LOWER BEAR RIVER WATERSHED PLAN

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1.0 EXECUTIVE SUMMARY

The lower Bear River watershed contains the terminal end of the Bear River and the Bear River watershed outlet to the Great Salt Lake. The Bear River travels over 550 miles from headwater to outlet and drains a watershed more than 7,500 square miles, including portions of Wyoming, Idaho, and Utah. The lower Bear River watershed (HUC 16010204) includes the Bear River below Cutler Reservoir as well as the lower Malad River downstream from the Idaho border to Bear River confluence near Bear River City, Utah.

This plan accompanies the Lower Bear River TMDL (Utah DEQ 2018) that addresses impaired segments of the Bear River and Malad River that are currently impaired for aquatic life use. The TMDL updates a total phosphorus TMDL completed by Utah Division of Water Quality (Utah DEQ) in 2002 (Utah DEQ 2002). Results from the updated TMDL are included in this document as needed to support the minimum planning elements required by EPA (2008). Each of these planning elements is included in this watershed plan (Table 1.1).

Table 1.1. Minimum planning elements required by the U.S. EPA for watershed planning (EPA 2008).

EPA Element	Description	Location in plan
a	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.	Chapter 5 (pollutant sources) Chapter 7 (watershed goals)
b	An estimate of the load reductions expected from management measures.	Chapter 6 (pollutant loads)
c	A description of the nonpoint source management measures that will need to be implemented to achieve load reductions in element b, and a description of the critical areas in which those measures will be needed.	Chapter 8 (management strategies)
d	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.	Chapter 9 (implementation)
e	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.	Chapter 9 (implementation)
f	Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.	Chapter 9 (implementation)
g	A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.	Chapter 9 (implementation)
h	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.	Chapter 9 (implementation)
i	A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item h immediately above.	Chapter 9 (implementation)

The purpose of this watershed plan is to provide necessary information for successfully implementing the pollutant load reductions required by the TMDL. Waste load allocations for point sources will be achieved as part of UPDES permitting. Load allocations for nonpoint sources rely on a voluntary, incentive based approach rather than regulatory requirements. This voluntary plan must recognize both the constraints and opportunities inherent in this approach. Some of the incentives are public-sector cost-share grants and subsidized financing options. This plan recognizes these opportunities and is organized to meet the requirements of these types of programs, especially those offered by the EPA and the State of Utah.

This watershed plan is organized as follows:

Chapter 2 includes an introduction to the watershed plan along with an explanation of the purpose and need for the plan, a description of the watershed team, and public participation activities that have taken place during the process to complete the updated TMDL and this watershed plan.

Chapter 3 provides a description of the watershed and its stakeholders, including physical and natural features and demographic aspects.

Chapter 4 describes the watershed conditions including water quality standards, assessment methods, and available monitoring data.

Chapter 5 describes the point and nonpoint pollutant sources addressed in the TMDL.

Chapter 6 quantifies the pollutant loads and the load reductions necessary to meet the TMDL and resolve the water quality impairments.

Chapter 7 identifies the watershed goals, objectives, and indicators that will be used in implementing this watershed plan. It also includes a discussion of the load reduction target based on the load allocation in the TMDL.

Chapter 8 identifies the management strategies relevant for the lower Bear River watershed and the relevant partners that can improve water quality. These strategies will ultimately attain the goals defined in Chapter 7.

Chapter 9 describes a program for implementing various management strategies. This program addresses the uncertainties of managing nonpoint pollutant sources including a tentative schedule for achieving milestones and estimates of the cost of implementing various practices. A key element to implementation is convincing local land managers to participate in various programs through an information and education program. This chapter concludes with a suggested monitoring program to assess water quality and help determine if and when beneficial uses are fully supported.

2.0 INTRODUCTION

A watershed management plan is "a strategy that provides assessment and management information for a geographically defined watershed, including the analysis, actions, participants, and resources related to developing and implementing the plan." (EPA 2008, Section 2.1) A successful watershed plan is supported by all stakeholders including landowners, private organizations, municipalities, and government agencies. The plan clearly defines a shared vision of what the watershed should be (goals), areas that need improvement (resource concerns), and how to turn the vision into reality (implementation).

Watershed planning incorporates many different interests and may have to rely on limited knowledge, but because planning is designed to be iterative, it can adjust over time as the environment changes or is better understood. Due to the complexity of the environments in which watershed planning occurs it usually takes several planning cycles to fully understand how to implement the plan.

2.1 WATER QUALITY IMPAIRMENTS

The lower Bear River was included on the Utah 303(d) list of impaired waters in 2000 (Utah DEQ 2000a) and also on the 2002 list. The current and historic water quality impairments in the lower Bear River watershed are summarized in Table 2.1. Figure 2.1 shows the two segments of the lower Bear River that are on these lists including Bear River-1 (UT16010204-003) and Bear River-2 (UT16010204-008). Mantua Reservoir (UT-L-16010204-033) was also included on Utah's 2000 section 303(d) list as needing TMDLs for total phosphorus, temperature, pH, and dissolved oxygen. An assessment was completed for the reservoir in 2000 and approved for total phosphorus, pH, and dissolved oxygen (Utah DEQ 2000b).

The most recent approved list of impaired waters for Utah is part of the 2016 DEQ Integrated Report (Utah DEQ 2016). In addition to Bear River-1 and Bear River-2, east side tributaries to the Bear River (Bear River Lower East – UT16010204-002_00) have been added for dissolved oxygen and total dissolved solids. Bear River-1 is now listed as impaired due to benthic macroinvertebrate bioassessments and dissolved oxygen. Bear River-2 (upstream of Bear River-1) is listed as impaired due to benthic macroinvertebrate bioassessments and temperature.

The updated TMDL for the lower Bear River addresses the total phosphorus impairment. This watershed plan includes the measures needed to successfully implement the total phosphorus load reductions in that TMDL. These measures will also have a positive influence on water quality by reducing pollutant loads that lead to other impairments in the lower Bear River watershed.

2.2 LOWER BEAR RIVER TMDL ADVISORY COMMITTEE

The Advisory Committee for the Lower Bear River TMDL was organized in 2012. The purpose of this committee is to guide development of the TMDL and provide input on selecting water quality improvement projects that restore beneficial use. The committee is comprised of local landowners, municipal leaders, and state and federal agencies. Table 2.2 lists all participating members of the Committee and the resource or area of expertise that each member represents.

As part of developing the TMDL, the Committee has met several times during the past 6 years (see list below). During these meetings, members of the Advisory Committee discussed and reviewed results of field surveys and information on water quality monitoring, pollutant sources, load calculations, and potential water quality improvement projects.

- November 27, 2012, Brigham City, Utah
- August 22, 2016, Tremonton, Utah
- October 11, 2016, Logan, Utah

Table 2.1. Section 303(d) listing history of the lower Bear River watershed.

Waterbody Name	Waterbody ID	303(d) Listed Impairments							
		2000[1]	2002[2]	2004[3]	2006[4]	2008[5]	2010[6]	2012 / 2014[7]	2016[8]
Bear River Bay – Great Salt Lake	Unknown		Amm. TRC						
Bear River Lower East - east side tributaries from Malad confluence south	UT16010204-002_00							DO TDS	DO TDS
Bear River-1 – the Bear River from the confluence w/Great Salt Lake to Malad River Confluence	UT16010204-003	TP	TP			TDS	Macro. TDS	Macro. DO	Macro. DO TDS
Bear River-2 – the Bear River from the Malad River Confluence to Cutler Reservoir	UT16010204-008	TP	TP			Macro.	Macro.	Macro. Temp	Macro. Temp
Malad River-1 – the Malad River from confluence with Bear River to Utah-Idaho state line	UT16010204-006		DO TRC			Macro.	Macro.		
Mantua Reservoir	UT-L-16010204-033_00	TP Temp. pH DO				Temp.	Temp.		

Notes

Amm. = ammonia; DO = dissolved oxygen, Macro = benthic macroinvertebrate bioassessments, TDS = total dissolved solids, Temp. = water temperature, TP = total phosphorus, TRC = total residual chlorine.

[1] Obtained online on January 12, 2016 from: http://bearriverinfo.org/files/publications/publication/pub__6580277.pdf.

[2] Obtained online on January 4, 2016 from: http://iaspub.epa.gov/waters10/attains_impaired_waters.impaired_waters_list?p_state=UT&p_cycle=2002.

[3] Obtained online on January 13, 2016 from: http://www.deq.utah.gov/ProgramsServices/programs/water/wqmanagement/assessment/docs/2006/08Aug/2004303dlistFINALall-11-04-04.pdf.

[4] Obtained online on January 13, 2016 from: http://www.deq.utah.gov/ProgramsServices/programs/water/wqmanagement/assessment/docs/2006/08Aug/2006_303d_submittal_3-31-06.pdf.

[5] Obtained online on January 13, 2016 from: http://www.deq.utah.gov/ProgramsServices/programs/water/wqmanagement/assessment/docs/2011/04Apr/IR2008/Part3/Final_Utah_2008_IR_303d_list.2.10.2012.pdf.

[6] Microsoft Excel file ("UT 303(d) List from final 2010 ADB.xlsx") obtained via email from Karl Herman, USEPA Region 8, January 6, 2016.

[7] Microsoft Excel file ("UT 2014 IR 303d 010516.xlsx") obtained via email from Karl Herman, USEPA Region 8, January 6, 2016.

[9]Microsoft Excel file ("chapter_3_all_river_and_stream_assessments_final2016ir_v2-1_ef.slxs") downloaded from DEQ website August 13, 2018.

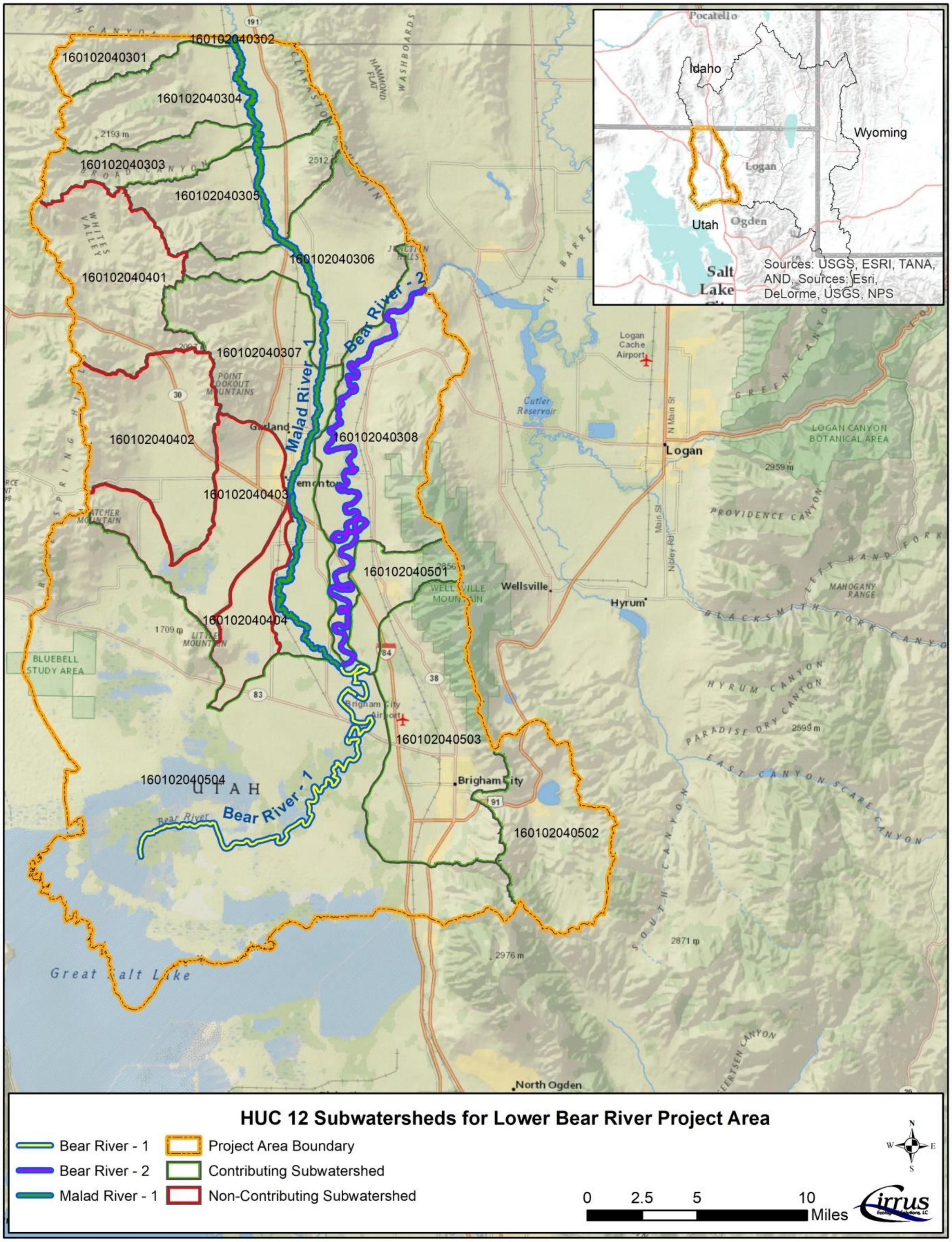


Figure 2.1. Lower Bear River watershed and subwatershed boundaries

Table 2.2. Membership of the lower Bear River TMDL advisory committee.	
Agriculture	
Farm Bureau	Northern Utah Conservation District
Farm Service Agency	Utah Department of Agriculture and Food (UDAF)
Agriculture, Business	
Dairy Producer	Tuleview Dairy
Noo Sun Dairy	
Education and Information	
Utah State University Extension	
Habitat	
Bridgerland Audubon Society	US Fish and Wildlife Service
The Nature Conservancy	Utah Division of Wildlife Resources
Trout Unlimited	Wasatch Audubon Society
Hydrology and Water Rights	
Bear River Water Conservation District	Utah Division of Water Rights
Cache County	Weber County Engineer
PacifiCorp	
Industry	
Procter and Gamble	
Irrigation, Water Rights	
Bear River Canal Company	
Municipalities	
Corrine City – represented by JUB Engineering	Garland City – represented by Cascade Earth Science
Deweyville	Tremonton City
Range, Agriculture, and Soil	
Natural Resources Conservation Service	Utah Cattlemen's Association
UDAF Grazing Improvement Program	
Urban and Rural	
Box Elder County	Weber County
Wastewater	
Public Works and Waste Water, Brigham City	
Water Quality	
Cirrus Ecological Solutions	Utah Farm Bureau-Water Quality Programs
Department of Environmental Quality	

Additional one-on-one meetings have taken place during the past 6 years with individual committee members to discuss information related to the TMDL. Progress updates on the TMDL were also provided during this same time period as part of regularly scheduled meetings of the Bear River Water Quality Task Force.

2.3 LAND OWNERSHIP AND PROJECT IMPLEMENTATION

Most pollutant sources in the lower Bear River watershed are located on private land including nearly all of the land adjacent to the lower Bear River and Malad River. As a result, projects with the greatest opportunity to immediately affect the river's water quality will be implemented and maintained by private landowners. While private landowners typically express an interest in improving water quality, they are often unable or unwilling to invest in projects that do not result in immediate and tangible benefits to their own operations. Therefore, implementation of successful projects requires additional benefits, perhaps unrelated to water quality.

Project implementation will most likely occur when it includes practices that stakeholders have confidence in, either from direct past experience or observations of successful implementation by neighbors or others in the watershed. An opinion survey was administered during the October 11, 2016 stakeholder meeting to determine which practices private landowners considered to be worthwhile and capable of improving water quality. The results of this survey are found in Table A1 (Appendix A). The survey included the five pollutant source categories identified in the updated TMDL. Each category had a short list of NRCS-approved Best Management Practices (BMPs) that could be applied to reduce total phosphorus loading. Stakeholders were asked to score each BMP ranging from 5 (highly effective) to 0 (waste of money). In general, BMPs with higher scores matched well with practices that have been previously implemented in the watershed. A few of the BMPs with high average scores included nutrient management, composting facility, fencing, off-site watering, and irrigation water management. Some of the BMPs with lower scores included filter strips and conservation cover (i.e. cover crops). These BMPs have potential to reducing pollutant loading from nonpoint sources in the watershed. Additional training and incentives may be needed before these BMPs can be implemented.

2.4 FUNDING FOR NONPOINT SOURCE PROJECTS

Federal and state agencies provide subsidies for private investment in water quality projects. Each of these programs has requirements for project selection and funding participation. As an example, Figure 2.2 shows the maximum funding provided through two programs, the EQIP program administered through the USDA's Farm Bill program and Section 319 funds provided by EPA and administered through the Utah DEQ. Even with substantial subsidies, the private land owner must still provide at least 20 percent of a project's cost, although the private component can come from in-kind labor and equipment. Regardless of the contribution from EQIP funds, EPA 319 and private funds must cover 60 percent and 40 percent (respectively) of the remaining cost, no matter the contribution from EQIP funding.

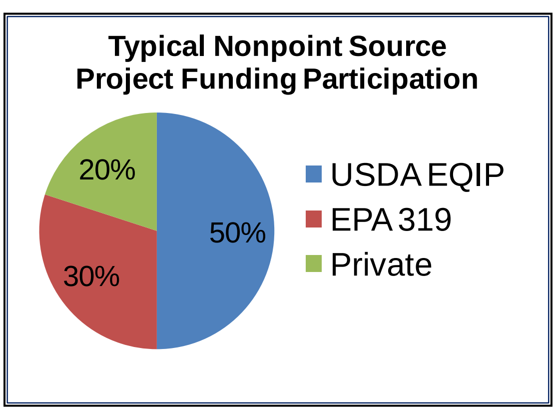


Figure 2.2. Typical structure of nonpoint source project funding.

3.0 WATERSHED DESCRIPTION

The project area for this watershed plan will generally be defined by the watershed boundary of land areas that contribute stream flow and surface runoff to the Utah portion of the Malad River and the Bear River below Cutler Reservoir (Figure 2.1). Due to the physical, political, and social aspects that are sometimes associated with management of water resources, the watershed plan will also examine certain processes that occur upstream of the project area (e.g., Cutler Reservoir management) that influence water quality and flow conditions.

3.1 WATERSHED BOUNDARIES

The Bear River Basin covers more than 7,500 square miles including portions of Utah, Idaho, and Wyoming. The Bear River channel travels more than 550 miles in this watershed and is known as the largest stream in the western Hemisphere that does not reach an ocean. The Lower Bear–Malad Subbasin is the most downstream of six watersheds that comprise the Bear River Basin. It has a drainage area of approximately 747 square miles in Utah alone, and includes areas that drain to the Bear River below Cutler Reservoir and the Malad River. The drainage area contributing to the Malad River comprises roughly 90 percent of the Lower Bear–Malad Subbasin. Approximately 52 percent of the Lower Bear–Malad Subbasin (nearly 478,000 acres) is located in Utah. The portion of the subbasin in Utah is the project area for this watershed plan and is referred to as the lower Bear River watershed.

There are 16 primary subwatersheds in the lower Bear River watershed including four that drain to wetland areas bordering the Great Salt Lake and not directly to the Bear River or the Malad River (Figure 2.1). Mountain ranges that form subwatershed boundaries include the Clarkston and Wellsville Mountains to the east and the Samaria mountains on the west. Approximately 55 percent of subwatershed areas in the lower Bear River watershed drain to the Bear River, 27 percent to the Malad River and 18 percent to the Great Salt Lake. The lowest subwatershed for the Bear River borders the Great Salt Lake and surface runoff can enter either waterbody, depending on the location.

This watershed plan will focus on areas and subwatersheds that drain to the impaired water bodies listed in Table 2.1. Recommendations for water quality improvements will likewise focus on pollutant sources in these areas but will also address sources outside these areas that are still in the lower Bear River watershed.

3.2 HYDROLOGY

The outlet of Cutler Reservoir is located at the east boundary of the project area. Discharge from the reservoir is the primary influence on hydrology in the watershed. Water in Cutler reservoir and the entire length of the Bear River is managed for hydroelectric power by PacifiCorp. As a result, flows in the lower Bear River are heavily regulated during the spring and summer seasons. Hydrology is further impacted by irrigation withdrawals, distribution through canals and ditches, tile drains that collect and divert groundwater, and return flows to natural surface waterbodies. Each process occurs multiple times along the 65 miles of the lower Bear River between the outlet of Cutler Reservoir and the mouth of the river at the Great Salt Lake.

The Malad River is the primary tributary to the Bear River in the watershed and originates in Idaho on the Caribou National Forest. The Malad River crosses the Idaho-Utah border then travels about 61 miles in the watershed before it flows into the west side of the Bear River three miles downstream of Bear River City. Small tributaries to the Bear River are found on the east side of the watershed including Willow Creek, Cottonwood Creek, and Salt Creek.

Water is diverted at multiple points along the lower Bear River for irrigation and also to sustain wildlife populations. The two largest irrigation diversions occur just below Cutler Reservoir and feed the West Side and East Side canals that divert about 191,000 and 39,000 acre-feet of water per year, respectively (UDWRe

2004). Diversions to the Bear River Migratory Bird refuge occur near the end of the lower Bear River, totaling about 84,000 acre-feet of water per year to support avian wildlife habitat along the shores of the Great Salt Lake.

Hydrology is characterized by two continuous flow gages on the Bear River including sites near Collinston (station 10118000) at the watershed inlet, and near Corinne (station 10126000) approximately 40 miles downstream of the outlet from Cutler Reservoir. Flow gages have been managed by the USGS at 15 other locations in the watershed but none of these are currently active. Flow records at the Collinston and Corinne gages extend well beyond 50 years at each location and are currently managed by Pacificorp and the USGS, respectively. Figure 3.1 displays mean annual flow at these two gages. Note that flows at each gage are very similar in spite of the additional watershed area contributing to the downstream gage near Corinne. Much of the additional area is contained in the Malad River watershed which extends into Idaho. The similar hydrographs in Figure 3.1 illustrate the limited influence of flow from the Malad River and other areas between the two gages, and the significance of Cutler Reservoir discharge on lower Bear River hydrology.

