Total Maximum Daily Load for *Escherichia coli (E. coli)* in the Fremont River Watershed

Prepared by
Utah Department of Environmental Quality
Division of Water Quality

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Utah Department of Environmental Quality
Division of Water Quality
Fremont River TMDL

Waterbody ID/Assessment Unit	Fremont River 2: UT14070003-005
Location	Fremont River and tributaries from Bicknell to Mill Meadow Reservoir near USFS boundary
Pollutants of Concern	*Escherichia coli (E. coli)*
Impaired Beneficial Uses	Class 2A: Frequent Primary Contact Recreation (Not yet 303(d) listed but 2 monitoring locations indicate impairment. Will be included on the 2020 list.)
Current Loading Loading Capacity (TMDL) Load Reduction	126 $X10^9$ MPN/day 15.4 X 10^9 MPN/day 88% (Calculations based on sampling location 4955330: Fremont River at Big Rocks Rd. Loading calculations are averages of recreation season months that require a reduction)
Wasteload Allocation Load Allocation Margin of Safety (10% of Loading Capacity)	0 organisms/day (no point sources) 15.4 X 10^9 MPN/day 15.4 X 10^8 MPN/day
Defined Targets/Endpoints	1. For recreation seasons (May 1st through October 30th) with ≥5 collection events, no more than 10% of samples shall exceed 409 MPN/100 mL. 2. For recreation seasons with ≥5 collection events, no 30-day interval geometric means shall exceed 126 MPN/100 mL. 3. For recreation seasons with ≥10 collection events, the geometric mean of all samples shall not exceed 126 MPN/100 mL.
Implementation Strategy	Stakeholders will employ a voluntary adaptive management approach to address all anthropogenic sources of *E. coli* loading with focus on improvements in grazing management and septic system inspection and maintenance. TMDL endpoints will be re-evaluated within 10 years.

Utah Department of Environmental Quality
Division of Water Quality
Fremont River TMDL

Waterbody ID/Assessment Unit	Fremont River 3: UT14070003-008
Location	Fremont River and tributaries from east boundary of Capitol Reef National Park to Bicknell
Pollutants of Concern	*Escherichia coli (E. coli)*
Impaired Beneficial Uses	Class 2A: Frequent Primary Contact Recreation
Current Loading Loading Capacity (TMDL) Load Reduction	399.7 X 10^9 MPN/day 110.5 X 10^9 MPN/day 72% (Calculations based on sampling location 4954390: Fremont River at Highway 12 Crossing. Loading calculations are averages of recreation season months that require a reduction)
Wasteload Allocation Load Allocation Margin of Safety (10% of Loading Capacity)	0 organisms/day (no point sources) 110.5 X 10^9 MPN/day 110.5 X 10^8 MPN/day
Defined Targets/Endpoints	1. For recreation seasons (May 1st through October 30th) with ≥5 collection events, no more than 10% of samples shall exceed 409 MPN/100 mL. 2. For recreation seasons with ≥5 collection events, no 30-day interval geometric means shall exceed 126 MPN/100 mL. 3. For recreation seasons with ≥10 collection events, the geometric mean of all samples shall not exceed 126 MPN/100 mL.
Implementation Strategy	Stakeholders will employ a voluntary adaptive management approach to address all anthropogenic sources of *E. coli* loading with focus on improvements to failing septic systems and grazing and irrigation management. TMDL endpoints will be re-evaluated within 10 years.

EXECUTIVE SUMMARY

This Total Maximum Daily Load (TMDL) study reviews the available *E. coli* data for the Fremont River needed to assess and restore the recreational beneficial use of the river as defined by Utah Administrative Code R317-2-6 and the Clean Water Act (CWA). States must develop a TMDL when water quality impairments result in their listing on the CWA Section 303(d) List of Impaired Waterbodies. The Fremont River watershed was listed as impaired in the Utah 2014 Integrated Report and was a high priority for *E. coli* TMDL development by the Utah Division of Water Quality (DWQ) due to the large number of people that recreate in the river in and around Capitol Reef National Park. *E. coli* is an indicator of recent fecal contamination, and ingestion of water containing fecal pathogens poses a public health risk.

Water quality concerns in the Fremont River were first identified through routine monitoring in 2010. A follow-up study conducted by Capitol Reef National Park staff showed high *E. coli* concentrations in park waters (Hackbarth et al, 2018). Since then, hundreds of *E. coli* samples have been collected throughout the watershed by DWQ, Utah State University Extension, Capitol Reef National Park, and Utah Water Watch to better understand the temporal and spatial extent of the problem.

E. coli data have been collected at 10 sampling sites throughout the Fremont River watershed on a monthly basis through the recreation season of May through October, as well as during non-recreation season months. Exceedances of the 2A recreation water quality standards are highest during the recreation season months, specifically July and August, and are driven by livestock (74% of load) and wildlife (25% of load) grazing in close proximity to the river, as well as potentially failing septic systems (1% of load).

DWQ believes *E. coli* loading will be reduced and beneficial uses restored and protected with implementation of the best management practices identified in this document.

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1.0 INTRODUCTION AND BACKGROUND

This document represents the TMDL analyses of two assessment units of the Fremont River watershed to fulfill Clean Water Act (CWA) requirements for impaired waters. A TMDL analysis determines the maximum amount of an identified pollutant (i.e., the load) that a waterbody can receive and still support its beneficial uses and meet state water quality standards. Once the pollutant loads and sources have been identified, controls are implemented to reduce those loads until the waterbody meets water quality standards. Upon completion of the TMDL analysis, the TMDL is submitted to the Utah Water Quality Board and the U.S. Environmental Protection Agency (EPA) for final approval.

The purpose of the CWA is to improve and protect the physical, chemical, and biological integrity of the nation's waters. The CWA requires EPA or delegated authorities such as states, tribes, and territories to evaluate the quality of waters, establish beneficial uses, and define water quality criteria to protect those uses. Section 303(d) of the CWA requires that every two years, as part of the Integrated Reporting process, each state publish a list of waterbodies that fail to meet state water quality standards. This list is made available for public review and submitted to the EPA for review as well. Waterbodies placed on the 303(d) list are referred to as impaired waters. The CWA requires a TMDL analysis for 303(d) waters for each pollutant responsible for the impairment of its designated use(s).

DWQ collects biological and water quality data as part of the Integrated Report process and assesses whether the waterbody is meeting water quality standards for its designated beneficial uses. The Fremont River (Fremont River-3: UT14070003-008, Fremont River and tributaries from east boundary of Capitol Reef National Park to Bicknell) was listed as impaired on the State of Utah's 303(d) list in 2014 for not meeting primary recreational uses due to exceedances of water quality standards for *E. coli* bacteria. The Fremont River segment addressed by this TMDL is part of the DWQ prioritization plan to meet EPA's Long-Term Vision for Assessment, Restoration, and Protection under the CWA Section 303(d) Program. This report defines the TMDL and water quality targets that, when attained, will bring the river into full support of its recreational (2A) beneficial uses.

2.0 TMDL Targets

2.1 Total Maximum Daily Load Definition

The State is required to develop a TMDL to reduce pollutant levels in impaired waters subsequent to 303(d) listing. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive on a daily basis and still meet water quality standards. It is the sum of individual wasteload allocations (WLAs) from point sources, load allocations (LAs) from nonpoint sources and natural background levels, and includes a margin of safety (MOS), either defined implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. This sum is calculated through the following equation:

$$\textbf{TMDL} = \sum \textbf{WLAs} + \sum \textbf{LAs} + \textbf{MOS}$$

The TMDL process consists of the following steps:

1. Review existing water quality data.
2. Identify sources and causes of pollutants.
3. Identify water quality goals.
4. Establish the amount of pollutant that can be allowed in total.
5. Allocate allowable pollutant loads to the various sources.
6. Identify and implement measures to achieve and maintain water-quality standards.
7. Monitor to assure that goals are met.

2.2 Study Area Boundary

The Fremont River watershed is located in south central Utah on the Wasatch Plateau (Figure 1) and drains approximately 1,980 mi^2. The majority of the Fremont River watershed is located in Wayne County, although small portions fall within Sevier, Piute, and Garfield counties as well. The river flows a distance of 95 miles from the headwaters to its confluence with Muddy Creek. The watershed is owned and managed by the following federal, state, and local entities:

- 41%: U.S. Bureau of Land Management
- 30%: U.S. National Forest
- 13%: National Park Service
- 11%: State Trust Land
- Five percent: private

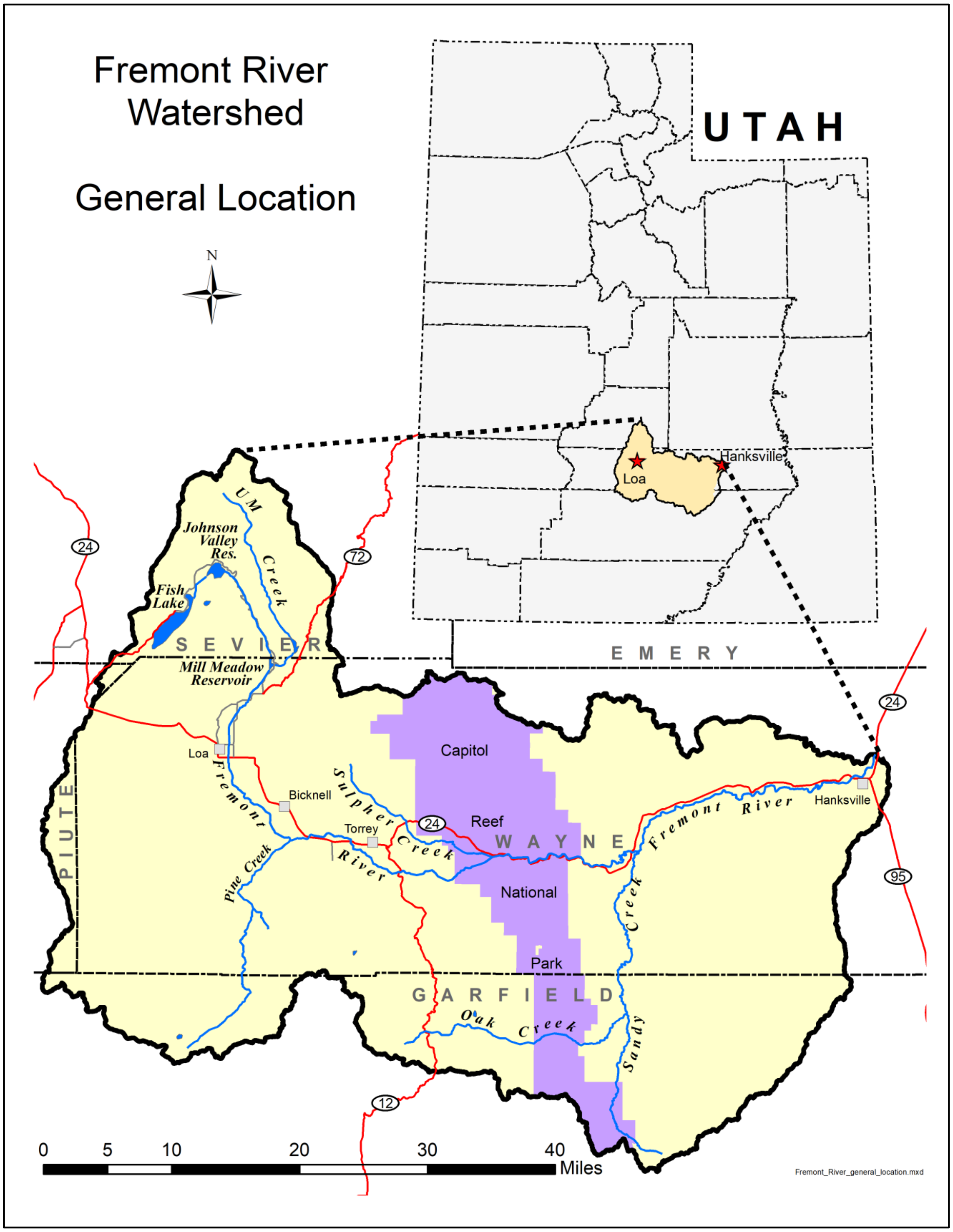


Figure 1. Location of the Fremont River watershed

2.3 Impairment of the Fremont River

Utah waters are assigned beneficial uses that delineate existing uses of the water (UAC R317-2-6). All uses have numeric criteria associated with them that must be met to ensure beneficial use support. The designated beneficial uses for the Fremont Watershed are provided in Table 1. Utah assesses surface waters of the state at the monitoring-site level then summarizes the site-level assessment up to a larger spatial scale known as an Assessment Unit.

Fremont River-3 (Fremont River and tributaries from the east boundary of Capitol Reef National Park to Bicknell) (Figure 2) is the only Fremont watershed assessment unit (AU) currently 303(d) listed for *E. coli* exceedances (DWQ 2016 Integrated Report). However, recent monitoring results within the upstream Fremont-2 AU (Fremont River and tributaries from Bicknell to Mill Meadow Reservoir near USFS boundary) indicate *E. coli* impairment, and this AU will be listed as part of the combined 2018/2020 Integrated Report. This study includes a TMDL for Fremont River-2 AU in advance of that listing, and the implementation plan includes recommended best management practices for that area. This TMDL for the Fremont River-2 AU provides interested landowners with the justification and support to receive technical and financial assistance if they want to make improvements prior to the issuance of the 2018/2020 Integrated Report.

Frequent primary contact recreational use (Class 2A) such as swimming is the beneficial use impaired by *E. coli* exceedances in the Fremont River. While full immersion is not common among all of the users who recreate in the river, there may be a substantial number engaged in primary contact activities, especially during the warmer summer months of the recreation season.

In addition to the *E. coli* impairment, Fremont River-3 is impaired for temperature and total dissolved solids (Table 2). Fremont River-2 is impaired for pH and temperature. DWQ will address these listings in the future.

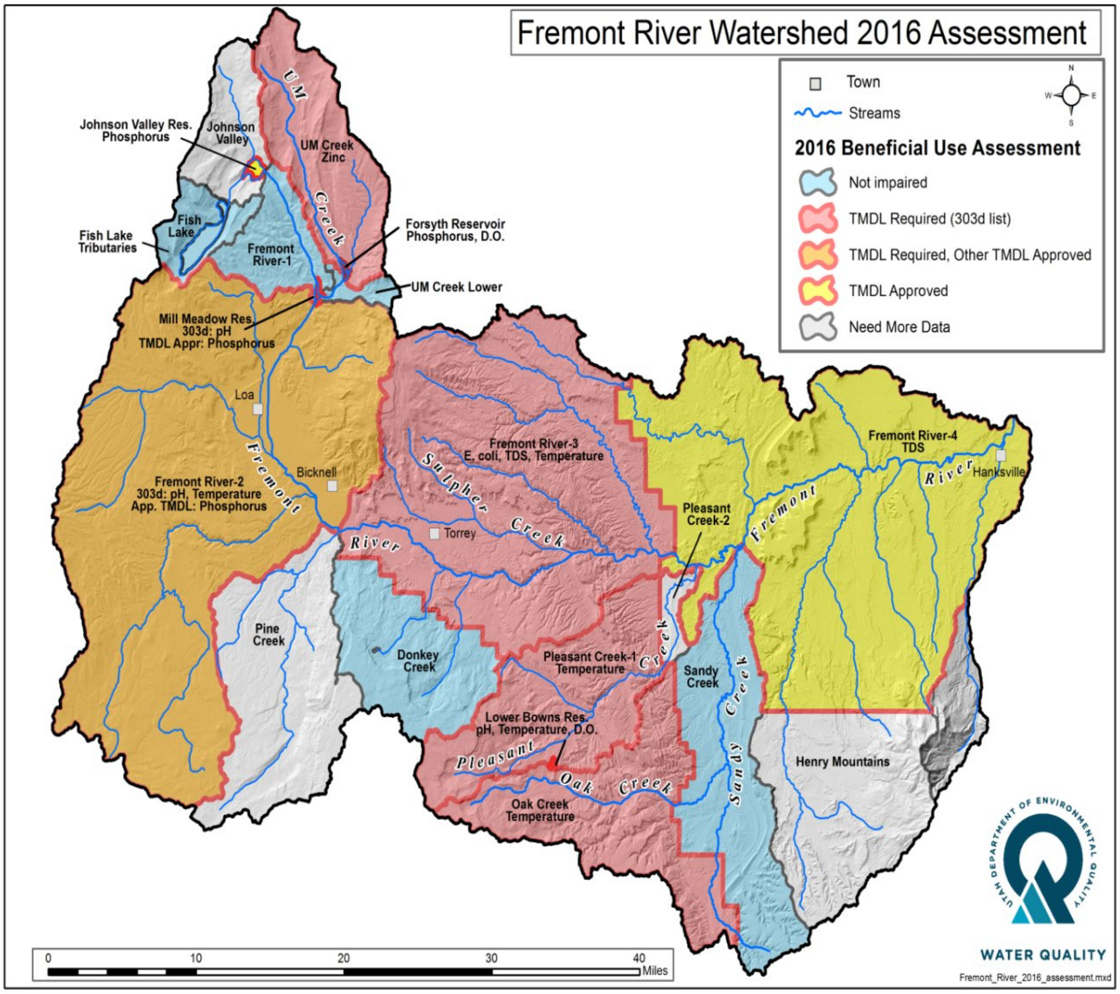


Figure 2. Map of the Fremont River watershed assessment units (AUs)

Table 1. Designated uses for the impaired Fremont River segments from Utah R317-2-13

Name	Designated Beneficial Uses
Fremont River and tributaries, through Capitol Reef National Park to headwaters	Domestic water source (1C) Frequent primary contact recreation (2A) Cold water fishery and other aquatic life (3A) Agricultural uses (4)

Table 2. Impaired assessment units in the Fremont River watershed

Assessment Unit Description	Assessment Unit ID	Cause of Impairment	Impaired Beneficial Use	Year Listed
Fremont River and tributaries from Bicknell to Mill Meadow Reservoir near USFS boundary	Fremont River 2: UT14070003-005	pH	1C, 2A, 3A, 4	2014
		Temperature	3A	2014
Fremont River and tributaries from east boundary of Capitol Reef National Park to Bicknell	Fremont River 3: UT14070003-008	*E. coli*	1C, 2A	2014
		Temperature	3A	2014
		Total Dissolved Solids	4	2014

2.4 Parameter of Concern (E. coli)

Routine monitoring of surface waters and assessment programs are needed to ensure the protection of public health. Surface waters are monitored as part of Utah's bacteriological monitoring program for pathogens that originate from fecal pollution from human and animal waste. It is not feasible to monitor for all pathogens in water, but by analyzing for certain indicator organisms, it is possible to assess potential health risks. Utah samples for *E. coli* concentrations in surface waters using EPA guidelines (EPA, 2012).

The use of indicator organisms as a means of assessing the presence of pathogens in surface waters has been adopted by the World Health Organization and EPA (WHO, 2001). *E. coli* are the most abundant coliform bacteria present in human and animal intestines, numbering up to one billion organisms per gram of feces. Their presence can be primarily attributed to fecal origin, and their presence in water can be an indication of recent contamination. Common sources include failing septic systems, leaking sewer lines, grazed pastures, confined feedlots, wildlife, and dog parks (Benham, 2006). Pathogenic bacteria are washed into surface waters during rainfall or snowmelt or are deposited directly in the water. These bacteria pose a threat to human health through incidental ingestion.

2.5 Applicable Water Quality Standards

Utah's numeric criteria for *E. coli* can be found in Utah Administrative Code, Standards of Quality for Waters of the State (UAC R317-2). These criteria vary based on the beneficial use assignment of the waterbody. Table 3 summarizes the *E. coli* standards pertaining to the 303(d) listed segment in the Fremont River-3 AU.

Table 3. Water quality standards for Fremont River-2 and Fremont River-3 AUs

Designated Use	Description	*E. coli* Geometric Mean (MPN*/100 mL)	*E. coli* Not to Exceed (MPN*/100 mL)
2A	Frequent Primary Contact Recreation	126	409

*MPN/100 mL= Most Probable Number [of colonies] per 100 milliliter of water

The *E. coli* numeric standard for Designated Beneficial Use Class 2A waters states that sample concentrations may not exceed 126 MPN per 100 mL as a 30-day and recreation season geometric mean, or a maximum of 409 MPN per 100 mL in more than 10% of samples collected during the recreation season. The 30-day geometric mean is based on no less than five samples collected more than 48 hours apart within 30 days.

Utah's 2014 303(d) assessment and listing methodology can be found in Appendix A.

2.6 TMDL Endpoints

TMDL endpoints represent water quality targets. The reductions specified in the TMDL report to meet the 30-day geometric mean water quality standard for *E. coli* will ensure no sample will exceed the acute (maximum) *E. coli* water quality standard based upon the current data set. The endpoints for the Fremont River *E. coli* TMDL are as follows:

1. For years with ≥5 collection events in any recreation season (May 1st through October 30th), no more than 10% of samples shall exceed 409 MPN/100 mL.
2. For recreation seasons with ≥5 collection events, no 30-day interval geometric means shall exceed 126 MPN/100 mL.
3. For recreation seasons with ≥10 collection events, the geometric mean of all samples shall not exceed 126 MPN/100 mL.

3.0 WATERSHED CHARACTERIZATION

3.1 Physical Features

3.1.1 Geology

The Fremont River flows eastward from approximately 11,000 feet in elevation from former glaciated land surfaces through a transition zone of intermediate elevations and erosional features to approximately 4,300 feet on the eastern side of the watershed. The headwaters of the watershed are covered with volcanic rock derived from lava flows, while the mid-watershed near Bicknell is characterized by Navajo sandstone, the Moenkopi formation, and the Shinarump conglomerate formation (Figure 3) (Chronic, 1990).

East of Capitol Reef National Park, in the lower watershed downstream of the TMDL study area, the geology changes again as gray hills of Mancos Shale appear around Caineville. Several of these strata are highly erodible and produce abundant sediment in the sand, silt, and clay size range. High concentrations of salts within the shale affect the quality of any water with which these sediments come in contact. Additionally, this sediment is easily mobilized during flood events and has the potential to carry with it fecal bacteria deposited on the ground or settled at the bottom of the stream.

