E. COLI TOTAL MAXIMUM DAILY LOADS FOR THE SHOSHONE RIVER WATERSHED

Topical Report RSI-2351

prepared for

Wyoming Department of Environmental Quality
Herschler Building 4-W
122 West 25th Street
Cheyenne, Wyoming 82002

October 2013

RESPEC
CONSULTING & SERVICES

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by

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October 2013

Total Maximum Daily Load Summary

Waterbody Name/Description	Dry Gulch (from the confluence with the Shoshone River to a point 7.0 miles upstream)
Assessment Unit I.D.	WYBH100800140107_01
Size of Impaired Waterbody	7.0 miles (11.3 kilometers)
Size of Watershed (Cumulative)	3.2 square miles (8.3 square kilometers)
Location	12-digit Hydrologic Unit Code (HUC): 100800140107
Impaired Designated Use(s)	Recreation
Impairment	*E. coli*
Stream Class	3B
Cause(s) of Impairment	Unknown
Cycle Most Recently Listed	2012
Total Maximum Daily Load Water-Quality Targets	Indicator Name: *E. coli* Primary Contact Recreation: Summer Recreation Season: a geometric mean of not less than five samples obtained during separate 24-hour periods for any 30-day period 126 organisms per 100 milliliters (org/100 mL). These criteria apply from May 1 through September 30. Winter Recreation Season: a geometric mean of not less than five samples obtained during separate 24-hour periods for any 30-day period 630 org/100 mL. These criteria apply from October 1 through April 30.
Analytical Approach	HSPF, Load Duration Curves

Summer Recreation *E. coli* Total Maximum Daily Load Component (expressed as 10^9 cfu/day)	**Flow Zone**				
	High	**Moist**	**Midrange**	**Dry**	**Low**
	> 18.0 cfs	**18.0–17.4 cfs**	**17.4–17.1 cfs**	**17.1–15.5 cfs**	**< 15.5 cfs**
Load Allocation	56	55	53	49	44
Wasteload Allocation	0	0	0	0	0
Margin of Safety	1	1	1	4	4
Total Maximum Daily Load	**57**	**56**	**54**	**53**	**48**

Total Maximum Daily Load Summary

Waterbody Name/Description	Bitter Creek (from the confluence with the Shoshone River to a point 13.9 miles upstream)
Assessment Unit I.D.	WYBH100800140206_01
Size of Impaired Waterbody	13.9 miles (22.4 kilometers)
Size of Watershed (Cumulative)	62.8 square miles (162.7 square kilometers)
Location	12-digit Hydrologic Unit Code (HUC): 100800140206
Impaired Designated Use(s)	Recreation
Impairment	Fecal Coliform (written for *E. coli*)
Stream Class	2AB
Cause(s) of Impairment	Unknown
Cycle Most Recently Listed	2012
Total Maximum Daily Load Water-Quality Targets	Indicator Name: *E. coli* Primary Contact Recreation: Summer Recreation Season: a geometric mean of not less than five samples obtained during separate 24-hour periods for any 30-day period 126 organisms per 100 milliliters (org/100 mL). These criteria apply from May 1 through September 30. Winter Recreation Season: a geometric mean of not less than five samples obtained during separate 24-hour periods for any 30-day period 630 org/100 mL. These criteria apply from October 1 through April 30.
Analytical Approach	HSPF, Load Duration Curves

Summer Recreation *E. coli* Total Maximum Daily Load Component (expressed as 10^9 cfu/day)	**Flow Zone**				
	High	**Moist**	**Midrange**	**Dry**	**Low**
	> 201 cfs	**201–155 cfs**	**155–133 cfs**	**133–106 cfs**	**< 106 cfs**
Load Allocation	742	525	427	344	135
Wasteload Allocation	23	23	23	23	23
Margin of Safety	41	72	31	42	172
Total Maximum Daily Load	**806**	**620**	**481**	**409**	**330**

Total Maximum Daily Load Summary	
Waterbody Name/Description	Whistle Creek (from the confluence with the Shoshone River to a point 8.7 miles upstream)
Assessment Unit I.D.	WYBH100800140303_01
Size of Impaired Waterbody	8.7 miles (14.0 kilometers)
Size of Watershed (Cumulative)	100.9 square miles (261.3 square kilometers)
Location	12-digit Hydrologic Unit Code (HUC): 100800140303
Impaired Designated Use(s)	Recreation
Impairment	Fecal Coliform (written for *E. coli*)
Stream Class	2AB
Cause(s) of Impairment	Unknown
Cycle Most Recently Listed	2012
Total Maximum Daily Load Water-Quality Targets	Indicator Name: *E. coli* Primary Contact Recreation: Summer Recreation Season: a geometric mean of not less than five samples obtained during separate 24-hour periods for any 30-day period 126 organisms per 100 milliliters (org/100 mL). These criteria apply from May 1 through September 30. Winter Recreation Season: a geometric mean of not less than five samples obtained during separate 24-hour periods for any 30-day period 630 org/100 mL. These criteria apply from October 1 through April 30.
Analytical Approach	HSPF, Load Duration Curves

Summer Recreation *E. coli* Total Maximum Daily Load Component (expressed as 10^9 cfu/day)	**Flow Zone**				
	High	**Moist**	**Midrange**	**Dry**	**Low**
	> 101 cfs	**101–92 cfs**	**92–89 cfs**	**89–84 cfs**	**< 84 cfs**
Load Allocation	341	296	280	265	230
Wasteload Allocation	0	0	0	0	0
Margin of Safety	8	14	5	10	30
Total Maximum Daily Load	**349**	**310**	**285**	**275**	**260**

Total Maximum Daily Load Summary

Waterbody Name/Description	Foster Gulch (from the confluence with the Shoshone River to a point 2.0 miles upstream)
Assessment Unit I.D.	WYBH100800140307_01
Size of Impaired Waterbody	2.0 miles (3.2 kilometers)
Size of Watershed (Cumulative)	47.5 square miles (123.0 square kilometers)
Location	12-digit Hydrologic Unit Code (HUC): 100800140307
Impaired Designated Use(s)	Recreation
Impairment	Fecal Coliform (written for *E. coli*)
Stream Class	2C
Cause(s) of Impairment	Unknown
Cycle Most Recently Listed	2012
Total Maximum Daily Load Water-Quality Targets	Indicator Name: *E. coli* Primary Contact Recreation: Summer Recreation Season: a geometric mean of not less than five samples obtained during separate 24-hour periods for any 30-day period 126 organisms per 100 milliliters (org/100 mL). These criteria apply from May 1 through September 30. Winter Recreation Season: a geometric mean of not less than five samples obtained during separate 24-hour periods for any 30-day period 630 org/100 mL. These criteria apply from October 1 through April 30.
Analytical Approach	HSPF, Load Duration Curves

Summer Recreation *E. coli* Total Maximum Daily Load Component (expressed as 10^9 cfu/day)	**Flow Zone**				
	High	**Moist**	**Midrange**	**Dry**	**Low**
	> 54 cfs	**54–49 cfs**	**49–47 cfs**	**47–40 cfs**	**< 40 cfs**
Load Allocation	187	162	149	133	109
Wasteload Allocation	0	0	0	0	0
Margin of Safety	10	4	3	12	16
Total Maximum Daily Load	**197**	**166**	**152**	**145**	**125**

Total Maximum Daily Load Summary	
Waterbody Name/Description	Polecat Creek (from the confluence with Sage Creek to a point 2.5 miles upstream)
Assessment Unit I.D.	WYBH100800140407_01
Size of Impaired Waterbody	2.5 miles (4.0 kilometers)
Size of Watershed (Cumulative)	40.0 square miles (103.6 square kilometers)
Location	12-digit Hydrologic Unit Code (HUC): 100800140407
Impaired Designated Use(s)	Recreation
Impairment	Fecal Coliform (written for *E. coli*)
Stream Class	2AB
Cause(s) of Impairment	Unknown
Cycle Most Recently Listed	2012
Total Maximum Daily Load Water-Quality Targets	Indicator Name: *E. coli* Primary Contact Recreation: Summer Recreation Season: a geometric mean of not less than five samples obtained during separate 24-hour periods for any 30-day period 126 organisms per 100 milliliters (org/100 mL). These criteria apply from May 1 through September 30. Winter Recreation Season: a geometric mean of not less than five samples obtained during separate 24-hour periods for any 30-day period 630 org/100 mL. These criteria apply from October 1 through April 30.
Analytical Approach	HSPF, Load Duration Curves

Summer Recreation *E. coli* Total Maximum Daily Load Component (expressed as 10^9 cfu/day)	Flow Zone				
	High	**Moist**	**Midrange**	**Dry**	**Low**
	> 63 cfs	**63–49 cfs**	**49–46 cfs**	**46–33 cfs**	**< 33 cfs**
Load Allocation	240.1	179.8	145.6	119.7	91.0
Wasteload Allocation	0.2	0.2	0.2	0.2	0.2
Margin of Safety	33.7	12.2	4.7	20.9	9.0
Total Maximum Daily Load	**274.0**	**192.2**	**150.5**	**140.8**	**100.2**

Total Maximum Daily Load Summary

Waterbody Name/Description	Sage Creek (from the confluence with the Shoshone River to a point 14.0 miles upstream)
Assessment Unit I.D.	WYBH100800140408_01
Size of Impaired Waterbody	14.0 miles (22.5 kilometers)
Size of Watershed (Cumulative)	376.4 square miles (974.9 square kilometers)
Location	12-digit Hydrologic Unit Code (HUC): 100800140408
Impaired Designated Use(s)	Recreation
Impairment	Fecal Coliform (written for *E. coli*)
Stream Class	2AB
Cause(s) of Impairment	Unknown
Cycle Most Recently Listed	2012
Total Maximum Daily Load Water-Quality Targets	Indicator Name: *E. coli* Primary Contact Recreation: Summer Recreation Season: a geometric mean of not less than five samples obtained during separate 24-hour periods for any 30-day period 126 organisms per 100 milliliters (org/100 mL). These criteria apply from May 1 through September 30. Winter Recreation Season: a geometric mean of not less than five samples obtained during separate 24-hour periods for any 30-day period 630 org/100 mL. These criteria apply from October 1 through April 30.
Analytical Approach	HSPF, Load Duration Curves

Summer Recreation *E. coli* Total Maximum Daily Load Component (expressed as 10^9 cfu/day)	Flow Zone				
	High	**Moist**	**Midrange**	**Dry**	**Low**
	> 323 cfs	**323–244 cfs**	**244–233 cfs**	**233–184 cfs**	**< 184 cfs**
Load Allocation	1,613.2	912.8	737.6	652.3	529.1
Wasteload Allocation	0.1	0.1	0.1	0.1	0.1
Margin of Safety	133.5	57.4	20.7	65.6	31.2
Total Maximum Daily Load	**1,746.8**	**970.3**	**758.4**	**718.0**	**560.4**

Total Maximum Daily Load Summary	
Waterbody Name/Description	Big Wash (from the confluence with Sage Creek upstream to Sidon Canal)
Assessment Unit I.D.	WYBH100800140408_02
Size of Impaired Waterbody	3.2 miles (5.1 kilometers)
Size of Watershed (Cumulative)	22.9 square miles (59.3 square kilometers)
Location	12-digit Hydrologic Unit Code (HUC): 100800140408
Impaired Designated Use(s)	Recreation
Impairment	Fecal Coliform (written for *E. coli*)
Stream Class	3B
Cause(s) of Impairment	Unknown
Cycle Most Recently Listed	2012
Total Maximum Daily Load Water-Quality Targets	Indicator Name: *E. coli* Primary Contact Recreation: Summer Recreation Season: a geometric mean of not less than five samples obtained during separate 24-hour periods for any 30-day period 126 organisms per 100 milliliters (org/100 mL). These criteria apply from May 1 through September 30. Winter Recreation Season: a geometric mean of not less than five samples obtained during separate 24-hour periods for any 30-day period 630 org/ 100 mL. These criteria apply from October 1 through April 30.
Analytical Approach	HSPF, Load Duration Curves

Summer Recreation *E. coli* Total Maximum Daily Load Component (expressed as 10^9 cfu/day)	Flow Zone				
	High	**Moist**	**Midrange**	**Dry**	**Low**
	> 11 cfs	**11–8 cfs**	**8–7 cfs**	**7–5 cfs**	**< 5 cfs**
Load Allocation	52	32	24	20	15
Wasteload Allocation	0	0	0	0	0
Margin of Safety	9	2	1	3	1
Total Maximum Daily Load	**61**	**34**	**25**	**23**	**16**

Total Maximum Daily Load Summary	
Waterbody Name/Description	Shoshone River (from the confluence with Bighorn Lake to a point 9.7 miles upstream)
Assessment Unit I.D.	WYBH100800140504_00
Size of Impaired Waterbody	9.7 miles (15.6 kilometers)
Size of Watershed (Cumulative)	1,481.3 square miles (3,836.5 square kilometers)
Location	12-digit Hydrologic Unit Codes (HUC): 100800140501, 100800140504
Impaired Designated Use(s)	Recreation
Impairment	Fecal Coliform (written for *E. coli*)
Stream Class	2AB
Cause(s) of Impairment	Unknown
Cycle Most Recently Listed	2012
Total Maximum Daily Load Water-Quality Targets	Indicator Name: *E. coli* Primary Contact Recreation: Summer Recreation Season: a geometric mean of not less than five samples obtained during separate 24-hour periods for any 30-day period 126 organisms per 100 milliliters (org/100 mL). These criteria apply from May 1 through September 30. Winter Recreation Season: a geometric mean of not less than five samples obtained during separate 24-hour periods for any 30-day period 630 org/ 100 mL. These criteria apply from October 1 through April 30.
Analytical Approach	HSPF, Load Duration Curves

Summer Recreation *E. coli* Total Maximum Daily Load Component (expressed as 10^9 cfu/day)	Flow Zone				
	High	**Moist**	**Midrange**	**Dry**	**Low**
	> 5,228 cfs	**5,228–1,747 cfs**	**1,747–1,317 cfs**	**1,317–947 cfs**	**> 947 cfs**
Load Allocation	18,692	9,817	3,103	1,961	701
Wasteload Allocation	1,578	1,578	1,578	1,578	1,578
Margin of Safety	1,314	4,651	616	496	648
Total Maximum Daily Load	**21,584**	**16,046**	**5,297**	**4,035**	**2,927**

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1.0 INTRODUCTION

Section 303(d) of the Clean Water Act (CWA) and the U.S. Environmental Protection Agency (EPA) Water Quality Planning and Management Regulations (40 CFR 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies not meeting applicable water-quality standards or guidelines for the protection of designated uses under technology-based controls. TMDLs specify the maximum pollutant load that a waterbody can receive and still meet water-quality standards. Based on a calculation of the total allowable load, TMDLs allocate pollutant loads to sources and incorporate a margin of safety (MOS). TMDL pollutant load reduction goals for significant sources provide a scientific basis for restoring surface water quality by linking the development and implementation of control actions to attaining and maintaining water-quality standards and designated uses.

The intent of this document is to identify the components of a TMDL, support adequate public participation, and to facilitate the EPA review. The TMDL was developed in accordance with Section 303(d) of the federal CWA and follows EPA guidance. This TMDL document addresses *E. coli* impairments in the Shoshone River Watershed.

Modeling bacteria concentrations and developing TMDLs for the entire watershed will provide a framework for the Wyoming Department of Environmental Quality (WDEQ) and watershed managers on which to base management decisions. TMDLs will also provide reasonable assurance that bacteria impairments will be addressed by continued best management practice (BMP) implementation and that future impairments will be readily addressed with an in-place model and TMDL. Furthermore, outcomes from the TMDLs, such as increased implementation, will protect the recreational designated uses and will not impair or threaten other designated uses assigned to these waterbodies.

1.1 CLEAN WATER ACT 303(d) LISTING INFORMATION

The Shoshone River Watershed has eight impaired segments located downstream of Buffalo Bill Reservoir and upstream of the Big Horn Reservoir (Figure 1-1). For the purpose of this TMDL, the project area is defined as below Buffalo Bill Reservoir located near Cody, Wyoming, to the confluence of the Shoshone River with the Bighorn Reservoir (also known as the Yellowtail Reservoir). The eight impaired stream segments are Dry Gulch, Bitter Creek, Whistle Creek, Foster Gulch, Polecat Creek, Sage Creek, Big Wash, and a segment of the Shoshone River below Lovell, Wyoming [Wyoming Department of Environmental Quality, 2012].

The state of Wyoming classifies streams into four categories and several subcategories. Each category is protected for specific designated uses. Streams within the project area are

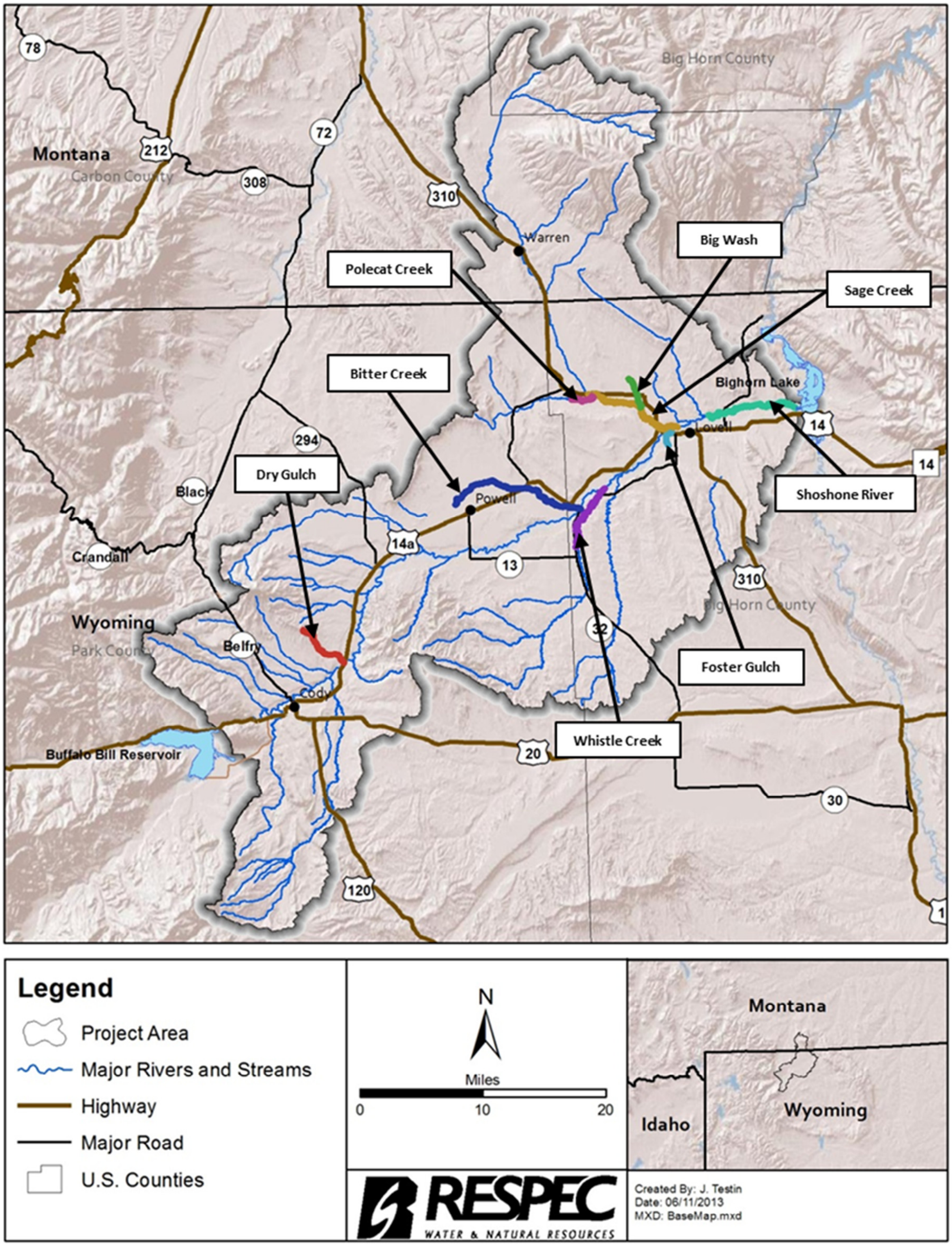

Figure 1-1. Shoshone River Total Maximum Daily Load Project Area Showing the Locations of the Eight Impaired Waterbodies.

classified as 2AB streams except for Foster Gulch, which is classified as 2C, and Dry Gulch and Big Wash, which are classified as 3B streams.

The Wyoming Department of Environmental Quality [2007] states that:

> *Class 2AB waters are those known to support game fish populations or spawning and nursery areas at least seasonally and all their perennial tributaries and adjacent wetlands and where a game fishery and drinking water use is otherwise attainable. Class 2AB waters include all permanent and seasonal game fisheries and can be either "cold water" or "warm water" depending on the predominance of cold-water or warm-water species present. All Class 2AB waters are designated as cold-water game fisheries unless they are identified as a warm-water game fishery by a "ww" notation in the "Wyoming Surface Water Classification List." Unless it is shown otherwise, these waters are presumed to have sufficient water quality and quantity to support drinking water supplies and are protected for that use. Class 2AB waters are also protected for nongame fisheries, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture, and scenic value uses.*
>
> *Class 2C waters are those known to support or that have the potential to support only nongame fish populations or spawning and nursery areas at least seasonally (including their perennial tributaries and adjacent wetlands). Class 2C waters include all permanent and seasonal nongame fisheries and are considered "warm water." Uses designated on Class 2C waters include nongame fisheries, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture, and scenic value.*
>
> *Class 3B waters are tributary waters (including adjacent wetlands) that do not support fish populations or drinking water supplies and where those uses are not attainable. Class 3B waters are intermittent and ephemeral streams with sufficient hydrology to normally support and sustain communities of aquatic life, including invertebrates, amphibians, or other flora and fauna that inhabit waters of the state at some stage of their life cycles. In general, Class 3B waters are characterized by frequent linear wetland occurrences or impoundments in, or adjacent to, the stream channel over its entire length. Such characteristics will be a primary indicator used in identifying Class 3B waters.*

The WDEQ set the primary contact recreation use *E. coli* target during the summer recreation season as a geometric mean of 126 organisms per 100 milliliters (org/100 mL) based on a minimum of five samples collected during separate 24-hour periods for any 30-day period. Note that the water-quality targets are in org/100 mL and laboratory and model results are reported as cfu/100 mL. These units are interchangeable. The summer recreation *E. coli* target is applicable from May 1 through September 30. Primary contact recreation is defined in the *Wyoming Water Quality Standards* [Wyoming Department of Environmental Quality, 2007] as "any recreational or other surface water use that could be expected to result in ingestion of the water or immersion." Some examples of primary contact could include swimming, wading, or boating. From October 1 through April 30, all waters are protected for the secondary contact recreation only and the winter recreation season standard, which has an *E. coli* target of a geometric mean of 630 org/100 mL based on a minimum of five samples obtained during separate 24-hour periods for any 30-day period. Other applicable water-quality standards in these Class 2AB and Class 2C stream segments are summarized in the Wy*oming Water Quality Rules and Regulations* [Wyoming Deparment of Environmental Quality, 2007]. Water-quality standards for Wyoming surface water also include a regulatory policy concerning antidegradation that protects water uses that were in existence on or after November 28, 1975; the level of water quality needed to protect those uses needs to be maintained and protected. To be listed as impaired, a waterbody has to exceed the criterion more than once in a 3-year period [Wyoming Department of Environmental Quality, 2007].

1.2 WATERSHED CHARACTERISTICS

The Shoshone River Watershed (Hydrologic Unit Code [HUC] 10080014) is located in parts of Park and Big Horn Counties in north-central Wyoming and in parts of Carbon and Big Horn Counties in south-central Montana (Figure 1-1). The project area drains approximately 950,262 acres. Upstream of the project area, the North Fork Shoshone River Watershed (HUC 10080012) drains approximately 546,146 acres, and the South Fork Shoshone River Watershed (HUC 10080013) drains approximately 416,211 acres [Natural Resources Conservation Service, 2012a]. The entire Shoshone River Watershed (all three HUCs) drains approximately 1,912,619 acres.

1.2.1 Land Cover and Land Use

The land cover summary is based on the 2006 National Land Cover Database (NLCD), a 21-category multilayer land cover classification dataset that is derived from Landsat imagery and ancillary data that provides consistent land cover data for all 50 states [Multi-Resolution Land Characteristics Consortium, 2012]. The majority of the land cover in the project area is scrub/shrub (43 percent) and grassland/herbaceous (33 percent). Other land covers include pasture/hay, cultivated crops, and evergreen forest, with small percentages of wetlands, developed land, and barren land (Figures 1-2 and 1-3, Table 1-1).

The project area is primarily represented by irrigated land and rangeland interspersed with small urban and suburban areas. Irrigated lands consist of croplands, hay fields/pastures, and small acreages. Some of the irrigated lands are being changed from cropland to small acreages; for example, 82 percent of the land owners in the Shoshone Irrigation District Garland Division own 22 percent of the irrigated lands and have acreages under 40 acres each [Startin, 2013; Trosper, 2013]. Portions of the watershed have oil and gas development as well as bentonite and gypsum mining [Wyoming Department of Environmental Quality, 2012].

Public lands make up approximately 55 percent of the Wyoming portion of the project area and private lands make up the remaining 45 percent. Approximately 89 percent of the publicly owned portion is managed by the Bureau of Land Management (BLM); 9 percent is managed by

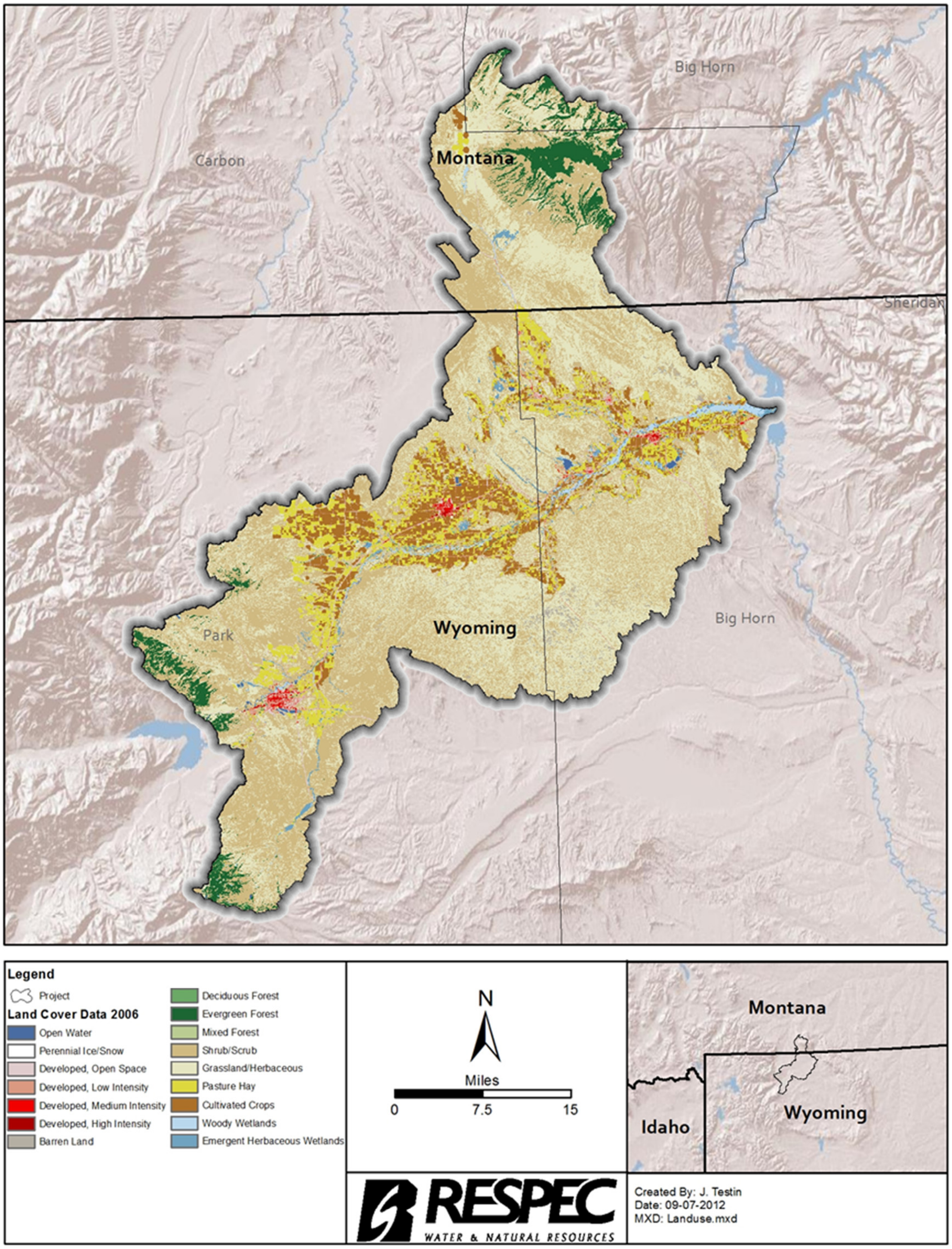

Figure 1-2. Predominant National Land Cover Database 2006.

the Wyoming Office of State Lands and Investments (OSLI); and the remaining 2 percent is managed by the Department of Defense (DOD), the U.S. Forest Service (USFS), the Wyoming Game and Fish Department (WGFD), and the National Park Service (NPS). Public lands make up approximately 70 percent of the Montana portion of the project area and private lands make up the remaining 30 percent. Approximately 36 percent of the publicly owned portion is managed by the USFS, 33 percent is managed by the BLM, 27 percent is managed by the Bureau of Indian Affairs (BIA), and 4 percent is managed by the Montana State Land Board.

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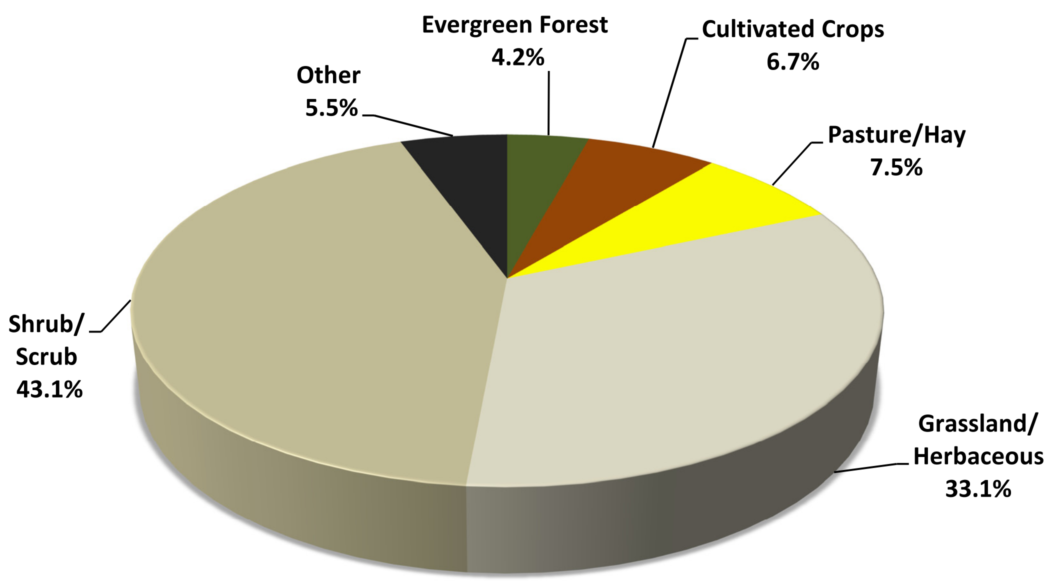

Figure 1-3. Project Land Cover.

1.2.2 Precipitation

Average annual precipitation varies greatly throughout the Shoshone project area and ranges from 5 inches in the lower elevations to 27 inches in the higher elevations of Montana (Figure 1-4). The maximum precipitation generally occurs in the spring.

1.2.3 Water Use

The largest consumptive use of water in the Shoshone project area is irrigation. Irrigated lands include cropland, hayland, and small acreages. Seven irrigation districts and several smaller irrigation diversions are located in the project area. These include four Bureau of Reclamation Shoshone Irrigation Project irrigation districts (Deaver Irrigation District, Shoshone Irrigation District, Heart Mountain Irrigation District, and Willwood Irrigation District), and three private irrigation districts (Cody Canal Irrigation District and Elk-Lovell

Table 1-1. Percentage of Land Cover for Each National Land Cover Database Category Within the Project Area by Impaired Reach

Land Cover Category	Total Project Area (%[a])	Land Cover by Impaired Reach[a] (Percent of Watershed)							
		Dry Gulch	Bitter Creek	Whistle Creek	Foster Gulch	Polecat Creek	Sage Creek	Big Wash	Shoshone River
Open Water	0.2	0.0	0.3	0.0	0.0	0.1	0.1	0.0	0.2
Developed, Open Space	1.2	5.7	3.1	0.4	0.3	1.2	0.9	1.5	1.2
Developed, Low Intensity	1.1	0.4	4.0	0.5	0.4	1.1	0.5	1.8	1.1
Developed, Medium Intensity	0.2	0.0	1.4	0.0	0.0	0.1	0.0	0.2	0.2
Developed, High Intensity	0.0	0.0	0.3	0.00	0.0	0.0	0.0	0.0	0.0
Barren Land	0.7	0	0.2	2.1	0.2	0.2	0.1	0.4	0.7
Deciduous Forest	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Evergreen Forest	4.2	0.0	0.0	0.0	0.0	0.0	10.4	0.0	4.2
Mixed Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shrub/Scrub	43.1	67.7	25.0	39.6	45.9	35.4	43.8	37.4	43.1
Grassland/Herbaceous	33.1	12.3	14.7	50.3	43.5	35.8	33.4	52.1	33.1
Pasture/Hay	7.5	5.5	19.1	2.5	4.5	14.5	5.8	3.2	7.5
Cultivated Crops	6.7	1.2	31.2	4.0	4.1	7.9	3.4	3.1	6.7
Woody Wetlands	1.2	0.4	0.3	0.4	0.9	1.1	0.8	0.2	1.2
Emergent Herbaceous Wetland	0.8	6.7	0.3	0.1	0.1	2.7	0.8	0.0	0.8

(a) Note: because they are rounded, numbers presented in this table do not always add up to exactly 100 percent.

