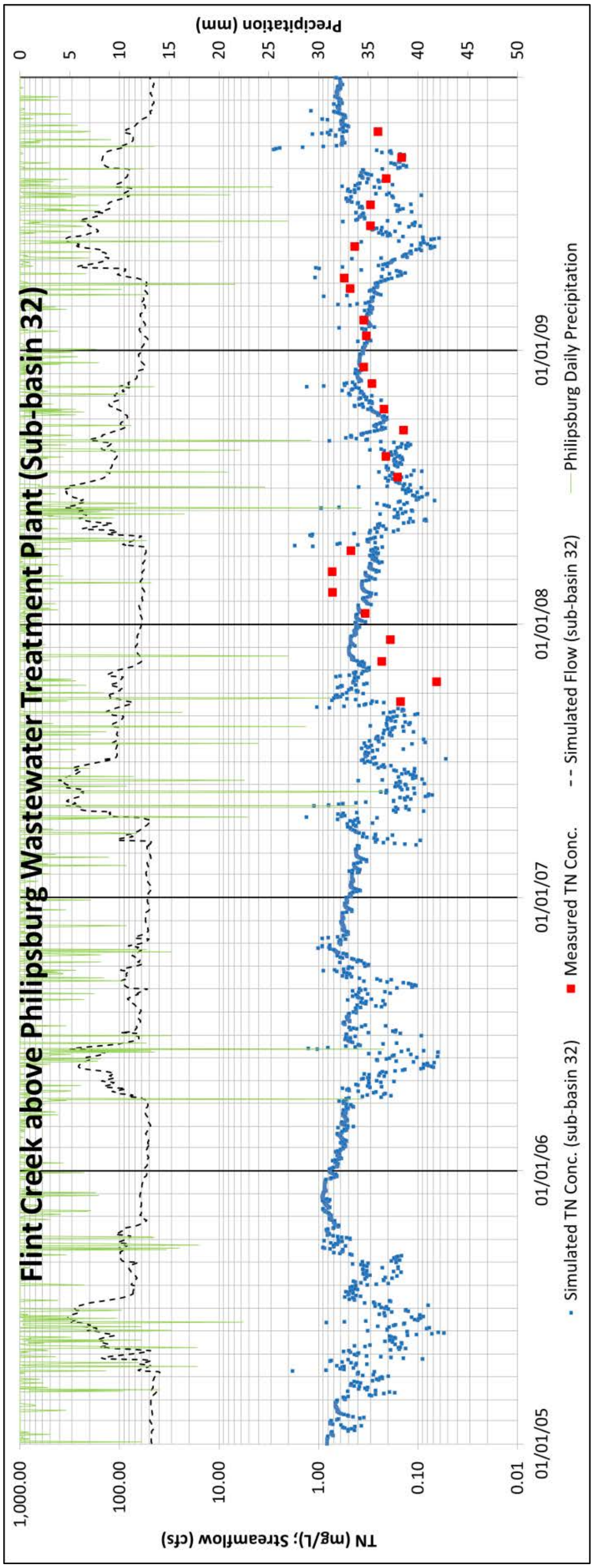


(a) Total Nitrogen

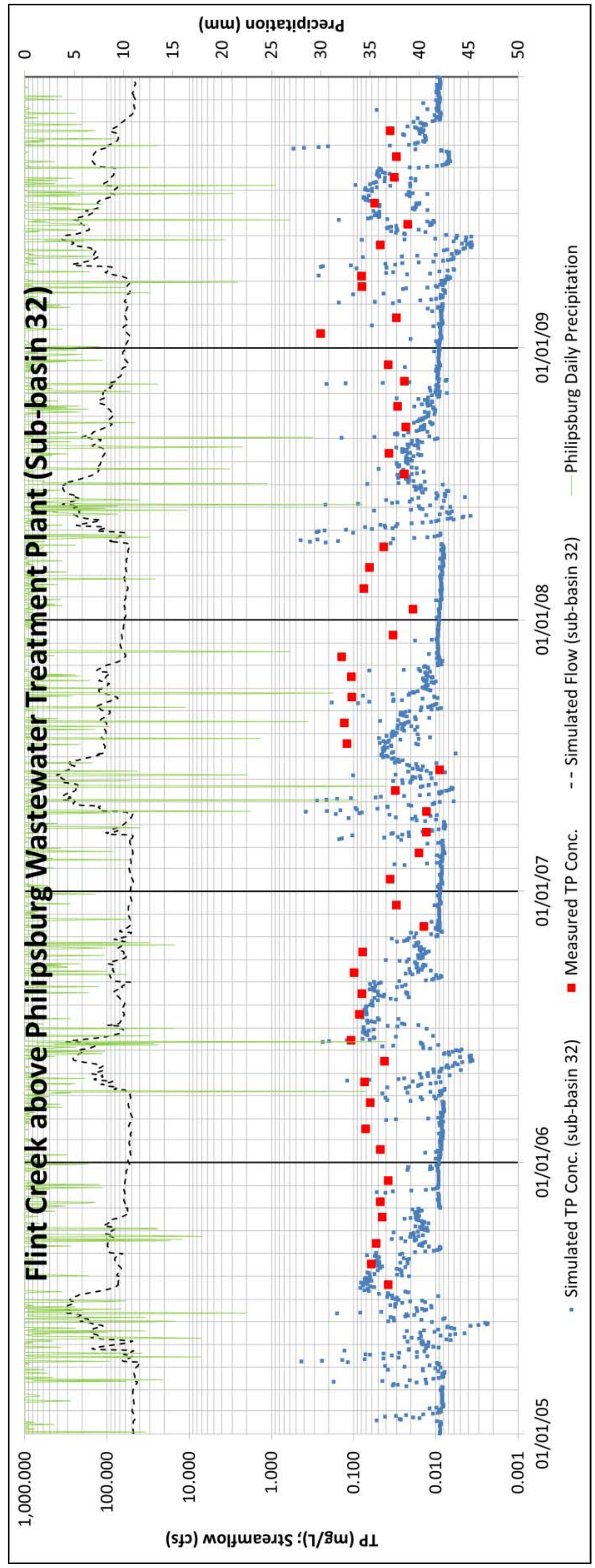


(b) Total Phosphorus

Figure EF-6. Nutrients for Flint Creek at Maxville

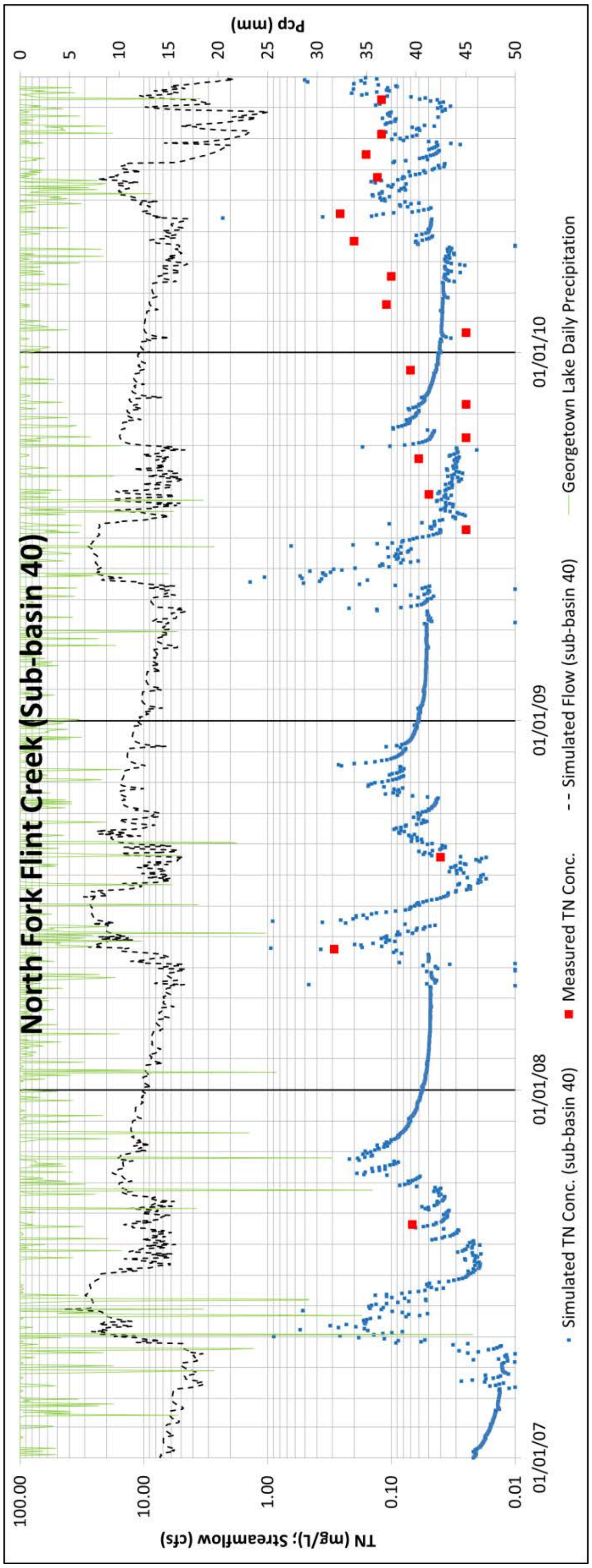


(a) Total Nitrogen

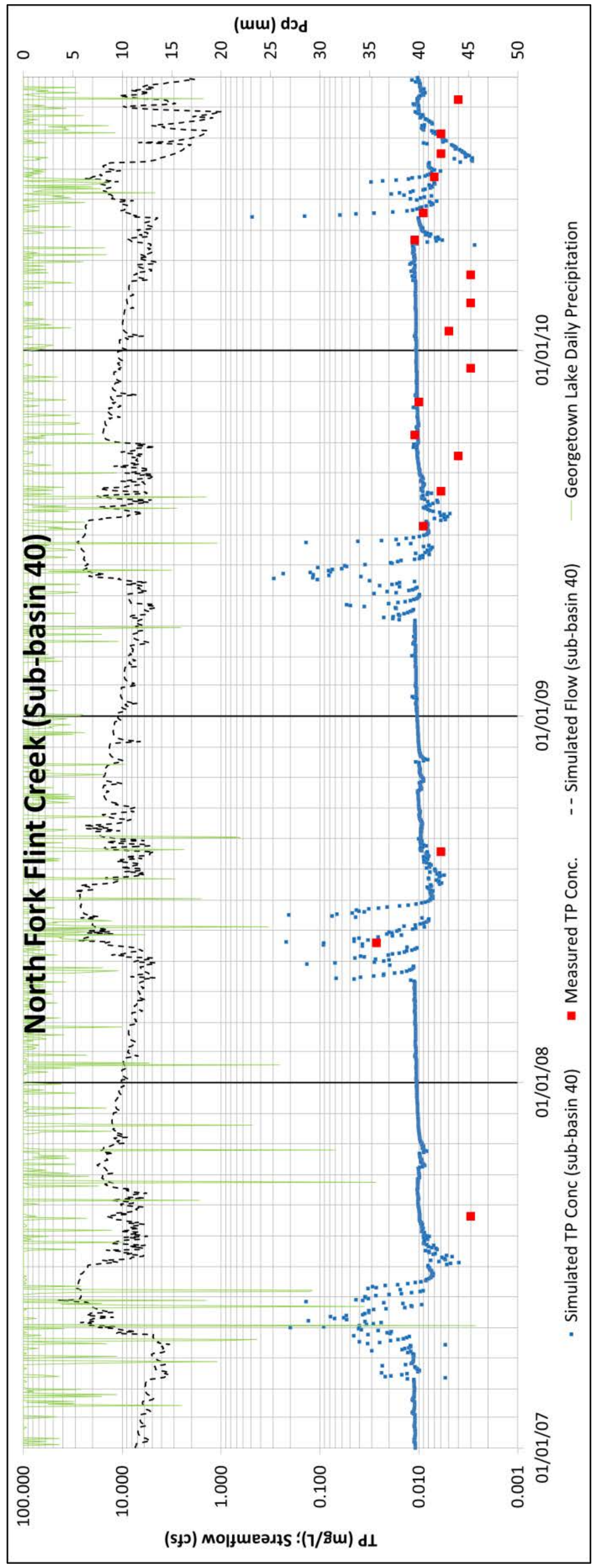


(b) Total Phosphorus

Figure EF-7. Nutrients for Flint Creek Above Wastewater Treatment Plan (Sub-basin 32)



(a) Total Nitrogen



(b) Total Phosphorus

Figure EF-8. Nutrients for North Fork Flint Creek (Sub-basin 40)

APPENDIX F – SUBSURFACE WASTEWATER TREATMENT SYSTEMS IN THE FLINT CREEK WATERSHED

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ACRONYMS

Acronym	**Definition**
DEQ	Department of Environmental Quality (Montana)
EPA	Environmental Protection Agency (U.S.)
GIS	Geographic Information System
MGWPCS	Montana Ground Water Pollution Control System
NRCS	Natural Resources Conservation Service
SWAT	Soil & Water Assessment Tool
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TPA	TMDL Planning Area
WWTP	Wastewater Treatment Plant

F1.0 INTRODUCTION

This is a technical report prepared to support the nutrient Total Maximum Daily Load (TMDL) process in the Flint Creek Watershed. This report will describe the current septic use locations and associated groundwater information. Information from this report will be used to construct a water quality model which will be used for TMDL source assessment and creating TMDL allocations. The water quality model (Soil & Water Assessment Tool (SWAT)) will assess the potential significance of nutrient loading from all sources within the watershed.

Wastewater is any water that has been adversely affected in quality by anthropogenic influence. It comprises liquid waste discharged by domestic residences, commercial properties, industry, and/or agriculture and can encompass a wide range of potential contaminants and concentrations. In the most common usage, it refers to the municipal wastewater that contains a broad spectrum of contaminants resulting from the mixing of wastewaters from different sources including household, industrial and commercial sources connected to a drainage system and routed to a treatment facility. Wastewater produced from septic systems, both on-site household treatment systems and larger multi-home systems, is the primary focus of this report. Wastewater sources that discharge to surface water are reviewed in a separate report.

F2.0 REGULATORY OVERVIEW

The Montana Department of Environment Quality (DEQ) regulates most subsurface wastewater treatment systems (septic systems) that are installed in Montana. Septic systems that are designed for less than 5,000 gallons per day and are not public systems are reviewed by the Department's subdivision section (if such as system is on a lot that is 20 acres or larger the system is only reviewed by the county). Septic systems that are designed for 5,000 gallons per day or greater are reviewed by the Department's wastewater discharge permit section along with any industrial facilities which discharge to groundwater. The systems reviewed by the wastewater discharge permit section are required to have a valid discharge permit to construct and operate the system (note that systems reviewed and approved by DEQ prior to May 1, 1998 do not need a permit until the system is modified or violates rule or statute). Public septic systems (schools, government buildings, etc.) designed for less than 5,000 gallons per day don't need a discharge permit, but are reviewed by the Department's Public Water Supply Section in a similar manner as those reviewed by DEQ's subdivision section.

All septic system reviews conducted by the Department have three major components: plan and specification review; site suitability; and water quality impact review. The plan and specification review is conducted to insure the design of the system meets the applicable technical standards in the Department's technical design circulars DEQ-2 and DEQ-4. The site suitability review is conducted to insure that the area chosen to dispose of the wastewater (typically through a drainfield or rapid infiltration bed) is suitable to hydraulically dissipate and treat the quantity and quality of the wastewater discharged. The site suitability is primarily based on the local hydrogeology and the soil type. The water quality impact review is to insure that the state waters that will be impacted by the wastewater discharge are not impacted beyond the allowable levels for nitrogen, phosphorus and bacteria.

The water quality impact review for each submitted project is typically completed in accordance with the state nondegradation rules, which applies to any new or increased source of pollutants to high quality state waters since April 29, 1993. Any source that is not subject to those nondegradation rules must comply with the water quality standards.

Under the nondegradation rules nitrogen impacts from septic systems may not cause the nitrate (as N) concentration to exceed 5.0 or 7.5 mg/L at the end of an approved groundwater mixing zone. The 5.0 mg/L limit applies to conventional septic systems. The 7.5 mg/L limit applies to level 2 septic systems (or to any septic system if the background nitrate in the groundwater is between 5 and 7.5 mg/L and that elevated nitrate concentration is primarily from sources other than human waste). When the discharge is close enough to a high-quality state surface water, the nitrate impacts to the surface water may be assessed with respect to the Circular DEQ-7 trigger value for nitrate, 0.01 mg/L. Under the trigger value criterion, the source may not increase the nitrate concentration in the surface water above the trigger value at the end of a surface water mixing zone. Alternatively, for surface water impacts, the source may be reviewed for compliance under the nondegradation narrative standard which requires that the source "… will not have a measurable effect on any existing or anticipated use or cause measurable changes in the aquatic life or ecological integrity." This review does not usually assess cumulative sources over time, only project by project impacts.

Under the nondegradation rules phosphorus discharges from septic systems must be adsorbed in the soils for at least 50 years before discharging to any high quality state surface water. When the discharge cannot meet the 50-year breakthrough criterion, the phosphorus impacts to the surface water may be assessed with respect to the Circular DEQ-7 trigger value for inorganic phosphorus, 0.001 mg/L. Under the trigger value criterion, the source may not increase the inorganic phosphorus concentration in the surface water above the trigger value at the end of a surface water mixing zone. Alternatively, the source may be reviewed for compliance under the nondegradation narrative standard which requires that the new source "… will not have a measurable effect on any existing or anticipated use or cause measurable changes in the aquatic life or ecological integrity." This review does not usually assess cumulative sources over time, only project by project impacts.

F3.0 Groundwater Waste Source Characterization

Sources of wastewater in the Flint Creek Watershed include municipal, industrial, public facility, multi-family and individual household wastewater treatment systems.

F3.1 Industrial Wastewater Treatment Systems

There are two industrial Montana Ground Water Pollution Control System (MGWPCS) groundwater discharge permits located in the watershed for the Sugar Loaf Wool Carding Mill located near Hall and for the Contact Mining Company located southeast of Phillipsburg (**Figure F-1**). Industrial groundwater discharges are required to obtain a MGWPCS permit regardless of the discharge volume.