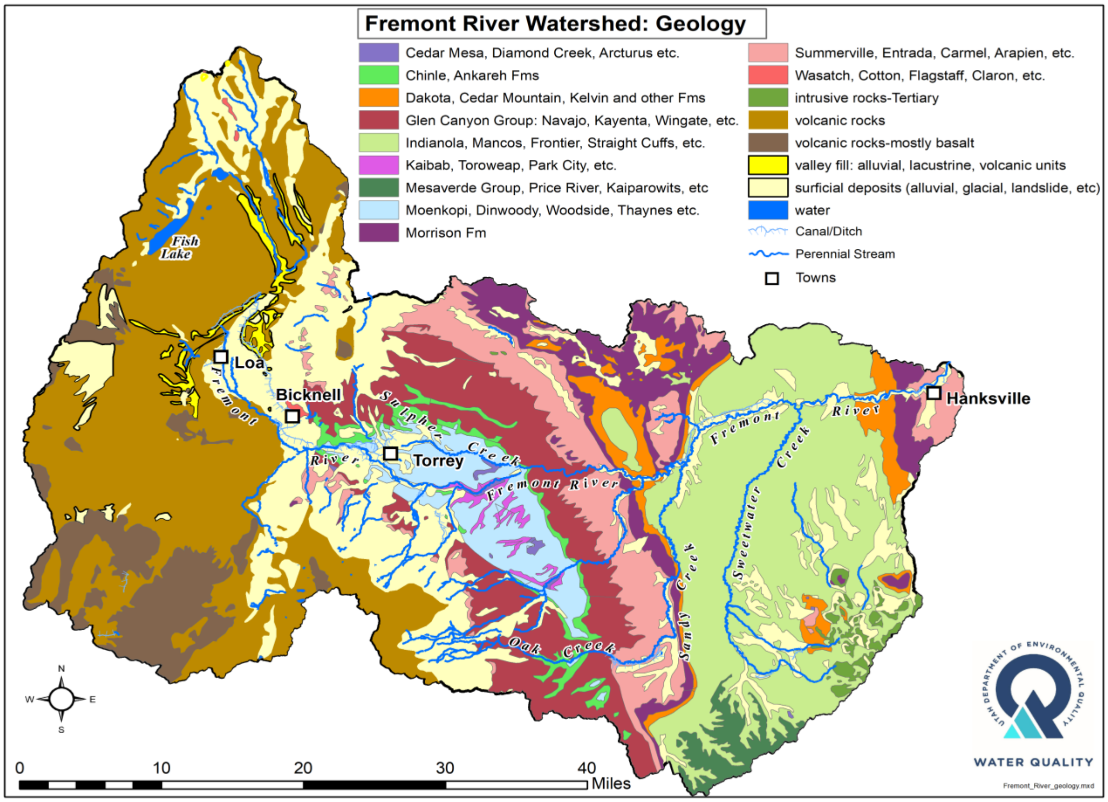


Figure 3. Geologic data in the Fremont River watershed

3.1.2 Hydrology

Flows throughout the Fremont River watershed are highly variable depending on the amount of precipitation and how much water is being diverted through irrigation canals throughout the area. Streams that originate in the high elevations near Fish Lake and Boulder Mountain are usually perennial and are diverted for agricultural use and/or storage (Table 4, Figure 4) (USDA, 2019).

The Fremont River originates from the outflow of Fish Lake at approximately 9,000 feet in elevation. The lake is fed primarily by snowmelt in the headwater streams. From Fish Lake, it flows approximately one mile through marshes and low-gradient natural stream channels into Johnson Valley Reservoir. The river continues to Mill Meadow Reservoir, where it is stored for irrigation use throughout the summer. Just below Mill Meadow Reservoir, a major withdrawal diverts surface water from the river during the irrigation season (April 1 to November 1). During the non-irrigation season (approximately November 1 to April 1), no water is released from the reservoir, though springs and seeps that arise below the dam provide some channel flow (approximately 0.5 to 3 cubic feet per second (cfs). Because all water is diverted from the channel, minimal pathogen loading is possible from the upper watershed above Mill Meadow Reservoir.

Springs and a few major tributaries contribute to the river below Mill Meadow Reservoir. These springs provide consistent discharge rates. Their flows enter the river during the non-irrigation season and are diverted to sprinkler systems during the irrigation season. Although the major tributaries drain some large watersheds, the runoff from these streams only enters the river during limited periods (days and weeks) associated with spring snowmelt (typically March/April) or during flash flooding following storms in August and September (USDA, 2019).

As the Fremont River enters the agricultural and municipal areas of Rabbit Valley from Loa to Bicknell, its flow and channel characteristics become increasingly altered. The entire flow is diverted into a canal system below Mill Meadow Reservoir. As a result, the stream channel between Mill Meadow Reservoir and its confluence with Spring Creek is most often dry. Water that arises from springs, seeps, and irrigation return flows is backed up behind "dry dams" and applied to pastures and cropland via flood or sprinkler irrigation methods. During the non-irrigation season, the river only flows where springs and seeps make it to the river. Even during this period, the river channel contains minimal flows (approximately 0.5 cfs) because water is diverted for stock watering where feasible. The flow increases incrementally as numerous springs join the river near the Bicknell Bottoms area. Three major tributaries (Big Hollow Creek, Pine Creek and Government Creek) join the Fremont River in this area.

The Fremont River becomes mostly perennial after its confluence with Spring Creek. There are numerous diversions (Figure 5) within this reach and portions of the channel are straightened. It continues through an area known as the Fremont Narrows, where flow can be near zero during dry periods. Flows increase due to recharge from springs and tributaries. Water is diverted to irrigate historic orchards in the Fruita Rural Historic District in Capitol Reef National Park. The river flows through the park for a distance of 13 miles. The river channel is heavily altered through the park as a result of the construction of

Highway 24. Sulphur Creek joins the Fremont River within the park. The Fremont River flows downstream from Capitol Reef for approximately 20 miles, with Pleasant Creek and Sandy Creek as tributary streams, until it reaches a large irrigation diversion. From there, the remaining flow continues another 10 miles until the confluence with Muddy Creek near Hanksville. At that point, the two rivers combine to form the Dirty Devil River, a tributary to the Colorado River.

Table 4. Summary of stream types in the Fremont River watershed

Stream Type *	Stream Length (mi)	Percent (%)
Intermittent	4,472	87.7
Perennial	483.7	9.5
Artificial Path	29.1	0.6
Canal/Ditch	72.2	1.4
Pipeline	4.8	0.1
Connector	35.2	0.7
Total	**5,097**	**100**

*Congress, in the Clean Water Act, explicitly directed agencies to protect "navigable waters." The 2020 Navigable Waters Protection Rule defines those and includes perennial and intermittent tributaries to traditional navigable waters.

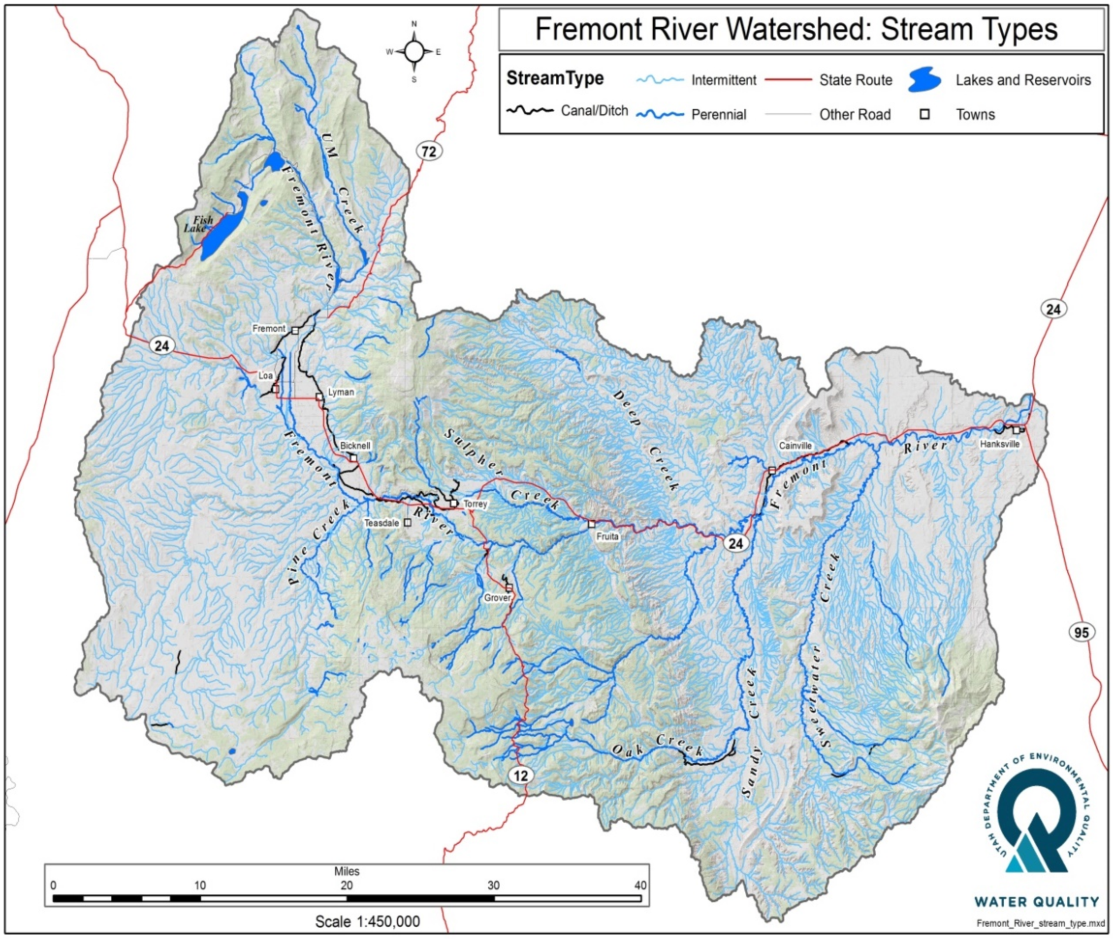


Figure 4. Stream types in the Fremont River watershed

3.1.3 Water Supply and Uses

Data from the Utah Division of Water Rights (October 1, 2018) indicate that 2,855 points of diversion exist in the Fremont River watershed (Table 5, Figure 5). Water-right holders in the region include the National Park Service, energy companies, water conservancy districts, private landowners, ditch companies, irrigation companies, and the U.S. Forest Service. Underground diversions (water from wells) make up the largest type of diversion in the watershed.

Table 5. Points of diversion in the Fremont River watershed

Type of Diversion	Number	Amount (acre-feet)
Underground (Wells)	787	1,119,485
Surface	499	242,256
Re-diversion	59	205,276
Point to Point	1,474	142
Return	23	141
Spring	13	4
Total	**2,855**	**1,567,304**

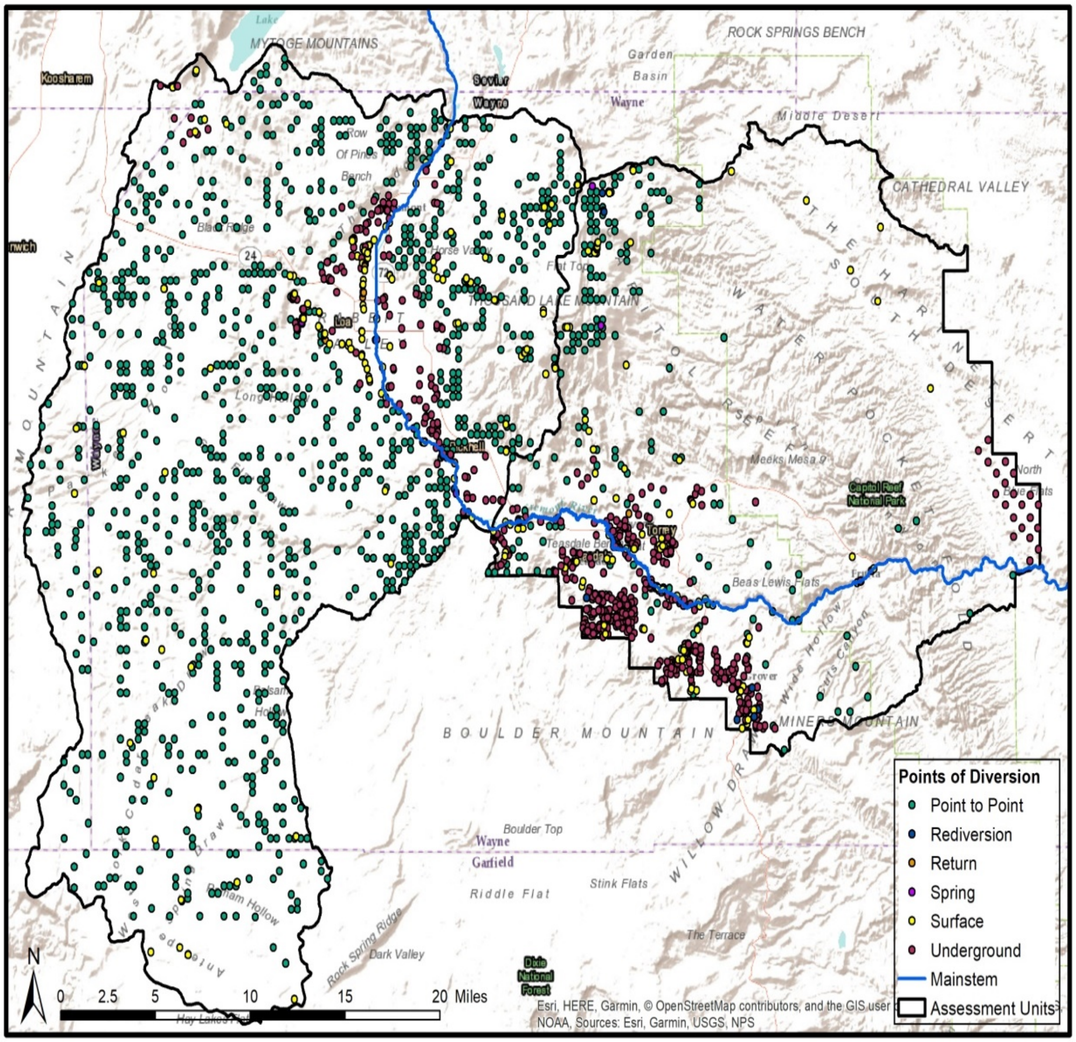


Figure 5. Points of diversion in the Fremont River Watershed

3.1.4 Precipitation and Climate

Annual temperatures and precipitation vary greatly within the watershed and are mainly tied to changes in elevation. Average annual temperatures range from 40°F at the high elevation headwaters near Fish Lake to 54° F at Hanksville near the confluence with Muddy Creek. Precipitation primarily falls during two distinct seasons. Frontal systems from the Pacific Northwest bring winter and spring precipitation in the form of snow at higher elevations and rain at lower elevations, and late summer monsoonal rains from the south bring moisture to the entire region. Average annual precipitation ranges from five inches near Hanksville in the very dry lower portion of the watershed to approximately 40 inches in the mountains near the headwaters on the Fishlake National Forest (Figure 6) (USDA, 2019).

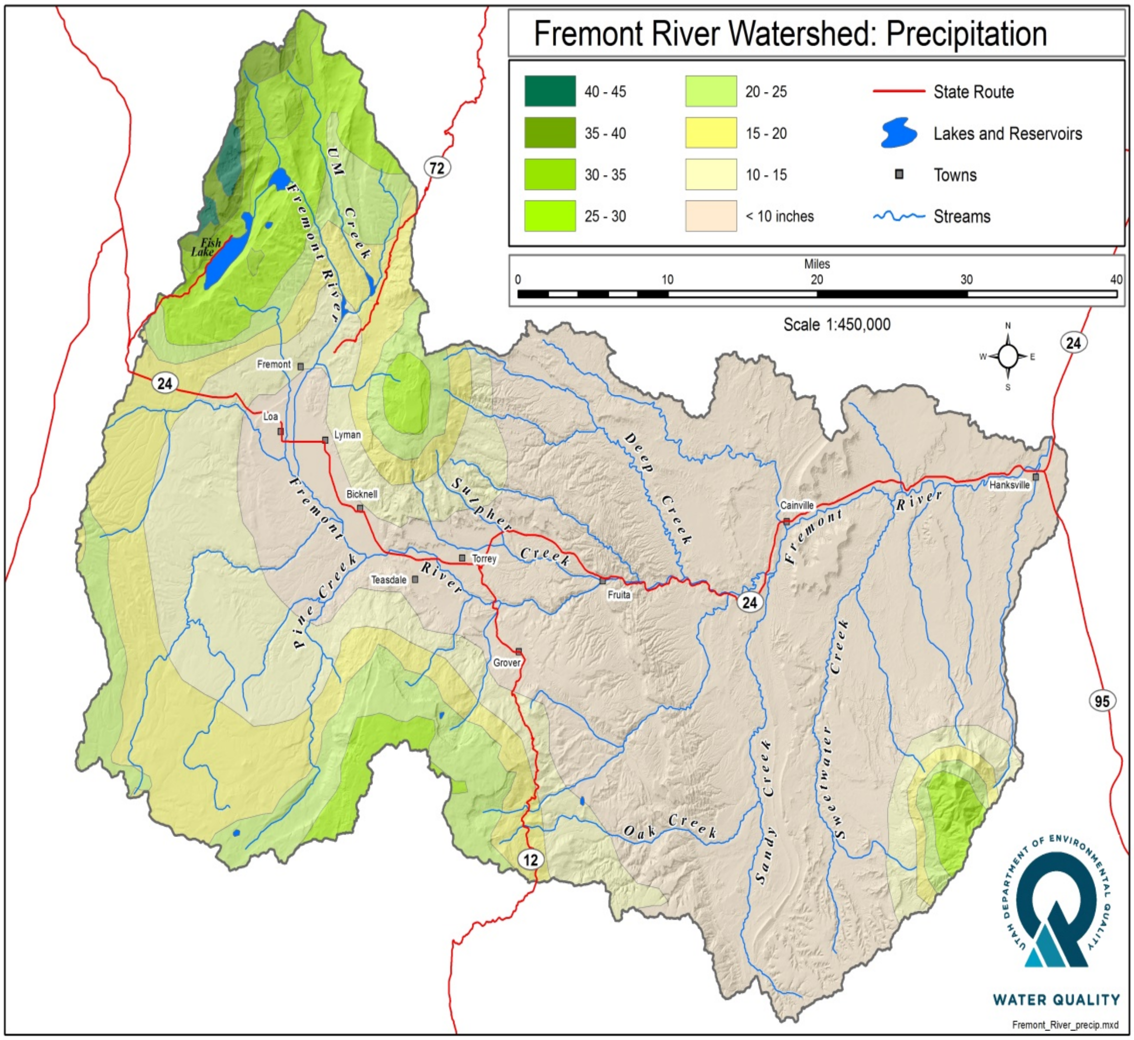


Figure 6. Annual precipitation (inches) in the Fremont River watershed

3.2 Biological Features

3.2.1 Fisheries

The main-stem Fremont River supports excellent fishing for larger trout in certain locations, and the headwater streams can offer good fishing for smaller fish. There are also small, high elevation lakes and reservoirs that support cold water fisheries.

Colorado River cutthroat trout are the only native game fish that occurs in the Fremont River watershed. Historically, the Fremont River watershed is also home to several fish species of high conservation concern within the greater Colorado River Basin, though these species are not currently thought to exist in the uppermost portion of the Fremont River. Blue-head sucker, flannel-mouth sucker, round-tail chub, humpback chub, bony tail, Colorado pike minnow, and razorback sucker are listed as "Species of Greatest Conservation Need" by the Utah Division of Wildlife Resources. Furthermore, the U.S. Fish and Wildlife Service also lists the latter four species as "Endangered." (USDA, 2019). Blue-head and flannel-mouth suckers occur in Capitol Reef National Park.

3.2.2 Wildlife

The Fremont River watershed provides habitat for several game and non-game wildlife species that are socially, economically, and biologically important to the area. Some of the more common species likely contribute to natural background *E.coli* loads in the Fremont River watershed. Big game species include mule deer, Rocky Mountain elk, desert bighorn sheep, and American pronghorn. Other game species include black bear, cougar, cottontail rabbit, snowshoe hares, chukar partridge, California and gambel quail, Chinese ringneck pheasant, wild turkey, and waterfowl. Furbearers include bobcat, beaver, raccoon, badger, striped skunk, muskrat, red fox, gray fox, and kit fox. Non-protected mammals include coyote and jackrabbit. (USDA, 2019)

A wide variety of nongame mammals and birds use this ecosystem, which ranges from subalpine forests to desert scrub. A large majority of these species utilize the drainages where perennial water sources exist. A large proportion of raptors use small mammals and birds in the ecosystem as their prey base, especially during the winter months. Many golden eagles, ferruginous hawks, and rough-legged hawks using this area seasonally.

The Bicknell Bottoms 670 acre Wildlife Management Area (WMA) west of Torrey attracts a large number of waterfowl and other birds. The area is a Utah Division of Wildlife Resources managed wetland complex along the Fremont River and Pine Creek. Although waterfowl contribute to *E. coli* loading in the watershed the monitoring location established approximately 1 mile downstream from the WMA boundary does not indicate significant bacteria loading from that area. Of 32 *E. coli* samples collected between 2016 and 2018, only two exceeded the maximum standard (6%).

One challenge with managing big game herds in the Fremont River watershed is easy access to agricultural lands. Agricultural fields are being utilized more for a feed resource, and as many of these pastures are adjacent to waterways, there is potential for *E. coli* loading from big game herds from those areas.

Greater sage-grouse occur in the Fremont River watershed, with the population on Parker Mountain being one of the largest populations in the State of Utah. This watershed also contains populations of endangered Southwest willow flycatchers as well as the threatened Utah prairie dogs and yellow-billed cuckoos. It is important to be aware of any protected plant and animal species within a watershed where best management practices are recommended. Extra considerations may be necessary prior to project implementation. The U.S Fish and Wildlife Service website provides a list of threatened and endangered species by county. Results for Wayne County, which includes the majority of the Fremont River watershed, include four bird species, four fish species, seven flowering plants and one mammal. This list, along with additional information, can found in Appendix F.