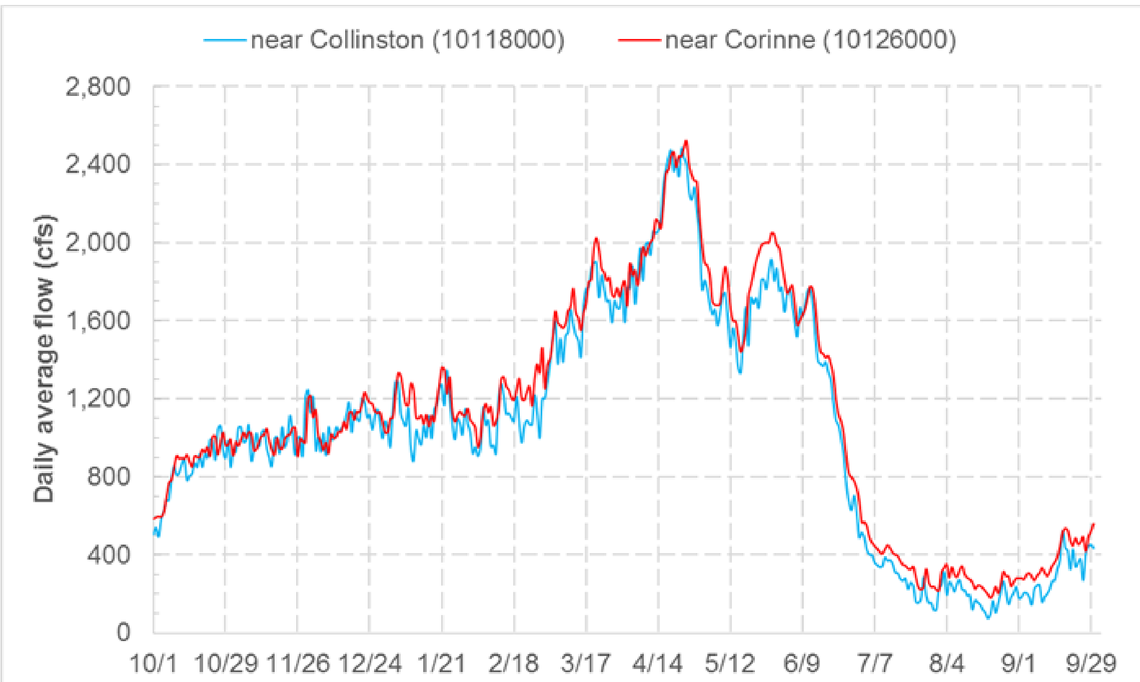


Figure 3.1. Mean annual hydrographs for the two continuous flow sites on the Bear River based on water years 2006-2015.

Water demand for municipal use is steadily increasing in Utah in response to population growth. The increased demand has potential to influence future hydrology in the lower Bear River. Options are being considered for development of 220,000 acre-feet of water right applications held by the Board of Water Resources (UDWRe 2014). One development option includes a 70,000 acre-feet storage reservoir located on the Bear River immediately downstream of Cutler Reservoir. The proposed reservoir would store peak flows in the Bear River that occur during snowmelt runoff. Water stored in this reservoir would be transferred to a treatment facility for culinary use outside the watershed.

3.3 LAND OWNERSHIP/LAND USE

Land ownership in the lower Bear River watershed is predominantly private (72 percent), with 19 percent federal and 9 percent state ownership. Figure A1 (Appendix A) shows land ownership for the watershed. The entire lower Bear River corridor is in private ownership which presents some challenges to implementing water quality improvement projects. National Forest land is located near the east boundary of the watershed on the Clarkston and Wellsville mountain ranges. Public land is found in the south and west areas of the watershed in wildlife refuges and rangelands. The most well-known public land in the watershed is the Bear River Migratory Bird Refuge managed by the U.S. Fish and Wildlife Service and located near the Great Salt Lake.

Land in the Malad River and Bear River valleys is predominantly used for agricultural including vegetables, grain, hay, and livestock pasture, with concentrated urban land uses near Tremonton and Brigham City. Fairly extensive wetland areas occur in the valley, primarily in the southern reaches of the watershed, closer to the Great Salt Lake. The foothills and mountains that flank the valleys are shrub/scrub with pockets of forest. Figure A2 (Appendix A) shows land cover for the watershed.

3.4 DEMOGRAPHICS

Over 55,000 people live in the lower Bear River watershed. The two largest urban areas in the watershed include Brigham City and Tremonton with populations of 17,899 and 7,647, respectively (US Census Bureau 2018). Smaller towns in the watershed are located primarily along the foothills of the Clarkston and Wellsville mountains. Some of these include Fielding, Deweyville, Honeyville, Bear River City, and Corinne. Population projections for Box Elder County estimate about 64,000 residents by the year 2030, a 22 percent increase in the county population from the 2010 census (University of Utah 2017).

The lower Bear River watershed supports a strong agricultural economy. As a whole, Box Elder County is located in one of the primary production regions for agriculture products in Utah. In 2012, the county ranked second in the state for total value of crops, including nursery and greenhouse crops and fourth for total value of agricultural products sold (USDA 2012). Approximately 46 percent of income from farms and ranches comes from livestock production while 34 percent comes from crop production. The remaining income for farms and ranches comes from off-farm income and other sources. The average per farm income in Box Elder County in 2012 was $39,894 (USDA 2012).

4.0 WATERSHED CONDITIONS

This chapter describes the watershed condition and health of the lower Bear River watershed based on results of monitoring data used to complete the updated TMDL (Utah DEQ 2018). Section 4.1 describes how Utah DEQ currently evaluates total phosphorus in order to determine impairment. Section 4.2 presents monitoring data (including flow and water quality) from phosphorus impaired segments of the lower Bear River. Section 4.3 includes the results of data analysis.

By way of reference, Table 2.1 includes a listing history of all impaired water bodies in the lower Bear River, including results from the 2016 Integrated Report. Figure 2.1 shows the location of impaired segments of the lower Bear River that are addressed in this watershed plan.

4.1 WATER QUALITY STANDARDS

Water quality standards are established to maintain or improve existing water quality and protect the beneficial use of each water body. The designated use of a body of water is based on goals adopted by the state to protect public health or welfare, enhance water quality, and protect its assigned beneficial uses. Numeric standards and criteria are science-based and incorporate the most recent understanding of human health, healthy ecosystem behavior, and response to pollutants. Narrative standards protect water quality from pollutants that are not suited for numeric criteria or haven't developed criteria so far. Pollution indicators are used in combination with standards to evaluate parameters that are not directly harmful (e.g. phosphorus) but contribute to a response and condition that can degrade water quality (e.g. algal blooms).

Defining a water quality standard for nutrients can be complex due to interactions that produce varying responses to nutrient inputs. In most situations, degradation occurs through a cascading effect that begins with high nutrient concentrations followed by impacts on algae, dissolved oxygen, and ultimately aquatic communities (i.e. animals and plants). Nutrient concentrations can be a particular concern where a transition occurs from moving water (e.g. rivers) to an impounded water body (e.g. lakes) due to a change in reaeration and mixing. Aesthetic values should also be considered for waters that have a designated recreational use, such as the lower Bear River.

Utah does not yet have numeric nutrient criteria, but the state is in the process of developing them. Screening criteria for total phosphorus are currently used until water quality standards (i.e. numeric criteria) are in place. The screening criteria (not to be considered binding water quality criteria) were developed during the 2008 303(d) listing cycle to determine if an assessment unit needed further study to determine impairment. Any water body with a mean total phosphorus concentration greater than 0.06 milligrams per liter (mg/L), and more than 10 percent of samples, exceed the 0.05 mg/L pollution indicator level is designated as one that needs further study (Toole 2010).

A total phosphorus concentration target not to exceed 0.075 mg/L was established in the 2002 Lower Bear River and Tributaries TMDL (Utah DEQ 2002) and will remain as the target for this watershed plan. The updated TMDL includes a detailed description of how the target value of 0.075 mg/L was selected (see Appendix A, Utah DEQ 2018). In summary, it is consistent with targets that have been previously established in approved TMDLs immediately upstream in the Bear River in both Utah and Idaho. Additionally, this value is consistent with total phosphorus targets established in approved TMDLs in rivers located in similar arid, agricultural settings in nearby Idaho and within the range of values identified in the literature.

4.2 MONITORING DATA

All available flow and water quality data were reviewed in the updated TMDL to characterize impairment from high concentrations of total phosphorus. The location of each station that was considered in the TMDL is shown in Figure 4.1.

Data used in the previous TMDL was current through 2000. Data analysis in the updated TMDL focused on monitoring data from 2006-2015 where it was available. Water quality data was evaluated using temporal, spatial, and hydrological analysis to identify trends that could help identify pollutant sources.

Load duration curves were developed from available data (2006–2015) from continuous flow gages and Utah DEQ monitoring sites below Cutler Reservoir and near Corrinne, UT. These results were used in the updated TMDL to identify pollutant sources and support load allocations.

4.2.1 FLOW DATA

Continuous flow records are available at 17 continuous flow gages in the Lower Bear- Malad subbasin. Only two of these gages are currently functioning. The USGS gage near Corinne, UT (10126000) is approximately 26 miles upstream of the mouth of the lower Bear River. The other functioning gage is located upstream near Collinston, UT (10126000) immediately below the outlet from Cutler Reservoir. This gage was managed by USGS until 2006 when it was turned over to PacifiCorp. Note the two periods of record shown for this gage in Table 4.1 indicate when the management change occurred.

Table 4.1 shows the period of record for each of the two active USGS gages in the watershed. Mean annual hydrographs for these two gages are presented in Figure 3.1. The contributing watershed area between the two gages is approximately 750 square miles. The similarity between the two hydrographs shows the limited influence of flow from this area and the significance of Cutler Reservoir discharge on hydrology in the watershed.

Table 4.1. Active streamflow gages currently operating in the lower Bear River watershed.

ID	Name	Drainage area (sq. mi.)	Period of record
10118000	Bear River near Collinston, UT	6,271	1902–2006 2007–2016
10126000	Bear River near Corinne, UT	7,029	1949–1957 1963–2016

Instantaneous flow measurements are collected by Utah DEQ from wadeable streams as part of their routine water quality monitoring operations. Locations of monitoring sites are show in Figure 4.1. Sites located on non-wadeable streams typically rely on recorded flows from the nearest continuous flow gage. Instantaneous flow records were identified from 10 sites on the lower Bear River and from 16 sites on the Malad River. Intensive monitoring was conducted by Utah DEQ during 2014–15 in the watershed and most instantaneous flow measurements were paired with water quality sampling. Instantaneous flow measurements were also collected by Utah DEQ in a cooperative effort with local conservation districts from field drains during 2009-2011 at 26 different locations (Roper and Hill 2010, Elsner 2012). A review of these records identified seven primary locations where field drain discharge occurred and these sites were used in the updated TMDL (Utah DEQ 2018).

4908731
4902940
4908720
4908745
4908713
Malad River
4902900
4901980
10118000
10092700
4901975
4901965
4901790
4908732
4902840
4902780
4902720
4908736
4902700
4901700
4902050
4901600
4902040
4902000
4908749
4901450
4901460
10126000
4901430
4901420
4901100
4901170
4901050
4901210
4901410
4901190
4901225
Bear River
4901395
4901180
UTAH
Great Salt Lake
Lewiston
Smithfield
Logan
Wellsville
Hyrum
Brigham City
Flow and water quality monitoring
Monitor Site
Flow
Water Quality
Impaired River
Project Area Boundary
Contributing Subwatershed
Non-Contributing Subwatershed
0 2.5 5 10 Miles

Figure 4.1. Flow and water quality monitoring sites in the lower Bear River watershed. Flow sites are managed by USGS or PacifiCorp. Water quality monitor sites are visited by Utah Division of Water Quality.

4.2.2 WATER QUALITY DATA

Total phosphorus measurements in the lower Bear River watershed are examined in detail in the updated TMDL (Utah DEQ 2018). They include measurements collected during 1996–2015 by Utah DEQ and Idaho DEQ at 36 different locations from eight different waterbodies. Records were also available from seven stormwater monitoring sites. The location of each water quality monitoring site is shown in Figure 4.1. A detailed review of water quality monitoring data is available in the updated TMDL.

Water quality can be characterized using total phosphorus data from two sites on the lower Bear River and two sites on the Malad River that have substantial monitoring records (Table 4.2). Monitoring on the two Bear River sites was completed as part of a cooperative effort between Idaho DEQ and Utah DEQ. All total phosphorus measurements from the Malad River were collected by Utah DEQ.

Monitoring results show that total phosphorus concentrations increase slightly on the lower Bear River between Cutler reservoir and Corinne. In contrast, measurements from the Malad River show a much larger increase in total phosphorus between the towns of Portage and Bear River City. The Malad River receives discharge from the Tremonton wastewater treatment plant and some of the increase is due to this source.

Table 4.2. Data summary of current (2006-2015) total phosphorus records collected from four water quality monitoring sites.

ID	Name	Count	Max (mg/L)	Min (mg/L)	Mean (mg/L)	% samples > 0.75 mg/L		
						All samples	Growing season	Non-growing season
4901980	Bear River below Cutler Reservoir at Up L bridge	65	0.30	0.03	0.13	86 %	84 %	88 %
4901100	Bear River near Corinne at U83 crossing	77	0.42	0.04	0.15	83 %	89 %	79 %
4902940	Malad River East of Portage	22	0.12	0.01	0.05	14 %	11 %	15 %
4902000	Malad River south of Bear River City	23	0.92	0.10	0.40	100 %	100 %	100 %

4.3 DATA ANALYSIS

This section includes a summary of data analysis results. Additional detail is included in Chapter 5 and in Appendix C of the updated TMDL (Utah DEQ 2018). Total phosphorus data were evaluated in the TMDL to identify spatial, temporal, or hydrological trends. The results of data analysis did identify limited evidence but in most cases, no trends were apparent through statistical and visual analyses.

Long term trends were examined from the four sites in Table 4.2 for the full period of record. No significant trends were identified for Bear River sites but the Malad River did indicate a recent increase in median concentrations at site 4902000 (Malad R. below Bear River City, Figure 4.2). No trends were identified from seasonal analysis of monthly concentrations and a comparison of growing season (May–September) to non-growing season (October–April) measurements. Spatial trends were evaluated using data from intensive monitoring completed in 2014–2015. Total phosphorus loads were calculated for all monitoring sites using data from each of the 12 intensive monitoring sample dates. No consistent spatial trends were observed in loads at lower Bear River sites. In regard to the Malad River, total phosphorus loads increased with distance downstream.

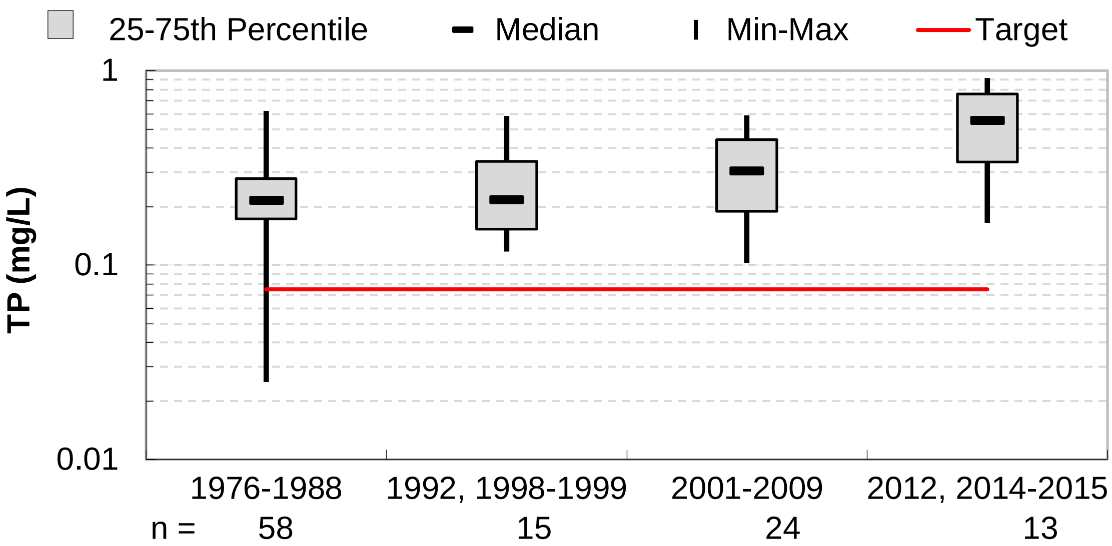


Figure 4.2. Temporal analysis of all total phosphorus concentrations collected from site 4902000 Malad River south of Bear River City.

The lack of trends identified by analysis could indicate that multiple sources of total phosphorus contribute to impairment. As discussed in Chapter 3, hydrology in the watershed is also influenced by multiple pathways (e.g., diversions, field drains, return flows, etc.) that effect how pollutant loads are transported to the lower Bear River. These conditions could also mask the appearance of trends in monitoring data.

Monitoring data (2006–2015) was compared to the 0.75 mg/L water quality target to determine the magnitude and extent of violations. This exceedance analysis was made for all sites using the entire data set as well as for the samples collected only in the growing or non-growing seasons. Results from four sites are shown in Table 4.2. Detailed results of the exceedance analysis are contained in Appendix C of the updated TMDL (Utah DEQ 2018). Samples across all waterbodies often exceeded the target of 0.075 mg/L phosphorus. Across all lower Bear River sites, 82 percent of samples exceeded the target including 77 percent during the growing season and 85 percent in the non-growing season. Far fewer samples were collected from the Malad River. At several sites however, every sample yielded TP concentrations greater than 0.075 mg/L and a total of 64 percent of all the samples exceeded the target. Almost all samples collected from storm drains exceeded the target in both the growing season and non-growing season.

5.0 POLLUTANT SOURCE ASSESSMENT (EPA ELEMENT A)

Pollutant sources are defined as point sources or nonpoint sources. This section includes a description of both types of pollutant sources in the lower Bear River watershed that contribute to the total phosphorus impairment. These are the sources that need to be managed in order to achieve the required load reduction defined in the TMDL.

Information in this chapter meets EPA watershed planning element a. Although both point source and nonpoint sources are discussed here, recommendations for reducing pollutant loads will be made later in the plan for nonpoint sources only. Recommendations for meeting reductions in point source loading are included in the UPDES permit for point source and outside the scope of this watershed plan.

5.1 POINT SOURCES

There are 29 facilities with authorizations, under seven permit types, with potential to discharge into waters that ultimately reach the lower Bear River including:

- Municipal
- Industrial
- Biosolids
- Construction Dewatering
- General Permit Pesticides
- Industrial Stormwater
- Construction Stormwater

The updated TMDL considered municipal facilities (treated wastewater) and stormwater from industrial facilities and construction sites a significant source of nutrients. The other permit types either did not discharge directly to a receiving water body or were not a source of nutrients. As such, they were not considered further in the TMDL.

The Corinne Wastewater Lagoons are the only municipal permittee that discharges to the lower Bear River, about 9 miles downstream of the Malad River. The Bear River City Lagoons and Tremonton Wastewater Treatment Plant (WWTP) discharge to the Malad River about 2 miles and 16 miles upstream, respectively, of the confluence with the Bear River. The Tremonton WWTP is the largest of the three permittees with a design flow of 2 million gallons per day (mgd). The Bear River City and Corinne facilities have design flows of approximately 0.4 mgd and 0.1 mgd, respectively.

Industrial stormwater includes 17 facilities covered by the *General Multi-Sector Industrial Storm Water Permit*. Dischargers covered under this permit shall not cause or have the reasonable potential to cause or contribute to a violation of a water quality standard. The general permit does not include specific discharge limits for total phosphorus and it is not expected that any facility is a significant source. Collectively, they may comprise a small, controllable load of total phosphorus.

Construction stormwater could come from any site located in the watershed. Utah Administrative Code R317-8-3.9 requires UPDES construction storm water permits for soil disturbances of an acre or more, including less than an acre if it is part of a common plan of development or sale greater than one acre. Soil disturbance is described as clearing, grading, or excavating. Stormwater discharges covered by this permit have potential for erosion from disturbed land, which could potentially include nutrients bound to soil particles. Loads from these sources are addressed in individual Stormwater Pollution Prevention Plans (SWPPP).

5.2 NONPOINT SOURCES

Nonpoint sources of pollution were identified based on a review of the previous TMDL, discussions with agencies, previous reports, and seasonal field surveys. All nonpoint sources of pollution were documented in a separate report (Cirrus 2016) and in the updated TMDL (Utah DEQ 2018). Based on that information, the following nonpoint pollutant source categories contribute to water quality impairment in the lower Bear River watershed:

1. Animal feeding operations including permitted CAFOS and Medium and Small AFOs.
2. Livestock Grazing.
3. Field Drains.
4. Diffuse Loads in surface runoff from rural and urban land use.

A description of each nonpoint source of total phosphorus is provided below. These sources were identified wherever they occur in the lower Bear River watershed, including areas that do not drain to impaired water bodies.

5.2.1 ANIMAL FEEDING OPERATIONS – LAND APPLIED MANURE

Livestock are found throughout the lower Bear River watershed. They are present in corrals and as well as on private and public grazing allotments. Field surveys identified the location of animal feeding operations and the seasonal patterns in grazing that occur in response to herds moving between public and private allotments (Cirrus 2016). The Utah DEQ provided information on the number of animals for each permitted CAFO in the project area. Each field survey included both ground-based and air-based observations. The number of animals at each location was estimated during the survey based on a count taken from the nearest public accessible road and verified from the airplane and later with air photos as necessary. The air survey provided access to remote locations in the project area, including large parcels not visible from the road. General locations of all feeding operations identified in the survey are shown in Figure A3 (Appendix A).

A total of 272 CAFOs and AFOs containing nearly 21,000 animals were identified in the watershed including permitted CAFOs and medium-small operations considered to be AFOs. In general, there are two components of loading from wastes generated at animal feeding operations. The first is direct runoff of animal waste from the operation site that enters adjacent water bodies. The second is loading from waste that is scraped, hauled, and land applied elsewhere in the watershed. The amount of total phosphorus contributed by runoff from each operation is a function of site conditions and manure management activities. NRCS personnel are tasked with working with livestock operations that discharge to receiving water bodies to develop Conservation Nutrient Management Plans (CNMPs).

The process of land application of manure is influenced by the number of livestock at each operation and the land available near each operation where manure could be applied. Larger operations have storage facilities such as lagoons or pits that collect manure until it can be land applied. Smaller operations generally remove manure on a seasonal basis. Very small operations (e.g. less than 10 animals) contain animals for brief periods when weather is severe and allow them to feed in nearby pastures during the rest of the year. Manure management and land application from small operations is likely minimal.

The locations with potential to receive land applied manure as shown in Figure A4 (Appendix A). The areas shown are an estimate of the maximum land cover that may receive manure applications during any given year. The actual extent of annual manure application is likely less than this total amount. A factor that is most likely to influence distribution of manure is land access. Small AFOs may only have access to limited areas due to ownership and lack of coordination that may be available to larger AFOs. Larger operations, including CAFOs and some Medium AFOs may also compost manure which is generally more suitable for use by farmers and some industries not associated with livestock feeding.

5.2.2 LIVESTOCK GRAZING

Livestock grazing in the lower Bear River watershed occurs on pastures and rangelands outside of confined operations. Livestock herds are moved between private land to public grazing allotments in the spring when conditions allow access to mountain pastures, many of which are located outside of the watershed. Livestock herds return to the watershed in the fall to graze in pastures and receive feed when conditions do not allow for grazing.

Approximately 12,000 animal units were counted in pastures and rangeland during the spring field survey and prior to when livestock were moved to public grazing allotments. In contrast, the summer field survey identified about 5,000 animal units grazing in areas outside of confined locations. The locations of grazing herds were recorded during each field survey. Visual observations, parcel boundaries, and satellite imagery were used to determine if animals had direct access to streams and the distance between herds and live water. Results of this analysis indicated that approximately 75 percent of grazing herds in the lower Bear River watershed are located within 100 feet of a water body of some type (e.g. river, stream, ditch, pond, etc.). Some of these water bodies are impaired or flow to an impaired water body. Location of grazing animals identified in field surveys are shown in Figure A5 (Appendix A).

5.2.3 FIELD DRAINS

Groundwater levels in the Bear River watershed are managed for agricultural purposes with the use of subsurface drainage systems (field drains) that collect water and discharge to streams, rivers, and ditches. Field drains can remove shallow groundwater along with salts and minerals, resulting in land that is suitable for farming or residential development. Over time, the normal operation of these systems can decline.