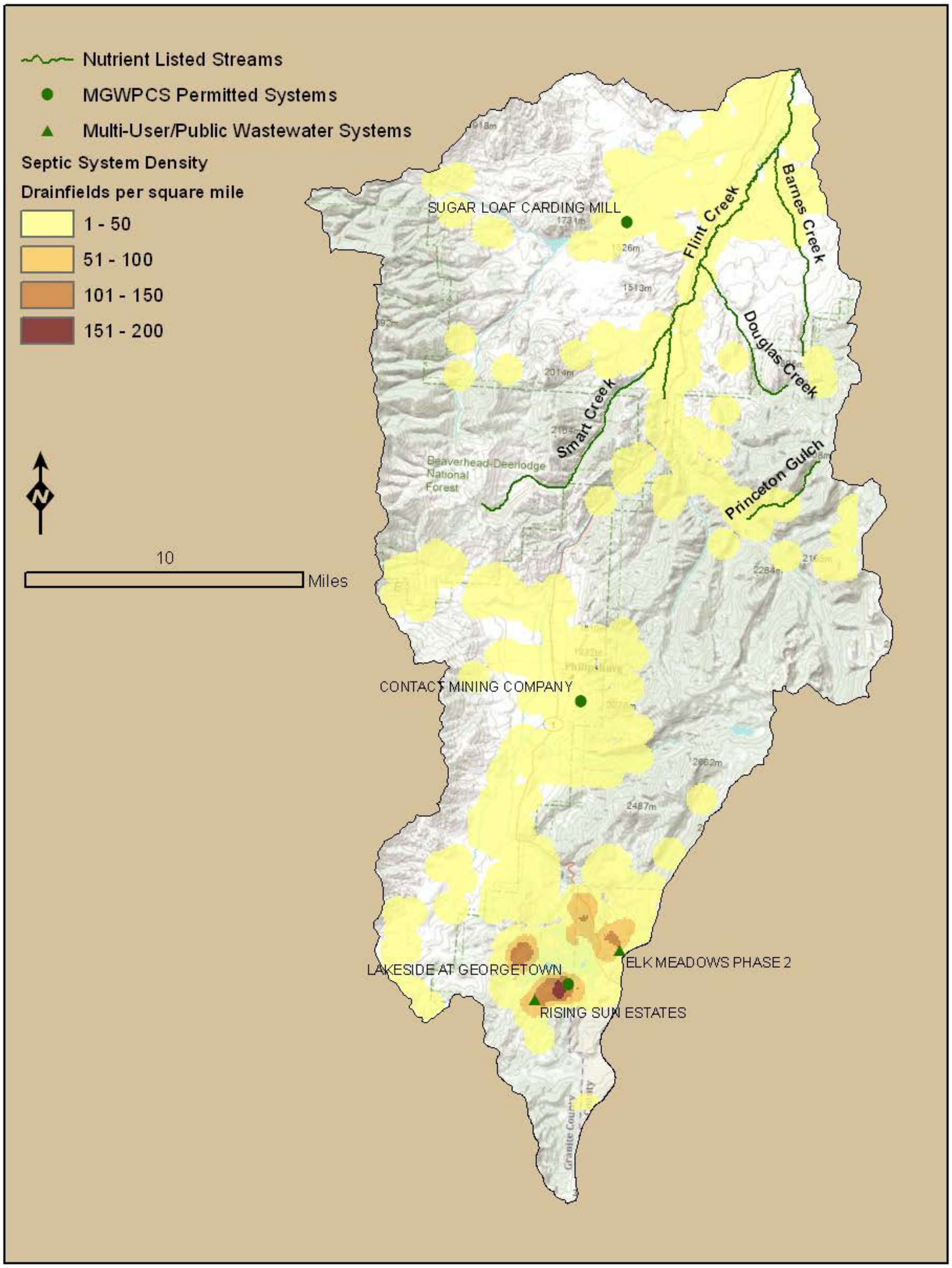

Figure F-1. Wastewater Contributions to Groundwater

F3.2 Municipal Wastewater Treatment Systems

The town of Phillipsburg is the only municipal sewered system that discharges wastewater within the TMDL Planning Area (TPA). The Phillipsburg system is discussed in the wastewater treatment plant (WWTP) point sources technical report for this project. The Philipsburg wastewater treatment system consists of a 2-celled facultative lagoon that discharges directly to Flint Creek and is therefore required to have an active Montana Pollutant Discharge Elimination System permit.

F3.3 Permitted, Public, and Multi-User Wastewater Treatment Systems

There is one active or pending MGWPCS discharge permit for human waste disposal within the TPA. That is for the Lakeside at Georgetown subdivision near Georgetown Lake (**Figure F-1**) that serves 22 single family homes. A MGWPCS permit is required for wastewater systems discharging to groundwater that are designed to treat 5,000 gallons per day or more.

Public wastewater treatment systems have at least 15 service connections or regularly serve at least 25 persons daily for any 60 days or more in a calendar year. Multi-user wastewater treatment systems have 3–14 service connections and don't regularly serve 25 or more persons for any 60 days in a calendar year. Multi-user and public wastewater systems that discharge to groundwater are not regulated via the MGWPCS unless they: 1) are designed to treat 5,000 gallons per day or more; or 2) are aerobic package plant systems, mechanical treatment plants, and nutrient removal systems, which require a high degree of operation and maintenance or systems which require monitoring pursuant to Administrative Rules of Montana 17.30.517(1)(d)(ix). The DEQ Subdivision Review Section database records three multi-user or public wastewater treatment systems that were approved since 2000 in the watershed (**Figure F-1**); one of those is Lakeside at Georgetown subdivision discussed above. The other two systems serve a total of 44 single family homes or condominiums, and are also in the vicinity of Georgetown Lake (**Figure F-1**). Records are not available for public or multi-user systems approved prior to 2000.

F3.4 Household Wastewater Treatment System Estimates

Using Geographic Information System (GIS) data, DEQ estimates that there are 1,623 septic systems in the Flint Creek watershed. DEQ reached this estimate using GIS layers of structures in Granite and Deer Lodge Counties. The counties had previously contracted a GIS consultant (MaPS, Inc.) to develop these layers to support emergency responders. Locations and type of structure were established by field mapping and aerial photograph interpretation, as of summer 2009. For DEQ, the location and type of structure are the relevant attributes.

DEQ reduced the dataset to structures within the watershed boundary, and of the following types: apartment, cabin, house, mobile home. Commercial, civic or other public facilities were excluded on the assumption that their wastewater systems serve the same population as the residences. DEQ recognizes that a subset of the residential structures in the watershed are seasonal or vacation homes, however there are no available data on occupancy.

The city of Philipsburg is sewered and served by a WWTP. Dick Hoehn of the Philipsburg Public Works Department provided a map of the sewer system. Using this, DEQ manually deleted those structures within the corresponding area.

F3.4.1 Distribution and Growth

Yearly septic permit approval rates in the watershed on parcels less than 20 acres could not be determined from the available databases. However, as an analogy to approximate population growth rates in the watershed, the number of subdivision lots under 20 acres approved in each state fiscal year since 1990 are shown in **Figure F-2** for both Granite and Deer Lodge Counties (the TPA lies primarily within Granite County but a small portion east of Georgetown Lake lies within Deer Lodge county). Note that a subdivision lot approval does not indicate occupancy of the lot, but rather that the lot was created for a residential or commercial use. Since 1990 the highest lot growth rate occurred in 2005 while the lowest lot growth rate occurred in 1993. Recently available information (Granite County Sanitarian, Lanes, Chad, personal communication 2013) indicates that approximately 390 septic permits were issued within the TPA between 1990 and 2010, which is much less than the number of lots created as shown in **Figure F-2**.

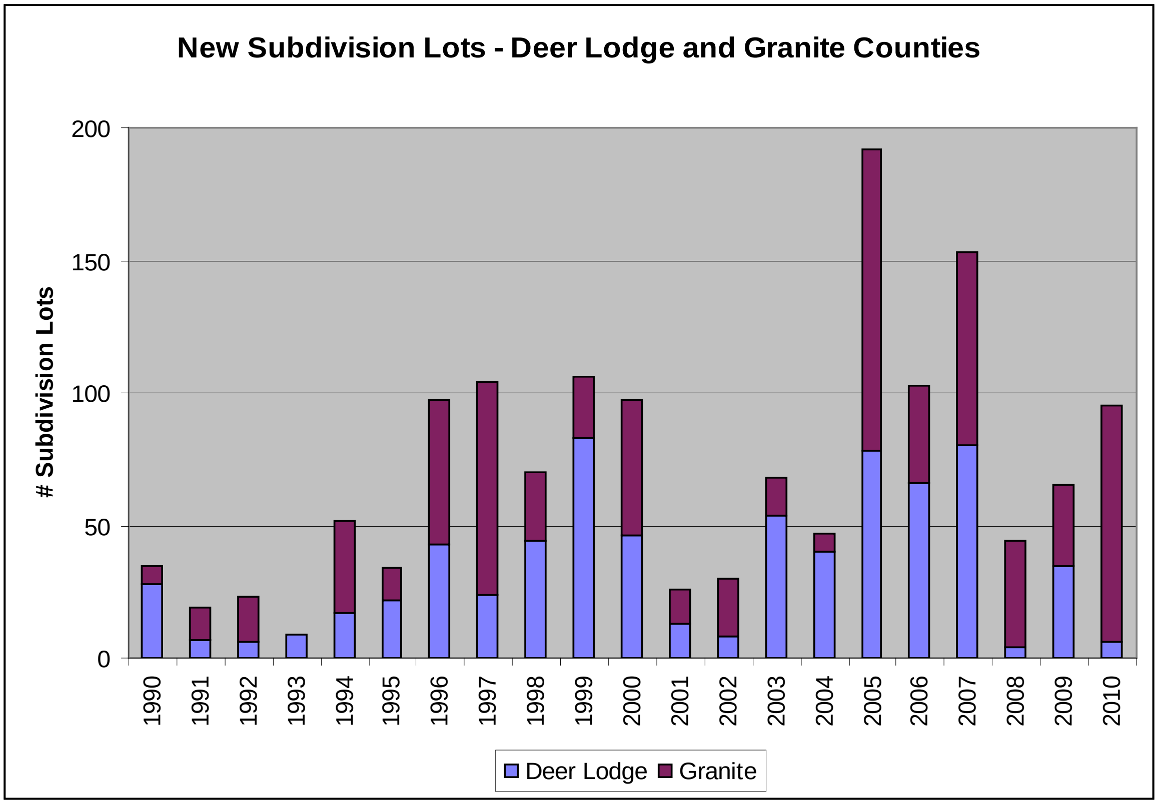

Figure F-2. Subdivision Lot Approvals in the Flint Creek Watershed by County

Using 2000 census data the distribution of septic systems within the TPA was estimated. Most of the medium (50-299 systems per square mile) and high density (300+ systems per square mile) areas are clustered around Georgetown Lake with some medium density areas near Philipsburg and Maxville. The remainder of the TPA has low septic density of less than 50 septic systems per square mile.

F3.4.2 Failure Rates

National septic failure rates may range from 10–20% (Environmental Protection Agency (EPA)/625/R-00/008). It is likely that there are lower failure rates in the Flint Creek watershed due to more recent population growth rates, and thus newer septic systems, when compared to national growth.

F4.0 Simple Septic Loading and Attenuation Estimates

A simple process for estimating household septic load estimates entering surface waters within the Flint Creek Watershed will be used to help determine if the parameterization and processes within SWAT produces reasonable septic load results. The input variables and results of this effort will be used to assist in parameterization of the septic related components of the SWAT model. Results of this simple assessment effort will also help determine if septic sources are represented reasonably within the Flint Creek SWAT model.

Methodology for the simple septic loading and attenuation assessment is provided in **Attachment A**. GIS was used to estimate how many septic systems are within certain distance to the stream network and to determine local soil types. The data derived from the GIS effort are then assessed via excel spreadsheet analysis. Simple loading and attenuation factors are applied to each septic system based upon the category it falls under, which are based upon soil type at the septic system, soil type at nearby stream and distance to the nearest gaining stream. The assessment also assumes all septic systems are conventional treatment, it does not account for consideration of level 2 systems, nor failing septic systems. The results of this effort provide an estimated load that enters any portion of the stream network in the watershed (**Table F-1**). The overall estimated treatment of nitrate and total phosphorus (TP) from septic systems to the point the load enters surface water is estimated at 64% and 85%, respectively. The loading values for nitrate and TP in **Table F-1** from single family homes are based on average drainfield loading rates of 30.5 lbs/year/home and 6.44 lbs/year/home, respectively.

Septic loading appears to be concentrated in two or three areas. Recently, the Georgetown Lake area has seen an increasing number of septic systems due to mostly recreational property development. The area around Philipsburg and the surrounding upper Flint Creek valley also contain higher septic density than surrounding parts of the watershed. Individual septic systems service the towns of Hall and Maxville which are located in the lower Flint Creek and Boulder sub-watersheds respectively.

Table F-1. Estimated Number of Systems, Nutrient Reduction, and Nutrient Loads from Septic Systems in the Flint Creek Watershed during 2009

Sub-Watershed	Number of Septic Systems	% Nitrate Reduction	% Phosphorus Reduction	Total Nitrate Loading at Drainfields (lbs/year)	Total Phos. Loading at Drainfields (lbs/year)	Total Nitrate Loading to Surface Water (lbs/year)	Total Phos. Loading to Surface Water (lbs/year)
Barnes Creek	24	66	88	732	155	249	19
Boulder Creek	106	57	74	3233	683	1390	177
Douglas Creek North	3	60	70	92	19	37	6
Georgetown Lake(1)	873	65	86	26627	5622	9319	787
Lower Flint Creek	167	67	91	5094	1075	1681	97
Lower Willow Creek	34	66	89	1037	219	353	24
Middle Flint Creek	92	65	86	2806	592	982	83
N. Fork Lower Willow Creek	6	67	90	183	39	60	4
Philipsburg	159	58	80	4850	1024	2037	205
Princeton Gulch	6	57	60	183	39	79	15
S. Fork Lower Willow Creek	3	67	90	92	19	30	2
Smart Creek	12	65	85	366	77	128	12
Trout Creek	55	67	91	1678	354	554	32
Upper Flint Creek	83	62	79	2532	535	962	112

Table F-1. Estimated Number of Systems, Nutrient Reduction, and Nutrient Loads from Septic Systems in the Flint Creek Watershed during 2009

Sub-Watershed	Number of Septic Systems	% Nitrate Reduction	% Phosphorus Reduction	Total Nitrate Loading at Drainfields (lbs/year)	Total Phos. Loading at Drainfields (lbs/year)	Total Nitrate Loading to Surface Water (lbs/year)	Total Phos. Loading to Surface Water (lbs/year)
WEIGHTED AVERAGE		**64**	**85**				
TOTALS	**1623**			**49502**	**10452**	**17860**	**1575**

(1) The loading values per home are based on typical occupancy rates for single-family homes. That occupancy rate may not apply in areas with a high percentage of vacation or second homes. In the Flint Creek watershed, the area surrounding Georgetown Lake likely falls into that category. Therefore, the nitrate and total phosphorus loading values in the Georgetown Lake sub-watershed may actually be 50%, or possibly even less, than what is listed depending on the actual home occupancy rate.

F5.0 Soil & Water Assessment Tool Model Groundwater Processing and Septic Assessment

F5.1 Soil & Water Assessment Tool Nutrient Processing in Soils and Groundwater

The SWAT depicts nitrogen and phosphorus transport in the groundwater profile in different manners. To understand this requires a basic understanding of SWAT's groundwater modeling approach. On a very basic level, SWAT splits the groundwater received from the soil layer in each sub-basin into two aquifers – a shallow, unconfined aquifer, and a deep, confined aquifer. Water entering the shallow aquifer can contribute back into the soil profile (revap), or back into the surface water system by recharging the main channel (groundwater/base flow). Water entering the deep aquifer is considered lost to the system (i.e., it flows back into the system outside of the modeled watershed).

Both nitrogen and phosphorus are modeled by SWAT in the soil profile, and also addressed within the shallow groundwater aquifer (any flows or nutrients entering the deep aquifer are considered lost to the system). Within the soil profile, nutrients are separated into different types based on solubility and reactivity. Nitrogen is divided into five separate types, including ammonium, nitrate, stable organic, reactive organic, and fresh organic. Phosphorus is divided into six separate types, including stable mineral, active mineral, soluble mineral, active organic, stable organic, and fresh organic. Each of these reacts within the soil profile via different mechanisms. Nutrients in the soil profile may move laterally within SWAT depending upon soil slope, hydraulic conductivity, distance to stream, and other factors. Lateral soil flow enters the stream at the sub-watershed node. However, only the soluble types are important to the groundwater function – the rest are important to overall SWAT modeling but do not influence the groundwater conditions.

F5.1.1 Nitrogen

After water containing soluble nitrate leaves the soil profile (but before it enters the aquifer), it enters the vadose zone. Although no chemical transformations or losses are simulated in the vadose zone, it does take time for the water to pass through this (depending on depth and other factors). To simulate this time lag, SWAT utilizes an exponential decay weighting function to account for the time spent in the vadose zone. This basically relates (on a daily basis) the amount of nitrate entering the shallow aquifer as a fraction of the nitrate in the water leaving the soil profile.

Once in the shallow aquifer, several things may happen to the nitrate. It may remain in the aquifer, move into the deep aquifer via recharge (where it is lost from the system), move into the main channel via groundwater/base flow, or move back into the soil profile (revap) as a response to low water content in the soil profile. Each of these functions is governed by a mass balance equation using a daily time step. Variables in these calculations include the inflows and incoming concentrations from other sources (shallow aquifer, deep aquifer, revap/soil profile, and groundwater flow between the main channel), which are based on additional SWAT algorithms and mass balances based upon field capacity, hydrologic conductivity, porosity and other factors.

Furthermore, nitrogen is reactive and can be removed from the groundwater via several mechanisms (e.g., uptake by bacteria present in the aquifer, undergo chemical transformations in the aquifer). To account for this, and all other biological or chemical transformations in the aquifer, SWAT uses a half-life function. This equation specifies the number of days that nitrate will remain in the shallow aquifer before the nitrate concentration is reduced by one-half. This is a standard half-life equation with the rate constant for nitrate removal equal to the natural log of two (2) divided by the half-life time. The user inputs the nitrate removal half-life. Based on the denitrification rate constant discussed in the nitrogen attenuation paper (**Attachment A**) (0.025 day-1), it would take about 11 years of travel time in the subsurface to remove almost all the nitrogen discharged from a septic system. So the half-life should be approximately 5.5 years in the SWAT model, with some adjustments that may also depend upon the vadose decay rate.

F5.1.2 Phosphorus

Phosphorus is much less soluble than nitrate, and therefore does not transport via groundwater as readily. It readily binds into the soil in many situations. Therefore, SWAT does not utilize any modeling for phosphorus determinations in groundwater. The user simply inputs a concentration of soluble phosphorus in the shallow aquifer, and groundwater flow into the main channel is then calculated based on hydraulic loading. The phosphorus concentration in the shallow groundwater remains constant throughout the simulation period. There is no phosphorus-related interaction between the soil horizon and the shallow aquifer; phosphorus is assumed to bind into the soil and remain there. Alternatively, the groundwater can transport a phosphorus load based upon a constant concentration of phosphorus that remains throughout the simulation. The groundwater phosphorus concentration is set by the user and is completely separate from any soil phosphorus functions. Therefore any phosphorus load artificially introduced into the soil layers to simulate a septic system is not transferred to the groundwater.

F5.1.3 Proposed Septic Nutrient Load Assessment for Flint Creek Soil & Water Assessment Tool Model

SWAT 2009 may provide a useful septic loading tool (Biozone module) that could be used simulate the 1,623 septic systems estimated to exist in the Flint Creek drainage. Otherwise, an alternative process will be incorporated into the SWAT model as was described in **Section F4.0**.

ATTACHMENT FA – NITROGEN AND PHOSPHORUS MIGRATION AND ATTENUATION ASSESSMENT FROM SUBSURFACE WASTEWATER TREATMENT SYSTEMS

FA1.0 INTRODUCTION

This document presents a summary of the factors affecting migration and attenuation of nitrogen and phosphorus after disposal from subsurface wastewater treatment systems (i.e., septic systems). This summary is used to support methods proposed for determining nitrogen and phosphorus reduction as these nutrients migrate towards surface waters.