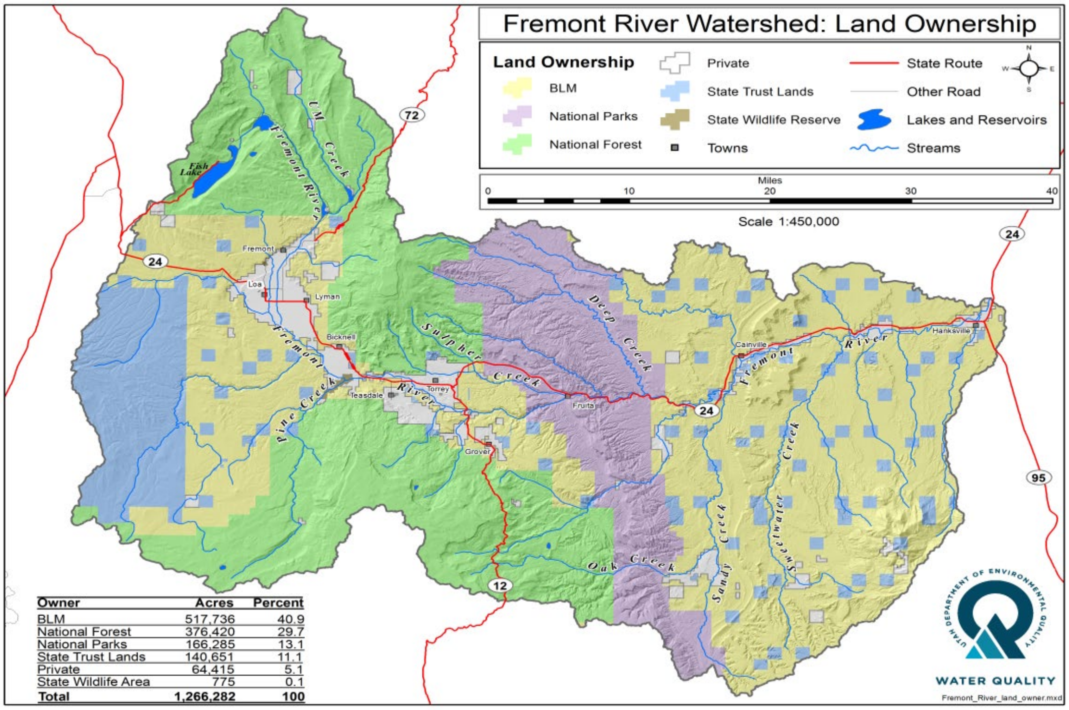
3.3 Land Use

3.3.1 Land Ownership

Various federal, state, and private entities are responsible for managing land throughout the Fremont River watershed. The Bureau of Land Management manages the majority of the land in the Fremont River watershed (41% of the total). The U.S. Forest Service manages the second largest amount (30%), which is composed of most of the land in the headwaters areas (Table 6, Figure 7).

Table 6. Land ownership in the Fremont River watershed

Landowner	Area (acre)	Area (mi^2)	Percent (%)
Bureau of Land Management	517,736	809	40.9
National Forest	376,420	588	29.7
National Parks	166,285	260	13.1
State Trust Land	140,651	220	11.1
Private	64,415	101	5.1
State Wildlife Area	775	1.2	0.1
Total	**1,266,282**	**1,979.2**	**100**



Owner	Acres	Percent
BLM	517,736	40.9
National Forest	376,420	29.7
National Parks	166,285	13.1
State Trust Lands	140,651	11.1
Private	64,415	5.1
State Wildlife Area	775	0.1
Total	**1,266,282**	**100**

Figure 7. Land Ownership in the Fremont River Watershed

3.3.2 Land Cover and Water Related Use

Land cover impacts the flow of water across the landscape and is an important parameter to consider when determining *E. coli* loads to receiving waterbodies. Generalized vegetation communities in the Fremont watershed are, in order: high elevation to low include coniferous forests, sagebrush grasslands, Pinyon-Juniper woodlands, shadscale deserts, and greasewood flats (Table 7, Figure 8).

Vegetation at the lower elevations within the Fremont watershed includes cottonwood trees, salt cedar, and numerous shrubs such as sagebrush, greasewood, willows, and wild rose. Higher in the mountain canyons, the streams are lined with willow, alder, and thickets of rose. The dominant land cover types are desert shrubs, juniper, and sagebrush. (USDA, 2019)

Water-related land use is predominately associated with irrigation of alfalfa and grass hay. Most irrigation occurs in the Rabbit Valley area from Loa downstream to Torrey and has been upgraded to sprinklers. Historic fruit orchards are flood irrigated in Capitol Reef National Park. In some areas throughout the watershed irrigation, return flows spill back into the river. This water has the potential to carry fecal pathogens, including *E. coli*, picked up via overland flow.

Table 7. Dominant land use and cover throughout the Fremont River watershed

Land Cover	Acres	Percent
Pinyon-Juniper	320,106	25.4
Desert shrub	284,647	22.6
Sagebrush	192,094	15.2
Spruce-Fir	151,507	12
Grasslands	151,505	12
Aspen	120,423	9.6
Mountain brush	7,632	0.6
Land Use		
Agricultural	21,191	1.7
Riparian	6,171	0.5
Water	5,663	0.4
Urban	4,037	0.3
Total	**1,260,939**	**100**

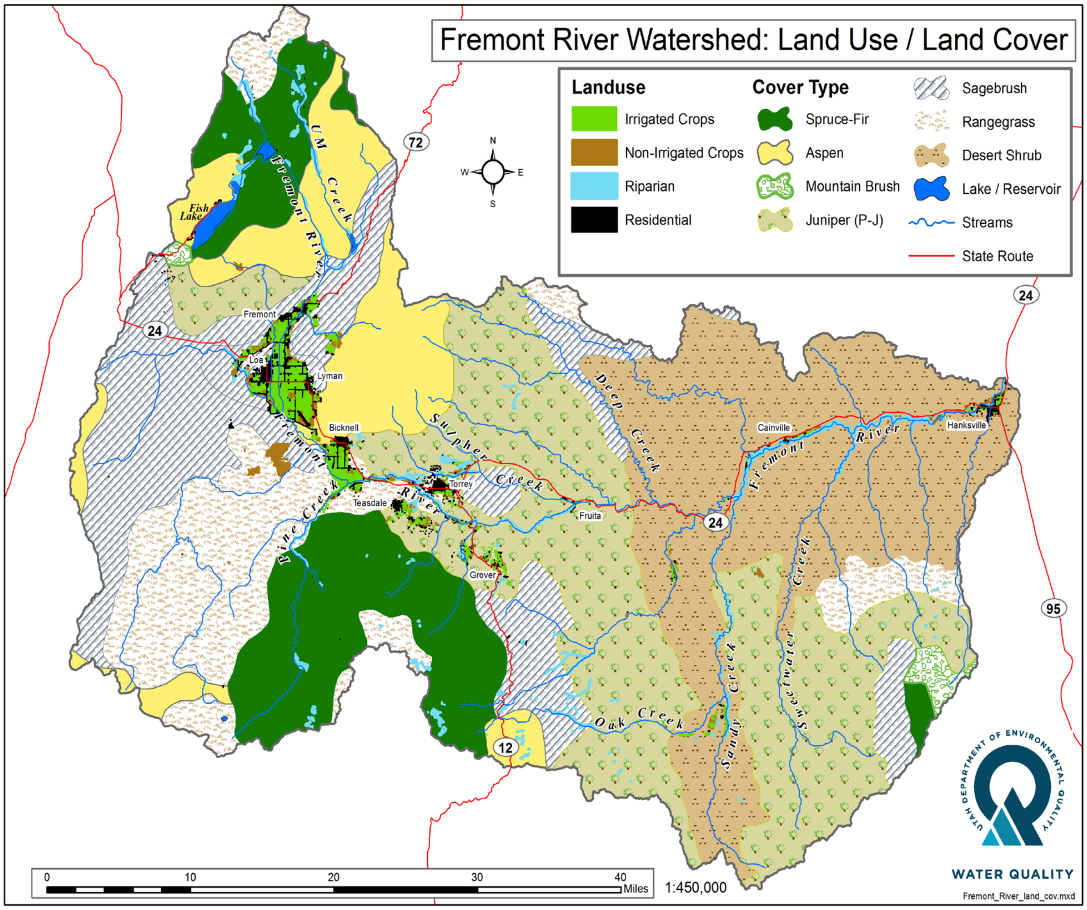


Figure 8. Dominant vegetation and land use in the Fremont River Watershed

4.0 WATER QUALITY DATA

4.1. Previous Bacteria Water Quality Study

The National Park Service (NPS) Northern Colorado Plateau Network collected *E. coli* samples in three Fremont River tributaries in Capitol Reef National Park (Park) from July 2008 to September 2017. The NPS increased collection efforts in response to the 2014 Integrated Report 303(d) listing of the Fremont River-3 for *E. coli* exceedances that year. Samples were collected monthly at two locations on Sulphur Creek, and one location each in Pleasant Creek (4954780) and Oak Creek (4954795) (Figure 9). Only one of these four monitoring locations (lower Sulphur Creek: 4954770) coincided with a DWQ monitoring location that was established for this TMDL study. *E. coli* concentrations exceeded both chronic and acute (maximum) state water-quality standards for recreational use at all four water-quality sites within the park (Hackbarth, 2018).

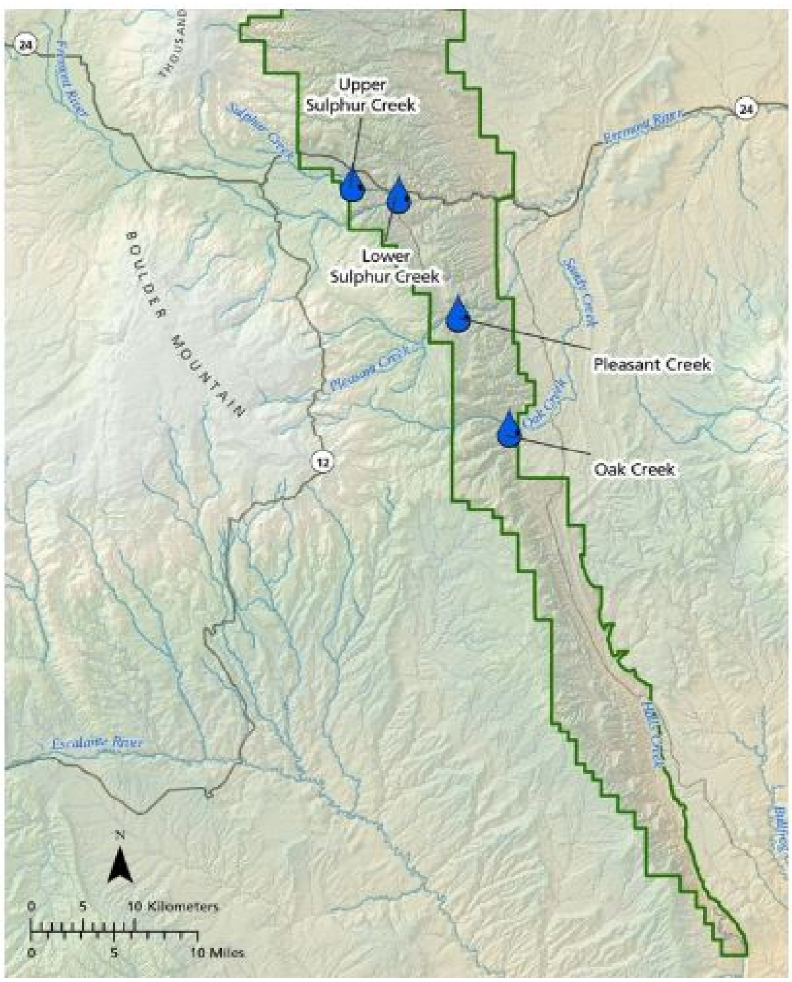


Figure 9. Monitoring locations from NPS *E. coli* study

E. coli exceedances occurred during low flow and low turbidity conditions at all four monitoring locations, suggesting that *E. coli* contamination is not isolated to flood events. Most exceedances occurred during the state-defined recreation season of May 1–October 31. This timeframe encompasses over 75% of the park's annual visitation and also corresponds to cattle trailing through Oak, Pleasant and Sulphur Creeks and the Fremont River in the park en route to the Lower South Desert, and dispersed livestock grazing on public lands upstream of the park in all three sub-watersheds. Paired samples taken in Sulphur Creek near the park's west boundary and in the park developed zone at the picnic area, above and below a popular hiking route, showed similar patterns in *E. coli* concentrations, suggesting that in Sulphur Creek, most *E. coli* contamination enters upstream of Capitol Reef National Park rather than from park visitation or infrastructure. Upstream and downstream comparisons are not available for Oak Creek and Pleasant Creek, which have less park infrastructure and visitation than Sulphur Creek.

Results from the NPS study supplemented the data collected by DWQ and Utah State University (USU) Extension staff as part of this TMDL and helped identify potential sources of bacteria loading in the watershed.

4.2 Flow Data

The only active stream flow gage in the Fremont River watershed is operated and maintained by the United States Geological Survey, with a period of record from 1976-present at that location. The gage is USGS 09330000 Fremont River near Bicknell, UT (Figure 11). Mean annual flows range between 60.2 (1980) and 138.4 (1985) cfs. Mean monthly discharges from 1986 to present can be seen in Figure 10. Flow at this location is substantially influenced by upstream diversions.

Flow measurements are critical for calculating pollutant loading in the river. Field monitoring personnel have consistently measured stream flow at all monitoring locations since 2017. Sampling prior to that did not include flow measurement. For instances when flow was not measured at the two target monitoring locations (Fremont River at Big Rocks Rd and Fremont River at U12 Crossing), flow was estimated using a simple linear regression based on the measured flows versus flows at the USGS Bicknell gage. For the Fremont River at Big Rocks Road the r^2 between the measured flow observations and the downstream flow gage measurements was 0.86. There were 8 measured flow observations and 23 estimated flows between 2016-2018. For the Fremont River at U12 Crossing the r^2 between the measured flow observations and the upstream flow gage measurements was 0.56. There were 18 measured flow observations and 68 estimated flows between 2008-2018. Measured and modeled flow values used for loading calculations can be found in Appendix F. The gage is located several miles from each of the target locations and there is considerable hydromodification throughout the watershed but this approach increased the number of flow observations for TMDL calculations, and therefore increased the confidence in the resulting necessary load reductions for each AU.

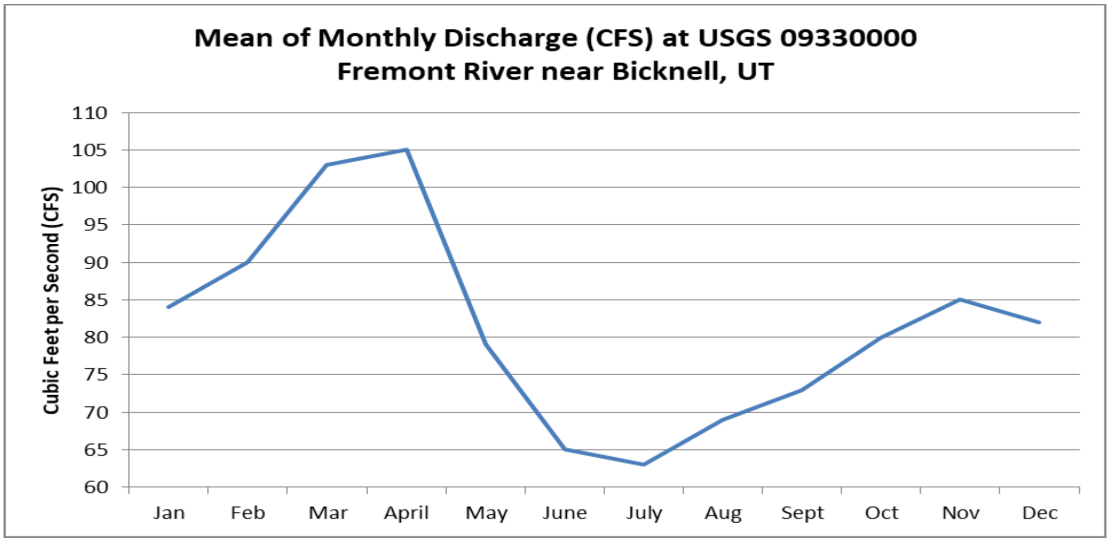


Figure 10. Mean of monthly discharge (cfs) at USGS 09330000 Fremont River near Bicknell, UT

4.3 Monitoring Results

Several monitoring locations (Figure 11) were established to better understand the temporal and spatial extent of impairment throughout the watershed in response to the 2014 303(d) listing. The Fremont River was first listed as 303(d) impaired for *E. coli* during the 2012-14 Integrated Report process. The impairment was based on exceedances measured at the following three monitoring locations in the Fremont River-3 AU:

- 4954390: Fremont River at U12 Crossing
- 4954480: Fremont River at Campground in Fruita
- 4954356: Fremont River at Falls 1.2 miles above the Confluence with Deep Creek[1]

[1] The Falls monitoring location (4954356) was once a very popular recreation and swimming spot in Capitol Reef National Park. Access was blocked in 2011 due to dangerous swimming conditions at this location and remains blocked today. The location is no longer monitored.

The upstream-most site established for this TMDL study is in the town of Loa on Spring Creek (4955310). There are only two monitoring locations in the Fremont-2 AU: 4955310 at Spring Creek at U24 crossing and 4955330 at Fremont River at Big Rocks Road. The remaining sites are in the Fremont-3 AU. The downstream-most site is the Fremont River at the Hickman Bridge Trailhead (4954360).

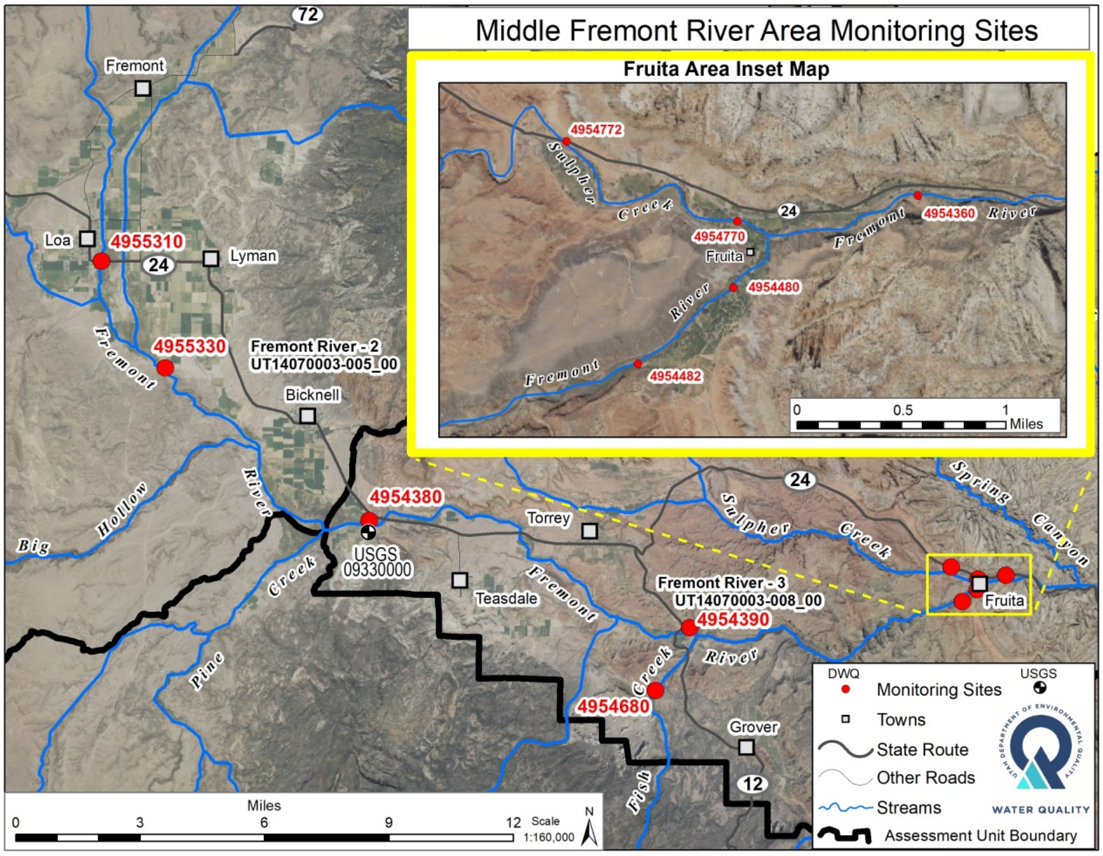


Figure 11. Fremont River *E. coli* monitoring locations

Table 8 includes *E. coli* summary statistics for the Fremont River watershed monitoring locations. It includes:

- The number of samples collected during the recreation season and year-round
- The data range
- The minimum and maximum reported *E. coli* concentrations for each location
- The geometric mean of all samples collected within the recreation season

Sites are listed upstream to downstream, and those highlighted in red triggered the 2014 303(d) listing.

Table 8. ***E. coli*** **summary statistics for Fremont River watershed monitoring locations. Sites are listed upstream to downstream. Site IDs shown in red triggered the 303(d) listing in 2014.**

Site ID	Site Name	Rec Season /All	Date Range	Minimum *E. coli* (MPN/100 mL)/Month it occurred	Maximum *E. coli* (MPN/100 mL)/Month it occurred	Geomean of all samples (MPN/100 mL) Rec Season/All
4955310	Spring Creek at U24 Crossing	18/33	2016-2018	7.5/Jan	2,419.6/July	549/267
4955330	Fremont River at Big Rocks Rd	16/31	2016-2018	26.2/Dec	2,419.6/Aug	312/234
4954380	Fremont River at Bicknell	19/34	2013-2018	9.1/March	1413.6/Aug	156/95
4954390	Fremont River at U12 Crossing	62/86	2008-2018	1.0/April	2,419.6/Sept	187/102
4954680	Fish Creek at Road Crossing	18/33	2016-2018	1.0/Feb, May and Dec	706.9/Oct	39/15
4954482	Fremont River above Hatties Field in CRNP	42/57	2011-2018	2.0/May	981.5/July	93/63
4954480	Fremont River at Campground in Fruita	59/76	2010-2018	4.6/March	1894.0/Aug	184/115
4954360	Fremont River at Hickman Bridge Trailhead	19/34	2013-2018	4.0/March	706.5/July	141/67
4954772	Sulphur Creek at First Road Crossing above confluence with Fremont River	32/46	2013-2018	1.0/March	926.0/July	91/57
4954770	Sulphur Creek above Fremont River at Picnic Area	46/64	2012-2018	1.7/March	2,192.3/June	200/114
4954356	Fremont River at Falls 1.2 miles above the Confluence with Deep Creek	47/61	2008-2015	2.0/Dec	1106.0/Aug	169/128
4954795	Oak Creek above Sandy Ranch Dam	8/10	2016-2017	1.0/April and May	166.4/Oct	11.2/12.2
4954780	Pleasant Creek South of Sleeping Rainbow Ranch	8/10	2016-2017	1.0/April, May and Nov	307.6/Aug	11.9/14.4

Table 9 shows the results of one of the three assessment scenarios that were performed as part of the Integrated Report's *E. coli* assessment methodology (see Appendix A).