Early mapping of field drains indicated approximately 64,000 acres were influenced by these systems in the Bear River watershed (USDA-SCS 1977). Field drains in Box Elder County alone were associated with about a third of this total acreage. Drain tile systems were first installed in Northern Utah during the early 1900’s and little information was recorded at that time in regard to their location or flow direction. A more recent effort was made to map field drain systems in Box Elder County by the Northern Utah Conservation District, Natural Resource Conservation District, and local landowners (UACD 2010). Location of field drains in the lower Bear River watershed is shown in Figure A6 (Appendix A).

An additional study was completed to evaluate how land use affects nutrient loading and general water quality in tiled field drain lines in the project area (Elsner 2012). Five types of land use were included: agricultural land with manure application, agricultural land with commercial fertilizer application, highly developed urban area, moderately developed rural area, and rural areas with minimal development. Water quality samples were routinely collected from each system during 2009–2011. Monitoring results identified high concentrations of nutrients as well the presence of optical brighteners and E. coli, indicating the potential for contamination by septic tank discharge. As a result, total phosphorus loads from field drains likely incorporate several sources of pollution including agriculture, stormwater runoff collected by catchments (e.g. curb and gutter) and diverted into field drains, and septic tanks leach fields.

5.2.4 DIFFUSE RUNOFF

Diffuse loads from runoff were defined in the updated TMDL study as anthropogenic loads associated with surface runoff that are not the result of manure produced by grazing animals. Some examples of diffuse loads include the following:

- Surface runoff from land cover types in rural areas, some of which receive applications of chemical fertilizers and pesticides.
- Nutrients and other constituents associated with erosion from human disturbed areas (including trails, dirt roads, and dispersed camping sites) and bank erosion from segments of the mainstem Bear River and Malad River.

- Stormwater runoff from hardened surfaces in urban areas that is not diverted to storm drains.

Most runoff in the project area is associated with spring snowmelt and summer thunderstorms that pass through the area. In general, pollutant loading associated with runoff is essentially related to land use, although other physical factors such as geology, soil type, vegetative cover, slope, riparian conditions, etc. are also important. Improperly applied irrigation water may also generate surface runoff. Based on discussions with NRCS, flood irrigation is efficiently applied to fields that have been leveled to minimize runoff and loss of irrigation water. Although some runoff from flood irrigated fields likely occurs, it is anticipated these contributions are captured in the diffuse runoff load calculations.

The condition of lands contributing diffuse runoff is also important. It is generally accepted that areas in close proximity to existing water courses have a greater likelihood of contributing pollutant loads, especially when poor conditions exist (unstable and eroding stream banks, lack of vegetative cover, disturbed soils, etc.). In the project area, the Bear River and Malad River pass through wide valleys that are developed by agriculture and interspersed with urban and rural development.

Tributary subwatersheds that drain to the Bear River and Malad River are crossed by canals, highways, roads, railroads and other linear features that intercept surface runoff flowing toward rivers and streams. As discussed previously, some subwatersheds in the Lower Bear River watershed do not directly contribute surface runoff to impaired segments of the Bear River or Malad River. These subwatersheds are shown in Figure 2.1. The location of land cover types, surface water courses, and subwatershed boundaries are shown in Figure A2 (Appendix A).

6.0 POLLUTANT LOADS AND WATER QUALITY (EPA ELEMENT B)

This chapter summarizes total phosphorus loads created by the sources described in Chapter 5. A phosphorus load can be calculated at a monitoring site from a measured concentration in a water quality sample and a flow measurement. These two values are used to define the mass of phosphorus produced by a source during a certain time period. Loads for nonpoint sources can be calculated without flow measurements if needed, using accepted literature values that define unit contributions from each source (e.g. phosphorus contained in livestock manure, runoff from land applied manure, etc.)

All loads in this watershed plan are defined as pounds of total phosphorus per day. The updated TMDL (Utah DEQ 2018) and supporting documents to the TMDL (Cirrus 2016) include details that describe how data was used to complete load calculations for each pollutant source. Total phosphorus loads are required in the TMDL for each pollutant source. The magnitude of these loads and the location of each pollutant source can be used to estimate their influence on loads that are measured at monitoring sites in the watershed.

The updated TMDL defined a maximum daily load at Bear River monitoring sites just below Cutler Reservoir and approximately 40 miles downstream near Corinne. The difference between observed loads at these locations and the TMDL defines the reduction needed from pollution sources in the watershed. The results of the TMDL analysis are included in this chapter along with a discussion of reductions from nonpoint sources in the watershed that are necessary to meet the TMDL.

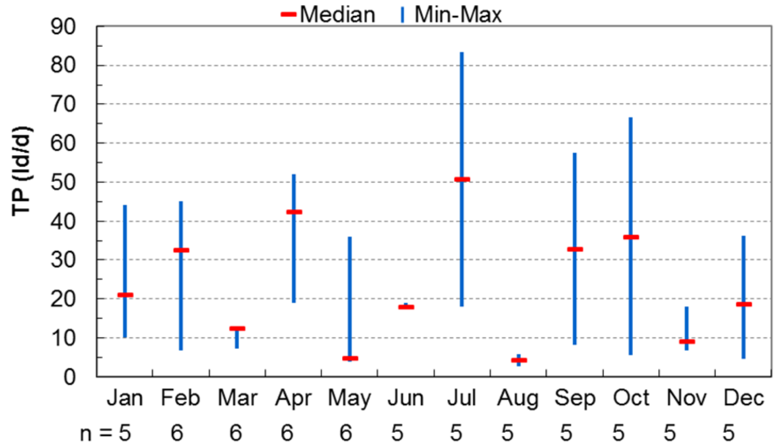
6.1 POINT SOURCE POLLUTANT LOADS

Pollutant loads from point sources were calculated with monitoring data collected from each of the three municipal wastewater sources in the watershed. Where available, all data 2005–2016 was used, although no source had a complete data record of both flow and total phosphorus for the entire period. Paired measurements of total phosphorus and flow for each facility were used to evaluate monthly loading. Figure 6.1 shows median monthly loads and the range of individual loads in each month. Individual loads ranged from 2.7–83.5 pounds per day (lbs/day) for the Tremonton WWTP, from 0.69–5.7 lbs/day for the Bear River City lagoons and from 0.2–18.2 lbs/day for the Corinne wastewater lagoons. Average annual daily loads were 24.1 lbs/day for Tremonton WWTP, 2.5 lbs/day for the Bear River City lagoons, and 2.0 lbs/day for the Corrinne wastewater lagoons. No discernable seasonal or long-term trends in pollutant loading were identified at any facility.

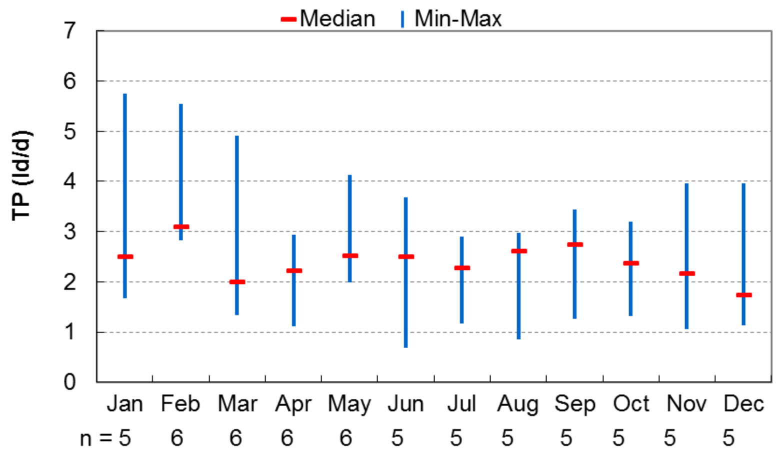
6.2 NONPOINT SOURCE POLLUTANT LOADS

Pollutant loads from nonpoint sources were calculated for all nonpoint pollutant sources in the lower Bear River watershed including land applied manure, livestock grazing, field drains, and diffuse runoff. Total phosphorus loads from land applied manure and livestock grazing were based on field surveys, phosphorus production rates used by the NRCS (2008), land cover and parcel boundary data, and information on how and when manure is applied in the watershed. Loads from field drains were based on paired measurements of flow and total phosphorus collected 2009–2011 (Elsner 2012). Land cover data and literature values were used to determine loads from diffuse runoff. A detailed discussion of methods and data used to calculate nonpoint source loads in the watershed are found in the updated TMDL (Utah DEQ 2018) and supporting documentation (Cirrus 2016).

Tremonton Wastewater Treatment Plant (UT0020303)



Bear River City Lagoons (UT0020311)



Corinne Wastewater Lagoons (UT0020931)

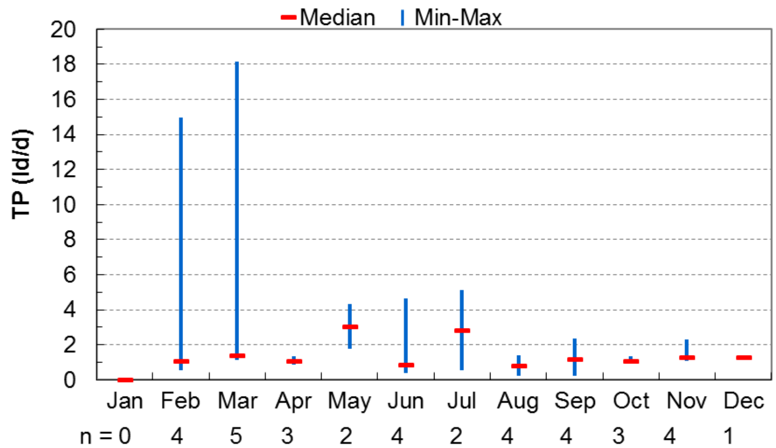


Figure 6.1. Monthly loads of total phosphorus from three municipal point sources in the lower Bear River watershed. Loads are based on available paired measurements of flow and total phosphorus collected from 2006–2015 as part of UPDES requirements.

The total annual load from all nonpoint sources in the project area is 760,405 lbs of total phosphorus. As indicated in Figure 2.1, four of the 16 subwatersheds in the project area do not flow directly to impaired segments of the Bear River and Malad River. Therefore, nonpoint source loads from these subwatersheds could be removed from the total watershed load for impaired water bodies.

Figure 6.2 shows the relative contribution by each source to the total nonpoint source load for the lower Bear River watershed. The greatest contribution comes from land applied manure (55 percent), followed by livestock grazing (29 percent), diffuse runoff (15 percent), and field drains (1 percent). Although loads from field drains appear to make a minor contribution to the total watershed load as it is calculated in this report, loads from this source are discharged directly to impaired waters. Other nonpoint source loads at the watershed level will be reduced by adsorption, plant uptake, and other processes as total phosphorus moves between the source location and impaired river segments.

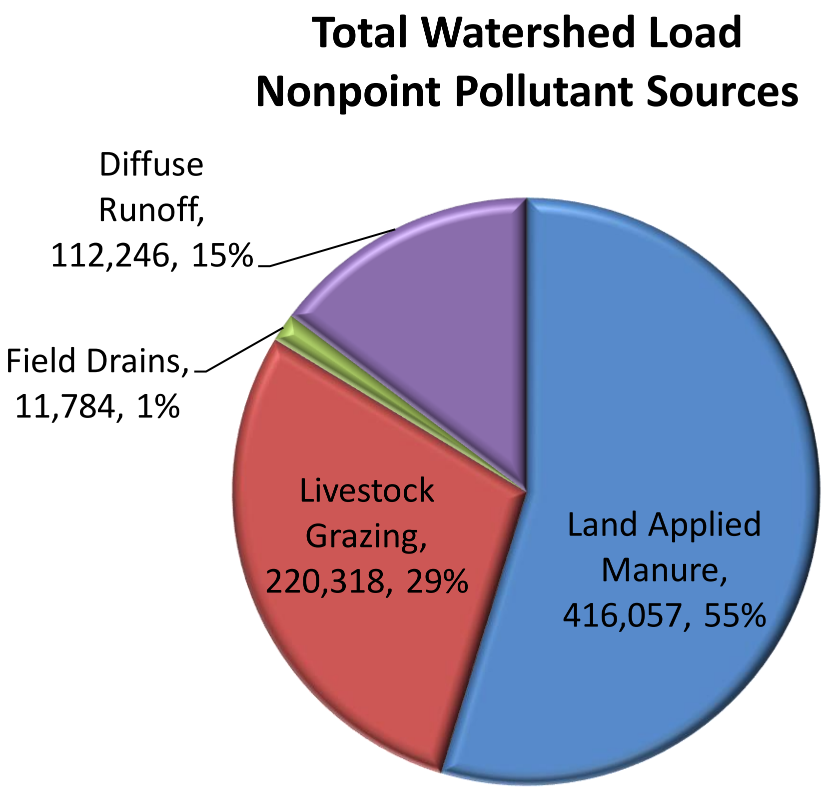


Figure 6.2. Summary of total phosphorus loads (lbs/year) from all nonpoint sources in the lower Bear River watershed area including land applied manure, livestock grazing, field drains, and diffuse runoff. The total load from all sources is 760,405 lbs/year.

Table 6.1 includes annual loads for all pollutant sources by subwatershed and the percent contribution from each source. Land applied manure contributes a majority of the total phosphorus load in the middle and lower portions of the watershed. Approximately one-third of the total watershed load consists of land applied manure in fields along the lowest segment of the Bear River. Livestock grazing also contributes significantly in many of the same areas as land applied manure, although a large portion of loads from grazing occur in areas that do not contribute to the Bear River or Malad River. Field drains contribute less than 10 percent to any subwatershed load. Diffuse runoff comprises a majority of subwatershed loads in the upper and middle segments of the lower Bear River watershed.

Table 6.1. Percent contribution from nonpoint pollutant sources to subwatershed loads. Shaded rows indicate subwatersheds that do not contribute flow to impaired segments of the Bear River or Malad River.

	Subwatershed Total P (lbs/day)	Land Applied Manure	Livestock Grazing	Field Drains	Diffuse Runoff
160102040301	1	0.0%	88.4%	0.0%	11.6%
160102040302	2	0.5%	0.0%	0.0%	99.5%
160102040303	12	2.0%	14.1%	0.0%	83.9%
160102040304	81	9.0%	77.4%	0.0%	13.6%
160102040305	53	54.2%	37.7%	0.0%	8.1%
160102040306	159	61.2%	23.2%	0.8%	14.8%
160102040307	284	72.2%	18.5%	6.6%	2.7%
160102040308	52	49.7%	29.5%	2.4%	18.4%
160102040401	73	0.0%	15.3%	0.0%	84.7%
160102040402	70	0.0%	62.8%	0.0%	37.2%
160102040403	45	3.4%	61.8%	0.1%	34.7%
160102040404	182	25.2%	49.6%	0.0%	25.2%
160102040501	143	34.1%	12.0%	4.1%	49.9%
160102040502	10	0.0%	11.5%	0.0%	88.5%
160102040503	185	29.3%	57.5%	0.0%	13.2%
160102040504[1]	732	81.1%	17.9%	0.3%	0.7%
Total	2,083				
Load from subwatersheds contributing to lower Bear River (lbs/day)			**1,844**		
Load from subwatersheds above Corinne[2] (lbs/day)			**1,112**		

[1] Most of the area in subwatershed 160102040504 is located below the Corinne monitoring site used in the TMDL to determine load allocations.

[2] Includes loads from all non-shaded rows except for subwatershed 160102040504.

Loads from all nonpoint sources generate approximately 760,405 lbs of total phosphorus each year throughout the entire watershed. Total phosphorus loads from subwatersheds that drain to the lower Bear River are 673,143 pounds per year (lbs/year). As discussed in Chapter 4, the lowest monitoring site on the Bear River with a considerable data record is located near Corinne (4901100) and roughly at the boundary between the lowest two subwatersheds. The contributing area above site 4901100 can be determined as the sum of all non-shaded subwatersheds in Table 6.1 except for subwatershed 160102040504. The total phosphorus load for this area is 405,893 lbs/year. For the sake of comparison to point source loads, the daily load for nonpoint source loads above the Corinne monitor site is 1,112 lbs/day; obtained by dividing the annual load by 365 (the number of days in a year)

6.3 LOAD DURATION CURVES AND TMDL

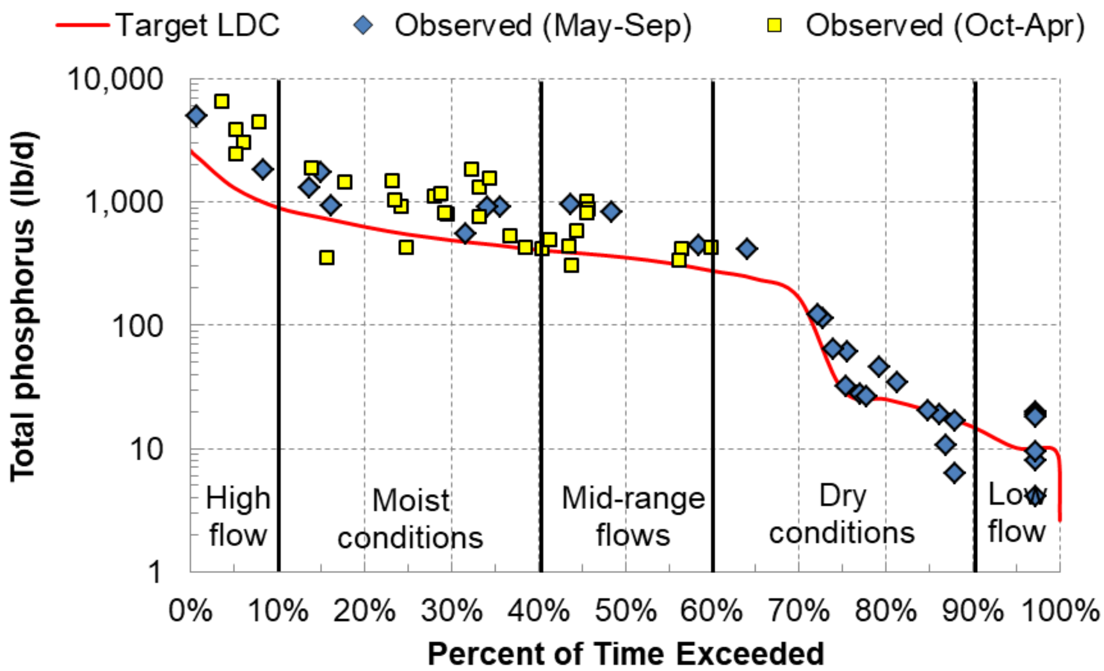
The TMDL for the lower Bear River is based on load duration curves calculated from flow and water quality measurements (2006-2015) at two monitoring sites including 4901980 – Bear River below Cutler Reservoir at UP&L bridge and 4901100 – Bear River near Corinne at U83 crossing. Continuous flow measurements are available near each site which enables analysis of phosphorus loads over a wide range of flow conditions.

A Load Duration Curve (LDC) approach is an acceptable method for determining TMDLs in areas with limited source data and complicated hydrology (EPA 2007). This approach calculates an allowable load over a range of flow conditions expected to occur in each impaired water body. A flow duration curve (FDC) is first created at a continuous flow monitoring site with data that span sufficient time to characterize watershed hydrology. The FDC is converted into an LDC by multiplying each flow data point by the total phosphorus target (i.e. 0.075 mg/L). As a result, the LDC represents a TMDL curve for any flow scenario. Loads from monitoring data based on paired measurements of flow and water quality are plotted as points on the TMDL curve to compare to the water quality standard/target, or LDC. Any points above the LDC need to be reduced to meet the water quality target.

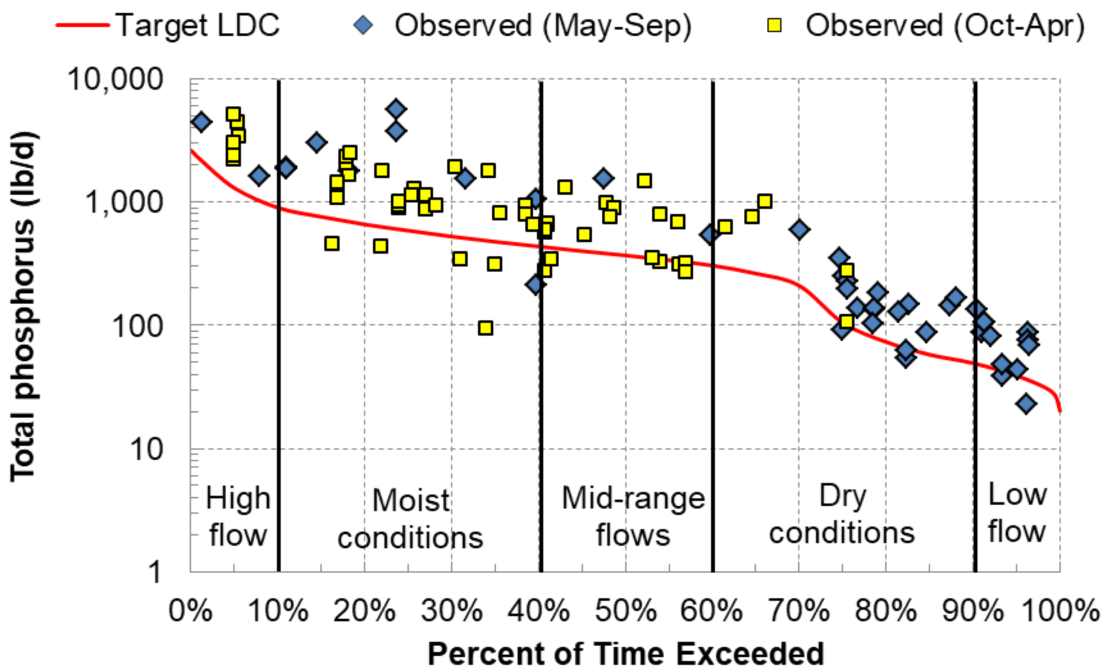
Figure 6.3 shows the LDC and individual loads from monitoring data at site 4901980 and site 4901100. Note the two symbol colors that represent loads during two seasons. The May-Sept loads occur primarily during dry and low flow regimes while the Oct-Apr loads occur in the mid-range to high flow regimes. Individual data points represent a daily load of total phosphorus (lbs/day) based on the product of paired phosphorus and flow measurements. The distance that loads are above the LDC represents the amount that total phosphorus loads must be reduced to meet water quality standards and targets. Any data point below the LDC does not need to be reduced.

TMDLs were developed for the Bear River below Cutler Reservoir and below Corinne (Table 6.2). Allocations were not developed for the TMDL above Cutler Reservoir since the watershed draining to Cutler Reservoir is outside of the lower Bear River watershed and because Utah DEQ already developed a TMDL for the Cutler Reservoir. Percent reductions to meet the TMDL were based on reduction of the median load in each flow regime. The TMDL analysis indicated that reductions in total phosphorus were needed across all flow regimes.

The TMDL for the Bear River below Corrinne included allocations for both nonpoint sources (LA) and point sources (WLA), as well as amounts reserved for future growth (RFG) and a margin of safety (MOS). The MOS provides reasonable assurance the TMDL will be met once all other reductions are met. The LA was not allocated to separate nonpoint sources in the TMDL. That allocation will take place in this watershed plan based on source load characteristics, available opportunities, site specific conditions, and stakeholder input.



LDC and instream loads in the Bear River below Cutler Reservoir (4901980).