The methods described in the document should not be used to determine nutrient attenuation on a small scale (e.g., single development/municipality discharge) due to the potentially wide variation in nutrient attenuation between sources in similar settings. These methods are designed for use on a larger basin-wide scale that effectively allows averaging of the processes that occur in the subsurface.

While the processes of nutrient attenuation described in this document are well documented, the attenuation percentages proposed are estimates. Where possible, the results of the methods described should be verified with site-specific data.

FA2.0 NITROGEN

Nitrogen in partially treated domestic wastewater (in the septic tank) is primarily in the form of ammonia. Disposal of wastewater in a properly constructed and sized drainfield will typically provide sufficient oxygen and naturally occurring bacteria to convert the ammonia to nitrite and then quickly to nitrate. Studies and regulations commonly assume that most or all the nitrogen is converted to nitrate after proper septic tank and drainfield (conventional) treatment (Montana Department of Environmental Quality, 2009; Morgan et al., 2007; Idaho Department of Environmental Quality, 2002; National Decentralized Water Resources Capacity Development Project, 2005a; Heatwole and McCray, 2006; Toor et al., 2011). Unless an advanced wastewater system is used (referred to as a level 2 system in Montana), conventional treatment removes between 10 and 30 percent of the nitrogen in the wastewater (Costa et al., 2002; Lowe et al., 2007; Gold and Sims, 2000; Laak, 1981; Pell and Nyberg, 1989; Rosen et al., 2006; Seabloom et al., 2004). That treatment level is accounted for in the nitrogen concentration (50 mg/L) that Montana estimates is discharged from the typical septic system serving a single-family home. Septic systems are not designed to complete the final step of the nitrogen cycle, conversion of nitrate to nitrogen gas (denitrification), which then dissipates into the atmosphere and does not have any further impacts to groundwater or surface water. Denitrification generally occurs after drainfield treatment, and is difficult to predict.

In Montana, the estimated nitrate loading rate for a single-family home septic system is based on an average concentration of 50 mg/L and an average effluent rate of 200 gallons per day (Montana Department of Environmental Quality, 2009). Those concentration and effluent rates are within the range of published values (U.S. Environmental Protection Agency, 2002). Those values provide a nitrogen loading rate of 30.5 lbs/year for a conventional wastewater system. For comparison purposes, the nitrogen loading rate for a level 2 system is 14.6 lbs/year.

Denitrification requires the correct environment to occur, the key factors are adequate temperature (typically above 10 °C), a food source for the bacteria (typically carbon), an anoxic environment (generally an oxygen range of less than 1-2 mg/L), and the correct bacteria. A riparian zone with shallow groundwater is the most common environment that has those conditions (Tri-State Water Quality Council, 2005; Gilliam, 1994; Gold and Sims, 2000; Rosenblatt et al., 2001; Harden and Spruill, 2008). A carbon source is cited as the most common limiting factor for denitrification (Gold and Sims, 2000; Rivett et al., 2008; Starr and Gillham, 1989). Studies have identified “micro-sites” of low oxygen in shallow groundwaters, which are typically assumed to be rich in oxygen, to provide the necessary anoxic environment (Gold and Sims, 2000; Jacinthe et al., 1998; Parkin, 1987). The required bacteria are generally ubiquitous in the environment, and will naturally thrive when the conditions are correct and there is a nitrogen source. However, it should be noted that the U.S. Environmental Protection Agency (2002) stated that “Denitrification has been found to be significant in the saturated zone only in rare instances where carbon or sulfur deposits are present”. This conclusion is contrary to the numerous studies that have found high denitrification rates in common environments; the same EPA document recognizes some of those studies.

Because fine-grained soils are more likely to contain two of the conditions necessary for denitrification, anoxic conditions and carbon, fine-grained soils typically provide better conditions for denitrification than coarse-grained soils (Mueller et al., 1995; Tesoriero and Voss, 1997; Umari et al., 1995; Briar and Dutton, 2000). Anderson (1998) used results from several studies to show a correlation (r=0.91) between denitrification rates and soil organic content. One study (Ricker et al., 1994) estimated the amount of denitrification beneath drainfields as 15% for sandy soils and 25% for finer soils.

Denitrification rates are site-specific and the rates can vary considerably in similar environments (Starr and Gillham, 1993; Robertson et al., 1991). Some studies have provided measurable chemical characteristics to determine where denitrification is more likely to occur (Trojan et al., 2002; Minnesota Pollution Control Agency, 1999), but the studies typically only provide relative denitrification rates (e.g., high or low). However, several studies (National Decentralized Water Resources Capacity Development Project, 2005c; Kirkland, 2001; McCray et al., 2005), have published a specific denitrification rate based on the median of cumulative frequency distributions of field measured denitrification rates (0.025 day-1). At that rate, it takes over 10 years to denitrify all of the nitrate from a source. At typical groundwater velocity rates of 0.1 to 10 ft/day wastewater could travel between 400 and 40,000 feet in that time. Using a single denitrification rate for all situations may be unrealistic as one study indicated it would take a denitrification rate that ranges over 3 orders of magnitude to provide a 95% confidence interval (Heatwole and McCray, 2006). McCray et al. (2005) could not correlate soil type to denitrification rate due to variability in the existing data; therefore, the median denitrification rate was not used for the proposed method of estimating nitrate reduction.

Another factor that has been correlated with denitrification is travel time in the environment: the longer the nitrate is in the environment the more time it has to encounter the correct conditions for denitrification (Kroeger et al., 2006). Distance is used in the proposed methods instead of travel time because it is easier to measure distances than groundwater travel time which requires three parameters that are difficult and/or expensive to measure for large areas: hydraulic gradient, hydraulic conductivity and effective porosity.

Based on the existing information, the following method has been developed to estimate the nitrogen reduction as wastewater migrates from a drainfield to a receiving surface. This method uses a matrix (see **Table FA-1**) combining three factors that impact the amount of denitrification: soil type beneath the drainfield; soil type in the riparian area; and distance to surface water. In **Table FA-1**, each drainfield is assigned a percent nitrate reduction for each of the three criteria. The percent reductions for each column are then added to provide the total percent nitrate removal for that septic system. The nitrate loading rate (30.5 lbs/year for a conventional system) to the surface water is then reduced accordingly. Any system with a 100% or higher reduction contributes no nitrate to the surface water.

This method assumes steady-state conditions; it does not account for the time needed for the nitrogen load from a new discharge source to migrate towards the receiving surface water. That lag time is dependent on the travel rate through both the vadose and saturated zones.

This method (and the phosphorus method described below) does not account for failing septic systems because the number of hydraulically failing systems where wastewater is flowing at the surface (and likely to bypass natural treatment in soils) is typically a small percentage of the total number of septic systems on a basin wide scale and is not a significant nutrient load for TMDL purposes. A surfacing, failing system is also likely to be repaired quickly, further minimizing any impacts to surface waters. However, there may be site-specific situations where failing septic systems are a significant source and need to be accounted for using a different method.

Table FA-1. Nitrogen Attenuation Factors for Septic System Discharges to Groundwater

Percent Nitrogen Load Reduction[1]	Soil Type @ Drainfield[2]	Soil Type within 100' of Surface Water[2]	Distance to Surface Water (ft)
0	A	A	0 – 100
10	B		101 – 500
20	C	B	501 – 5,000
30	D	C	5,001 – 20,000
50		D	20,001+

[1] The total nitrogen reduction is the sum of the individual reductions for each column of the table. For example a drainfield that is in a type C soil (20%) that drains to a surface water with type B soil (20%) and is 200 feet from the surface water (10%) would reduce their nitrogen load to the surface water by 50% from what is discharged from the drainfield.

[2] Soil descriptions are available via the Natural Resources Conservation Service (NRCS) web soil survey at: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm Once the area of interest has been defined information is accessed by clicking on following links: “Soil Data Explorer” – “Soil Properties and Qualities” -- “Soil Qualities and Features” – “Drainage Class”. The NRCS soil survey has seven soil drainage classes that are correlated to the A, B, C and D designation in the table as follows:

A = excessively drained or somewhat excessively drained
B = well drained or moderately well drained
C = somewhat poorly drained
D = poorly drained or very poorly drained

Within the defined area of interest, the soil survey application provides the percent of soil types with these attributes. That feature provides a quick way to determine the percent of each soil type and therefore the percent reduction for each area of interest defined.

FA3.0 PHOSPHORUS

Phosphorus, which has much lower mobility than nitrogen, is removed in soils below drainfields by two primary processes, adsorption and precipitation. Precipitation is a slower process compared to adsorption but may be the more important process for retarding the migration of phosphorus. Soils may have a limited amount of adsorption capacity which could allow migration of phosphorus after reaching equilibrium (Gold and Sims, 2000). However, precipitation reactions may occur indefinitely with the correct conditions thereby limiting phosphorus migration indefinitely (Lombardo, 2006; Robertson et al., 1998). Lombardo (2006) estimated that phosphorus travel times to nearby surface waters could range from tens of years to hundreds of years depending on the types of soils between the source and waterbody. The vadose zone is considered the primary location for phosphorus retardation, once it reaches groundwater phosphorus migration is generally faster than in the vadose zone.

In Montana, the estimated phosphorus loading rate for a single-family home septic system is based on an average concentration of 10.6 mg/L and an average effluent rate of 200 gallons per day (Montana Department of Environmental Quality, 2009). Those concentration and effluent rates are within the range of published values (U.S. Environmental Protection Agency, 2002). Those values provide a loading rate of 6.44 lbs/year for a conventional wastewater system.

Non-calcareous soils retard the movement of phosphorus more than calcareous soils due to the calcareous soils ability to maintain pH levels where phosphorus precipitation does not readily occur (Lombardo, 2006; Robertson et al., 1998). Typically, non-calcareous soils are derived from igneous or metamorphic parent rocks. Lombardo (2006) defined calcareous soils as those containing more than 15% calcium carbonate and non-calcareous soils as those containing less than 1% calcium carbonate.

Finer-grained soils also tend to retard phosphorus migration more than coarser soils due primarily to their greater surface area that provides more locations for adsorption.

Easily measurable wastewater phosphorus plumes extend a relatively short distance from the source, creating high concentrations of phosphorus in soils immediately below drainfields with low levels beyond that location (Makepeace and Mladenich, 1996; Gold and Sims, 2000; Lombardo, 2006; Reneau et al., 1989; Robertson et al., 1998). This indicates that a significant portion of the phosphorus is quickly bound up shortly after being discharged. However, in many cases low level phosphorus detection limits are not used in groundwater analyses, and the existence of long, low concentration phosphorus plumes may have been overlooked (Houston, 2001).

Due to the small amount of phosphorus that migrates significant distances, some methods assume that only failing systems contribute phosphorus to surface water. For example, the MANAGE (Method for Assessment, Nutrient-Loading, and Geographic Evaluation of Nonpoint Pollution) nutrient migration model (Kellogg et al., 2006) only accounts for phosphorus discharges from failing drainfields. Other information (Tri-State Water Quality Council, 2005; Gold and Sims, 2000; National Decentralized Water Resources Capacity Development Project, 2005b) also implicates failing or improperly sited drainfields (e.g., drainfields located over shallow groundwater, in coarse soils, or too close to surface water) as a greater threat to surface water than properly constructed and sited systems.

Lombardo (2006) suggested that phosphorus migration to surface waters is only a problem in areas with high groundwater tables and higher groundwater velocities (the report provided a lower end for the high velocities of approximately 0.2 to 3 feet/day). Below those velocities soils typically contain higher amounts of clay and/or silt, thus increasing the soils adsorption capacity.

Except for failing or poorly sited septic systems, existing evidence indicates that only small amounts of phosphorus migrate to surface waters, but that in some cases even small amounts can have noticeable impacts to surface water quality. To be consistent with existing information on phosphorus migration the proposed method to estimate phosphorus reduction was designed to estimate relatively high percentages of phosphorus removal.

Based on the existing information, the following method has been developed to estimate the phosphorus reduction as wastewater migrates from a drainfield to a receiving surface. This method uses (**Table FA-2**) a matrix, similar to the one used for nitrogen , combining three factors that impact the amount of phosphorus reduction: soil type beneath the drainfield; calcium carbonate percent in the soil beneath the drainfield; and distance to surface water. In **Table FA-2**, each drainfield is assigned a percent phosphorus reduction for only one of the three soil type columns (which combines the soil and calcium carbonate type), and then an additional percent phosphorus reduction for the last column (distance to surface water). The percent reductions for each column are then added to provide the total percent phosphorus removal for that septic system. The phosphorus loading rate (6.44 lbs/year for a conventional or level 2 system) to the surface water is then reduced accordingly. Any system with a 100% or higher reduction contributes no phosphorus to the surface water.

This method assumes steady-state conditions; it does not account for the time needed for the phosphorus load from a new discharge source to migrate towards the receiving surface water. That lag time is dependent on the travel rate through both the vadose and saturated zones.

Table FA-2. Phosphorus Attenuation Factors for Septic System Discharges to Groundwater

Percent Phosphorus Load Reduction[1]	Soil Type @ Drainfield[2, 3] ($CaCO_3$ <= 1%)	Soil Type @ Drainfield[2, 3] ($CaCO_3$ >1% and <15%)	Soil Type @ Drainfield[2, 3] ($CaCO_3$ >=15%)	Distance to Surface Water (ft)
0	A	A	A	0 – 100
10			B	
20		B	C	
30	B		D	101 - 500
40		C		
60	C	D		501 - 5,000
90	D			
100				5,001 +

[1] The total phosphorus reduction is the sum of the individual reductions for the soil type (only use one of the three soil columns) and the distance to surface water. For example a drainfield that is in a type B soil with less than 1% CaCO3 (30%) and is 200 feet from the surface water (30%) would reduce their nitrogen load to the surface water by 60% from what is discharged from the drainfield.

[2] Soil descriptions are available via the Natural Resources Conservation Service (NRCS) web soil survey at: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm Once the area of interest has been defined information is accessed by clicking on following links: "Soil Data Explorer" – "Soil Properties and Qualities" -- "Soil Qualities and Features" – "Drainage Class". The NRCS soil survey has seven soil drainage classes that are correlated to the A, B, C and D designation in the table as follows:

A = excessively drained or somewhat excessively drained
B = well drained or moderately well drained
C = somewhat poorly drained
D = poorly drained or very poorly drained

Within the defined area of interest, the soil survey application provides the percent of soil types with these attributes. That feature provides a quick way to determine the percent of each soil type and therefore the percent reduction for each area of interest defined.

(3) $CaCO_3$ percent is available via the NRCS web soil survey at: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm Once the area of interest has been defined information is accessed by clicking on following links: "Soil Data Explorer" – "Soil Properties and Qualities" -- "Soil Chemical Properties" – "Calcium Carbonate ($CaCO_3$)". Within the defined area of interest, the soil survey application provides the percent of land with the percent of $CaCO_3$. That feature provides a quick way to determine the percent of area of different $CaCO_3$ percentages and therefore the percent reduction for each area of interest defined.

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APPENDIX G – FLINT CREEK TMDL PLANNING AREA NUTRIENT SOURCE REVIEW, TASK 1: DISCRETE SOURCE CHARACTERIZATION, GRANITE AND DEER LODGE COUNTIES

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ACRONYMS

Acronym	**Definition**
ARM	Administrative Rules of Montana
BOD	Biochemical Oxygen Demand
DEQ	Department of Environmental Quality (Montana)
ECHO	Enforcement Compliance History Online
EPA	Environmental Protection Agency (U.S.)
GIS	Geographic Information System
MCA	Montana Code Annotated
MGWPCS	Montana Ground Water Pollution Control System
MPDES	Montana Pollutant Discharge Elimination System
NPDES	National Pollutant Discharge Elimination System
NRIS	Natural Resource Information System (Montana)
SWAT	Soil & Water Assessment Tool
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
WWTP	Wastewater Treatment Plant

G1.0 INTRODUCTION

G1.1 BACKGROUND

The Flint Creek watershed is located in the northern Rocky Mountains of southwestern Montana. The watershed covers an area of approximately 500 square miles, from Georgetown Lake to the Clark Fork near the city of Drummond, as shown in **Figure GA-1.** An inter-basin diversion from the East Fork Rock Creek Reservoir also contributes flow to Flint Creek through its tributary, Trout Creek. Land use in the Flint Creek watershed is primarily forest and grazing, with agriculture in the valleys. Philipsburg is the only urban area, but other communities are found scattered throughout the watershed especially at lower elevations. Historically, the Flint Creek watershed had considerable mining activity, some of which continues to the present.

Water quality sampling of streams in the Flint Creek watershed has shown that several waterbodies are not meeting designated uses and are considered impaired for excess nutrients, as shown in **Table G1-1**. Nutrient sources in the watershed include natural, wastewater, mining, and various agricultural-related activities, but their effect on stream conditions has not been quantified. As a result, a Total Maximum Daily Load (TMDL) study is being developed for area.

Table G1-1. Streams in the Flint Creek Watershed Listed as Impaired for Nutrients

Stream Name	Waterbody ID	Impairment
Barnes Creek	MT76E003_070	Nitrite + Nitrate, Ammonia + Organic Nitrogen, Total Phosphorus
Douglas Creek	MT76E003_020	Nitrates
Flint Creek	MT76E003_012	Total Nitrogen and Total Phosphorus
Princeton Gulch	MT76E003_090	Nitrates
Smart Creek	MT76E003_110	Total Phosphorus

As part of this TMDL and in an effort to better understand the water quality of the watershed, the Montana Department of Environmental Quality (DEQ) is developing a Soil & Water Assessment Tool (SWAT) model of the Flint Creek watershed. For this model, DEQ needs accurate and timely information on the sources and quantities of nutrients being transported through the Flint Creek watershed. DEQ also needs information to understand how land use, water use, and related factors influence water quality.

G1.2 PURPOSE AND SCOPE

The purpose of this report is to characterize the discrete sources of nutrients, primarily nitrogen and phosphorus, entering the streams and groundwater in the Flint Creek watershed. These sources include surface water discharges that are also called “point sources”. Also considered in this document are discrete sources to groundwater that are permitted by the State of Montana, but at a watershed scale are not point sources to impaired streams. The information provided will be used to assist in constructing a nutrient-based TMDL for the area’s impaired stream reaches. A companion report is being prepared to characterize the nutrients derived from nonpoint sources (Houston Engineering, Inc., 2011). Impairments caused by other factors, such as elevated trace-element concentrations, are not considered in this scope of work; atmospheric nutrient contributions are also not reviewed in this document. Much of the data used to quantify the nutrient point sources are documented as part of the Montana Pollutant Discharge Elimination System (MPDES) permitting process. Additional information was determined from other sources, or interpolation and/or extrapolation from sources, as described in the text.

This report contains a summary of each permitted nutrient point source, including Wastewater Treatment Plants (WWTPs), industrial sources, and mining. Source summaries include information on the source location and associated receiving water. Information is also given on permit limits and the reported source discharge and effluent concentrations. Past and projected changes in the quantity of nutrient loads are evaluated when possible. Reported discharge/effluent values are summarized in a user-friendly format for easy conversion into the required format for entry into the SWAT watershed loading model.

G1.3 Information Sources

Much of the data used to characterize the nutrient point sources of the watershed were obtained from the Montana Natural Resource Information System (NRIS). NRIS, organized under the Montana State Library, is a repository and clearing house for much of the state's Geographic Information System (GIS), water resources, and natural heritage information. NRIS was the primary source used for GIS data, including basic watershed and stream information. The NRIS was also relied upon as the most current repository for public water supply systems resulting from the Source-Water Protection program.