Seasonal assessment

The seasonal assessment against the maximum criterion states that "for each monitoring location with >5 collection events in any recreation season, no more than 10% of samples collected from May 1st through October 30th may exceed 409 MPN/100 mL for 2A waters" (DWQ, 2014 IR). Both monitoring locations within the Fremont-2 AU exceed that, and as a result, the Fremont-2 AU will be included in the next 303(d) list as part of the 2018/2020 Integrated Report. Three of the ten monitoring locations in the Fremont-3 AU exceed the 10% threshold.

Table 9. Percent exceedance of 2A maximum criterion (409 MPN/100mL) for Fremont River watershed monitoring locations

Assessment Unit	MLID	Site Description	% Exceedance 409 MPN/100mL max criterion
Fremont River-2: Fremont River and tributaries from Bicknell to Mill Meadow Reservoir near USFS boundary	4955310	Spring Creek at U24 Crossing	44%
	4955330	Fremont River at Big Rocks Rd	35%
Fremont River-3: Fremont River and tributaries from east boundary of Capitol Reef National Park to Bicknell	4954380	Fremont River at Bicknell	6%
	4954390	Fremont River at U12 Crossing	19%
	4954482	Fremont River above Hatties Field in CRNP	5%
	4954480	Fremont River at Campground in Fruita	16%
	4954360	Fremont River at Hickman Bridge Trailhead	3%
	4954680	Fish Creek at Road Crossing	3%
	4954772	Sulphur Creek at First Road Crossing above confluence with Fremont River	7%
	4954770	Sulphur Creek above Fremont River at Picnic Area	20%

	4954795	Oak Creek above Sandy Ranch Dam	0%
	4954780	Pleasant Creek South of Sleeping Rainbow Ranch	0%

Seasonal geometric mean

Table 10 reflects another of the three assessment scenarios: seasonal geometric mean assessment. For each AU with ≥10 collection events in any recreation season, the geometric mean of all samples should not exceed 126 MPN/100 mL for 2A waters. It is important to note that none of the Fremont River watershed monitoring locations had a sufficient number of samples collected in any recreation season to apply this assessment scenario. However, even with an insufficient numbers of samples, it is still useful to consider the recreation season geometric mean to get a general sense of which sites have elevated concentrations. Future monitoring may include collection of 10 or more samples during the recreation season.

Table 10. Summary of monitoring location recreation season geometric means. Geometric means highlighted in red exceed the seasonal geometric mean of 126 MPN/100 mL.

AU	Site ID	Site Name	2011	2012	2013	2014	2015	2016	2017	2018
Fremont River- 2	4955310	Spring Creek at U24 Crossing						660.3	658.6	380
	4955330	Fremont River at Big Rocks Rd						272	221.5	452.1
Fremont River-3	4954380	Fremont River at Bicknell						89.7	143.3	377.7
	4954390	Fremont River at U12 Crossing	336.6	123.6	650.2	136.1	271.5	102.5	204	176.5
	4954482	Fremont River above Hatties Field in CRNP	211.8	51.2	91.5	56	54.4	142.2	87.3	98.2
	4954480	Fremont River at Campground in Fruita	402	82.5	497.2	224.3	132.3	119.9	120.7	71.7
	4954360	Fremont River at Hickman Bridge Trailhead						192.4	166.7	87.7
	4954680	Fish Creek at Road Crossing						80.6	24.6	29.7
	4954772	Sulphur Creek at First Road Crossing above confluence with Fremont River			100.4	114.2	253.7	43.9	58.2	99.9
	4954770	Sulphur Creek above Fremont River at Picnic Area		539.4	186.1	270.8	216.2	225.5	162.8	134.4
	4954795	Oak Creek							12.7	

		above Sandy Ranch Dam								
	4954780	Pleasant Creek South of Sleeping Rainbow Ranch							14.0	

4.3.1 Monitoring Location Details

(Sites listed from upstream to downstream)

Spring Creek at U24 Crossing: 4955310

Spring Creek originates at a spring located on a valley margin 2.5 miles north of Loa, Utah. The stream is diverted numerous times along its seven-mile length until it reaches the confluence with the Fremont River. Flow from the spring is a constant 13 cfs. By the time Spring Creek reaches the Highway 24 crossing south of Loa, it has flow rates that vary between four cfs during irrigation diversion and 22 cfs during spring runoff. The stream follows generally the same course as the one surveyed in the late 1800s, but considerable straightening and diverting have occurred since that time. The creek carries a substantial amount of irrigation return flow. It is bordered by irrigated pastures that are often grazed by cattle, sheep, and wildlife.

Based on data from this monitoring station, the Fremont River-2 AU was listed as impaired for temperature and pH in the 2014 Integrated Report. This TMDL, however, focuses solely on the *E. coli* impairment. Based on recent data (44% of *E. coli* samples collected from 2016-2018 exceeded the recreation use standard), the Fremont-2 AU will be listed as impaired for *E. coli* as part of the 2018/2020 Integrated Report in 2020 (Figure 13).

Figure 12. Image of 4955310: Spring Creek at U24 Crossing, September 2019

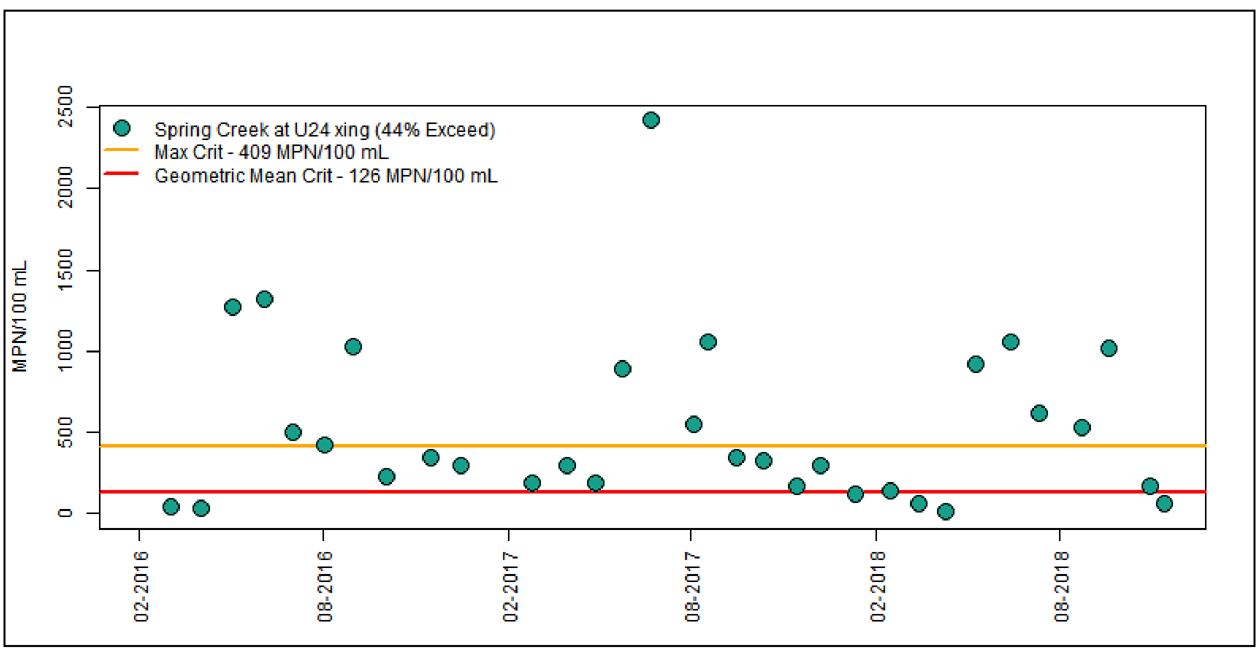


Figure 13. *E. coli* concentrations at 4935310 Spring Creek at U24 Crossing from 2016-2018

Fremont River at Big Rocks Road: 4955330

The Fremont River channel between Mill Meadow Reservoir and Spring Creek is generally dry most of the year as water is held in the reservoir or diverted just below the reservoir for irrigation. The confluence of the Fremont River and Spring Creek is less than a mile upstream of this monitoring location. Spring Creek contributes a majority of the flow, with the slight addition of some springs and irrigation return flows. This site has the potential to be dry at times throughout the year depending on upstream water diversion and use. Flow slows as it moves through this marshy area. Thirty-five percent of *E. coli* samples collected from 2016-2018 exceeded the maximum criterion recreation use standard (Figure 14).

Figure 14. Image of 4955330: Fremont River at Big Rocks Road

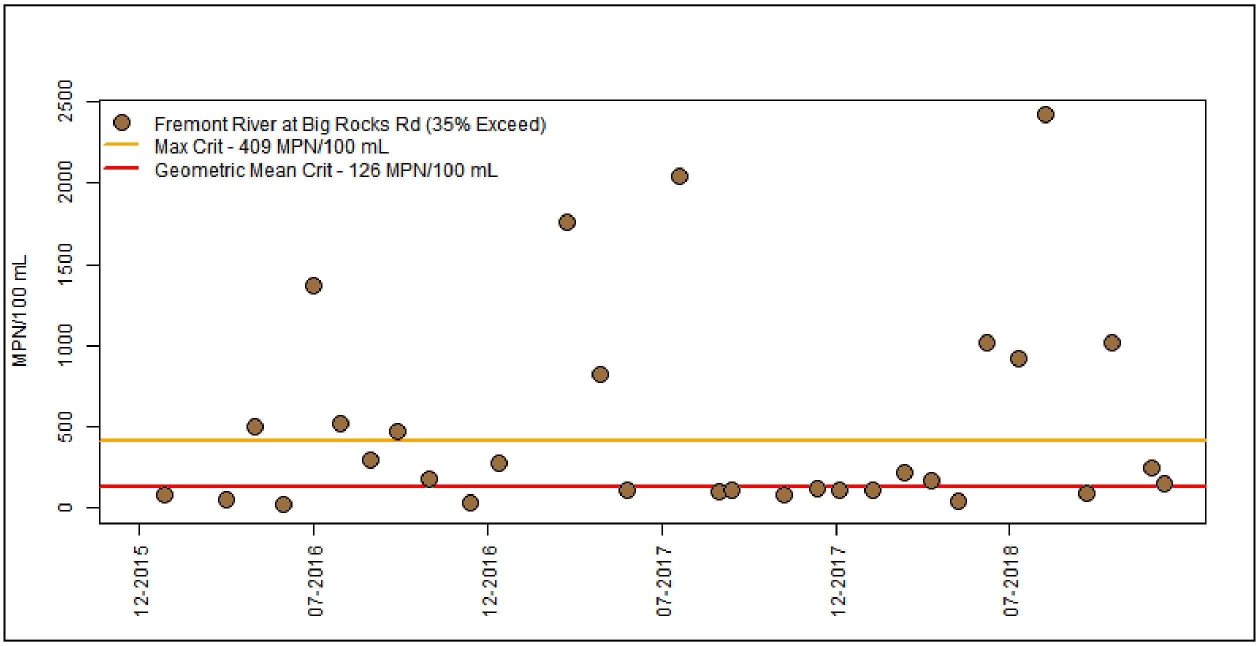


Figure 15. *E. coli* concentrations at 4955330 Fremont River at Big Rocks Road from 2015-2018

Fremont River at Bicknell: 4954380

As the Fremont River flows downstream of Big Rocks Road, the tributaries of Pine Creek and Government Creek as well as several springs, join it. This is the only location with an active USGS flow gage (USGS 09330000) in the watershed. Approximately 10-30% of the flow at this location comes from Spring Creek based on paired flow measurements of both monitoring locations.

This is the uppermost monitoring location in the impaired Fremont-3 AU. Even when upstream monitoring locations have *E. coli* exceedances, the concentrations usually drop below the water quality standard at this Bicknell location. Of 32 samples collected between 2016 and 2018, only two exceeded the maximum standard (6%) (Figure 17), indicating that the upper impaired Fremont-2 AU has a minimal impact on the water quality of the adjacent downstream Fremont River-3 AU.

Figure 16. Image of 4954380: Fremont River at Bicknell

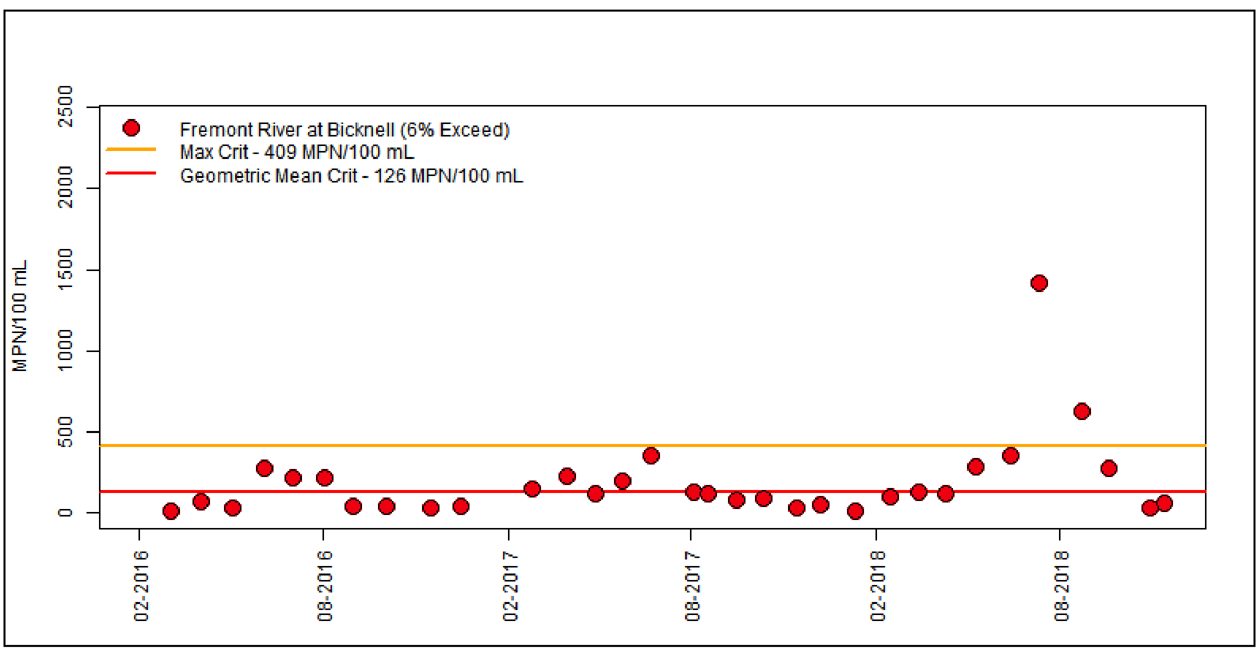


Figure 17. *E. coli* concentrations at 4954380 Fremont River at Bicknell from 2016-2018

Fremont River at U12 Crossing: 4954390

The Fremont River continues downstream from the Bicknell site, where much of the river is diverted for irrigation in and around the towns of Torrey, Teasdale, and Grover, Utah. Flow increases with additional spring inputs below Bicknell. The river flows through several miles of irrigated pastures that are often grazed by cattle and wildlife just upstream of this Highway 12 monitoring location. *E. coli* exceedances at this site triggered the original 303(d) listing in 2014 for the Fremont-3 AU. This site was the first to be monitored in the watershed, with the earliest samples collected in 2008. Nineteen percent of samples collected at this location between 2008 and 2018 exceeded the maximum standard (Figure 18).

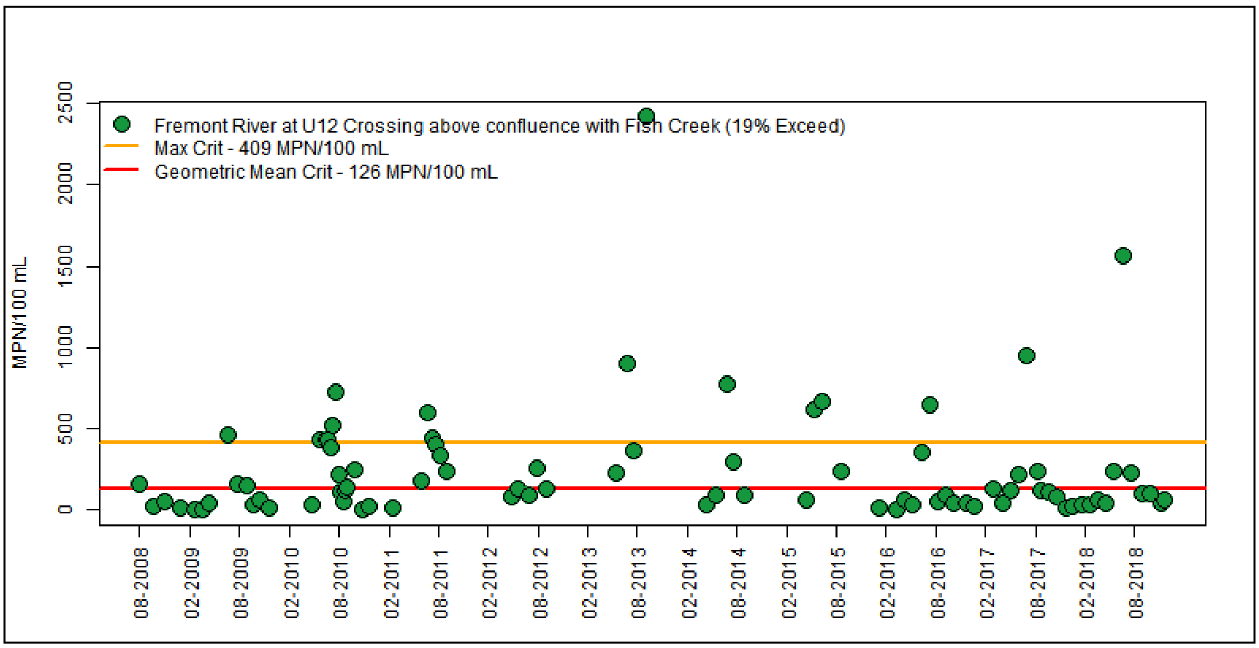


Figure 18. *E. coli* concentrations at 4954390 Fremont River at U12 Crossing from 2008-2018

Fish Creek at County Road Crossing: 4954680

Fish Creek originates in the high elevations of Boulder Mountain and flows northeast down to its confluence with the Fremont River. The Fish Creek monitoring location was established to get a sense of *E. coli* loading from perennial flowing streams with grazing allotments on US Forest Service land near the headwaters. There is a small development called Fish Creek Cove with several homes just upstream of this monitoring location. This site consistently had low *E. coli* concentrations with only one exceedance of the 2A maximum criterion measured out of 30 monitoring events (3%) (Figure 19).

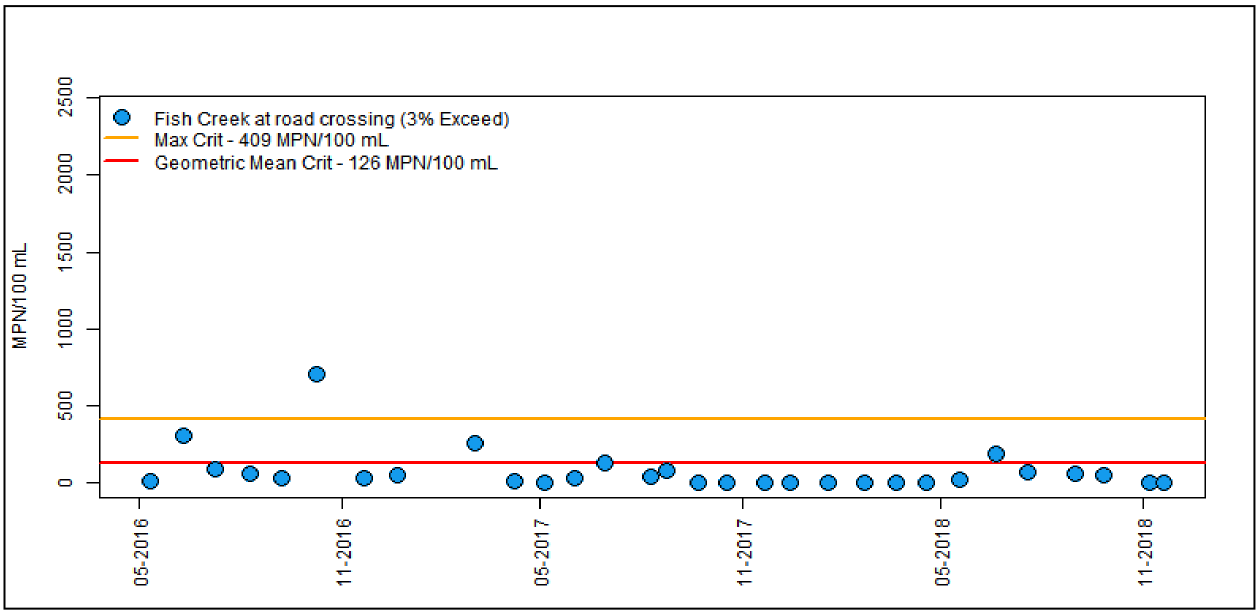


Figure 19. E. coli concentrations at 4954680 Fish Creek at County Road Crossing from 2016-2018

Fremont River above Hatties Field in Capitol Reef National Park: 4954482

Below the Highway 12 crossing, Fish Creek and Carcass Creek join the Fremont River as it flows approximately five miles downstream into Capitol Reef National Park. The river moves through steeper-walled rocky terrain that is difficult to access. The surrounding land use shifts away from irrigated pastures and grazing. The Fremont River above the Hattie's Field monitoring location is in the National Park just upstream of flood irrigated fruit orchards and the park campground. This location was first sampled for *E. coli* in 2011. Since then, only 5% of monitoring events resulted in exceedances (Figure 20).