LDC and instream loads in the Bear River near Corinne (4901100).

Figure 6.3. Load Duration Curves (LCD) and total phosphorus loads calculated at upstream (4901980) and downstream (4901100) monitoring sites.

Table 6.2. Total Maximum Daily Load (TMDL) for the lower Bear River watershed above Corinne. All loads are total phosphorus (lbs/day). The TMDL for Cutler Reservoir is also shown in this table to indicate the reductions from sources upstream of the lower Bear River watershed.

Flow condition (Duration interval)	High flows (0-10%)	Moist (10-40%)	Mid-range (40-60%)	Dry (60-90%)	Low flows (90-100%)
TMDL - Cutler Reservoir discharge (lbs/day)	**1,303**	**546**	**356**	**30**	**10**
Observed load (lbs/day)	3,821	932	467	32	14
Reduction to meet TMDL (%)	66%	41%	24%	6%	29%
TMDL - Lower Bear River at Corinne (lbs/day)	**1,302**	**588**	**370**	**105**	**39**
Load Allocation	1,143.8	502.6	306.8	68.9	9.7
Waste Load Allocation	23.8	22.4	22.0	21.4	21.2
Reserve for Future Growth	4.2	4.2	4.2	4.2	4.2
Margin of Safety	130.2	58.8	37.0	10.5	3.9
Observed load (lbs/day)	3,888	1,105	652	146	82
Reduction to meet TMDL (%)	67%	47%	43%	28%	52%
Existing daily load increase at Corinne (lbs/day)[1]	67	173	185	114	68
% of existing daily load at Corinne that comes from lower Bear River watershed	2%	16%	28%	78%	83%
Reduction to meet Corinne TMDL(lbs/day)[2]	2,586	517	282	41	43
Reduction achieved by Cutler TMDL (lbs/day)[3]	2,518	386	111	2	4
Reduction needed from lower Bear River watershed above Corinne (lbs/day)[4]	68	131	171	39	39

[1] Difference between observed load at Corinne and Cutler discharge.

[2] Difference between observed load and TMDL load at Corinne.

[3] Difference between observed load and TMDL load from Cutler.

[4] Difference between reduction to meet TMDL and reduction achieved by Cutler TMDL. These amounts represent the reduction from nonpoint source loads that the watershed plan must address.

7.0 WATERSHED GOALS

The lower Bear River watershed plan expresses goals and objectives of stakeholders. These goals are derived from concerns by individuals, management directives of organizations active in the watershed, or needs specific to a particular group of stakeholders. In most cases, a watershed goal is broad enough to encompass multiple concerns. Watershed goals should be specific and clearly written. To ensure that progress is made toward achieving the goals, it is helpful to define indicators, milestones, targets, and management objectives that articulate actions necessary to move toward the goals. In order to accomplish these management objectives, this plan articulates management strategies and management practices that would help to reduce nonpoint source pollution.

A conceptual description of each planning term is provided in Table 7.1. Some of these planning terms are reviewed in the sections below. Other terms will be mentioned in Chapters 8 and 9 in the discussion on how to implement the watershed plan.

Table 7.1. Definition of watershed planning terms.

Watershed Planning Term	Description
Watershed Goals	What the watershed should be, sometimes defined by what it should not be. Goals can be defined by stakeholders' concerns.
Indicators	What to measure to know the watershed is getting closer to the goal(s).
Targets	Measurable values of indicators that show when goals have been achieved and when enough has been done.
Management Objectives	Management actions that affect the creation, movement, deposition, or treatment of pollutants such that water quality indicators move toward their target levels.
Milestones	How much management action should be accomplished by what date. Milestones include a management objective, a measured amount of progress, and a timeline.

Goals can be extracted from several sources. Examples include scientific understanding of what is required for water quality to be useful for different beneficial uses, concerns expressed by stakeholders, or hopes and desires for better land or water conditions. Goals should incorporate concerns from all stakeholder groups and all geographic areas within the lower Bear River watershed. Some of the organizations on the TMDL advisory committee that contribute to developing goals for this watershed are shown in Figure 7.1. Goals can also be taken from previous watershed planning activities including TMDL efforts, resource management plans, source water assessments, stormwater management plans, facility plans, and wetland assessments.

Watershed goals in the lower Bear River watershed include concerns identified by the Utah DEQ in the updated TMDL (Utah DEQ 2018) and the 2016 303(d) list. This watershed plan will focus primarily on restoring impaired water bodies in the lower Bear River watershed by meeting Utah water quality standards. Future iterations of this plan are strongly encouraged to evaluate progress and incorporate changes to watershed goals. Plan updates will likely be necessary when other impairments identified in the 2016 IR are addressed including dissolved oxygen, temperature, OE bioassessment, and total dissolved solids (Table 2.1).

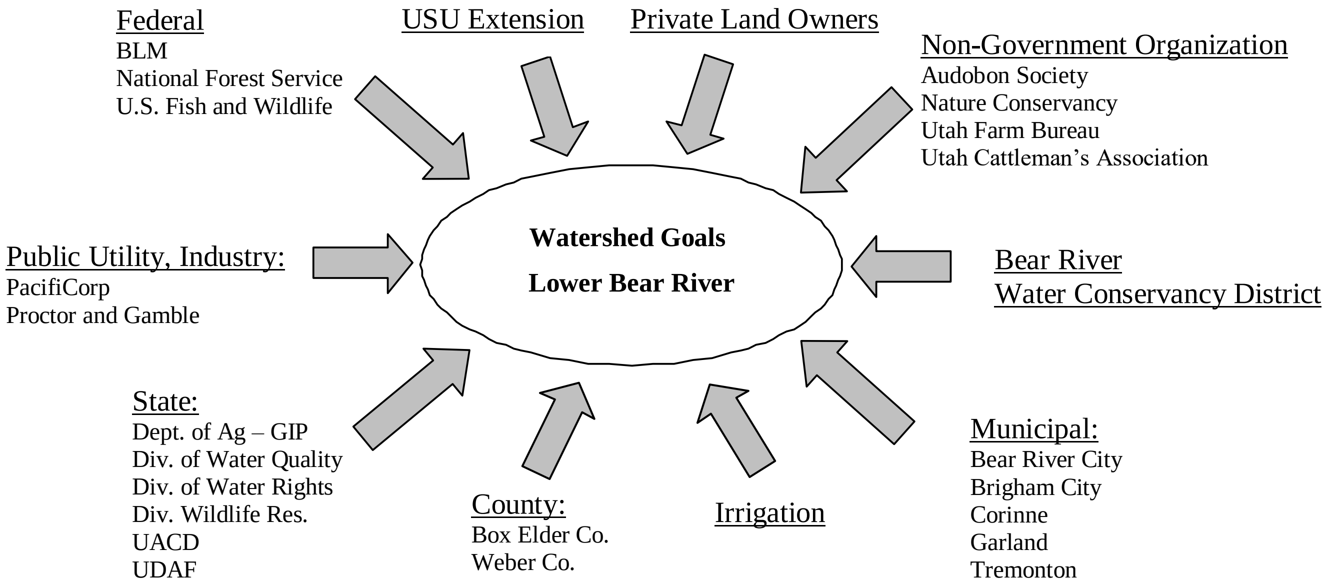


Figure 7.1. Entities participating in the development of lower Bear River watershed goals.

Concerns expressed by agencies and private landowners include goals that are specific to water quality as well as other goals for the watershed that may indirectly benefit water quality. Water quality-specific goals are associated with thresholds that protect and support beneficial uses. Other watershed goals may be associated with topsoil conservation, bank stabilization (to protect property), properly functioning field drains, and effectively managing manure in a way that minimizes cost and maximizes crop yield. Each of these goals can indirectly improve water quality while directly benefiting the agriculture operations of private landowners. Watershed goals are also reflected by management objectives. These objectives are essentially actions that influence pollutant sources and how they are transferred to receiving water bodies. Indicators are measured to determine if progress is being made towards watershed goals. This chapter will define management objectives and indicators with regard to current understanding of pollutant sources described in Chapter 5 and achieving the load reductions defined in the updated TMDL. The remainder of this chapter will describe the load reduction target and the method used to determine what reductions are needed from nonpoint pollutant sources in the watershed.

7.1 MANAGEMENT OBJECTIVES AND INDICATORS

Before deciding what strategies to use to resolve water quality problems, it is important to define the objectives for management. Management objectives should move the indicators of water quality in the desired direction, and address the location and timing of pollutant sources that are causing water quality problems. Specific management objectives should be defined to support each goal, but the same management objective may affect more than one indicator.

7.1.1 MANAGEMENT OBJECTIVES

The primary watershed goal at this time is to restore beneficial uses impaired by total phosphorus. However, management objectives should also consider factors that could influence the success of different activities that have potential to improve water quality. Some of these factors are specific to location, land ownership, and land use. Initial management objectives in this plan were selected based on discussions with stakeholders, field surveys, and a watershed scale review of GIS information. Some of the factors that were considered include the following:

- **Impaired water bodies:** Do impairments exist in other locations of the watershed, beyond those water bodies identified in the updated TMDL?

- **Conditions that mitigate pollutant loading:** Where do good management practices and conditions currently exist that provide some control of nonpoint source loading? What areas can be assigned a lower priority for responsibility of pollutant loading, because, for example, they are distant from the impaired segment, or impractical to change?

- **Opportunities and barriers to implementation:** What is the potential for success in implementing management practices in different locations or among various stakeholder groups? What success has been achieved in the past with nonpoint source control measures with respect to location, practice type, and group? Do stakeholders realize benefits such as increases to crop production, water volume, or property value as well as water quality improvements?

- **Location with respect to impaired water bodies:** What is the distance between impaired reaches and pollutant sources? How does this distance vary by pollutant source and season?

- **Land ownership:** Most pollutant sources are located on private land. What influence does voluntary involvement and landowner cost have on the likelihood of participation and implementation?

Once management objectives have been established, management strategies can be developed to guide the choice of specific management practices. Management objectives that were identified for the lower Bear River watershed included:

1. Reduce the number and duration of livestock in proximity to receiving water bodies and their defined bed and banks.
2. Increase use of better nutrient management practices including land application of manure.
3. Increase percentage of AFOs, CAFOs, and grazing operations following CNMPs and utilizing waste management structures and practices.
4. Reduce land erosion that transports sediment (and total phosphorus) to waterways, especially from disturbed lands, agricultural fields, and pastures.
5. Reduce field drain discharge from agricultural fields and pastures that transports high concentrations of total and dissolved phosphorus to surface waterways.

7.1.2 WATER QUALITY INDICATORS

Water quality indicators provide a means for measuring progress towards watershed goals in several phases of watershed planning and development. Indicators can be used during the initial planning phase when existing conditions are characterized and again following implementation of water quality improvement projects. Environmental indicators are used to define the linkage between pollutant sources and environmental conditions. The cause and effect relationship defined between indicators and watershed goals can be used to determine pollutant load reductions that will result in achieving targets. Programmatic and social indicators are indirect measures of progress towards watershed goals. They include measures of information and education programs used to protect water quality and changes in behavior that result in improvements to water quality. Regardless of type, indicators should be a quantified measure of progress towards watershed goals.

The water quality indicators selected for this watershed plan include the following:

1. In-stream total phosphorus concentration at the Cutler and Corinne monitoring sites and additional sites recommended in Chapter 9.
2. Water quality parameters that indicate impairment from total phosphorus including dissolved oxygen, chlorophyll-a, and OE bioassessment scores. These parameters will be measured at the same sites monitored for total phosphorus. All water quality samples will need to be paired with in-stream flow measurements at sites without continuous flow monitoring.

7.2 LOAD REDUCTION AND SOURCE ALLOCATION

This section describes the load reduction needed to meet the TMDL load allocation for nonpoint sources. The load reduction needed from nonpoint sources is defined as the difference between the observed load from nonpoint sources and the load allocation in the TMDL.

The load allocation is the portion of the TMDL assigned to nonpoint sources and natural background levels. It was calculated as the remainder of the loading capacity after allocations were made to point sources, a margin of safety, and loads from future growth.

Load allocations were not made in the TMDL to individual nonpoint sources or categories. This approach was used because sufficient data are not available to estimate current delivered loads from each nonpoint source category and to provide stakeholders with as much flexibility as possible for implementation. Based on the best available information, this watershed plan will recommend load allocations and reductions for each nonpoint source category. These recommendations are preliminary and may need to be adjusted in the future as additional information becomes available.

7.2.1 Load Reduction Target

The primary target for the watershed plan at this time is the load reduction (lbs/day) from nonpoint sources needed to meet the TMDL at Corinne. Other targets will be mentioned in Chapter 8 when BMPs are recommended to reduce pollutant loading. Each of these targets are related to meeting the main watershed goal of restoring beneficial use to impaired water bodies in the lower Bear River watershed.

Table 6.2 shows the increase in existing daily loads at Corinne that represent load contributions from the lower Bear River watershed only. This contribution is greatest for the mid-range flow regime at 185 lbs/day. The percent contribution from sources in the watershed to the existing load at Corinne is greater for lower flow regimes (78–83 percent) and minimal for the highest flow regime (2 percent).

The reduction needed to meet the TMDL can come from two sources including Cutler Reservoir discharge and sources in the lower Bear River watershed. The last row of Table 6.2 shows the reductions needed only from sources in the watershed, assuming the TMDL for Cutler Reservoir discharge is met. These reductions range from 39 – 171 lbs/day.

The greatest load reduction from sources in the lower Bear River watershed needed to meet the TMDL is 171 lbs/day under the mid-range flow regime. This is the largest reduction needed under any flow regime. The reduction from nonpoint sources only would be 164 lbs/day given that roughly 7 lbs/day would be reduced when the Tremonton WWTP meets the TMDL. Therefore, 164 lbs/day is selected as the load reduction target for nonpoint sources addressed in this watershed plan. This target is conservative in that it will meet the TMDL under any other flow regime. A critical assumption that supports this target is the Cutler Reservoir TMDL will also be met.

Reasonable assurances the TMDL will be met for the lower Bear River watershed under any flow regime include the following:

- Much of the load at Corrinne during high, moist, and mid-range flow conditions can be attributed to Cutler (98%, 84%, and 72% respectively). Meeting the Cutler TMDL will resolve all or most loading concerns in these flow intervals.
- The load reduction target (164 lbs/day) will meet the TMDL under any flow regime, including the dry and low flow regimes when sources in the lower Bear River watershed make significant contributions (78 and 83 percent of the daily load, respectively).
- The load reduction target is more than double the reduction needed for other flow conditions, except for the moist flow regime.
- Flow (and loading) at Corinne are well correlated with discharge from Cutler Reservoir (see Figure 3.1). As a result, there is high confidence if the Cutler TMDL is met, the same reduction will transfer to Corinne.
- The TMDL for the Malad River in Idaho is in place (ERI 2006) and recommends a target concentration of 0.075 mg/L at the Idaho/Utah border. Meeting this TMDL would result in a 7 percent reduction equivalent to 961 lbs/year or 2.6 lbs/day entering the lower Bear River watershed.

7.2.2 SOURCE ALLOCATIONS TO MEET THE LOAD REDUCTION TARGET

Nonpoint source loads of total phosphorus were defined in the TMDL for each significant source including animal feeding operations, livestock grazing, and diffuse runoff. These loads were estimated at the location of each source. The quantity reaching the Bear River via surface water or groundwater pathways (i.e., the “delivered load”) was not estimated. Given the amount of anthropogenic manipulation that has occurred in the watershed (e.g., dams, irrigation withdrawals, returns, field drains) it is likely that pathways between sources and surface waterbodies are very complex.

The percent reduction needed at Corinne to meet the TMDL under the mid-range flow regime is 43 percent of the observed load (Table 6.2). This same percent reduction is recommended from the total load of 1,112 lbs/day generated by all nonpoint sources that contribute to the Bear River and Malad River above the Corinne gage (Table 6.1). This reduction is equivalent to 478 lbs/day and is a reasonable level of reduction based on existing data and current understanding of hydrology, pollutant sources, and other local factors that influence delivery of pollutant loads.

The 43 percent reduction could be applied to any nonpoint source of pollution in the watershed. Given the uncertainty that exists between most nonpoint sources and the monitoring site at Corinne, it is reasonable to allocate the reduction based on factors that influence the delivered load. Some of these include distance to receiving waters, magnitude and extent of loading, and likelihood of implementing practices that will reduce loading. Based on these factors a proposed reduction that would meet the target of 478 lbs/day is shown in Table 7.2.

Results from analysis of the load duration curves (Figure 6.3) can also be used to determine what sources to focus on. Table 7.3 defines the relationship between flow regimes on a load duration curve and pollutant sources. Table 6.2 suggests that phosphorus concentrations in the mid-flow and lesser flow regimes measured at Corinne are mostly influenced by sources in the watershed and less so by Cutler Reservoir. Table 7.3 indicates that points sources, field drains, and livestock grazing in and near streams could make significant contributions of total phosphorus in these flow regimes.

Uncertainty in the relationship between pollutant sources and the delivered load can be addressed through the adaptive management approach discussed in the updated TMDL. This is a systematic approach for improving resource management that allows for flexible decision-making. There is an inherent amount of uncertainty involved in the TMDL process that includes determining effects of BMP implementation, among other things. Use of an adaptive management approach allows for adjustments to allocations and load reduction targets, as necessary. This approach will be used in the watershed plan. Future changes will be made to the plan based on measurements of proposed indicators and milestones.

Table 7.2. Daily total phosphorus loads (lbs/day) and proposed reductions needed to meet the lower Bear River TMDL. Non-shaded rows contribute to the Malad River; shaded rows contribute to the Bear River.

Subwatershed ID	Land Applied Manure (lbs/day)	Livestock Grazing (lbs/day)	Field Drains (lbs/day)	Diffuse Runoff (lbs/day)	Subwatershed Total (lbs/day)
160102040301	0	1	0	0.17	1
160102040302	0.01	0	0	2	2
160102040303	0	2	0	10	12
160102040304	7	63	0	11	81
160102040305	29	20	0	4	53
160102040306	98	37	1	24	159
160102040307	205	52	19	8	284
160102040308	90	54	4	34	182
160102040501	49	17	6	71	143
160102040502	0	1	0	9	10
160102040503	54	106	0	24	185
160102040504[1]	594	131	2	5	732
Total (above Corinne)	532	353	30	196	1,112
Total (all subwatersheds)	1,126	485	32	201	1,844
% reduction	45%	45%	45%	35%	43%
Load reduction - priority areas above Corinne	239	159	14	69	481
% reduction	45%	45%	45%	30%	44%
Load reduction - all direct subwatersheds	507	218	14	69	808

1 This subwatershed is located downstream of Corinne. All other subwatersheds contribute to flow in the Bear River and Malad River upstream of Corinne.

Table 7.3. Relationship between load duration curve zones and contributing sources (Utah DEQ 2018).

Contributing Source Area	Duration Curve Zone				
	High Flows	**Moist**	**Mid-Range**	**Dry**	**Low Flows**
Point Sources	1	2	3	4	5
Groundwater sources (e.g., septic systems, leaching from heavily grazed areas)	1	2	3	4	5
Direct deposition (e.g. livestock, waterfowl, beavers)	1	2	3	4	5
Near-Stream Overland Flow	5	5	3	2	1
Far-Field Runoff	5	4	3	2	1

"1" (green) indicates least importance

"5" (red) indicates greatest importance

8.0 IDENTIFICATION OF MANAGEMENT STRATEGIES (EPA ELEMENT C)

Management strategies are those activities that accomplish particular management objectives, e.g., replanting riparian vegetation along an eroding streambank (strategy) to reduce streambank erosion (objective). The ultimate implementation of a management strategy is referred to as a management practice, but these are typically just variations in regard to a specific practice—planting willow bundles versus cottonwood cuttings, size and material of a pipe for irrigation projects, choice of concrete or wood walls for animal waste storage, etc.

The key to choosing successful management strategies for nonpoint source water pollution is finding those that are effective in controlling sources of pollution, economical, and easy to maintain. The construction and maintenance costs of management strategies are of primary concern to private landowners. The process followed to choose strategies must consider these and other concerns besides reduction efficiency in order to achieve the desired levels of implementation.

8.1 EXISTING MANAGEMENT STRATEGIES

Information on existing management strategies in the lower Bear River watershed was retrieved during a request to local agencies for summary documentation. No confidential information was released by agencies. These records provide valuable information on strategies that have worked well. The reports also provided insight on overall progress and attitudes toward implementation and where improvements can be made.

8.1.1 STRUCTURAL CONTROLS

Structural controls are BMPs that include a structure or built feature. Some of these include detention basins, filter strips, fencing, diversion berms, etc. Structural controls usually include a maintenance cost that occurs over time to keep the structure functioning properly.

The NRCS has worked with local farmers and landowners for many years to implement practices in the lower Bear River watershed to improve water quality. Table 8.1 includes a list of practices that have been proven to be effective in reducing NPS pollution in Box Elder County, including many watershed areas of the lower Bear River. Practices that rank the highest are related to irrigation, topsoil management, and waste management. Irrigation BMPs can reduce surface erosion and the amount of return flow from field drains or runoff. Cover crops maintain vegetation at the soil surface and reduce topsoil losses to erosion by water and wind. Cover crops also maintain organic material in topsoil and promote infiltration. Waste storage facilities include bunkers, lagoons, and other structures where liquid or solid waste is temporarily stored. Less common practices in the watershed include fencing, filter strips, prescribed grazing, etc. These practices could be useful in reducing total phosphorus loads to impaired waters. Additional incentives may be needed to implement these and other similar measures.

Utah DEQ is required to track and document all water quality improvement projects associated with their section 319 nonpoint source pollution control program (Elsner 2016). Table 8.2 includes information on recent practices implemented in the lower Bear River watershed, including implementation cost and estimated reductions in total phosphorus loading. The total practice cost shown in Table 8.2 includes contributions from the 319 program, EQIP (NRCS), and the property owner where projects are implemented. Structural controls in Table 8.2 address pollution loading from AFO runoff, field drains, and riparian areas. Projects that reduced AFO runoff and pollution ranged from roughly $15,000–$60,000 with phosphorus reductions of 16–240 lbs/year, respectively. Other projects include rerouting field drains and restricting livestock access to streams and rivers.

Table 8.1. Number and type of best management practices implemented 2010-2018 in the lower Bear River watershed (Utah DEQ 2017).

Practice	2010	2011	2012	2013	2014	2015	2016	2017[1]	2018[1]	Total
Structure for Water Control (587)	1	1	4				3			9
Cover Crop (340)	1							3	2	6
Irrigation Water Management (449)	1		1	1					1	4
Pumping Plant (533)	1	1	1	1						4
Irrigation Water Conveyance-High Pressure Underground (430DD)	1	1		1						3
Waste Storage Facility (313)	1	1		1						3
Irrigation System, Microirrigation (441)	1	1								2
Irrigation Water Conveyance (430)							2			2
Nutrient Management (590)				1	1					2
Pipeline (516)	1		1							2
Fence (382)							1			1
Filter Strip (393)							1			1
Heavy Use Area Protection (561)							1			1
Irrigation Water Conveyance-Low Pressure Underground (430EE)			1							1
Manure Transfer (634)	1									1
Pond Sealing or Lining, Flexible Membrane (521A)			1							1
Prescribed Grazing (528)									1	1
Solid/Liquid Waste Separation Facility (632)			1							1
Watering Facility (614)	1									1
TOTAL	10	5	10	5	1	0	8	3	4	46

[1] Projects were not approved for funding when information was provided by NRCS.