Most of the water quality data provided in this report was obtained from the Integrated Compliance Information System. The U.S. Environmental Protection Agency's (EPA) Enforcement Compliance History Online (ECHO) website was consulted to verify or supplement data obtained from NRIS and other state and local agencies. Additional data was supplied by the City of Philipsburg via additional voluntary monitoring efforts undertaken by the community and provided to the State of Montana.

DEQ also provided other information related to the Flint Creek watershed including numerous references, reports pertaining to the watershed and paper copies of the existing MPDES permits in the area (Kron, Darrin, personal communication 2010). Other DEQ permit information included MPDES Statement of Basis reports and EPA National Pollutant Discharge Elimination System (NPDES) compliance reports. Except where noted, in the case of discrepancies between sources, the information provided directly by DEQ and other state and local agency personnel was considered to be the most accurate and is included in the report.

G2.0 Nutrient point sources

G2.1 Permitted Surface Water Discharges

The NPDES program requires that all point sources have a permit to discharge into waters of the state. In Montana, the State has regulatory authority for implementing the NPDES program and all sources discharging into state or federal waters must obtain and comply with a MPDES permit from the State of Montana. A MPDES permit, which is equivalent to an NPDES permit for surface water dischargers or a Montana Ground Water Pollution Control System (MGWPCS) permit (not an NPDES permit), is required from DEQ to construct, modify or operate a disposal system or to construct or use any outlet for discharge of sewage, industrial, or other wastes into state surface water or groundwater. A permit is not required for the discharge of certain wastes under specific circumstances (see Administrative Rules of Montana (ARM) 17.30.1310, 75-5- 401(1)(b) and 75-5-401(5), Montana Code Annotated (MCA)).

Six MPDES-permitted sites are located in the Flint Creek watershed and may be potential nutrient point sources to the area. Three of the six permitted sites are permitted to discharge into surface waters. The remaining three sites are permitted to discharge to groundwater with one site having a permit for two outfalls. In addition to these permits, the watershed also contains six Stormwater Construction or Temporary Turbidity permits. Locations of all permitted surface and groundwater dischargers can be found in **Figure GA-2**.

G2.1.1 Treated Wastewater Sources

The Town of Philipsburg owns and operates the only WWTP in the study watershed. The plant is a two-cell facultative lagoon with no disinfection and a continuous discharge. It was built in 1961 and upgraded in the early 1990s. The plant discharges directly to Flint Creek via a single outfall location (at the end of ditch) and has a 300 foot mixing zone. With a maximum design flow of 0.16 million gallons per day (mgd), the WWTP serves 520 hookups (over 900 citizens) from the Town of Philipsburg.

Prior to September 2004, the Town of Philipsburg WWTP had an individual permit for a minor facility. This permit (MTG580005) was issued under the MPDES General Discharge Permit for domestic wastewater lagoons. Monthly nutrient monitoring was required by this permit. A letter from DEQ in 1998 stated that nutrient monitoring was no longer required. As the permit expired in September 2004, DEQ determined, under ARM 17.30.1341(4), the facility no longer qualified for authorization under the Domestic Sewage Treatment General Permit. A new permit (MT0031500) was issued to comply with stated limit effluents for discharging into waters of the state.

Discharge and water quality data associated with the WWTP was provided by DEQ from MPDES Discharge Monitoring Reports and the ECHO website (*i.e.,* Integrated Compliance Information System). **Table G2-1** displays information associated with the WWTP's most current permit, issued in August 2007.

Table G2-1. Wastewater Treatment Plant within the Flint Creek TMDL Planning Area

NPDES Number	Outfall Number	Name	Description	Receiving Waterbody	Permit Expiration Date	Design Flow (mgd)
MT0031500	001	Town of Philipsburg Wastewater Treatment Plant	Wastewater Treatment Plant	Flint Creek	07/31/2012	0.16

Per the August 2007 MPDES permit renewal, the WWTP is required to monitor and report the quantity of their effluent five times per week. The effluent's quality is to be monitored and reported anywhere from once a week to once a quarter, depending on the parameter. Nutrient concentrations are required to be monitored and reported every month. Discharge data was retrieved from 2000 to the present. Phosphorus and nitrogen have been sampled from June 2005 to the present, while ammonia, total kjedhal nitrogen, and nitrate + nitrite have been sampled from August 2007 to the present. Data from 2007 to the present was obtained from the Integrated Compliance Information System database, while data preceding this time frame were provided directly from DEQ. **Table G2-2** summarizes the permitted nutrient effluent load limitations that pertain to the existing permit. Per the 2007 Statement of Basis for proposed permit limits (Permit MT0031500), the nutrient load limits are set upon a nondegradation basis. No specific nutrient effluent concentration limits were set in the permit.

Table G2-2. Nutrient Effluent Limits for Phillipsburg Wastewater Treatment Plant

MPDES Number	Total Phosphorus (lb/day)	Total Nitrogen (lb/day)
MT0031500	10.2	40.8

Monthly effluent data for the Philipsburg WWTP was available from January 2000 through March 2010 and is shown in **Figure G2-1**. According to this data, the plant's overall mean discharge rate during this time is 0.115 mgd. From November 2004 through December 2006, the reported average monthly discharges are 2-3 times greater than previous average monthly discharges. In January 2007, discharge rates returned to pre-November 2004 levels. This jump in flow readings is likely due to the replacement of a corroded outflow flume in November 2004. The installation of the new flume likely had an effect on the accuracy of the readings and thus during 2005 and 2006 discharges appear elevated. Furthermore, in December 2006, a broken sanitary sewer service line was identified and repaired. The broken sewer line was allowing Camp Creek water to enter the sanitary sewer system and, therefore, the WWTP (Hoehne, Dick, personal communication 2010). These repairs reduced the volume of water discharging from the plant, as shown in **Figure G2-1**. Future discharges from the plant are expected to follow recent trends. This expectation is based on the fact that the population of Philipsburg has remained constant since at least 1990 (United States Census Bureau,2012); using that data, no appreciable population growth or new hookups are expected. However, if the city's population increases, there would be an expected associated increase in discharge rate. Discharge data for the Philipsburg WWTP can be found in **Attachment GB, Table GB-1**.

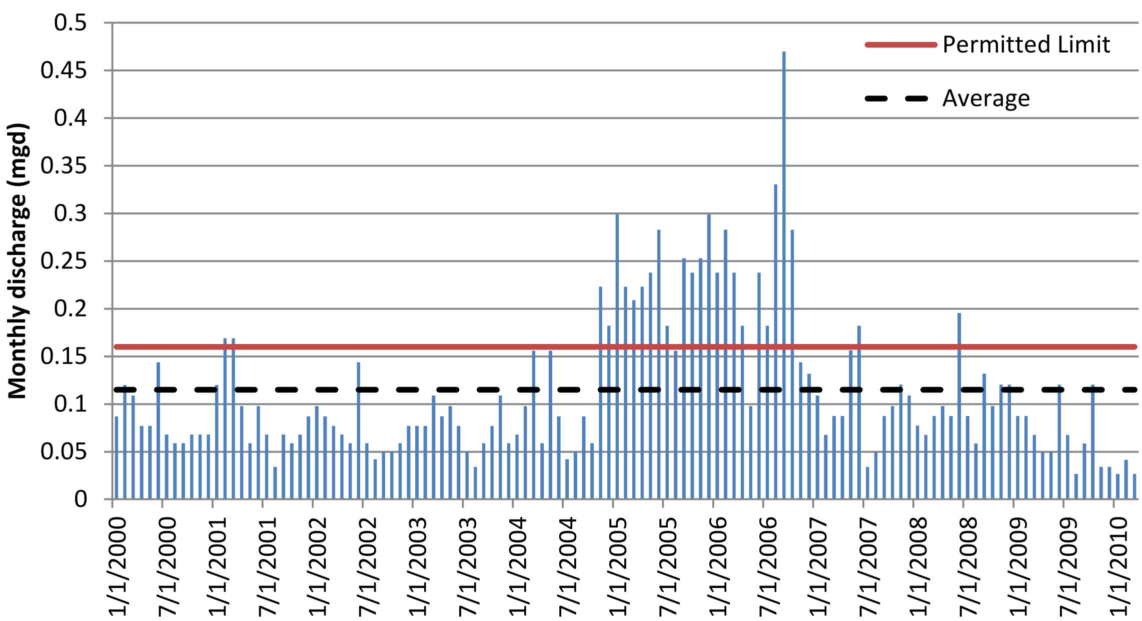
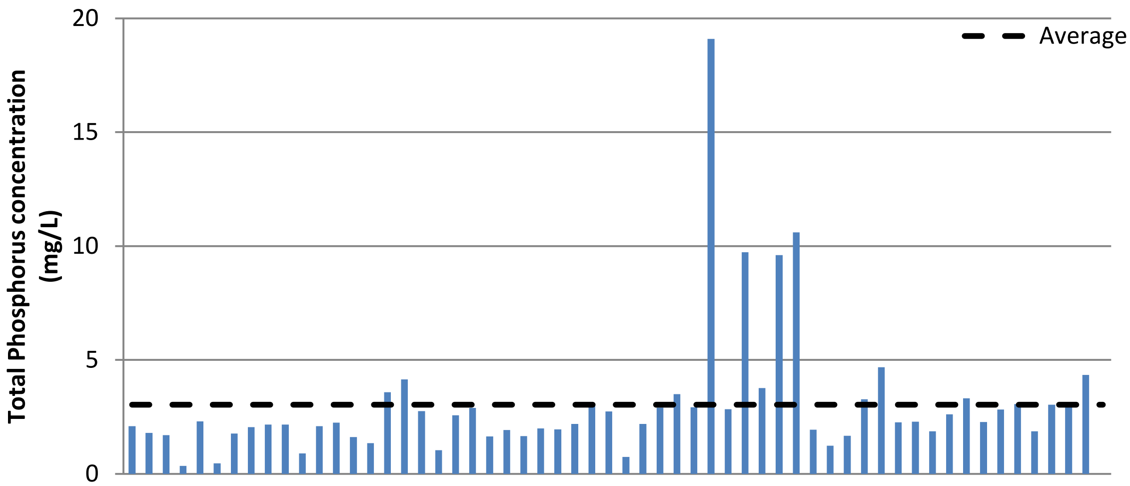
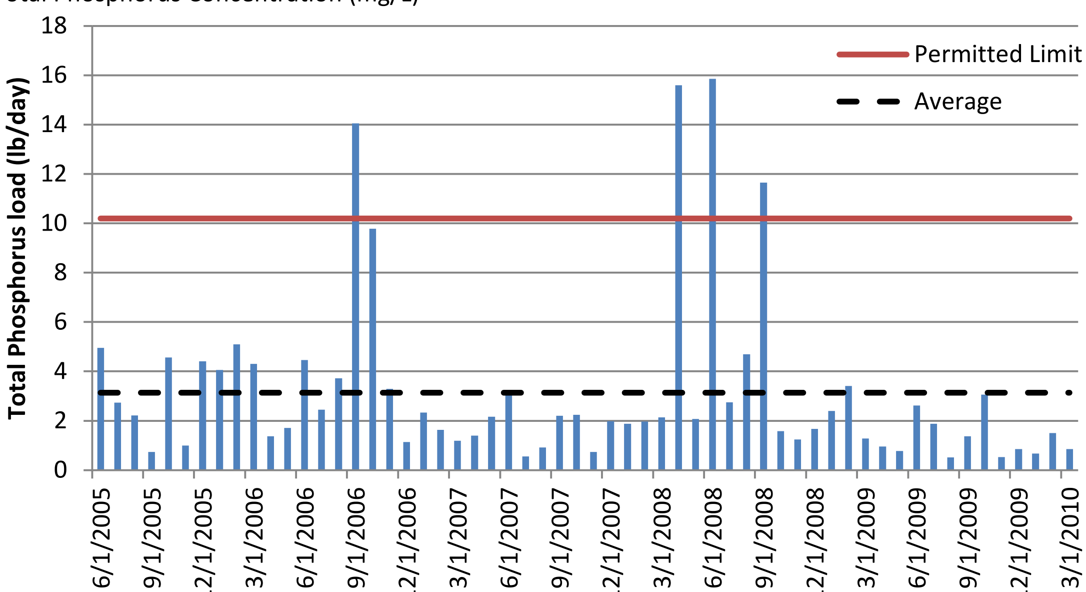


Figure G2-1. Philipsburg Wastewater Treatment Plant Effluent Discharge (mg/d) from January 2000 through March 2010

Total phosphorus (TP) and total nitrogen (TN) data are available for the Philipsburg WWTP from June 2005 through March 2010. Data were retrieved from DEQ and the Integrated Compliance Information System database. TP concentrations range from 0.35-19.10 mg/L with an average of 3.04 mg/L, as shown in **Figure G2-2**. Summertime (July-September) TP concentration averages are 3.33 mg/L. Similarly, TP loads range from 0.51-15.85 lb/day with an average of 3.14 lb/day. The summertime average is 3.49 lb/day. Since June 2005, TP effluent has exceeded the permitted limit four times with three of these times being in the fall of 2008. Past trends showed no distinct seasonal fluxes and little fluctuation occurs from month to month. Monthly average TN concentrations range from 2.03-24.10 mg/L with an average of 10.34 mg/L and show relatively little change throughout this timeframe (**Figure G2-3**). Average summertime TN concentrations are 7.56 mg/L. TN loads range from 1.10-38.19 lb/day with an average of 10.68 lb/day and a summertime average of 9.20 lb/day. No clear pattern in TN concentrations/loads exists. Nutrient data can be found in **Attachment GB, Table GB-1.**

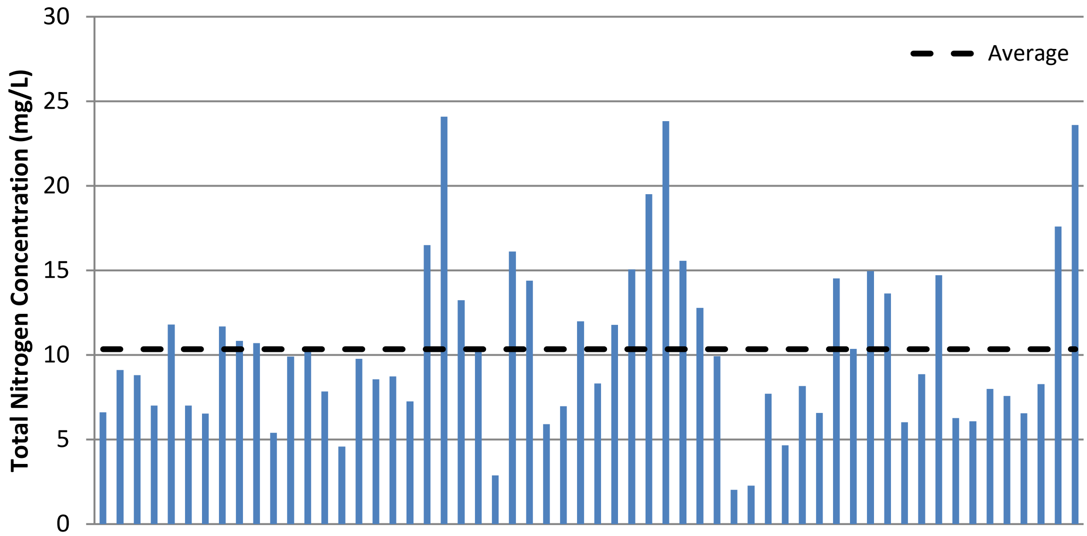


(a) Total Phosphorus Concentration (mg/L)

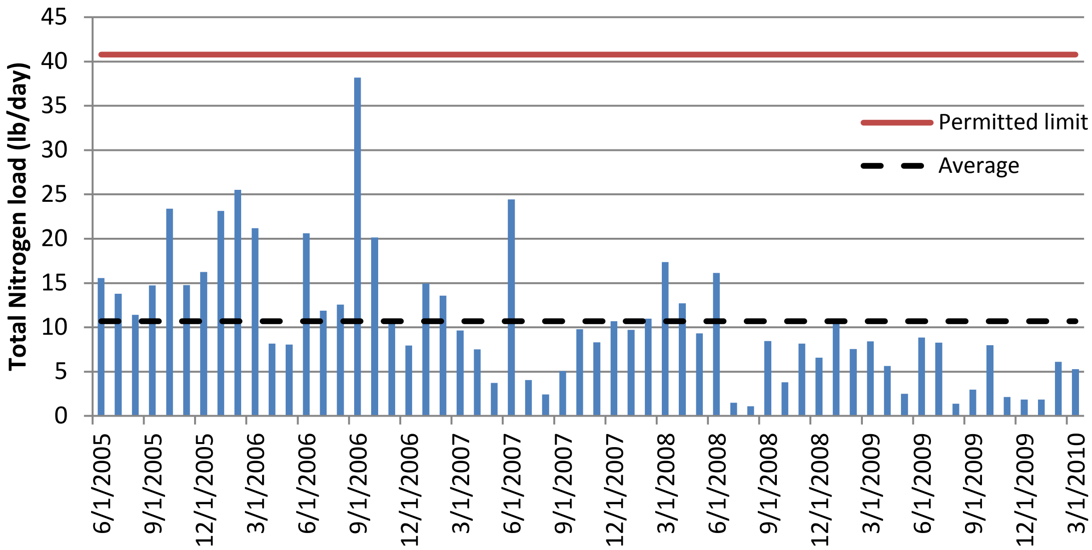


(b) Total Phosphorus Load (lb/day)

Figure G2-2. Philipsburg Wastewater Treatment Plant Total Phosphorus Concentration (mg/L) and load (lb/day) from June 2005 through March 2010



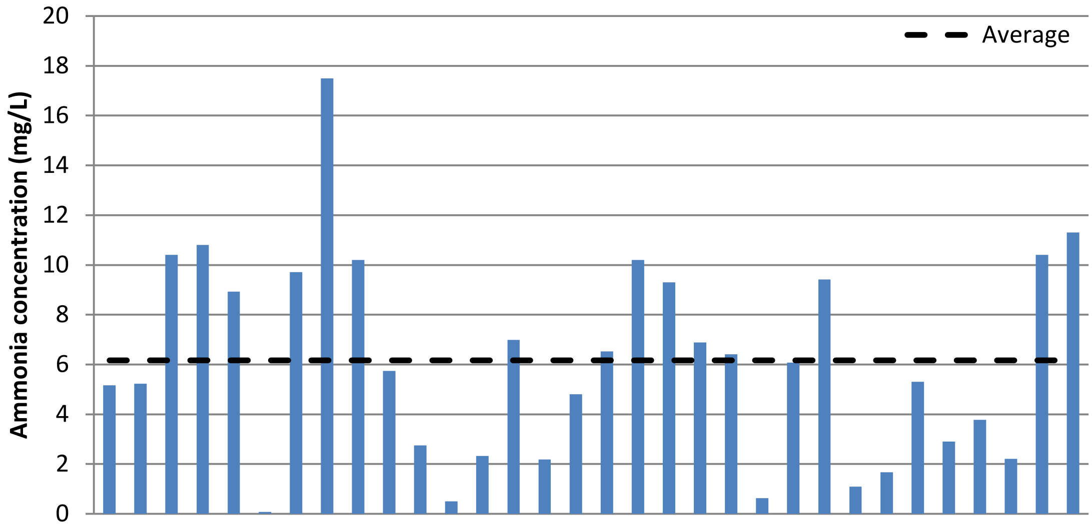
(a) Total Nitrogen Concentration (mg/L)