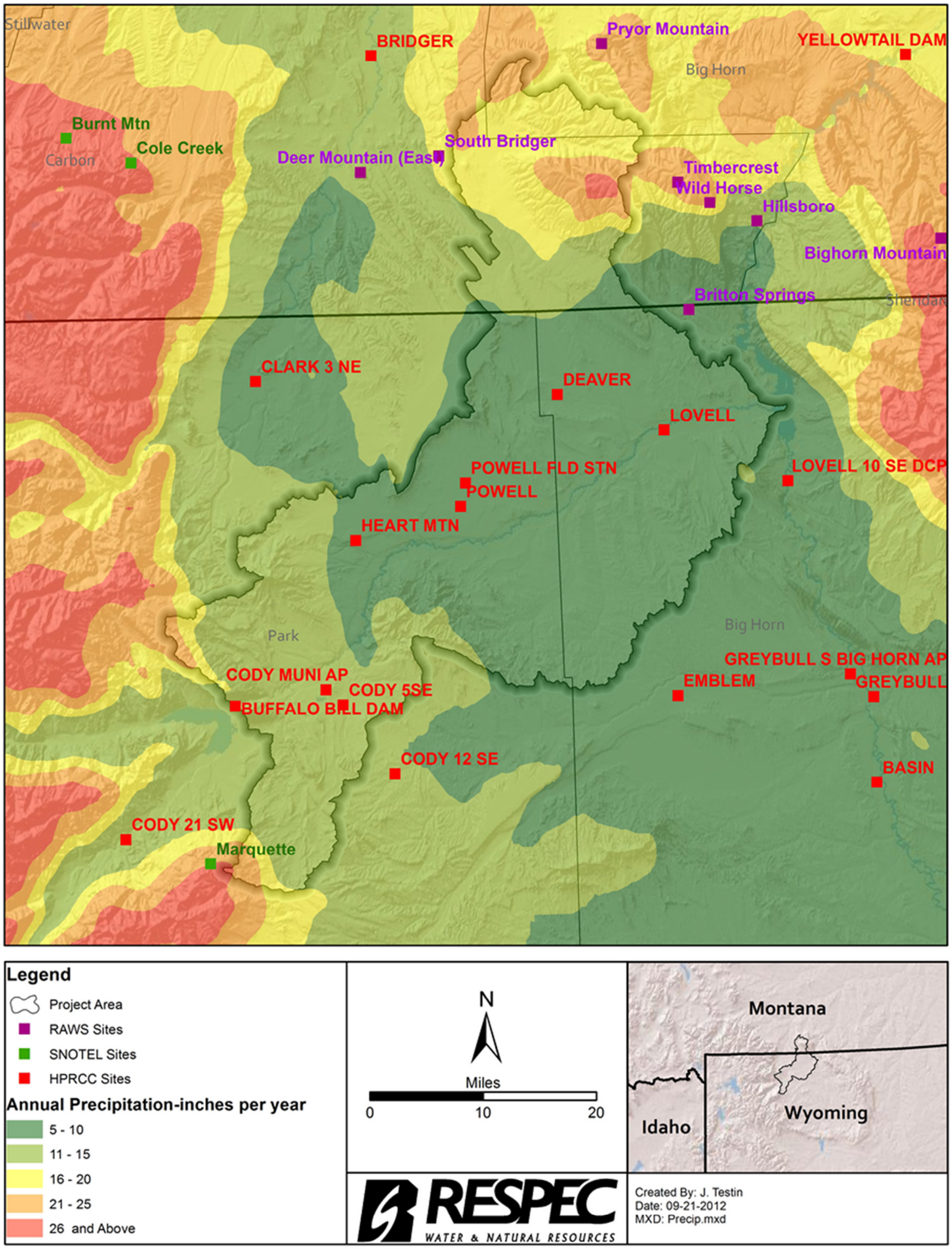

Figure 1-4. Average Annual Precipitation Obtained From Natural Resources Conservation Services' Geospatial Gateway [Natural Resources Conservation Service, 2012b].

Irrigation District, and Sidon Irrigation District). Additionally, a small amount of water from Lakeview Irrigation District, which is a private irrigation district located above the project area, is used within the project area. Buffalo Bill Reservoir, which serves as the project boundary, stores water from the North Fork Shoshone River and South Fork Shoshone River upstream of the project area. Buffalo Bill Reservoir supplies a majority of the water entering the project area and supplies water to irrigators served by a series of approximately 1,120 miles of canals, laterals, and ditches.

Canals diverting from within the project area include Garland/Frannie-Deaver Canal (three canals with a single diversion), Willwood Canal, Elk-Lovell Canal, Sidon Canal, Hunt Canal, and Globe Canal. Lakeview Canal and Cody Canal divert from the South Fork of the Shoshone River. Their return flows reenter the system below Buffalo Bill Reservoir within the project area. Heart Mountain Canal diverts directly from the reservoir, and its return flows also reenter the system within the project area.

1.2.4 Geology and Soils

The Shoshone River Watershed is located in the Big Horn Basin, an intermontane basin of the Rocky Mountains located in north-central Wyoming and southern Montana. The basin is bounded by faulted Laramide orogeny uplifts including the Big Horn Mountains to the east, the Owl Creek Mountains to the south, and the Beartooths and Absaroka Volcanic Plateau to the west (Figure 1-5) [Wyoming State Geological Survey, 2012].

The central region of the watershed consists primarily of Quaternary deposits overlying Tertiary volcanic rocks (Figure 1-6 and Table 1-2). The Quaternary alluvium and terrace deposits cover almost one-third of the watershed and consist of clay-to-boulder-sized clasts deposited as streams, pediments, paleochannels, fan deposits, and terrace fills. In the central region of the watershed, primarily within Park County, a large portion of the terrace deposits directly overlie igneous rocks of the Wiggins Formation (Thorofare Creek Group). The Wiggins Formation consists of conglomerate, volcanic breccia, tuff, and ash beds several hundred feet thick that originated from eruptions in the Yellowstone-Absaroka region approximately 50 million years ago during the Eocene age. These volcanic deposits cover approximately 16 percent of the watershed.

More than 6,000 meters of Paleozoic through Cenozoic sedimentary rocks fill the basin. Looking outward from the center of the watershed, the bedrock becomes progressively older toward the southwest and the north-northeast. The southwestern portion of the watershed is dominated by various Cretaceous age formations and older, Paleozoic outcrops on the anticline near Cody. The third most dominant unit, the Cody Shale, covers approximately 11 percent of the watershed. The southwestern edge of the project also contains two areas of extensive landslide deposits along the slopes of the Absaroka Mountains. The northern half of the watershed also consists of Mississipian through Cretaceous Formations. Younger units are located toward the central region of the watershed and become older toward the north and into Montana.

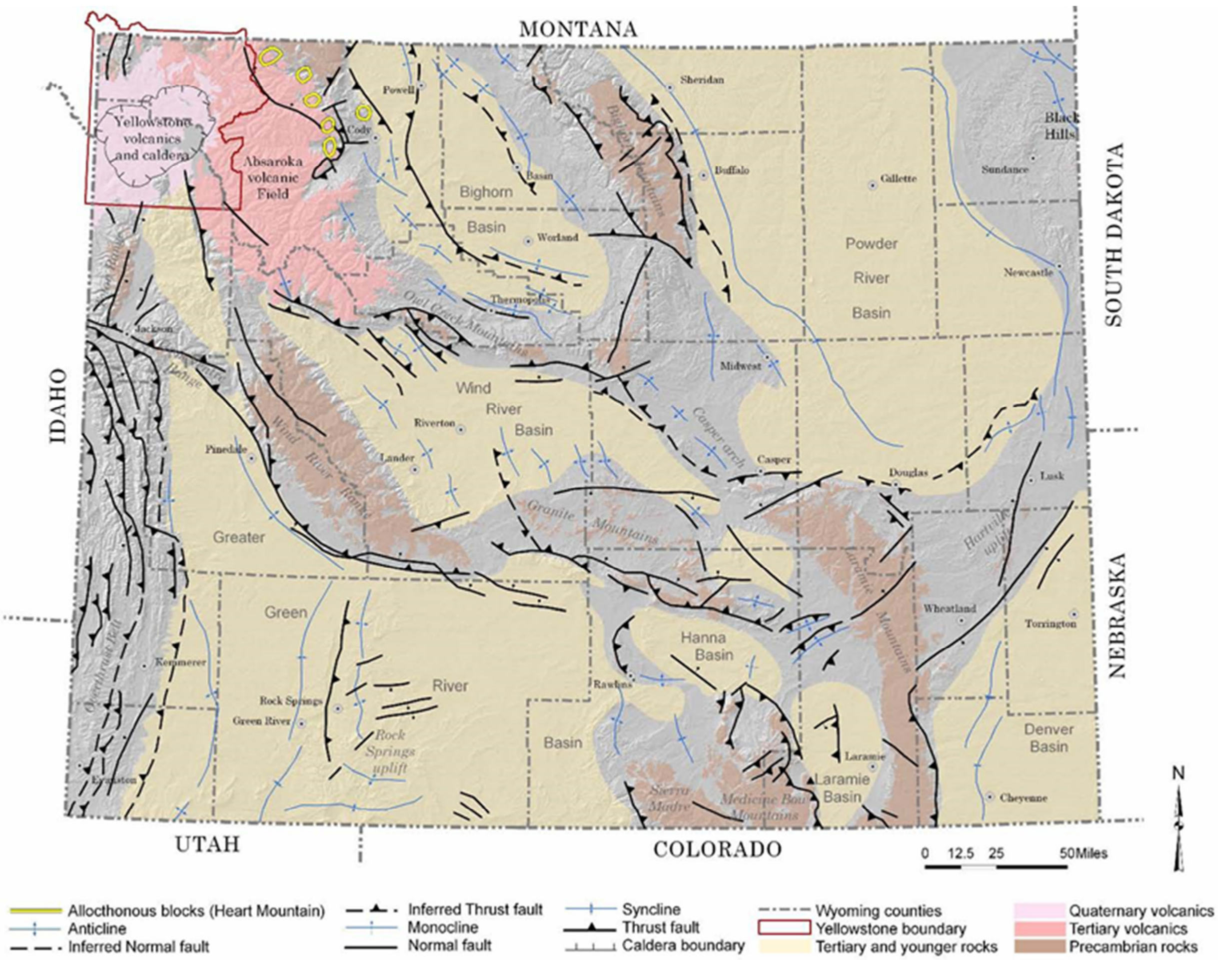

Figure 1-5. Major Structural Elements in Wyoming [Wyoming Geological Survey, 2012].

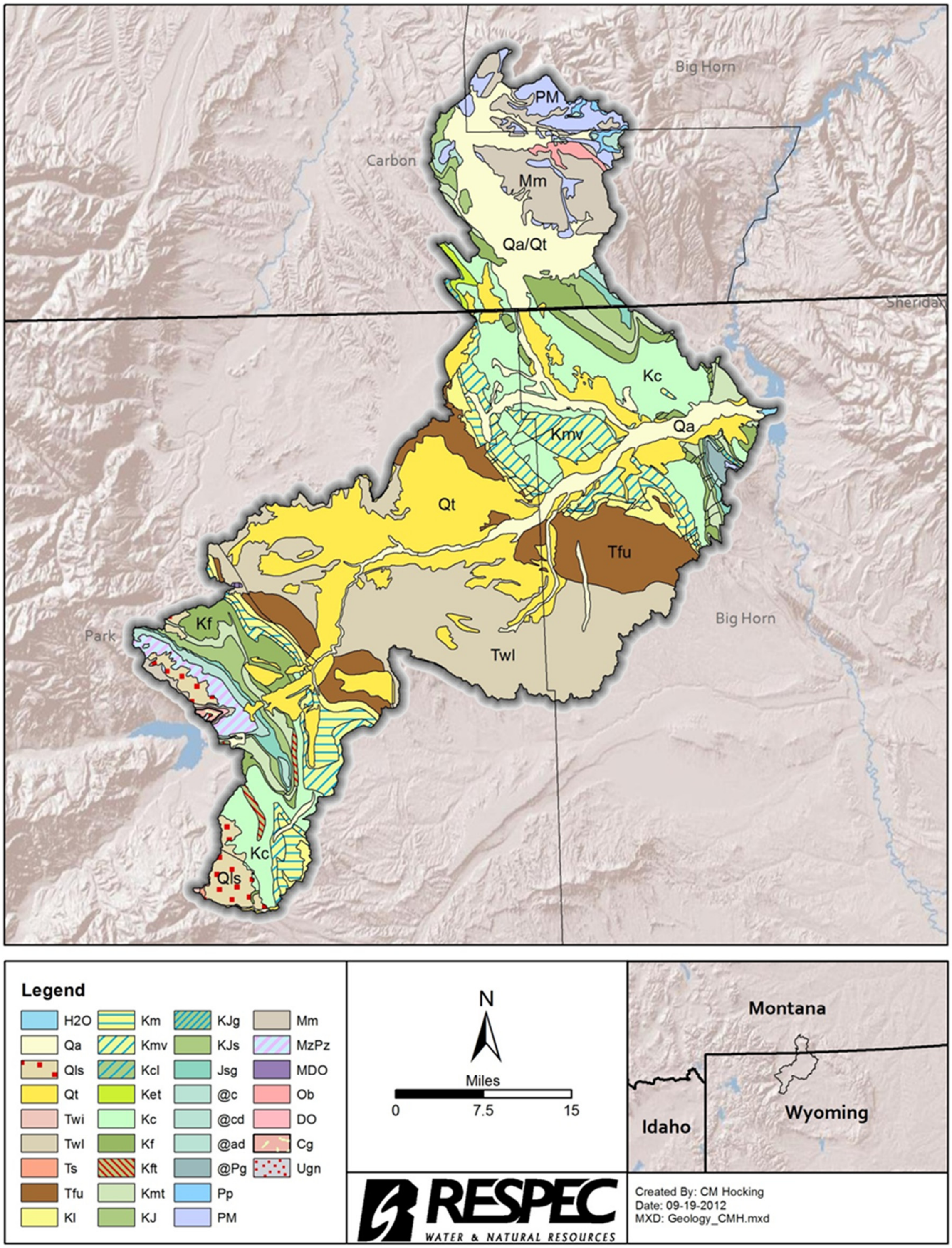

Figure 1-6. Bedrock Geologic Units (See Table 1-2 for Descriptions).

Table 1-2. Bedrock Geologic Units and Watershed Acres (Page 1 of 2)

Map Unit		Area (acres)	Percent of Total
Legend	Name–Description		
H_2O	**Water**	412	0.04
Qa	**Alluvium**–(Quaternary)	107,626	11.33
Qls	**Landslide deposits**–(Quaternary)	19,436	2.05
Qt	**Terrace deposits**–(Quaternary) clay-to-boulder-sized clasts deposited as pediments, paleochannels, fan deposits, and terrace fills of former flood plains	182,177	19.18
Twi and Twl	**Wiggins/Thorofare Creek**–(Eocene) light gray volcanic conglomerate and white tuff, containing igneous clasts	158,338	16.67
Ts	**Sunlight**–(Eocene) intrusive igneous rocks	241	0.03
Tfu	**Fort Union**–(Paleocene) gray shale and sandstone	76,418	8.05
Kl	**Lance**–(Cretaceous) buff sandstone, green shale, and thin conglomerate lenses	19,063	2.01
Km	**Meeteetse**–(Cretaceous) gray-to-white silty sandstone, bentonitic claystone	25,641	2.70
Kmv	**Mesaverde**–(Cretaceous) light-colored sandstone, gray sandy shale, and coal beds	51,595	5.43
Kcl	**Claggett**–(Cretaceous) shale with iron-stained concretions and locally interbedded sandstone	751	0.08
Ket	**Eagle**–(Cretaceous) sandstone and shaley sandstone with few lignite beds	2,432	0.26
Kc	**Cody Shale**–(Cretaceous) upper beds of buff sandy shale and sandstone, lower gray marine shale; seleniferous	104,425	11.00
Kf	**Frontier**–(Cretaceous) gray sandstone and shale	38,450	4.05
Kft	**Frontier, Mowry, and Thermopolis Shales**–(Cretaceous)	2,883	0.30
Kmt	**Mowry and Thermopolis**–(Cretaceous) gray-to-black shale	25,431	2.68
KJ	**Cloverly, Morrison, and Kootenia**–(Jurrassic/Cretaceous) sandstone, shale	21,571	2.27
KJg	**Cloverly, Morrison, and Sundance**–(Jurrassic/Cretaceous) sandstone, shale	416	0.04
KJs	**undifferentiated**–(Triassic) calcareous shale and sandstone	2,994	0.32
Jsg	**Sundance and Gypsum Spring**–(Jurassic) greenish-gray sandstone and shale; red shale and gypsum	8,992	0.95
@c	**Chugwater**–(Triassic) red sandstone and siltstone	1,020	0.11
@cd	**Chugwater and Dinwoody**–(Triassic) red siltstone, sandstone, and shale	6,874	0.72
@ad	**Dinwood, Thaynes, and other Triassic units**–conglomerate, sandstone, and shale	4,548	0.48
@Pg	**Goose Egg**–(Triassic) red sandstone and siltstone, gypsum, halite, and dolomite	2,316	0.24
Pp	**Phosphoria and other undifferentiated**–(Permian) chert, sandstone, and minor limestone	2,447	0.26

Table 1–2. Bedrock Geologic Units and Watershed Acres (Page 2 of 2)

Map Unit		Area (acres)	Percent of Total
Legend	**Name–Description**		
PM	**Quadrant Quartzite and other undifferentiated–** (Pennsylvanian)	22,931	2.41
Mm	**Big Snowy and Madison groups–**(Mississippian) sandstone, shale, and limestone	43,880	4.62
MzPz	**Undifferentiated–**(Mesozoic and Paleozoic)	10,899	1.15
MDO	**Madison, Darby, and Three Forks**	211	0.02
Ob	**Undifferentiated–**(Ordovician) includes Bighorn Dolomite, quartzite, and other sedimentary rocks	3,704	0.39
DO	**Three Forks, Jefferson, and Beartooth–**(Devonian/ Ordovician)	552	0.06
Cg	**Gallatin Limestone and Gros Ventre–**(Cambrian)	901	0.09
Ugn	**Oldest Gneiss Complex**	138	0.01
Total		**949,713**	**100**

Approximately 42 percent of the project area has hydrologic group B soils, 18 percent has hydrologic group C soils, and 40 percent has hydrologic group D soils (Figure 1-7). Of the hydrologic soil groups present in the project area, group B has the highest infiltration rates and the lowest runoff potential, and group D has the lowest infiltration rates and the highest runoff potential. These data are based on the State Soil Geographic Database (STATSGO); soils data were not available for the entire project area from the Soil Survey Geographic Database (SSURGO).

1.2.5 Elevation and Slope

Elevations range from approximately 3,640 feet to 10,670 feet (Figure 1-8). The lowest elevations are generally found throughout the center of the project area and along the Shoshone River, and the lowest elevation is at the eastern portion near the outlet of the project area. The highest elevations exist in the mountainous areas on the southwestern and northeastern portions of the project area. Generally, the drainage flows from west to east. The average slope for the project area is approximately 10 percent.

1.2.6 Socioeconomics

Populations in all four counties within the project area increased from years 2000 to 2010. In Wyoming, the Park County population increased by 3 percent, and the Big Horn County population increased by 9 percent. In Montana, the Big Horn County population increased by 2 percent, and the Carbon County population increased by 5 percent [Headwaters Economics, 2012a; 2012b; 2012c; 2012d]. The overall population increase in cities and towns in the project area was approximately 10 percent, and the percent change in individual towns ranged from –25 percent in Frannie to 18 percent in Powell (Table 1-3).

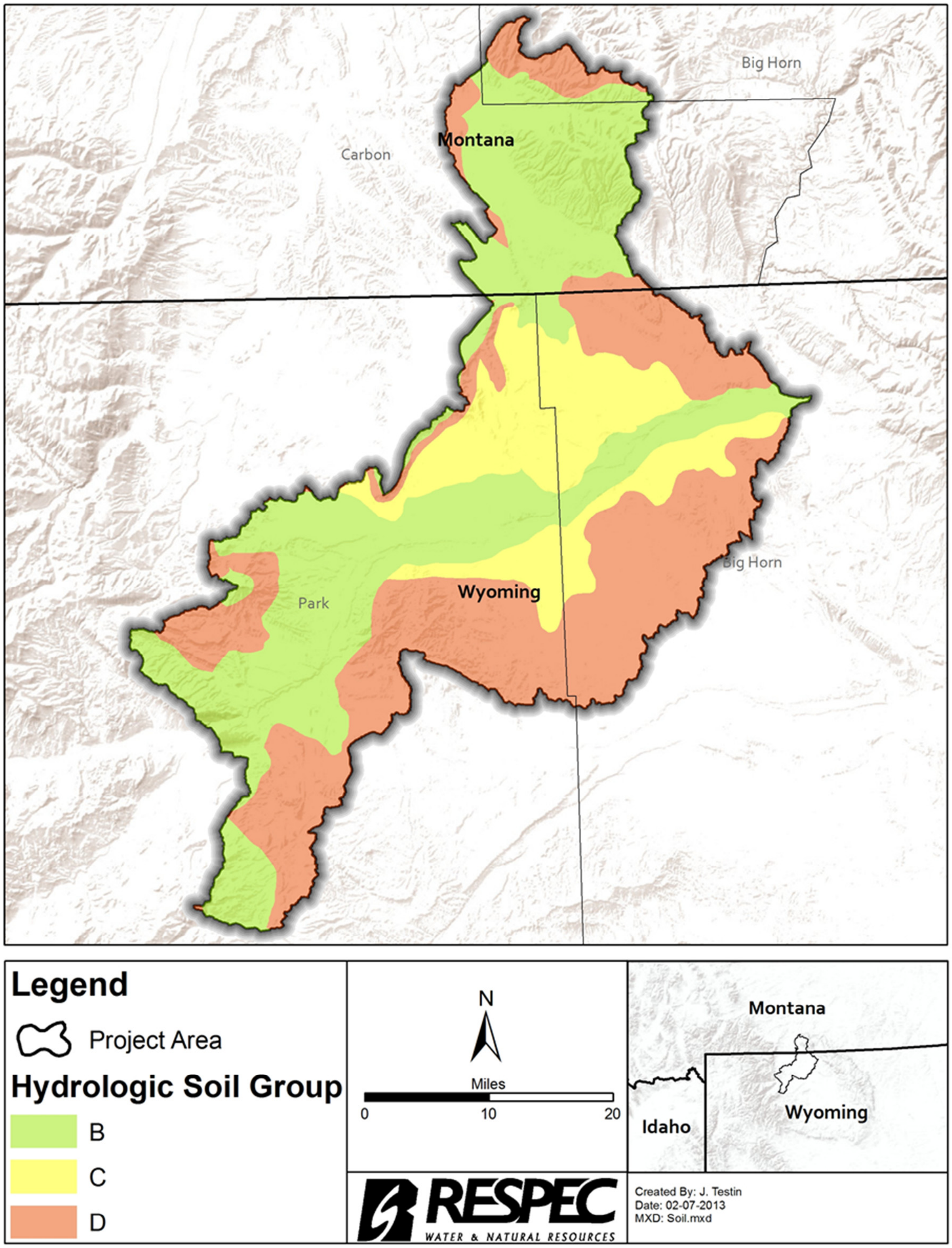

Figure 1-7. Hydrologic Soil Groups.

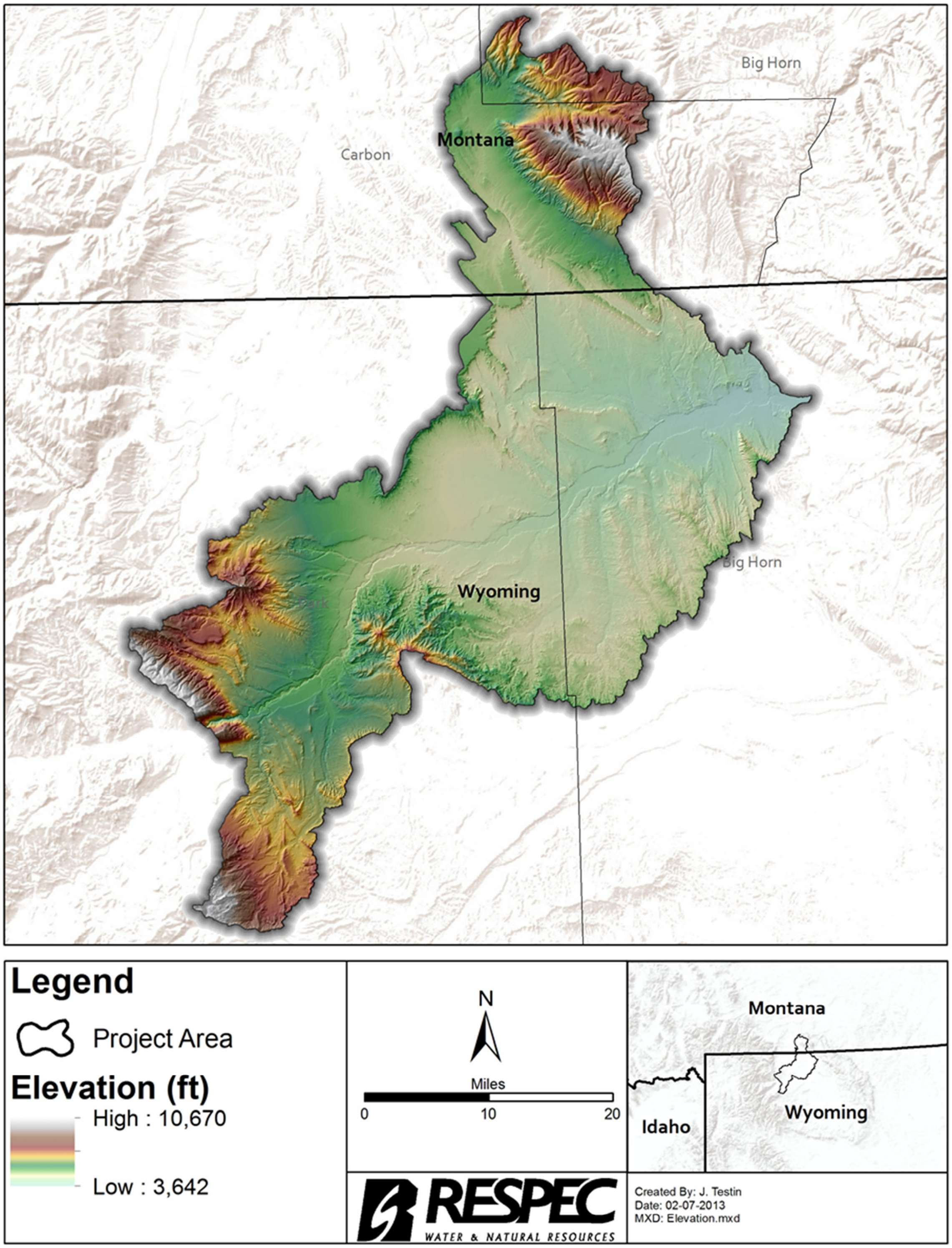

Figure 1-8. Elevations.

Table 1-3. Census (2000 and 2010) Populations for Cities and Towns in the Shoshone Project Area

Town	2000 Population	2010 Population	Population Change (%)
Byron	557	593	6
Cody	8,835	9,520	8
Cowley	560	655	17
Deaver	177	178	1
Frannie	209	157	–25
Lovell	2,281	2,360	3
Powell	5,373	6,314	18

The majority of employment in the nonservice-related industries occurs in the farming, mining, and construction sectors, and the majority of the employment in the service-related industries occurs in the retail trade and services sectors in these four counties (Table 1-4). The government sector accounts for approximately 20 percent of employment. Average annual wages across the sectors range from $11,623 in the leisure and hospitality sector in Big Horn County (Wyoming) to $100,745 in the mining sector in Park County (Wyoming) (Table 1-5). Agriculture is the largest water-using industry sector, and irrigation occurs on approximately 14 percent of the service-related project area (a majority of the cropland and hayland acres in Table 1-1) [Headwaters Economics, 2012a; 2012b; 2012c; 2012d].

Table 1-4. Percent of Total Employment by Industry (2000) and County [Headwaters Economics, 2012a; 2012b; 2012c; 2012d]

Industry Sector	Big Horn, Wyoming (%)	Park, Wyoming (%)	Big Horn, Montana (%)	Carbon, Montana (%)
Nonservice-Related	39.9	23.2	26.6	32.1
Farm	10.7	5.5	12.3	17.4
Agricultural services, forestry, fishing, and other	4.1	1.9	2.8	2.5
Mining (including fossil fuels)	13.9	3.3	7.7	1.1
Construction	6.3	8.2	2.9	8.1
Manufacturing (including forest products)	4.9	4.4	0.9	3.0
Service-Related	40.4	57.5	32.5	55.2
Transportation and public utilities	4.3	3.3	2.3	2.3
Wholesale trade	2.6	2.2	1.3	2.1
Retail trade	11.6	17.0	10.9	16.8
Finance, insurance, and real estate	4.5	7.1	2.3	7.5
Other services	17.4	28.0	15.6	26.4
Government	22.4	19.2	40.6	12.8

Table 1-5. Average Annual Wages by Industry Sector and County [Headwaters Economics, 2012a; 2012b; 2012c; and 2012d]

Industry Sector	Average Annual Wages			
	Big Horn, Wyoming ($)	Park, Wyoming ($)	Big Horn, Montana ($)	Carbon, Montana ($)
Total Average Annual Wage	35,952	36,997	26,676	27,552
Private	35,630	34,903	39,469	25,645
Nonservice-Related	45,340	51,879	64,174	32,088
Natural resources and mining	51,316	73,187	66,983	38,857
Agriculture, forestry, fishing, and hunting	29,071	27,729	24,739	31,111
Mining (including fossil fuels)	55,766	100,745	73,070	57,307
Construction	36,177	39,101	45,443	29,059
Manufacturing (including forest products)	38,830	37,382	41,164	26,984
Service-Related	27,449	29,874	26,005	24,188
Trade, transportation, and utilities	26,760	29,783	27,240	32,250
Information	45,058	31,534	19,221	23,648
Financial activities	39,866	37,004	35,609	35,348
Professional and business services	32,593	44,140	40,856	31,977
Education and health services	22,193	39,395	29,443	29,801
Leisure and hospitality	11,623	18,397	15,068	14,921
Other services	29,039	27,270	20,966	14,606
Government	36,499	43,030	34,084	33,529
Federal government	44,727	50,734	57,467	49,229
State government	43,779	49,266	30,923	67,338
Local government	34,560	39,933	28,633	29,312

Irrigation is a very important component of socioeconomics because of its impacts to farmers, ranchers, and the local communities. The irrigation system in the project area is a system of canals, drains, and pipes serving over 100,000 acres in Park and Big Horn Counties.

1.3 DISCHARGE AND WATER-QUALITY CONDITIONS

Water-quality data (both *E. coli* and fecal coliform) were provided electronically to the WDEQ and can be obtained from them. All available discharge, *E. coli*, and fecal coliform data throughout the watershed were used for this project. All data (flow and water-quality) used for the TMDL analysis are available for download on the WDEQ TMDLs Shoshone River website (*http://deq.state.wy.us/wqd/watershed/TMDL/Shoshone%20RFP/ShoshoneTMDL.htm*). A copy may be requested by contacting WDEQ's TMDL program coordinator. A summary of the discharge and water-quality conditions are included in the following sections.

1.3.1 Discharge

Throughout the project area, several entities are involved in gathering and reporting discharge data from streams and rivers, irrigation deliveries and wasteways, and reservoir inflows and outflows. Within the project area, a total of 24 stations have discharge data available (Figure 1-9). Fifteen of the discharge stations are on streams or rivers (Table 1-6) and nine of the discharge stations are on canals or ditches (Table 1-7). Data were provided by the U.S. Geological Survey (USGS), the U.S. Bureau of Reclamation (BoR), Wyoming State Engineers Office (WYSEO), and the WDEQ. This dataset was used for creating and calibrating the hydrology model used in the source assessment, and it ultimately formed the foundation of setting the TMDL for the impaired stream segments. The sites range from a small intermittently flowing stream (Dry Gulch) to the Shoshone River near Lovell with an average of 940 cfs over the period of record (Table 1-8). Because the period of record varies by site, data should not be compared on a site-by-site basis. Discharge data were provided electronically to the WDEQ and can be obtained from them.

1.3.2 Water Quality

The USGS, the Cody Conservation District, the Powell-Clarks Fork Conservation District, the Shoshone Conservation District, and the WDEQ collected *E. coli* data throughout the project area (Figure 1-10). All laboratory results are reported as cfu, which is a measure of the number of organisms in the sample. Data collected from May 1 through September 30 (summer recreation season) were used to calculate geometric means for computing the percent exceedance of the summer recreation season *E. coli* criterion of 126 org/100 mL. There are 21 sites with five or more *E. coli* samples available during the summer recreation season, and all but seven of these sites had sufficient data to calculate at least one 30-day geometric mean. Of the sites with at least one 30-day geometric mean, 11 sites had at least one geometric mean above the 126 org/100 mL criterion (Table 1-9). There is a gradual increase in *E. coli* concentrations from upstream to downstream along the mainstem of the Shoshone River, because tributaries and irrigation return flows begin to impact the river (Figure 1-11).