Table 8.2. Management strategies implemented in the lower Bear River and Malad River subwatersheds (2007-2015).

Description	Total Cost[1]	Estimated phosphorus reduction (lb/yr)[2]
AFO runoff - Bear River Divert runoff away from feedlots. Runoff from feedlots contained and routed (dikes 700 ft.). Off-site watering (1 site, 220 ft. pipeline). Fencing to restrict livestock access to Bear River (625 ft.). Nutrient management plan (225 ac.).	$14,964	16
Field drains Reroute field drain (975 ft.) around housing unit to prevent anthropogenic inflow and pollution.	$21,213	NA[3]
I&E Eight newsletter articles produced for public on nutrient enrichment and TMDL development. Document before-after conditions North Utah Mini Water Conference, discussing water quality and quantity, erosion control, and sediment reduction practices.	$3,150	NA
AFO runoff – Bear River Divert runoff away from dairy, reshape surface (118 ton of fill). Waste transfer pipeline from solid waste facility.	$27,892	32
AFO runoff – Malad River Runoff from feedlot contained and routed (400 ft. diversion) Retention pond Fencing to restrict livestock access to Malad River. Off-site watering (3 sites, 3,500 ft. pipe)	$23,945	212
I&E North Utah Mini Water Conference, discussing water quality and quantity, erosion control, and sediment reduction practices. Materials for educational seminar	$2,498	NA
AFO runoff – Bear River Enclose return flow ditch in pipe (1,800 ft.) to prevent contamination by feedlot runoff.	$59,824	240
Riparian restoration – Bear River Fencing to restrict livestock access to Bear River (1,639 ft).	$3,509	16
I&E Bear River Celebration (2015) Targeted Basin Workgroup (2015) Lower Bear River Water Quality Project Tour (2015) Soil health and water quality tour	$3,333	NA

[1]Total costs for structural controls were paid for by grants from the Section 319 Non-Point Source Pollution Control Program and Environmental Quality Incentives Program (EQIP), and matching contributions by landowners.

[2]Load reductions were estimated using the Utah Animal Feedlot Runoff Risk Index (UAFRRI) worksheet and the Spreadsheet Tool For Estimating Pollutant Loads (STEPL) model.

3Pre-implementation monitoring data indicate 3.5 lbs/day total phosphorus from the field drain. Post-implementation data is not currently available.

Projects in Table 8.2 have direct and significant benefits to water quality in regard to reducing loads of total phosphorus. Corresponding benefits to landowners as a result of implementing these projects also occur but the benefits are less than those from projects involving irrigation or topsoil management. As a result, extra incentives may be needed to implement a substantial number of projects that directly benefit water quality and have less benefit for landowners.

8.1.2 NONSTRUCTURAL CONTROLS

Nonstructural controls are BMPs that do not involve a structured solution. They include practices such as information and education (I&E), site planning, stormwater regulations, livestock management (e.g. timed grazing), etc.

The greater Bear River Basin has a long history of outreach to stakeholders that include I&E activities. Table 8.2 includes a brief summary of efforts and cost of recent I&E activities that have occurred in the lower Bear River watershed. Some of these activities include:

- distributing water quality fact sheets at conferences, fairs, and other gatherings,
- staffing booths at conventions and seminars to provide updates on water quality projects,
- organizing and conducting the annual Northern Utah Mini Water conference,
- convening Field Day events to show landowners how practices can improve yields and water quality simultaneously, and
- arranging meetings for the Targeted Basin workgroup.

Table 8.1 includes non-structural practices such as nutrient management and prescribed grazing. These practices may require limited infrastructure in some situations (e.g. manure storage or fencing) but primarily require planning and a change in existing behavior.

Implementing nonstructural controls are critical to achieving improved water quality. Aside from cost, one of the largest barriers to implementing projects can be perspectives about water quality and traditions that influence how agricultural resources are managed. If stakeholders can see secondary benefits to improved water quality, they are more likely to change behaviors that influence nonpoint source pollution.

8.2 CRITICAL SOURCE AREAS

Watershed plans should identify and focus on areas where implementing BMPs will be most effective in achieving watershed goals (EPA 2018). Critical source areas (CSAs) are watershed areas where disproportionate amounts of pollution are generated and delivered to impaired water bodies (Giri et al. 2016). Improvements in water quality are most likely to occur when practices are implemented in critical source areas. The process for defining CSAs and opportunities for implementing BMPs is the last step in a four step process that includes (EPA 2018):

1. Establish priorities by defining goals, objectives, and necessary reductions in pollutant loading.
2. Describe connections between pollutant sources and monitoring data.
3. Estimate relative contributions from each pollutant source.
4. Define CSAs and options for implementing BMPs.

Previous chapters of this watershed plan have defined the necessary components to complete steps 1-3. This section of the plan will provide the necessary information to complete step 4 of the process and provide a basis for recommending BMPs for each pollutant source identified in Chapter 5.

At the watershed level, there are four subwatersheds that do not drain to the Malad River or Bear River (Figure 2.1 and Table 6.1). This watershed plan will address pollutant sources in the 12 subwatersheds that discharge directly to the Malad and Bear Rivers. Furthermore, all land areas (and pollutant sources) located within a quarter-mile of impaired water bodies or tributaries are considered a priority area. Nonpoint sources that directly discharge to impaired waters (i.e. field drains and livestock grazing) are a particular concern. Opportunities to reduce loads from pollutant sources in the priority area are identified as well as sources located outside of the priority area.

Opportunities for implementing BMPs for each of the four nonpoint sources of pollution defined in the updated TMDL are found Tables B.1-B.4 (Appendix B). These tables summarize areas of land, lengths of stream channel, and livestock feeding operations in each subwatershed where BMPs could be implemented to reduce total phosphorus loads. Opportunities located within one-quarter mile of the Bear River and Malad River are identified for each nonpoint source of pollution with the exception of diffuse runoff. The quarter-mile corridor near major impaired water bodies should be addressed first when considering where BMPs should be implemented. This area represents a relatively greater potential for pollution loading and subsequent measured improvements in water quality after BMPs are implemented. In regard to diffuse runoff, BMPs should be considered anywhere in the watershed that opportunities exist.

The most downstream subwatershed that drains to the lower Bear River is located below the Corinne monitor site. The TMDL defined a load allocation for sources above this site. However, field surveys indicated substantial nonpoint source pollution in the subwatershed area below the Corinne monitor site. Opportunities for implementing BMPs are identified in this lowest subwatershed as well as for the other 11 priority subwatersheds.

8.3 OTHER STRATEGIES NEEDED TO ACHIEVE WATERSHED GOALS

The next step in the planning process is to quantify how much implementation would be required to achieve the load reductions defined in the TMDL. Tables 8.3-8.6 show how much of each management strategy would be recommended to reduce annual pollutant loads and meet allocations in the updated TMDL. Several assumptions have been made to complete the necessary calculations. Key assumptions include the following:

1. Load allocations were taken from the updated TMDL and reflect a reasonable level of assurance that water quality standards will be met following implementation.
2. The same BMP can be recommended for different pollutant sources. Reductions were not double-counted, but in reality the same BMP could reduce pollutant loads from more than one source (e.g. converting from flood irrigation to sprinkler irrigation could potentially reduce loads from land applied manure and field drains.)
3. Field level recommendations were not made in regard to where BMPs should be implemented. GIS mapping resources are considered accurate and identify existing opportunities. It is likely that BMPs are already implemented in some of these areas but considerable opportunities still exist at levels needed to meet load allocations in the updated TMDL.
4. Unit reductions (phosphorus removed by a BMP for each treated acre or length of stream channel) assumed that pollution was distributed equally in areas where sources exist (e.g. grazed pastures, cultivated fields, etc.).

5. Differences exist between load reductions made using models, literature values, and best professional judgement. Adaptive management is a critical element to adjusting how, when, and where BMPs should be implemented to meet load allocations in the updated TMDL.
6. Reductions from implementing BMPs are based on professional literature and incorporate a certain amount of uncertainty. Some of this uncertainty is addressed using conservative estimates of reduction efficiency and recommendations for focusing on critical areas where pollutant sources have more potential to impact water quality.

8.3.1 Structural Controls

Recommendations for reducing total phosphorus from each nonpoint source of pollution are included in Tables B.1-B.4 (Appendix B). These recommendations will be discussed for each source along with suggestions for how and where they should be implemented.

Table 8.3 includes recommendations for reducing loads from land applied manure. Detailed information supporting the recommendations in Table 8.3 is found in Table C.1 (Appendix C). This source has the greatest potential to impact water quality when it is not incorporated into the soil, particularly in areas near receiving water bodies and during times when runoff is likely to occur (e.g. late winter and early spring). Nutrient management plans address how and when manure is applied and effectively reduce opportunities for loss of manure to runoff. This is a cost-effective means for reducing loads from this source. Each plan should include requirements for incorporating manure into the soil shortly after it is applied and applying manure on fields at agronomic rates. Total phosphorus loads from this source can be reduced substantially by following these two requirements. Other reductions in surface runoff can occur by transitioning from flood irrigation to sprinkler irrigation. This practice is appealing to private landowners due to savings in time commitment and potential increased crop yield. Composting operations reduce the concentration of phosphorus in manure before it is applied to fields and provide additional options for storage compared to wet and liquid manure. Composting is also less expensive than other practices that reduce surface runoff. Irrigation land leveling promotes consistent application of water and maximizes opportunities for infiltration during flood irrigation.

Table 8.4 includes recommendations for reducing loads from livestock grazing. Detailed information supporting the recommendations in Table 8.4 is found in Table C.2 (Appendix C). Reducing loads from this source should focus on enticing livestock away from streams and river channels or limiting opportunities to directly access waterbodies. This effort would lower the potential for manure deposition in streams and areas near streams where surface runoff is likely to reach the channel. Off-stream watering facilities and shelter structures that provide shade are two methods that move livestock away from receiving water. Fencing is a simple practice that eliminates stream access or restricts access to specific locations. There are numerous intermittent and perennial stream channels in grazed pastures (Table B.2, Appendix B) and fencing is one method that can be used to reduce loads from these areas. Fences can also provide opportunities to implement grazing management. Filter strips are a highly effective method for removing total phosphorus from surface runoff. Vegetation in these buffers also provides bank stability and reduces potential loading from bank erosion. However, private landowners sometimes view filter strips negatively due to the loss of crop land or pasture. Prescribed grazing can reduce phosphorus loading by improving the health and vigor of surface vegetation, which in turn limits surface erosion and filters runoff. Irrigation management can also reduce surface runoff from grazed areas but is relatively more expensive than other grazing BMPs.

Table 8.3. Recommended BMPs to reduce loads from land applied manure.									
Source Reduction Target (lbs/day) = 239						**Unit cost ($)**		**Total cost ($)**	
Practice	**Reduction efficiency (%)**	**Phosphorus reduction/ unit**	**No. of Units**	**Units of practice**	**Total Reduction (lbs/day)**	**Min**	**Max**	**Min**	**Max**
590 - Nutrient Management	50%	0.015	10,000	acre	154	$4	$27	$40,000	$270,000
442 - Sprinkler System , Irrigation Water Management	40%	0.012	1,000	acre	12	$613	$692	$613,000	$692,000
317 - Composting Facility	40%	0.012	5,000	acre	62	$110	$333	$550,000	$1,665,000
464 - Irrigation Land Leveling	35%	0.011	1,100	acre	12	$864	$864	$950,400	$950,400
		Total reduction (lbs/day)			240	TOTAL		$2,153,400	$3,577,400

Table 8.4. Recommended BMPs to reduce loads from livestock grazing.									
Source Reduction Target (lbs/day) = 159						**Unit cost ($)**		**Total Cost ($)**	
Practice	**Reduction efficiency (%)**	**Phosphorus reduction/ unit**	**No. of Units**	**Units of practice**	**Total Reduction (lbs/day)**	**Min**	**Max**	**Min**	**Max**
614 - Watering Facility	50%	3.52E-01	200	each	70	$180	$700	$36,000	$140,000
576 - Livestock Shelter Structure	30%	2.11E-01	50	each	11	$1,805	$2,965	$90,250	$148,250
382 - Fence	50%	1.76E-03	40,000	feet	70	$1	$6	$40,000	$240,000
393 - Filter Strip	50%	1.76E-03	1,500	acre	3	$65	$240	$97,500	$360,000
528 - Prescribed Grazing	10%	7.05E-04	10,000	acre	7	$4	$24	$40,000	$240,000
442 - Sprinkler System , Irrigation Water Management	40%	2.82E-03	1,000	acre	3	$613	$692	$613,00 0	$692,000
		Total reduction (lbs/day)			164	TOTAL		$916,75 0	$1,820,250

Pollutant loading from field drains can be reduced by treating discharge or limiting groundwater inflow to drain lines. Table 8.5 includes recommendations for both methods. Detailed information supporting the recommendations in Table 8.5 is found in Table C.3 (Appendix C). Constructed wetlands provide opportunities for treating discharge through settling, adsorption, and nutrient uptake. Field drain discharge can also be treated by filtration using iron enhanced sand or other sorption materials such as steel slag waste, fly ash, foundry sand, or recycled gypsum. Some of these materials may be waste products generated by Nucor Steel, located in the northwest part of the watershed. Treating field drain discharge with constructed wetlands or media adsorption are both highly effective, but the latter method requires less space and potentially lower cost. Reducing inflow to field drains can occur by managing surface irrigation, either by converting flood irrigation to pressurized sprinklers or through managing application to meet crop needs. Some existing field drains in the lower Bear River watershed have eliminated inflow from housing developments with septic systems. Additional efforts should be made to identify potential inflow from urban development to any field drains in the watershed, particularly for drains that directly discharge to streams and rivers.

Table 8.5. Recommended BMPs to reduce loads from field drains.

Source Reduction Target (lbs/day) = 14						**Unit cost ($)**		**Total Cost**	
Practice	**Reduction efficiency (%)**	**Phosphorus reduction/ unit**	**No. of Units**	**Units of practice**	**Total Reduction (lbs/day)**	**Min**	**Max**	**Min**	**Max**
656 - Constructed Wetland	40%	0.062	100	Field drain outlet	6	$1,400	$11,500	$140,000	$1,150,000
Media Adsorption Bed	50%	0.078	60	Field drain outlet	5	$5,000	$5,000	$300,000	$300,000
442 - Sprinkler System Irrigation Water Management	30%	0.001	2,000	acre	3	$613	$692	$1,226,000	$1,384,000
Reroute lines to eliminate sewer/storm inflow	-	-	-	-	-	-	-	-	-
		Total reduction (lbs/day)			14	TOTAL		$1,666,000	$2,834,000

Phosphorus loading from diffuse runoff can occur at any location in the watershed. Some of the recommended BMPs for other sources will also reduce surface runoff and potential loading from this source in areas near the Bear River and Malad River. Recommended BMPs (Table 8.6) to reduce loads from diffuse runoff will utilize a crop rotation that removes nutrients from the soil and promotes soil health. Detailed information supporting each recommendation in Table 8.6 is found in Table C4 (Appendix C). Cover crops limit surface erosion and promote infiltration by maintaining surface cover outside of the traditional growing season. Cover crops are efficient at reducing phosphorus loads and have a relatively low cost. Range planting in areas where vegetation is limited provides a similar benefit as cover crop. As described earlier, irrigation land leveling reduces surface runoff and erosion by promoting infiltration. This practice would be particularly beneficial on fields near tributaries and rivers. Finally, AFO/CAFO facilities are a pollutant source that is typically evaluated separately from other sources. Loads from AFO/CAFOs are incorporated with loads from diffuse runoff in the updated TMDL. Recent improvements to AFOs have been documented (Elsner 2016). Modeled load reductions from improvements to an average operation ranged from 2.9 – 6.5 lbs/day phosphorus. Based on this information and the number of operations identified in the watershed, substantial load reductions could be made in the watershed with AFO/CAFO improvements.

Table 8.6. Recommended BMPS to reduce loads from diffuse runoff.

Source Reduction Target (lbs/day) = 69						**Unit cost ($)**		**Total Cost ($)**	
Practice	**Reduction efficiency (%)**	**Phosphorus reduction/ unit**	**No. of Units**	**Units of practice**	**Total Reduction (lbs/day)**	**Min**	**Max**	**Min**	**Max**
328 - Conservation Crop Rotation	50%	1.22E-03	1,500	ac	1.83	$2	$360	$3,000	$540,000
340 - Cover Crop	40%	9.78E-04	1,500	ac	1.47	$60	$122	$90,000	$183,000
550 - Range Planting	10%	1.96E-05	500	ac	0.01	$170	$250	$85,000	$125,000
464 - Irrigation Land Leveling	30%	7.33E-04	200	ac	0.15	$1,400	$1,500	$280,000	$300,000
AFO/CAFO improvements		4.69	15	feedlot	70.35	$15,000	$60,000	$225,000	$900,000
	Total reduction (lbs/day)				74	TOTAL		$683,000	$2,048,00 0

8.3.2 NONSTRUCTURAL CONTROLS

Some recommendations for nonstructural controls have already been identified, including those practices where a change in behavior is needed. These practices primarily include nutrient management and prescribed grazing. A critical part of implementing and maintaining these types of projects occurs when a landowner is able to experience secondary benefits (i.e. other than water quality). These benefits can occur as a cost-savings in regard to the amount of time or materials needed to support past practices. Sometimes benefits are hard to quantify and may not occur immediately. As they, opinions and perspectives can change which in turn can change traditional behaviors that influence nonpoint source pollution. A detailed review of other nonstructural controls is included in section 9.6 Information and Education.

8.4 SUMMARY AND CONCLUSIONS

Past management strategies that have been used to improve water quality are generally considered to be acceptable to private land owners. Some of the recommendations made here can be used to improve water quality by reducing loads from several pollutant sources. A review of recent management strategies implemented in the watershed includes improvements to AFOs, some riparian restoration, fencing, and improvements to field drains.

Critical source areas include subwatersheds that drain directly to the Bear River or Malad River. Additional focus should be paid to the land areas directly adjacent to these rivers that have a high potential to contribute surface runoff and loading. This area is considered to generally extend one-quarter mile from the channel bank.

Opportunities for implementing BMPs were based on acres of land that receive manure application and flood irrigation, length of intermittent and perennial stream channels, number and location of field drain outlets, acres of cultivated land, and number of AFO/CAFO facilities. Selection of management strategies can now be made based on knowledge of where pollutant sources are located and where opportunities exist for implementation. Greatest opportunities seem to exist for nutrient management, composting, and AFO/CAFO improvements. Ultimately, any success achieved with regards to water quality improvement is dependent upon the willingness of landowners to implement and maintain management strategies.

The estimated cost of implementing all recommended practices is $5,419,150 - $10,279,650. A reasonable estimate of total cost can be based on the midpoint of this range ($7,349,400) with an increase for future inflation at 10 percent, resulting in a total cost of $8,084,340.

9.0 IMPLEMENTATION PROGRAM DESIGN

This section describes a proposed schedule to implement the BMPs and other measures to improve water quality in the lower Bear River watershed. Defining specific tasks and the associated timeframes with their implementation is necessary to develop a focused and purposeful approach to implement the recommendations in this watershed plan. In addition, this section describes a monitoring approach to quantify the effectiveness of BMPs and other measures to achieve the needed water quality improvements.

9.1 IMPLEMENTATION APPROACH

The Lower Bear River TMDL is a phased TMDL. Implementation of pollutant controls in the lower Bear River watersheds is most likely to be successful using an adaptive management strategy. This approach is a systematic process for improving resource management by learning from management outcomes and implementing that knowledge with flexible decision-making. There is an inherent amount of uncertainty involved in the TMDL process, including establishing water quality targets, calculating existing pollutant loads and necessary load allocations, and projecting the effectiveness of BMP implementation. Use of an adaptive management approach based on continued monitoring of project implementation will help manage resource commitments and achieve success in meeting water quality standards and supporting water quality beneficial uses. This approach allows for adjustments to restoration goals, TMDLs, and/or allocations, as necessary.

Adaptive management allows for changes in recommended BMPs as new information is acquired, but it still sets milestones for implementation to ensure progress toward water quality goals. Section 9.3 establishes milestones for implementing various strategies. Applying adaptive management to remedy nonpoint pollutant sources relies on incentive-based approaches, which require substantial outreach to encourage land owners to adopt best management practices. The information and education components used to encourage landowners are outlined in Section 9.6.

Finally, successful adaptive management relies on intensive monitoring of water quality indicators, pollutant loading, implementation success, and water body response, as well as how the public views success of the watershed plan itself. Section 9.7 addresses the monitoring needed to reduce uncertainty in the lower Bear River watershed so that adaptive management can be successful in achieving state water quality standards.

9.2 IMPLEMENTATION SCHEDULE (EPA ELEMENT F)

Remedying water quality impairments in the lower Bear River watershed will take several years. This section proposes an outline and timeline for implementing programs and strategies for the initial planning horizon of 10 years.

There are three components to implementing this watershed plan including (1) Information and Education (I&E) to promote adoption of BMPs to reduce NPSs, (2) implementing on-the-ground BMP projects to achieve NPS pollution reduction, and (3) monitoring effectiveness of these efforts to reduce NPS. Table 9.1 provides a list and schedule for necessary actions to implement the watershed plan. Water quality monitoring is already on-going in the lower Bear River system, although additional monitoring sites are needed to improve spatial resolution of the data. Increasing the number of monitoring stations is an early task. Long-term studies of water quality, e.g., monitoring canals and streams after storm events, need to begin as soon as possible. Defining connections between streams and canals or characterizing the impacts of reservoir management on water quality are short term activities, but necessary if a water quality model will be used in future assessments.

Table 9.1. Best management practices implementation schedule in the lower Bear River watershed.

Implementation Task	Year									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Information and Education (I&E) (Section 9.6)										
a. Identify target audience and means of delivering I&E message.	X									
b. Develop I&E message.	X									
Tasks to Support Implementation of Best Management Practices (BMPs)										
a. Secure funding to support implementation of BMPs outlined in Section 8.	X									
b. Obtain commitments of land managers to implement BMPs outlined in Section 8.	X	X	X	X						
BMPs (Section 8.2)										
a. Prioritize implementation of BMPs based on participant interest, potential effectiveness, and funding.		X	X							
b. Develop participant commitments to participate in BMPs.		X	X	X	X					
c. Implement BMPs to reduce pollutant loading.			X	X	X	X	X	X	X	X
Monitoring (Section 9.7)										
a. Ongoing collection of water quality data at existing monitoring stations.	X	X	X	X	X	X	X	X	X	X
b. Establish additional monitoring stations.	X	X	X	X	X	X	X	X	X	X

Two activities in particular should be implemented in the first year. The first activity should update the datasets on AFO/CAFO operations and projects that have been implemented at these facilities since the previous TMDL was approved. Each AFO/CAFO should be evaluated to determine if the facility has an updated, functional nutrient management plan in place. A special focus should be made on operations within a quarter mile of the Bear River or Malad River. Information from this evaluation will add spatial detail to results of the updated TMDL and help focus actions recommended in this plan.

Most projects to reduce NPSs will require voluntary actions by individual landowners. This is a difficult task as water quality benefits resulting from NPS improvement projects accrue downstream and sometimes do not directly benefit landowners that implement projects. The second activity occurring in the first year of implementing the plan should include a concerted effort to promote the adoption of better management practices. This is a primary role of the Watershed Stewardship Group or the local Conservation District. Table 9.2 outlines a number of actions and a schedule that should be undertaken by members of these groups or by professional staff under their direction.