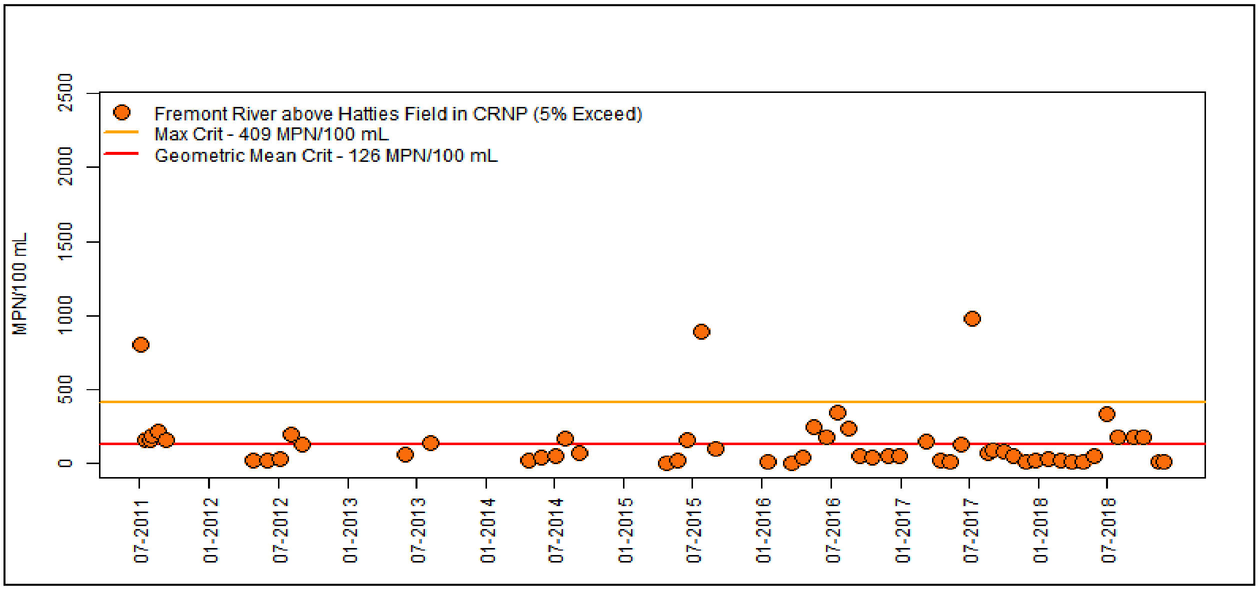


Figure 20. E. coli concentrations at 4954482 Fremont River above Hatties Field in Capitol Reef National Park from 2011-2018

Fremont River at Campground in Fruita: 4954480

This monitoring location is approximately 0.5 mile downstream of the Hatties Field site. It was established to get a better understanding of any *E. coli* loading from flood irrigation of the fruit orchards and a pasture grazed by horses that are adjacent to the river. This site is popular for people recreating in the river during the warm summer months of the recreation season. Most of the campsites are within close proximity to the river, with easy access down to the water. Results show an increase in percent exceedance from 5% to 16% compared to the upstream site above Hatties Field (Figure 20 and Figure 21).

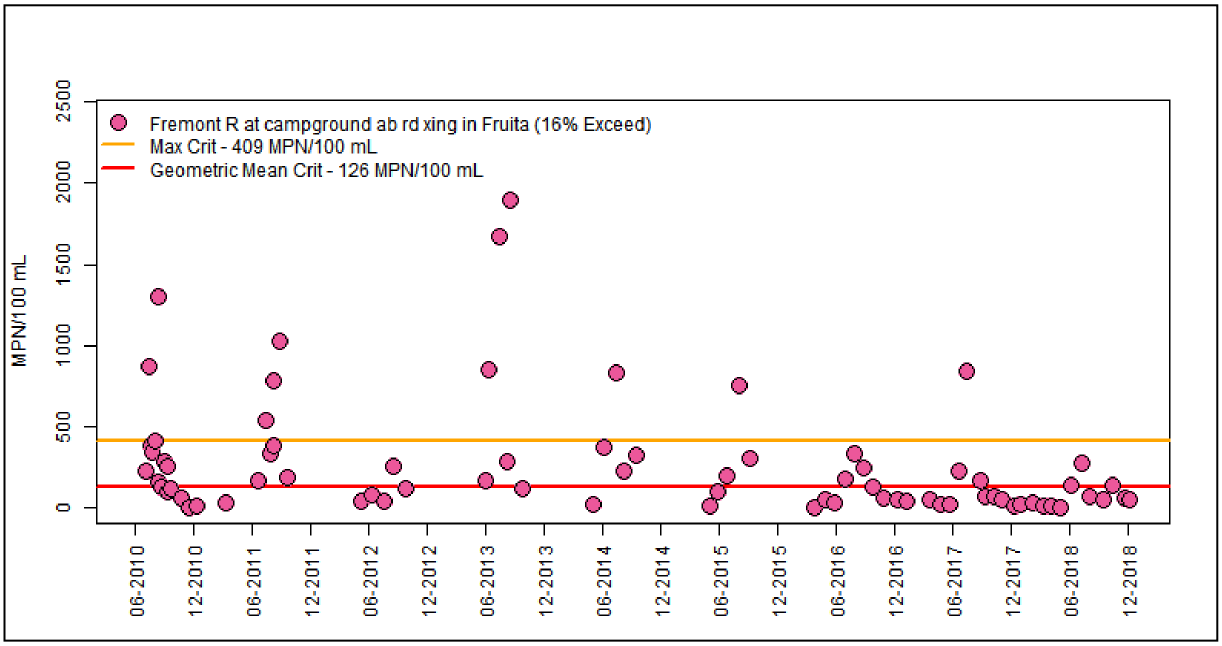


Figure 21. *E. coli* concentrations at 4954480 Fremont at Campground in Fruita from 2010-2018

Figure 22. Image of 4954480: Fremont River at Campground in Fruita, August 2019

Sulphur Creek at First Road Crossing above confluence with Fremont River: 4954772

Sulphur Creek flows six miles within the Park before its confluence with the Fremont River. Annual peak flows ranged from 78 to 2,600 cfs between 1959 and1974 (Sulphur Creek near Fruita, USGS gage number 09330120). Recently measured (2014-2017) non-flood flows are generally one to five cfs, decreasing to zero during summer months due to lower spring and snow input as well as upstream diversions.

Sulphur Creek is a popular hiking route for Park visitors, with many people hiking in and along it just upstream of this monitoring location. Monitoring results from 2013-2018 show a 7% exceedance of the Utah maximum criterion standard (Figure 23).

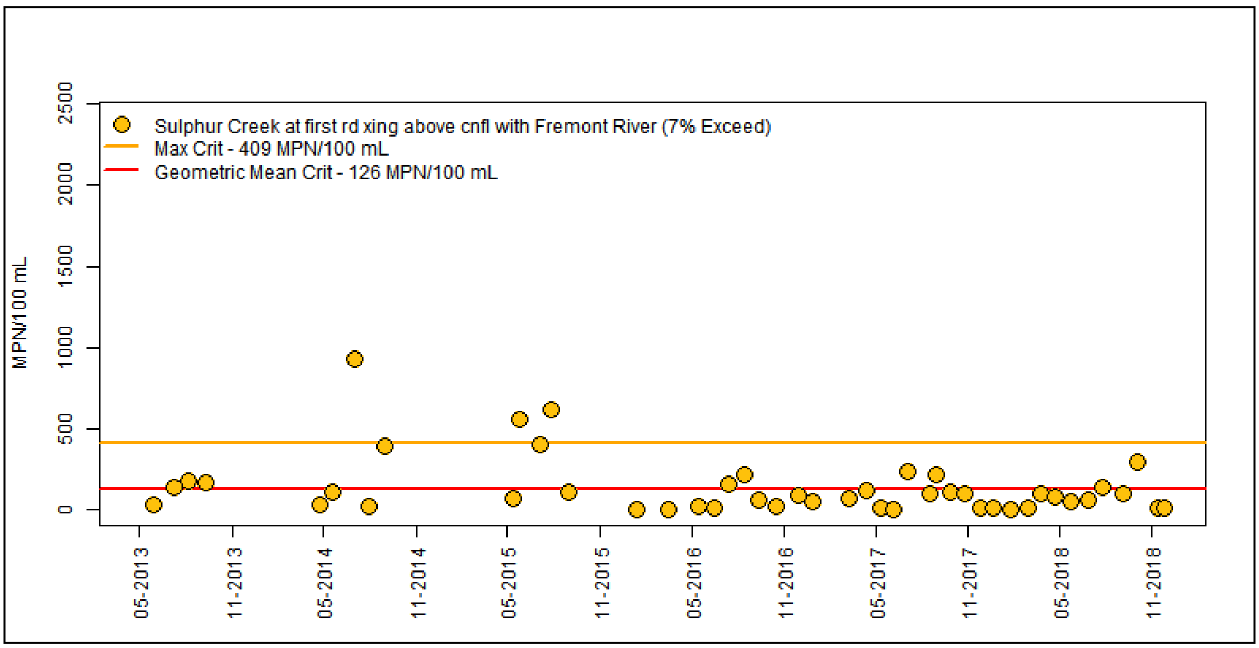


Figure 23. *E. coli* concentrations at 4954772 Sulphur Creek at First Road Crossing above confluence with Fremont River from 2013-2018

Figure 24. Image of 4954772: Sulphur Creek at first road crossing above Fremont River. August 2019

Sulphur Creek above Fremont River at the Picnic Area: 4954770

This monitoring location is 1.3 miles downstream of Sulphur Creek at the road crossing (4954772). There are potential sources of pathogen-loading between the two sites including return flows from fruit orchards that are flood irrigated using Fremont River water, and an onsite septic system that manages the waste from the Park's visitor center, administrative offices, and employee housing. Similar to other monitoring locations in the park, many people recreate in the water here. It generally has very low flow and several easy access points. There is an increase in *E. coli* exceedances from 7% at the upper Sulphur Creek site (Figure 23) to 20% at the lower (Figure 25). This is higher than what was observed in the NPS study in which the Park monitored for a longer period of time (2008-2017) at this picnic area monitoring location and the upstream site on Sulphur Creek near the Park's west boundary. That study showed no significant difference in *E. coli* concentrations between the two Sulphur Creek monitoring locations. Future monitoring could include a Sulphur Creek site upstream of the Park boundary to better characterize the water quality upstream of the Park.

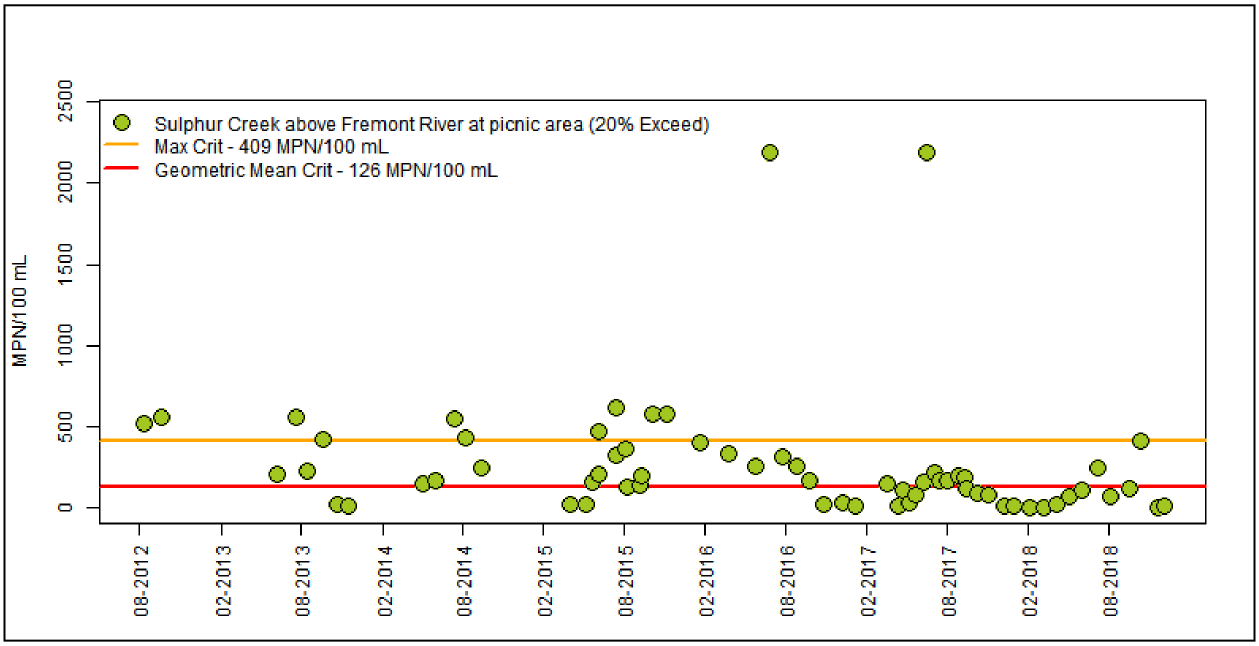


Figure 25. *E. coli* concentrations at 4954770 Sulphur Creek at picnic area above Fremont River from 2012-2018

Figure 26. Image of 4954770: Sulphur Creek at picnic area above Fremont River. August 2019

Fremont River at Hickman Bridge Trailhead: 4954360

The most downstream monitoring location for this TMDL study is the Fremont River at Hickman Bridge Trailhead. It was selected to determine *E. coli* concentrations several miles downstream of the campground site with exceedances that triggered the 2014 303(d) listing. Between 2016 and 2018 only one sample out of 30 exceeded the maximum criterion (3%) (Figure 27).

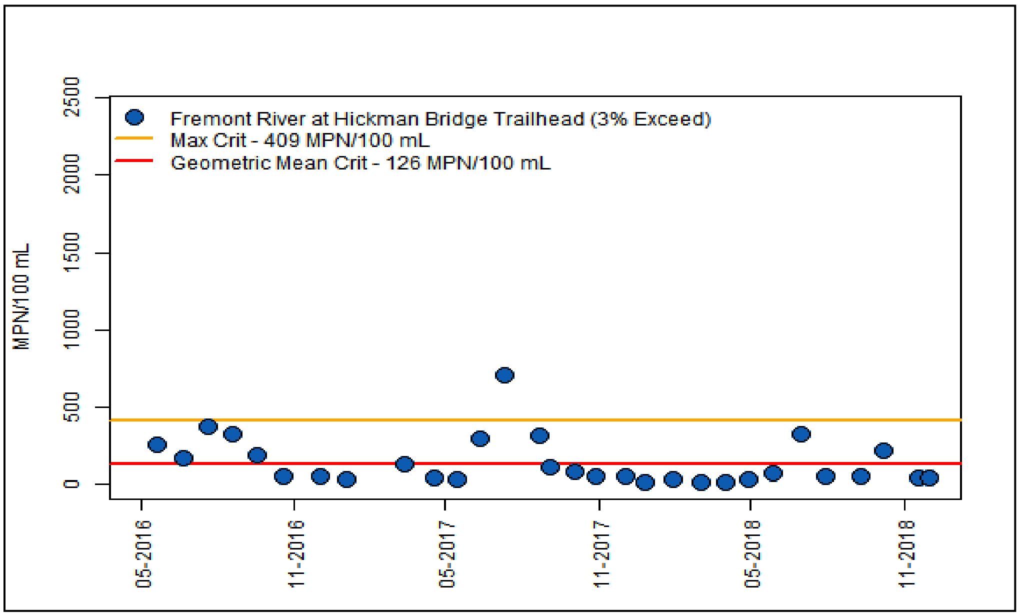


Figure 27. *E. coli* concentrations at 4954360: Fremont River at Hickman Bridge Trailhead from 2016-2018

4.4 Water Quality Analysis

The 2014 303(d) listing was based off of the following three monitoring locations in the Fremont-3 AU:

- 4954390: Fremont River at U12 Crossing
- 4954480: Fremont River at the campground in Fruita
- 4954356: Fremont River at Falls 1.2 miles above the confluence with Deep Creek

The target sites for the impaired Fremont-3 AU are:

- 4954390: Fremont River at U12 Crossing
- 4954480: Fremont River at the campground in Fruita
- 4954770: Sulphur Creek above Fremont River at the picnic area

Target sites were selected to get a sense of loading upstream of the Park where the greatest percent reduction in loading is required, as well as within the Park where recreation is occuring.

The target site for this TMDL for the the Fremont-2 AU is 4955330: Fremont River at Big Rocks Road. This is the most downstream monitoring location within the Fremont-2 AU and is most representative of the water quality within that stream segment.

The ultimate goal of the TMDL process is delisting of the waterbody from the 303(d) list. Information about delisting requirements can be found in Utah's assessment methods.

4.5 Supplemental Monitoring Techniques

Pharmaceuticals and Personal Care Products

EPA defines pharmaceuticals and personal care products (PPCPs) as any product used by individuals for personal health or cosmetic reasons or used by agribusiness to enhance growth or health of livestock. PPCPs have been detected in surface and groundwater worldwide and often remain relatively persistent in the environment. Sources include elimination from the human body, flushing of unused products, leachate from landfills, rinse water from showering or bathing, and agricultural runoff. Potential health effects for humans and aquatic species are still being studied. A 2002 USGS study (Kolpin et al., 2002) found that of 130 waterways surveyed in 30 states, eighty percent contained trace amounts of PPCPs.

PPCPs analysis results can be useful in indicating failure of onsite wastewater treatment systems in a watershed. Properly sized and maintained septic tanks and leach fields allow for adequate degradation and sorption of organic wastewater compounds. However, aging and failing systems may contribute PPCPs directly or indirectly to surface and groundwater.

PPCP samples were collected in the Fremont River watershed at the following five locations:

- 4955310: Spring Creek at U24 crossing
- 4954390: Fremont River at U12 crossing
- 4954880: Fremont River at Campground in Capitol Reef National Park
- 4954772: Sulphur Creek at First Road Crossing above Fremont River

- 4954770: Sulphur Creek at picnic area above confluence with Fremont River

EPA Method 1694 was used for analysis. All results came back as non-detect suggesting that septic sources are not predominant. Analytes included hormones, prescription and over-the -counter medications, soaps, cosmetics, and cleaning products. The complete analyte list is as follows:

- Acetaminophen
- Bis Phenol A
- Butalbital
- Caffeine
- Carbamazepine
- Cotinine
- Diazepam
- Diclafenac
- Erythromycin
- Estradiol
- Estrone
- Ethinyl Estradiol
- Fluoxetine
- Gemfibrozil
- Ibuprofen
- Naproxen
- Perflourooctanoic Acid (PFOA)
- Primidone
- Progesterone
- Sulfamethoxazole
- Testosterone
- Triclosan
- Trimethoprim

5.0 TMDL

5.1 Calculation of Loading Capacity and Existing Load

The loading capacity is the amount of pollutant that can be assimilated by a waterbody while still meeting water quality standards and protecting the waterbody's designated beneficial uses. This loading capacity is calculated by multiplying the water quality standard, the corresponding flow, and a conversion factor to determine the allowable pollutant load. The existing load is the amount of pollution that is observed in the river at the time of sample collection. This load is calculated by multiplying the measured pollutant concentration, flow, and a conversion factor. If the existing load exceeds the loading capacity, the waterbody may be assessed as impaired and loading must be reduced. The loading capacity is equivalent to the Total Maximum Daily Load (TMDL) and is allocated among identified sources, including wasteload allocations (point sources), load allocations (nonpoint sources), and a margin of safety. There are no point source wastewater discharges in the Fremont River watershed that are likely to contribute to the bacteria loading to the river, which indicates that all *E. coli* loading originates from nonpoint sources.

5.2 Load Duration Curve

Load Duration Curves (LDC) were calculated for the target sites to compare existing water quality conditions with those required to meet water quality standards. A LDC identifies the allowable and existing loads, uses data for all flow and loading conditions, and provides insight into critical conditions. LDCs are well-suited for analysis of periodic monitoring data collected by grab samples.

The LDC calculation included the following steps:

1. Available flow data (measured and modeled) were used to generate a flow frequency table that consisted of ranking all the observed flows from the lowest observed flow to the highest. The ranked flows were plotted to create a flow duration curve.
2. The flow duration curve was translated into a load duration curve by multiplying each flow by the water quality standard (126 MPN/100 mL) and a correction factor and plotting the results. This curve represents the loading capacity (or TMDL) for each observation.
3. Each in-stream sample value was converted to a daily load by multiplying the observed concentration by the corresponding observed flow and a correction factor.
4. The difference between the observed load and loading capacity for each flow regime quantifies the necessary load reductions during critical conditions. Both observed loads and loading capacities for conditions ranging from high flow to low flow were then graphed.
5. Loads plotted above the load duration curve represent exceedances of the loading capacity. Loads plotted below the curve represent allowable daily loads and are in attainment of water quality standards.

The load duration curve approach can help identify the major issues contributing to the impairment and differentiate between various types of sources. Loads that plot above the allowable load curve in the 1-10% flow ranges (rare high-flow conditions) represent hydrologic conditions of flooding. Loads plotting above the curve between the 10-60% flow ranges likely reflect precipitation-driven contributions. Those plotting above the curve in 70-90% flow ranges are indicative of constant discharge sources. Loads that plot above the curve in greater than 90% of all recorded flows reflect hydrologic conditions of drought (Table 11).

An underlying premise of the LDC approach is correlation of water quality impairments to flow conditions. The LDC alone does not consider specific fate and transport mechanisms, which can vary depending on watershed or pollutant characteristics. The load duration approach helps identify the issues surrounding the impairment and roughly differentiate among sources. Table 11 summarizes the relationship between the five hydrologic regimes and potential contributing source areas. For example, when a stream is dominated by effluent loading under drier conditions, the loads calculated from observed in-stream data will form a linear cluster in the drier conditions of the LDC figure. If the linear cluster plots are above the LDC, then the effluent loading is causing the impairment.

Table 11. Relationship between LDC hydrologic regimes and potential contributing sources (Source: EPA 2017a)

	Hydrologic Regime				
Contributing Source Area	High	Moist	Mid-Range	Dry	Low
Point Source	L	L	L	M	H
On-site Wastewater Treatment	L	L	L	M	L
Riparian Areas	L	H	H	H	L
Stormwater: Impervious	L	H	H	H	L
Stormwater: Upland	H	H	M	L	L
Bank Erosion	H	H	L	L	L

The load duration curves for the Fremont sites show that exceedances occur at all four target monitoring locations during all flow conditions. This indicates the potential for multiple contributing source areas in the watershed.
Load duration curves are shown below for each of the four target sites for both the calendar season (spring, summer, fall, winter) and for recreation season (recreation season versus non-recreation season) (Figures 28-35). The majority of exceedances occurred during mid- to low-flow conditions.