Data collected from October 1 through April 30 (winter recreation season) were used to calculate geometric means for computing the percent exceedance of the winter recreation season *E. coli* criterion of 630 org/100 mL. Only four of the 11 sites with winter *E. coli* data had sufficient data to calculate at least one 30-day geometric mean. The *E. coli* criterion was not exceeded at these four sites (Table 1-10). The low geometric means at these sites suggest that the winter recreation criterion is not exceeded often. All waterbodies are assumed to meet the water-quality standards for the winter recreation season, if they also meet the water-quality standards for the summer recreation season.

Fecal coliform data were collected throughout the watershed (Figure 1-12). These data are more limited than the *E. coli* data, and few fecal coliform geometric means were calculated because the data were insufficient. Of the nine sites with fecal coliform data, six sites had

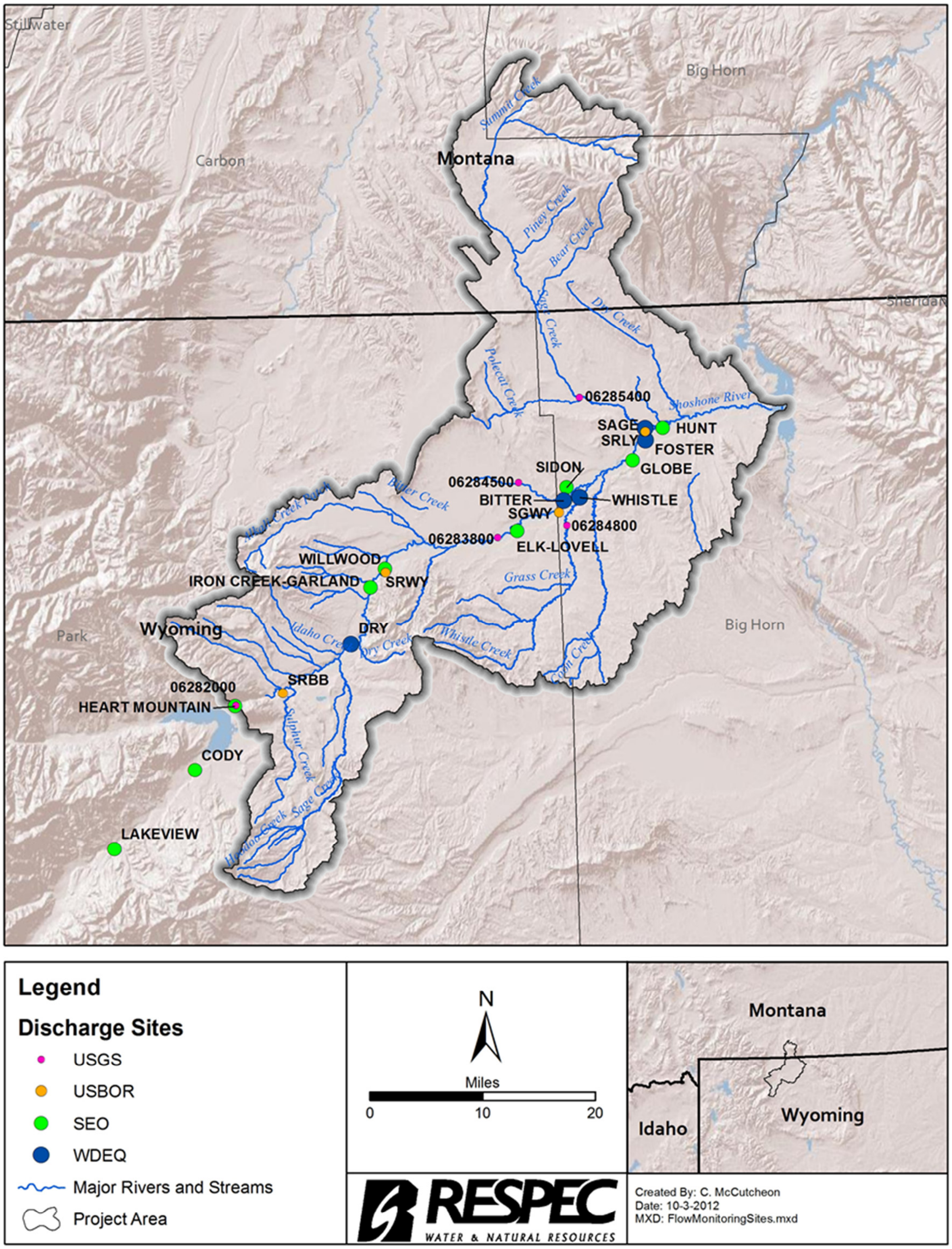

Figure 1-9. Discharge Monitoring Stations Within the Shoshone River Total Maximum Daily Load Project Area.

Table 1-6. Available Flow Data of Stream and River Sites Within the Shoshone Total Maximum Daily Load Project Area

Site Description	Reporting Agency and Site I.D.	Type	Years Available
Shoshone River below Buffalo Bill Reservoir, WY	USGS 06282000	Daily Average	1921–2011
		Instantaneous	1975–1983
	BoR SRBB (slightly downstream of USGS)	Daily Average	1985–2012
Dry Gulch	WDEQ DRY	Hourly	2012
Shoshone River above Willwood Dam, near Willwood	USGS 06283800	Daily Average	1979–1982
		Instantaneous	1979–1981
	BoR SRWY	Daily Average	1996–2012
Shoshone River near Garland, below Sidon	BoR SGWY	Daily Average	1996–2009
Bitter Creek near Garland	USGS 06284500	Daily Average	1950–1987
		Instantaneous	1950–2010
Bitter Creek	WDEQ BITTER	Hourly	2012
Whistle Creek near Garland	USGS 06284800	Daily Average	1958–1986
		Instantaneous	1959–1987
Whistle Creek	WDEQ WHISTLE	Hourly	2012
Foster Gulch	WDEQ FOSTER	Hourly	2012
Shoshone River near Lovell	USGS 06285100	Daily Average	1966–2012
		Instantaneous	1973–2012
	BoR SRLY	Daily Average	1993–2012
Sage Creek at Sidon Canal near Deaver	USGS 06285400	Daily Average	1958–1987
		Instantaneous	1958–1987
Sage Creek	WDEQ SAGE	Hourly	2012

Table 1-7. Canal and Ditch Sites With Available Flow Data Within the Shoshone Total Maximum Daily Load Project Area

Site Description	Reporting Agency and Site I.D.	Type	Years Available
Willwood Canal	WYSEO WILLWOOD	Daily Average	1980-2012
Iron Creek–Garland Canal	WYSEO Iron Creek–Garland	Daily Average	1985–2012
Elk-Lovell Canal	WYSEO Elk-Lovell	Daily Average	1980–2012
Sidon Canal	WYSEO Sidon	Daily Average	1980–2012
Globe Ditch	WYSEO Globe	Daily Average	1980–2012
Hunt Canal	WYSEO Hunt	Daily Average	1980–2012
Cody Canal	WYSEO Cody	Daily Average	1980–2012
Heart Mountain Canal	WYSEO Heart Mountain	Daily Average	1982–2009
Lakeview Canal	WYSEO Lakeview	Daily Average	1980–2011

Table 1-8. Statistical Summary of Stream and River Daily Average Discharge Data Available During Modeling Period

Site Description	Reporting Agency and Site I.D.	Minimum Discharge (cfs)	25th Percentile Discharge (cfs)	Median Discharge (cfs)	75th Percentile Discharge (cfs)	Maximum Discharge (cfs)	Average Discharge (cfs)
Shoshone River below Buffalo Bill Reservoir	USGS 06282000	104	353	660	1,140	15,100	938
Shoshone River below Buffalo Bill Reservoir	BoR SRBB	97	289	615	1,142	8,390	919
Dry Gulch	WDEQ DRY	1	10	13	14	20	11
Shoshone River at Willwood Dam	BoR SRWY	26	92	210	476	6,033	598
Shoshone River above Willwood Dam near Willwood	USGS 06283800	185	350	467	590	14,600	877
Shoshone River near Garland below Sidon	BoR SGWY	2	140	340	868	8,575	884
Bitter Creek near Garland	USGS 06284500	10	21	80	253	598	135
Bitter Creek	WDEQ BITTER	24	147	159	168	183	153
Whistle Creek near Garland	USGS 06284800	0	1	6	42	493	23
Whistle Creek	WDEQ WHISTLE	4	66	78	86	99	71
Foster Gulch	WDEQ FOSTER	16	30	37	40	47	35
Shoshone River near Lovell	USGS 06285100	34	400	560	772	15,200	823
Shoshone River near Lovell	BoR SRLY	22	412	597	847	9,062	940
Sage Creek at Sidon Canal near Deaver	USGS 06285400	4	16	52	106	327	64
Sage Creek	WDEQ SAGE	88	197	227	258	288	220

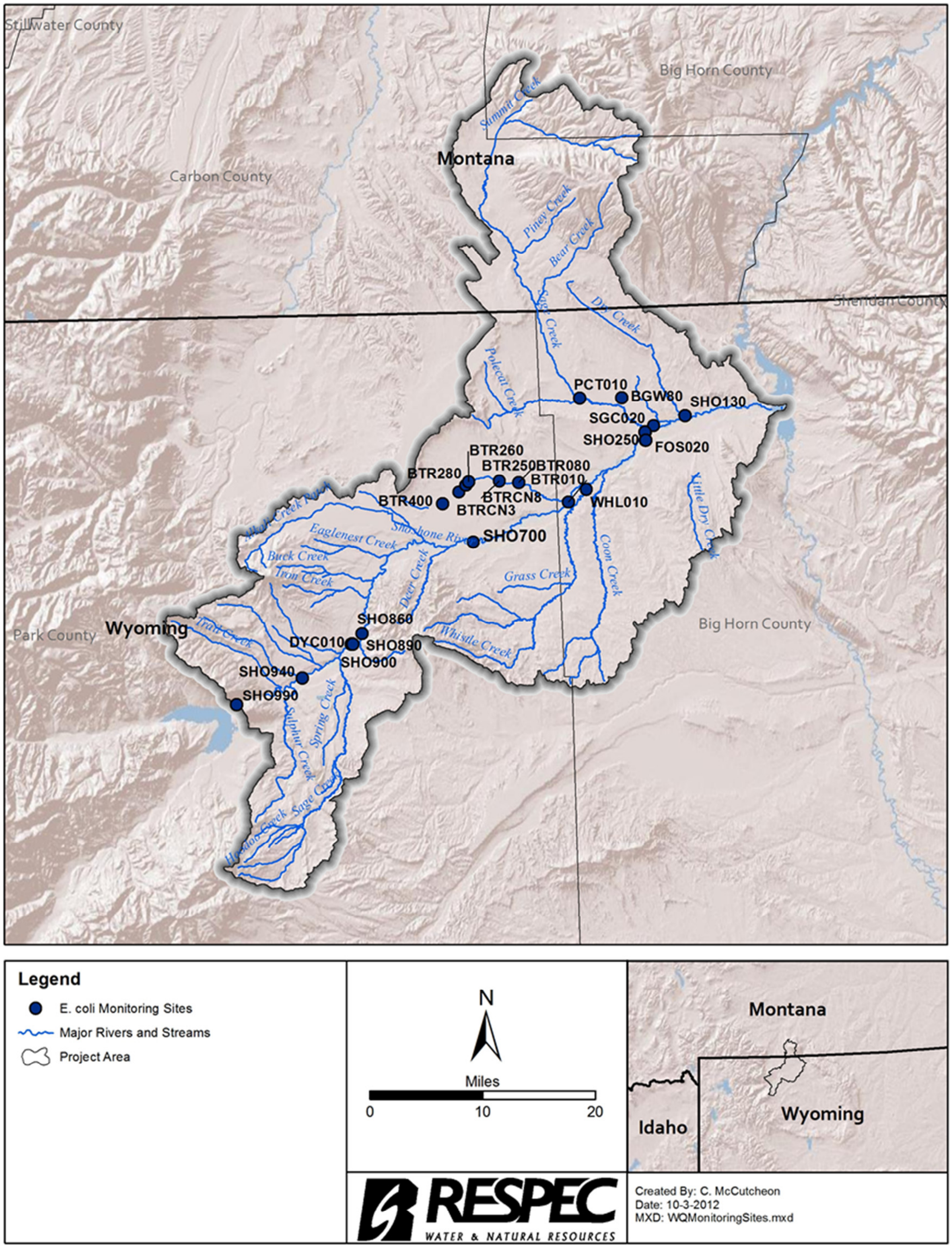

Figure 1-10. Water-Quality Monitoring Stations With Five or More *E. coli* Samples During the Summer Recreation Season and/or the Winter Recreation Season.

Table 1-9. Summer Recreation Season *E. coli* Total Maximum Daily Load Development Data Availability (Replicates Not Used, Sites With Five or More Samples)

Map Identifier	Total Number of Samples	Total Number of Geometric Mean Samples	Percent Exceedance of 126 org/100 mL	Geometric Mean Concentration Range (cfu/100 mL)	Date Range
SHO990	5	0	N/A[(a)]	N/A	08/10/2004–09/04/2004
SHO940	18	9	0	9.4–22	08/10/2004–07/13/2005
SHO900	17	6	0	35.5–63.8	08/10/2004–07/13/2005
DYC010	18	9	100	326.5–524.7	08/10/2004–07/13/2005
SHO890	16	6	17	78.1–174.1	08/24/2004–07/13/2005
SHO860	18	9	0	47.2–73	08/10/2004–07/13/2005
SHO700	5	0	N/A	N/A	08/09/2010–08/13/2012
BTR400	32	16	100	196.9–357.2	06/09/2010–08/13/2012
BTRCN3	58	26	100	226.5–1,163.8	06/21/2007–08/13/2012
BTR260	9	0	N/A	N/A	05/01/2007–07/27/2009
BTR250	68	28	100	286.3–1,181.3	05/01/2007–08/13/2012
BTRCN8	59	25	96	99.0–1,297.0	05/24/2007–08/13/2012
BTR080	5	0	N/A	N/A	07/18/2000–08/06/2002
BTR010	63	25	100	282–1,368.8	05/24/2007–08/15/2012
WHL010	16	1	100	1,895.9	07/17/2003–08/05/2009
FOS020	15	1	100	1,411.5	06/08/2008–08/05/2009
PCT010	15	0	N/A	N/A	07/17/2003–07/26/2009
BGW80	10	0	N/A	N/A	06/08/2008–07/26/2009
SGC020	16	1	100	978.2	07/17/2003–08/05/2009
SHO250	5	0	N/A	N/A	07/20/2000–08/06/2002
SHO130	9	1	100	533.5	06/28/2009–09/25/2009

(a) N/A = percent exceedances and concentration range not applicable because of insufficient data to calculate 30-day geometric mean.

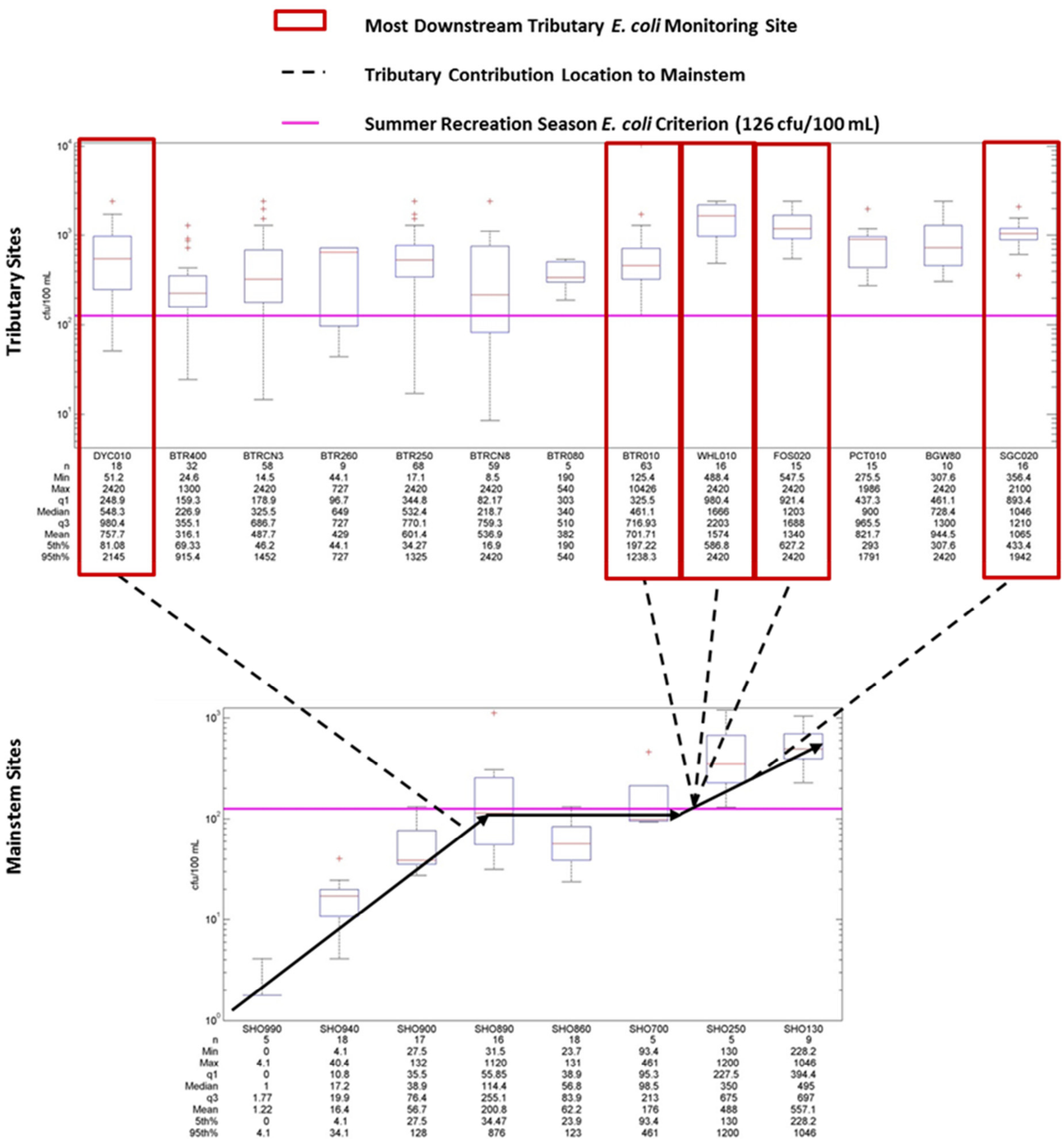

Figure 1-11. Boxplots Summarizing Single-Sample *E. coli* Data (No Replicate Data, Sites With Five or More Samples) in the Shoshone River Total Maximum Daily Load Project Area During the Summer Recreation Season.

sufficient data to calculate 30-day geometric means. The geometric means ranged from 361 to 2,739 cfu/100 mL (Table 1-11). There are no fecal coliform water-quality criteria, and fecal coliform data were not evaluated with respect to the summer and winter recreation seasons.

Table 1-10. Winter Recreation Season *E. coli* Total Maximum Daily Load Development Data Availability (No Replicate Data, Sites With Five or More Samples)

Map Identifier	Total Number of Samples	Total Number of Geometric Mean Samples	Percent Exceedance of 630 org/100 mL (%)	Geometric Mean Concentration Range (cfu/100 mL)	Date Range
BTR400	8	2	0	8.4–9.2	03/30/2010–10/17/2012
BTRCN3	8	0	N/A	N/A	10/16/2007–10/17/2012
BTR280	6	0	N/A	N/A	03/13/2007–03/13/2007
BTR260	7	2	0	29.9–36.0	03/13/2007–04/24/2007
BTR250	22	6	0	19.4–30.6	03/13/2007–10/17/2012
BTRCN8	8	0	N/A	N/A	10/16/2007–10/17/2012
BTR080	6	0	N/A	N/A	12/21/2000–02/04/2003
BTR010	9	0	N/A	N/A	10/16/2007–10/24/2012
SHO250	6	1	0	128.9	12/21/2000–02/04/2003

The fecal coliform data were not used directly to calculate the TMDL, which is written for *E. coli*. However, the fecal coliform data were used to calibrate the HSPF model application (discussed in Section 2.2.1 Model Methods). The relationships between all available paired fecal coliform and *E. coli* data in the project area was based on 21 sets of samples at two sites (BTR080 and SHO250). This relationship were used to convert fecal coliform to an equivalent *E. coli* concentration using linear regression. The regression had a coefficient of determination (R^2) of 0.96 and is shown in Equation 1-1 and Figure 1-13.

$$C_E = 0.639 \times C_F + 42.261 \qquad (1\text{-}1)$$

where:

C_E = *E. coli* concentration

C_F = fecal coliform concentration.

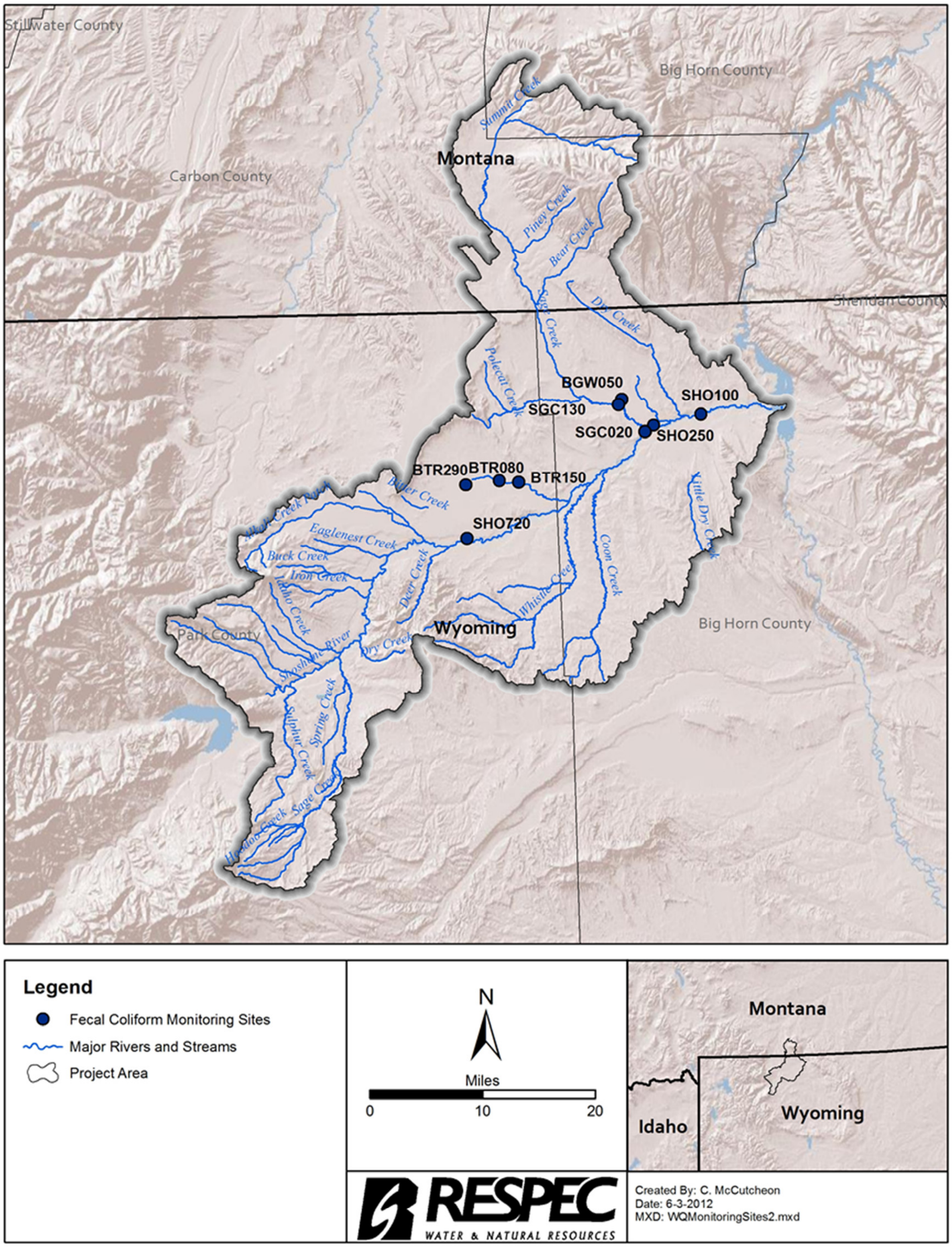

Figure 1-12. Water-Quality Monitoring Stations Within the Shoshone River Total Maximum Daily Load Project Area With Five or More Fecal Coliform Samples (Not Including Replicate Data).

Table 1-11. Fecal Coliform Data Summary (All Months, No Replicate Data, Sites With Five or More Samples)

Map Identifier	Total Number of Samples	Total Number of Geometric Mean Samples	Geometric Mean Concentration	Date Range
SHO720	6	1	360.9	06/13/2001–07/17/2001
BTR290	5	0	N/A	06/06/2000–06/15/2000
BTR150	6	0	N/A	06/06/2000–06/21/2000
BTR080	36	1	461.0	01/26/2000–08/14/2007
SHO250	29	0	N/A	07/20/2000–08/14/2007
BGW050	7	1	1,019.5	06/21/2000–07/09/2001
SGC020	6	1	2,227.2	06/13/2001–07/17/2001
SGC130	6	1	2,739.4	06/13/2001–07/17/2001
SHO100	6	1	1,984.5	06/13/2001–07/17/2001

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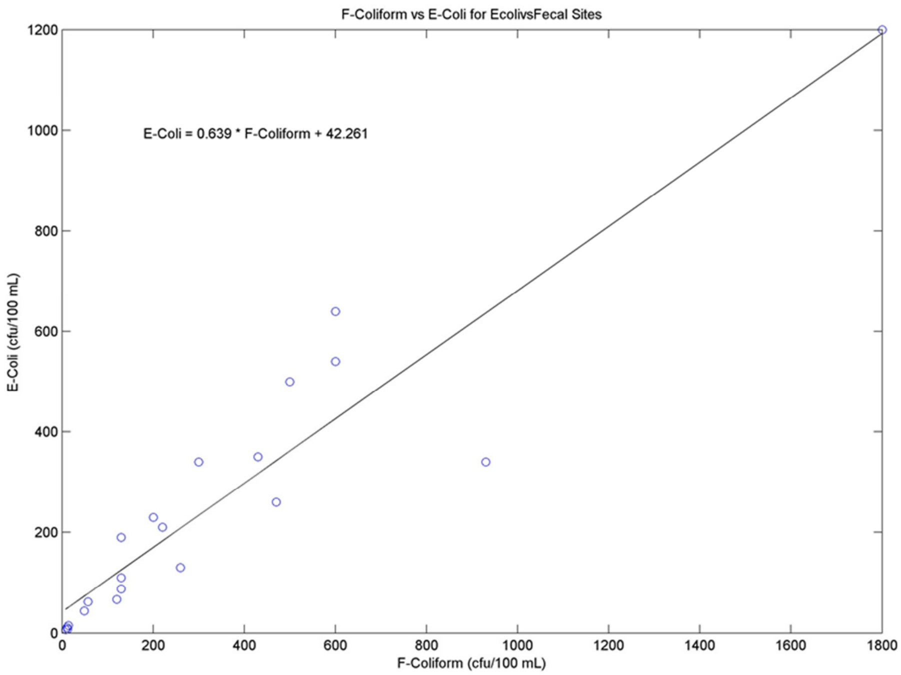

Figure 1-13. Regression Analysis Relationship Between All Available Paired Fecal Coliform and *E. coli* Samples.

There are six Wyoming Pollutant Discharge Elimination System- (WYPDES-) permitted wastewater treatment facilities (WWTFs) in the project area: the towns of Lovell, Byron, Frannie, and Deaver and the cities of Cody and Powell. All WWTF permits have recently switched from having fecal coliform effluent limits to having *E. coli* effluent limits. The monthly average and daily maximum fecal coliform and *E. coli* data from these facilities show that permit limits are often exceeded (Table 1-12). No data were available from the Frannie WWTF because it has never discharged. The city of Cody's permit limits were derived using a mass balance report (discussed further in the Point Sources Section of this report) and are much higher than the limits at the other facilities.

Table 1-12. Summary of Permit Limits and Available Point-Source Data

Permit	Facility	Parameter	Recreational Season	Statistical Type	Permit Limit (cfu/100 mL)	Start Date	End Date	Number of Samples	Number of Exceedances	Exceedance (%)
WY0020061	Town of Lovell	*E. coli*	Summer	Daily Maximum	567	7/1/2010	6/30/2012	11	1	9
				Monthly Average	126	7/1/2010	6/30/2012	11	1	9
			Winter	Daily Maximum	630	11/1/2010	4/30/2012	11	3	27
				Monthly Average	630	11/1/2010	4/30/2012	10	3	30
		Fecal coliform[a]	Year-Round	Daily Maximum	400	4/1/2004	6/30/2010	67	35	52
				Monthly Average	200	4/1/2004	6/30/2010	67	38	57
WY0020281	Town of Byron	*E. coli*	Summer	Daily Maximum	567	6/1/2009	6/30/2012	14	8	57
				Monthly Average	126	6/1/2009	6/30/2012	14	8	57
			Winter	Daily Maximum	630	4/1/2009	4/30/2012	11	3	27
				Monthly Average	630	4/1/2009	4/30/2012	11	3	27
		Fecal coliform[a]	Year-Round	Daily Maximum	400	7/1/2002	1/31/2009	41	7	17
				Monthly Average	200	7/1/2002	1/31/2009	41	6	15
WY0020451	City of Cody	*E. coli*	Summer	Daily Maximum	40,490	6/1/2012	9/30/2012	4	0	0
				Monthly Average	20,787	6/1/2012	9/30/2012	4	0	0
			Winter	Daily Maximum	32,108	N/A	N/A	N/A	N/A	N/A
				Monthly Average	32,108	N/A	N/A	N/A	N/A	N/A
		Fecal coliform[a]	Summer	Daily Maximum	65,488	6/1/2007	5/31/2012	25	0	0
				Monthly Average	25,000	6/1/2007	5/31/2012	9,325	0	0
			Winter	Daily Maximum	24,123	10/1/2007	4/30/2012	35	2	6
				Monthly Average	11,757	10/1/2007	4/30/2012	35	1	3
WY0020648	City of Powell	*E. coli*	Summer	Daily Maximum	567	8/1/2007	8/31/2012	31	0	0
				Monthly Average	126	10/1/2008	8/31/2012	23	0	0
			Winter	Daily Maximum	630	11/1/2007	4/30/2012	26	2	8
				Monthly Average	630	11/1/2008	4/30/2012	21	0	0
		Fecal coliform[a]	Year-Round	Daily Maximum	400	3/1/2002	9/30/2008	61	1	2
				Monthly Average	200	3/1/2002	9/30/2008	48	0	0
WY0021580	Town of Deaver	*E. coli*	Summer	Daily Maximum	567	6/1/2010	10/31/2010	2	0	0
				Monthly Average	126	6/1/2010	10/31/2010	2	0	0
			Winter	Daily Maximum	630	4/1/2010	3/31/2012	9	3	33
				Monthly Average	630	4/1/2010	3/31/2012	9	3	33
		Fecal coliform[a]	Year-Round	Daily Maximum	400	10/1/2001	3/31/2010	35	11	31
				Monthly Average	200	10/1/2001	3/31/2010	35	12	34

(a) Facilities have changed effluent concentrations from fecal coliform to *E. coli* in most recent permit so fecal coliform standards no longer apply.

2.0 SOURCE ASSESSMENT

This chapter describes the bacteria sources in the project area, which include point and nonpoint sources. The point sources are WWTFs and the nonpoint sources consist of sources that can be transported through watershed runoff. The sources are first described, and then the methods and results of the source load assessment are presented.

2.1 BACTERIA SOURCE INVENTORY

2.1.1 Point Sources

There are six permitted WWTFs in the project area: the towns of Byron, Deaver, Frannie, and Lovell, and the cities of Cody and Powell (Table 2-1). The permit limits of these facilities are the same concentrations as the summer and winter recreation standard concentrations (126 and 630 org/100 mL, respectively), except for the limits at the city of Cody facility. For receiving waters that have a perennial flow, like the Shoshone River, a WLA calculation is performed to calculate the effluent limit. This involves a mass balance approach to determine the maximum allowable concentration in the effluent, so that when mixed with the receiving stream, the instream standard of the constituent is not violated. The mass balance approach uses the upstream 7Q10 (the lowest 7-day average flow that occurs on average once every 10 years) of the receiving stream, the maximum effluent discharge volume, the upstream background concentration of the constituent, and instream standards to calculate the maximum allowable concentration of the constituent in the effluent. Considering that Cody discharges to a stretch of stream that supports its uses, there are no other point sources in the immediate areas that contribute to the impairments, and the facility is many miles upstream of the impaired reach, it was determined that the mass balance approach was appropriate for calculating the effluent limit.

The Byron WWTF is a three-cell aerated lagoon system operated in series. It has chlorine disinfection with a contact chamber. This WWTP discharges continuously 1 month per year. Cell one is approximately 782,708 gallons, cell two is 1.93 million gallons, and cell three is 1.92 million gallons.

The Deaver WWTF is a four-cell, nonaerated (facultative) lagoon system with no disinfection capabilities. Cells one through three are operated in series and are north of State Route 114. The fourth cell is left from the old, abandoned lagoon system south of State Route 114 and is seldom used. During the past 10 years, the cells have discharged five times in January, twice in February, ten times in March, once in April, twice in June, three times in October, six times in November, and nine times in December. They discharge most frequently in the first and fourth quarters of the year. Cell one is approximately 650,000 gallons, cell two is 1.7 million gallons, cell three is 1.6 million gallons, and cell four is 1.5 million gallons.