The first set of tasks focus on convincing private and public land managers of the importance of adopting better management practices for the entire watershed. This plan has discussed some of the benefits that are expected following implementation of listed BMPs, but support is needed to implement these practices, particularly on private land.

Table 9.2. Implementation Schedule - Watershed Stewardship Group or Conservation District.										
Implementation Task	**Year**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Promote better management on private ground.										
a. Validate secondary benefits of BMPs with landowners; Survey landowners to determine awareness.	X	X	X							
b. Define WQ and other benefits relevant for landowners whose lands have direct impacts on impaired segments.	X	X	X	X	X	X	X	X	X	X
c. Develop materials for stakeholder groups needing education regarding nonpoint pollution and sources.	X	X	X	X	X					
Promote BMP strategies in public sector management plans.										
a. Determine awareness and priorities of public agencies regarding sources of water quality problems.	X	X	X							
b. Participate in processes to incorporate water quality strategies in long term planning efforts in the lower Bear River watershed.		X	X	X	X	X	X	X	X	X
Develop and coordinate capabilities for technical assistance from federal, state, and local agencies.										
a. Program offerings and requirements.	X	X	X	X						
b. Nonpoint strategies.	X	X	X	X						
c. Secondary benefits.	X	X	X	X						
d. Using technical assistance.	X	X	X	X	X	X	X	X	X	X

Such long term and diffuse programs as those required to control NPSs are often complex and change over the years in terms of eligibility, application requirements, etc. A strong role exists for providing technical assistance to individual landowners. Past technical assistance has already made many projects possible throughout the watershed. It is important these technical assistance efforts continue and are coordinated to focus on critical areas that influence water quality and the objectives and watershed goals in this plan. Table 9.2 lists several categories of efforts, from providing information on program offerings to helping landowners obtain technical assistance.

9.3 INTERIM MILESTONES (EPA ELEMENT G)

This watershed plan builds on findings and recommendations developed in the updated TMDL. Table 9.3 proposes specific milestones for implementing BMPs to reduce total phosphorus loading. This table refers to projects triggered by new actions beginning in year 2, assuming it will take some time to develop the necessary programs and materials to promote those actions. It should be recognized that substantial efforts are already ongoing that will result in some projects being undertaken in year 1.

Table 9.3. Specific milestones for implementing BMPs to reduce total phosphorus loading.												
Implementation Task	**Year**										**Total**	**Target**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
BMPs to reduce loads from land-applied manure.												
a. Nutrient Management (acre)	500	1,000	1,000	2,000	2,000	2,000	1,000	500			10,000	10,000
b. Sprinkler System, Irrigation Water Management (acre)		100	100	100	100	200	200	200			1,000	1,000
c. Compost Facility (acre)	100	200	500	1,000	1,000	1,000	1,000	200			5,000	5,000
d. Irrigation Land Leveling (acre)		150	150	200	200	200	200				1,100	1,100
BMPs to reduce loads from livestock grazing.												
a. Prescribed grazing	500	1,000	2,000	2,000	2,000	2,000	500				10,000	10,000
b. Watering facility (structures)	10	20	20	30	30	30	30	20	10		200	200
c. Fencing (feet)	2,000	2,000	5,000	10,000	10,000	6,000	5,000				40,000	40,000
d. Filter strip (acre)	50	50	50	100	200	200	200	300	300	50	1,500	1,500
BMPs to reduce loads from field drains.												
a. Constructed Wetlands (field drain outlets)	5	10	10	15	20	20	20				100	100
b. Sprinkler Systems (acre)		100	100	100	100	400	400	400	400		2,000	2,000
c. Media Absorption Beds (field drain outlets)	5	20	30	5							60	60
BMPs to reduce loads from diffuse runoff.												
a. Conservation crop rotation		200	200	200	200	200	200	200	100		1,500	1,500
b. Cover Crop	200	400	400	400	100						1,500	1,500
c. Range planting				100	200	200					500	500
d. Irrigation land leveling			50	50	50	50					200	200
e. AFO/CAFO improvements	2	3	5	5							15	15
Determine locations to collect monitoring data.	x	x										
Collect water quality and related data		x	x	x	x	x	x	x	x	x		

Note that only a portion of the total needed projects will be accomplished in this first 10-year planning horizon. This recognizes a realistic lag in increasing program participation, but also recognizes a need to learn more about the watershed so as to refine the recommendations on specific kinds and locations of needed projects. The next planning horizon for years 10-20 should build on the knowledge gained during the first 10 years, and assumes this plan will be revisited toward the end of that first horizon.

9.4 INDICATORS TO MEASURE PROGRESS

Indicators listed in this section will facilitate the assessment of progress toward the watershed goals and objectives listed in Chapter 7. The BMPs recommended in this plan are designed to move indicators in the direction of accomplishing watershed goals and objectives regarding total phosphorus. Ultimately, the most important measurement of progress toward water quality goals are the actual water quality concentrations, measured at the right location, frequency, and time of year. Careful attention to monitoring details is particularly important due to the dynamic processes that influence NPS pollution. A water quality monitoring strategy for evaluating progress in the lower Bear River watershed is included in Section 9.7.

Indicators other than water quality concentrations are also useful, such as assessments of riparian habitat conditions, streambank height, vegetative cover, irrigation methods, and participation in conservation programs. Although the cause and effect relationships between these types of indicators and water quality concentrations may not be as direct, they are still considered to be important measures of water quality progress for impaired water bodies and their contributing watersheds.

The indicators suggested for monitoring progress in this watershed plan include the list of water quality indicators in section 7.1 as well as the following:

1. Percent of Small, Medium, and Large AFOs in the watershed with functioning nutrient management plans. This plan recommends emphasizing the subwatersheds that directly drain to the lower Bear River and Malad River
2. Acres of land converted from flood to sprinkler irrigation.
3. Acres of land within one-quarter mile of the Bear River and Malad River that receive land-applied manure.
4. Percent of field drain outlets within a quarter-mile of the Malad or Bear River that are treated with wetlands or media adsorption beds.
5. Number of off-stream watering developments.
6. Linear feet of installed fence to restrict or eliminate livestock access to receiving water bodies.
7. Linear feet of buffer strip planted next to intermittent or perennial streams.
8. Acres of conservation cover crop planted.

9.5 COSTS AND TECHNICAL ASSISTANCE NEEDED

Nonpoint source pollution control programs are usually incentive-based. Therefore, the total cost to design and implement conservation practices is typically shared between public sector agencies charged with improving water quality and stakeholders who must implement the practices. In recent years, the typical distribution of funding sources discussed in section 2.4 represents costs associated only with implementation of particular projects; it does not include the costs of technical assistance or program management.

Technical assistance is an important component; information and education programs recommended in this chapter suggest how resource managers can encourage participation. Once stakeholders agree to participate in conservation practices, agencies can help directly by providing assistance with application forms to qualify for federal and state funding sources, as well as design and construction consultation. Technical assistance in designing simple conservation projects (e.g. fencing, animal crossings, spring development, nutrient management, and livestock grazing) can be provided at no cost by trained technicians and engineers. For more complex practices, applicants may also choose to hire independent technical service providers.

Ongoing operation and maintenance is also a consideration. Individuals who receive water quality program funding are required by contract to maintain projects for a minimum time period depending upon the type of project. In some cases, however, they may choose not to continue maintenance beyond the required period, which may reduce the effectiveness of the project. The watershed coordinator can play a vital role by maintaining communication over the long term with individuals who have implemented conservation practices to encourage them to continue to maintain these projects. In the process, the watershed coordinator should also take advantage of educational opportunities to demonstrate and reinforce the benefits of water quality.

Tables 8.3-8.6 provide a range of cost estimates for implementing recommended BMPs and management strategies. Public involvement efforts including I&E are a critical part of the success of this plan and should be funded along with structural controls. The total cost for implementing the watershed plan ranges from $5.4–$10.3 million. Costs to implement various management strategies in the lower Bear River watersheds were estimated based on the NRCS cost list (NRCS 2016) and a recent cost report that provided multiple scenarios with cost information for each NRCS practice code (NRCS 2015). Documentation to date indicates the cost of past I&E activities are low and typically less than $5,000 per year. The cost of I&E could increase in the future as additional efforts are made to engage stakeholders which could require a larger portion of the total plan cost.

9.6 INFORMATION AND EDUCATION ACTIVITIES (EPA ELEMENT E)

The I&E component of the watershed plan fulfills EPA element e of the nine minimum elements in a watershed plan. An I&E program is used to "…enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented." Activities associated with an I&E program should be integrated directly into efforts to implement the watershed plan. Participation in water quality improvements is voluntary and depends on many factors that are not easily recognized and defined. The I&E program presented in this section should be periodically evaluated to determine which methods are effective and which are not.

9.6.1 Goals and Objectives

Goals and objectives of the I&E program should support and reinforce the goals and objectives defined in Chapter 7. The primary goal of this watershed plan is to restore beneficial uses impaired by total phosphorus. Impairment of water bodies has resulted in part from human activities that generate pollution. Therefore, I&E goals and objectives should work to change human behaviors and activities that contribute to pollution. Changes in human behavior take time and voluntary participation. In general, efforts to change human behaviors that contribute to NPS pollution should focus on creating awareness, providing information, and encouraging action. The initial goals and objectives of the I&E program for this watershed plan consider these areas. I&E considerations that support objectives listed in Chapter 7 are discussed in the following sections.

9.6.1.1 Target Audience

The target audience for the I&E program will be those individuals who have the greatest potential for improving water quality. These individuals primarily include land owners and managers of land areas that contribute to water quality impairment through their management actions. Efforts to inform and educate people living in the lower Bear River Watershed should initially focus on those individuals who have the greatest potential for improving water quality. This potential can be defined in terms of the following factors:

- Location: Where do people live with respect to critical areas and impaired water bodies?

- Livelihood: What do people do for a living or participate in that may directly or indirectly affect water quality? Do these daily actions contribute pollution to impaired water bodies?
- History: Have individuals participated in water quality improvement projects in the past? If so, are these projects being properly maintained?
- Visibility: Do people with potential to influence others have opportunities to implement conservation practices?

Individuals that live adjacent to impaired water bodies or manage property in river corridors have the greatest opportunities to reduce pollutant loading from processes that were identified in the TMDL. These individuals can be located geographically by examining property ownership adjacent to impaired water bodies. This information can be obtained by searching public records, including plat maps and tax records. Prior to contacting this group, the list of individuals should be cross referenced with NRCS records to identify which individuals have already participated in conservation programs. Land owners with no prior involvement in programs should be contacted first to discuss key principles of the I&E program, including funding opportunities to improve water quality, and the secondary benefits of doing so.

9.6.1.2 I&E Message

The core principles of the I&E message must be centered on the benefits of improving water quality in impaired segments. These principles tie directly back to the watershed goals outlined in Section 7.1.1. The watershed goal is focused on restoring beneficial uses impaired by total phosphorus. The path to achieving this goal includes implementing practices that restore watershed conditions. The basic task of the I&E program is to convince stakeholders that involvement in activities that achieve watershed goals is desirable.

Few people are opposed to enjoying the benefits of good water quality. Difficulties arise when it becomes necessary to take actions or make changes to stop pollution or improve degraded conditions. People can be opposed to participating in improvement efforts for a number of reasons including lack of conviction (e.g. disbelief that their actions are contributing pollution), cost of implementation, lack of information, and even apathy. It is likely that good water quality is important to most individuals, particularly those individuals (both public and private) involved with land and resource management. In regards to private landowners, good water quality may be a lower priority simply due to the cost or inconvenience of implementing conservation practices.

Voluntary participation in this watershed plan is a reality that must be addressed in the I&E program. Therefore, the focus of the I&E message should be directed towards helping stakeholders recognize the secondary benefits of implementing conservation practices to themselves as well as direct water quality benefits to downstream locations. These benefits should be clearly defined and incorporated in any messages delivered to the target audience.

9.6.1.3 Delivering the message

The I&E program can be implemented by delivering the message to stakeholders. Characteristics of the target audience should be considered when delivering the message such as age, background, experience and other factors that may influence how the message is received. For instance, older members of the target audience can be reached through radio, newspaper, or television while younger members are more likely to be reached through the internet, social media, public schools, and youth programs. Some methods that can be used to deliver the I&E message include:

- Conduct public awareness campaign through radio, newspaper, and printed media (flyers or brochures) in the local communities regarding the watershed plan and goals and objectives established by the plan.

- Provide information via radio stations that can be heard in Tremonton, Brigham City, and the surrounding areas including KSOP 104.3 FM, KUBL 93.3 FM, and KVNU 102.1 FM and 610 AM .
- Distribute information regarding water quality concerns and secondary benefits of conservation practices at the Box Elder County Fair.
- Contact members of the target audience through in-person interviews.
- Collaborate with individuals to implement conservation practices. Discuss secondary benefits of implementing conservation practices.
- Attend Northern Utah Conservation District meetings and present information regarding secondary benefits of conservation practices and funding opportunities.
- Submit monthly editorial column to the *Box Elder News Journal* (Brigham City), *the Leader* (Tremonton), and the *Herald Journa*l (Northern Utah) discussing a water quality topic, accomplishments of stewardship group, and meeting times and dates.
- Participate in education programs to be held at public schools including elementary, middle, and high school schools located in east Box Elder County. Create age-appropriate activities to involve students including hands-on demonstrations that will indicate influences of degraded water quality.
- With support of teachers and staff in middle and high school science programs, develop and implement an on-going water quality monitoring curriculum. Subjects could include collection and assessment of data, publication of results through internet-based media, and interaction with other schools in different geographic regions involved in similar programs.
- Develop and maintain website discussing watershed goals and objectives, recent water quality improvement activities, water quality data, and information describing secondary benefits of conservation practices. Provide links to the Bear River Watershed Information System that contains data and helpful resources that characterize water quality concerns in the lower Bear River Watershed.
- Establish a Facebook page for lower Bear River water users to disseminate information and follow-up on programs identified above.

9.6.1.4 Evaluation

Progress towards achieving I&E goals and objectives should be evaluated and measured on a regular basis. It is recommended the I&E program be evaluated every year following approval of this watershed plan. The methods and approaches used to implement the I&E program will change over time. Evaluation of the I&E program is critical to ensure the best methods and approaches are being used to provide information to stakeholders and promote participation in conservation practices and programs.

Measurements of I&E success and progress towards goals and objectives can be defined by measuring indicators that reflect change in programmatic, social, and environmental categories. Some examples of each indicator include:

Programmatic	Social	Environmental
Newspaper articles printed. People educated/trained. Public meetings held. Volunteers attending.	People surveyed with increased knowledge of issues. People surveyed with changes in behavior. Participation at watershed events.	AFO/CAFOs with nutrient management plans. Acres of conservation cover crop. Miles of filter strips or fencing near streams.

Progress towards goals and objectives may be difficult to directly measure, such as raising awareness of water quality or defining opinions regarding water quality issues. Opinion surveys are a valuable tool in quantifying perceptions and attitudes. Education of stakeholders can be evaluated based in part on opinion surveys as well as the number and type of activities where water quality information is distributed. Changes in human behavior are one of the most conclusive metrics for evaluating progress of the I&E program.

9.7 MONITORING APPROACH (EPA ELEMENTS H AND I)

One purpose of a watershed monitoring program is to determine if progress is being made toward the watershed goals and objectives specified in Section 7.1.1. Watershed goals are currently defined in terms of restoring beneficial uses impaired by total phosphorus. Watershed objectives include actions that reduce or eliminate pollutant loading. An additional purpose of a monitoring plan is to clearly define existing water quality conditions. The TMDL contained an initial review of existing water quality in impaired segments but also identified areas where data is limited. This watershed plan will include recommendations to collect additional data to define existing water quality conditions and characterize the cause and effect relationship between water quality and pollutant sources.

The relationship between water quality and pollutant sources is difficult to define in nearly any situation. Two factors that complicate this relationship include total area of the watershed (approximately 747 square miles in Utah) and the distance between receiving water bodies and pollution sources. Both factors are prevalent in the lower Bear River watershed. A simple question the monitoring program attempts to answer is "What will concentrations be after this practice is implemented?" A properly designed watershed monitoring program will determine if the recommended conservation practices are being effective in improving water quality and reducing pollutant loads. In order to accurately respond to this question, monitoring must take place before, during, and after conservation practices are implemented.

Monitoring efforts will measure indicators listed in Section 7.1.2 as well as the recommended practices and programs that are implemented. The design of the monitoring program will change over time as additional information is gathered that defines critical locations, events, and sources that contribute to water quality impairment.

The objectives for monitoring and assessment in the lower Bear River watershed, as outlined in the updated TMDL include:

1. Strengthening the understanding of a nutrient stressor-response.
2. Developing a better understanding of:
    a. watershed hydrology,
    b. nutrient source pathways, and
    c. the importance of individual pollutant source categories.
3. Tracking restoration projects as they are implemented to assess their effectiveness.
4. Monitoring trends over time to assess progress toward water quality targets in the TMDL.

Recommendations to meet these objectives are provided below.

9.7.1 NUTRIENT STRESSOR-RESPONSE

An intensive sampling effort is recommended during the summer growing season, at representative sites along the Bear River and Malad River, to develop a better understanding of the nutrient stressor-response relationship and to answer the questions posed in Section 8.1 of the updated TMDL (Utah DEQ 2018). The parameter list should include both phosphorus and nitrogen, discharge, and response variables including measures of water column and benthic algae, dissolved oxygen (DO), 5-day biochemical oxygen demand (BOD_5), macroinvertebrates, and turbidity or some other measure of the water column sediment concentration. 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.

Some specific considerations include:

- **Number of Samples**: A minimum of 12 samples are recommended, during the summer growing season, for phosphorus, nitrogen, water column sediment, and discharge.
- **Dissolved Oxygen**: Elevated daily DO delta values (daily maximum minus the daily minimum, or delta) may indicate high productivity and the potential for impacts on fish and aquatic life. DO sampling is recommended for at least three of the sampling events to determine the delta value. The daily minimum can be measured pre-dawn–8:00 am, while the daily maximum usually occurs between 2:30–5:00 pm. Alternatively, a long-term DO dataset could be collected by deploying a YSI 6600 (or similar instrument) for at least 1 full day, with a 15-min time step (3 times).
- **BOD_5**: At least three BOD_5 sampling events are recommended. High BOD_5 can indicate presence of large quantities of dissolved and suspended organic matter, whose decomposition can produce a large DO demand and can help determine if DO sags are caused by high primary productivity, high BOD_5, or both.
- **Benthic Algae Biomass**: At least three sampling events for benthic algal biomass are recommended.
- **Diatoms and Macroinvertebrates**: At least two diatom and macroinvertebrate sampling events are recommended.
- **Macrophytes**: The types of aquatic macrophyte species present at a site can provide insight regarding potential nutrient impairment. The type and percent cover of aquatic macrophytes should be assessed at least once, but, additional assessment is recommended if conditions change throughout the growing season.
- **Site Selection**: A large number of sites need not be selected, but sample sites should be selected in both the Bear River and Malad River. Consideration should be given to the selection of sites coincident with active stream gages and historic Utah DEQ sample sites.

9.7.2 WATERSHED HYDROLOGY

The hydrology of the Malad River and lower Bear River is not well understood. Monitoring will be designed to increase the understanding of the hydrology of the lower Bear River watershed, particularly as it relates to water quality. The monitoring effort will address the following:

Malad River: The Malad River is the largest tributary to the lower Bear River and discharge has not been measured continuously since 1981. Instantaneous flow measurements are limited. Therefore, the significance of TP loading from a large portion of the lower Bear River watershed is unknown and the limited data precludes completion of a detailed analysis of the potential impact of TP loading from the Tremonton WWTP. Given the importance of the Malad River in assessing and ultimately managing the nutrient impairment in the lower Bear River watershed, coordination with potential partners such as USGS or PacifiCorp to install and maintain one or more continuously recording stream gages is recommended. Additional synoptic flow measurements may also be needed to understand flow losses and gains longitudinally from the Idaho border to the mouth, with special attention to the reach from just upstream of the discharge from the Tremonton WWTP down to the mouth.

Hydromodification and Irrigation: The hydrology of the lower Bear River is highly manipulated. Natural flows at Collinston (formerly USGS gage 1011800, which is now operated by PacifiCorp) are affected by storage reservoirs, power developments, diversions for irrigation, and possibly return flow from irrigated areas (USGS 2006). For example, two irrigation canals divert water from the east and west sides of Cutler Dam during the irrigation season. This water is diverted just upstream of the Bear River near Collinston gage (10118000) and is therefore, unaccounted for at the gage (1011800).

Natural flows at the downstream-most site at Corrine (USGS gage 10126000) is affected by Cutler Dam, power development, diversions for irrigation, return flow from irrigated areas, and backwater from the Bear River Bird Refuge about 5 miles downstream (USGS 2016). Nutrient loading pathways cannot be fully understood without a thorough understanding of watershed hydrology. A "desktop" analysis is proposed to map the irrigation conveyance system in the lower Bear River watershed, including known points of diversion and return and primary conveyances. Available flow data (for the irrigation withdrawals, returns and the mainstem Bear River and tributaries) should be compiled and a water balance should be developed.

Drainage Tiles: The lower Bear River watershed is extensively tiled. This drainage tile network provides a conduit for direct transport of nutrients and other pollutants from a substantial portion of the watershed directly to the Bear River and tributaries. A desktop GIS analysis, where the drainage tile network is overlain on potential sources of nutrients (e.g., septic systems, livestock grazing areas, concentrated livestock feed areas, land application areas), may be helpful in better understanding nutrient source pathways.

Additional monitoring, including flow and water quality is needed to estimate nutrient loading from field drains. All field drain outlets within a quarter mile of the Bear River and Malad River (including those that discharge directly to rivers) should be field verified and monitored for flow and water quality. Loading data from individual drain outlets is limited and the potential exists for unquantified loading from this source.

9.8 CONCLUSION

Water quality in the lower Bear River watershed is impaired. Remedying these impairments will require substantial short and long term actions on the part of both private and public land managers. Many pollutant sources in the watershed are nonpoint in nature. This requires promoting benefits beyond water quality improvements, which accrue mainly downstream. It is possible to calculate an initial set of project requirements that could resolve all of the impairments due to NPS loading, but it will take many years to implement them and realize the benefit from the results. An adaptive management approach can help to ensure a focus on projects relevant to the impairments, and flexibility with respect to new understandings of the dynamics of the watershed. It is possible to provide appropriate direction even as the necessary implementation plans are refined over time. Significant improvements are possible even in the first 10 year planning horizon. Measuring and reporting improvements are critical for successfully implementing this plan. Stakeholders will be much more willing to engage in increased efforts during the continual planning process if they see positive results in response to implementing water quality improvement projects.

10.0 WATERSHED PLAN IMPLEMENTATION UPDATES

This chapter reserved for future updates to the Lower Bear River Watershed Plan.