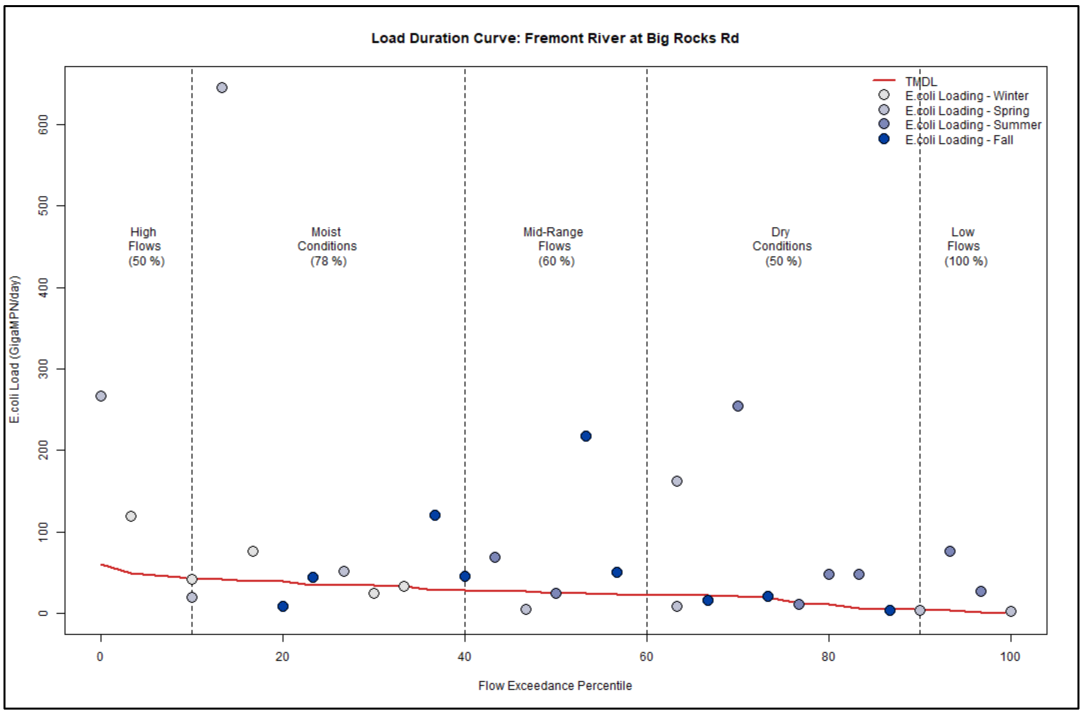


Figure 28. Calendar season load duration curve for 4955330: Fremont River at Big Rocks Road with data from 2016-2018

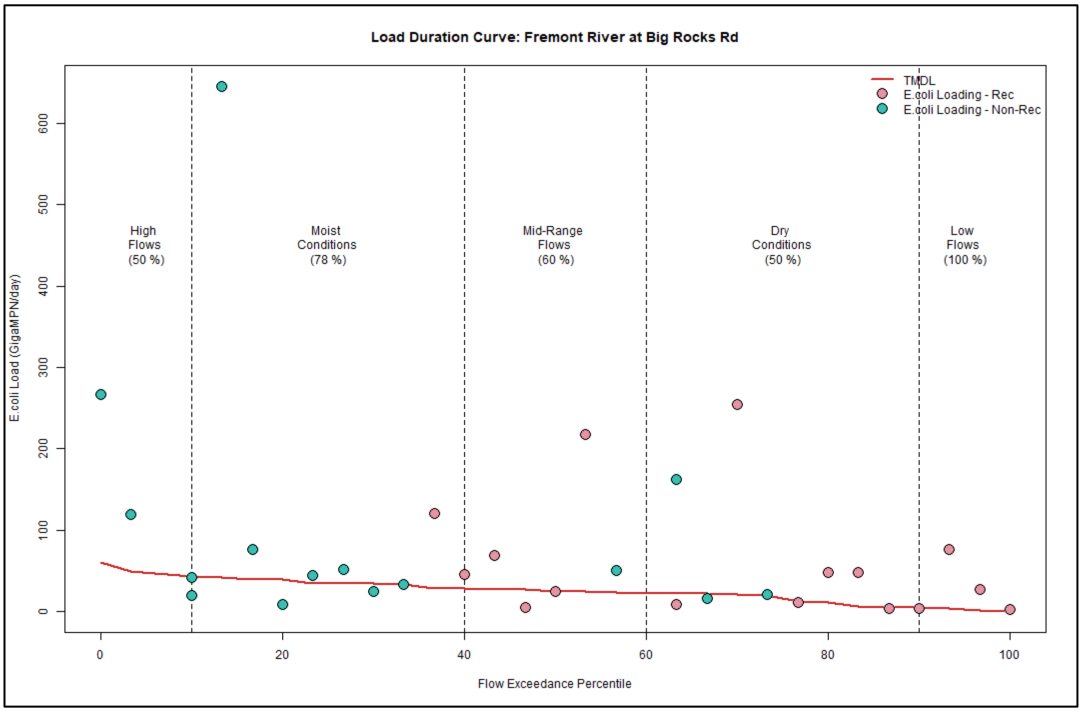


Figure 29. Recreation season load duration curve for 4955330: Fremont River at Big Rocks Road with data from 2016-2018

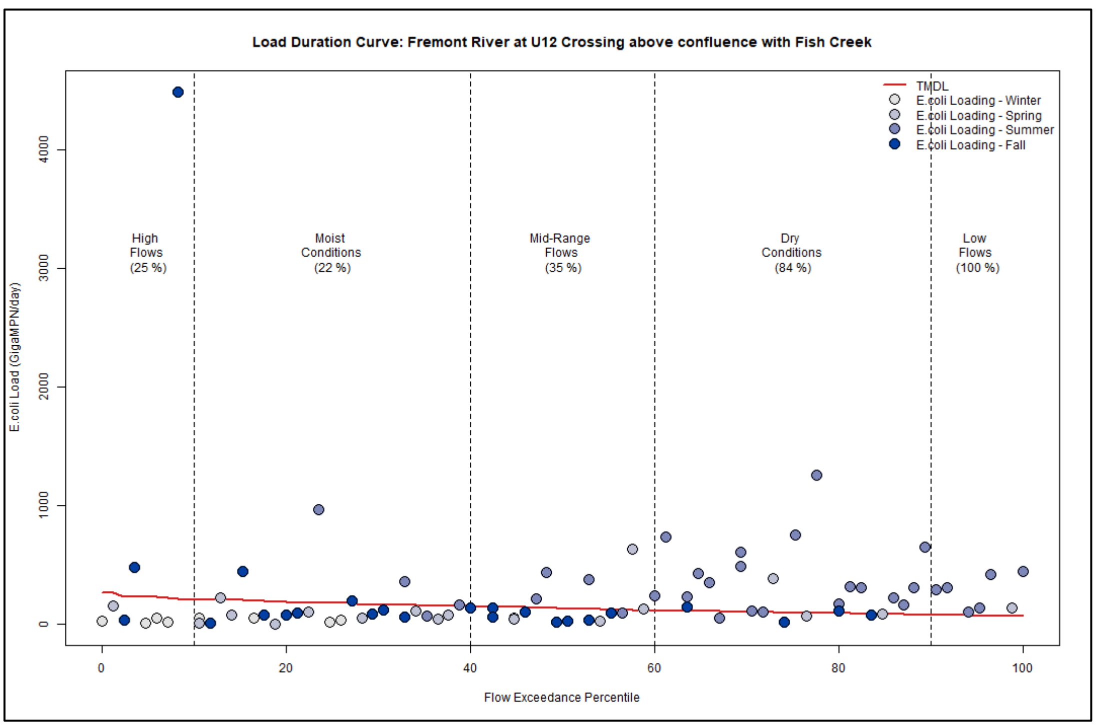


Figure 30. Calendar season load duration curve for 4954390: Fremont River at U12 Crossing with data from 2008-2018

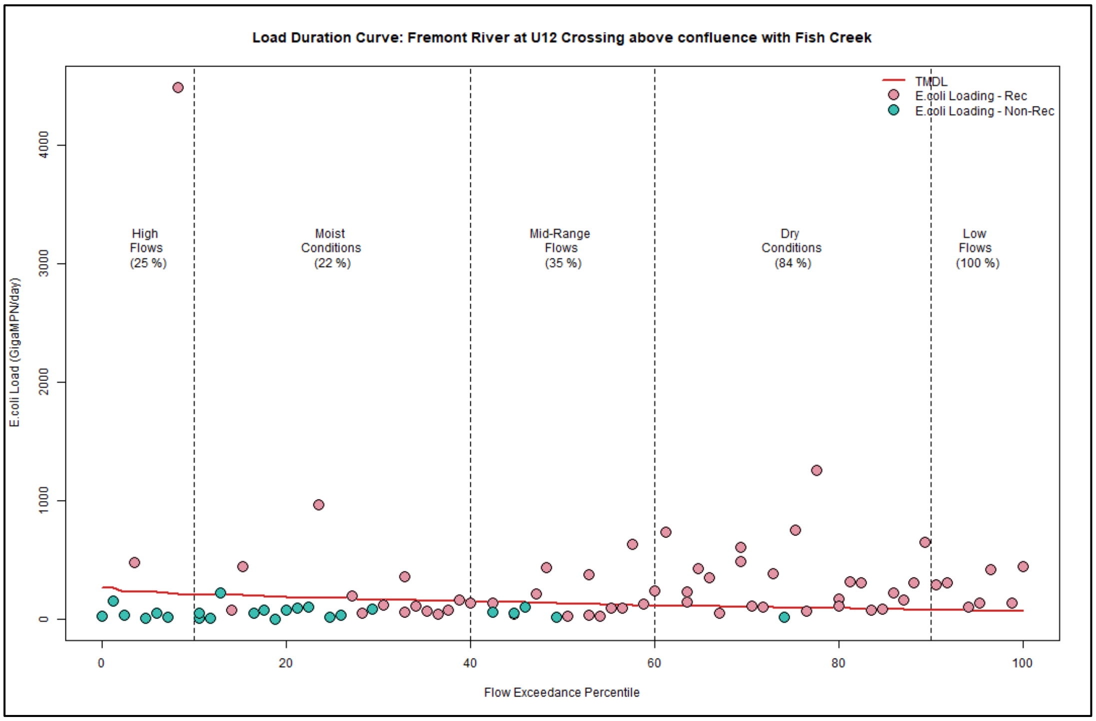


Figure 31. Recreation season load duration curve for 4954390: Fremont River at U12 Crossing with data from 2008-2018

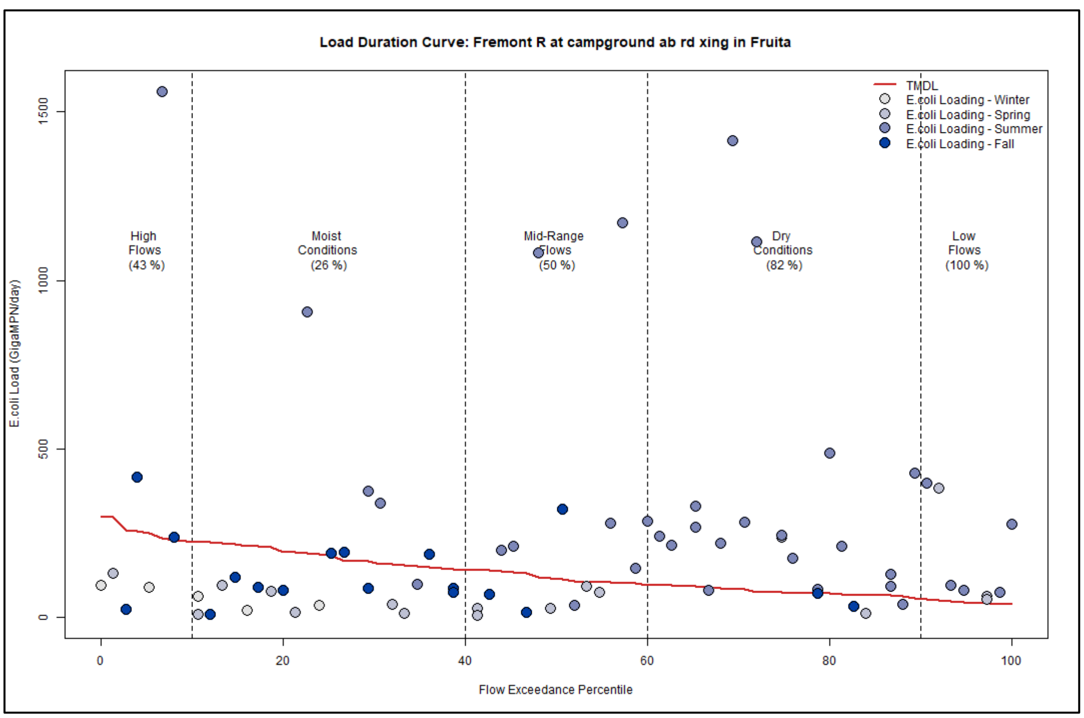


Figure 32. Calendar season load duration curve for 4954480: Fremont River at campground above road crossing in Fruita with data from 2010-2018

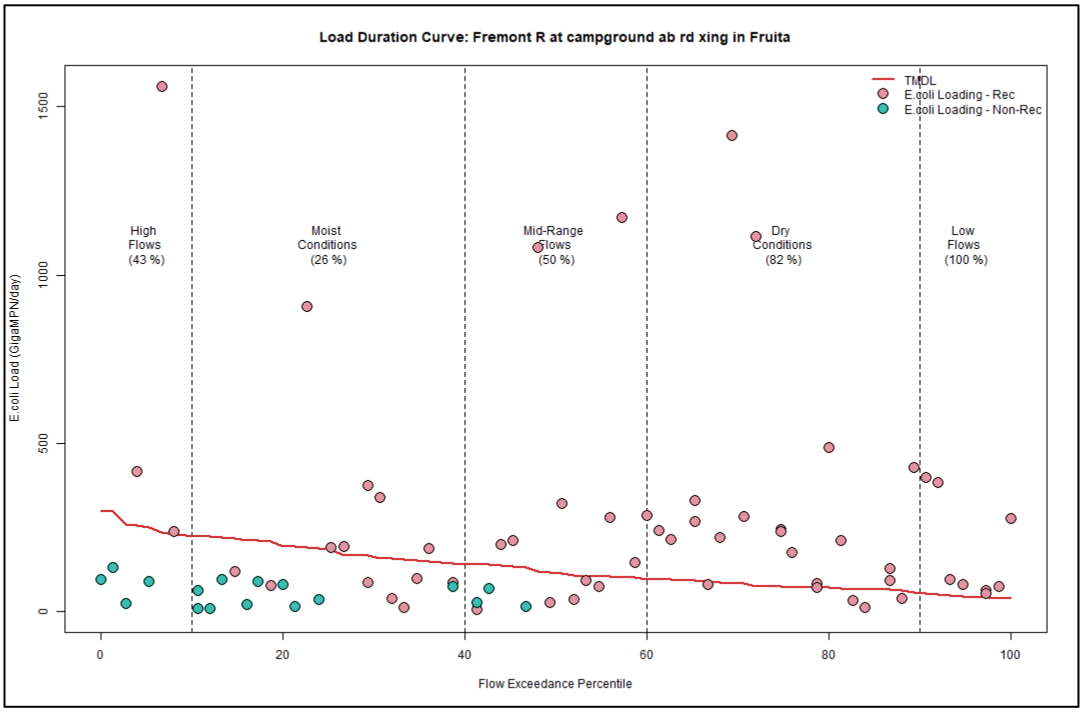


Figure 33. Recreation season load duration curve for 4954480: Fremont River at campground above road crossing in Fruita with data from 2010-2018

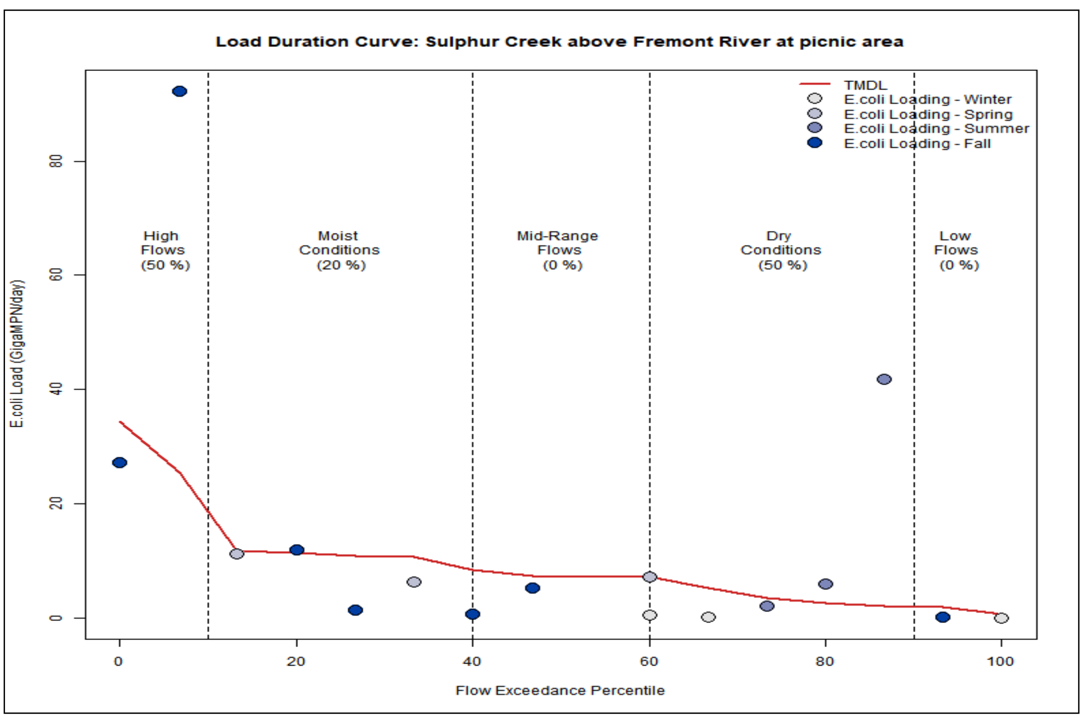


Figure 34. Calendar season load duration curve for 4954770: Sulphur Creek above Fremont River at picnic area with data from 2017-2018

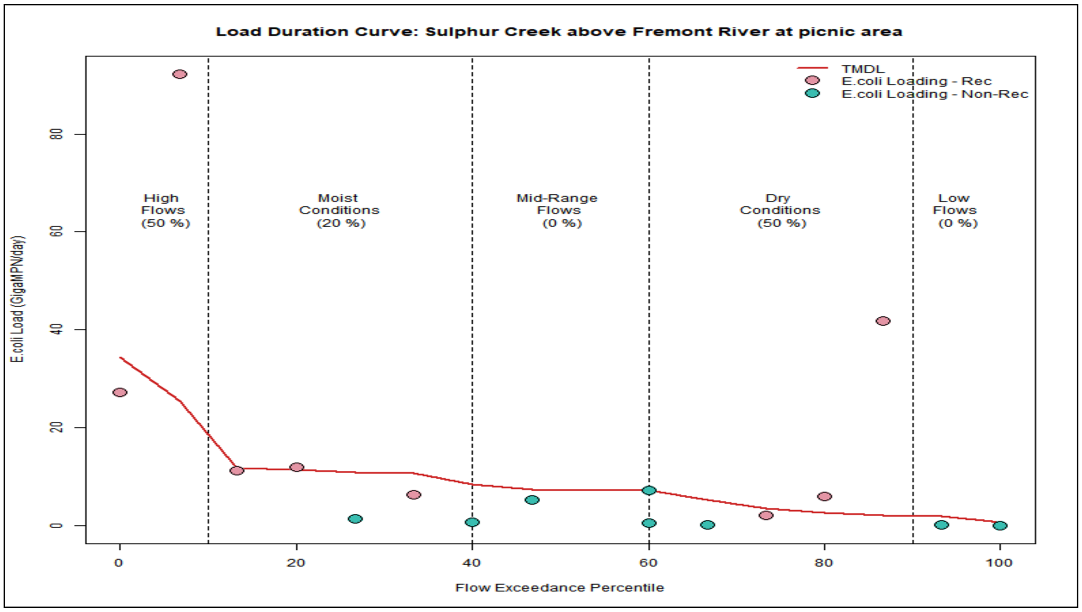


Figure 35. Recreation season load duration curve for 4954770: Sulphur Creek above Fremont River at picnic area with data from 2017-2018

5.3 TMDL Results

TMDL results were calculated using daily flow measurements and daily geometric means of *E. coli* concentrations. For each target site, the loading capacities and observed loadings of all recreation-season months were calculated. Then loading capacities and observed loadings of all recreation-season months that require a reduction were averaged to calculate the final percent reduction necessary. Monthly calculations are included in Tables 12 and 13. The geometric mean standard of 126 MPN/100mL was used for determination of the loading capacity.

5.4 Seasonality

Data for this TMDL were collected not only during the recreation season of May through October but also through the winter months to get a sense of the seasonality of exceedances.

The critical season for this *E. coli* TMDL is the recreation season. June, July and August are the months with the highest concentrations and greatest necessary percent reductions in loading for the target monitoring locations. Figures 36-39 show summaries of monthly observed *E. coli* concentrations for the target sites. These box plots show the range of concentrations, including the minimum, maximum, and median values observed.