Table 2-1. Permitted Point Sources in the Project Area

WWTF	WYPDES Permit Number	County	Impacted Impaired Stream	Design Flow (mgd)	May–September Monthly Average *E. coli* Limit (cfu/100 mL)	October–April Monthly Average *E. coli* Limit (cfu/100 mL)	May–September *E. coli* WLA (10^9 cfu/day)	October–April *E. coli* WLA (10^9 cfu/day)
Byron	WY0020281	Big Horn	Shoshone River	0.3	126	630	1.4	7.2
Cody	WY0020451	Park	Shoshone River	2.0	20,787	32,108	1,573.7	2,430.8
Deaver	WY0021580	Big Horn	Polecat Creek, Sage Creek, Shoshone River	0.05	126	630	0.2	1.2
Frannie	WY0020052	Big Horn	Sage Creek, Shoshone River	0.02	126	630	0.1	0.5
Lovell	WY0020061	Big Horn	Shoshone River	0.6	126	630	2.9	14.3
Powell	WY0020648	Park	Bitter Creek, Shoshone River	4.9	126	630	23.4	116.9

The Frannie WWTF is a three-cell nonaerated lagoon system operated in series with no disinfection capabilities. The system has never discharged. Cell one is approximately 1.54 million gallons, cell two is 1 million gallons, and cell three is 1.12 million gallons.

The Lovell WWTF is a three-cell aerated lagoon system operated in series with no disinfection capabilities. The system discharges continuously during middle and late summer. Cell one is between 90,000 and 150,000 gallons, cell two is 290,000 gallons, and cell three is 175,000 gallons.

The Cody WWTF is a two-cell aerated lagoon system with five slow sand infiltration ponds. The two cells (which receive flow continuously) are operated in series, and the infiltration ponds are operated on a rotational basis (one pond at a time) for 2 to 4 week intervals. It does not have disinfection capabilities and discharges continuously. Cell one is approximately 24 million gallons and cell two is 20 million gallons. The infiltration cells are designed to hold up to 4 feet of water but because they infiltrate into an underdrain system to the outfall they seldom have four feet of water in them.

The Powell WWTF is an eight-cell nonaerated (facultative) lagoon system with no disinfection capabilities. Cells one through four are operated in series and cells five through eight are operated in parallel/series where five and six are operated in parallel and seven and eight are operated in parallel. The facility discharges continuously. Cells one through four are approximately 320,000 gallons. Cell five is approximately 415,000 gallons, cell six is 450,000 gallons, cell seven is 480,000 gallons, and cell eight is 510,000 gallons.

One concentrated animal feeding operation (CAFO) is located in the project area. This CAFO was WYPDES-permitted until 2011 when it ceased operating. While it was permitted, it was not allowed to discharge, except in the case of a chronic or catastrophic storm event that would cause an overflow from the runoff and/or wastewater control structure.

2.1.2 Nonpoint Sources

Based on a review of available land-use information and communication with state and local authorities, the primary nonpoint sources of bacteria within the project area include livestock, wildlife, human, and pet sources. Manure from livestock is a potential source of bacteria to the stream. Livestock contribute bacteria loads directly by defecating in the stream and indirectly by defecating on pastures or cropland that can be washed off during precipitation events, snow melt, or irrigation applications. Livestock in the project area are predominantly cattle and sheep, and other livestock types include horses, poultry, goats, and pigs. Wildlife, including waterfowl and large game species, also contribute bacteria loads directly by defecating while wading or swimming in the stream and indirectly by defecating on lands that produce watershed runoff during precipitation events.

Human bacteria sources in urban settings can include cross connections between sanitary sewers and storm drain systems, leaks or overflows from sanitary sewer systems, and wet weather discharges from centralized wastewater collection and treatment facilities. Outside of city limits, septic systems are a potential human source of bacteria loads. Flood irrigation can potentially raise the groundwater table, and the closer to the surface the water table is, the more likely it is that bacteria from septic systems would reach streams and rivers.

Pet waste is a potential source of bacteria in the project area. Pet waste that is not properly disposed of along a stream and within a stormwater drainage network can be washed off during precipitation events [U.S. Environmental Protection Agency, 2001].

2.2 SOURCE LOAD ASSESSMENT

An **HSPF** model application was developed for the project area to determine the contribution of *E. coli* bacteria from identified sources and to evaluate different scenarios of implementing BMPs to control these sources. The model application can be used to predict the range of flows that have historically occurred in the modeled area, to quantify the load contributions from a variety of point and nonpoint sources in a watershed, and to help quantify source contributions when paired flow and concentration data are limited.

HSPF is a comprehensive watershed model of hydrology and water quality that includes modeling land surface and subsurface hydrologic and water-quality processes, which are linked and closely integrated with corresponding stream and reservoir processes. The framework can be used to determine the critical environmental conditions (e.g., certain flows or seasons) for the impaired segments by providing continuous flow and load predictions at any point in the system. **HSPF** simulates the fate and transport of bacteria and can simulate subsurface concentrations in addition to surface concentrations (where appropriate).

The bacteria accumulation and storage rates of nonpoint sources were calculated using the **Bacteria Source Load Calculator** (**BSLC**). The sum of the source estimates from the **BSLC** (including accumulation, storage rates, and direct defecation) were then entered into **HSPF**, and the bacteria buildup and washoff were simulated using **HSPF**. The following sections provide more detail on the source assessment approach and provide the quantitative results of the source load assessment.

2.2.1 Model Methods

The primary components of developing an **HSPF** model application include the following:

- Gathering and developing time-series data
- Characterizing and segmenting the watershed
- Estimating bacteria loads and modeling bacteria accumulation and storage rates
- Calibrating and validating the model.

2.2.1.1 Gathering and Developing Time-Series Data

Data requirements for developing and calibrating an **HSPF** model application are both spatially and temporally extensive. The modeling period was from 1980 through 2012. Time-series data used in developing the model application included the following:

- Meteorological data
- Stream flow and water-quality boundary conditions
- Point-source loads (WWTFs).

Precipitation, potential evapotranspiration, air temperature, wind speed, solar radiation, dew-point temperature, and cloud cover data are needed for **HSPF** to simulate hydrology (including snow processes). A boundary condition was used at Buffalo Bill Reservoir to account for stream flow and water-quality constituents from areas upstream of the project area that were not modeled in this application. A time series of *E. coli* load at the boundary condition was developed using the boundary condition flow data at Buffalo Bill Reservoir and an *E. coli* concentration of 2.5 cfu/100 mL. This concentration was selected to represent the low *E. coli* concentrations at the reservoir outflow. Other boundary conditions that represented upstream irrigation waters were added.

2.2.1.2 Segmenting and Characterizing the Watershed

The project area was delineated into 174 subwatersheds to capture hydrologic and water-quality variability. Then, the watershed was segmented into individual land and channel pieces that are assumed to demonstrate relatively homogeneous hydrologic, hydraulic, and water-quality characteristics. This segmentation provides the basis for assigning similar or identical input and/or parameter values or functions to all portions of a land area or channel length contained in a model segment. The individual land and channel segments are linked together to represent the entire project area.

The land segmentation was defined by land cover. Land use and land cover affect the hydrologic and water-quality response of a watershed through their impact on infiltration, surface runoff, and water losses from evapotranspiration. The movement of water through the system is affected by land cover. Land use affects the rate of the accumulation of pollutants, such as bacteria, because certain land uses often support different pollutant sources.

All cropland or hayland was assumed to be irrigated, because growing crops and hay in this arid watershed without irrigation is difficult. A majority of the irrigation occurring in this watershed is flood irrigation, and over approximately 100 inches per acre of irrigated land (some of which is lost through inefficiencies or not applied) are diverted annually for irrigation. While washoff from nonirrigated land does occur occasionally with an average annual precipitation of 5 to 10 inches, bacteria washoff occurs far more consistently from flood-irrigated lands.

Land cover categories (based on the NLCD) were combined into seven groups with similar characteristics and integrated with riparian areas (Figure 2-1). The urban categories were divided into pervious and impervious areas based on an estimated percentage of effective impervious area (EIA). The term “effective” implies that the impervious region is directly connected to a local hydraulic conveyance system (e.g., open channel and river), and the resulting overland flow will not run onto pervious areas but will rather directly enter the reach network.

The channel segmentation considers river travel time, riverbed slope continuity, temporal and spatial cross section and morphologic changes or obstructions, the confluence of tributaries, impaired reaches, and locations of flow and bacteria calibration and verification gages. After the reach network was segmented, the hydraulic characteristics of each reach were computed, and the areas of the land cover categories that drain to each reach were calculated. Reach hydraulics are specified by a reach function table (F-table), which is an expanded rating curve that contains the reach surface area, volume, and discharge as functions of depth. F-tables were developed for each reach segment by using channel cross-sectional data. Unsurveyed tributaries were assigned the geometry of hydraulically similar channels.

2.2.1.3 Estimating Bacteria Loads and Modeling Bacteria Accumulation and Storage Rates

The **BSLC**, developed by the Center for TMDL and Watershed Studies [2007], was used to estimate *E. coli* loads. The **BSLC** estimates bacteria accumulation and storage from nonpoint-source runoff, which consists of livestock, wildlife, and pet waste. The **BSLC** also estimates direct stream defecation from livestock, wildlife, and failing septic systems within the riparian zone.

The **BSLC** outputs fecal coliform estimates. Translation from fecal coliform to *E. coli* is completed as a part of the **HSPF** calibration process. The distributions from the **BSLC** tool are the drivers of the bacteria portion of the model, and when calibration occurs, instream concentrations are calibrated to observed *E. coli* data. The *E. coli* load estimates were then used in an **HSPF** model application to assess the fate and transport of *E. coli*.

Livestock population estimates for the **BSLC** in the project area were derived from the 2007 Agricultural Census [U.S. Department of Agriculture, 2007] and conservation district estimates. The livestock density estimates were combined with fecal coliform production estimates for each animal type [Wagner and Moench, 2009] to estimate the amount of fecal coliform produced per day per animal type in the project area (Table 2-2).

Bacteria load estimates for big game such as deer, antelope, and elk were based on the WGFD 2005–2009 annual job completion reports, and whitetailed deer and small game estimates (Table 2-3) were based on suggested densities from the Center for TMDL and Watershed Studies [2007].

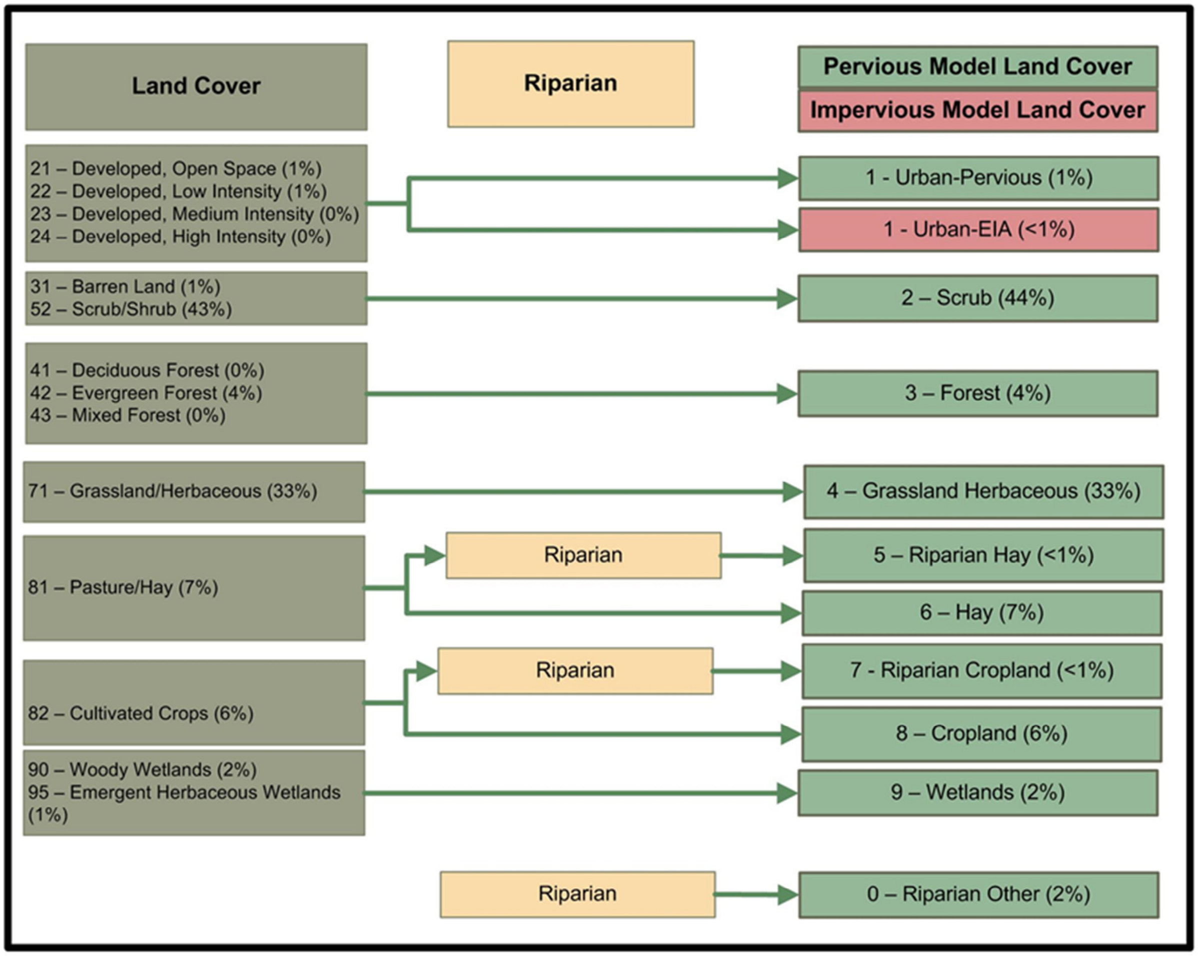

Figure 2-1. Model Land Cover Representation.

Table 2-2. Project Area Livestock Estimates

Livestock Category	Season	Estimated Project Area Population (number of animals)	Fecal Coliform Produced per Animal (cfu/day)	Fecal Coliform Produced in Project Area (cfu/day)
Cattle and Calves	All	29,890	8.55×10^{9}	2.56×10^{14}
Goats	All	1,000	4.32×10^{9}	4.32×10^{12}
Horses and Ponies	Summer	2,920	3.64×10^{8}	1.06×10^{12}
Horses and Ponies	Winter	5,910	3.64×10^{8}	2.15×10^{12}
Poultry	All	2,000	3.34×10^{8}	6.68×10^{11}
Sheep and Lambs	Summer	9,010	5.80×10^{10}	5.23×10^{14}
Sheep and Lambs	Winter	15,000	5.80×10^{10}	8.70×10^{14}

Table 2-3. Wildlife Estimates

Wildlife Category	Estimated Population in Project Area	Fecal Coliform Produced per Animal (cfu/day)	Fecal Coliform Produced in Watershed (cfu/day)
Raccoons	11,960	5.00×10^{7}	5.98×10^{11}
Muskrats	6,350	2.50×10^{7}	1.59×10^{11}
Beavers	1,280	2.00×10^{5}	2.56×10^{8}
Geese–Peak	3,151	8.00×10^{8}	2.52×10^{12}
Geese–Nesting	341	8.00×10^{8}	2.73×10^{11}
Ducks–Peak	11,648	2.40×10^{9}	2.80×10^{13}
Ducks–Nesting	7,604	2.40×10^{9}	1.82×10^{13}
Wild Turkey	800	9.30×10^{7}	7.44×10^{10}
Whitetailed Deer	4,933	1.68×10^{9}	8.29×10^{12}
Antelope (Summer)	1,418	1.41×10^{9}	2.00×10^{12}
Antelope (Winter)	1,224	1.41×10^{9}	1.73×10^{12}
Elk	868	7.64×10^{9}	6.63×10^{12}
Mule Deer (Summer)	4,948	1.68×10^{9}	8.31×10^{12}
Mule Deer (Winter)	4,283	1.68×10^{9}	7.20×10^{12}

The number of septic systems was estimated using county population, urban population, and average household size from the 2010 Census [U.S. Census Bureau, 2012]. It was assumed that if a household is not in an area that has a WWTF, then it has a septic system. Using this assumption, the number of septic systems in the project area was estimated to be approximately 3,703. The number of septics was converted to the number of individuals using septics using an average household size. A human fecal coliform production rate of 2.0×10^9 cfu/person/day (suggested by the **BSLC**) was used in the **BSLC**.

Total households from the 2010 Census were used to estimate the pet population. The **BSLC** suggests a default of one dog (which is assumed to equal two cats) per household, with a fecal coliform production rate of 4.5×10^8 cfu/pet/day.

The **BSLC** does not estimate loading rates from WWTFs. These loads are estimated using available observed monthly average flow and *E. coli* data from each facility supplied by the WDEQ. Missing data were filled using monthly averages of monthly average data

2.2.1.4 Calibrating and Validating the Model

Model calibration involved hydrologic and water-quality calibration using observed flow and water-quality data to compare to simulated results. Because water-quality simulations depend highly on watershed hydrology, the hydrology calibration was completed first, followed by the bacteria calibration. The 21 stream discharge sites with time-series data (Figure 1-8) were used for the calibration and validation. Data from all but the first year of the simulation period (1980 through 2012) were used to calibrate the model. The initial year (1980) was simulated for the model to adjust to existing conditions. The 32-year simulation period included a range of dry and wet years. This range of precipitation improves the model calibration and validation and provides a model application that can simulate hydrology and water quality during a broad range of climatic conditions.

Hydrologic calibration is an iterative process intended to match simulated flow to observed flow by methodically adjusting model parameters. **HSPF** hydrologic calibration is divided into the following four sequential phases of adjusting parameters to improve model performance:

- Annual runoff
- Seasonal or monthly runoff
- Low- and high-flow distribution
- Individual storm hydrographs.

By iteratively adjusting calibration parameters within accepted ranges, the simulation results are improved until an acceptable comparison of simulated results and measured data is achieved. The procedures and parameter adjustments involved in these phases are more completely described in Donigian et al. [1984] and Lumb et al. [1994].

The bacteria calibration optimized alignment among (1) the bacteria accumulation that was determined using the **BSLC**, (2) the loads predicted to be transported throughout the system, and (3) the observed instream concentrations. Water-quality data from monitoring sites with five or more *E. coli* or fecal coliform samples during the recreation season (Figures 1-9 and 1-11) were used to calibrate the model to observed conditions. The model application was calibrated to the *E. coli* dataset alone and to a combination of the *E. coli* and translated *E. coli* datasets.

Several parameters can be adjusted to calibrate *E. coli* loads and concentrations. To calibrate under baseflow conditions, adjustments are typically made to parameters that represent continuous discharges and that do not depend on transport via runoff mechanisms, (i.e., direct sources). Direct sources include contributions from direct deposition from wildlife or livestock, bacteria from failing septic systems, leaking or overflowing wastewater collection system infrastructure, or cross connections between sanitary and storm sewer lines. Direct sources may also involve other mechanisms that are difficult to quantify explicitly, including illicit discharges and the resuspension of bacteria associated with sediment. To calibrate under watershed runoff conditions, parameters that relate to bacteria washoff from land surfaces are adjusted. Adjustments of the first-order decay rate for bacteria are also used to calibrate the instream concentrations.

2.2.2 Model Calibration Results

The hydrology calibration was evaluated using a weight-of-evidence approach based on a variety of graphical comparisons and statistical tests. The performance criteria are described in more detail in Donigian [2002]. Graphical comparisons included monthly and average flow volume comparisons, daily time-series data comparisons, and concentration-duration plots. Statistical tests included annual and monthly runoff errors, low-flow and high-flow distribution errors, and storm volume and peak flow errors.

The flow time-series plots, comparing observed and simulated data at the most downstream continuous flow gage along the Shoshone River in the project area (Figure 2-2) and at the most downstream continuous flow gage along Sage Creek (Figure 2-3), show that the flow peaks and baseflow conditions are adequately represented by the model application. Sage Creek flows into the Shoshone River at the downstream end of the project area; flows from this Sage Creek site and from the most downstream Shoshone River site (which receives flow from all tributaries upstream of the confluence with Sage Creek), represent total flow from everywhere in the watershed, except downstream of the Shoshone River confluence with Sage Creek.

The simulated and observed *E. coli* concentrations in the most downstream modeled reach of Whistle Creek illustrate that the model is representing watershed conditions well (Figure 2-4). Similarly, concentration-duration curves that compare observed and simulated concentrations at all impaired reaches show that the model is representative of the actual watershed conditions. Figures 2-5 and 2-6 show example concentration-duration curves from Bitter Creek and Sage Creek, respectively.

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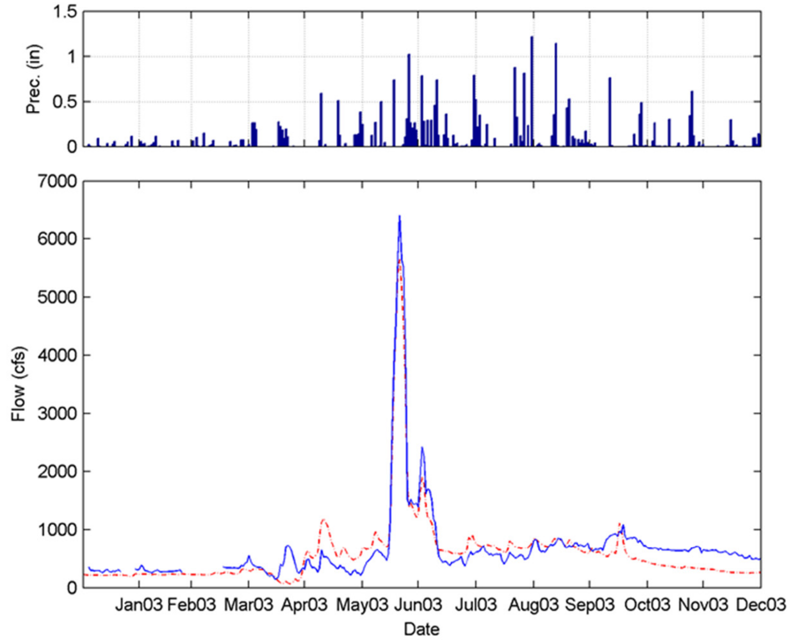

Figure 2-2. Simulated and Observed Discharge at USGS 06285100 in 2003.

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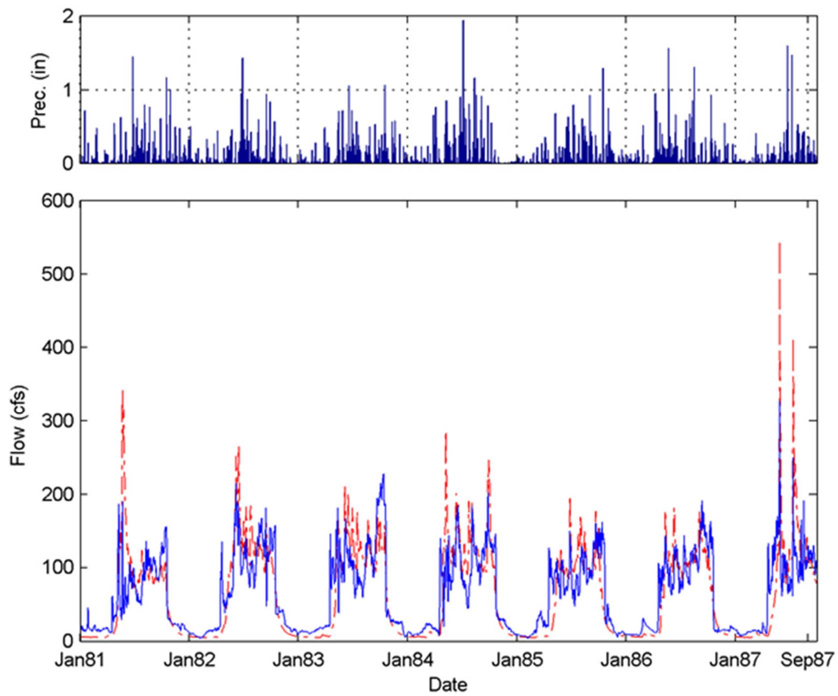

Figure 2-3. Simulated and Observed Discharge at USGS 06285400.

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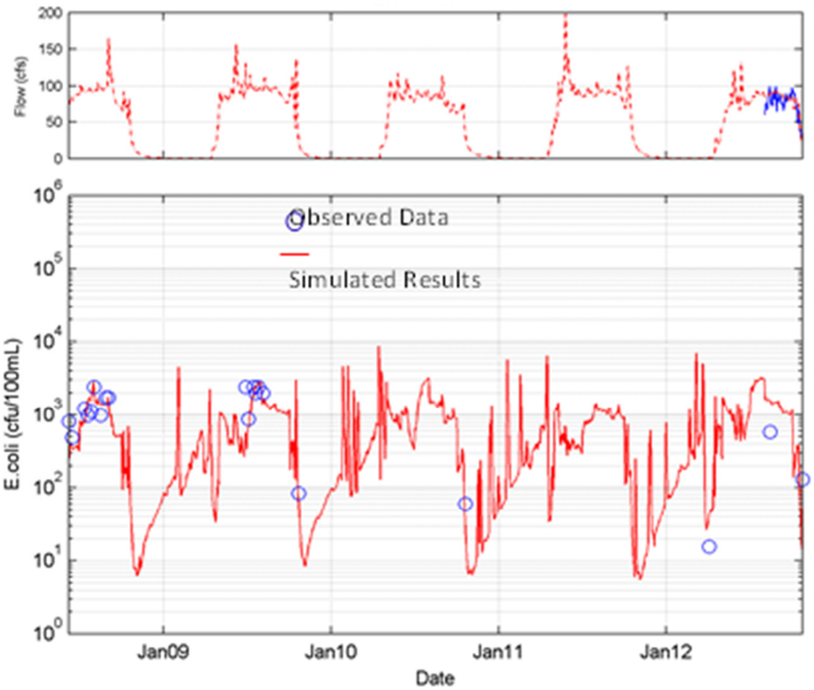

Figure 2-4. Simulated and Observed *E. coli* Concentrations in the Most Downstream Modeled Reach of Whistle Creek.

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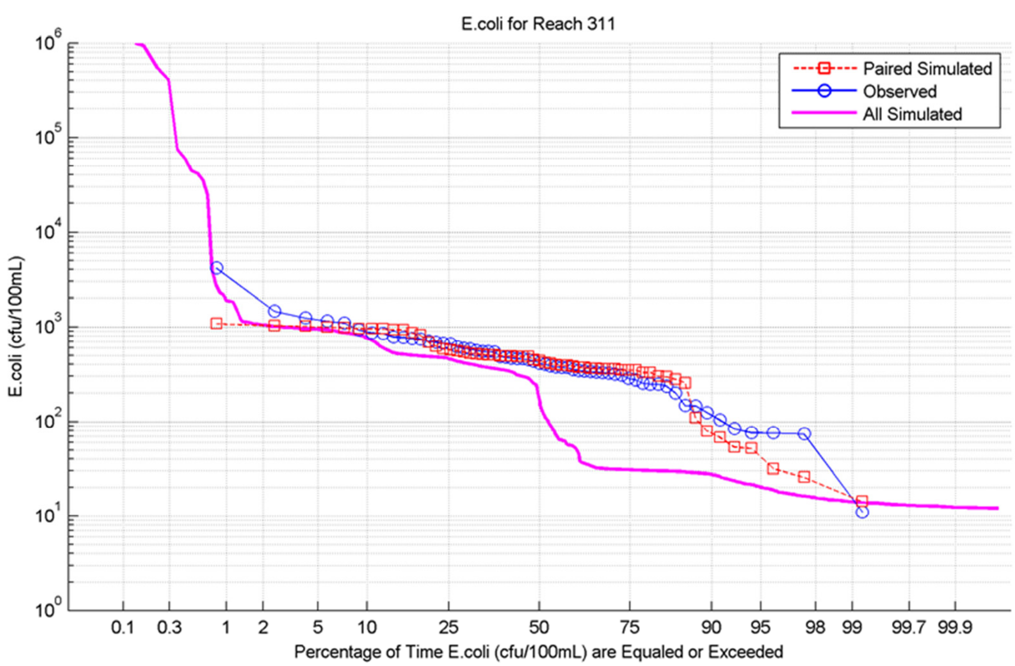

Figure 2-5. Concentration-Duration Curve for Bitter Creek.

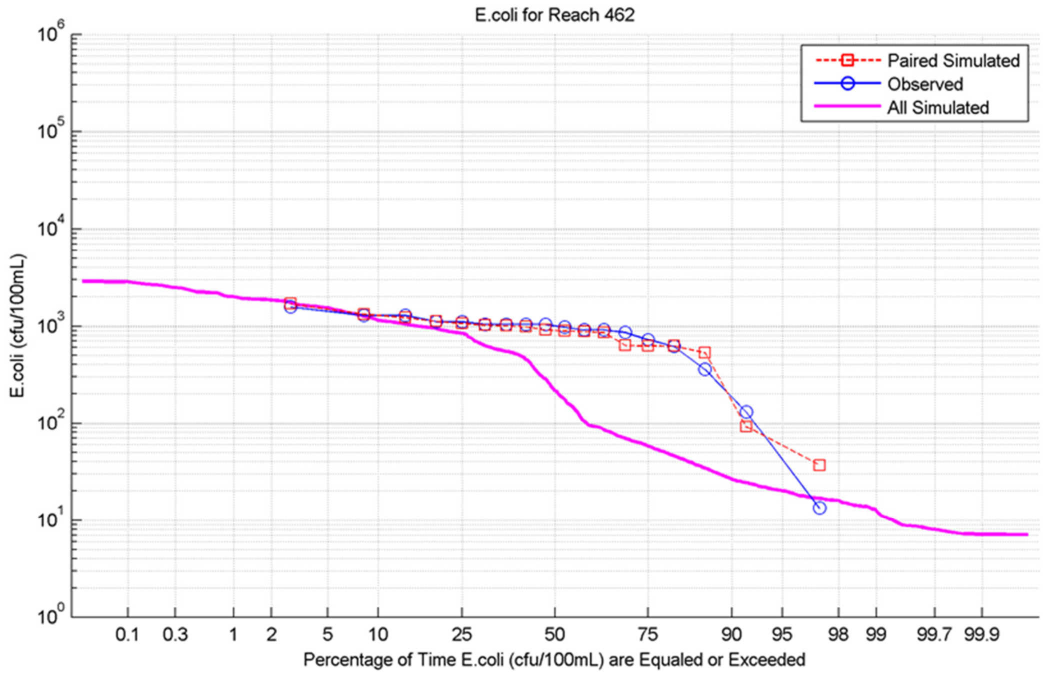

Figure 2-6. Concentration-Duration Curve for Sage Creek.

2.2.3 Source Assessment

Sources to the impaired reach of the Shoshone River represent the entire project area. Approximately 97 percent of the loading within the project area is linked to irrigated cropland (Figure 2-7 and Table 2-4), which includes runoff from irrigated lands, leakage from canals and drains, and irrigation return flows. Trends for all impaired reaches were very similar to the impaired reach of the Shoshone River, because each has over 90 percent of their loading linked to irrigated cropland. Note that, although irrigation is the primary delivery mechanism of bacteria to rivers and streams in the project area, defecation from animals and humans is the source of the bacteria deposition and buildup.

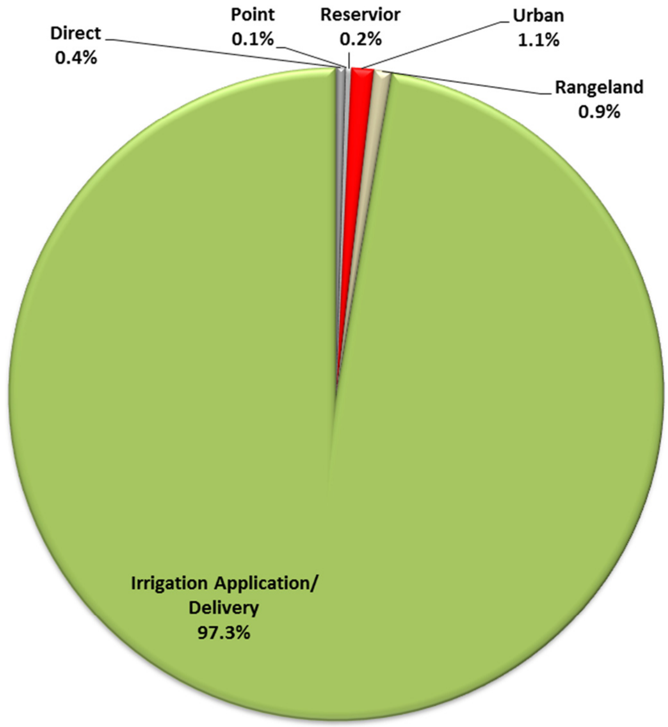

Figure 2-7. Source Allocations for the Impaired Reach of the Shoshone River.

Table 2-4. *E. coli* Loads by Source Within the Project Area During the Summer Recreation Season

Source	*E. coli* Load (%)							
	Dry Gulch	Bitter Creek	Whistle Creek	Foster Gulch	Polecat Creek	Big Wash	Sage Creek	Shoshone River[a]
Indirect Sources								
Irrigated Cropland	99.28	96.94	98.64	99.36	97.9	90.33	97.19	97.29
Urban	0.01	2.48	0.75	0.28	1.09	5.24	0.75	1.12
Rangeland	0.25	0.04	0.32	0.27	0.33	1.32	1.35	0.89
Nonirrigated Riparian	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01
Forest	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00
Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Direct Sources								
Direct Defecation and Septic Contributions	0.46	0.53	0.29	0.09	0.66	3.09	0.67	0.43
WWTFs	0.00	0.01	0.00	0.00	0.02	0.00	0.02	0.10
Buffalo Bill Reservoir (Upstream Boundary Condition)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16

(a) The impaired reach of the Shoshone River is the most downstream reach assessed by the model and is essentially a culmination of all water-quality processes that occur upstream.