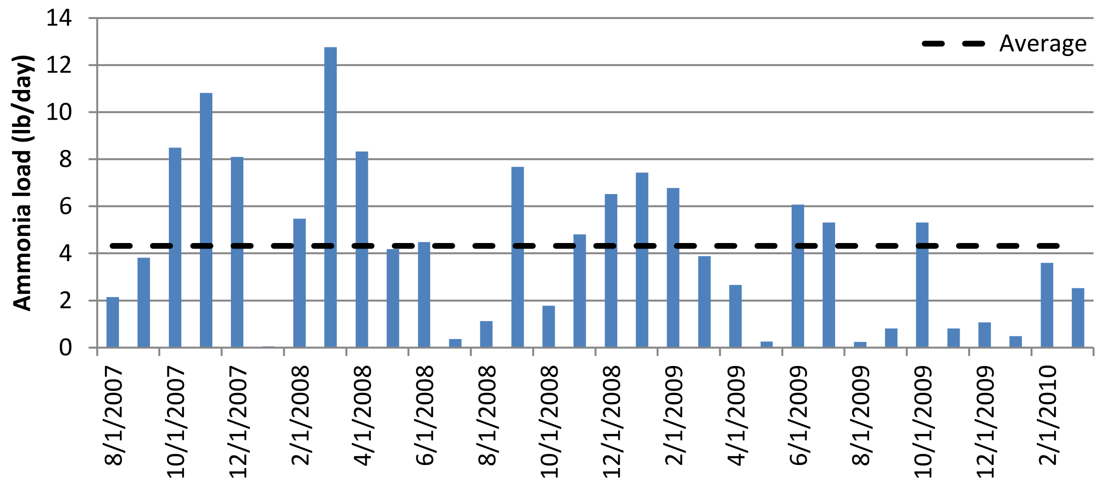
(b)Total Nitrogen Load (lb/day)

Figure G2-3. Philipsburg Wastewater Treatment Plant Total Nitrogen Concentration (mg/L) and Load (lb/day) from June 2005 through March 2010

Ammonia, Total Kjeldahl Nitrogen (TKN), and Nitrite + Nitrate loads from the WWTP were reported from August 2007 through March 2010. No stated effluent limits were set for these parameters. As shown in **Figure G2-4**, the plant effluent's ammonia concentrations range from 0.08-17.5 mg/L (average = 6.17 mg/L) and loads range from 0.05-12.75 lb/day (average = 4.32 lb/day). Ammonia concentrations show a cyclical trend with concentrations rising and falling throughout the year. TKN concentrations range from 2.03-23.8 mg/L (average = 10.42 mg/L) while loads range from 1.03-17.34 lb/day (average = 6.86 lb/day). TKN concentrations follow a similar cyclical pattern to Ammonia (**Figure G2-5**). **Figure G2-6** shows the reported Nitrite + Nitrate concentrations which range from 0.003 – 0.79 mg/L (average = 0.20 mg/L) and loads which range from 0 – 0.33 lb/day (average = 0.08 lb/day). These concentrations and loads show no clear trends. Nutrient data can be found in **Attachment GB, Table GB-1.**

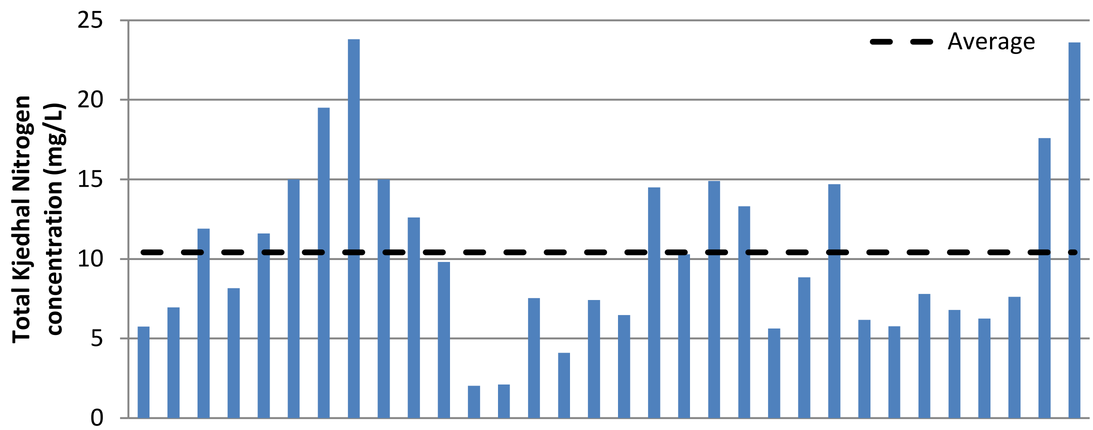


(a) Ammonia Concentration (mg/L)

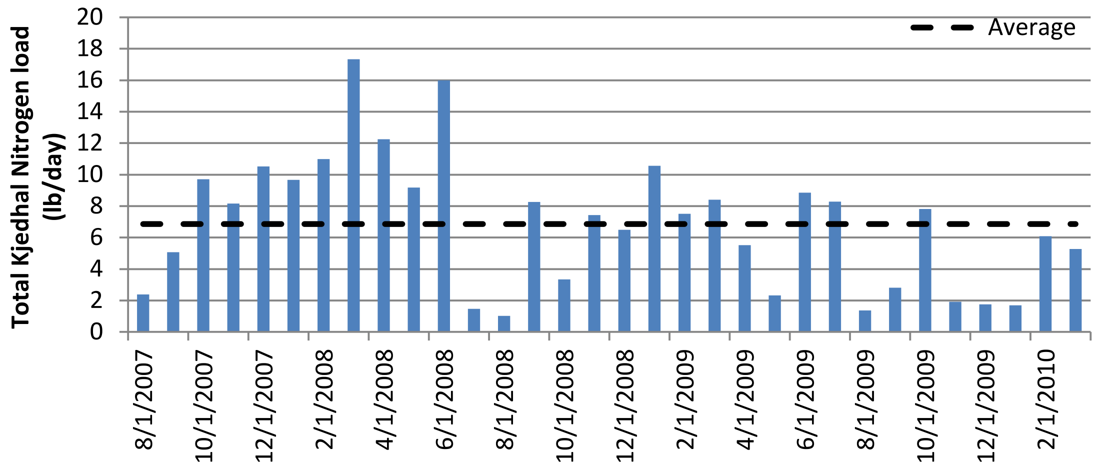


(b) Ammonia Load (lb/day)

Figure G2-4. Philipsburg Wastewater Treatment Plant Ammonia Concentration (mg/L) and Load (lb/day) from August 2007 through March 2010

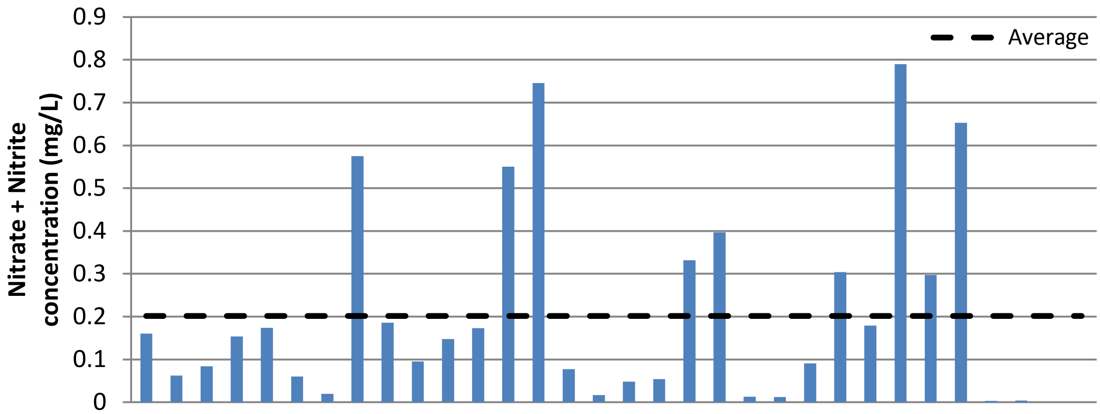


(a) Total Kjedhal Nitrogen Concentration (mg/L)

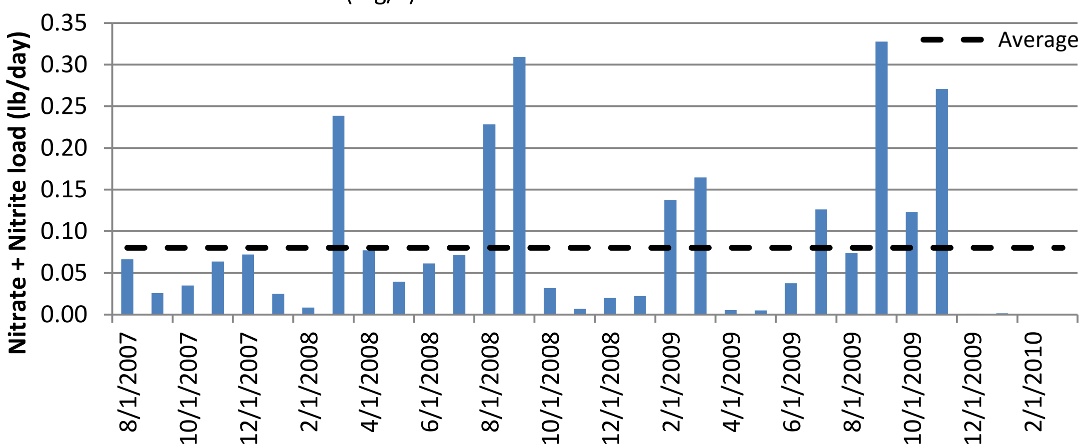


(b) Total Kjedhal Nitrogen Load (lb/day

Figure G2-5. Philipsburg Wastewater Treatment Plant Total Kjeldahl Nitrogen Concentration (mg/L) and Load (lb/day) from August 2007 through March 2010



(a) Nitrate + Nitrite Concentration (mg/L)



(b) Nitrate + Nitrite Load (lb/day)

Figure G2-6. Philipsburg Wastewater Treatment Plant Nitrate + Nitrite Concentration (mg/L) and Load (lb/day) from August 2007 through March 2010

According to their permit, Statements of Basis, and other information from DEQ and City staff (Hoehne, Dick, personal communication 2010; Kron, Darrin, personal communication 2010), the Philipsburg WWTP made minor facility upgrades in 1993, replaced a corroded outflow flume in the fall of 2004, repaired a leaking septic pipe contributing to infiltration in December 2006, and installed water meters in homes in 2009 for water conservation. According to the MPDES permit (MT0031500), future upgrades needed include removing overloaded biosolids in the lagoons and reducing inflow and infiltration in the WWTP system.

Due to numerous limit exceedances in 2008 and 2009 for Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD), and pH, the WWTP has been placed under an enforcement action with DEQ. As such, the WWTP must follow the Administrative Order on Consent (Docket No. WQ-09-10) to continue operating until the WWTP can come into compliance with the effluent limits set forth in the permit. The Administrative Order on Consent is an agreement and plan to remediate noncompliance issues for the permitted location. The Philipsburg Town Council agreed to install a *Bio Lac* system to upgrade their wastewater treatment system in April 2009. The *Bio Lac* system is an activated sludge process that will comprehensively reduce biosolids, TSS, BOD, and pH; it also has the potential to reduce nutrient effluents. The proposed *Bio Lac* system consists of an aeration basin, clarifier, and aerated sludge holding pond. The Philipsburg WWTP is primarily utilizing the *Bio Lac* system to reduce TSS, BOD, and pH effluent and not focusing on nutrients since they are not under an enforcement action to do so (Hoehne, Dick, personal communication 2010). Stated achievements using a *Bio Lac* system include a 30-70 day sludge treatment, less than 10 mg/L BOD and TN effluent, and complete nitrification (<1 mg/L) of all sludge (Parkson Corporation, 2009). TP can be reduced using the *Bio Lac* system if it is set up using an anaerobic/aerobic system; however no specific TP achievements are stated by the Parkson Corporation. The Administrative Order on Consent compliance timeline is stated in **Table G2-3.**

Table G2-3. Remediation Timeline for Philipsburg Wastewater Treatment Plant Biosolids, Total Suspended Solids, Biochemical Oxygen Demand, pH, and Some Nutrients

Date	Compliance Action Required
July 1, 2011	Philipsburg must submit plans and specifications for the proposed *Bio Lac* system
October 1, 2012	Philipsburg must complete construction of the *Bio Lac* system
October 1, 2013	Philipsburg must ensure completeness and proper functioning of the *Bio Lac* system

The City of East Helena, Montana, WWTP has been operating a *Bio Lac* system since 2002. As such, Discharge Monitoring Report data from this facility (Permit MT0022560) was used to provide insight to possible nutrient reductions that may be achieved at the Philipsburg WWTP once the *Bio Lac* system is in use. East Helena Discharge Monitoring Report data goes back to 1997 and shows no significant reduction in TP or TN as a result of the *Bio Lac* system being installed. Given this outcome, it is therefore anticipated that the Philipsburg WWTP will see no significant impact on their effluent nutrient concentrations/loads as a result of installing the *Bio Lac* system.

The Town of Philipsburg is planning to remediate most of the known inflow and infiltration problems during the summer of 2011, when sections of the main transmission line entering the lagoons will be lined (Hoehne, Dick, personal communication 2010). Once the lining of the transmission line is complete all known significant sources of inflow and infiltration will be eliminated (Montana Department of Environmental Quality, 2009).

G2.1.2 Industrial Sources

A search of the Integrated Compliance Information System showed no industrial sites in the Flint Creek watershed. A follow-up search of the NRIS (which incorporates the Integrated Compliance Information System database) confirmed the finding.

G2.1.3 Mining Sources

Mining operations permitted to discharge wastewater into surface waters of the state were identified using the Integrated Compliance Information System database and DEQ hardfiles. **Table G2-4** summarizes the permitted mining operations within the Flint Creek watershed.

Table G2-4. Permitted Mines within the Flint Creek TMDL Planning Area

NPDES Number	Outfall Number	Permittee	Description	Receiving Water	Permit Expiration Date
MTR300080	001	Asarco Inc.	Stormwater - Mining and Oil	Smart Creek	9/30/2013
MTR300080	002	Asarco Inc.	Stormwater - Mining and Oil	South Fork Lower Willow Creek	9/30/2013
MT0031569	---	Teras Resources Inc. - Golden Jubilee Mine	None found; permit pending. Suspect mining wastewater	Integrated Compliance Information System-provided map suggests drainage to stream draining Fred Burr Lake to Flint Creek	Unknown

Permit MTR300080 is issued to Asarco, Inc. for stormwater related to mining and oil at the Black Pine Mine. The facility is located approximately 12 miles southwest of Philipsburg and is permitted to drain stormwater at two outfalls. Outfall 001 is a pipe emptying into a constructed basin. Water discharges from the basin via a channel on the downgradient end and into Smart Creek. Outfall 002 is a small ditch system created to collect and direct water away from waste rock piles. A pipe discharges water directly into the South Fork Lower Willow Creek.

The pertinent flow and nutrient concentration data for the Black Pine Mine was provided via Discharge Monitoring Reports by DEQ. The Discharge Monitoring Reports show effluent discharge measurements on a semi-annual basis. The flow rate at Outfall 001 was reported eight times between December 2003 and December 2009 with an average rate of 4.19 gpm (**Figure G2-7**). Outfall 002 had no reported discharge flow rates during the same timeframe. When no discharge occurred at an outfall during a reporting period the permittee provided a description in the Discharge Monitoring Reports of "No Discharge" or "Analysis not conducted/No sample." See **Attachment GB, Table GB-2** for discharge data.

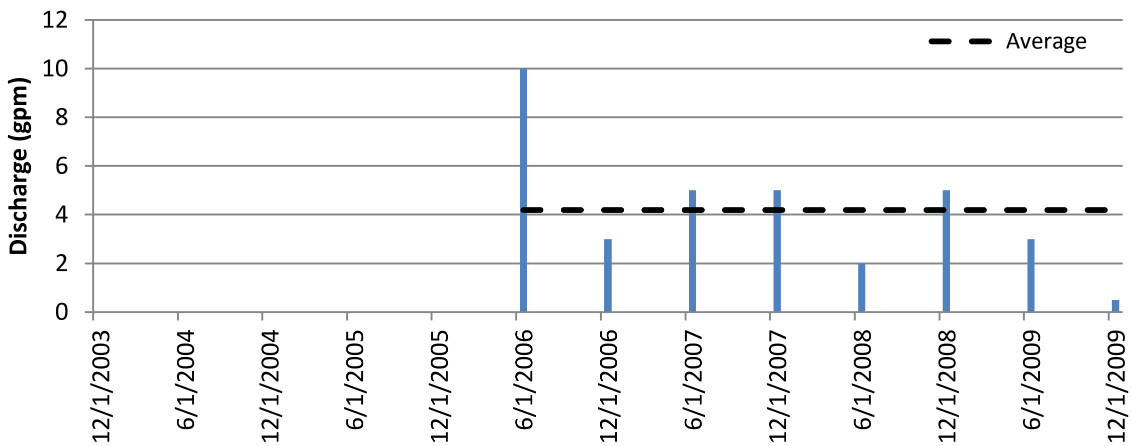


Figure G2-7. Black Pine Mine Outfall 001 (Asarco Inc.) Bi-Annual Effluent Discharges (gpm) from December 2003 through December 2009

Nitrite + Nitrate values were reported three times at Outfall 001 and two times at Outfall 002 from June 1994 through June 2010. Ammonia and TP were both reported once at Outfall 001 and twice at Outfall 002 between June 1994 and December 2002. Due to the majority of sampling periods reporting "No Discharge" for nutrient data, trends were not able to be assessed for either outfall from this facility. Effluent limits for all nutrient parameters are listed in **Table G2-5** for Permit MTR300080 (Cleary, Devin, personal communication 2010). All nutrients are listed in **Attachment GB, Table GB-2.**

Table G2-5. Nutrient Effluent Limits for Permit MTR300080

Nutrient Parameter	Effluent Limit
Nitrite + Nitrate	0.68 mg/L
Total Phosphorus	2.0 mg/L
Ammonia	19 mg/L

Asarco Inc. filed for bankruptcy on 08/09/2005. After court proceedings were finalized on 12/09/09, the deed to the Black Pine Mine was turned over to the Montana Environmental Trust Group LLC, a subsidiary of the Greenfield Environmental Trust Group (Byron, 2009). The land is being held in trust for the State and Montana and, under DEQ's supervision, the Black Pine Mine is now being remediated for mining contaminants (Cleary, Devin, personal communication 2010). The permit remains active in the event it is needed during the cleanup efforts. Technically, Permit MTR300080 has been in noncompliance since the property was turned over to Montana Environmental Trust Group LLC due to failure to report Discharge Monitoring Reports. No formal enforcement actions have been brought against Montana Environmental Trust Group LLC for the noncompliance issues.