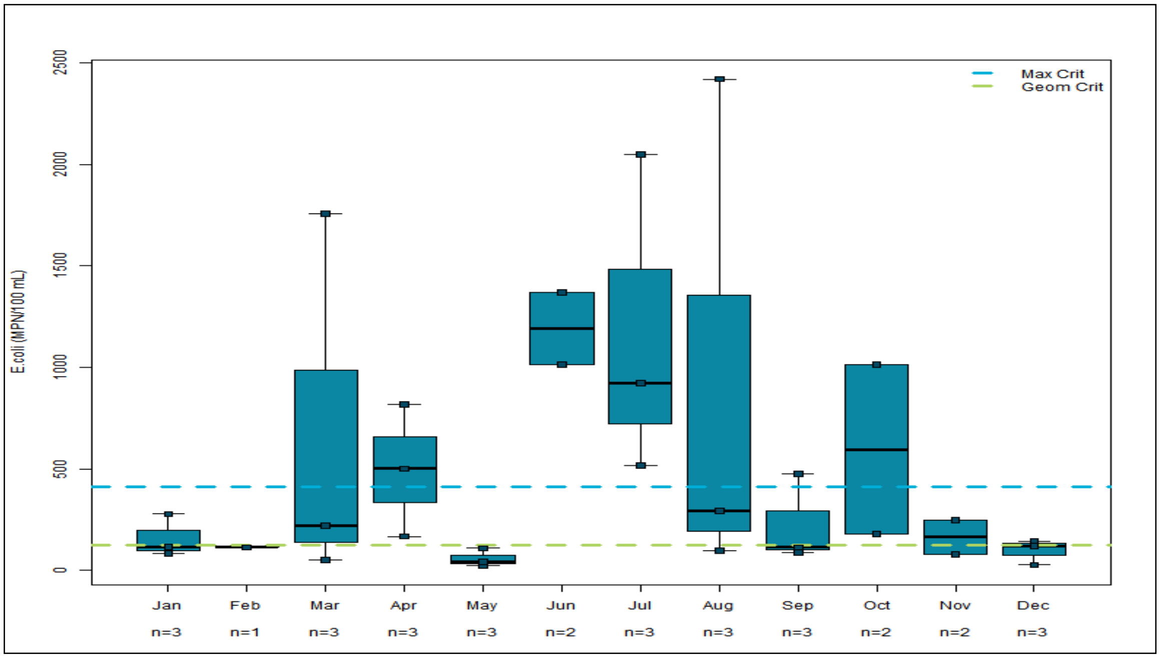


Figure 36. Monthly observed *E. coli* concentration summary for 4955330 Fremont River at Big Rocks Road from 2016-2018

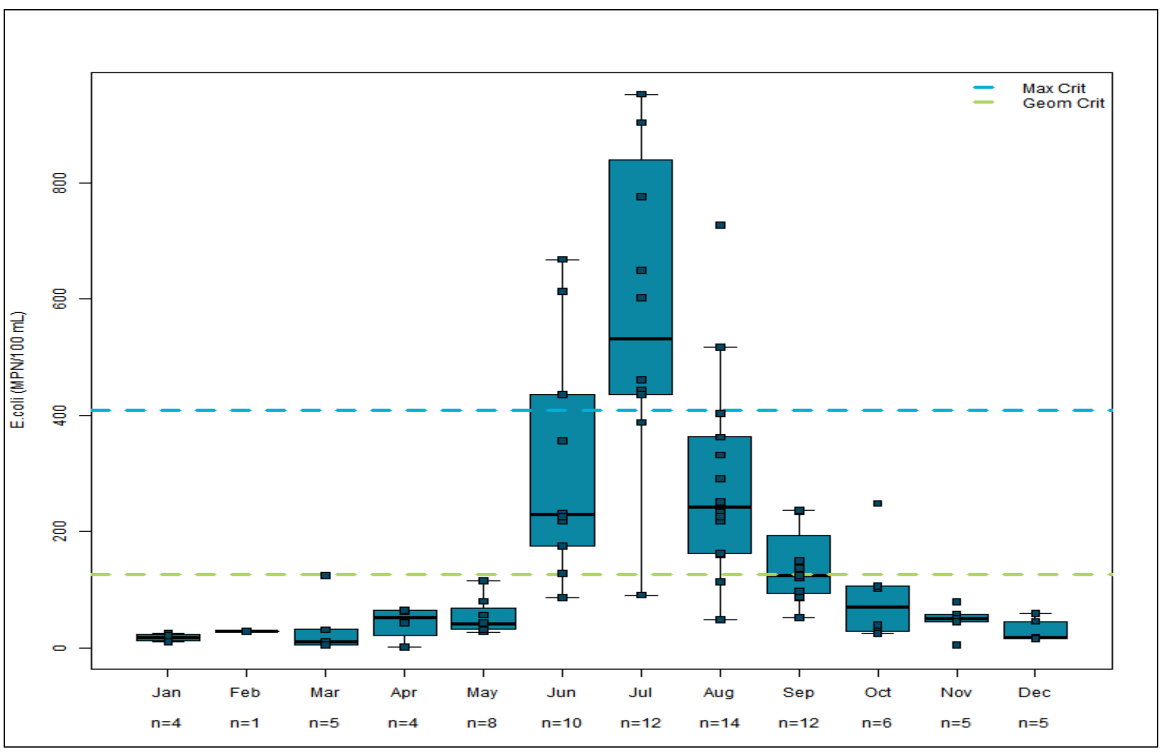


Figure 37. Image of 4954390: Fremont River at U12 Crossing from 2008-2018

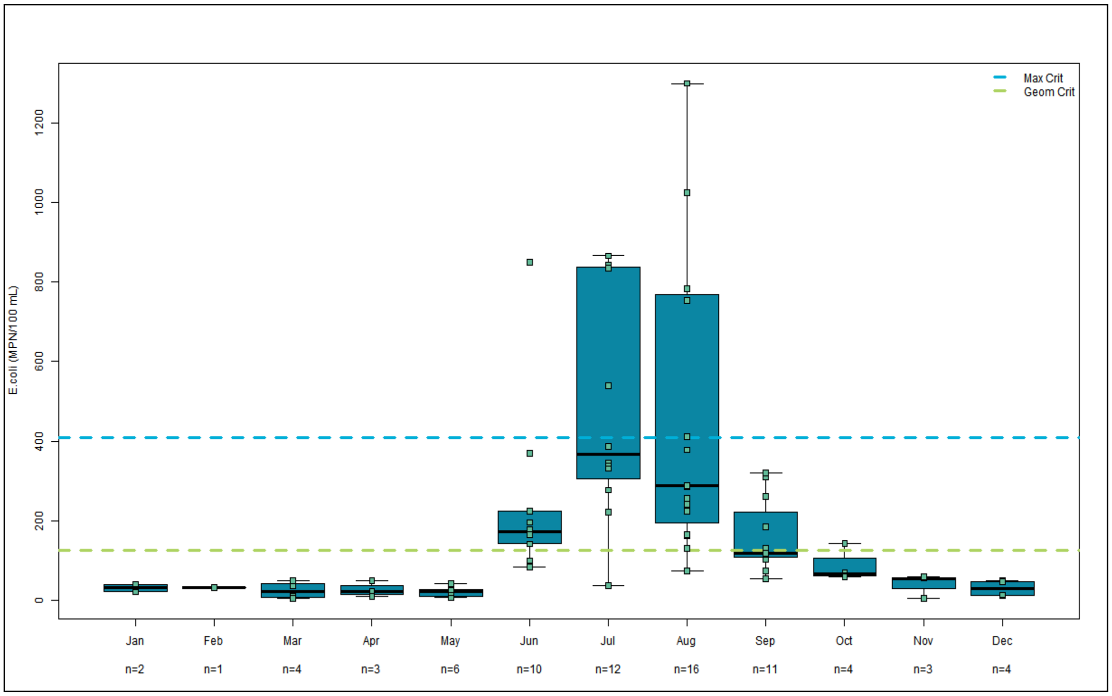


Figure 38. Monthly observed *E. coli* concentration summary for 4954480 Fremont River at Campground in CRNP from 2010-2018

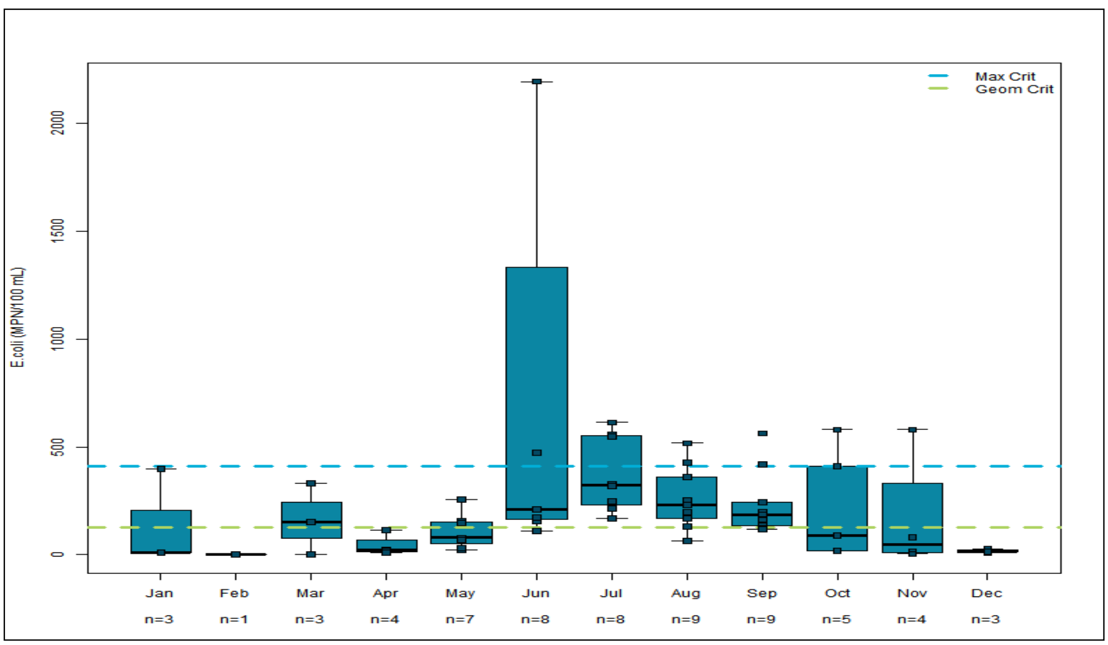


Figure 39. Monthly observed *E. coli* concentration summary for 4954770 Sulphur Creek above Fremont River at picnic area from 2012-2018

5.5 Margin of Safety

The margin of safety (MOS) refers to the required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving waterbody (CWA section 303(d)(1)(C)). The MOS can be implicit through use of conservative assumptions and values for calculations, or explicit as a certain percentage of the loading capacity. For the Fremont River TMDL, the MOS is explicitly included as 10% of the loading capacity. Implicit components include the use of the more conservative geometric mean standard of 126 MPN/100 mL for calculations, as well as averaging the recreation season months that required reductions to get the final TMDL calculations. Tables 12-15 show the *E. coli* TMDLs, including the observed loading, margin of safety, loading capacity, and the necessary percent reductions.

Table 12. Loading capacity, observed loading and necessary percent reductions based on 4955330 Fremont River at Big Rocks Road monitoring site data from 2016-2018

Month	**Loading Capacity (TMDL)** *GigaMPN/day based on Geomean Std, minus 10% Margin of Safety*	**Observed Load** *GigaMPN/day based on Geomean Std*	**Necessary Reduction**
May (n=3)	17.9	6.13	0%
June (n=2)	10.7	128.7	92%
July (n=3)	6.0	41.13	85%
Aug (n=3)	14.3	278.8	95%
Sept (n=3)	19.5	49.8	61%
Oct (n=2)	26.5	131.5	80%

Table 13. Loading capacity, observed loading and necessary percent reductions based on 4954390 Fremont River at U12 Crossing monitoring site data from 2008-2018

Month	Loading Capacity (TMDL) *GigaMPN/day based on Geomean Std, minus 10% Margin of Safety*	Observed Load *GigaMPN/day based on Geomean Std*	Necessary Reduction
May (n=8)	149.6	65.7	0%
June (n=10)	98.7	270.7	64%
July (n=12)	96.9	533.5	82%
Aug (n=14)	106.6	271.0	61%
Sept (n=12)	139.8	523.7	73%
Oct (n=6)	153.3	137.9	0%

Table 14. Loading capacity, observed loading and necessary percent reductions based on 4954480 Fremont River at campground in CRNP monitoring site data from 2018-2018

Month	**Loading Capacity (TMDL)** *GigaMPN/day based on Geomean Std, minus 10% Margin of Safety*	**Observed Load** *GigaMPN/day based on Geomean Std*	**Necessary Reduction**
May (n=6)	104.6	28.5	0%
June (n=10)	78.3	148.8	47%
July (n=12)	80.7	371.1	78%
Aug (n=16)	102.9	497.0	79%
Sept (n=11)	138.6	194.3	29%
Oct (n=4)	168.6	120.2	0%

Table 15. Loading capacity, observed loading and necessary percent reductions based on 4954770 Sulphur Creek above Fremont River at picnic area monitoring site data from 2017-2018

Month	**Loading Capacity (TMDL)** *GigaMPN/day based on geomean std, minus 10% Margin of Safety*	**Observed Load** GigaMPN/day based on geomean std	**Necessary Reduction**
May (n=1)	10.7	6.4	0%
June (n=2)	5.1	21.7	76%
July (n=1)	2.7	5.9	54%
Aug (n=1)	3.6	2.1	0%
Sept (n=1)	11.4	11.9	4%
Oct (n=2)	29.7	50.1	41%

6.0 SOURCE ASSESSMENT

This section provides a summary of the sources of *E. coli* that contribute to the water-quality impairment in the Fremont River watershed. Typically, sources are characterized as either point or nonpoint sources. Point sources are spatially discrete and regulated under the Utah Pollution Discharge Elimination System (UPDES), and nonpoint sources are spatially distributed and not regulated. A summary of each source is provided below along with an estimate of the relative contribution of each.

6.1 Point Sources

A point source is defined by the CWA section 502(14) as "any discernible, confined and discrete conveyance, including any ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agriculture stormwater discharges and return flow from irrigated agriculture."

A point source may discharge effluent to a waterbody if the discharge is covered by a National Pollutant Discharge Elimination System (NPDES) permit. Effluent discharges are illegal when they violate the terms and conditions of an NPDES permit or if they are not covered by a NPDES permit. In Utah, EPA issues NPDES permits for point sources on federal property and tribal property. DWQ issues Utah Pollutant Discharge Elimination System (UPDES) permits for discharges from all other point sources.

DWQ issues two types of UPDES permits: individual and general. Individual permits are for discharges from a single entity and encompass a comprehensive permit application process. General permits cover a similar type of discharge across multiple entities. The general permits contain requirements for all permittees and are not specific to a single entity.

NPDES and UPDES permits are reissued every five years or when a permit must be modified to account for alterations to the point source. As NPDES/UPDES permits are reissued, they must be consistent with WLAs for point sources that are developed in the TMDL process. Both NPDES/UPDES permits and TMDLs protect waterbodies from receiving more pollutant loading than the waterbody can assimilate.

There are eight UPDES permits in the Fremont River watershed (Table 16). Two are included in the general permit for fish hatcheries throughout the state, but fish are cold blooded and therefore not expected to be a source of *E. coli*. Two are industrial stormwater permits that are issued to control runoff from industrial facilities. One is for water supply and irrigation, and three are included in the state general permit for pesticides. Pollutants most likely to be produced from these permitted activities include sediment, nutrients, and pesticides. Although all are located within the Fremont-2 and Fremont-3 AUs, none are likely to be sources of pathogen loading to the Fremont River watershed, so this source assessment will focus solely on nonpoint sources that include humans, wildlife, and livestock.

Table 16. UPDES permits in the Fremont River watershed

Permittee	UPDES Permit #	Activity
Utah Division of Wildlife Resources	UTG130003	Fish Hatchery (Loa)
Utah Division of Wildlife Resources	UTG130007	Fish Hatchery (Bicknell)
Capitol Reef National Park	UT0025798	Water Supply and Irrigation
Wayne County	UTR000708	Industrial Stormwater
Torrey Quarry	UTR275925	Industrial Stormwater
Wayne County and Capitol Reef National Park	UTG170052 UTG170053 UTG170090	General Permit Pesticides

6.2 Nonpoint Sources

Nonpoint source pollution comes from diffuse sources that do not originate from a single distinct point but is an accumulation of small sources of pollution throughout the watershed. Nonpoint source pollution enters waterbodies through surface water runoff, such as rainfall or snowmelt, or is deposited directly into streams. Potential contributors of nonpoint source *E. coli* pollution within the Fremont River watershed are humans, wildlife, and livestock.

To gain a better understanding of *E. coli* sources in the watershed, DWQ gathered and assessed information from the National Park Service, U.S. Forest Service, Bureau of Land Management, Utah Division of Wildlife Resources, School and Institutional Trust Lands Administration (SITLA), Central Utah Public Health Department, and local landowners. The intent of the assessment was to qualitatively evaluate potential sources so that financial and technical resources can be directed in the most efficient way possible to reduce their contribution.

6.2.1 Humans

Septic Systems

When properly designed and maintained, onsite wastewater treatment systems pose no significant threat to surface water quality. However, failing or improperly designed systems must be considered as a potential source of bacteria to waterways. The Central Utah Public Health Department (CUPHD) records show 1,287 individual septic systems in the portion of the Fremont River watershed where this study was conducted (email with Nathan Selin, CUPHD, 10/2/18). There are likely more systems than that, since the recordkeeping only began in the early 1980s. There are also several large underground wastewater disposal systems (LUWDS) in the area (email with Robert Beers, DWQ, 11/14/19). These systems are required to have an operating permit with the state that can be renewed every five years. One condition of the operating permit is an annual inspection performed by an onsite professional and submitted to DWQ. It is also likely there may be some unpermitted LUWDS that predate the permitting process. Those systems are shown in Tables 17 and 18.

The onsite wastewater treatment system in Capitol Reef National Park is subject to an annual inspection by the National Park Service regional public health officer as part of a survey of water and wastewater safety requirements. That system is also inspected every 3 years by the Utah State Engineer's Office as part of a sanitary survey of Park water and wastewater systems.

Table 17. Individual onsite wastewater treatment systems in the Fremont River TMDL area

Individual Onsite Septic Systems	
Town	**Number**
Bicknell	230
Fremont	83
Grover	53
Loa	265
Lyman	77

Teasdale	180
Torrey	382
Other	17

Table 18. Large underground wastewater disposal systems in the Fremont River TMDL area

Large Underground Wastewater Disposal Systems		
Town	**Name**	**Average Flow (gallons per day)**
Loa	Brian Auto, Inc.	660
Torrey	Capitol Reef Inn and Cafe	5,000
Torrey	Capitol Reef Resort	>15,000
Torrey	Days Inn	5,650
Torrey	Noor Hotel	12,000
Torrey	Redridge Subdivision	9,600

There is currently no map available for these septic systems. The state is working on compiling all septic system information into a database so mapping will be an option in the future.

Recreation

Capitol Reef National Park and the surrounding area is an internationally known tourist destination, with visitation numbers increasing annually. Many visitors are drawn to recreate in the water, especially during the summer months when temperatures are high. From 2009-2017, approximately 74-82% of the Park's annual visitation occurred during the recreation season months of May through October (NPS 2018). Hiking in and adjacent to Park waters is very popular.

Capitol Reef National Park receives over a million visitors annually. It is likely that a very small percentage of those visitors are not properly disposing of human waste. While it is a challenge to quantify this behavior, improper disposal of waste does not appear to be problematic within Park boundaries, leading to the assumption that hikers are an unlikely source of significant pathogen loading to the Fremont River.

6.2.2 Wildlife

Wildlife are sources of *E. coli* loading in a watershed. The animal habitat and proximity to surface waters are principal factors that determine if animal waste can be transported to surface waters. Waterfowl and riparian mammals deposit waste directly into streams, while other riparian species deposit waste in the floodplain, which can be transported to surface waters by runoff from precipitation events. Animal waste deposited in upland areas can also be transported to streams and rivers; however, due to the distance from uplands to surface streams, only larger precipitation events can sustain sufficient amounts of runoff to transport upland animal waste to surface waters (Colorado DPHE, 2019).

The Fremont River watershed overlaps the Plateau Fish Lake Thousand Lakes Wildlife Management Unit (WMU) (Figure 40). The Utah Division of Wildlife Resources' Richfield office (UDWR) provided population estimates for big game for the WMU (personal communication between Jim Lamb, UDWR, and Amy Dickey, DWQ, October 4, 2018). The Fremont River watershed accounts for approximately 29% of the WMU. UDWR estimates that there are 2,200 elk, 5,800 deer, 200 turkeys, and 1,000 pronghorn antelope within the Fremont-2 and Fremont-3 AUs.

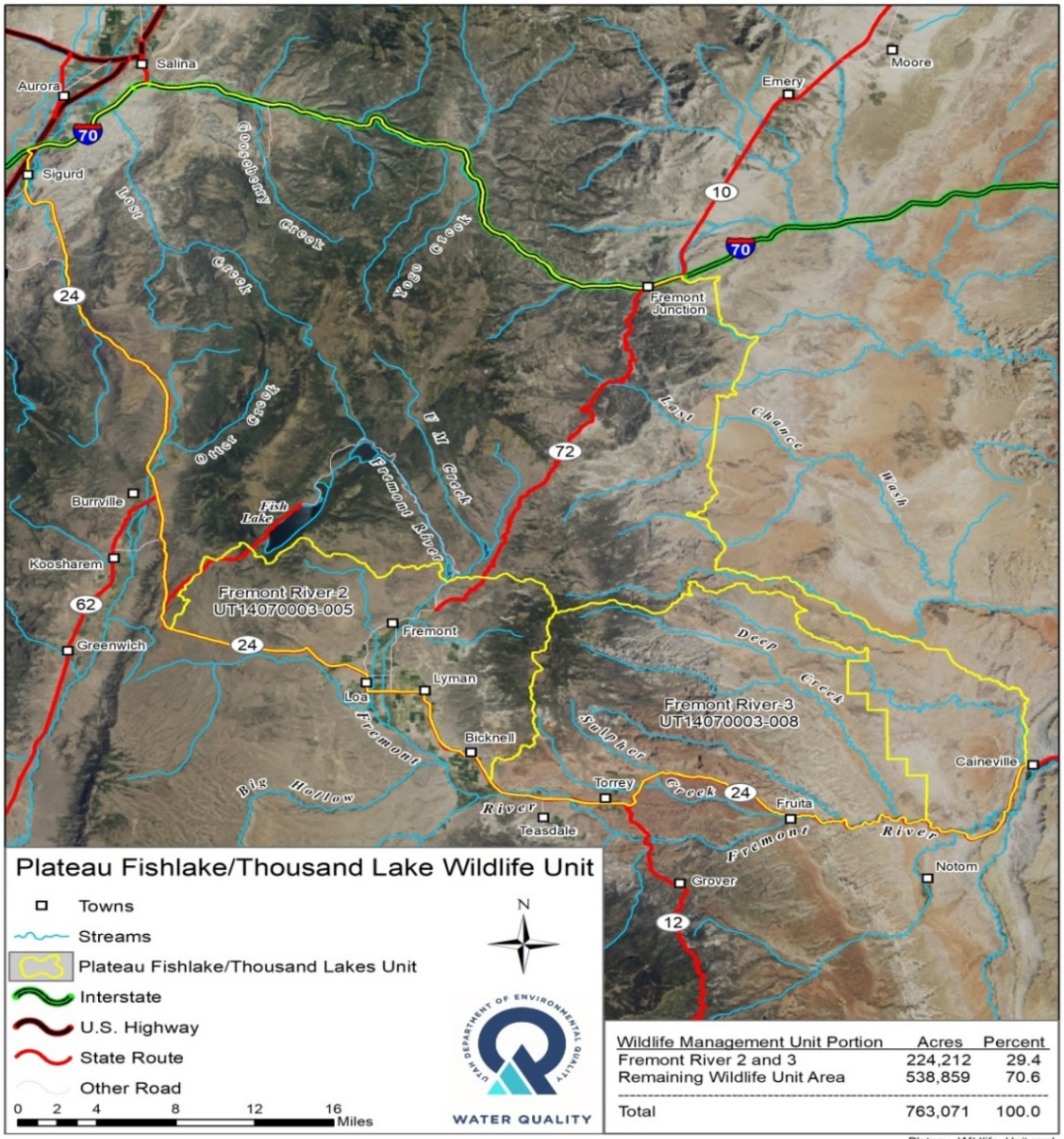


Figure 40. Utah Division of Wildlife Resources Plateau Fishlake/Thousand Lake Wildlife Management Unit

6.2.3 Livestock

Livestock grazing occurs on both private and federal land in the Fremont River watershed. In many cases, livestock are in close proximity to the river and have direct access to the river for stock watering. There are also instances of livestock grazing on pastures that are actively being irrigated with return flows entering the river.