3.0 TOTAL MAXIMUM DAILY LOAD AND ALLOCATIONS

Load duration curves (LDCs), which represent the allowable daily load under any given flow condition, were used to represent the loading capacity and allocations of each impaired reach. This approach results in a flow-variable target that considers the entire flow regime within the time period of interest. Five flow intervals were identified for each reach, and the loading capacity and allocations were developed for each flow interval. The five flow intervals were high (0–10 percent), moist (10–40 percent), midrange (40–60 percent), dry (60–90 percent), and low (90–100 percent) in adherence to guidance provided by the U.S. Environmental Protection Agency [2007]. The loading capacities were based on the geometric mean standard.

Two sets of allocations were developed for each impaired reach: one for the summer recreation season that was based on the 126 org/100 mL standard (in effect from May 1 through September 30) and one for the winter recreation season that was based on the 630 org/100 mL standard (in effect from October 1 through March 30). Because of the lack of flow and *E. coli* data at the downstream ends of the impaired reaches, the **HSPF** model application was used to simulate flow and bacteria concentrations at the endpoints of each impaired reach. Simulated data from the summer recreation season and winter recreation time periods were used to calculate the TMDL and associated components for the summer recreation season and winter recreation season TMDLs, respectively. The loading capacities and allocations are all presented in the units of cfu/day.

3.1 LOADING CAPACITY

The TMDL is the loading capacity of a reach and is the sum of the load allocation (LA), the wasteload allocation (WLA), and a MOS, shown in Equation 3-1.

$$\mathrm{TMDL} = \mathrm{LA} + \mathrm{WLA} + \mathrm{MOS} \tag{3-1}$$

LDCs were used to represent the loading capacity. The flow component of the loading capacity curve is the running 30-day geometric mean flow of the simulated daily average flows, and the concentration component is the applicable *E. coli* concentration criterion. The loading capacities presented in the TMDL tables are the products of the 95th percentile simulated flow in each flow interval, the applicable concentration criterion, and a unit conversion factor, as shown in Equation 3-2.

$$\frac{C\,mpn}{100\,\mathrm{mL}} \times \frac{Q\,\mathrm{ft}^3}{1\,s} \times \frac{86{,}400\,s}{1\,d} \times \frac{28{,}317\,\mathrm{mL}}{1\,\mathrm{ft}^3} \times \frac{1}{10^9} = C \times Q \times 0.0245\,\frac{\mathrm{cfu} \times 10^9}{\mathrm{day}} \tag{3-2}$$

where:

C = concentration
Q = flow
L = load.

3.2 MARGIN OF SAFETY

The MOS is an unallocated load intended to account for uncertainties in the allocations (e.g., monitored or modeled loads from tributary streams and the effectiveness of controls). An explicit MOS was calculated as the difference between the loading capacity at the midpoint of each of the five flow zones and the loading capacity at the minimum flow in each zone. A substantial MOS is provided using this method, because the loading capacity is typically much less at the minimum flow of a zone when compared to the midpoint [U.S. Environmental Protection Agency, 2007]. Because the allocations are a direct function of flow, accounting for potential flow variability is an appropriate way to address the MOS.

3.3 WASTELOAD ALLOCATION

The WLA is the sum of the permitted point-source allocations within each reach. The only permitted point sources in the project area were WWTFs. The design flow (which was calculated by WYPDES based upon average flow [Coleman, 2014]), the bacteria concentration limit used to calculate the WLAs, and the WLA for each facility are included in Table 2-1. The WLAs were based on the WYPDES permit limits and were calculated as the product of the total WWTF design flows in each reach, the applicable criterion concentration (summer or winter recreation season), and the unit conversion factor (Equation 3-2). Some of the WWTFs are located in the watersheds of multiple impaired reaches; these facilities each receive one WLA, and that WLA is reflected in the combined WLA of each impaired reach (Table 3-1). The WLAs do not vary based on flow.

Table 3-1. Shoshone Total Maximum Daily Load *E. coli* Point-Source Allocations

Impaired Reach	WLA Facilities (all Wastewater Lagoons)	Facilities Accounted for in an Upstream WLA	Individual Summer Recreation Season WLA (10^9 cfu/day)	Total Reach Summer Recreation Season WLA (10^9 cfu/day)	Individual Winter Recreation Season WLA (10^9 cfu/day)	Total Reach Winter Recreation Season WLA (10^9 cfu/day)
Bitter Creek	Powell	N/A	23.4	23.4	116.9	116.9
Polecat Creek	Deaver	N/A	0.2	0.2	1.2	1.2
Sage Creek	Frannie	Deaver	0.1	0.1	0.5	0.5
Shoshone River	Cody	Deaver and Frannie	1,573.7	1,578.0	2,430.8	2,452.3
	Byron		1.4		7.2	
	Lovell		2.9		14.3	

3.4 LOAD ALLOCATION

The LA represents the load allowed from nonpoint sources. The LA was calculated as the loading capacity minus the MOS and the WLA.

3.5 LOAD REDUCTIONS TO MEET TOTAL MAXIMUM DAILY LOAD

The percent load reductions needed to meet the loading capacity in each flow interval were calculated to provide a sense of the overall magnitude of the reductions needed. The percent reductions also help focus management recommendations; if higher reductions are needed in a certain flow interval, management practices should focus on the sources that most likely exist under those flow conditions. Exceedances of the criteria during high flows are typically caused by indirect pollutant sources that reach surface waters through watershed runoff. Low-flow exceedances are typically caused by direct pollutant loads or sources in close proximity to the stream, such as direct defecation by wildlife or livestock in the stream channel or failing septic systems [U.S. Environmental Protection Agency, 2007]. Low-flow exceedances can also be caused by runoff from snow melt or irrigation applications.

To calculate the percent reductions needed, the current load in each flow zone was approximated by the 30-day running geometric mean of the daily simulated load at the 95th percentile within that flow interval. The load reduction required to meet the TMDL in each flow zone was then calculated by subtracting the loading capacity from the current load. The overall percent reduction required for all flow regimes in an impaired reach was a weighted average and was calculated by multiplying the fraction of time flows that are equaled or exceeded in each flow zone (0.1 for high, 0.3 for moist, 0.2 for midrange, 0.3 for dry, and 0.1 for low) by the load reductions and current loads for each flow zone and calculating the quotient of the two flow-weighted values. Required reductions were calculated separately for the summer and winter recreation seasons.

3.6 LOAD DURATION CURVES/TOTAL MAXIMUM DAILY LOAD TABLES

This section presents the LDCs for the summer recreation season (Figures 3-1 through 3-8) and the TMDL tables for the summer and winter recreation seasons (Tables 3-2 through 3-17). These figures and tables are grouped by impaired reach. The tables include one TMDL table per impaired reach for the summer recreation season and one for the winter recreation season. The figures illustrate the loading capacity, the WLA (where applicable), the observed *E. coli* loads, and the simulated *E. coli* loads. The loading capacity and the WLA are represented by LDCs, and the simulated loads are represented by boxplots of geometric means in each flow zone. Monitoring data from 2008 through 2012 were used to calculate the observed loads by multiplying the observed 30-day running geometric mean concentration by the simulated flow at the applicable flow percentile. The geometric means were means of the observed data within that 30-day time period, if more than five samples were available. Sufficient data were not always available to calculate a 30-day geometric mean for every impaired reach during this time period. Data that are higher than the loading capacity LDC exceed the water-quality criterion, and those below the curve are in compliance. The *E. coli* equivalents of the fecal coliform monitoring data are not included in the figures. Because the flow and water-quality monitoring data (see Sections 1.3.1 and 1.3.2) were used to calibrate the model application, they were also indirectly used to develop each LDC.

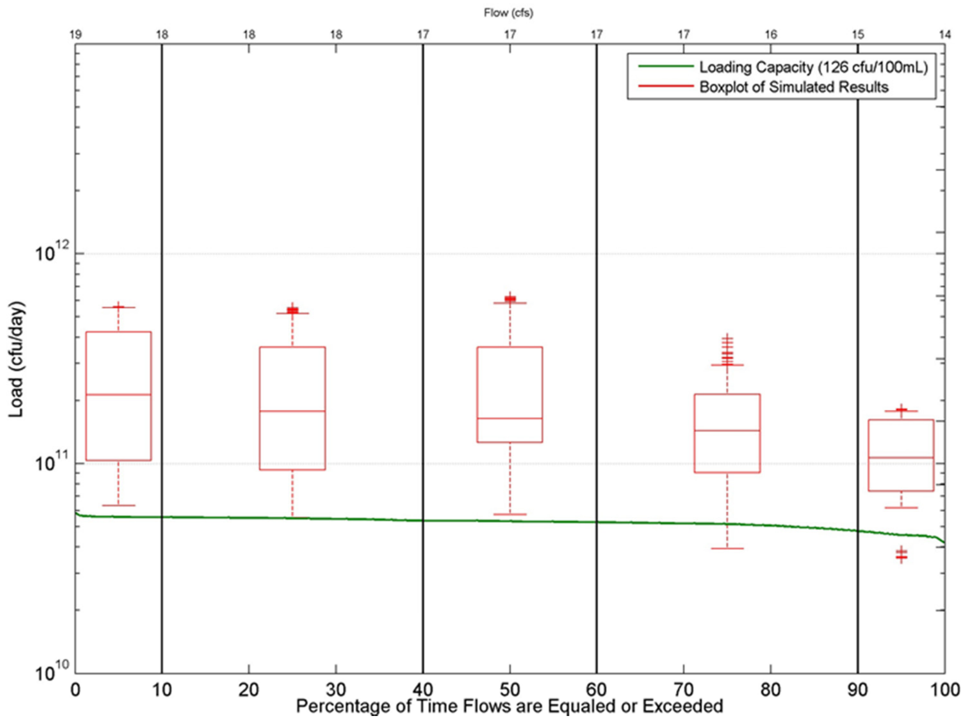

Figure 3-1. Dry Gulch Load Duration Curve Representing Geometric Mean *E. coli* Loads Based on Summer Recreation Season Criterion.

Table 3-2. Summer Recreation Season Total Maximum Daily Load Table for Dry Gulch

***E. coli* TMDL Component (expressed as 10^9 cfu/day)**	**Flow Zone**				
	High	**Moist**	**Midrange**	**Dry**	**Low**
	> 18.0 cfs	**18.0–17.4 cfs**	**17.4–17.1 cfs**	**17.1–15.5 cfs**	**< 15.5 cfs**
LA	56	55	53	49	44
WLA	0	0	0	0	0
MOS	1	1	1	4	4
TMDL	57	56	54	53	48
Current Load	556	519	587	295	178
Load Reduction	499	463	533	242	130
% Reduction	90	89	91	82	73
Overall Reduction Required = 88%					

Table 3-3. Winter Recreation Season Total Maximum Daily Load Table for Dry Gulch

E. coli **TMDL Component (expressed as 10^9 cfu/day)**	**Flow Zone**				
	High	**Moist**	**Midrange**	**Dry**	**Low**
	> 0.180 cfs	**0.180–0.047 cfs**	**0.047–0.012 cfs**	**0.012–0.002 cfs**	**< 0.002 cfs**
LA	21.63	1.77	0.52	0.11	0.02
WLA	0	0	0	0	0
MOS	4.23	0.67	0.15	0.07	0.01
TMDL	25.86	2.44	0.67	0.18	0.03
Current Load	18.31	9.69	7.55	6.10	6.32
Load Reduction	0	7.25	6.88	5.92	6.29
% Reduction	0	75	91	97	100
Overall Reduction Required = 68%					

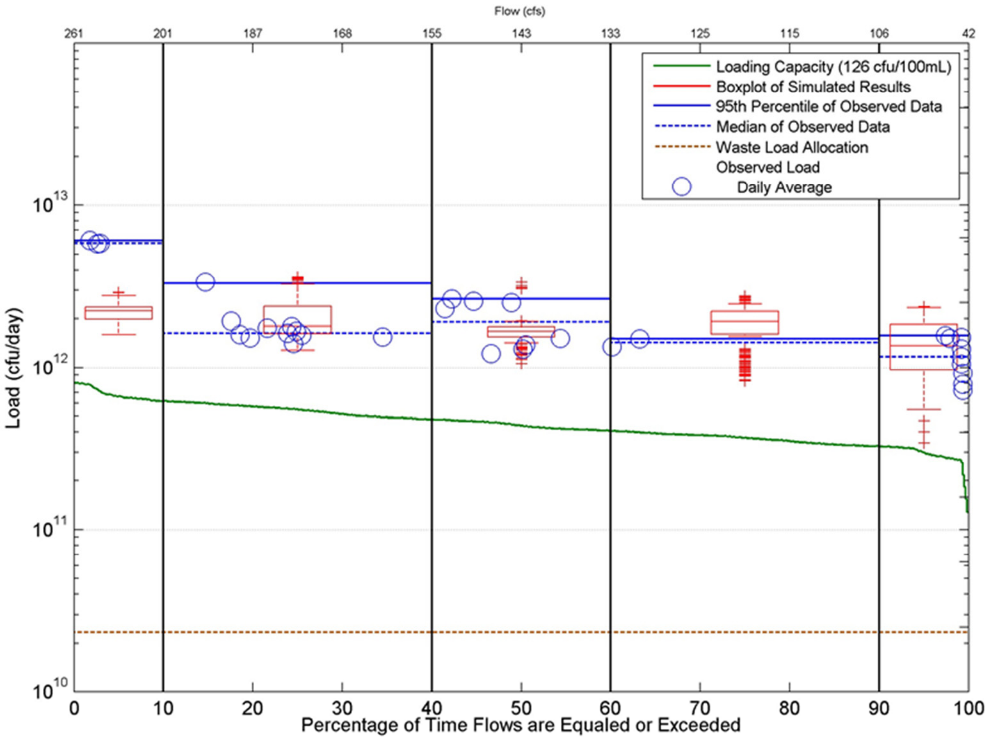

Figure 3-2. Bitter Creek Load Duration Curve Representing Geometric Mean *E. coli* Loads Based on Summer Recreation Season Criterion.

Table 3-4. Summer Recreation Season Total Maximum Daily Load Table for Bitter Creek

***E. coli* TMDL Component (expressed as 10^9 cfu/day)**	**Flow Zone**				
	High	**Moist**	**Midrange**	**Dry**	**Low**
	> 201 cfs	**201–155 cfs**	**155–133 cfs**	**133–106 cfs**	**< 106 cfs**
LA	742	525	427	344	135
WLA	23	23	23	23	23
MOS	41	72	31	42	172
TMDL	806	620	481	409	330
Current Load	2,809	3,018	3,297	2,816	1,957
Load Reduction	2,003	2,398	2,816	2,407	1,627
% Reduction	71	79	85	85	83
Overall Reduction Required = 82%					

Table 3-5. Winter Recreation Season Total Maximum Daily Load Table for Bitter Creek

E. coli TMDL Component (expressed as 10^9 cfu/day)	Flow Zone				
	High	**Moist**	**Midrange**	**Dry**	**Low**
	> 54 cfs	**54–19 cfs**	**19–17 cfs**	**17–16 cfs**	**< 16 cfs**
LA	1,353	528	167	147	72
WLA	117	117	117	117	117
MOS	589	84	4	6	67
TMDL	2,059	729	288	270	256
Current Load	200	29	30	29	29
Load Reduction	0	0	0	0	0
% Reduction	0	0	0	0	0
Overall Reduction Required = 0%					

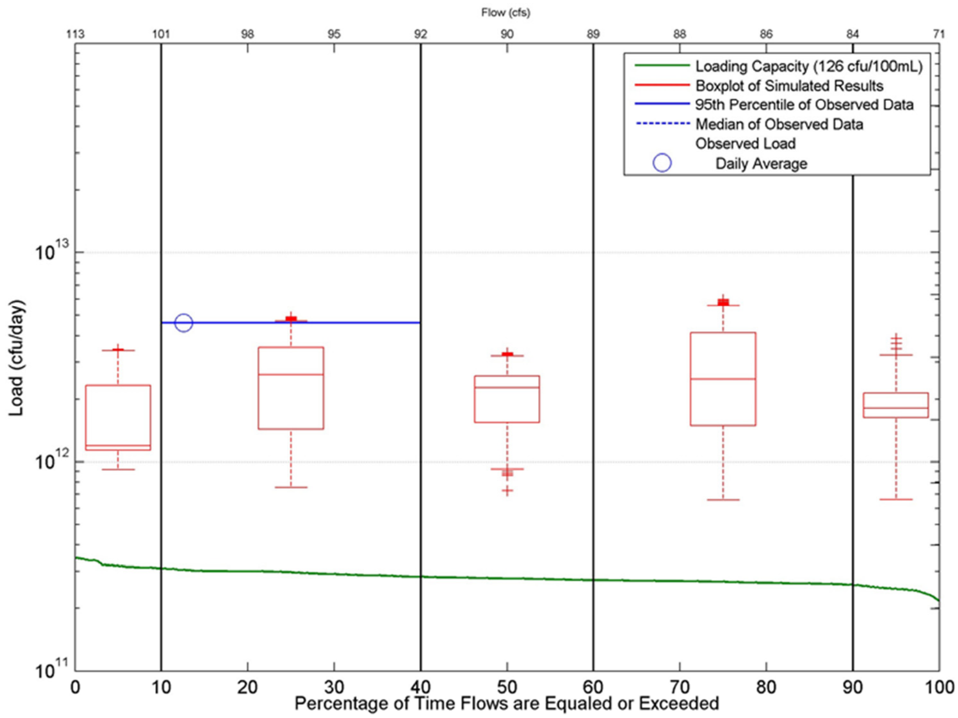

Figure 3-3. Whistle Creek Load Duration Curve Representing Geometric Mean *E. coli* Loads Based on Summer Recreation Season Criterion.

Table 3-6. Summer Recreation Season Total Maximum Daily Load Table for Whistle Creek

***E. coli* TMDL Component (expressed as 10^9 cfu/day)**	**Flow Zone**				
	High	**Moist**	**Midrange**	**Dry**	**Low**
	> 101 cfs	**101–92 cfs**	**92–89 cfs**	**89–84 cfs**	**< 84 cfs**
LA	341	296	280	265	230
WLA	0	0	0	0	0
MOS	8	14	5	10	30
TMDL	349	310	285	275	260
Current Load	3,397	4,698	3,210	5,587	3,319
Load Reduction	3,048	4,388	2,925	5,312	3,059
% Reduction	90	93	91	95	92
Overall Reduction Required = 93%					

Table 3-7. Winter Recreation Season Total Maximum Daily Load Table for Whistle Creek

***E. coli* TMDL Component (expressed as 10^9 cfu/day)**	**Flow Zone**				
	High	**Moist**	**Midrange**	**Dry**	**Low**
	> 8.6 cfs	**8.6–0.8 cfs**	**0.8–0.4 cfs**	**0.4–0.2 cfs**	**< 0.2 cfs**
LA	440	85	10	4	1
WLA	0	0	0	0	0
MOS	179	22	1	2	1
TMDL	619	107	11	6	2
Current Load	71	7	4	3	2
Load Reduction	0	0	0	0	0
% Reduction	0	0	0	0	0
Overall Reduction Required = 0%					

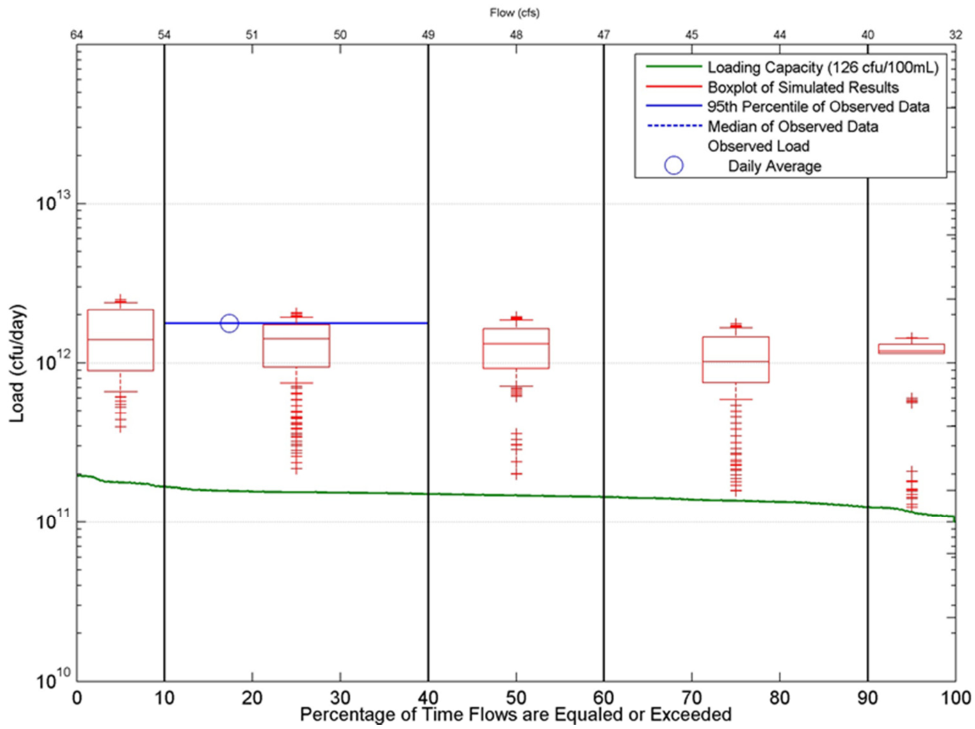

Figure 3-4. Foster Gulch Load Duration Curve Representing Geometric Mean *E. coli* Loads Based on Summer Recreation Season Criterion.

Table 3-8. Summer Recreation Season Total Maximum Daily Load Table for Foster Gulch

***E. coli* TMDL Component (expressed as 10^9 cfu/day)**	**Flow Zone**				
	High	**Moist**	**Midrange**	**Dry**	**Low**
	> 54 cfs	**54–49 cfs**	**49–47 cfs**	**47–40 cfs**	**< 40 cfs**
LA	187	162	149	133	109
WLA	0	0	0	0	0
MOS	10	4	3	12	16
TMDL	197	166	152	145	125
Current Load	2,385	1,928	1,849	1,649	1,419
Load Reduction	2,188	1,762	1,697	1,504	1,294
% Reduction	92	91	92	91	91
Overall Reduction Required = 91%					

Table 3-9. Winter Recreation Season Total Maximum Daily Load Table for Foster Gulch

E. coli TMDL Component (expressed as 10^9 cfu/day)	Flow Zone				
	High	Moist	Midrange	Dry	Low
	> 4.7 cfs	4.7–0.7 cfs	0.7–0.4 cfs	0.4–0.2 cfs	< 0.2 cfs
LA	238	54	8	4	2
WLA	0	0	0	0	0
MOS	83	6	2	2	1
TMDL	321	60	10	6	3
Current Load	15	2	2	1	1
Load Reduction	0	0	0	0	0
% Reduction	0	0	0	0	0
Overall Reduction Required = 0%					

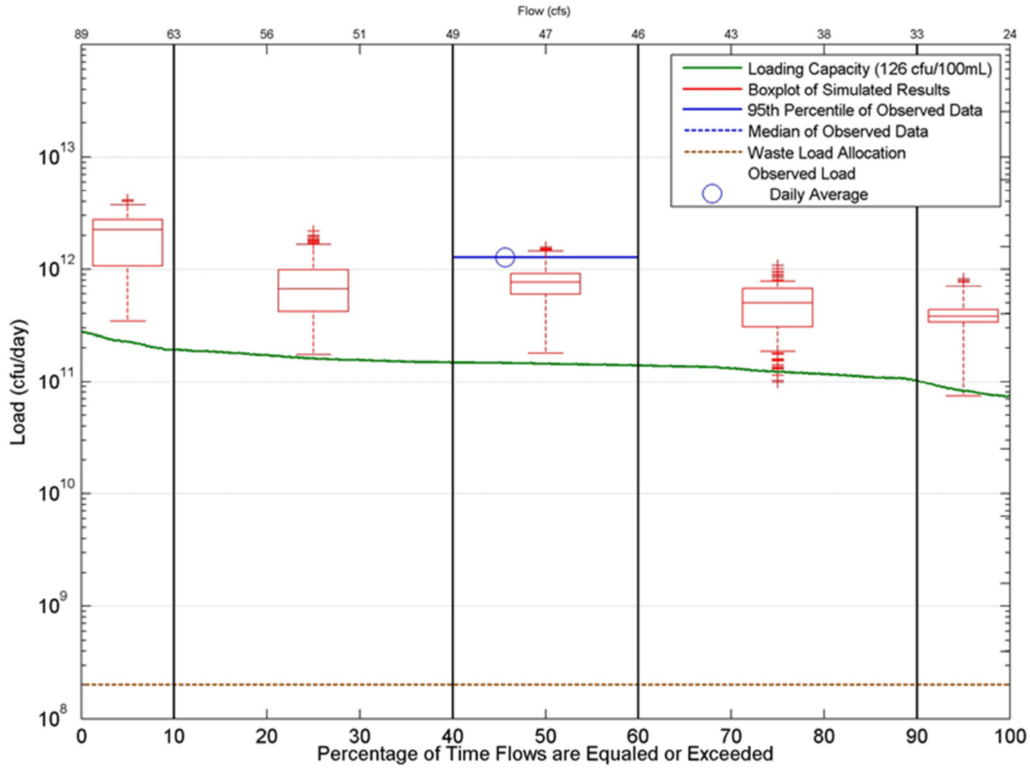

Figure 3-5. Polecat Creek Load Duration Curve Representing Geometric Mean *E. coli* Loads Based on Summer Recreation Season Criterion.

Table 3-10. Summer Recreation Season Total Maximum Daily Load Table for Polecat Creek

***E. coli* TMDL Component (expressed as 10^9 cfu/day)**	**Flow Zone**				
	High	**Moist**	**Midrange**	**Dry**	**Low**
	> 63 cfs	**63–49 cfs**	**49–46 cfs**	**46–33 cfs**	**< 33 cfs**
LA	240.1	179.8	145.6	119.7	91.0
WLA	0.2	0.2	0.2	0.2	0.2
MOS	33.7	12.2	4.7	20.9	9.0
TMDL	274.0	192.2	150.5	140.8	100.2
Current Load	3,738.9	1,675.9	1,454.5	785.1	728.9
Load Reduction	3,464.9	1,483.7	1,304.0	644.3	628.7
% Reduction	93	89	90	82	86
Overall Reduction Required = 89%					

Table 3-11. Winter Recreation Season Total Maximum Daily Load Table for Polecat Creek

E. coli TMDL Component (expressed as 10^9 cfu/day)	Flow Zone				
	High	Moist	Midrange	Dry	Low
	> 11 cfs	11–2 cfs	2–1 cfs	1–0 cfs	< 0 cfs
LA	471.4	123.6	21.1	11.4	5.8
WLA	1.2	1.2	1.2	1.2	1.2
MOS	121.3	32.5	5.3	3.4	0.4
TMDL	593.9	157.3	27.6	16.0	7.4
Current Load	39.1	14.6	10.2	4.0	3.8
Load Reduction	0	0	0	0	0
% Reduction	0	0	0	0	0
Overall Reduction Required = 0%					

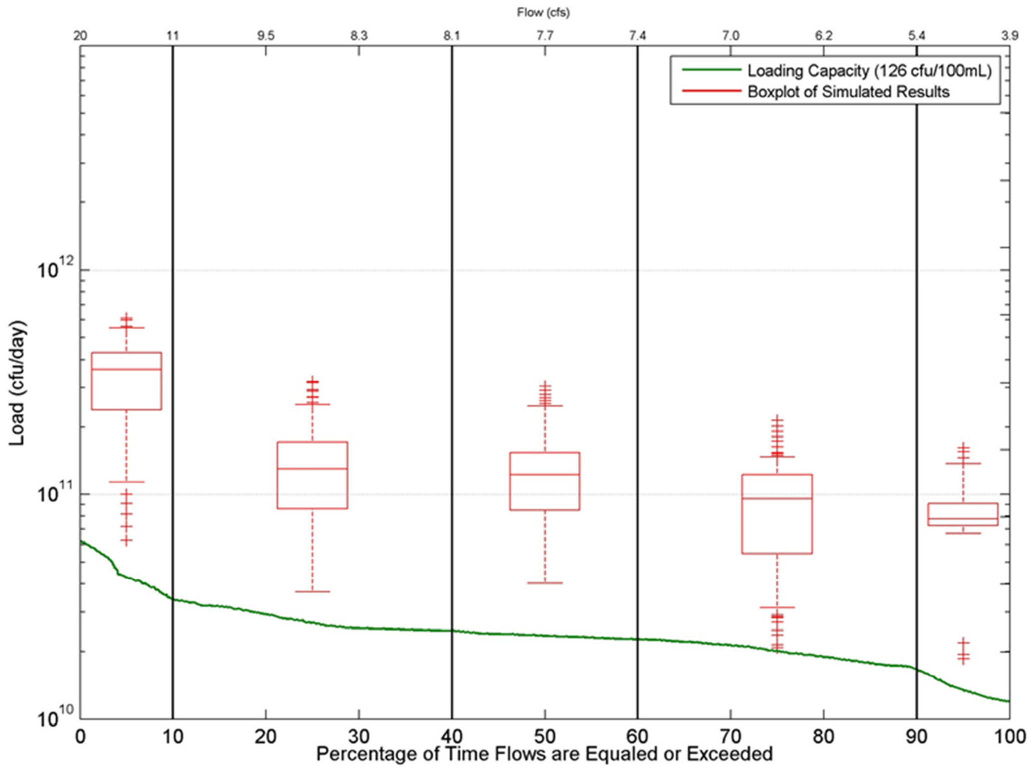

Figure 3-6. Big Wash Load Duration Curve Representing Geometric Mean *E. coli* Loads Based on Summer Recreation Season Criterion.

Table 3-12. Summer Recreation Season Total Maximum Daily Load Table for Big Wash

E. coli **TMDL Component (expressed as 10^9 cfu/day)**	**Flow Zone**				
	High	**Moist**	**Midrange**	**Dry**	**Low**
	> 11 cfs	**11–8 cfs**	**8–7 cfs**	**7–5 cfs**	**< 5 cfs**
LA	52	32	24	20	15
WLA	0	0	0	0	0
MOS	9	2	1	3	1
TMDL	61	34	25	23	16
Current Load	555	252	250	148	141
Load Reduction	494	218	225	125	125
% Reduction	89	87	90	84	89
Overall Reduction Required = 88%					

Table 3-13. Winter Recreation Season Total Maximum Daily Load Table for Big Wash

E. coli TMDL Component (expressed as 10^9 cfu/day)	Flow Zone				
	High	Moist	Midrange	Dry	Low
	> 2.90 cfs	2.90–0.41 cfs	0.41–0.16 cfs	0.16–0.02 cfs	< 0.02 cfs
LA	95.1	32.3	3.8	1.6	0.2
WLA	0	0	0	0	0
MOS	23.3	6.8	2.3	0.8	0.1
TMDL	118.4	39.1	6.1	2.4	0.3
Current Load	14.1	8.0	5.9	2.6	2.3
Load Reduction	0	0	0	0.2	2.0
% Reduction	0	0	0	8	87
Overall Reduction Required = 4%					

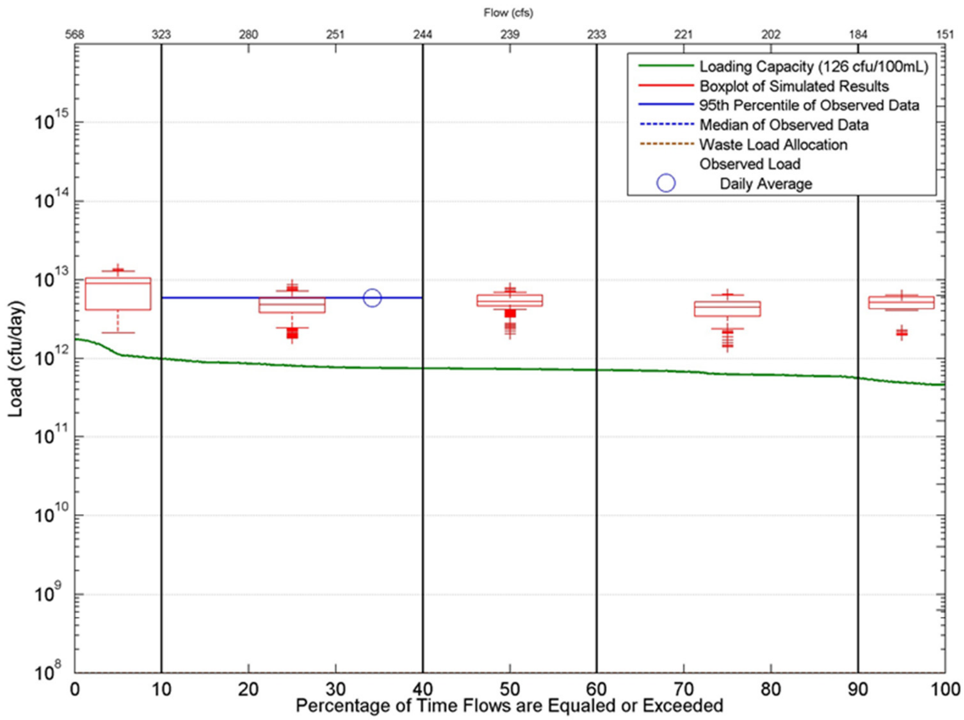

Figure 3-7. Sage Creek Load Duration Curve Representing Geometric Mean *E. coli* Loads Based on Summer Recreation Season Criterion.