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APPENDIX A – STAKEHOLDER SURVEY RESULTS AND ADDITIONAL MAPS

LOWER BEAR RIVER

Suggested BMP Score Sheet

highly effective	effective	sometimes effective	seldom effective	not effective	waste of money	Suggested BMPs	response 1	response 2	response 3	response 4	response 5	response 6	response 7	sum of points	# of responses	averaged response		
						CAFOs / AFOs												**CAFOs / AFOs**
5	4	3	2	1	0	Waste Storage Facility	4	3	4	4	3	5	4	27	7	**3.9**	3.9	Waste Storage Facility
5	4	3	2	1	0	Short term animal waste storage	4	5	2	3	2	5	3	24	7	**3.4**	3.7	Nutrient Management
5	4	3	2	1	0	Waste Treatment Lagoon	5	4	3	4	3	5	1	25	7	**3.6**	3.6	Waste Treatment Lagoon
5	4	3	2	1	0	Nutrient Management	5	3	4	3	3	3	5	26	7	**3.7**	3.4	Short term animal waste storage
						Land Applied Manure												**Land Applied Manure**
5	4	3	2	1	0	Composting Facility	5	5	4	4	2	4	4	28	7	**4.0**	4.1	Nutrient Management
5	4	3	2	1	0	Conservation cover	3	0	2	3	5	4	2	19	7	**2.7**	4.0	Composting Facility
5	4	3	2	1	0	Field Border	3	0	4	3	5	3	0	18	7	**2.6**	2.7	Conservation cover
5	4	3	2	1	0	Filter Strip	3	0	3	3	5	3	0	17	7	**2.4**	2.6	Field Border
5	4	3	2	1	0	Grassed Waterway	3	3		1	1	3	3	14	6	**2.3**	2.4	Filter Strip
5	4	3	2	1	0	Nutrient Management	5	5	4	4	4	3	4	29	7	**4.1**	2.3	Grassed Waterway
						Livestock Grazing												**Livestock Grazing**
5	4	3	2	1	0	Brush management	1	5		0	4	0	4	14	6	**2.3**	4.5	Fence
5	4	3	2	1	0	Channel bank vegetation	3	3		3	2	4	4	19	6	**3.2**	4.2	Watering facility
5	4	3	2	1	0	Fence	4	5		5	4	4	5	27	6	**4.5**	3.8	Riparian herbaceous cover
5	4	3	2	1	0	Filter strip	3			3	5	4	0	15	5	**3.0**	3.7	Stream bank and shoreline protection
5	4	3	2	1	0	Riparian herbaceous cover	3	5		3	4	4	4	23	6	**3.8**	3.5	Prescribed Grazing
5	4	3	2	1	0	Use exclusion	2	2		1	3	2	3	13	6	**2.2**	3.2	Channel bank vegetation
5	4	3	2	1	0	Prescribed Grazing	2	5		2	4	4	4	21	6	**3.5**	3.0	Filter strip
5	4	3	2	1	0	Stream bank and shoreline protection	4	5		3	3	4	3	22	6	**3.7**	2.3	Brush management
5	4	3	2	1	0	Watering facility	3	5		4	4	4	5	25	6	**4.2**	2.2	Use exclusion
						Field Drains												**Field Drains**
5	4	3	2	1	0	Irrigation system tailwater recovery	5	0	4	2	4	3	4	22	7	**3.1**	3.6	Irrigation water management
5	4	3	2	1	0	Irrigation water management	3	5	4	2	4	2	5	25	7	**3.6**	3.4	Drainage water management
5	4	3	2	1	0	Pond sealing or lining	1	5	3	1	2	2	4	18	7	**2.6**	3.1	Irrigation system tailwater recovery
5	4	3	2	1	0	Drainage water management	5	4	5	2	3	2	3	24	7	**3.4**	2.7	Nutrient management
5	4	3	2	1	0	Nutrient management	3	0	4	2	3	3	4	19	7	**2.7**	2.7	Constructed Wetland
5	4	3	2	1	0	Constructed Wetland	4	4		3	2	2	1	16	6	**2.7**	2.6	Pond sealing or lining
						Diffuse Loads												**Diffuse Loads**
5	4	3	2	1	0	Conservation cover	3	0		3	5	4	1	16	6	**2.7**	4.0	Stormwater runoff control
5	4	3	2	1	0	Diversion	4	2		4	2	4	3	19	6	**3.2**	3.2	Diversion
5	4	3	2	1	0	Grade stabilization	3	3		2	2	4	3	17	6	**2.8**	3.0	Heavy use area stabilization
5	4	3	2	1	0	Land reclamation	3	4		2	2	4	2	17	6	**2.8**	2.8	Grade stabilization
5	4	3	2	1	0	Heavy use area stabilization	3	2		3	3	3	4	18	6	**3.0**	2.8	Land reclamation
5	4	3	2	1	0	Stormwater runoff control	5	4		4	4	4	3	24	6	**4.0**	2.7	Conservation cover

Table A1. Stakeholder survey results (October 11, 2016) indicating preference for suggested BMPs that could reduce phosphorus loading from nonpoint sources in the lower Bear River watershed.

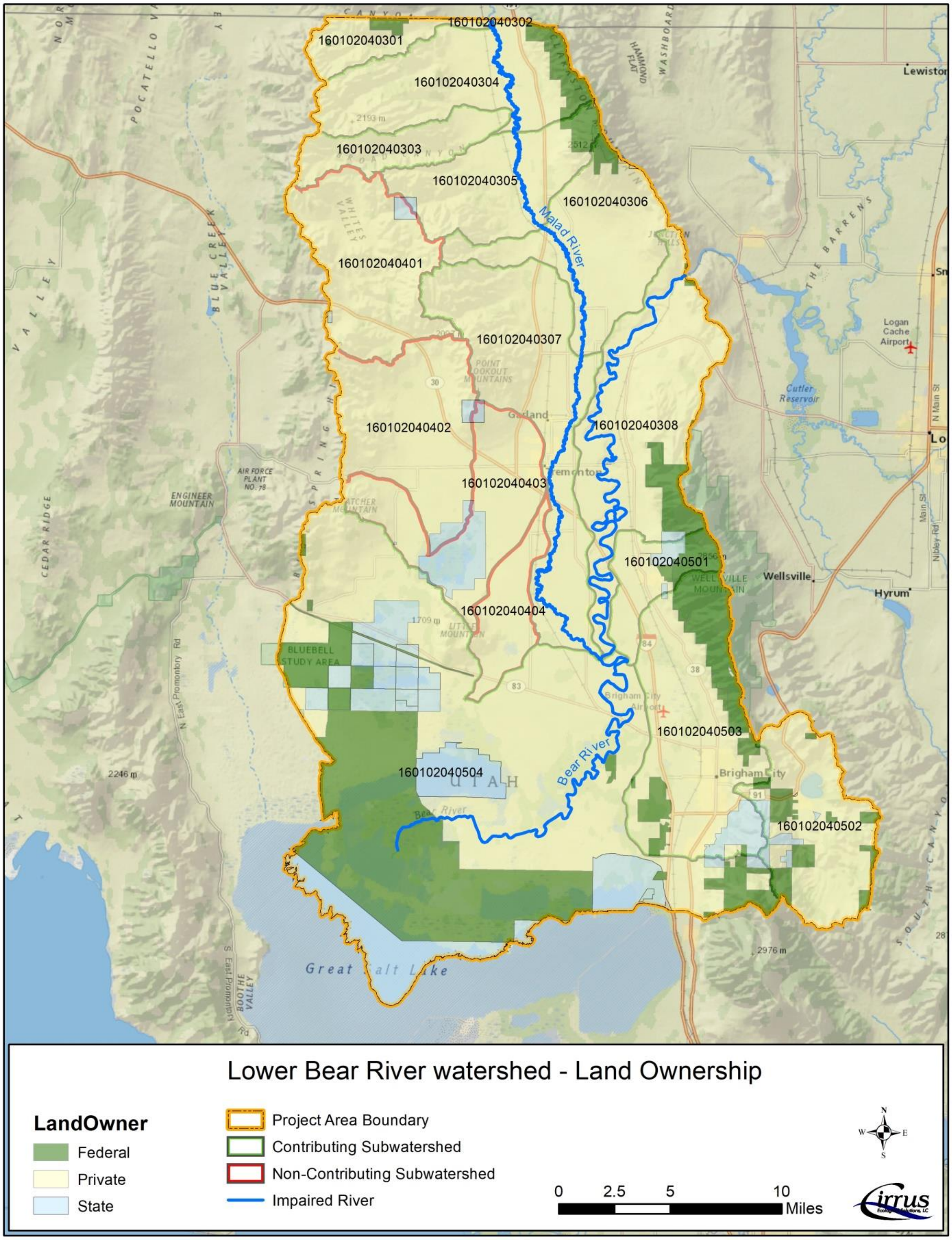

Figure A1. Land ownership categories in the lower Bear River watershed.

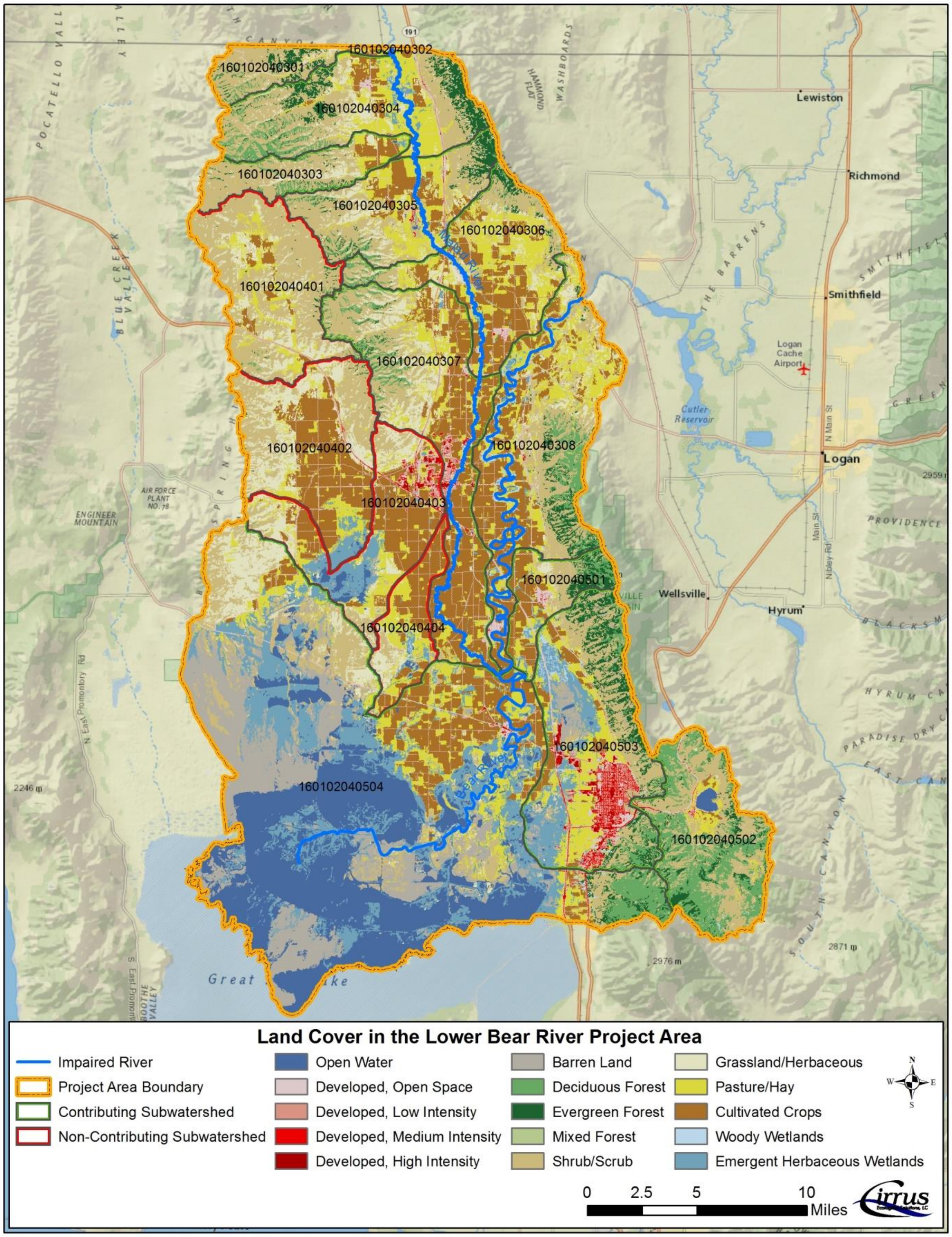

Figure A2. Land cover in the lower Bear River watershed.

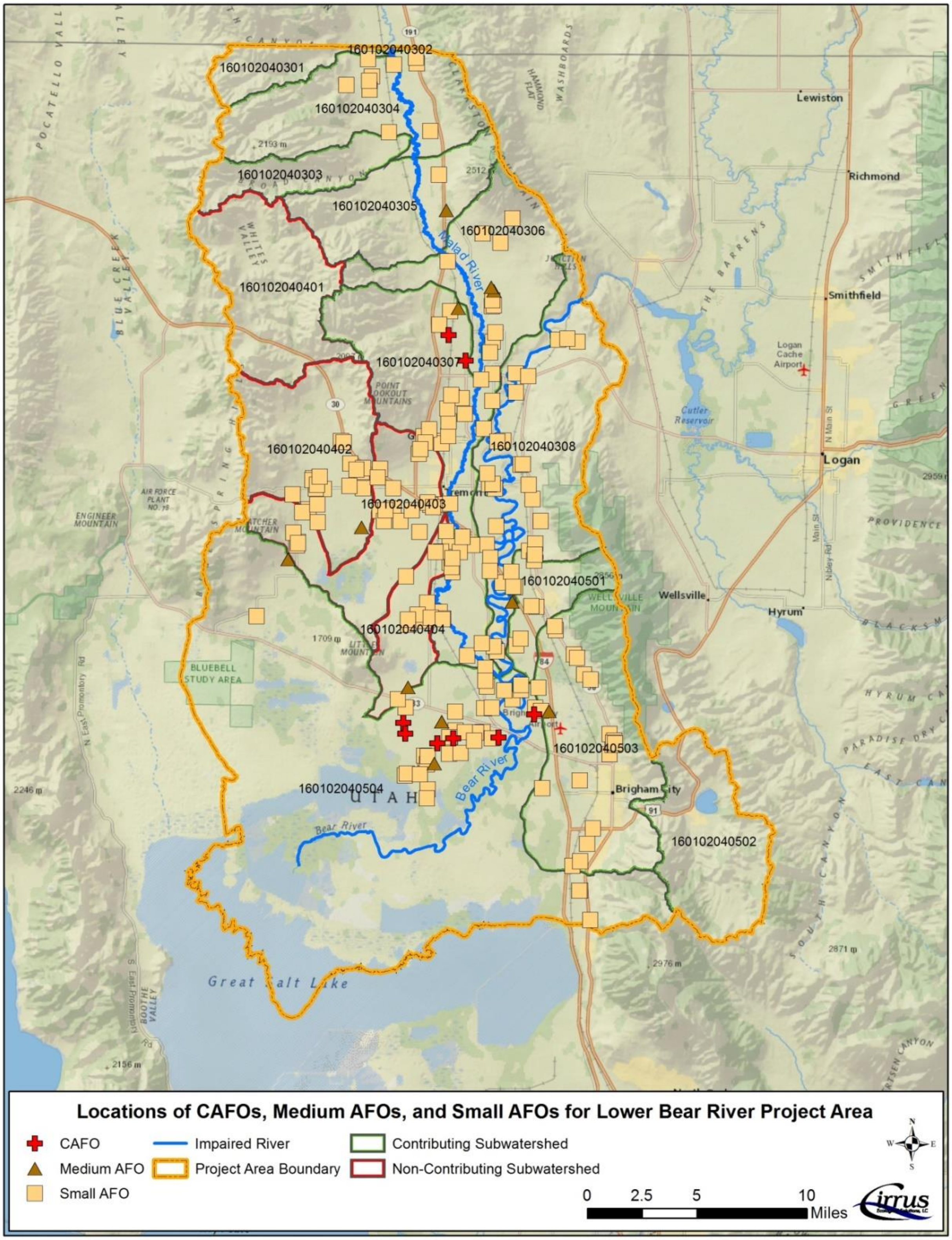
Locations of CAFOs, Medium AFOs, and Small AFOs for Lower Bear River Project Area
CAFO
Medium AFO
Small AFO
Impaired River
Project Area Boundary
Contributing Subwatershed
Non-Contributing Subwatershed
0
2.5
5
10
Miles
160102040301
160102040302
160102040304
160102040303
160102040305
160102040306
160102040401
160102040307
160102040402
160102040308
160102040403
160102040501
160102040404
160102040503
160102040504
160102040502
Malad River
Bear River
Great Salt Lake
Lewiston
Richmond
Smithfield
Logan
Wellsville
Hyrum
Brigham City
UTAH

Figure A3. Locations of CAFOs, medium AFOs, and small AFOs in the lower Bear River watershed.

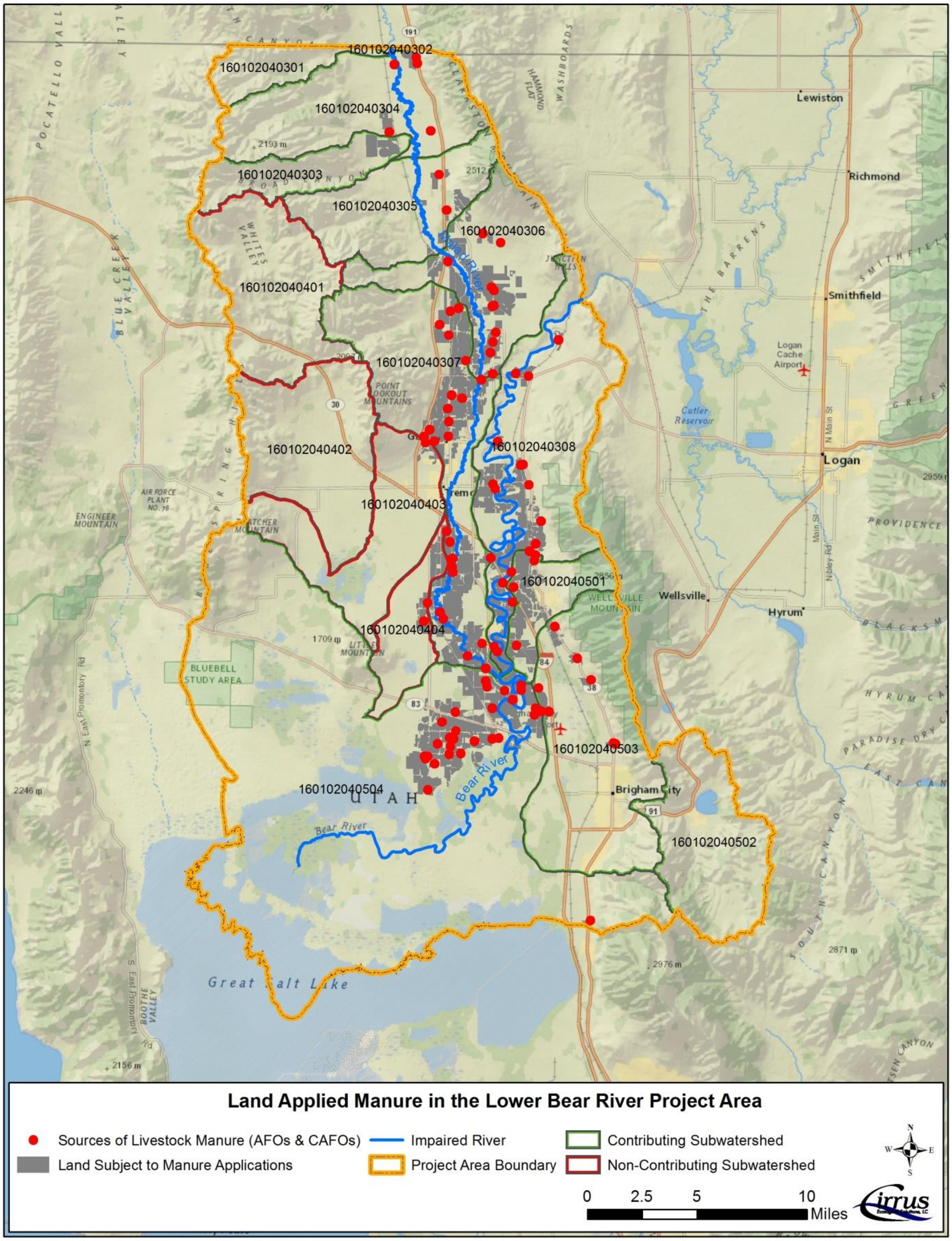
Land Applied Manure in the Lower Bear River Project Area
Sources of Livestock Manure (AFOs & CAFOs)
Land Subject to Manure Applications
Impaired River
Project Area Boundary
Contributing Subwatershed
Non-Contributing Subwatershed
0 2.5 5 10 Miles
160102040301
160102040302
160102040303
160102040304
160102040305
160102040306
160102040307
160102040308
160102040401
160102040402
160102040403
160102040404
160102040501
160102040502
160102040503
160102040504
Bear River
Great Salt Lake
Lewiston
Richmond
Smithfield
Logan
Wellsville
Hyrum
Brigham City

Figure A4. Land applied manure in the lower Bear River watershed.