Permit MT0031569, is currently in the process of being issued to Teras Resources, Inc. for the Golden Jubilee Mine. The permit application was received without a fee in 2007 and Teras Resources, Inc. has not pursued the permit any further since then. As such, no nutrient data, discharge data, or conditions were applicable for this permit. The map provided through Integrated Compliance Information System by the OTIS (On-line Tracking Information System) suggests that the site is in the Fred Burr Creek sub-watershed. They are currently still under a small miners exclusion permit for exploration work, which exempts the need for an NPDES permit. This mining operation may need an industrial stormwater permit in the future if it produces a certain amount of ore.

G2.2 Groundwater Sources

Permitted groundwater sources are those that discharge directly to groundwater, via percolation or direct injection, that will not become part of the surface water flow and nutrient budget until (or if) the groundwater discharges via dispersed flow to a surface water. Direct discharge to groundwater requires an individual state-issued permit (non-NPDES). Dischargers must obtain and comply with a MGWPCS permit to discharge wastewater to the groundwater either directly or via percolation. A permit is not required for the discharge of certain wastes to groundwater under specific circumstances (see ARM 17.30.1310, 75-5- 401(1)(b) and 75-5-401(5), MCA). Location of all permitted groundwater sources can be found in **Figure GA-2**.

G2.2.1 Montana Ground Water Pollution Control System Permitted Groundwater Discharges

There are three MGWPCS-permitted discharges to the sub-surface waters of the Flint Creek watershed. These dischargers are summarized in **Table G2-6**; a figure of all groundwater discharging facilities can be found in **Figure GA-2**.

Table G2-6. Montana Ground Water Pollution Control System-Permitted Dischargers within the Flint Creek TMDL Planning Area

MGWPCS Number	Outfall Number	Permittee	Description	Receiving Water (Closest Waterbody)	Permit Expiration Date
MTX000002	002-A	Contact Mining Company	Ore mining	Groundwater (Douglas Creek)	7/31/2015
MTX000002	003-A	Contact Mining Company	Ore mining	Groundwater (Douglas Creek)	7/31/2015
MTX000134	001	Sugar Loaf Wool Carding Mill	Wool processing	Groundwater (Spring Creek)	7/31/2015
MTX000201	001	Georgetown Development, LLC	Single family home development	Groundwater (Georgetown Lake)	9/30/2013

Permit MTX000002, issued to Contact Mining Company, is for the stated purpose of producing lead, silver, copper, and gold ores. The facility originally had an administrative order against it that included unreported discharge of mine drainage, ineffective or lacking best management practices, and ineffective capture of subsurface mine drainage, and thereafter became a groundwater permitted facility. This facility is a custom mill site and operates intermittently when ore processing can be contracted. The facility sits on top of prior mill tailings from the Granite Mill site; a larger historic and abandoned operation. Wastewater from Contact Mill operations is pumped into tailings impoundments and discharged by leakage/infiltration. Primary settling is the treatment method for wastewater outfalls at this facility. Outfall 002-A pertains to East tailings impoundment, Outfall 003-A is the West impoundment and Site MW1-A is the pump house (not an outfall) prior to distribution into the tailings impoundments.

The August 2010 MGWPCS permit requires the Contact Mining Company to monitor their effluent flow rate on a continuous basis and report the data monthly. Ammonia and Nitrate + Nitrite values are required to be monitored every week with monthly reporting. No other nutrient monitoring is required. Applicable permit limits for this site are shown in **Table G2-7**. In addition to monitoring the characteristics of their effluent, Contact Mining is also required to monitor and report on the Ammonia and Nitrite + Nitrate levels in their groundwater on a quarterly basis; however, there is no groundwater quality data available because the originally completed monitoring wells were dry when drilled to the bedrock interface and therefore monitoring has not occurred. DEQ is requiring installation of new monitoring wells and groundwater monitoring during the current permit cycle. Contact Mining Company is currently processing ore from the Drumlummon Mine near Marysville, Montana.

Table G2-7. Nutrient Effluent Limits for Individual Groundwater Discharge Permits

MGWPCS Number	Total Phosphorus		Total Nitrogen		Ammonia	Nitrate + Nitrite	Nitrate	Total Kjeldahl Nitrogen	Effluent Flow Rate
	mg/L	lb/d	mg/L	lb/d	mg/L	mg/L	mg/L	mg/L	gpd
MTX000002	-	-	TNL	-	TNL	-	-	-	TNL
MTX000134	-	-	7.5	-	-	-	TNL	TNL	165
MTX000201	10.0	0.46	25.7	1.18	TNL	TNL	TNL	TNL	5,550

TNL = Tested but no limit set
“-“ = Not required to test

The MTX000002 Discharge Monitoring Reports for Outfall 002-A show monthly monitoring from October 2002 through September 2009 (**Attachment GB, Table GB-3**). However, most of these values were blank and some had descriptions such as: “No Discharge”, “Conditional Monitoring - Not Required This Period”, “Operation Shutdown”, and “Below Detection Limit/No Detection”. “Operation Shutdown” was reported monthly starting during 2008 and continuing through 2009, with no subsequent reports provided. Much of the past decade, the facility was intermittently operated and therefore had no discharge to monitor. Only trace element concentrations and specific conductance were reported, flow and nutrient concentrations were not. As such, no trends were able to be discerned for flow or nutrient concentrations due to lack of numeric information.

Discharge from MTX000002 Outfall 003-A was also reported monthly from October 2002 through September 2009. A table reporting Nitrite + Nitrate nitrogen concentrations was provided, but Discharge Monitoring Report values were blank with the same descriptions as Outfall 002-A. Monitoring Site MW1-A (the pump house) was also listed, but the report was similar to the other sites, with no information concerning discharge flows or nutrient concentrations. Previous and future trends were not able to be discerned due to lack of numeric information.

Permit MTX000134 is issued to Sugar Loaf Wool Carding Mill to discharge industrial wastewater into a sub-surface drainfield. As per the 2010 MGWPCS permit, Nitrate and TKN are to be sampled quarterly, while flow is to be sampled continuously. All effluent data must be reported quarterly. TP is not monitored because a breakthrough analysis showed non-significant degradation.

No water quality data was available for July 2003 through June 2008 for this permit because Sugar Loaf Wool Carding Mill did not collect and analyze the required samples. Limited data was available from July 2008 to the present; this data included four sampling periods (**Attachment GB**, **Figure GB-4**). Due to limited data, no discharge or nutrient trends were able to be discerned for this facility.

The discharge system is designed to handle an average of 165 gallons per day (gpd) and 250 gpd during peak flows. Administrative orders pertaining to the facility include an order to collect and analyze the stated effluent parameters and an order to complete Discharge Monitoring Reports on a regular basis. No historic or future changes in discharge practices were found in the reviewed information. Applicable permit limits are found in **Table G2-7**.

Permit MTX000201 is issued to Georgetown Development, LLC for the Lakeside at Georgetown home development project. The development is permitted to discharge residential strength wastewater, at a rate of up to 5,550 gpd, from a wastewater treatment system single zone drainfield. The facility has effluent limits on both TP and TN, as shown in **Table G2-7**. According to their October 2008 MGWPCS permit, Georgetown Development is supposed to monitor their effluent flow rate (prior to reaching the drainfield) on a daily basis and report the data quarterly; water quality data should be monitored/ reported quarterly. In addition to their effluent monitoring, the development is also required to monitor the quality of their groundwater quarterly.

This development is still in the process of being constructed and no current data exists for this permit. A groundwater monitoring location is being developed at this time. No administrative orders or future upgrade conditions were found for this facility due to the fact that it is not functional at this time.

Two other multi-family wastewater treatment systems exist within the watershed: the Rising Sun Estates and Elk Meadows Phase 2 housing complexes. These two systems are located near Georgetown Lake (**Figure GA-2**). Neither of these housing complexes have an MPDES permit to discharge to groundwater and thus are outside the scope of this report.

G2.2.2 Small Individual / Shared Subsurface Sewage Treatment Systems

An accurate count of Subsurface Sewage Treatment Systems, or septic systems, is difficult to accurately obtain. Individual septic systems are differentiated from multi-user or municipal wastewater treatment systems in that they are independent systems serving single housing structures. DEQ, using Geographic Information System (GIS) layers of structures within Granite and Deer Lodge Counties, estimated there are 1,623 small septic systems within the watershed (Regensburger et al., 2010). Since the number of individual septic systems increases with human population, areas with higher population densities also contain the highest septic system concentrations. As such, septic systems in the Flint Creek watershed are mainly concentrated near Georgetown Lake, while moderately concentrated septic systems are near Philipsburg, Lower Flint Creek, and Boulder Creek. Other areas of the watershed have low septic system densities (Regensburger et al., 2010). **Figure GA-3** was created with information provided as part of DEQ's septic system study and shows the locations of individual septic systems in the study area.

As part of their septic system report, DEQ estimated nutrient loadings at drainfields and to surface waters. The GIS-based assessment using soil properties and distance to surface water estimated that on average 64% of Nitrate and 85% of TP entering the drainfields is treated before entering surface waters. They also estimated that septic system loading occurs at 30.5 lb/year/home for nitrate and 6.44 lb/year/home for TP. Based on those assumptions, the estimated total nitrate and TP loading into the Flint Creek watershed's surface waters from septic systems is 17,860 and 1,575 lbs/year, respectively (Regensburger et al., 2010).

Detailed information regarding septic systems within the Flint Creek watershed can be found in DEQ's subsurface wastewater treatment report (Regensburger et al., 2010). Results from DEQ's subsurface wastewater treatment report (Regensburger et al., 2010) effort will provide a basic estimate in which the SWAT septic source assessment routines will be compared during calibration. The method of simulating septic systems in the SWAT model (and data for entry into the model) will be determined by DEQ.

G2.3 Stormwater Facilities

Table G2-8 lists the MPDES-permitted sites that are not considered elsewhere in this report as mining-related or wastewater, or that are listed as terminated or expired. The three sites listed are in sub-watersheds that are tributary to Georgetown Lake. These are the construction permits for the Georgetown Development - Lakeside at Georgetown Subdivision (Permit MTR103118), Hutton Fine Builders - Bobak Residence (Permit MTR103475), and Mungas Co. Inc - Southern Cross Reclamation (Permit MTR101311). These three sites are covered by the general permit for stormwater discharges associated with construction activities. Facilities covered under this general permit are required to implement BMPs and conduct regular inspections but are not typically required to conduct water quality monitoring.

Table G2-8. Permitted Stormwater Dischargers Associated with Construction Activities

NPDES Number	Permitee	Description	Receiving Waterbody	Permit Expiration Date	Permit Status	Outfall Location
MTR103118	Georgetown Development - Lakeside at Georgetown Subdivision	Stormwater Construction	Georgetown Lake	12/31/2011	Effective	Latitude: 46.171550 Longitude: -113.288100
MTR103475	Hutton Fine Builders - Bobak Residence	Stormwater Construction	Georgetown Lake	12/31/2011	Effective	Latitude: 46.191944 Longitude: -113.306944
MTR101311	Mungas Co. Inc - Southern Cross Reclamation	Stormwater Construction - Excavation Work	Drainage To North Fork Flint Creek	12/31/2011	Effective	Latitude: 46.195833 Longitude: -113.240278

Permit MTR103118, issued to Georgetown Development – Lakeside at Georgetown subdivision, is for the stormwater runoff at the construction site of condominiums and homes.

Permit MTR103475, issued to Hutton Fine Builders, is for home building sites on a 1.8 acres disturbed area. This area has a moderate soil-erodability factor (K) of 0.25. This means the soils are moderately susceptible to being picked up in runoff and moving downgradient. To prevent the soil from reaching Georgetown Lake, a silt fence was installed around the construction site with a 75 foot natural grass buffer between the construction site and Georgetown Lake.

Permit MTR101311, issued to Mungas Company Inc., is in the process of constructing a quarter-mile road leading to a building. To reduce sediment transported via runoff, silt fencing was installed (Kron, Darrin, personal communication 2010).

Stormwater runoff from urban surfaces is commonly transported through Municipal Separate Storm Sewer Systems (MS4s), from which it is often discharged untreated into local surface waters. To prevent harmful pollutants from being washed or dumped into an MS4, operators must obtain a NPDES permit and develop a stormwater management program. Philipsburg, the largest town in the Flint Creek watershed evaluated for this report, and other municipalities in the watershed are not presently required to obtain a permit under the MS4 program due to their small population size and will be treated as nonpoint source urban runoff.

G2.4 Other Facilities

Active permitted mines are discussed above, but there are many mines throughout the watershed that are abandoned or inactive. While not explicitly addressed above, these mines may pose a threat to environmental health. NRIS provided information and GIS coverages for three abandoned-mine data bases originating from: 1) The Montana Bureau of Mines and Geology; 2) The Montana State Library, incorporating data from the U.S. Bureau of Mines Mineral Information Locator Service; and 3) DEQ's Abandoned Mines Bureau. All abandoned mine locations in the Flint Creek watershed are shown in **Figure GA-4** with no attempt to sort out duplicate entries, resulting in many overprinted identifiers. These mines and waste pile areas often are a source of water discharge because they intercept groundwater aquifers or expose crushed rock weathering conditions. Because mines expose material to weathering that might otherwise remain harmlessly bound in the rocks, discharge water or diffuse groundwater may carry a broad assortment of contaminants (particularly acidic waters with elevated trace elements which are beyond the scope of this data compilation). Also carried with the water may be small concentrations of nutrient compounds, although this probably is not a significant source. Residues of explosives used during mining often contain substantial quantities of nitrogen compounds. Because most of these nitrogen-based compounds are very water soluble, they probably have long since been washed away or degraded.

Phosphate had been actively mined in many parts of the northern Rocky Mountains, and the Flint Creek drainage is no exception. The abandoned mines where phosphate was mined (often with other products that also were mined) are shown in **Figure GA-4**. A literature review was performed to determine whether residues or other exposed material from phosphate mining leads to detrimental levels of phosphorus in waters downstream. No evidence of any direct effect was identified although several discussions dealt with collateral effects including increased sediment transport, changes in flow volumes, and concerns about elevated concentrations of co-occurring contaminants.

According to DEQ records the Philipsburg landfill (license #265) was in operation as early as 1966 and may have existed prior to that time. It was officially closed by the state in 1995. The site was located approximately 1 mile north of Philipsburg in the northwestern quadrant of section 24, Township 7N, Range 14W. It was licensed as a class II landfill, which means it was licensed to accept general household waste. Class II landfills are not allowed to accept septic tank waste or other semi-liquids or liquids without an exemption - the DEQ file does not indicate an exemption to accept those wastes was ever granted. Records indicate the dump did not have a liner. Due to the type of waste disposed there appears to be a low risk of significant nutrient impacts to the groundwater.

According to DEQ records the Charles Park landfill near Drummond (license #267) was licensed and in operation between 1985 and 1992 when it was officially closed by the state. The site was located 2.5 miles south and 1.5 miles east of Drummond in the southwestern quadrant of section 8, Township 10N, Range 12W. It was licensed as a class II landfill, which means it was licensed to accept general household waste. Class II landfills are not allowed to accept septic tank waste or other semi-liquids or liquids without an exemption - the DEQ file does not indicate an exemption to accept those wastes was ever granted. Due to the type of waste disposed there appears to be a low risk of significant nutrient impacts to the groundwater.

G3.0 SUMMARY

The purpose of this report is to characterize the point sources and permitted groundwater discharge facilities that may influence nutrients in the Flint Creek watershed. Information put forth in this report will support the creation of a SWAT watershed loading model, which DEQ plans to construct as part of a TMDL study. Various sources of data were used to gather and report information on the area's nutrient source locations and operations, associated receiving water, permitted limits and reporting requirements, and past and projected changes in the quantity of nutrient loads (when possible).

The Flint Creek watershed contains six permitted nutrient sources which discharge directly to either surface or groundwater. Three permitted sources discharge to surface waters and three discharge to groundwater. In addition to these permitted sites, the watershed also contains three Stormwater Construction permits. The locations of all these sites are shown in a series of attached maps.

Various qualities of monitoring data were available for these facilities/sources. The Phillipsburg WWTP had the most comprehensive record of flow and water quality data with ten years of reported monthly flow data and 6 years of reported monthly nutrient values. Most facilities had little to no data available because the facilities have either had few discharge events or are not required to conduct water quality monitoring. No flow or water quality data were available for the permitted stormwater construction sites. **Attachment GB** summarizes the reported flow and nutrient water quality data available for each permitted facility.

G4.0 REFERENCES

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ATTACHMENT GA - MAPS

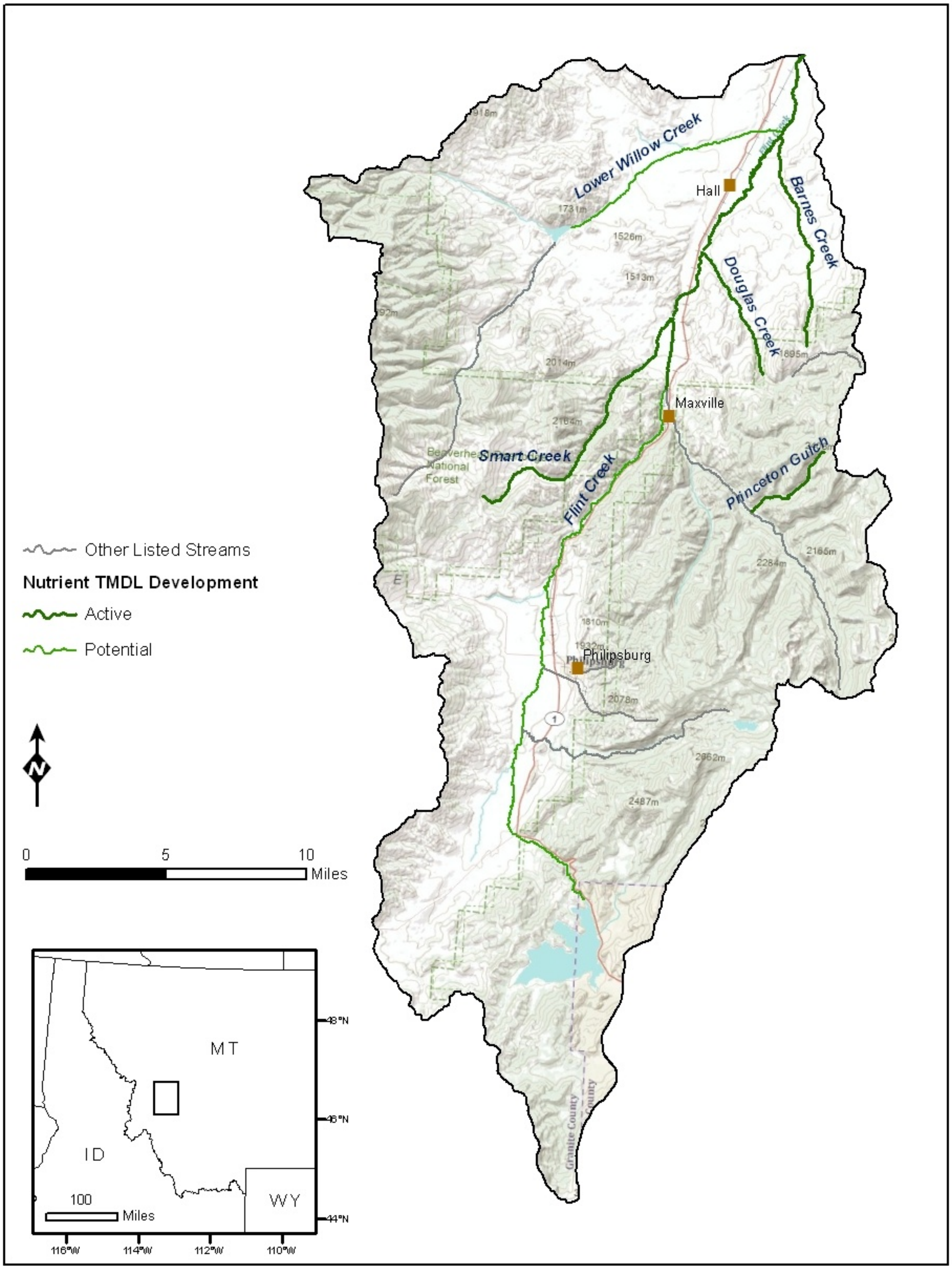

Figure GA-1. Impaired and Potentially Impaired Streams within the Flint Creek Watershed, Montana