Table 3-14. Summer Recreation Season Total Maximum Daily Load Table for Sage Creek

***E. coli* TMDL Component (expressed as 10^9 cfu/day)**	**Flow Zone**				
	High	**Moist**	**Midrange**	**Dry**	**Low**
	> 323 cfs	**323–244 cfs**	**244–233 cfs**	**233–184 cfs**	**< 184 cfs**
LA	1,613.2	912.8	737.6	652.3	529.1
WLA	0.1	0.1	0.1	0.1	0.1
MOS	133.5	57.4	20.7	65.6	31.2
TMDL	1,746.8	970.3	758.4	718.0	560.4
Current Load	12,866.2	7,251.1	6,909.3	6,398.9	6,352.0
Load Reduction	11,119.4	6,280.8	6,150.9	5,680.9	5,791.6
% Reduction	86	87	89	89	91
Overall Reduction Required = 88%					

Table 3-15. Winter Recreation Season Total Maximum Daily Load Table for Sage Creek

E. coli TMDL Component (expressed as 10^9 cfu/day)	Flow Zone				
	High	Moist	Midrange	Dry	Low
	> 53 cfs	53–13 cfs	13–9 cfs	9–6 cfs	< 6 cfs
LA	2,032	608	165	115	87
WLA	1	1	1	1	1
MOS	431	121	30	15	5
TMDL	2,464	730	196	131	93
Current Load	222	64	64	25	19
Load Reduction	0	0	0	0	0
% Reduction	0	0	0	0	0
Overall Reduction Required = 0%					

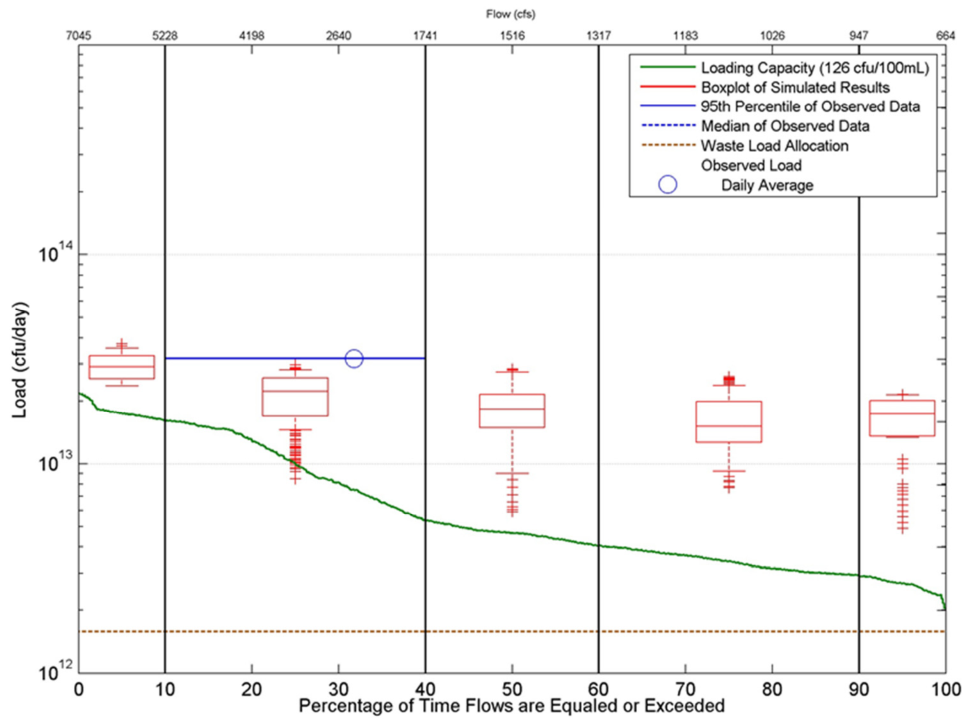

Figure 3-8. Shoshone River Load Duration Curve Representing Geometric Mean *E. coli* Loads Based on Summer Recreation Season Criterion.

Table 3-16. Summer Recreation Season Total Maximum Daily Load Table for Shoshone River

E. coli **TMDL Component (expressed as 10^9 cfu/day)**	**Flow Zone**				
	High	**Moist**	**Midrange**	**Dry**	**Low**
	> 5,228 cfs	**5,228–1,741 cfs**	**1,741–1,317 cfs**	**1,317–947 cfs**	**< 947 cfs**
LA	18,692	9,817	3,103	1,961	701
WLA	1,578	1,578	1,578	1,578	1,578
MOS	1,314	4,651	616	496	648
TMDL	21,584	16,046	5,297	4,035	2,927
Current Load	36,049	28,205	27,468	23,690	21,435
Load Reduction	14,465	12,159	22,171	19,655	18,508
% Reduction	40	43	81	83	86
Overall Reduction Required = 64%					

Table 3-17. Winter Recreation Season Total Maximum Daily Load Table for Shoshone River

E. coli TMDL Component (expressed as 10^9 cfu/day)	Flow Zone				
	High	Moist	Midrange	Dry	Low
	> 791 cfs	791–482 cfs	482–466 cfs	466–292 cfs	< 292 cfs
LA	17,572	8,316	4,922	2,235	1,030
WLA	2,452	2,452	2,452	2,452	2,452
MOS	3,756	733	99	2,535	1,024
TMDL	23,780	11,501	7,473	7,222	4,506
Current Load	1,444	384	455	468	432
Load Reduction	0	0	0	0	0
% Reduction	0	0	0	0	0
Overall Reduction Required = 0%					

4.0 SEASONALITY

Monthly precipitation, stream flows, and *E. coli* concentrations in the Shoshone River project area vary seasonally. Average monthly precipitation in Cody, Powell, and Lovell is generally the highest in spring (April, May, and June) and fall (September and October) (Figure 4-1). Short-duration, high-intensity rainstorms are common during the summer months. These localized summer storms can cause significant runoff and increased bacteria concentrations for a relatively short period of time and only slightly increase stream flows.

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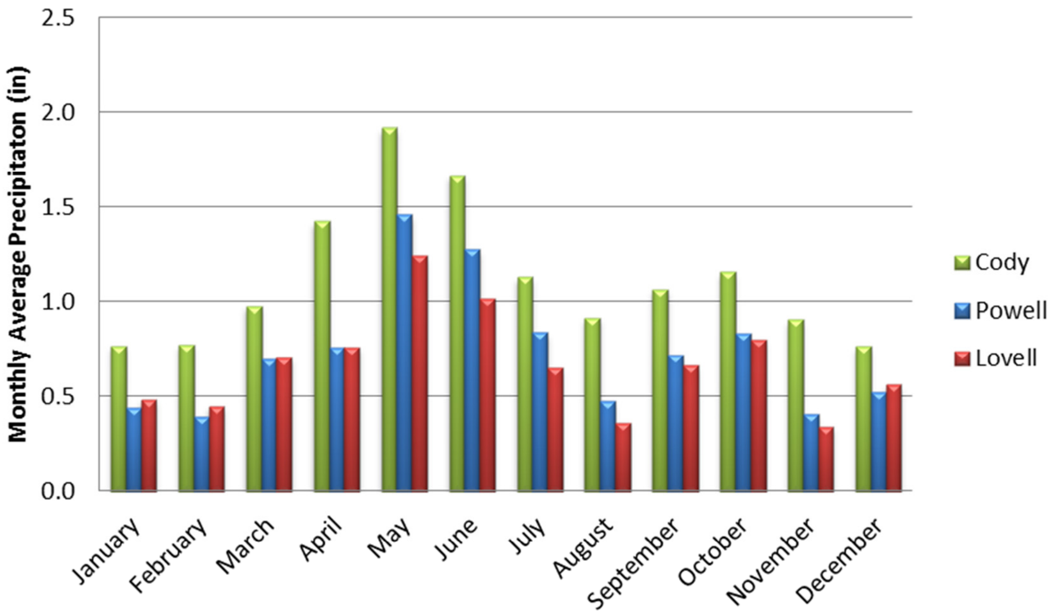
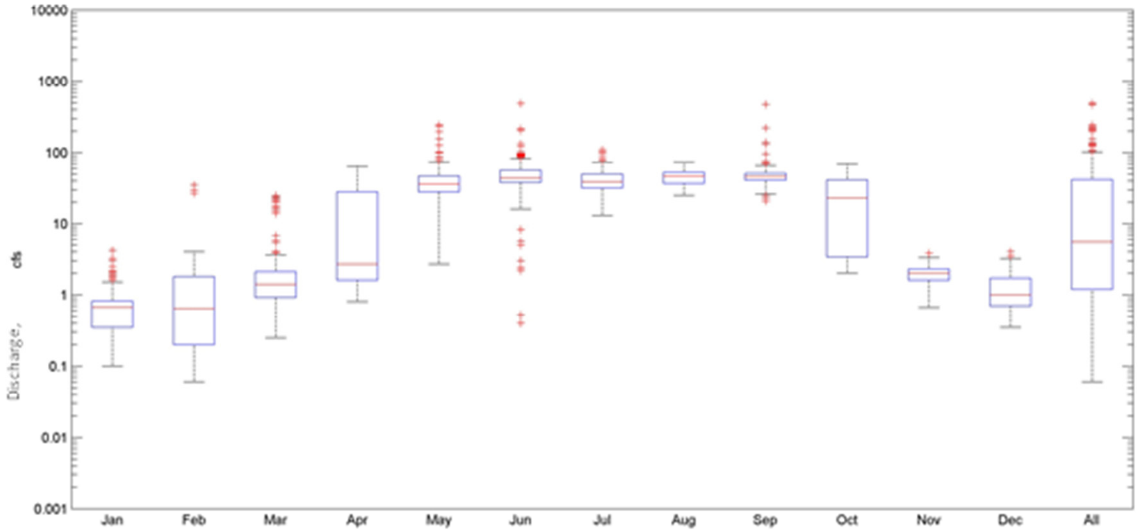


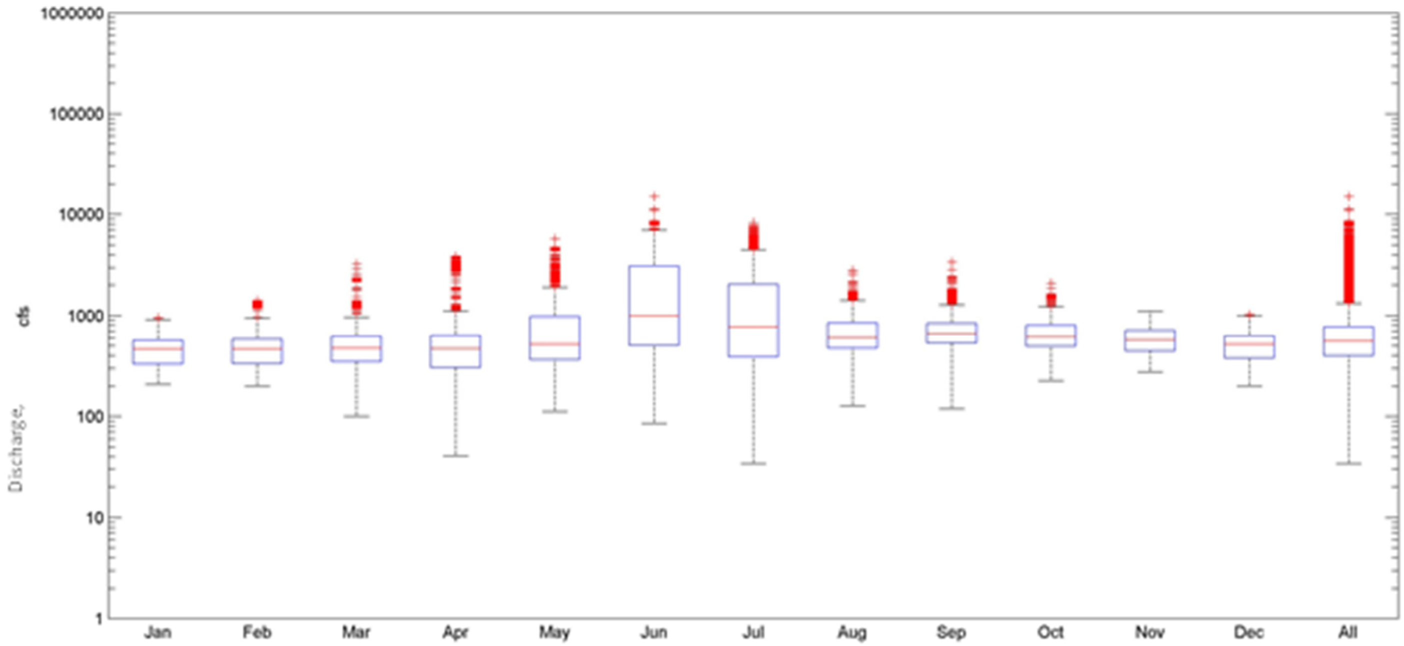
Figure 4-1. Monthly Average Annual Precipitation From the High Plains Regional Climate Center From 1981 Through 2011 at Cody, Powell, and Lovell, Wyoming.

Flows in the project area were typically highest on the Shoshone River (near Lovell) and Whistle Creek (near Garland, Wyoming) during the late spring and early summer months and lowest during fall and winter months (Figures 4-2 and 4-3). The Shoshone River near Lovell was selected as a representative mainstem site near the downstream end of the project area, and Whistle Creek was selected as a representative tributary site. The greatest median flow on the Shoshone River near Lovell occurred in June (995 cubic feet per second [cfs]), and the smallest median flow (466 cfs) occurred in January and February (Figure 4-2). At Whistle Creek, the greatest median flow occurred in August (47 cfs) and the smallest median flows (1 cfs) occurred in December, January, February, and March (Figure 4-3).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All
n	217	198	196	203	198	199	186	186	180	156	169	186	2274
Min	0	0	0	1	3	0	13	25	21	2	1	0	0
Max	4	35	25	64	244	493	110	74	477	69	4	4	493
q1	0	0	1	2	28	38	32	37	41	3	2	1	1
Median	1	1	1	3	36	44	39	47	46	23	2	1	6
q3	1	2	2	28	47	57	50	53	51	42	2	2	42
Mean	1	1	3	14	42	52	42	46	51	23	2	1	23
90th%	2	2	4	39	67	80	61	62	61	46	2	2	53
95th%	2	3	16	46	84	94	69	66	69	48	3	2	61

Figure 4-2. Monthly Boxplot of Flow at the Shoshone River Near Lovell (USGS 06285100), 1980–2012.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All
n	992	904	1012	990	1023	990	1023	1018	990	1023	990	972	11927
Min	210	200	100	41	111	85	34	126	118	226	276	200	34
Max	950	1400	3250	3890	5730	15200	8270	2800	3390	2060	1100	1020	15200
q1	330	335	351	305	367	508	389	476	536	499	446	380	400
Median	466	466	477	472	522	995	772	605	662	617	577	520	560
q3	571	584	623	632	979	3110	2037	847	842	800	716	628	772
Mean	465	492	553	693	872	1982	1532	694	758	668	599	521	823
90th%	640	681	822	1195	2312	4790	4132	1120	1250	981	879	736	1418
95th%	691	830	1270	3040	2774	5690	5581	1370	1520	1134	965	840	2740

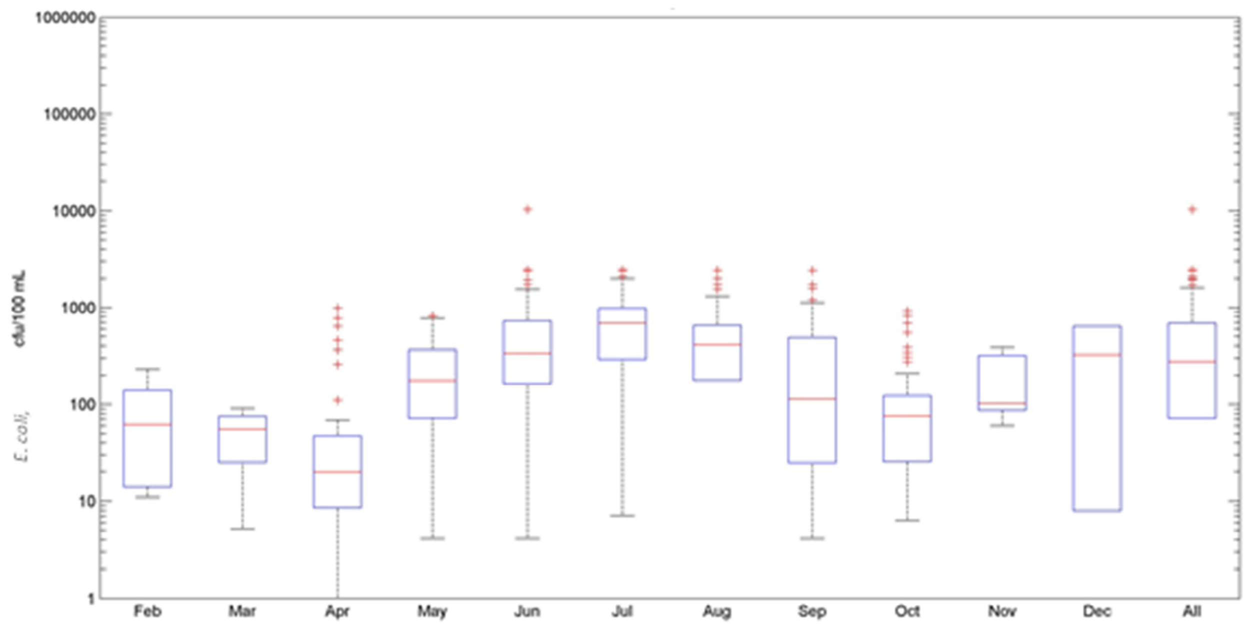
Figure 4-3. Monthly Boxplot of Flow at Whistle Creek Near Garland (USGS 06284800), 1980–2012.

The highest average and median bacteria concentrations in the project area occurred in the spring and summer months (Figure 4-4). The highest median bacteria concentrations occurred in July (727 cfu/100 mL) and August (411 cfu/100 mL), and the lowest occurred in April (18 cfu/100 mL) and October (28 cfu/100 mL). Higher flows and higher bacteria concentrations occur during the late spring to early summer months, and by extension, bacteria loads are also highest during this time period.

The LDC approach to develop the TMDL allocations for five flow zones accounts for the seasonal variability in flow and *E. coli* loads (e.g., the high-flow zone contains flows that primarily occur in May and June). The TMDL itself is seasonal, because the summer recreation season criterion is lower (i.e., more protective) than the winter recreation season criterion.

Accounting for seasonality is critical for a bacteria TMDL because of the seasonal differences in land-use practices. Within the project area, livestock are commonly moved from lower elevations to higher elevations in the mountains in the summer. This change in land management during the summer months introduces a seasonal component to bacteria accumulation rates in the watershed. Irrigation diversions and return flows to the streams also impact seasonal hydrology; irrigation is a seasonal land-use practice that creates artificial seasonality instream flow. This seasonal pattern is addressed in the TMDL with the LDC approach that is applied separately to the summer and winter seasons.

Seasonality was also addressed by using a continuous simulation. Bacteria accumulation in the model accounted for seasonality by accounting for the seasonal movement of wildlife and livestock (i.e., wildlife migration or cattle grazing allotment rotations). The model calibration also accounted for seasonality by calibrating to duration curves, daily time series, and monthly averages.



	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All
n	5	15	42	38	168	144	118	50	81	7	2	670
Min	11	5	1	4	4	7	0	4	6	60	8	0
Max	230	91	990	816	10426	2420	2420	2420	921	387	640	10426
q1	14	25	9	71	164	293	179	25	25	86	8	71
Median	62	56	20	176	337	687	411	113	75	102	324	276
q3	140	75	47	365	727	980	649	488	123	320	640	687
Mean	86	49	103	266	567	754	512	371	117	183	324	463
90th%	230	79	394	715	1178	1733	1046	1083	236	383	640	1046
95th%	230	88	692	753	1571	2420	1661	1573	460	387	640	1553

Figure 4-4. Boxplot of Monthly *E. coli* Concentrations From All Available *E. coli* Data (No Replicates).

5.0 PUBLIC PARTICIPATION

The efforts to facilitate public education, review, and comment while developing the Shoshone River Watershed TMDLs included presentations on the findings of the assessment at public meetings to stakeholders in the watershed, quarterly newsletters, a project website, public announcements, and a 30-day public notice period for review and comment. The findings and comments from these public meetings were taken into consideration when developing the TMDLs. The public notice was announced for one day during the week of August 19 in the *Casper Star*, *Lovell Chronicle*, *Powell Tribune*, and *Cody Enterprise*. The comment period was August 19 to September 16. A notice of the public comment period was also sent to individual emails on WDEQ's ListServe email service. Copies of the TMDL were made available at each conservation district and online at the WDEQ TMDL website. Comments received during the public comment period and responses to those comments are presented in Appendix A.

A public involvement plan was developed specifically for this project to facilitate and document all public outreach throughout the project. Public information objectives provided stakeholders with information about the project, the opportunity to comment and ask questions, and an opportunity to participate on the project's Technical Advisory Committee.

A total of seven public meetings were held during the project (Table 5-1). Two project kick-off meetings were held near the start of the project, one public meeting was held at the end of both the Watershed Characterization Phase and the TMDL Analysis Phase, and three public meetings were held at the end of the TMDL Implementation Recommendations Phase. The public meetings were held as informal, open-house meetings where the project team presented information before an open discussion of issues and concerns. Public meetings for this project were open to the general public with a special emphasis on watershed stakeholders. The locations of the public meetings were moved throughout the watershed to maximize public involvement.

Table 5-1. Schedule of Public Meetings

Number of Meetings	Project Phase	Dates	Locations
2	Kick-Off Meetings	August 22 and 23, 2012	Cody and Lovell
1	Watershed Characterization Phase	September 27, 2012	Powell
1	TMDL Analysis Phase	April 25, 2013	Lovell
3	TMDL Implementation Recommendations Phase	July 23 and 24, 2013	Cody, Powell, and Lovell

The purpose of the Technical Advisory Committee was to establish a group of stakeholders that monitored the project's progress and provided guidance to the project team. Conference calls were scheduled almost every month to discuss project progress, address technical concerns, and assist the project team by providing information about the watershed. An email was sent approximately 1 week before meetings to remind participants, and a toll-free, call-in number was provided. A total of ten Technical Advisory Committee meetings were held on the following dates:

September 25, 2012	February 27, 2013
October 30, 2012	March 27, 2013
November 28, 2012	April 24, 2013
December 19, 2012	May 29, 2013
January 30, 2013	June 26, 2013

The following communication tools were used to disseminate project information and promote community engagement:

- **WDEQ Project Website for the Public.** A public website (*http://deq.state.wy.us/wqd/watershed/TMDL/Shoshone%20RFP/ShoshoneTMDL.htm*) was established by the WDEQ, and it provided project information and upcoming meeting dates and locations.
- **Project Website for the Project Team.** A project website, using Microsoft SharePoint software, was created for members of the project team and the Technical Advisory Committee. The website was used to upload and download files and maintain a project calendar. Access to the SharePoint project website was assigned individually through a designated login and password.
- **Public Announcements.** Public announcements were distributed to six local news publications and four radio stations to announce upcoming public meetings. The public announcements included the date, time, and location of each public meeting. Public announcements were distributed both 1 month before and 2 weeks before each meeting.
- **Email Contact List.** An email contact list was maintained and updated throughout the project to distribute information. The email contact list included contact information collected from attendees at the scheduled public meetings and contact information for members of stakeholder groups. Email was the primary means for contacting stakeholders.
- **PowerPoint Presentations.** A presentation discussing the project background, project status, and public involvement opportunities was prepared for each set of public meetings. PowerPoint presentations were available after each meeting on the public website. A total of four presentations were prepared for public meetings. In addition, PowerPoint presentations were prepared for Technical Advisory Committee meetings as needed.

- **Information Banners.** Displays that explained project background information and project status in more detail were developed for public meetings.
- **Quarterly Update Newsletters.** Project updates were provided quarterly in a newsletter format to the local conservation districts for inclusion in district newsletters and/or on district websites. The quarterly update newsletters were also emailed to individuals and agencies included in the project's email contact list. A total of four quarterly update newsletters were distributed.
- **Fact Sheets.** A fact sheet summarizing the presentation from each of the four sets of public meetings was distributed during the public meetings. The fact sheets summarized the TMDL project background, status, and conclusions and recommendations developed during each phase.
- **Sign-In Sheets.** Sign-in sheets that identified attendees and collected contact information for the email contact list were available at the public meetings.
- **Comment Cards.** Comment cards were distributed at the public meetings as an additional forum for the public and other stakeholders to provide input.
- **Watershed Tour.** A tour of the watershed was conducted on August 22 and 23, 2012, to familiarize the project team and stakeholders with the watershed and the BMPs that have been implemented in the watershed.

6.0 MONITORING STRATEGY

During and after the implementation of management practices, monitoring will be necessary to evaluate the attainment of the TMDLs. A detailed monitoring plan that identifies additional monitoring sites should be completed as part of future efforts in the project area. The purpose of monitoring is to decrease TMDL uncertainty, evaluate TMDL attainment, and evaluate BMP effectiveness. Currently, the conservation districts have approved sampling and analysis plans that are in place to ensure that chemical, physical, and biological data are valid under the "Credible Data Law" [Wyoming Department of Environmental Quality, 2007]. The conservation districts have been monitoring many key locations in the watershed and typically collect five individual samples in a 30-day period to meet the data needs for evaluating the geometric mean criteria. The locations that the conservation districts have been sampling are well positioned to evaluate the TMDL in the future. Additional monitoring would be helpful at other sites upstream and downstream of areas where canals enter (either intentionally via drains or unintentionally via leakage) the mainstem Shoshone River or its tributaries. Monitoring canals, drains, shallow soils, and shallow groundwater in these locations would help evaluate their contribution to the tributaries. It would also be beneficial to monitor where land-use transitions from one type to another, such as where rangeland shifts to irrigated lands, to further clarify the sources of bacteria loading from individual land-use types. Monitoring upstream and downstream of areas with multiple small acreages would be beneficial. Also, instream monitoring directly upstream and downstream of permitted discharges would help develop a greater understanding of point sources–especially the Cody facility, which was effluent concentration limits higher than the instream concentration criteria.

Continuous discharge data across a broad range of flows improves load calculations. Future monitoring should include additional synoptic discharge measurements at existing water-quality sampling locations and at new sites to fill in data gaps at diversions, confluences, irrigation returns, and upstream and downstream segment endpoints in the watershed. Continuous-stage recorders should be installed at key locations in the watershed, and stage-discharge relationships should be developed to convert continuous stage to continuous flow. Relatively low-cost, low-maintenance technologies are available to record continuous stage. Synoptic and continuous flow data will increase the accuracy in future load calculations and the evaluation of BMPs and implementation practices.

Monitoring BMP effectiveness helps evaluate the adequacy of implementation strategies that are targeted to reduce bacteria loads or transport. Monitoring strategies depend on the type of BMP but typically include water-quality sampling and discharge measurements upstream and downstream of the BMP. Optimally, historic *E. coli* and flow data would exist for segments immediately upstream and downstream of BMPs to allow for a robust trend and BMP effectiveness analysis. BMP effectiveness data will improve the understanding of bacteria implementation and management measures. These data will increase the knowledge base that will help watershed managers select the most appropriate BMPs that are targeted toward local watershed characteristics.

The WDEQ will use this monitoring strategy to reevaluate the TMDL as implementation proceeds. This evaluation will occur at a minimum of every 5 years, as outlined in the WDEQ TMDL work plan [Wyoming Department of Environmental Quality, 2008]. The WDEQ will notify the EPA, and a new public review will be made available if any changes or adjustments are needed after the reevaluation.

7.0 RESTORATION STRATEGY

The restoration strategy addresses the *E. coli* load reductions needed for the impaired reaches to reach water-quality standards. The overall load reductions required a range from 4 percent in Big Wash during the winter recreation season to 93 percent in Whistle Creek during the summer recreation season (Table 7-1). Reductions are required in all flow zones for all impairments during the summer recreation season. During the winter recreation season, reductions are needed in Dry Gulch (all but the high-flow zone) and Big Wash (dry- and low-flow zones). However, the winter recreation season exceedances occur when flows are extremely low (less than 0.2 cfs).

Table 7-1. Load Reductions Needed

TMDL Reach	Season	Overall Reduction Required (%)	Load Reductions Required By Flow Zone (%)				
			High	Moist	Midrange	Dry	Low
Dry Gulch	Summer	88	90	89	91	82	73
Bitter Creek		82	71	79	85	85	83
Whistle Creek		93	90	93	91	95	92
Foster Gulch		91	92	91	92	91	91
Polecat Creek		89	93	89	90	82	86
Big Wash		88	89	87	90	84	89
Sage Creek		88	86	87	89	89	91
Shoshone River		64	40	43	81	83	86
Dry Gulch	Winter	68	0	75	91	97	100
Big Wash		4	0	0	0	8	87

7.1 EXISTING WATERSHED MANAGEMENT EFFORTS

Some conservation accomplishments and BMPs have already been implemented in the project area. These accomplishments can be attributed to the local watershed planning and implementation efforts of proactive, locally led, conservation districts that have developed mutually beneficial partnerships with farmers, ranchers, residents, commodity groups and companies, school districts, city and county governments, irrigation districts and canal companies, weed departments, coordinated resource management groups, grazing associations, and many other organizations. The majority of implementation projects have been planned and implemented to improve water quality, rangeland condition, irrigation efficiency, and wildlife habitat on private and public lands. Implementation projects include improving irrigation efficiency, prescribed grazing, spring development, land leveling, off-site water, riparian areas, and wetlands, and other BMPs. Additionally, many septic system rehabilitation projects that reduce *E. coli* discharge by providing sufficient storage capacities, proper soil adsorption treatment, and suitable setback distances for residential sewage discharges have been implemented.

Watershed plans have been developed for the Shoshone River [Shoshone River Watershed Steering Committee, 2008] and for Bitter Creek [Powell-Clarks Fork Conservation District and Bitter Creek Watershed Steering Team, 2005]. A draft combination of these two plans is currently available [Powell-Clarks Fork Conservation District, Cody Conservation District, and Shoshone River Watershed Steering Committee, 2012] from the Powell-Clarks Fork Conservation District. Additionally, the *Shoshone Watershed Management Plan* [Shoshone Conservation District Board, Shoshone Watershed Steering Committee, and Conservation District Landowners, 2006] is available from the Shoshone Conservation District. These plans summarize the overall condition of the watershed, describe the physical characteristics and water-quality issues, and highlight BMPs for long-term watershed planning. In 1996, the Wyoming Association of Conservation Districts (WACD), the Natural Resources Conservation Service (NRCS), and the Wyoming Department of Agriculture (WDA) recognized the need to lead watershed management efforts and to represent local interests in state and federal watershed planning. The WACD formed the “Watershed Strategic Planning Task Force,” developed a watershed strategic plan, and conducted a watershed survey [Wyoming Association of Conservation Districts, 2000] This strategic plan and subsequent activities provided various levels of assistance to districts that are leading the initiation of watershed planning and management efforts.

7.2 EVALUATION OF MANAGEMENT SCENARIOS

A variety of BMPs could be considered in developing a water-quality management implementation plan for the project area. The following listed and discussed control measures are recommended to reduce the identified bacteria sources.

The following eight incremental management scenarios were simulated for each impaired segment using the HSPF model application:

1. Irrigation Efficiency: improve efficiency by 75 percent
2. Irrigated Land: decrease load applied to irrigated land by 75 percent
3. Direct Defecation: decrease direct defecation to waterbodies by 75 percent
4. Range Land: decrease load applied to rangeland by 75 percent
5. Failed Septic Systems: decrease number of failing septic systems by 75 percent

6. Urban/Residential Land: decrease load applied to urban and residential areas by 75 percent

7. Forest Land: decrease load applied to forest land by 75 percent

8. Riparian Land: decrease load applied to riparian land by 75 percent.

Individual percent reductions represent the simulated load reduction for each management scenario individually. The greatest predicted individual reductions in the project area occur by improving irrigation efficiency and by reducing the irrigated land loading (Table 7-2). All other scenarios individually reduce loads by less than five percent in each impaired reach. The simulated reductions from the individual BMPs provide watershed managers the ability to assess the relative efficiency of implementing the individual BMP scenarios within each of the watersheds of the impaired reaches. Cumulative percent reductions represent simulated load reductions from cumulative BMP management scenarios. For all reaches except Big Wash, the management scenarios were sufficient to meet the required reductions (Table 7-3). For Big Wash to meet the required reductions, the efficiencies of the management scenarios were increased from 75 percent to 85 percent. The simulated cumulative load reductions provide reasonable assurance that the required reductions are attainable (Table 7-4).

Table 7-2. Individual Percent Reductions From Simulated *E. coli* Best Management Practices

Recreation Season	Impaired Reach	Simulated Load Reduction by BMP Scenario (%)							
		Irrigation Efficiency	Irrigated Land	Direct Defecation	Range Land	Failed Septic System	Urban/ Residential Land	Forest Land	Riparian Land
Summer	Dry Gulch	86	62	5	3	0	0	0	0
	Bitter Creek	93	73	0	0	0	0	0	0
	Whistle Creek	82	74	0	0	0	0	0	0
	Foster Gulch	77	74	0	0	0	0	0	0
	Polecat Creek	74	73	0	0	0	0	0	0
	Big Wash	65	67	2	1	0	0	0	0
	Sage Creek	78	72	1	1	0	0	0	0
	Shoshone River	80	73	0	1	0	0	0	0
Winter	Dry Gulch	30	14	50	1	5	0	0	0
	Big Wash	14	19	9	2	0	0	0	0

Table 7-3. Cumulative Percent Reductions (Left to Right) From Simulated *E. coli* Best Management Practices

Recreation Season	Impaired Reach	Required Reductions (%)	Irrigation Efficiency (%)	Irrigated Land (%)	Direct Defecation (%)	Range Land (%)
Summer	**75% Implementation**					
	Dry Gulch	88	86	91	94	95
	Bitter Creek	82	93	97	97	97
	Whistle Creek	93	82	94	95	95
	Foster Gulch	91	77	94	94	94
	Polecat Creek	89	74	92	92	92
	Big Wash	88	65	82	85	86
	Sage Creek	88	78	92	92	94
	Shoshone River	64	80	93	93	94
	85% Implementation					
	Big Wash	88	75	86	89	90
Winter	**75% Implementation**					
	Dry Gulch	68	30	33	79	79
	Big Wash	4	14	22	31	34

Note: Scenarios required to meet required reductions are shaded.