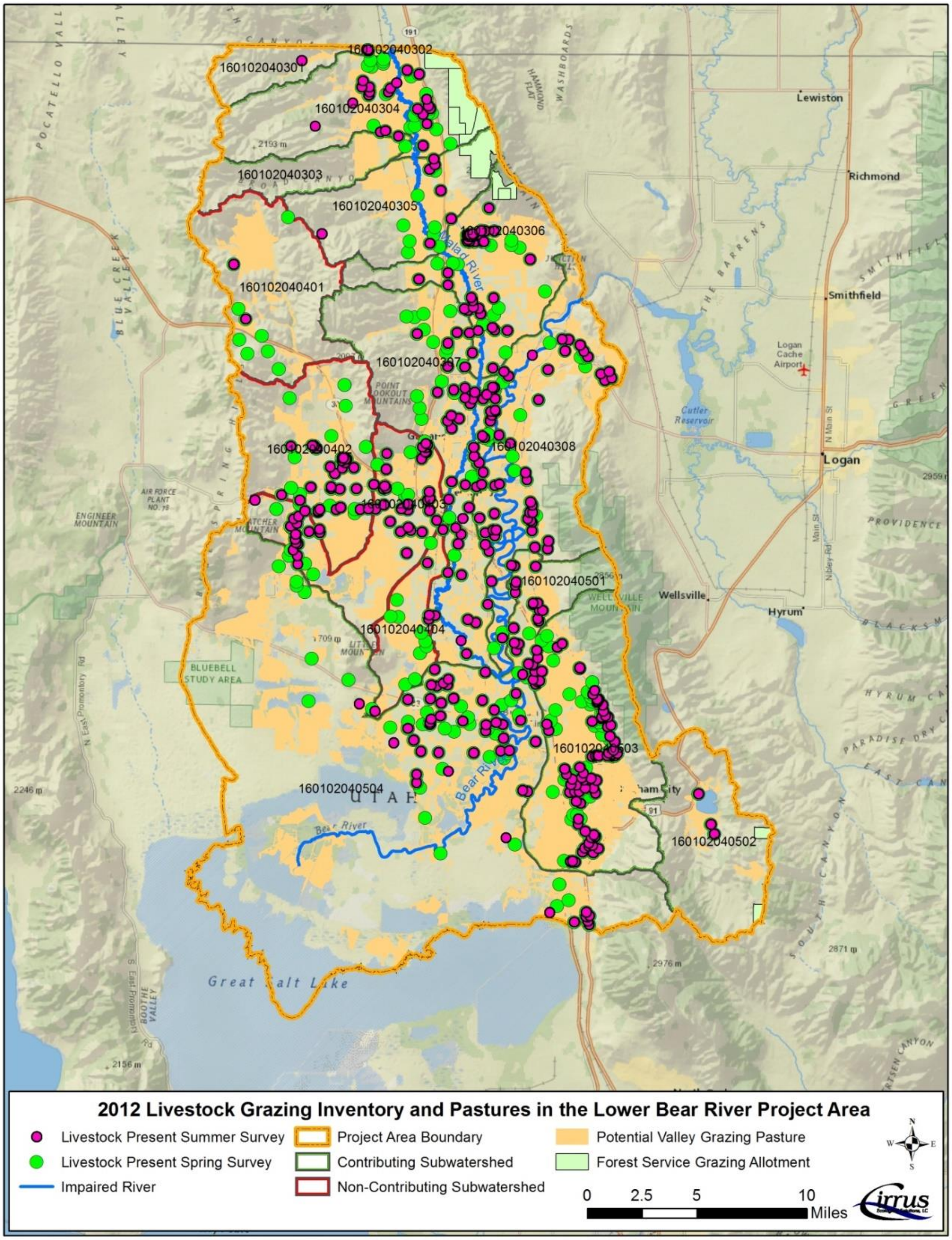
2012 Livestock Grazing Inventory and Pastures in the Lower Bear River Project Area
Livestock Present Summer Survey
Livestock Present Spring Survey
Impaired River
Project Area Boundary
Contributing Subwatershed
Non-Contributing Subwatershed
Potential Valley Grazing Pasture
Forest Service Grazing Allotment
0
2.5
5
10
Miles
160102040301
160102040302
160102040303
160102040304
160102040305
160102040306
160102040307
160102040308
160102040401
160102040402
160102040403
160102040404
160102040501
160102040502
160102040503
160102040504
Malad River
Bear River
Great Salt Lake
Lewiston
Richmond
Smithfield
Logan
Wellsville
Hyrum
Logan Cache Airport
Cutler Reservoir
BLUEBELL STUDY AREA
ENGINEER MOUNTAIN
AIR FORCE PLANT NO. 78

Figure A5. 2012 Livestock grazing inventory and pastures in the lower Bear River watershed.

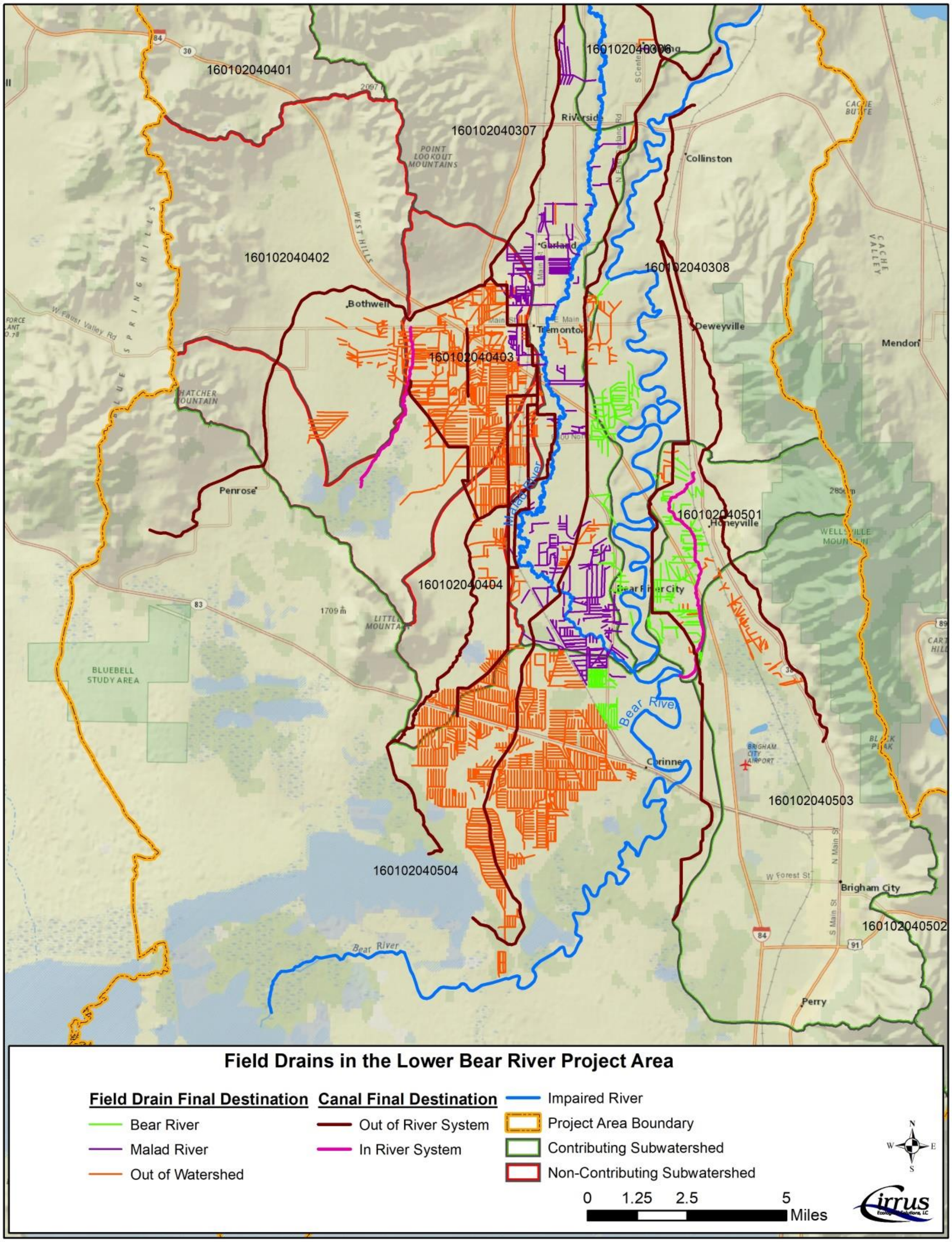

Figure A6. Field drains in the lower Bear River watershed.

APPENDIX B – OPPORTUNITIES TO REDUCE LOADS USING BEST MANAGEMENT PRACTICES

Table B.1. BMP opportunities to reduce loads from land applied manure.						
	Daily total phosphorus load (lbs/day)		All acres receiving land applied manure		Acres receiving land applied manure and flood irrigation	
Subwatershed	**Total (lbs/day)**	**Priority Area Only (lbs/day)**	**Total**	**Priority Area Only**	**Total (ac)**	**Priority Area Only (ac)**
160102040302	0	0	1	0	0	
160102040303	0	0	764	0	0	
160102040304	7	0	505	0	51	
160102040305	29	4	747	203	46	
160102040306	98	40	5,054	1,836	1,041	641
160102040307	205	37	10,875	3,375	8,564	3,277
160102040308	90	61	5,937	4,030	4,350	2,894
160102040501	49	9	2,943	489	2,765	488
160102040503	54	0	878	0	691	
160102040504	594	97	8,899	2,098	8,418	2,007
Total	1,126	248	36,604	12,031	25,926	9,306

Table B.2. BMP opportunities to reduce loads from livestock grazing.							
		Grazed pastures		Grazed pastures receiving flood irrigation		Perennial/intermittent streams in grazed pastures	
Subwatershed	**Daily load (lbs/day)**	**All (ac)[1]**	**Near (ac)[2]**	**All (ac)[1]**	**Near (ac)[2]**	**All (ft)[1]**	**Near (ft)[2]**
160102040301	0.3	540	18	103.1	4.2	17,732	
160102040302	0.0	125	92	24.9	17.4		
160102040303	1.7	1,735	43			40,834	2,872
160102040304	58.4	8,402	2,104	294.5	12.3	112,969	22,838
160102040305	31.5	6,608	1,431			103,956	26,869
160102040306	44.7	11,676	1,598	224.4	73.5	64,570	24,509
160102040307	93.9	9,238	2,487	833.3	256.7	65,063	15,438
160102040308	56.6	13,580	4,540	862.9	391.2	109,978	33,934
160102040501	16.1	2,385	137	368.7	50.1	24,384	1,271
160102040502	1.1	1,747		167.1		23,787	
160102040503	118.7	20,432		4,139.2		196,244	
160102040504	361.2	34,782	4,140	3,838.7	670.9	694,657	114,833
Total	784.2	111,251.4	16,590.5	10,856.8	1,476.1	1,454,174	242,564

[1] All – includes all livestock grazing, [2] Near – includes livestock grazing within 0.25 miles of Bear and Malad Rivers.

Table B.3. BMP opportunities to reduce loads from field drains.										
	Daily loads (lbs/day)			**Field Drains**			**Areas connected to field drains (ac)**		**Flood irrigation on areas connected to field drains (ac)**	
Subwatershed	**All[1]**	**Near[2]**	**Direct [3]**	**All[1]**	**Near[2]**	**Direct [3]**	**All[1]**	**Near[2]**	**All[1]**	**Near[2]**
160102040306	1.32	1.24	1.24	1	1	1	263	8	12	6
160102040307	18.72	13.45	10.88	95	54	41	3,736	777	2,668	559
160102040308	4.28	4.28	3.51	14	9	6	855	219	519	106
160102040501	5.80	0.24		60	1	0	1,157	56	936	45
160102040504	2.08	0.00		28	0	0	416	20	541	16
Total	32	19	16	198	65	48	6,427	1,080	4,676	731

[1] All – includes all field drains, [2] Near – includes field drains within 0.25 miles of Bear and Malad Rivers, [3] Direct – includes only those field drains discharging directly to the Bear and Malad Rivers.

Table B.4. BMP opportunities to reduce loads from diffuse runoff.								
		Cultivated fields - All		**Cultivated fields - Flood irrigation**		**Rangeland**		
Subwatershed	**Daily Load (lbs/day)**	**Area (ac)**	**Load (lbs/day)**	**Area (ac)**	**Load (lbs/day)**	**Area (ac)**	**Load (lbs/day)**	**Med - Small Feeding Operations**
160102040301	0.2	164	0.4	57	0.1	4,986	0.9	0
160102040302	1.8	57	0.1	18	0.04	2	0.0004	-
160102040303	10.0	993	2.4			7,618	1.5	0
160102040304	11.0	1,645	4.0	55	0.1	13,543	2.6	13
160102040305	4.3	2,643	6.5	16	0.0	10,997	2.2	-
160102040306	23.5	7,462	18.2	1,762	4.3	6,981	1.4	18
160102040307	7.8	14,324	35.0	10,674	26.1	12,225	2.5	43
160102040308	33.6	10,110	24.7	5,049	12.3	11,483	2.3	34
160102040501	71.2	2,717	6.6	2,336	5.7	2,112	0.4	13
160102040502	8.8	179	0.4	76	0.2	9,852	1.8	0
160102040503	24.5	2,116	5.2	1,660	4.1	8,609	1.6	25
160102040504	4.8	12,036	29.4	10,212	25.0	22,813	4.6	48
Total	201.3	54,446	133.1	31,915	78.0	111,221	21.8	194

APPENDIX C – RECOMMENDED BEST MANAGEMENT PRACTICES FOR NON-POINT SOURCE LOADING

Table C.1. BMPs recommended for nonpoint source loading from land applied manure.							
NRCS Code	Name and Description	Effect[1]	Rationale	% reduction	Cost[2]	Unit	Reference
464	Irrigation Land Leveling	Slight to Moderate Improvement	The uniform surface that results from this practice increases infiltration and reduces the potential for transport of nutrients to surface water.	25-50	$864	ac[3]	Das et al. (2018), Delp (2016)
590	Nutrient Management	Substantial Improvement	Amount, source, placement, and timing provides nutrients when plants need them most.	40 - 66	$3.15-$26.50	ac	Crowder and Young (1985), Langdale et al. (1985), Shirmohammadi and Shoemaker (1988)
318	Short Term Storage of Animal Waste and Byproducts	Moderate to Substantial Improvement	Short term storage provides flexibility in rate, timing, and location of waste application, with the potential for reductions of contaminants available for transport.		$0.56	ft^3	
442	Sprinkler System	Slight to Moderate Improvement	Erosion and runoff are reduced by the efficient application of irrigation water.	40 - 60	$613-$691.03	ac	Based on general improvement efficiency in water use moving from flood to sprinkle irrigation.
317	Composting Facility	Moderate to Substantial Improvement	Facility will properly treat manure or other agricultural by-products into a stable material. The nutrients are slowly available and less susceptible to losses from runoff or leaching.	23 - 50	$11,017 - $33,354	facility	Sikora and Preusch (2004), Casman (1990)
592	Feed Management	Slight to Moderate Improvement	Reducing the amount of nutrients excreted in manure can reduce the potential for over-application of nutrients on land which the manure is applied, thus reducing the potential for loss to surface waters.	20 - 30	$1.77-$30.38	per animal	USDA (2006)
393	Filter Strip	Substantial Improvement	Solid organics and sediment-attached nutrients are filtered out. Soluble nutrients infiltrate the soil and may be taken up by plants or utilized by soil organisms.	19 - 80	$63 - $241	ac	EPA (2002), CRJC (2000), Schmitt et.al. (1999), USDA (1991), Dillaha et al. (1988), Daniels and Gillman (1996), Lorimor et. al. (2002).
449	Irrigation Water Management	Slight to Moderate Improvement	Water is applied at rates that reduce the potential for erosion and detachment, and minimize nutrient transport to surface water.		$7.20 - $32.94	ac	
591	Amendments for Treatment of Agricultural Waste	Slight to Moderate Improvement	Amendments are often used to remove nutrients and organics from the waste stream		$432.57	ton	

[1] Effect categories defined by the Conservation Practices Physical Effects (CPPE) – National Template. Indicates the magnitude of the practice's effect on the resource concern (i.e.total phosphorus) assuming the practice is fully functional. The term Slight generally signifies no more than a 10 percent change in measurable quantities achievable at the site level. The term Substantial usually indicates more than a 50 percent change at the site level. The term Moderate generally indicates change between 10 – 50 percent at the site level.

[2] Cost Estimates from NRCS (2015).

Table C.2. BMPs recommended for nonpoint source loading from livestock grazing.							
NRCS Code	**Name and Description**	**Effect[1]**	**Rationale**	**% reduction**	**Cost**	**Unit**	**Reference**
576	Livestock Shelter Structure	Moderate Improvement	Moving livestock away from streams and riparian areas will decrease the probability of excess manure nutrients in the water		\$3.61-\$5.93	ft^2	
528	Prescribed Grazing	Slight Improvement	The action increases plant vigor and uptake of nutrients.		\$3.44-\$23.70	ac	
550	Range Planting	Slight Improvement	Improving vegetative cover will reduce runoff and erosion, and reduce the delivery of organics and nutrients to surface water.		\$166-\$246.87	ac	
580	Streambank and Shoreline Protection	Slight Improvement	Stabilizing eroding banks will reduce the delivery of nutrients and organic material in the soil profile to surface water.		\$17.26-\$126.15	ft	
614	Watering Facility	Moderate to Substantial Improvement	When used in place of an in-stream water source, this action decreases manure deposition in stream.	80 - 99	\$0.89-\$3.48	gal	Sheffield et al. (1997), Miner et al. (1992)
472	Access Control	Slight Improvement	Excluding animals, people and vehicles influences vigor and health of vegetation and soil condition reducing runoff when applied with other management practices.		\$26-\$33	ac	
382	Fence	Slight to Moderate Improvement*	Fencing will prevent or restrict access to stream channels	40 - 79	\$0.60-\$5.12	ft	Meals (2001), Line et al. (2000), CBC (2015)
561	Heavy Use Area Protection	Slight Improvement	HUAs will allow collection of manure that would otherwise runoff to contaminate surface water		\$1.05-\$3.69	ft^2	
390	Riparian Herbaceous Cover	Substantial Improvement	Permanent vegetation will uptake excess nutrients.	25 - 65	\$922-\$1775	ac	EPA (2002), Allaway (2003), Dinnes (2004), USDA (1991), Dillaha et al. (1988), Daniels and Gillman (1996)
393	Filter Strip	Substantial Improvement	Solid organics and sediment-attached nutrients are filtered out. Soluble nutrients infiltrate the soil and may be taken up by plants or utilized by soil organisms.	19 - 80	\$63 - \$241	ac	EPA (2002), CRJC (2000), Schmitt et.al. (1999), USDA (1991), Dillaha et al. (1988), Daniels and Gillman (1996), Lorimor et. al. (2002)

[1] Effect categories defined by the Conservation Practices Physical Effects (CPPE) – National Template. Indicates the magnitude of the practice's effect on the resource concern (i.e.total phosphorus) assuming the practice is fully functional. The term Slight generally signifies no more than a 10 percent change in measurable quantities achievable at the site level. The term Substantial usually indicates more than a 50 percent change at the site level. The term Moderate generally indicates change between 10 – 50 percent at the site level.

[2] Cost Estimates from NRCS (2015).

Table C.3. BMPs recommended for nonpoint source loading from field drains.

NRCS Code	Name and Description	Effect[1]	Rationale	% reduction	Cost	Unit	Reference
412	Grassed waterway	Slight to Moderate Improvement	The vegetation in the channel will filter out some sediments, and the vegetation will utilize some nutrients.	34	$1,557.77-$2383.07	ac	EPA (2002)
378	Pond	Slight to Moderate Improvement	The action impounds water reducing the delivery of nutrients to surface water downstream.	19 - 51	$2.04 - $3.86	yd^3	EPA (2002), ASCE (2000)
350	Sediment Basin	Substantial Improvement	The action will tend to accumulate contaminants attached to sediments, and infiltrating waters will remove soluble contaminants.	19	$2.51-$5.09	yd^3	EPA (2002)
646	Shallow Water Development and Management	Slight Improvement	The action traps nutrients and organics which are broken down and used by wetland plants.		$63.94-$161.70	ac	
442	Sprinkler System	Slight Improvement	The action improves water use efficiency resulting in decreased deep percolation.	40 - 60	$613-$691.03	ac	Based on general improvement efficiency in water use moving from flood to sprinkle irrigation.
656	Constructed Wetland	Moderate to Substantial Improvement	The action traps nutrients and organics which are broken down and used by wetland plants.	2 - 76	$1,368 (0.1 ac), $11,157 (1 ac)	ac	Braskerud (2002), Kovacic et al. (2000), Kynkaanniemi et al. (2013), Reinhardt et al. (2005), Tonderski et al. (2005); Erickson et al. (2017)
	Phosphorus Sorption Beds	Moderate to Substantial Improvement	Construct phosphorus removal structures to trap phosphorus carried in runoff and tile drainage.	25 - 33	Build: $5,000 - $10,000 O&M : $1,200	each	Stokes (2017), Penn et al. (2013)
	Iron Enhanced Sand	Moderate to Substantial Improvement	Using iron enhanced sand in drain field to maximize retention of dissolved and particulate phosphorus	42 - 95	Build: $5,000 - $10,000 O&M : $1,200	each	Erickson et al. (2017), Stokes (2017), Penn et al. (2013)
	Steel Slag (Calcium based)	Slight to Substantial Improvement	Using steel slag as a filter to remove dissolved and particulate phosphorus	23 - 89	Build: $5,000 - $10,000 O&M : $1,200	each	Stokes (2017), Penn et al. (2013), Christianson et al. (2017)
	MDR (mine drainage treatment residuals)	Moderate to Substantial Improvement	Using acid mine drainage treatment residuals as a filter to remove dissolved and particulate phosphorus	56 - 98	Build: $5,000 - $10,000 O&M : $1,200	each	Stokes (2017), Penn et al. (2013), Christianson et al. (2017)

[1] Effect categories defined by the Conservation Practices Physical Effects (CPPE) – National Template. Indicates the magnitude of the practice's effect on the resource concern (i.e.total phosphorus) assuming the practice is fully functional. The term Slight generally signifies no more than a 10 percent change in measurable quantities achievable at the site level. The term Substantial usually indicates more than a 50 percent change at the site level. The term Moderate generally indicates change between 10 – 50 percent at the site level.

[2] Cost Estimates from NRCS (2015).

Table C.4. BMPs recommended for nonpoint source loading from diffuse runoff and overland flow.

NRCS Code	Name and Description	Effect[1]	Rationale	% reduction	Cost	Unit	Reference
327	Conservation Cover	Moderate to Substantial Improvement	Less erosion and runoff reduces transport of nutrients. Permanent cover can take up excess nutrients and convert them to stable organic forms.		$72 - $414	ac	
328	Conservation Crop Rotation	Slight to Moderate Improvement	Crops can remove excess phosphorus and nutrients in soil. Slow release nitrogen is provided by legumes and reduce need for additional nitrogen.	83	$2 - $356	ac	Smith et al. (2015)
393	Filter Strip	Substantial Improvement	Solid organics and sediment-attached nutrients are filtered out. Soluble nutrients infiltrate the soil and may be taken up by plants or utilized by soil organisms.	19 - 80	$63 - $241	ac	EPA (2002), CRJC (2000), Schmitt et.al. (1999), USDA (1991), Dillaha et al. (1988), Daniels and Gillman (1996), Lorimor et. al. (2002)
484	Mulching	Slight to Moderate Improvement	The action reduces erosion and runoff, reducing the loss of dissolved and sediment-bound nutrients from the site.		$299	ac	
464	Irrigation Land Leveling	Slight to Moderate Improvement	The uniform surface that results from this practice increases infiltration and reduces the potential for transport of nutrients to surface water.	10 - 50	$1,406 - $1,500	ac	
345	Residue and Tillage Management, Reduced Till	Slight to Moderate Improvement	Less erosion and runoff reduces transport of nutrients.		$39.41 - $171.93	ac	
390	Riparian Hebaceous Cover	Substantial Improvement	Permanent vegetation will uptake excess nutrients.	19 - 80	$922-$1775	ac	EPA (2002), Allaway (2003), Dinnes (2004), USDA (1991), Dillaha et al. (1988), Daniels and Gillman (1996)
359	Waste Treament Lagoon	Moderate to Substantial Improvement	Storage provides flexibility in rate, timing, and location of waste application, with the potential for reductions of contaminants available for transport.	60	$0.22	ft^3	EPA (2002)
340	Cover Crop	Slight to Moderate Improvement	The action reduces erosion and runoff and transport of nutrients. Cover crops can uptake excess nutrients.	27-52	$59.14-$122.15	ac	Aronsson et al. (2011) as cited in Hansen et.al. (2016), Nelson, et al. (2015), Iowa Agriculture Water Alliance (2018)
550	Range Planting	Slight Improvement	Improving vegetative cover will reduce runoff and erosion, and reduce the delivery of organics and nutrients to surface water.	10	$166-$246.87	ac	

[1] Effect categories defined by the Conservation Practices Physical Effects (CPPE) – National Template. Indicates the magnitude of the practice's effect on the resource concern (i.e., total phosphorus) assuming the practice is fully functional. The term Slight generally signifies no more than a 10 percent change in measurable quantities achievable at the site level. The term Substantial usually indicates more than a 50 percent change at the site level. The term Moderate generally indicates change between 10 – 50 percent at the site level.

[2] Cost Estimates from NRCS (2015).

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