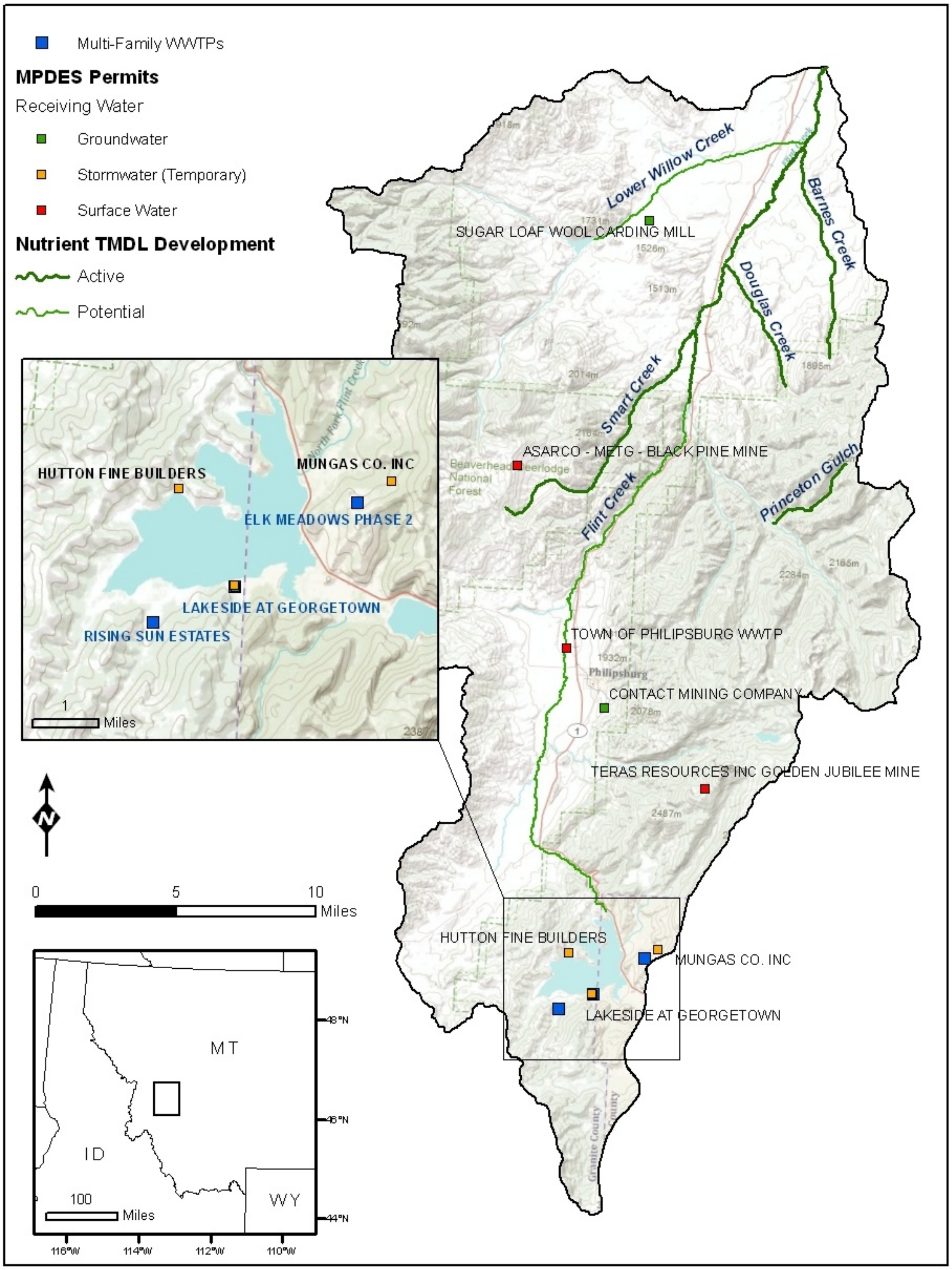

Figure GA-2. Locations of Permitted and Non-Permitted Wastewater Dischargers in the Flint Creek Watershed, Montana

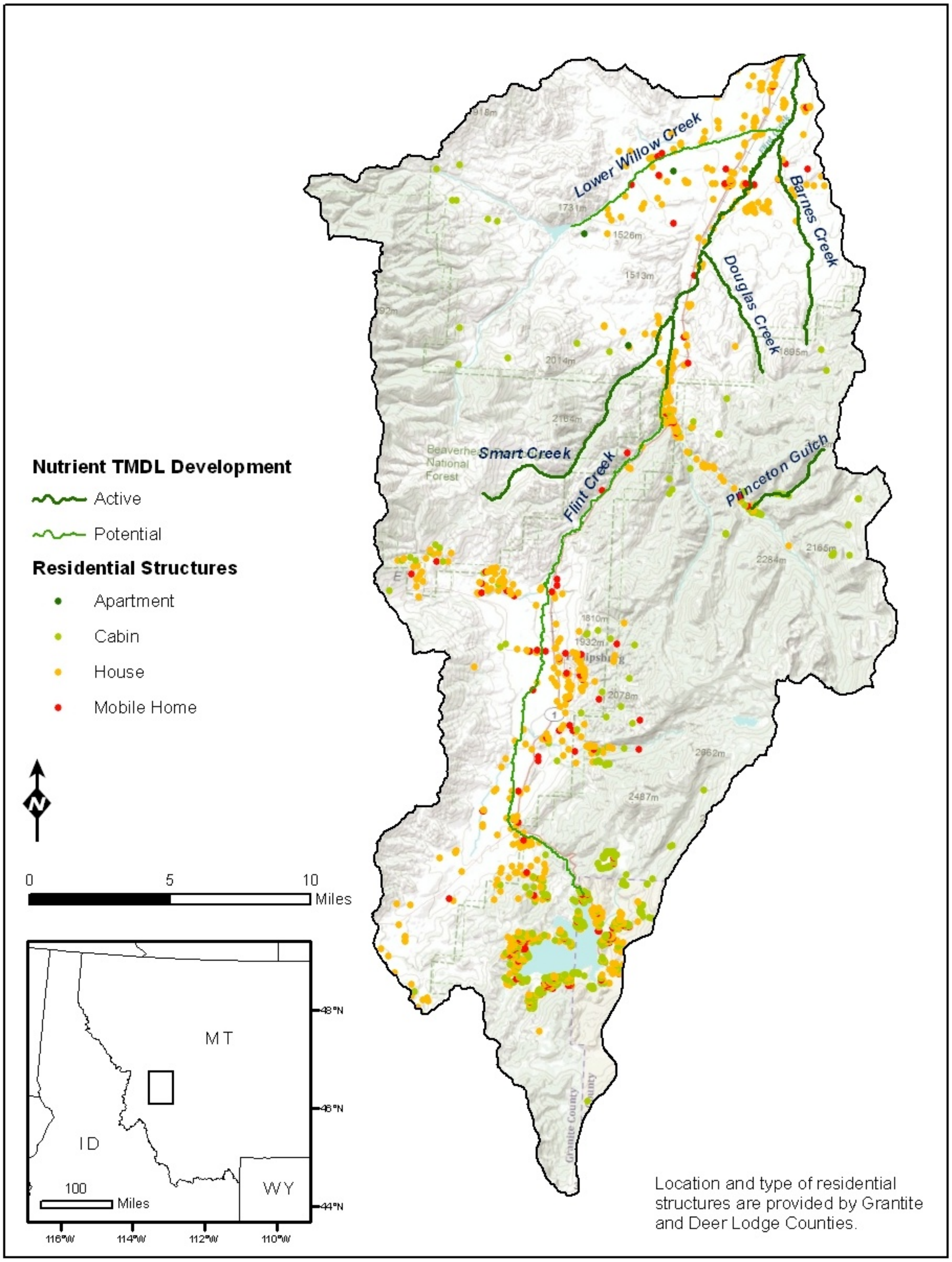

Figure GA-3. Locations of Individual Septic Systems in the Flint Creek Watershed, Montana

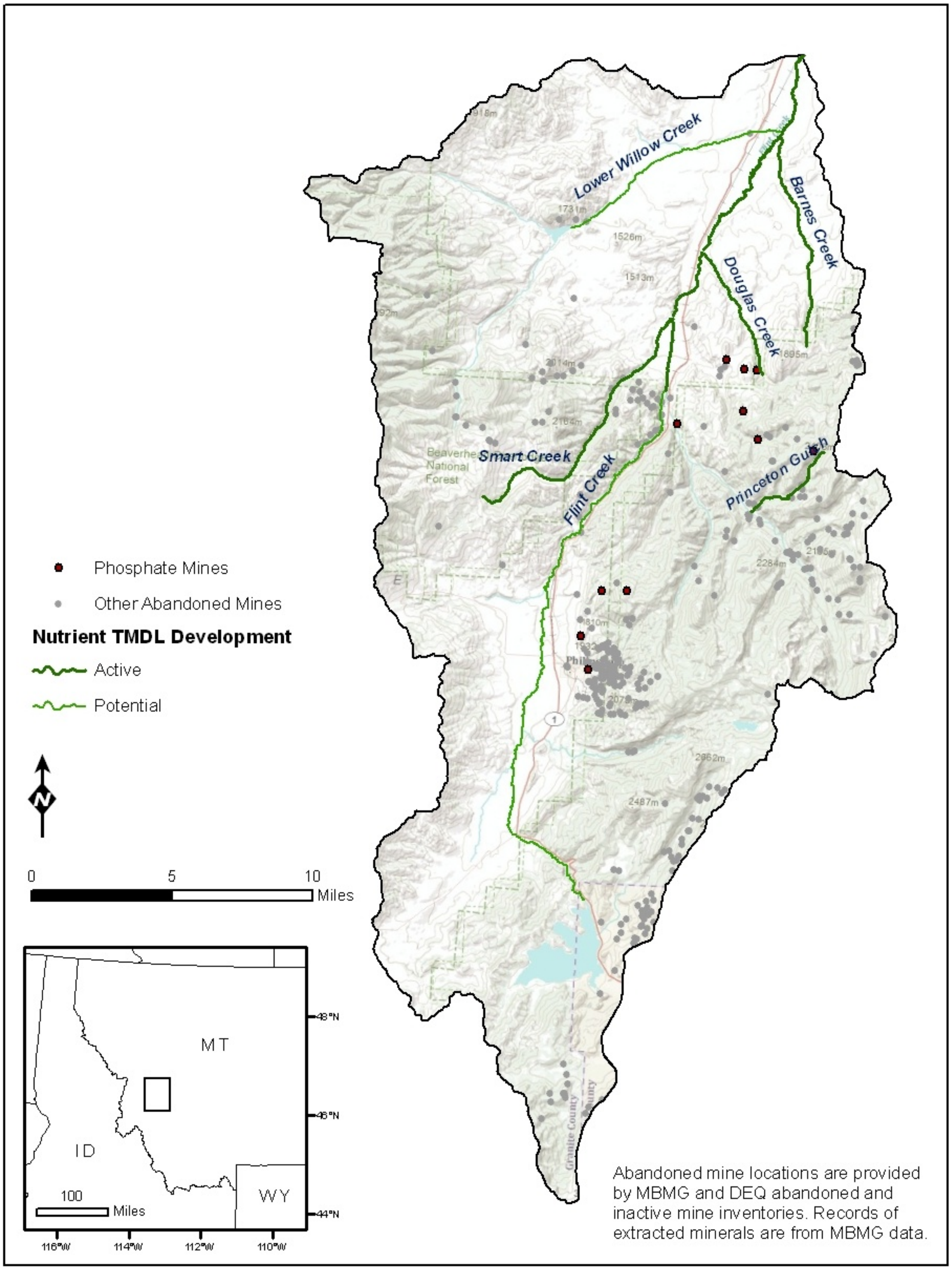

Figure GA-4. Locations of Abandoned Mines within the Flint Creek Watershed, Montana

ATTACHMENT GB – POINT SOURCE DISCHARGE MONITORING REPORTS

Table GB-1. Philipsburg WWTP

Permit: MT0031500													
	Discharge			Total Phosphorus		Total Nitrogen		Ammonia		TKN		Nitrate + nitrite	
Date	mgd average	mgd max	m3/d	mg/L	lb/day	mg/L	lb/day	mg/L	lb/day	mg/L	lb/day	mg/L	lb/day
1/31/2000	0.09		329.30										
2/29/2000	0.12		454.20										
3/31/2000	0.11		412.57										
4/30/2000	0.08		291.45										
5/31/2000	0.08		291.45										
6/30/2000	0.14		545.04										
7/31/2000	0.07		257.38										
8/31/2000	0.06		223.32										
9/30/2000	0.06		223.32										
10/31/2000	0.07		257.38										
11/30/2000	0.07		257.38										
12/31/2000	0.07		257.38										
1/31/2001	0.12		454.20										
2/28/2001	0.17		639.67										
3/31/2001	0.17		639.67										
4/30/2001	0.10		370.93										
5/31/2001	0.06		223.32										
6/30/2001	0.10		370.93										
7/31/2001	0.07		257.38										
8/31/2001	0.03		128.69										
9/30/2001	0.07		257.38										
10/31/2001	0.06		223.32										
11/30/2001	0.07		257.38										
12/31/2001	0.09		329.30										
1/31/2002	0.10		370.93										
2/28/2002	0.09		329.30										
3/31/2002	0.08		291.45										
4/30/2002	0.07		257.38										
5/31/2002	0.06		223.32										
6/30/2002	0.14		545.04										
7/31/2002	0.06		223.32										
8/31/2002	0.04		158.97										
9/30/2002	0.05		189.25										
10/31/2002	0.05		189.25										
11/30/2002	0.06		223.32										
12/31/2002	0.08		291.45										
1/31/2003	0.08		291.45										
2/28/2003	0.08		291.45										
3/31/2003	0.11		412.57										
4/30/2003	0.09		329.30										
5/31/2003	0.10		370.93										

Table GB-1. Philipsburg WWTP

Permit: MT0031500														
	Discharge			Total Phosphorus		Total Nitrogen		Ammonia		TKN		Nitrate + nitrite	
Date	mgd average	mgd max	m3/d	mg/L	lb/day	mg/L	lb/day	mg/L	lb/day	mg/L	lb/day	mg/L	lb/day
6/30/2003	0.08		291.45										
7/31/2003	0.05		189.25										
8/31/2003	0.03		128.69										
9/30/2003	0.06		223.32										
10/31/2003	0.08		291.45										
11/30/2003	0.11		412.57										
12/31/2003	0.06		223.32										
1/31/2004	0.07		257.38										
2/29/2004	0.10		370.93										
3/31/2004	0.16		590.46										
4/30/2004	0.06		223.32										
5/31/2004	0.16		590.46										
6/30/2004	0.09		329.30										
7/31/2004	0.04		158.97										
8/31/2004	0.05		189.25										
9/30/2004	0.09		329.30										
10/31/2004	0.06		223.32										
11/30/2004	0.22		844.06										
12/31/2004	0.18		688.87										
1/31/2005	0.30		1131.72										
2/28/2005	0.22		844.06										
3/31/2005	0.21		791.07										
4/30/2005	0.22		844.06										
5/31/2005	0.24		900.83										
6/30/2005	0.28		1071.16	2.10	4.95	6.60	15.55						
7/31/2005	0.18		688.87	1.80	2.73	9.10	13.79						
8/31/2005	0.16		590.46	1.70	2.21	8.80	11.43						
9/30/2005	0.25		957.61	0.35	0.74	7.00	14.75						
10/31/2005	0.24		900.83	2.30	4.56	11.80	23.39						
11/30/2005	0.25		957.61	0.47	0.99	7.01	14.77						
12/31/2005	0.30		1131.72	1.77	4.41	6.53	16.26						
1/31/2006	0.24		900.41	2.05	4.06	11.68	23.14						
2/28/2006	0.28		1071.00	2.16	5.09	10.83	25.52						
3/31/2006	0.24		900.41	2.17	4.30	10.69	21.18						
4/30/2006	0.18		689.48	0.90	1.37	5.39	8.18						
5/31/2006	0.10		370.85	2.10	1.71	9.90	8.08						
6/30/2006	0.24		900.41	2.25	4.46	10.40	20.60						
7/31/2006	0.18		689.48	1.61	2.44	7.84	11.89						
8/31/2006	0.33		1251.41	1.35	3.72	4.57	12.58						
9/30/2006	0.47		1777.92	3.59	14.04	9.76	38.19						
10/31/2006	0.28		1071.00	4.15	9.78	8.55	20.15						
11/30/2006	0.14		544.71	2.75	3.30	8.73	10.46						
12/31/2006	0.13		499.15	1.04	1.14	7.24	7.96						
1/31/2007	0.11		412.16	2.57	2.33	16.50	14.96						