Table 7-4. Summary of Simulated Cumulative Percent Load Reductions and the Required Percent Load Reductions Needed to Meet the Total Maximum Daily Load for Each Impaired Stream Reach

Recreation Season	Impaired Stream[a]	Cumulative Simulated Load Reductions (%)	Required Load Reductions Needed to Meet the TMDL (%)
Summer	Dry Gulch	95	88
	Bitter Creek	97	82
	Whistle Creek	95	93
	Foster Gulch	94	91
	Polecat Creek	92	89
	Big Wash	90	88
	Sage Creek	94	88
	Shoshone River	94	64
Winter	Dry Gulch	68	79
	Big Wash	4	34

(a) An 85 percent load reduction was necessary to meet required TMDL reductions for Big Wash during the summer recreation season. A 75 percent load reduction was sufficient for all impaired streams to meet their required TMDL reductions.

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APPENDIX A

PUBLIC COMMENTS AND RESPONSES

Shoshone River *E. coli* TMDL Comments

Ann Trosper, Powell Clarks Fork Conservation District

1. We did like the language in the implementation plan that discussed work that had been completed by the conservation and irrigation districts. We would like to see similar language added to the TMDL document as well.

Response: More implementation plan text was added to the TMDL document in the Existing Watershed Management Efforts Section (Section 7.1).

2. We did not see any discussion of the economic benefits of agriculture in the watershed. We would like to see some discussion on this topic.

Response: A statement was added to the Socioeconomics section about the benefits of agriculture in the watershed.

3. Page 6 indicates there are 9 major irrigation districts. Please name them and organize by project type. The Bureau of Reclamation projects separate from the rest as they have different organization.

Response: Irrigation districts were updated and listed by project type.

4. I did not see any discussion regarding small acreage and the growing change in land use from cropland to small acreage ownership. Please check, I did provide the Shoshone Irrigation District data on this topic.

Response: We do not have resolution to quantify bacteria from small acreages. A discussion was added about the small acreage ownership and the change in land use from cropland to small acreage ownership in Section 1.2.1, and a statement about monitoring upstream and downstream of areas with multiple small acreages was added to Section 6.0.

Shoshone River *E. coli* TMDL Comments

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Bill Cox, Shoshone Irrigation District President

This letter is in response to the July 2013 **Draft** of the E. Coli Total Maximum Daily Loads for the Shoshone River Watershed Topical Report RSI-2351.

On June 5, 2013, the Shoshone Irrigation District (District) Board of Commissioners invited you to meet with them at the District office to discuss their concerns regarding the direction your findings were beginning to take. Ann Trosper of the local NRCS was also present at the meeting. The Board's concerns expressed at the meeting were in regard to the findings, at that point, being largely attributed to agriculture. As well, the suggestion of the conversion of existing surface irrigated fields to sprinkler irrigation was not acceptable and a concern of the Board.

After much discussion, it was agreed that the opinion regarding changing the method of irrigation would be stricken as possible management. Animal numbers were discussed and was agreed that more realistic numbers would be included in report.

After reviewing the **Draft**, the Shoshone Irrigation District Board of Commissioners wish to comment as they are disappointed in seeing that agriculture is still being identified as a major contributor to the TMDL's in your report. Thru WWDC grants monies as well as thru District monies, the District spends over 1.5 million dollars annually for operation and maintenance of its canal system, enclosing open laterals with pipe and other water conservation measures. Betterment of the delivery system is a top priority of the District.

Response: The TMDL findings attribute the bacteria loads to irrigation application and delivery as opposed to only agriculture. A discussion was added to clarify that irrigated lands include cropland, pasture/hay, and small acreages. The recommendation is to improve irrigation efficiency and decrease loads applied to irrigated lands. Animal numbers were discussed in a majority of the TAC meetings and agreed upon by local area experts. The final animal numbers, as agreed upon by the TAC, are provided in Section 2.

Klodette Stroh, Shoshone Irrigation District 5 Water Commissioner

I have been attending Shoshone River watershed TMDL study as member of Technical Advisory Committee or TAC. During TMDL meetings I have been representing agriculture sector in Park and Big horn counties. Irrigation system historical background including water rights, irrigation practices, federal financial lean and farmers payment obligation and economic impact of Shoshone Irrigation district to this area. Unfortunately this valuable information has not been included in RESPEC, Topical Report RSI-2351 TMDL report.

Under Small Reclamation Project Act (SRPA), Shoshone Irrigation Project was able to borrow $7.5 million from the federal government for an R&B program in 1992. Total federal loan and Wyoming Water Commission finances are $15,000,000 dollars. Each district, Shoshone, Deaver, Willwood and Heart Mountain, had a portion of this money available to repair and update their irrigation system. R&B repairs have paid off and this project has given Park County an economic impact of $85.5 million annually. The repayment schedule is guided by Contact No. 2-07-60-W0884, Article 8. Annual repayment for four districts is in sum of is $187,500 for 40 years.

The Shoshone Irrigation Project Joint Power Board (SIPJPB), which has a representative from each district on the board of directors, has an obligation to collect the repayment and send it to the Bureau of Reclamation for the next 40 years. I represent Shoshone Irrigation District on this board.

Response: A TMDL is defined by the EPA as "a written plan and analysis established to ensure that a waterbody will attain and maintain water quality standards including consideration of existing pollutant loads and reasonable foreseeable increases in pollutant loads. It is intended to provide an opportunity to compare relative contributions from all sources and consider technical and economic trade-offs between point and non-point sources [USEPA, 2013]." In the case of this Shoshone River TMDL, non-point sources were found to be the primary cause of the bacteria impairment, and therefore any point source implementation impacts would likely be minimal. A statement was added to the Socioeconomics section about the benefits of agriculture in the watershed.

US Environmental Protection Agency, 2013. *Establishing and Implementing TMDLs*. http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/TMDL-ch3.cfm Accessed September 26, 2013.

I am very disappointed about Shoshone River TMDL report published. I believe RESPEC TMDL report will impair agriculture sector that has brought prosperity in my county and town of Powell. Shoshone River water is our people's livelihood. TMDL report will direct high expenses on Park and Big Horn county farmers and force many farmers out of business. $138.6 million economic enhancement will be lost in Park county alone and Big Horn county will have loses in $126.8 million garniture gain annually.

Response: Non-point source implementation is voluntary; implementation will only occur on agricultural land if stakeholders choose to implement on their land.

1-**Table of contents** of this report should include information page of economic impact and obligation to R&B which shows agriculture expenses to better this system. On page 13 under 1.2.6 Socioeconomics; there is no information about economic impact of farmers and ranchers.

Response: A sentence was added about the economic impact to farmers, ranchers, and the local communities.

2- **Page 18 under 1.3.2 water Quality** irrigation return flow has been blamed for pollution. Any scientist will tell you E.coli is a living organism and will not survive much tribulation through mud and change of temperature. This statement directs Shoshone River water pollution to farmers. As TAC members Ann Trosper and I asked for correction in animal count. Powell Clark Conservation District Board provided followings; , Whitetail Deer 13,160, Mule Deer summer 4,450, Mule Deer winter 3,980,Elk summer 250, Elk winter 860, Winter sheep 15,000, Antelope summer 1,370 and winter 1,220. Raccoon population was reported at 11,960 and Duck at 11,648. I specifically asked Cory Forman that wildlife population count would be included in TMDL report and he answer yes. This information should be corrected because wildlife lives around Shoshone River, it is their natural habitat.

Response: E. coli dynamics are complicated and are accounted for within the HSPF model application. Animal counts in the wildlife table were shifted up one column. This error was corrected. The final numbers in the report reflect discussions with local area experts in Wyoming and Montana which are not reflected in the above comment.

3- **Page 18 under 1.3.2 Water Quality** first paragraph the last line blames irrigation return flow impacting river water. Shoshone Irrigation system works on return flow system to conserve water. Farmers use the water then they release it to the next farm. This water may be used by at least five or six farmers before returned to the river to be used by farmers in Big Horn County. This issue should be corrected. Majority of our farms located in Garland toward the end of irrigation system will go dry without the return flow.

Response: Non-point source implementation is voluntary; implementation will only occur on agricultural land if stakeholders choose to implement on their land. Impacts to the irrigation system should be evaluated prior to implementation of best management practices.

4- **Shoshone, Deaver, Willwood, and Heart Mountain irrigation districts** have a fourth year's repayment obligation to the federal government. As I have explained the four districts have borrowed money under the Small Reclamation Projects Act (SRPA) of August 6, 1956, 70 stat. on June 26,2013 at the meeting held at Farm Serves Agency in present of NRCS board member Floyd Derry and Ann Trosper this issue was discussed . Technical Advisory Committee was assured the past project and plan in Shoshone watershed would be included in to an implementation plan. TMDL report should honor farmer's investment to improve water quality, management, and conservation practices.

Response: The implementation plan is a separate document which outlines the past projects and plans in the Shoshone watershed and future possibilities. Text from this implementation plan was added to Section 7.1 (Existing Watershed Management Efforts) of the TMDL document to highlight past accomplishments.

KH/rm/13-1180

ENCLOSURE 2

EPA REGION 8 TMDL REVIEW FORM AND DECISION DOCUMENT

TMDL Document Info:

Document Name:	***E. Coli*** **Total Maximum Daily Loads for the Shoshone River Watershed, Wyoming**
Submitted by:	**Kevin Hyatt, Wyoming Department of Environmental Quality**
Date Received:	**August 14, 2013**
Review Date:	**September 13, 2013**
Reviewer:	**Vern Berry, US Environmental Protection Agency**
Rough Draft / Public Notice / Final Draft?	**Public Notice**
Notes:	

Reviewers Final Recommendation(s) to EPA Administrator (used for final draft review only):

☐ Approve
☐ Partial Approval
☐ Disapprove
☐ Insufficient Information

Approval Notes to the Administrator:

This document provides a standard format for EPA Region 8 to provide comments to state TMDL programs on TMDL documents submitted to EPA for either formal or informal review. All TMDL documents are evaluated against the TMDL review elements identified in the following 8 sections:

1. Problem Description
   1.1. TMDL Document Submittal
   1.2. Identification of the Waterbody, Impairments, and Study Boundaries
   1.3. Water Quality Standards
2. Water Quality Target
3. Pollutant Source Analysis
4. TMDL Technical Analysis
   4.1. Data Set Description
   4.2. Waste Load Allocations (WLA)
   4.3. Load Allocations (LA)
   4.4. Margin of Safety (MOS)
   4.5. Seasonality and variations in assimilative capacity
5. Public Participation
6. Monitoring Strategy
7. Restoration Strategy
8. Daily Loading Expression

Under Section 303(d) of the Clean Water Act, waterbodies that are not attaining one or more water quality standard (WQS) are considered "impaired." When the cause of the impairment is determined to be a pollutant, a TMDL analysis is required to assess the appropriate maximum allowable pollutant loading rate. A TMDL document consists of a technical analysis conducted to: (1) assess the maximum pollutant loading rate that a waterbody is able to assimilate while maintaining water quality standards; and (2) allocate that assimilative capacity among the known sources of that pollutant**.** A well written TMDL document will describe a path forward that may be used by those who implement the TMDL recommendations to attain and maintain WQS.

Each of the following eight sections describes the factors that EPA Region 8 staff considers when reviewing TMDL documents. Also included in each section is a list of EPA's review elements relative to that section, a brief summary of the EPA reviewer's findings, and the reviewer's comments and/or suggestions. Use of the verb "must" in this review form denotes information that is required to be submitted because it relates to elements of the TMDL required by the CWA and by regulation. Use of the term "should" below denotes information that is generally necessary for EPA to determine if a submitted TMDL is approvable.

This review form is intended to ensure compliance with the Clean Water Act and that the reviewed documents are technically sound and the conclusions are technically defensible.

1. Problem Description

A TMDL document needs to provide a clear explanation of the problem it is intended to address. Included in that description should be a definitive portrayal of the physical boundaries to which the TMDL applies, as well as a clear description of the impairments that the TMDL intends to address and the associated pollutant(s) causing those impairments. While the existence of one or more impairment and stressor may be known, it is important that a comprehensive evaluation of the water quality be conducted prior to development of the TMDL to ensure that all water quality problems and associated stressors are identified. Typically, this step is conducted prior to the 303(d) listing of a waterbody through the monitoring and assessment program. The designated uses and water quality criteria for the waterbody should be examined against available data to provide an evaluation of the water quality relative to all applicable water quality standards. If, as part of this exercise, additional WQS problems are discovered and additional stressor pollutants are identified, consideration should be given to concurrently evaluating TMDLs for those additional pollutants. If it is determined that insufficient data is available to make such an evaluation, this should be noted in the TMDL document.

1.1 TMDL Document Submittal

When a TMDL document is submitted to EPA requesting review or approval, the submittal package should include a notification identifying the document being submitted and the purpose of the submission.

Review Elements:

☒ Each TMDL document submitted to EPA should include a notification of the document status (e.g., pre-public notice, public notice, final), and a request for EPA review.

☐ Each TMDL document submitted to EPA for final review and approval should be accompanied by a submittal letter that explicitly states that the submittal is a final TMDL submitted under Section 303(d) of the Clean Water Act for EPA review and approval. This clearly establishes the State's/Tribe's intent to submit, and EPA's duty to review, the TMDL under the statute**.** The submittal letter should contain such identifying information as the name and location of the waterbody and the pollutant(s) of concern, which matches similar identifying information in the TMDL document for which a review is being requested.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information ☐ N/A

Summary: *The notification of the availability of the public notice draft TMDL document was submitted to EPA via email received on August 14, 2013. The email included the draft TMDL document, details of the public notice, and requests the submittal of comments to WDEQ by September 16, 2013.*

Comments: *None.*

1.2 Identification of the Waterbody, Impairments, and Study Boundaries

The TMDL document should provide an unambiguous description of the waterbody to which the TMDL is intended to apply and the impairments the TMDL is intended to address. The document should also clearly delineate the physical boundaries of the waterbody and the geographical extent of the watershed area studied. Any additional information needed to tie the TMDL document back to a current 303(d) listing should also be included.

Review Elements:

☒ The TMDL document should clearly identify the pollutant and waterbody segment(s) for which the TMDL is being established. If the TMDL document is submitted to fulfill a TMDL development requirement for a waterbody on the state's current EPA approved 303(d) list, the TMDL document submittal should clearly identify the waterbody and associated impairment(s) as they appear on the State's/Tribe's current EPA approved 303(d) list, including a full waterbody description, assessment unit/waterbody ID, and the priority ranking of the waterbody. This information is necessary to ensure that the administrative record and the national TMDL tracking database properly link the TMDL document to the 303(d) listed waterbody and impairment(s).

☒ One or more maps should be included in the TMDL document showing the general location of the waterbody and, to the maximum extent practical, any other features necessary and/or relevant to the understanding of the TMDL analysis, including but not limited to: watershed boundaries, locations of major pollutant sources, major tributaries included in the analysis, location of sampling points, location of discharge gauges, land-use patterns, and the location of nearby waterbodies used to provide surrogate information or reference conditions. Clear and concise descriptions of all key features and their relationship to the waterbody and water quality data should be provided for all key and/or relevant features not represented on the map

☒ If information is available, the waterbody segment to which the TMDL applies should be identified/geo-referenced using the National Hydrography Dataset (NHD). If the boundaries of the TMDL do not correspond to the Waterbody ID(s) (WBID), Entity ID information or reach code (RCH_Code) information should be provided. If NHD data is not available for the waterbody, an alternative geographical referencing system that unambiguously identifies the physical boundaries to which the TMDL applies may be substituted.

Recommendation:
☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

<u>Summary:</u>

Physical Setting and Listing History*:*

This TMDL document includes eight (8) impaired stream segments within the Shoshone River basin in Wyoming. All eight impaired segments are located within Park and Shoshone Counties, Wyoming and are part of the 8-digit HUC 10080014 defined as the Shoshone Watershed. The larger watershed, which includes portions of Montana, covers a drainage area of approximately 950,000 acres.

The eight impaired segments included in this TMDL document are: ***1)*** *Dry Gulch from the confluence with the Shoshone River to a point 7.0 miles upstream (7.0 miles; WYBH100800140107_01);* ***2)*** *Bitter Creek from the confluence with the Shoshone River to a point 13.9 miles upstream (13.9 miles;*

*WYBH100800140206_01); **3)** Whistle Creek from the confluence with the Shoshone River to a point 8.7 miles upstream (8.7 miles; WYBH100800140303_01); **4)** Foster Gulch from the confluence with the Shoshone River to a point 2.0 miles upstream (2.0 miles; WYBH100800140307_01); **5)** Polecat Creek from the confluence with the Sage Creek to a point 2.5 miles upstream (2.5 miles; WYBH100800140407_01); **6)** Sage Creek from the confluence with the Shoshone River to a point 14.0 miles upstream (14.0 miles; WYBH100800140408_01); **7)** Big Wash from the confluence with Sage Creek upstream to Sidon Canal (3.2 miles; WYBH100800140408_02); and **8)** Shoshone River from the confluence with Big Horn Lake to a point 9.7 miles upstream (9.7 miles; WYBH100800140504_00).*

These segments are listed as impaired for either E. coli or fecal coliform bacteria and are a high priority for TMDL development.

The Wyoming Surface Water Classification List, Table A assigns the following classifications for the stream segments in this TMDL document:

***Class2AB –** Bitter Creek, Whistle Creek, Polecat Creek, Sage Creek and Shoshone River*

***Class 2C –** Foster Gulch*

***Class 3B –** Dry Gulch and Big Wash*

The designated uses for Class 2AB, 2C and 3B streams are discussed in the Water Quality Standards section below.

***Impairment status**:*
The 2012 Wyoming Integrated Report identifies the 8 stream segments as impaired based on the following information:

Stream Segment	**Designated Use / Support Status**	**Impairment Cause**	**TMDL Priority**
Dry Gulch WYBH100800140107_01	*Recreation / Not Supporting*	*E. coli*	*High*
Bitter Creek WYBH100800140206_01	*Recreation / Not Supporting*	*Fecal coliform*	*High*
Whistle Creek WYBH100800140303_01	*Recreation / Not Supporting*	*Fecal coliform*	*High*
Foster Gulch WYBH100800140307_01	*Recreation / Threatened*	*Fecal coliform*	*High*
Polecat Creek WYBH100800140407_01	*Recreation / Not Supporting*	*Fecal coliform*	*High*
Sage Creek WYBH100800140408_01	*Recreation / Not Supporting*	*Fecal coliform*	*High*
Big Wash WYBH100800140408_02	*Recreation / Not Supporting*	*Fecal coliform*	*High*
Shoshone River WYBH100800140504_00	*Recreation / Not Supporting*	*Fecal coliform*	*High*

Comments: *None.*

1.3 Water Quality Standards

TMDL documents should provide a complete description of the water quality standards for the waterbodies addressed, including a listing of the designated uses and an indication of whether the uses are being met, not being met, or not assessed. If a designated use was not assessed as part of the TMDL analysis (or not otherwise recently assessed), the documents should provide a reason for the lack of assessment (e.g., sufficient data was not available at this time to assess whether or not this designated use was being met).

Water quality criteria (WQC) are established as a component of water quality standard at levels considered necessary to protect the designated uses assigned to that waterbody. WQC identify quantifiable targets and/or qualitative water quality goals which, if attained and maintained, are intended to ensure that the designated uses for the waterbody are protected. TMDLs result in maintaining and attaining water quality standards by determining the appropriate maximum pollutant loading rate to meet water quality criteria, either directly, or through a surrogate measurable target. The TMDL document should include a description of all applicable water quality criteria for the impaired designated uses and address whether or not the criteria are being attained, not attained, or not evaluated as part of the analysis. If the criteria were not evaluated as part of the analysis, a reason should be cited (e.g. insufficient data were available to determine if this water quality criterion is being attained).

Review Elements:

☒ The TMDL must include a description of the applicable State/Tribal water quality standard, including the designated use(s) of the waterbody, the applicable numeric or narrative water quality criterion, and the anti-degradation policy. (40 C.F.R. §130.7(c)(1)).

☒ The purpose of a TMDL analysis is to determine the assimilative capacity of the waterbody that corresponds to the existing water quality standards for that waterbody, and to allocate that assimilative capacity between the identified sources. Therefore, <u>all TMDL documents must be written to meet the existing water quality standards</u> for that waterbody (CWA §303(d)(1)(C)). *Note: In some circumstances, the load reductions determined to be necessary by the TMDL analysis may prove to be infeasible and may possibly indicate that the existing water quality standards and/or assessment methodologies may be erroneous. However, the TMDL must still be determined based on existing water quality standards. Adjustments to water quality standards and/or assessment methodologies may be evaluated separately, from the TMDL.*

☒ The TMDL document should describe the relationship between the pollutant of concern and the water quality standard the pollutant load is intended to meet. This information is necessary for EPA to evaluate whether or not attainment of the prescribed pollutant loadings will result in attainment of the water quality standard in question.

☒ If a standard includes multiple criteria for the pollutant of concern, the document should demonstrate that the TMDL value will result in attainment of all related criteria for the pollutant. For example, both acute and chronic values (if present in the WQS) should be addressed in the document, including consideration of magnitude, frequency and duration requirements.

Recommendation:
☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

Summary: *All eight (8) segments included in the Shoshone River TMDL document are impaired based on fecal coliform or E. coli bacteria concentrations impacting the recreational uses. These segments are listed as "not supporting" or as "threatened" due to exceedances of the E. coli water quality standards or for fecal coliform bacteria (i.e., based on the standard that was in effect at the time the waters were listed as impaired).*

In 2008 WDEQ revised the State water quality standards. In these revisions the WDEQ eliminated the fecal coliform bacteria standards, retaining only the E. coli bacteria standards for the protection of recreational uses. These changes in the water quality standards were recommended by the US Environmental Protection Agency as E. coli is believed to be a better indicator of recreational use risk (i.e., incidence of gastrointestinal disease).

The eight (8) bacteria impaired segments in the Shoshone watershed include Class 2AB, 2C and 3B streams. The designated uses for each of these classifications are as follows:

> *Class 2AB waters are those known to support game fish populations or spawning and nursery areas at least seasonally and all their perennial tributaries and adjacent wetlands and where a game fishery and drinking water use is otherwise attainable. Class 2AB waters include all permanent and seasonal game fisheries and can be either "cold water" or "warm water" depending upon the predominance of cold water or warm water species present. All Class 2AB waters are designated as cold water game fisheries unless identified as a warm water game fishery by a "ww" notation in the "Wyoming Surface Water Classification List". Unless it is shown otherwise, these waters are presumed to have sufficient water quality and quantity to support drinking water supplies and are protected for that use. Class 2AB waters are also protected for nongame fisheries, fish consumption, and aquatic life other than fish, recreation, wildlife, industry, agriculture and scenic value uses.*
>
> *Class 2C waters are those known to support or have the potential to support only nongame fish populations or spawning and nursery areas at least seasonally including their perennial tributaries and adjacent wetlands. Class 2C waters include all permanent and seasonal nongame fisheries and are considered "warm water". Uses designated on Class 2C waters include nongame fisheries, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture, and scenic value.*
>
> *Class 3B waters are tributary waters including adjacent wetlands that are not known to support fish populations or drinking water supplies and where those uses are not attainable. Class 3B waters are intermittent and ephemeral streams with sufficient hydrology to normally support and sustain communities of aquatic life including invertebrates, amphibians, or other flora and fauna which inhabit waters of the state at some stage of their life cycles. In general, 3B waters are characterized by frequent linear wetland occurrences*

or impoundments within or adjacent to the stream channel over its entire length. Such characteristics will be a primary indicator used in identifying Class 3B waters.

Numeric E. coli criteria for Wyoming Class 2AB, 2C and 3B streams have been established and are presented in the Table below.

Wyoming Bacteria Water Quality Standards for Class 2AB, 2C and 3B Streams.

Parameter	Standard	
	Geometric Mean[1]	**Maximum**[2]
E. coli Bacteria (May 1 – Sept 30)	126 organisms per100 mL	235-576 organisms per 100 mL
E. coli Bacteria (Oct 1 – April 30)	630 organisms per 100 mL	

[1] Expressed as a geometric mean of not less than 5 samples collected during any 30-day period.
[2] The value is based on the type of summer recreational season contact use which includes: high use swimming areas (235); moderate full body contact (298); lightly used full body contact (410); and infrequently used full body contact (576). The appropriate recreational use category is determined by the administrator as needed, on a case-by-case basis.
Note: Although the WDEQ E. coli standards are expressed as the number of organisms per 100 mL of the sample, most laboratories report bacteria analytical results as the number of colony forming units (cfu) per 100 mL.

Comments:
1) We recommend that the description of the numeric E. coli criterion include a description of the Single Sample Maximum Concentration use categories [WDEQ, WQ Rules and Regulations, Chapter 1, page 1-23] and values, as well as any WDEQ Administrator's single sample summer recreational use determinations made for the segments included in this TMDL document.

WDEQ Response: The description of the Wyoming *E. coli* standard stated on page 4 is correct. The description describes the *E. coli* criterion that is used to determine if the recreational designated use is impaired. Single-sample maximum values may be used to postrecreational use advisories in public recreation areas and to derive single-sample maximum effluent limitations on point-source discharges. An exceedance of the single-sample maxima shall not be cause for listing a waterbody on the State 303(d) list or developing a TMDL or watershed plan. The appropriate recreational use category (i through iv) shall be determined by the administrator as needed, on a case-by-case basis. In making such a determination, the administrator may consider such site-specific circumstances as type and frequency of use, time of year, public access, proximity to populated areas, and local interests [Wyoming Department of Environmental Quality, 2007].

Wyoming Department of Environmental Quality, 2007. "Water Quality Rules and Regulations," prepared by Wyoming Department of Environmental Quality, Cheyenne, WY.

2) We recommend deleting the term "impairment" within the first sentence of the existing paragraph (page 3, near the bottom of the page) […E. coli impairment…] because the determination of impairment is an independent action from the statement of the applicable water quality standards.

WDEQ Response: The term "impairment" was deleted from the sentence.

2. Water Quality Targets

TMDL analyses establish numeric targets that are used to determine whether water quality standards are being achieved. Quantified water quality targets or endpoints should be provided to evaluate each listed pollutant/water body combination addressed by the TMDL, and should represent achievement of applicable water quality standards and support of associated beneficial uses. For pollutants with numeric water quality standards, the numeric criteria are generally used as the water quality target. For pollutants with narrative standards, the narrative standard should be translated into a measurable value. At a minimum, one target is required for each pollutant/water body combination. It is generally desirable, however, to include several targets that represent achievement of the standard and support of beneficial uses (e.g., for a sediment impairment issue it may be appropriate to include a variety of targets representing water column sediment such as TSS, embeddedness, stream morphology, up-slope conditions and a measure of biota).

Review Elements:

☐ The TMDL should identify a numeric water quality target(s) for each waterbody pollutant combination. The TMDL target is a quantitative value used to measure whether or not the applicable water quality standard is attained. *Generally, the pollutant of concern and the numeric water quality target are, respectively, the chemical causing the impairment and the numeric criteria for that chemical (e.g., chromium) contained in the water quality standard. Occasionally, the pollutant of concern is different from the parameter that is the subject of the numeric water quality target (e.g., when the pollutant of concern is phosphorus and the numeric water quality target is expressed as a numerical dissolved oxygen criterion). In such cases, the TMDL should explain the linkage between the pollutant(s) of concern, and express the quantitative relationship between the TMDL target and pollutant of concern. In all cases, TMDL targets must represent the attainment of current water quality standards.*

☐ When a numeric TMDL target is established to ensure the attainment of a narrative water quality criterion, the numeric target, the methodology used to determine the numeric target, and the link between the pollutant of concern and the narrative water quality criterion should all be described in the TMDL document. Any additional information supporting the numeric target and linkage should also be included in the document.

Recommendation:
☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

<u>Summary:</u> *The water quality targets for these TMDLs are based on the numeric water quality standards for E. coli bacteria established to protect the recreational beneficial uses for the eight (8) impaired stream segments in the Shoshone River watershed.*

Bacteria analytical results are typically expressed in coliform forming units (cfu) per 100 milliliters (mL) of the water sample. Therefore, the E. coli target for each impaired segment is: 126 cfu/100 mL during the summer recreation season from May 1 to September 30, and 630 cfu/100 mL during the off-

season from October 1 to April 30. Both values are calculated as the geometric mean of five or more samples for any 30-day period.

<u>Comments:</u>
1) We recommend including a sentence that clearly states the E. coli TMDL targets being used for these impaired stream segments.

WDEQ Response: The words "numeric criterion for *E. coli* impairment" were changed to "*E. coli* targets."

2) We recommend adding a sentence that states that the E. coli TMDL targets being used for these stream segments (i.e., based on the recreational use) will protect all other designated uses for these stream segments because it is the most sensitive use for bacteria.

WDEQ Response: Recreational use protection involves maintaining a level of water quality which is safe for human contact. It does not guarantee the availability of water for any recreational purpose [Wyoming Department of Environmental Quality, 2012]. The criterion that is used to evaluate the recreation use is *E. coli*. The *E. coli* limit has been determined by EPA to protect human health [U.S. Environmental Protection Agency, 1986]. Wyoming also supports that this *E. coli* limit is protective of the Wyoming recreation use, but does not use it to make any determination of other uses.

Wyoming Department of Environmental Quality, 2012. *Wyoming's Methods for Determining Surface Water Quality Conditions and TMDL Prioritization*. Prepared by: WDEQ – WQD, Cheyenne, WY. Document number 13-0352.

U.S. Environmental Protection Agency, 1986. *Quality Criteria for Water 1986.* Office of Water Regulations and Standards, Washington DC. EPA 440/5-86-001.

3) The waterbody summary tables at the beginning of the TMDL document contain TMDL "Criteria Threshold Values" which appear to be the same as the applicable E. coli water quality standards. We assume the term is also meant to be equivalent to, or similar to, TMDL water quality targets. If the criteria threshold values are also the TMDL target values, we recommend adding a sentence to the document that makes this point clear.

WDEQ Response: Instead of adding a sentence explaining that these are the same, the phrase "Criteria Threshold Values" in the summary tables was changed to "Water Quality Targets"

3. Pollutant Source Analysis

A TMDL analysis is conducted when a pollutant load is known or suspected to be exceeding the loading capacity of the waterbody. Logically then, a TMDL analysis should consider all sources of the pollutant of concern in some manner. The detail provided in the source assessment step drives the rigor of the pollutant load allocation. In other words, it is only possible to specifically allocate quantifiable loads or load reductions to each identified source (or source category) when the relative load contribution from each source has been estimated. Therefore, the pollutant load from each identified source (or source category) should be specified and quantified. This may be accomplished using site-specific monitoring data, modeling, or application of other assessment techniques. If insufficient time or resources are available to accomplish this step, a phased/adaptive management approach may be appropriate. The approach should be clearly defined in the document.

Review Elements:

☒ The TMDL should include an identification of the point and nonpoint sources of the pollutant of concern, including the geographical location of the source(s) and the quantity of the loading, e.g., lbs/per day. This information is necessary for EPA to evaluate the WLA, LA and MOS components of the TMDL.

☒ The level of detail provided in the source assessment should be commensurate with the nature of the watershed and the nature of the pollutant being studied. Where it is possible to separate natural background from nonpoint sources, the TMDL should include a description of both the natural background loads and the nonpoint source loads.

☒ Natural background loads should not be assumed to be the difference between the sum of known and quantified anthropogenic sources and the existing *in situ* loads (e.g. measured in stream) unless it can be demonstrated that the anthropogenic sources of the pollutant of concern have been identified, characterized, and quantified.

☒ The sampling data relied upon to discover, characterize, and quantify the pollutant sources should be included in the document (e.g. a data appendix) along with a description of how the data were analyzed to characterize and quantify the pollutant sources. A discussion of the known deficiencies and/or gaps in the data set and their potential implications should also be included.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

Summary: *The TMDL document includes the landuse breakdown for the Shoshone River watershed based on the 2006 National Land Cover Dataset (NLCD) data. In 2006, the dominant land use in the watershed was agriculture consisting of irrigated land and rangeland uses. Approximately 43 percent of the landcover in the watershed was scrub / shrub and 33 percent was grassland / herbaceous. The remaining 24 percent was forest, cropland, pasture hay, wetlands, developed space or barren.*

The largest consumptive use of water in the Shoshone River watershed is agricultural irrigation. Nine major irrigation districts and several smaller irrigation diversions are located in the project area. Buffalo Bill Reservoir, which serves as the project boundary, stores water from the North Fork

Shoshone River and South Fork Shoshone River upstream of the project area. Buffalo Bill Reservoir supplies a majority of the water entering the project area and supplies water to irrigators served by a series of approximately 1,120 miles of canals, laterals, and ditches.

Section 2.0, Source Assessment, beginning on page 31 of the TMDL document, provides the pollutant source analysis for the listed segments in the Shoshone River watershed. There are six (6) known municipal wastewater treatment facilities (WWTFs) that have point source discharges located within the drainage area of these listed stream segments. These WWTFs have point source permits to discharge wastewater from the towns of Lovell, Byron, Deaver, and Frannie and the cities of Cody and Powell.

One permitted, concentrated animal feeding operation was located within the Shoshone project area until 2011, when it stopped operating. While it was permitted, it was not allowed to discharge, except in the case of a chronic or catastrophic storm event that would cause an overflow from the runoff and/or wastewater control structure.

Nonpoint source bacterial pollution to these segments originates from various agricultural, wildlife and human sources in the watershed. Livestock (predominately cattle and sheep), wildlife, septic systems as well as pet wastes, are all potential bacteria contributors in the Shoshone River watershed. The Bacteria Source Load Calculator was used to estimate the bacteria accumulation and storage from the nonpoint sources that are associated with the land uses in the watershed. The E. coli loadings were incorporated into the HSPF model to assess the fate and transport of the bacteria loadings throughout the watershed. The source assessment modeling results, provided in Table 2-4 of the TMDL document, are summarized by land-use categories for overland load washed into the stream through rainfall/runoff processes, direct defecation of wildlife or livestock into streams, and on-site wastewater treatment tank failures (i.e., septics). A pie chart of the source assessment for the impaired segment of the Shoshone River (i.e., the most downstream segment in the watershed) is provided in Figure 2-7 of the TMDL document. Generally, point sources are a small portion of the E. coli load to each impaired stream segment.

Comments:
1) The TMDL document does not mention the number of AFOs within the watershed. Well managed and permitted CAFOs are a low risk for bacterial contamination, however smaller AFOs located near streams can cause significant localized bacteria problems. This information is helpful, but not required for the TMDL approval; however it will be particularly important during the BMP implementation step of the process.

WDEQ Response: AFOs will be addressed during implementation. AFO animals were accounted for in the BSLC and model calibration process.

2) Table 2-2, Livestock Loading Estimates, shows higher bacterial loads per animal, and for the entire watershed, from sheep than from cattle. Other literature sources estimate bacteria loading from sheep to be 2-10 times lower per animal than cattle. EPA's CAFO definitions require 10,000 sheep vs only 1,000 cattle. This is a ratio of 10 sheep for every 1 cattle (e.g., an animal unit = 1 cattle = 10 sheep). Please, check the calculations that went into the data contained in Table 2-2 for errors.

WDEQ Response: Calculations were done to check the data contained in Table 2-2. No errors were found. We also verified numbers using the Education Program for Improved Water Quality in Copano Bay Task Two Report [2009].

Wagner, K. and E. Moench, 2009. *Education Program for Improved Water Quality in Copano Bay Task Two Report*, prepared by Texas Water Resources Institute, College Station, Texas for Texas State Soil and Water Conservation Board, Temple, TX.

4. TMDL Technical Analysis

TMDL determinations should be supported by an analysis of the available data, discussion of the known deficiencies and/or gaps in the data set, and an appropriate level of technical analysis**.** This applies to **all** of the components of a TMDL document. It is vitally important that the technical basis for **all** conclusions be articulated in a manner that is easily understandable and readily apparent to the reader.

A TMDL analysis determines the maximum pollutant loading rate that may be allowed to a waterbody without violating water quality standards. The TMDL analysis should demonstrate an understanding of the relationship between the rate of pollutant loading into the waterbody and the resultant water quality impacts. This stressor → response relationship between the pollutant and impairment and between the selected targets, sources, TMDLs, and load allocations needs to be clearly articulated and supported by an appropriate level of technical analysis. Every effort should be made to be as detailed as possible, and to base all conclusions on the best available scientific principles.

The pollutant loading allocation is at the heart of the TMDL analysis. TMDLs apportion responsibility for taking actions by allocating the available assimilative capacity among the various point, nonpoint, and natural pollutant sources. Allocations may be expressed in a variety of ways, such as by individual discharger, by tributary watershed, by source or land-use category, by land parcel, or other appropriate scale or division of responsibility.

The pollutant loading allocation that will result in achievement of the water quality target is expressed in the form of the standard TMDL equation:

$$TMDL = \sum WLAs + \sum LAs + MOS$$

Where:

TMDL	=	Total Maximum Daily Load (also called the Loading Capacity)
LAs	=	Load Allocations
WLAs	=	Wasteload Allocations
MOS	=	Margin Of Safety

Review Elements:

☒ A TMDL must identify the loading capacity of a waterbody for the applicable pollutant, taking into consideration temporal variations in that capacity. EPA regulations define loading capacity as the greatest amount of a pollutant that a water can receive without violating water quality standards (40 C.F.R. §130.2(f)).

☒ The total loading capacity of the waterbody should be clearly demonstrated to equate back to the pollutant load allocations through a balanced TMDL equation. In instances where numerous LA, WLA and seasonal TMDL capacities make expression in the form of an equation cumbersome, a table may be substituted as long as it is clear that the total TMDL capacity equates to the sum of the allocations.

☒ The TMDL document should describe the methodology and technical analysis used to establish and quantify the cause-and-effect relationship between the numeric target and the identified pollutant sources. In many instances, this method will be a water quality model.

☒ It is necessary for EPA staff to be aware of any assumptions used in the technical analysis to understand and evaluate the methodology used to derive the TMDL value and associated loading allocations. Therefore, the TMDL document should contain a description of any important assumptions (including the basis for those assumptions) made in developing the TMDL, including but not limited to:

- the spatial extent of the watershed in which the impaired waterbody is located and the spatial extent of the TMDL technical analysis;
- the distribution of land use in the watershed (e.g., urban, forested, agriculture);
- a presentation of relevant information affecting the characterization of the pollutant of concern and its allocation to sources such as population characteristics, wildlife resources, industrial activities etc…;
- present and future growth trends, if taken into consideration in determining the TMDL and preparing the TMDL document (e.g., the TMDL could include the design capacity of an existing or planned wastewater treatment facility);
- an explanation and analytical basis for expressing the TMDL through surrogate measures, if applicable. Surrogate measures are parameters such as percent fines and turbidity for sediment impairments; chlorophyll *a* and phosphorus loadings for excess algae; length of riparian buffer; or number of acres of best management practices.

☒ The TMDL document should contain documentation supporting the TMDL analysis, including an inventory of the data set used, a description of the methodology used to analyze the data, a discussion of strengths and weaknesses in the analytical process, and the results from any water quality modeling used. This information is necessary for EPA to review the loading capacity determination, and the associated load, wasteload, and margin of safety allocations.

☒ TMDLs must take critical conditions (e.g., steam flow, loading, and water quality parameters, seasonality, etc…) into account as part of the analysis of loading capacity (40 C.F.R. §130.7(c)(1)). TMDLs should define applicable critical conditions and describe the approach used to determine both point and nonpoint source loadings under such critical conditions. In particular, the document should discuss the approach used to compute and allocate nonpoint source loadings, e.g., meteorological conditions and land-use distribution.

☐ Where both nonpoint sources and NPDES permitted point sources are included in the TMDL loading allocation, and attainment of the TMDL target depends on reductions in the nonpoint source loads, the TMDL document must include a demonstration that nonpoint source loading reductions needed to implement the load allocations are actually practicable [40 CFR 130.2(i) and 122.44(d)].

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

Summary: *The technical analysis should describe the cause-and-effect relationship between the identified pollutant sources, the numeric targets, and achievement of water quality standards. It should* *also include a description of the analytical processes used, results from water quality modeling, assumptions and other pertinent information. The technical analysis for the Shoshone River watershed TMDLs describes how the E. coli loads were derived in order to meet the applicable water quality standards for the 303(d) impaired stream segments.*

The TMDL loads and loading capacities were derived using the load duration curve (LDC) approach. To better correlate the relationship between the pollutant of concern and the hydrology of each Section 303(d) listed waterbody, LDCs were developed for each stream segment.

The available water-quantity and water-quality data within the Shoshone River watershed was used to simulate continuous hydrology and bacteria data using the Hydrological Simulation Program – FORTRAN (HSPF) model. Data used in developing the model for this watershed included meteorological data (precipitation, potential evapotranspiration, air temperature, wind speed, solar radiation, dew point, and cloud cover), stream flow, water quality boundary conditions and point source loading. The meteorological data was used to simulate the watershed hydrology (including snow processes). A boundary condition was used at Buffalo Bill Reservoir to account for stream flow and water-quality constituents from areas upstream that were not modeled in this application. E. coli time series loads at the boundary condition were developed using the boundary condition flow data at Buffalo Bill Reservoir and an E. coli concentration of 2.5 cfu/100 mL. This concentration was selected to represent the low E. coli concentrations at the reservoir outflow.

The project area was delineated into 174 sub-watersheds to capture hydrologic and water quality variability. Then, the watershed was segmented into individual land and channel pieces that are assumed to demonstrate relatively homogeneous hydrologic, hydraulic, and water quality characteristics. This segmentation provides the basis for assigning similar or identical input and/or parameter values or functions to all portions of a land area or channel length contained in a model segment. The land segmentation was defined by land cover. Land cover affects the hydrologic and water-quality response of a watershed through the impact on infiltration, surface runoff, and water losses from evapotranspiration. Land use affects the rate of the accumulation of pollutants, such as bacteria, because certain land uses often support different pollutant sources. All cropland or hayland was assumed to be irrigated, because growing crops and hay in this arid watershed without irrigation is difficult. A majority of the irrigation occurring in this watershed is flood irrigation. Approximately 100 inches per acre of irrigated land (some of which is lost through inefficiencies or not applied) are diverted annually for irrigation. The average annual precipitation for most of the watershed area is 5 to 10 inches. Therefore, runoff from non-irrigated land may occur occasionally. However, bacteria washoff occurs far more consistently from the areas within the watershed with flood irrigated lands.

Land cover categories (based on the NLCD) were combined into seven groups with similar characteristics and integrated with riparian areas. The channel segmentation considers river travel time, riverbed slope continuity, temporal and spatial cross section and morphologic changes or obstructions, the confluence of tributaries, impaired reaches, and locations of flow and bacteria calibration and verification gages. After the reach network was segmented, the hydraulic characteristics of each reach were computed and, the areas of the land cover categories that drain to each reach were calculated.

The time period for model calibration and verification was from 1980 to 2012. In-stream flow monitoring points, illustrated in Figure 1-9 of the TMDL document, were used for hydrologic calibration of the HSPF model. Model calibration involved hydrologic and water-quality calibration using observed flow and water-quality data to compare to simulated results. Because water-quality simulations depend highly on watershed hydrology, the hydrology calibration was completed first, followed by the bacteria calibration. The 32-year simulation period included a range of dry and wet years. This range of precipitation improves the model calibration and validation and provides a model application that can simulate hydrology and water quality during a broad range of climatic conditions.

The bacteria accumulation and storage rates in the watershed were calculated using the Bacteria Source Load Calculator (BSLC) developed by the Center for TMDL and Watershed Studies at Virginia Tech. The buildup and washoff of bacteria were simulated based on these rates and precipitation. Failing on-site wastewater treatment systems, as well as livestock and wildlife in streams, are direct sources that were modeled similar to point sources, because the bacteria loads that they produce are independent of rainfall/runoff processes. The BSLC was used to calculate bacteria loadings that represent livestock in streams and human sources, which were then used as inputs to the HSPF model.

Table 2-4 of the TMDL document provides the E. coli source assessment modeling results summarized by land-use categories for overland load washed into the stream through rainfall/runoff processes, direct defecation of wildlife or livestock into streams, and on-site wastewater treatment tank failures (i.e., septics). The impaired segment of the Shoshone River (from Bighorn Lake to a point 9.7 miles upstream) is the most downstream reach assessed by the model and is essentially a culmination of all water-quality processes that occur upstream of this TMDL reach.

The TMDLs for each impaired segment were developed using the load duration curve (LDC) approach and resulted in flow-variable targets that considered the entire flow regime within the primary contact recreation season (May 1–September 30) and within the secondary contact recreation season (October 1–April 30). The LDCs are dynamic expressions of the allowable daily loads for any given flow within each specified season. To aid in interpreting and implementing each TMDL, the TMDL and LDC flow intervals were grouped into five flow zones that included high flows (0–10 percent), moist conditions (10–40 percent), midrange flows (40–60 percent), dry conditions (60– 90 percent), and low flows (90–100 percent) in adherence to guidance provided by the EPA. The LDCs for each impaired stream segment as well as the TMDL loading tables (e.g., loading capacity, wasteload allocation, load allocation, margin of safety) are included in Section 3.6 of the TMDL document.

The TMDLs are in effect from May 1 through September 30 for the primary contact standard of 126 cfu/100 mL and from October 1 through March 30 for the secondary contact standard of 630 cfu/100 mL.

Comments: *None.*

4.1 Data Set Description

TMDL documents should include a thorough description and summary of all available water quality data that are relevant to the water quality assessment and TMDL analysis. An inventory of the data used for the TMDL analysis should be provided to document, for the record, the data used in decision making. This also provides the reader with the opportunity to independently review the data. The TMDL analysis should make use of all readily available data for the waterbody under analysis unless the TMDL writer determines that the data are not relevant or appropriate. For relevant data that were known but rejected, an explanation of why the data were not utilized should be provided (e.g., samples exceeded holding times, data collected prior to a specific date were not considered timely, etc…).

Review Elements:

☒ TMDL documents should include a thorough description and summary of all available water quality data that are relevant to the water quality assessment and TMDL analysis such that the water quality impairments are clearly defined and linked to the impaired beneficial uses and appropriate water quality criteria.

☒ The TMDL document submitted should be accompanied by the data set utilized during the TMDL analysis. If possible, it is preferred that the data set be provided in an electronic format and referenced in the document. If electronic submission of the data is not possible, the data set may be included as an appendix to the document.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary**: The locations of the water-quality monitoring sites in the project area where data was collected are illustrated in Figure 1-10 of the TMDL document. The data collected from the water-quality monitoring sites and the flow monitoring sites, along with the HSPF model, was ultimately used to develop each load duration curve. A summary of the bacteria water quality data from the Shoshone River watershed is included in Tables 1-9 and 1-10 of the TMDL document. The flow data summary information is included in Table 1-8. A summary of the bacteria data from point sources located in the watershed is included in Table 1-12. The full E. coli water quality data set for the Shoshone River watershed was emailed to EPA.*

***Comments**: None.*

4.2 Waste Load Allocations (WLA):

Waste Load Allocations represent point source pollutant loads to the waterbody. Point-source loads are typically better understood and more easily monitored and quantified than nonpoint source loads. Whenever practical, each point source should be given a separate waste load allocation. All NPDES permitted dischargers that discharge the pollutant under analysis directly to the waterbody should be identified and given separate waste load allocations. The finalized WLAs are required to be incorporated into future NPDES permit renewals.

Review Elements:

☒ EPA regulations require that a TMDL include WLAs, which identify the portion of the loading capacity allocated to individual existing and future point source(s) (40 C.F.R. §130.2(h), 40 C.F.R. §130.2(i)). In some cases, WLAs may cover more than one discharger, e.g., if the source is contained within a general permit. If no allocations are to be made to point sources, then the TMDL should include a value of zero for the WLA.

☐ All NPDES permitted dischargers given WLA as part of the TMDL should be identified in the TMDL, including the specific NPDES permit numbers, their geographical locations, and their associated waste load allocations.

Recommendation:
☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

Summary: *The WLAs provided in Table 3-1 of the TMDL document are the sum of the permitted point-source allocations within each reach. The individual WLAs for each point source are also shown in Table 3-1. The WLAs were calculated as the product of the total design flows in each reach, the specified criteria (primary or secondary recreation criteria), and a unit conversion factor. Additional information about each of the point sources located in the watershed is included in Table 2-1.*

There are six (6) known municipal wastewater treatment facilities (WWTFs) that have point source discharges located within the drainage area of these listed stream segments. These WWTFs have point source permits to discharge wastewater from the towns of Lovell, Byron, Deaver, and Frannie and the cities of Cody and Powell.

One permitted, concentrated animal feeding operation was located within the Shoshone project area until 2011, when it stopped operating. While it was permitted, it was not allowed to discharge, except in the case of a chronic or catastrophic storm event that would cause an overflow from the runoff and/or wastewater control structure.

Comments:
1) Page 21 includes a brief description of the point sources in the watershed and says there are 5 permitted WWTFs. The description of point sources on page 31 says there are 6 permitted WWTFs as shown in Table 2-1. One or both of the sections should be revised should be consistent throughout the TMDL document.

WDEQ Response: The sixth WWTF was added to the list on page 21.

2) Table 1-12, page 30, does not include any data for the Town of Frannie. Has there been a discharge from this facility in the past? If so, the data should be summarized and added to the table.

WDEQ Response: A sentence was added "No data were available from the Frannie WWTF."

3) Table 2-1, page 31, the design flow for the Town of Deaver appears to be off by one decimal place. Based on the permit limits given in Table 2-1, the design flow would need to be 0.05 mgd so that the calculated WLA matches the WLA shown in Table 3-1.

WDEQ Response: The Deaver design flow was corrected.

4) Pages 21 and 31 mention the permit limits for the City of Cody being "…based on the capacity of the receiving stream…" How is the stream "capacity" derived for calculation of the permit limits? Is it based on bankfull capacity or an average instream flow rate? Why was the Cody facility given such high permit limits and WLAs when the other facilities in the watershed have limits equal to the WQS?

WDEQ Response: Statements regarding the capacity of the receiving stream were changed to discuss the mass balance approach. Additionally, errors found in the City of Cody fecal coliform limits rows of Table 1-2 were corrected.

Additional information needs to be provided in the TMDL document to explain the basis and derivation of the E. coli discharge limits for this permit and the impact of this discharge on the downstream water quality. The allowable discharge concentrations from Cody's WWTF is well above the applicable E. coli water quality standards and has the potential to cause localized in-stream water quality exceedances. Reasonable assurance may need to be included for the Shoshone River if the point-source discharge is being given a less stringent WLA based on the assumption that additional NPS load reductions will occur.

WDEQ Response: The following information was added: **"**For receiving waters that have a perennial flow, like the Shoshone River, a WLA calculation is performed to calculate the effluent limit. This involves a mass balance approach to determine the maximum allowable concentration in the effluent, so that when mixed with the receiving stream, the in-stream standard of the constituent is not violated. The mass balance approach uses the upstream 7Q10 (the lowest 7-day average flow that occurs on average once every 10 years) of the receiving stream, the maximum effluent discharge volume, the upstream background concentration of the constituent, and in-stream standards to calculate the maximum allowable concentration of the constituent in the effluent. Considering that Cody immediately discharges to a stretch of stream that supports its uses, that there are no other point sources in the immediate area that contribute to the impairment, and that the facility is many miles upstream of the impaired reach, it was determined that the mass balance approach was appropriate for calculating the effluent limit."

5) Additional information for each of the other point source discharges should also be added to the permit such as the number and size of lagoon cells; the basis of the design flow (i.e., are they average discharge flows derived from DMR data, or are they flows derived from the size of outlet pipe or weir?); and the annual discharge frequency (e.g., twice per year during spring and fall seasons; once per year in late spring).

WDEQ Response: Information for each point source discharge was added, including number and size of lagoon cells, basis of design flow, and discharge frequency.

4.3 Load Allocations (LA):

Load allocations include the nonpoint source, natural, and background loads. These types of loads are typically more difficult to quantify than point-source loads, and may include a significant degree of uncertainty. Often it is necessary to group these loads into larger categories and estimate the loading rates based on limited monitoring data and/or modeling results. The background load represents a composite of all upstream pollutant loads into the waterbody. In addition to the upstream nonpoint and upstream natural load, the background load often includes upstream point-source loads that are not given specific waste load allocations in this particular TMDL analysis. In instances where nonpoint source loading rates are particularly difficult to quantify, a performance-based allocation approach, in which a detailed monitoring plan and adaptive management strategy are employed for the application of BMPs, may be appropriate.

Review Elements:

☒ EPA regulations require that TMDL expressions include LAs which identify the portion of the loading capacity attributed to nonpoint sources and to natural background. Load allocations may range from reasonably accurate estimates to gross allotments (40 C.F.R. §130.2(g)). Load allocations may be included for both existing and future nonpoint source loads. Where possible, load allocations should be described separately for natural background and nonpoint sources.

☒ Load allocations assigned to natural background loads should not be assumed to be the difference between the sum of known and quantified anthropogenic sources and the existing *in situ* loads (e.g., measured in stream) unless it can be demonstrated that the anthropogenic sources of the pollutant of concern have been identified and given proper load or waste load allocations.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

Summary*: The TMDL document includes the land use breakdown for the watershed based on the 2006 National Land Cover Dataset (NLCD) data. In 2006, the dominant land use in the Shoshone River watershed was agriculture consisting of irrigated land and rangeland uses. Approximately 43 percent of the land cover in the watershed was scrub / shrub and 33 percent was grassland / herbaceous. The remaining 24 percent was forest, cropland, pasture hay, wetlands, developed space or barren.*

The largest consumptive use of water in the Shoshone River watershed is agricultural irrigation. Nine major irrigation districts and several smaller irrigation diversions are located in the project area. Buffalo Bill Reservoir, which serves as the project boundary, stores water from the North Fork Shoshone River and South Fork Shoshone River upstream of the project area. Buffalo Bill Reservoir supplies a majority of the water entering the project area and supplies water to irrigators served by a series of approximately 1,120 miles of canals, laterals, and ditches.

Nonpoint source bacterial pollution to these segments originates from various agricultural, wildlife and human sources in the watershed. Livestock (predominately cattle and sheep), wildlife, septic systems as well as pet wastes are all potential bacteria contributors in the Shoshone River watershed. The Bacteria Source Load Calculator was used to estimate the bacteria accumulation and storage from the nonpoint sources that are associated with the land uses in the watershed. The E. coli loadings were incorporated into the HSPF model to assess the fate and transport of the bacteria loadings throughout the watershed.

The source assessment modeling results, provided in Table 2-4 of the TMDL document, are summarized by land-use categories for overland load washed into the stream through rainfall/runoff processes, direct defecation of wildlife or livestock into streams, and on-site wastewater treatment tank failures *(i.e., septics). The modeling indicates that over 90 percent of the E. coli loading within the project area is linked to irrigated cropland, which includes runoff from irrigated lands, leakage from canals and drains, and irrigation return flows. Although irrigation is the primary delivery mechanism of bacteria to the impaired stream segments in the watershed, the sources of the bacteria deposition and buildup are predominately nonpoint sources originating from animals and humans.*

Comments: *None.*

4.4 Margin of Safety (MOS):

Natural systems are inherently complex. Any mathematical relationship used to quantify the stressor → response relationship between pollutant loading rates and the resultant water quality impacts, no matter how rigorous, will include some level of uncertainty and error. To compensate for this uncertainty and ensure water quality standards will be attained, a margin of safety is required as a component of each TMDL. The MOS may take the form of a explicit load allocation (e.g., 10 lbs/day), or may be implicitly built into the TMDL analysis through the use of conservative assumptions and values for the various factors that determine the TMDL pollutant load → water quality effect relationship. Whether explicit or implicit, the MOS should be supported by an appropriate level of discussion that addresses the level of uncertainty in the various components of the TMDL technical analysis, the assumptions used in that analysis, and the relative effect of those assumptions on the final TMDL. The discussion should demonstrate that the MOS used is sufficient to ensure that the water quality standards would be attained if the TMDL pollutant loading rates are met. In cases where there is substantial uncertainty regarding the linkage between the proposed allocations and achievement of water quality standards, it may be necessary to employ a phased or adaptive management approach (e.g., establish a monitoring plan to determine if the proposed allocations are, in fact, leading to the desired water quality improvements).

Review Elements:

☒ TMDLs must include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA §303(d) (1) (C), 40 C.F.R. §130.7(c)(1)). EPA's 1991 TMDL Guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS).

☐ If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS should be identified and described. The document should discuss why the assumptions are considered conservative and the effect of the assumption on the final TMDL value determined.

☒ If the MOS is explicit, the loading set aside for the MOS should be identified. The document should discuss how the explicit MOS chosen is related to the uncertainty and/or potential error in the linkage analysis between the WQS, the TMDL target, and the TMDL loading rate.

☐ If, rather than an explicit or implicit MOS, the TMDL relies upon a phased approach to deal with large and/or unquantifiable uncertainties in the linkage analysis, the document should include a description of the planned phases for the TMDL as well as a monitoring plan and adaptive management strategy.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

Summary: *The Shoshone River watershed TMDL document includes explicit MOSs for each of the listed segments in the watershed. An explicit MOS was calculated using information from the load duration curve for each impaired segment. The MOS values were derived using the difference between the loading capacity at the midpoint of each of the five flow zones and the loading capacity at the minimum flow in each zone. A substantial MOS is provided using this method, because the loading capacity is typically much less at the minimum flow of a zone when compared to the midpoint. Because the allocations are a direct function of flow, accounting for potential flow variability is an appropriate way to address the MOS.*

Comments: *None.*

4.5 Seasonality and variations in assimilative capacity:

The TMDL relationship is a factor of both the loading rate of the pollutant to the waterbody and the amount of pollutant the waterbody can assimilate and still attain water quality standards. Water quality standards often vary based on seasonal considerations. Therefore, it is appropriate that the TMDL analysis consider seasonal variations, such as critical flow periods (high flow, low flow), when establishing TMDLs, targets, and allocations.

Review Elements:

☒ The statute and regulations require that a TMDL be established with consideration of seasonal variations. The TMDL must describe the method chosen for including seasonal variability as a factor. (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)).

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

Summary: *By using the load duration curve approach to develop the TMDL allocations seasonal variability in E. coli loading is taken into account. The highest steam flows typically occur during late spring, and the lowest stream flows typically occur during the winter months. The TMDLs also consider seasonality because the primary E. coli criteria are in effect from May 1 to September 30, as defined by the main recreation season in Wyoming.*

Comments: *None.*

5. Public Participation

EPA regulations require that the establishment of TMDLs be conducted in a process open to the public, and that the public be afforded an opportunity to participate. To meaningfully participate in the TMDL process it is necessary that stakeholders, including members of the general public, be able to understand the problem and the proposed solution. TMDL documents should include language that explains the issues to the general public in understandable terms, as well as provides additional detailed technical information for the scientific community. Notifications or solicitations for comments regarding the TMDL should be made available to the general public, widely circulated, and clearly identify the product as a TMDL and the fact that it will be submitted to EPA for review. When the final TMDL is submitted to EPA for approval, a copy of the comments received by the state and the state responses to those comments should be included with the document.

Review Elements:

☒ The TMDL must include a description of the public participation process used during the development of the TMDL (40 C.F.R. §130.7(c)(1)(ii)).

☐ TMDLs submitted to EPA for review and approval should include a summary of significant comments and the State's/Tribe's responses to those comments.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

Summary: *The TMDL document includes a summary of the public participation process that has occurred. It describes the opportunities the public had to be involved in the TMDL development process. The efforts that were taken to facilitate public education, review, and comment during developing the Shoshone River watershed TMDLs included presentations on the findings of the assessment at public meetings to stakeholders in the watershed, quarterly newsletters, a project website, public announcements, and a 30-day public notice period for review and comment. The findings from these public meetings and comments were taken into consideration when developing the TMDLs.*

A Public Involvement Plan was developed specifically for the Shoshone River watershed TMDL project to aid in facilitating and documenting all public outreach throughout the project. Public information objectives during the TMDL project were to provide information to stakeholders, provide stakeholders the opportunity to comment and ask questions, and provide an opportunity for stakeholders to participate on the project's Technical Steering Committee. A total of seven public meetings were held during the project. The locations of the public meetings were moved throughout the watershed to maximize public involvement. Additional outreach activities are detailed in Section 5.0 of the TMDL document.

Comments: *The placeholder for the information about the public notice period should be completed as part of the revisions for the final document (Section 5.0, page 69, first paragraph).*

WDEQ Response: The placeholder was updated to contain public notice information.

6. Monitoring Strategy

TMDLs may have significant uncertainty associated with the selection of appropriate numeric targets and estimates of source loadings and assimilative capacity. In these cases, a phased TMDL approach may be necessary. For Phased TMDLs, it is EPA's expectation that a monitoring plan will be included as a component of the TMDL document to articulate the means by which the TMDL will be evaluated in the field, and to provide for future supplemental data that will address any uncertainties that may exist when the document is prepared.

Review Elements:

☐ When a TMDL involves both NPDES permitted point source(s) and nonpoint source(s) allocations, and attainment of the TMDL target depends on reductions in the nonpoint source loads, the TMDL document should include a monitoring plan that describes the additional data to be collected to determine if the load reductions provided for in the TMDL are occurring.

☐ Under certain circumstances, a phased TMDL approach may be utilized when limited existing data are relied upon to develop a TMDL, and the State believes that the use of additional data or data based on better analytical techniques would likely increase the accuracy of the TMDL load calculation and merit development of a second phase TMDL. EPA recommends that a phased TMDL document or its implementation plan include a monitoring plan and a scheduled timeframe for revision of the TMDL. These elements would not be an intrinsic part of the TMDL and would not be approved by EPA, but may be necessary to support a rationale for approving the TMDL. http://www.epa.gov/owow/tmdl/tmdl_clarification_letter.pdf

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

Summary: *After implementation of the recommended best management practices, monitoring will be necessary to ensure attainment of the TMDLs within the Shoshone River watershed. The conservation districts have been monitoring key locations in the watershed to collect the data needed to evaluate the progress towards meeting the geometric mean E. coli criteria. The monitoring data is needed to ensure that the goals of the Shoshone River watershed TMDLs will be met if the implementation efforts continue as planned. Additional monitoring recommendations are included in Section 6.0 of the TMDL document.*

Comments: *None.*

7. Restoration Strategy

The overall purpose of the TMDL analysis is to determine what actions are necessary to ensure that the pollutant load in a waterbody does not result in water quality impairment. Adding additional detail regarding the proposed approach for the restoration of water quality is not currently a regulatory requirement, but is considered a value added component of a TMDL document. During the TMDL analytical process, information is often gained that may serve to point restoration efforts in the right direction and help ensure that resources are spent in the most efficient manner possible. For example, watershed models used to analyze the linkage between the pollutant loading rates and resultant water quality impacts might also be used to conduct "what if" scenarios to help direct BMP installations to locations that provide the greatest pollutant reductions. Once a TMDL has been written and approved, it is often the responsibility of other water quality programs to see that it is implemented. The level of quality and detail provided in the restoration strategy will greatly influence the future success in achieving the needed pollutant load reductions.

Review Elements:

☐ EPA is not required to and does not approve TMDL implementation plans. However, in cases where a WLA is dependent upon the achievement of a LA, "reasonable assurance" is required to demonstrate the necessary LA called for in the document is practicable). A discussion of the BMPs (or other load reduction measures) that are to be relied upon to achieve the LA(s), and programs and funding sources that will be relied upon to implement the load reductions called for in the document, may be included in the implementation/restoration section of the TMDL document to support a demonstration of "reasonable assurance".

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

Summary: *A variety of BMPs were considered for purposes of developing a water-quality management implementation plan for the Shoshone River watershed. The control measures listed below are recommended to address the nonpoint sources identified in the source assessment section of the TMDL. Based on water-quality monitoring and HSPF model results, it is likely that the recommended control measures would achieve the required load reductions and attain the TMDL E. coli targets for the impaired stream segments in the Shoshone River watershed.*

The eight incremental management scenarios that were simulated for each bacteria impaired segment using the HSPF model include the following:
1. Irrigation Efficiency: Improve efficiency by 75 percent;
2. Irrigated Land: Decrease load applied to irrigated land by 75 percent;
3. Direct Defecation: Decrease direct defecation to waterbodies by 75 percent;
4. Range Land: Decrease load applied to rangeland by 75 percent;
5. Failed Septic Systems: Decrease number of failing septic systems by 75 percent;
6. Urban/Residential Land: Decrease load applied to urban and residential areas by 75 percent;
7. Forest Land: Decrease load applied to forest land by 75 percent; and
8. Riparian Land: Decrease load applied to riparian land by 75 percent.

Individual percent reductions represent the simulated load reduction for each management scenario individually. The greatest predicted individual reductions in the project area occur by improving irrigation efficiency and by reducing the irrigated land loading (see Table 7–2 in the TMDL document). Cumulative percent reductions represent simulated load reductions from cumulative BMP management scenarios. For all reaches except Big Wash, the management scenarios were sufficient to meet the required reductions (see Table 7–3 in the TMDL document). For Big Wash to meet the required reductions, the efficiencies of the management scenarios were increased from 75 percent to 85 percent.

Comments: *None.*

8. Daily Loading Expression

The goal of a TMDL analysis is to determine what actions are necessary to attain and maintain WQS. The appropriate averaging period that corresponds to this goal will vary depending on the pollutant and the nature of the waterbody under analysis. When selecting an appropriate averaging period for a TMDL analysis, primary concern should be given to the nature of the pollutant in question and the achievement of the underlying WQS. However, recent federal appeals court decisions have pointed out that the title TMDL implies a "daily" loading rate. While the most appropriate averaging period to be used for developing a TMDL analysis may vary according to the pollutant, a daily loading rate can provide a more practical indication of whether or not the overall needed load reductions are being achieved. When limited monitoring resources are available, a daily loading target that takes into account the natural variability of the system can serve as a useful indicator for whether or not the overall load reductions are likely to be met. Therefore, a daily expression of the required pollutant loading rate is a required element in all TMDLs, in addition to any other load averaging periods that may have been used to conduct the TMDL analysis. The level of effort spent to develop the daily load indicator should be based on the overall utility it can provide as an indicator for the total load reductions needed.

Review Elements:

☒ The document should include an expression of the TMDL in terms of a daily load. However, the TMDL may also be expressed in temporal terms other than daily (e.g., an annual or monthly load). If the document expresses the TMDL in additional "non-daily" terms the document should explain why it is appropriate or advantageous to express the TMDL in the additional unit of measurement chosen.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

Summary: *The Shoshone River watershed TMDL document includes daily loads for E. coli expressed as colony forming units per day for the listed stream segments in the watershed. The daily TMDL loads for each segment are included in the Load Duration Curves / Total Maximum Daily Loads Tables section (Section 3.6) of the document.*

Comments: *None.*