Table GB-1. Philipsburg WWTP

Permit: MT0031500														
	Discharge			Total Phosphorus		Total Nitrogen		Ammonia		TKN		Nitrate + nitrite	
Date	mgd average	mgd max	m3/d	mg/L	lb/day	mg/L	lb/day	mg/L	lb/day	mg/L	lb/day	mg/L	lb/day
2/28/2007	0.07		256.44	2.90	1.64	24.10	13.60						
3/31/2007	0.09		331.11	1.64	1.19	13.23	9.64						
4/30/2007	0.09		331.11	1.92	1.40	10.33	7.53						
5/31/2007	0.16		591.91	1.66	2.16	2.86	3.73						
6/30/2007	0.18		689.48	2.00	3.03	16.12	24.45						
7/31/2007	0.03		128.41	1.96	0.55	14.38	4.06						
8/31/2007	0.05	0.08	188.49	2.20	0.91	5.90	2.45	5.16	2.14	5.74	2.38	0.16	0.07
9/30/2007	0.09	0.27	331.19	3.02	2.20	6.97	5.08	5.23	3.81	6.96	5.07	0.06	0.03
10/31/2007	0.10	0.14	370.93	2.74	2.24	11.98	9.78	10.40	8.49	11.90	9.71	0.08	0.03
11/30/2007	0.12	0.27	454.96	0.74	0.74	8.31	8.32	10.80	10.81	8.16	8.17	0.15	0.06
12/31/2007	0.11	0.17	412.19	2.19	1.99	11.77	10.68	8.93	8.10	11.60	10.52	0.17	0.07
1/31/2008	0.08	0.12	292.96	2.91	1.88	15.06	9.71	0.08	0.05	15.00	9.67	0.06	0.02
2/29/2008	0.07	0.09	256.24	3.50	1.97	19.50	10.99	9.71	5.47	19.50	10.99	0.02	0.01
3/31/2008	0.09	0.12	331.19	2.93	2.14	23.82	17.36	17.50	12.75	23.80	17.34	0.58	0.24
4/30/2008	0.10	0.17	370.93	19.10	15.59	15.58	12.71	10.20	8.32	15.00	12.24	0.19	0.08
5/31/2008	0.09	0.24	331.19	2.84	2.07	12.79	9.32	5.74	4.18	12.60	9.18	0.10	0.04
6/30/2008	0.20	0.31	740.35	9.73	15.85	9.92	16.15	2.75	4.48	9.82	16.00	0.15	0.06
7/31/2008	0.09	0.22	331.19	3.77	2.75	2.03	1.48	0.50	0.36	2.03	1.48	0.17	0.07
8/31/2008	0.06	0.20	221.80	9.61	4.69	2.26	1.10	2.32	1.13	2.11	1.03	0.55	0.23
9/30/2008	0.13	0.47	499.24	10.60	11.64	7.70	8.46	6.99	7.68	7.53	8.27	0.75	0.31
10/31/2008	0.10	0.13	370.93	1.94	1.58	4.65	3.80	2.18	1.78	4.10	3.35	0.08	0.03
11/30/2008	0.12	0.25	454.96	1.24	1.24	8.17	8.17	4.80	4.80	7.42	7.43	0.02	0.01
12/31/2008	0.12	0.17	454.96	1.67	1.67	6.56	6.57	6.52	6.53	6.48	6.49	0.05	0.02
1/31/2009	0.09	0.17	331.19	3.28	2.39	14.52	10.58	10.20	7.43	14.50	10.57	0.05	0.02
2/28/2009	0.09	0.17	331.19	4.68	3.41	10.35	7.54	9.30	6.78	10.30	7.51	0.33	0.14
3/31/2009	0.07	0.12	256.24	2.26	1.27	14.95	8.43	6.88	3.88	14.90	8.40	0.40	0.16
4/30/2009	0.05	0.13	188.49	2.29	0.95	13.63	5.65	6.41	2.66	13.30	5.52	0.01	0.01
5/31/2009	0.05	0.16	188.49	1.87	0.78	6.03	2.50	0.63	0.26	5.63	2.33	0.01	0.00
6/30/2009	0.12	0.36	454.96	2.62	2.62	8.85	8.86	6.07	6.08	8.84	8.85	0.09	0.04
7/31/2009	0.07	0.13	256.24	3.32	1.87	14.71	8.29	9.42	5.31	14.70	8.29	0.30	0.13
8/31/2009	0.03	0.28	101.44	2.28	0.51	6.27	1.40	1.09	0.24	6.18	1.38	0.18	0.07
9/30/2009	0.06	0.20	221.80	2.82	1.38	6.07	2.96	1.67	0.81	5.77	2.82	0.79	0.33
10/31/2009	0.12	0.25	454.96	3.06	3.06	7.99	8.00	5.31	5.32	7.81	7.82	0.30	0.12
11/30/2009	0.03	0.06	128.31	1.87	0.53	7.58	2.14	2.90	0.82	6.79	1.92	0.65	0.27
12/31/2009	0.03	0.06	128.31	3.03	0.86	6.55	1.85	3.78	1.07	6.25	1.76	0.00	0.00
1/31/2010	0.03	0.06	101.44	3.00	0.67	8.27	1.85	2.21	0.49	7.62	1.70	0.00	0.00
2/28/2010	0.04	0.07	157.46	4.34	1.50	17.60	6.10	10.40	3.60	17.60	6.10	0.00	0.00
3/31/2010	0.03	0.06	101.44	3.81	0.85	23.60	5.27	11.30	2.52	23.60	5.27	0.00	0.00

Table GB-2. Asarco - Black Pine Mine

Permit: MTR300080				
	Outfall 001-A		Outfall 002-A	
Date	DMR value	Description	DMR value	Description
Flow rate - Effluent Gross - Gallons per minute				
12/31/2003		No discharge		No Discharge
6/30/2004		No discharge		No Discharge
12/31/2004		No discharge		Analysis Not Conducted/No Sample
6/30/2005		No discharge		No Discharge
12/31/2005		No discharge		No Discharge
6/30/2006	10			No Discharge
12/31/2006	3			No Discharge
6/30/2007	5			No Discharge
12/31/2007	5			No Discharge
6/30/2008	2			No Discharge
12/31/2008	5			No Discharge
6/30/2009	3			No Discharge
12/31/2009	0.5			
6/30/2010	Property turned over to Montana Environmental Trust Group			
Nitrite + nitrate total 1 det. (as N) Effluent gross - mg/L				
6/30/1994	0.01		.01	
12/31/1994				
6/30/1995		No discharge		No Discharge
12/31/1995				
6/30/1996		No discharge		No Discharge
12/31/1996		No discharge	.29	
6/30/1997		No discharge		No Discharge
12/31/1997		No discharge		No Discharge
6/30/1998		No discharge		No Discharge
12/31/1998		No discharge		No Discharge
6/30/1999		No discharge		No Discharge
12/31/1999		No discharge		No Discharge
6/30/2000		No discharge		No Discharge
12/31/2000		No discharge		No Discharge
6/30/2001		No discharge		No Discharge
12/31/2001		No discharge		No Discharge
6/30/2002		No discharge		
12/31/2002		No discharge		
1/1/2003 - 12/31/2008		Conditional monitoring - not required this period		
6/30/2009	0.34			
12/31/2009	3.22			
6/30/2010	Property turned over to Montana Environmental Trust Group			
Nitrogen, ammonia total (as N) Effluent gross - mg/L				
6/30/1994	0.44		.44	
12/31/1994				
6/30/1995		No Discharge		No Discharge
12/31/1995				
6/30/1996		No discharge		No Discharge

Table GB-2. Asarco - Black Pine Mine

Permit: MTR300080				
	Outfall 001-A		Outfall 002-A	
Date	DMR value	Description	DMR value	Description
12/31/1996		No discharge	1.9	
6/30/1997		No discharge		No Discharge
12/31/1997		No discharge		No Discharge
6/30/1998		No discharge		No Discharge
12/31/1998		No discharge		No Discharge
6/30/1999		No discharge		No Discharge
12/31/1999		No discharge		No Discharge
6/30/2000		No discharge		No Discharge
12/31/2000		No discharge		No Discharge
6/30/2001		No discharge		No Discharge
12/31/2001		No discharge		No Discharge
6/30/2002		No discharge		
12/31/2002		No discharge		
TP - effluent gross, mg/L				
6/30/1994	.06		.06	
12/31/1994				
6/30/1995		No Discharge		No Discharge
12/31/1995				
6/30/1996		No Discharge		No Discharge
12/31/1996		No Discharge	4.21	
6/30/1997		No Discharge		No Discharge
12/31/1997		No Discharge		No Discharge
6/30/1998		No Discharge		No Discharge
12/31/1998		No Discharge		No Discharge
6/30/1999		No Discharge		No Discharge
12/31/1999		No Discharge		No Discharge
6/30/2000		No Discharge		No Discharge
12/31/2000		No Discharge		No Discharge
6/30/2001				No Discharge
12/31/2001				No Discharge
6/30/2002				
12/31/2002				

Table GB-3. Contact Mining Company

Permit: MTX000002										
Outfall 002-A				Outfall 003-A				Outfall MW1-A		
Nitrite plus nitrate total 1 det. (as N) - mg/L										
Monitoring Period End Date	Maximum DMR Value	Description		Monitoring Period End Date	Maximum DMR Value	Description		Monitoring Period End Date	Maximum DMR Value	Description
10/31/2002				10/31/2002				10/31/2002		
11/30/2002				11/30/2002				11/30/2002		
12/31/2002		No Discharge		12/31/2002		No Discharge		12/31/2002		Insufficient Flow for Sampling
1/31/2003		Conditional		1/31/2003		No		1/31/2003		Conditional

Table GB-3. Contact Mining Company

Permit: MTX000002										
Outfall 002-A				**Outfall 003-A**				**Outfall MW1-A**		
Nitrite plus nitrate total 1 det. (as N) - mg/L										
Monitoring Period End Date	**Maximum DMR Value**	**Description**		**Monitoring Period End Date**	**Maximum DMR Value**	**Description**		**Monitoring Period End Date**	**Maximum DMR Value**	**Description**
		Monitoring - Not Required This Period				Discharge				Monitoring - Not Required This Period
2/28/2003		Conditional Monitoring - Not Required This Period		2/28/2003		No Discharge		2/28/2003		Conditional Monitoring - Not Required This Period
3/31/2003		No Discharge		3/31/2003		No Discharge		3/31/2003		No Discharge
4/30/2003		Conditional Monitoring - Not Required This Period		4/30/2003		No Discharge		4/30/2003		Conditional Monitoring - Not Required This Period
5/31/2003		Conditional Monitoring - Not Required This Period		5/31/2003		No Discharge		5/31/2003		Conditional Monitoring - Not Required This Period
6/30/2003		No Discharge		6/30/2003		No Discharge		6/30/2003		No Discharge
7/31/2003		Operation Shutdown		7/31/2003		No Discharge		7/31/2003		Operation Shutdown
8/31/2003		Operation Shutdown		8/31/2003		No Discharge		8/31/2003		Operation Shutdown
9/30/2003		Operation Shutdown		9/30/2003		No Discharge		9/30/2003		Operation Shutdown
10/31/2003		No Discharge		10/31/2003		No Discharge		10/31/2003		No Discharge
11/30/2003		No Discharge		11/30/2003		No Discharge		11/30/2003		No Discharge
12/31/2003		No Discharge		12/31/2003		No Discharge		12/31/2003		No Discharge
1/31/2004		Conditional Monitoring - Not Required This Period		1/31/2004		Conditional Monitoring - Not Required This Period		1/31/2004		Conditional Monitoring - Not Required This Period
2/29/2004		Conditional Monitoring - Not Required This Period		2/29/2004		Conditional Monitoring - Not Required This Period		2/29/2004		Conditional Monitoring - Not Required This Period

Table GB-3. Contact Mining Company

Permit: MTX000002										
Outfall 002-A				Outfall 003-A				Outfall MW1-A		
Nitrite plus nitrate total 1 det. (as N) - mg/L										
Monitoring Period End Date	Maximum DMR Value	Description		Monitoring Period End Date	Maximum DMR Value	Description		Monitoring Period End Date	Maximum DMR Value	Description
3/31/2004		No Discharge		3/31/2004		No Discharge		3/31/2004		No Discharge
4/30/2004		Conditional Monitoring - Not Required This Period		4/30/2004		Conditional Monitoring - Not Required This Period		4/30/2004		Conditional Monitoring - Not Required This Period
5/31/2004		Conditional Monitoring - Not Required This Period		5/31/2004				5/31/2004		Conditional Monitoring - Not Required This Period
6/30/2004		Operation Shutdown		6/30/2004		Operation Shutdown		6/30/2004		Operation Shutdown
7/31/2004		Conditional Monitoring - Not Required This Period		7/31/2004		Conditional Monitoring - Not Required This Period		7/31/2004		Conditional Monitoring - Not Required This Period
8/31/2004		Conditional Monitoring - Not Required This Period		8/31/2004		Conditional Monitoring - Not Required This Period		8/31/2004		Conditional Monitoring - Not Required This Period
9/30/2004		Operation Shutdown		9/30/2004		Operation Shutdown		9/30/2004		Operation Shutdown
10/31/2004		Conditional Monitoring - Not Required This Period		10/31/2004		Conditional Monitoring - Not Required This Period		10/31/2004		Conditional Monitoring - Not Required This Period
11/30/2004				11/30/2004				11/30/2004		
12/31/2004		Operation Shutdown		12/31/2004		Operation Shutdown		12/31/2004		Operation Shutdown
1/31/2005				1/31/2005				1/31/2005		
2/28/2005				2/28/2005				2/28/2005		
3/31/2005		Operation Shutdown		3/31/2005		Operation Shutdown		3/31/2005		Operation Shutdown
4/30/2005				4/30/2005				4/30/2005		
5/31/2005				5/31/2005				5/31/2005		
6/30/2005		Operation Shutdown		6/30/2005		Operation Shutdown		6/30/2005		Operation Shutdown
7/31/2005		No Discharge		7/31/2005		No Discharge		7/31/2005		No Discharge

Table GB-3. Contact Mining Company

Permit: MTX000002										
Outfall 002-A				Outfall 003-A				Outfall MW1-A		
Nitrite plus nitrate total 1 det. (as N) - mg/L										
Monitoring Period End Date	Maximum DMR Value	Description		Monitoring Period End Date	Maximum DMR Value	Description		Monitoring Period End Date	Maximum DMR Value	Description
8/31/2005		No Discharge		8/31/2005		No Discharge		8/31/2005		No Discharge
9/30/2005		No Discharge		9/30/2005		No Discharge		9/30/2005		No Discharge
10/31/2005		No Discharge		10/31/2005		No Discharge		10/31/2005		No Discharge
11/30/2005		Operation Shutdown		11/30/2005		Operation Shutdown		11/30/2005		Operation Shutdown
12/31/2005		Operation Shutdown		12/31/2005		Operation Shutdown		12/31/2005		Operation Shutdown
1/31/2006				1/31/2006				1/31/2006		
2/28/2006				2/28/2006				2/28/2006		
3/31/2006		Operation Shutdown		3/31/2006		Operation Shutdown		3/31/2006		Operation Shutdown
4/30/2006		No Discharge		4/30/2006		No Discharge		4/30/2006		No Discharge
5/31/2006		No Discharge		5/31/2006		No Discharge		5/31/2006		No Discharge
6/30/2006		No Discharge		6/30/2006		No Discharge		6/30/2006		No Discharge
7/31/2006		No Discharge		7/31/2006		No Discharge		7/31/2006		No Discharge
8/31/2006		No Discharge		8/31/2006		No Discharge		8/31/2006		No Discharge
9/30/2006		No Discharge		9/30/2006		No Discharge		9/30/2006		No Discharge
10/31/2006				10/31/2006				10/31/2006		
11/30/2006				11/30/2006				11/30/2006		
12/31/2006		No Discharge		12/31/2006		No Discharge		12/31/2006		No Discharge
1/31/2007				1/31/2007				1/31/2007		
2/28/2007				2/28/2007				2/28/2007		
3/31/2007		No Discharge		3/31/2007		No Discharge		3/31/2007		No Discharge
4/30/2007				4/30/2007				4/30/2007		
5/31/2007				5/31/2007				5/31/2007		
6/30/2007		No Discharge		6/30/2007		No Discharge		6/30/2007		No Discharge
7/31/2007		No Discharge		7/31/2007		No Discharge		7/31/2007		No Discharge
8/31/2007				8/31/2007				8/31/2007		
9/30/2007				9/30/2007				9/30/2007		
10/31/2007		No Discharge		10/31/2007		No Discharge		10/31/2007		No Discharge

Table GB-3. Contact Mining Company

Permit: MTX000002										
Outfall 002-A				Outfall 003-A				Outfall MW1-A		
Nitrite plus nitrate total 1 det. (as N) - mg/L										
Monitoring Period End Date	Maximum DMR Value	Description		Monitoring Period End Date	Maximum DMR Value	Description		Monitoring Period End Date	Maximum DMR Value	Description
11/30/2007		No Discharge		11/30/2007		No Discharge		11/30/2007		No Discharge
12/31/2007		No Discharge		12/31/2007		No Discharge		12/31/2007		No Discharge
1/31/2008				1/31/2008				1/31/2008		
2/29/2008				2/29/2008				2/29/2008		
3/31/2008		Operation Shutdown		3/31/2008		Operation Shutdown		3/31/2008		Operation Shutdown
4/30/2008		No Discharge		4/30/2008		No Discharge		4/30/2008		No Discharge
5/31/2008		No Discharge		5/31/2008		No Discharge		5/31/2008		No Discharge
6/30/2008		No Discharge		6/30/2008		No Discharge		6/30/2008		No Discharge
7/31/2008		Operation Shutdown		7/31/2008		Operation Shutdown		7/31/2008		Operation Shutdown
8/31/2008		Operation Shutdown		8/31/2008		Operation Shutdown		8/31/2008		Operation Shutdown
9/30/2008		No Discharge		9/30/2008		No Discharge		9/30/2008		No Discharge
10/31/2008		Operation Shutdown		10/31/2008		Operation Shutdown		10/31/2008		No Discharge
11/30/2008		Operation Shutdown		11/30/2008		Operation Shutdown		11/30/2008		Operation Shutdown
12/31/2008		Operation Shutdown		12/31/2008		Operation Shutdown		12/31/2008		Operation Shutdown
1/31/2009		Operation Shutdown		1/31/2009		Operation Shutdown		1/31/2009		Operation Shutdown
2/28/2009		Operation Shutdown		2/28/2009		Operation Shutdown		2/28/2009		Operation Shutdown
3/31/2009		Operation Shutdown		3/31/2009		Operation Shutdown		3/31/2009		Operation Shutdown
4/30/2009		Operation Shutdown		4/30/2009		Operation Shutdown		4/30/2009		Operation Shutdown
5/31/2009		Operation Shutdown		5/31/2009		Operation Shutdown		5/31/2009		Operation Shutdown
6/30/2009		Operation Shutdown		6/30/2009		Operation Shutdown		6/30/2009		Operation Shutdown
7/31/2009		Operation Shutdown		7/31/2009		Operation Shutdown		7/31/2009		Operation Shutdown
8/31/2009		Operation Shutdown		8/31/2009		Operation Shutdown		8/31/2009		Operation Shutdown
9/30/2009		Operation Shutdown		9/30/2009		Operation Shutdown		9/30/2009		Operation Shutdown

Table GB-3. Contact Mining Company

Permit: MTX000002										
Outfall 002-A				Outfall 003-A				Outfall MW1-A		
Nitrite plus nitrate total 1 det. (as N) - mg/L										
Monitoring Period End Date	Maximum DMR Value	Description		Monitoring Period End Date	Maximum DMR Value	Description		Monitoring Period End Date	Maximum DMR Value	Description
10/31/2009				10/31/2009				10/31/2009		
11/30/2009				11/30/2009				11/30/2009		
12/31/2009				12/31/2009				12/31/2009		
1/31/2010				1/31/2010				1/31/2010		
2/28/2010				2/28/2010				2/28/2010		
3/31/2010				3/31/2010				3/31/2010		
4/30/2010				4/30/2010				4/30/2010		
5/31/2010				5/31/2010				5/31/2010		
6/30/2010				6/30/2010				6/30/2010		
7/31/2010				7/31/2010				7/31/2010		
8/31/2010				8/31/2010				8/31/2010		
9/30/2010				9/30/2010				9/30/2010		
10/31/2010				10/31/2010				10/31/2010		
11/30/2010				11/30/2010				11/30/2010		

Table GB-4. Sugar Loaf Wool Carding Mill

Permit: MTX000134					
	Discharge	Nitrate + nitrite	Total Kjeldahl Nitrogen	Total Nitrogen	Total Phosphorus
	mgd	mg/L	mg/L	mg/L	mg/L
5/22/2008		0.49	11.1	11.59	
8/2/2008		0.49	11.1	11.59	
11/2/2008					
3/9/2009		0.07	49	49.07	
3/2/2010		<0.05	54.4		2.5