Private Land

Landowners are not required to report the number of animals on their property, and the numbers vary from year to year depending on landowner choices. The upper watershed is not conducive to year-round grazing due to the snowpack and lack of accessibility. Estimates from the Utah Agriculture 2017 Census for Wayne County for the number of animals grazing private land are provided in Table 19. The majority of the watershed suitable for grazing and raising animals falls within the study area of Fremont-2 and Fremont-3, so the total number from the census was included for each animal type. Based on conversations with the Fremont River Conservation District, as well as with federal land grazing program staff, it was estimated that >95% of animals from private land spend part of the year on public grazing allotments. The public land estimates include those private animals so only 5% of the private land grazing estimates were used for the source assessment calculations.

Table 19. Livestock estimates on private property. (Source: 2017 Utah Agricultural Census)

Animal Type	Estimated number in watershed per season	Number used for TMDL source assessment calculations
Cows	18,156	908 (5% of total)
Sheep	7,575	379 (5% of total)
Horses	50	50
Hogs	60	60

Public Land

The US Forest Service, Bureau of Land Management (BLM) and SITLA all manage rangelands throughout Utah for multiple uses including wildlife habitat and livestock grazing. The rangelands are divided into allotments and pastures for management purposes. BLM Range Management staff provided the estimates shown below of livestock numbers during the recreation season for the allotments that are within the TMDL study area (Paul Caso, BLM Richfield

Office). US Forest Service estimates were taken from the Fremont River Conservation District's Fremont River Watershed Plan finalized in 2019 (NRCS, 2019). SITLA estimates were provided by the Resource Specialist for that region (Slate Stewart, SITLA Richfield) and can also be found on its online map of active grazing permits. Animals are grazed on public lands year-round but the source assessment calculations only consider those present during the recreation season when the *E. coli* standard applies. Tables and maps of allotment information and animal numbers for all three agencies can be found in Appendices B – D.

Table 20. Livestock estimates on public lands

Animal Type	Estimated number in watershed per recreation season		
	US Forest Service	Bureau of Land Management	SITLA
Cows	2,493	1,094	536
Sheep	1,063	2,692	57

6.3 Source Assessment Summary

An evaluation of *E. coli* loads by source was conducted using the bacteria production rate per animal and the number of animals in the watershed. The bacteria production rates presented below are based on research of fecal coliform bacteria, of which *E. coli* constitutes a large proportion. Fecal coliform levels have been shown to be well correlated with *E. coli* concentrations (Francy et al. 1993). It should also be noted that this assessment is specific to the impaired Fremont River AUs and does not include the high elevation headwaters or the portion of the watershed downstream of Capitol Reef National Park. The intent of this evaluation was to compare the different sources relative to each other and provide evidence of likely contributors to the impairment and help ensure that appropriate implementation measures can be taken. Several assumptions were used in this assessment, all of which are described below.

6.3.1 Bacteria Production

Bacteria production rates vary by animal, with cows and horses producing the largest loads and deer producing the lowest (Table 21) (Zeckoski et. al. 2005). In cases where literature estimates were not available (i.e., elk and bighorn sheep), estimates from livestock were used. For instance, the bacteria production rate for elk was assumed to be the same as a cow, and the production rate for bighorn sheep was assumed to be the same as domestic sheep, based on their similar weights.

Table 21. Bacteria production by animal

Animal[1]	Bacteria Production Rate (cfu[2]/animal/day)
Humans	2.00×10^{9}
Elk	3.30×10^{10}
Bighorn Sheep	1.20×10^{10}
Deer	3.50×10^{8}
Cows	3.30×10^{10}
Sheep	1.20×10^{10}
Horses	4.20×10^{10}

[1]all literature values were taken from Zeckoski et. al. 2005

[2]cfu = colony forming unit. Note that CFU and MPN are similar measurements of bacterial concentration, byt they may vary slightly in values (Cho et al. 2010)

6.3.2 Source Assessment

Bacteria production rates from Table 21 were coupled with the number of animals in the watershed to identify the relative contribution of bacteria by source during the recreation season. The number of animals in the watershed per source was estimated based on available data. One hundred percent of the DWR estimates for wildlife in the study area were used. For livestock, the private grazing and public grazing numbers were summed to get a total number of cows, sheep, hogs and horses. For humans, the number of septic systems was used with an assumed household population of three (U.S. Census Bureau Website) and a system failure estimate of 50%. That number is based on the Bacteria Source Load Calculator Model (Zeckoski, 2005) which estimates that 20% of systems installed between 1966 and 1985 are failing, coupled with the knowledge that data is likely missing for some of the systems installed prior to 1985 throughout the watershed. Bacteria production was then summed by source to determine the relative contribution of humans versus livestock versus wildlife (Figure 41). According to this analysis, livestock contribute 74% of the *E. coli* loading compared to wildlife at 25% and humans at 1%.

Table 22. Bacteria contribution by source during the recreation season

Source	Bacterial Source	Fecal coliform production rate (cfu/animal/day)	Number in Fremont-2 and Fremont-3 AUs/rec season	Total bacteria production/rec season
Elk	Wildlife	3.30×10^{10}	2200	1.34×10^{16}
Deer	Wildlife	3.50×10^{8}	5800	3.74×10^{14}
Pronghorn Antelope	Wildlife	3.50×10^{8}	1000	6.44×10^{13}
Turkeys	Wildlife	9.30×10^{7}	200	3.42×10^{12}
Septic Systems	Human	2.0×10^{9}	1931	7.10×10^{14}
Private Hogs	Livestock	3.50×10^{8}	60	3.86×10^{12}
Private Horse	Livestock	4.20×10^{10}	50	3.86×10^{14}

Private Cow	Livestock	3.30×10^{10}	908	5.51×10^{16}
Private Sheep	Livestock	1.20×10^{10}	379	8.36×10^{14}
Public Cow	Livestock	3.30×10^{10}	4123	2.91×10^{16}
Public Sheep	Livestock	1.20×10^{10}	3812	8.42×10^{15}

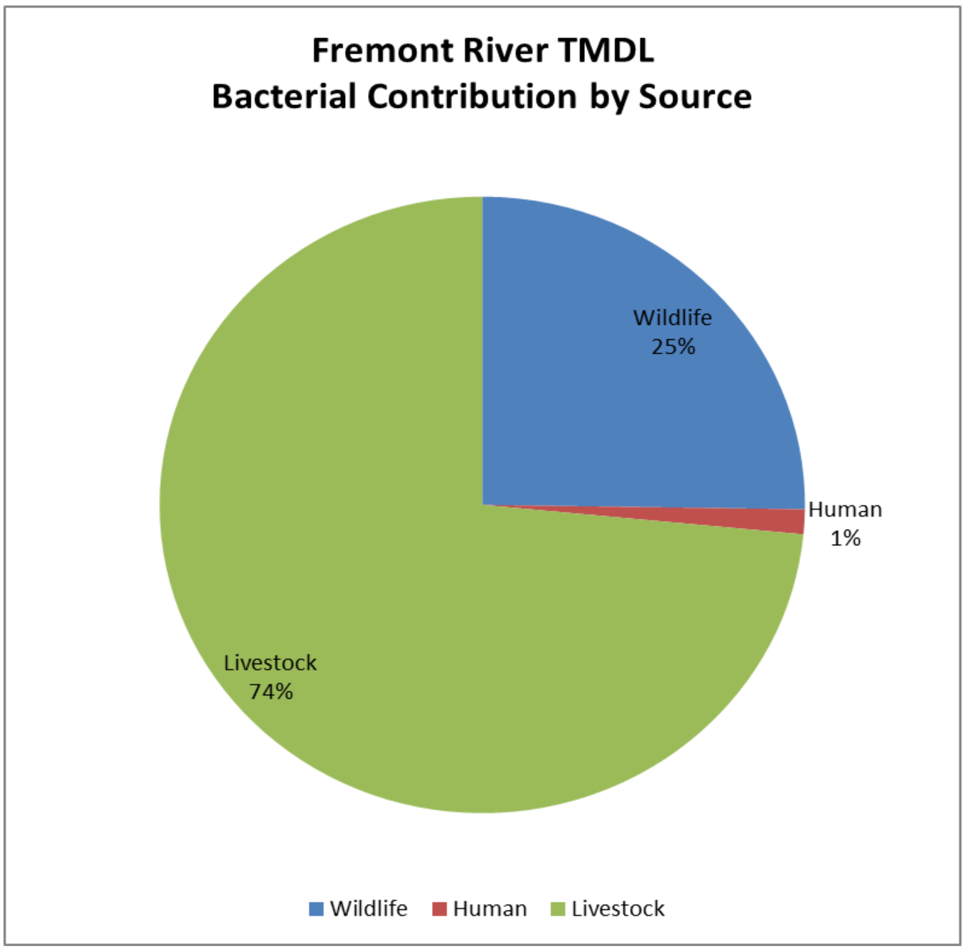


Figure 41. Estimated bacteria contribution by source during the recreation season

6.3.3 Assumptions and Uncertainty

Several assumptions were used in conducting this source assessment, and there are areas of uncertainty that are impossible to avoid in a study of this nature. For example, DWR wildlife estimates do not take into consideration the movement of animals in and out of the study area. This analysis also does not account for any wildlife species other than deer, elk, turkeys, and pronghorn antelope.

Private land grazing numbers for livestock were estimates, and vary from year to year dependent on producer choices.

For septic systems, it is likely that there are more systems in the watershed than recorded by the health department. However, not all septic systems are in proximity to a perennial waterway, which makes them less likely to contribute *E. coli*. A 50% failure rate was used for calculations.

For the human recreation source estimate, the assumption was made that humans were not likely to be defecating in or near the river, so no human recreation estimate was included in this source assessment.

Ideally this section would include a source assessment unique to each of the Fremont AUs since the sources are most likely different between the upper Fremont-2AU (predominately livestock) and the lower Fremont-3 AU (more potential for human and wildlife). Unfortunately it's not feasible to increase the resolution on the source assessment with the data currently available.

6.3.4 Transport Pathways

The source assessment presented above was conducted assuming that bacteria are directly deposited into the river. In reality, it is much more likely that most defecation occurs on the landscape and the majority of the bacteria contained in the feces expire without ever reaching the waterway. A portion of the feces are transported to the river or to irrigation canals during overland flow events.

That is particularly true for livestock and wildlife that graze in flood-irrigated fields. Irrigation return flows are present in scattered locations throughout the Fremont-2 and Fremont-3 AUs. Water is diverted from rivers and canals at points along the pastures where it then runs through the grass. Any water in excess of what the soil can absorb becomes return flow that spills back into the river. If the water has come in contact with fresh fecal material, it is likely the return flows will be impacting water quality as a source of fecal pathogen loading. Due to the complexity of the irrigation network, DWQ has not conducted a comprehensive mapping exercise. Therefore, at this time, it is not possible to determine individual bacteria loads from each return flow.

7.0 IMPLEMENTATION PLAN

It will be necessary to implement Best Management Practices (BMP) to achieve TMDL endpoints. BMPs are practices used to protect and improve the physical, chemical, and biological integrity of surface and groundwater, primarily with regard to nonpoint sources of pollution. BMPs are most effective when combined to create a BMP system that comprehensively reduces or eliminates pollution from a single source. It should be noted that no single BMP system is considered to be the most effective way of controlling a particular pollutant in all situations; rather, the design of a BMP system should consider local conditions that are known to influence the production and delivery of nonpoint source pollutants.

The design of a BMP system should not only account for the type and source of pollutant, but should also consider background factors such as the physical, climatic, biological, social, and economic setting.
Implementing BMPs in the Fremont River Watershed to improve water quality has already proven to be effective. The Fremont River Conservation District, in cooperation with its partners, has implemented many projects in the watershed to improve water quality. Since 2002, over 2.5 miles of stream bank between the towns of Bicknell and Grover have been reshaped, stabilized, and re-vegetated. The District also worked with 17 different landowners in the watershed to relocate animal feeding operations from the riparian corridor or install BMPs that restrict runoff from leaving the feedlots. The Fremont River Conservation District has also played a large role in converting fields that were flood irrigated to more efficient sprinkler irrigation. The combination of these practices has resulted in a significant reduction in nutrient concentrations in the Fremont River, and river was removed from the 303(d) list of impaired waterbodies for excess phosphorous in 2014.

BMPs applied to the Fremont River watershed to reduce *E. coli* concentrations should include both structural and nonstructural techniques. Structural BMPs require a physical structure and could include projects such as installing vegetative buffer strips to filter out contaminants before they reach the stream, restricting livestock access to stream channels by installing fencing, and installing off-site watering systems or access points so livestock still have access to clean drinking water without spending a lot of time in and adjacent to the river. Repair or replacement of septic systems that are not functioning properly could reduce *E. coli* contamination from urban areas.

Development of grazing management plans is one nonstructural technique that could result in water quality improvement. While this practice is not considered structural, grazing management plans often require the installation of structures such as fencing and watering facilities to better manage livestock grazing.

Other practices that help address natural resource concerns outside of the scope of this study may be implemented in conjunction with the projects recommended in this plan to support the larger goal of improving the overall condition of the watershed.

7.1 Animal Feeding Operations

An animal feeding operation (AFO) is a feedlot or facility where animals are stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period AND crops, vegetation, forage, or postharvest residues are not sustained in the normal growing season over any portion of the lot or facility (Utah R317-8-10). Historically, feedlots were constructed near rivers or streams so the animals could have access to water. However, feedlots located adjacent to waterways are likely to be a source of pathogen loading to those waterways. DWQ has made it a high priority to address all AFOs that have been identified as potential *E. coli* sources. Per state law (Utah Water Quality Act, Section 105.5), AFOs that discharge to the waters of the state are in violation of water quality regulations and may be subject to fines if action is not taken to eliminate runoff from the facility.

Feedlots that are adjacent to rivers, streams, or open canals should be relocated where feasible to another location where runoff from the feedlot will not reach the waters of the state. If this is not possible, proper BMPs should be installed to contain the runoff leaving the facility. These BMPs can consist of fences and offsite watering systems to restrict animal access to open ditches and streams. Berms should also be installed to catch any runoff leaving the facility.

There are several feedlots located in the Fremont River watershed. While some have been improved or relocated, there is a possibility that some are in need of additional repairs or maintenance. It would be beneficial to conduct an inventory of the feedlots in the watershed that have potential to discharge into the Fremont River. This inventory would help identify operations that may need additional assistance to come into compliance with state water quality standards. If operations are in need of improvements, the Fremont River Conservation District, along with DWQ and partner agencies, can provide technical and funding assistance to complete the work.

The cost to address AFOs can range from $1,000 to $150,000. Some AFOs can be fixed with the installation of a simple berm to prevent water from leaving the operation, while others may require that the feedlot be decommissioned and rebuilt in another location. Conservation planners can work with the landowners on a case-by-case basis to determine the most cost-effective approach while maintaining the functionality of the feedlot.

7.2 Grazing Management

Grazing management will require both structural and non-structural practices. Proper grazing management is a viable option in some areas of the watershed where landowners are able to distribute their cattle across a very large landscape. This may not be as effective in other areas where livestock are concentrated in smaller areas, such as sprinkler irrigated pastures. In some situations, it may be necessary to install fences along the creek to restrict livestock access to the riparian area. The protected area may still be grazed, but the animals will need to be removed when the riparian vegetation becomes stressed or overgrazed. This would also require installation of offsite watering troughs at access points to provide clean drinking water for livestock.

Installation of cross fencing is also a possible solution to help better distribute livestock across the landscape. Additional cross-fencing will allow landowners to better manage the feed within their pastures, allowing for increased rest periods. This can help improve plant health, thereby increasing the amount of feed available for livestock and reducing the amount of time the livestock spend in the riparian corridor.

Using aerial photography, DWQ estimated that approximately 15 miles of pasture adjacent to the Fremont River may be overgrazed and could potentially be contributing to the *E. coli* loading in the Fremont River. Follow up ground truthing on a site by site basis is recommended. While there are some grazing impacts in the tributaries, most appeared to be in good condition.

The types of practices that should be installed to help restrict livestock access to the river will be determined on a case-by-case basis. Conservation planners should work with the landowners to determine which practices will work better for their operations while also improving water quality.

The terms and conditions for grazing state and federal lands are included in the permits and leases issued, and contain habitat and vegetation goals. State and federal land grazing program managers are responsible for monitoring the condition of the allotments, responding as necessary to drought, fire and other resource conditions, and making improvements when necessary to minimize any potential impacts to natural resources including water quality.

7.3 Septic Systems

One of the potential sources of *E. coli* loading to the Fremont River are septic systems that were either improperly installed or are not being properly maintained. Septic systems that are properly planned, designed, sited, installed, operated, and maintained can provide excellent wastewater treatment. However, systems that are sited in densities that exceed the treatment capacity of regional soils, and systems that are poorly designed, installed, and operated, can cause water quality problems (EPA 2018).

The cost of annually maintaining a septic system can range from $250-$500, which is a fraction of the cost to replace an entire system. The average household septic system should be inspected at least every three years by a septic service professional. Household septic tanks are typically pumped every three to five years. Four major factors influence the frequency of septic pumping:

- Household size
- Total wastewater generated
- Volume of solids in wastewater
- Septic tank size

Since it can be challenging to know which households are properly maintaining their septic systems and which are not, one of the best ways to address this issue is to inform and educate the public about the impacts their septic tanks can have on public health and what they can do to better maintain them. One plan recommendation is to inventory and digitize septic systems to prioritize those most likely to be impacting water quality, as well as provide cost-sharing to homeowners who are willing to have their septic systems inspected or maintained, and assist with repairs or pumping if needed.

7.4 Information and Education Strategy

Only 5% of the Fremont River watershed is privately owned. However, many of the resource concerns that contribute to the *E. coli* impairment are found on private property. The Utah Nonpoint Source Information and Education Strategy developed in 2013 states that land owners and residents need to:

- Understand the importance of managing for clean water and the potential benefits proper management can have on their operations and other landscape-scale resources including soil, forage, animal health, and water availability on their lands.

- Understand and be trained in Best Management Practices (BMPs) that can be used to improve or protect water quality.
- Be aware of the various sources of funding and other technical assistance available to help in implementing best management practices.
- Be aware of changes in regulatory requirements.
- Understand local TMDLs and other watershed-based management approaches (Utah DWQ 2013).

One of the best ways to educate all interested stakeholders is to establish a local working group where all of the relevant topics impacting the watershed can be discussed. Topics addressed by this group can include potential BMPs for the watershed, local landowner input, reports on the current status of water quality in the watershed, and identification of the short-term and long-term goals of each member of the working group.

While some residents of the watershed may be aware of the water quality issues in their area, it is more likely that many are unaware that their practices could be contributing to water quality degradation. This plan recommends increased outreach to producers, including a dinner and presentation to discuss current water quality concerns and possible solutions.
Demonstration projects are very effective when helping landowners decide to implement BMPs on their property. This allows landowners to gain trust in the process and agency staff. It also gives other landowners the opportunity to see an example of successful BMPs and how they can improve their agricultural operations and water quality.

One of the best ways to address degraded water quality from improperly installed or maintained septic systems is to conduct an intensive information and educational campaign that presents the impacts septic systems may be having on water quality as well as ways homeowners can properly maintain those systems. DWQ recommends the development of an educational flier that can be distributed to Fremont River watershed stakeholders.

DWQ also recommends creation of an incentive program to help homeowners inspect and maintain their septic systems. In some instances, this incentive program could help pay for systems to be replaced if it is determined that the system is failing or is contributing to the *E. coli* loading in the watershed. This program should be developed by the local working group.

The Information and Education Strategy for the Fremont River consists of six main action items:

- Develop a local workgroup that helps inform local landowners, state and federal agencies, and environmental groups on pertinent issues within the watershed.
- Work with the Fremont River Conservation District to hold an education event with local landowners to inform them of the problems that exist, potential solutions, and entities that can provide technical and financial assistance.
- Implement demonstration projects that show local landowners the benefits of improved grazing management and relocation of feedlots away from the river.
- Develop an education campaign addressing the need for septic inspection and maintenance.
- Develop an incentive program to help landowners pay for the inspection and maintenance of their septic systems.
- Develop an education campaign addressing proper disposal of human waste on public lands in the watershed.
- Continue the Capitol Reef National Park Leave No Trace education program including the component on proper disposal of waste.

7.5 Implementation Cost and Technical Assistance

Implementation of nonpoint source projects is voluntary. The ability to correct the issues encountered will depend on the willingness of homeowners and producers to implement the recommended practices. A Project Implementation Plan will be developed that highlights the funding needs once individual projects and willing partners are identified. To fully fund all of the projects needed to achieve the required E. coli load reduction, it will be necessary to obtain funding from other partner agencies. Table 23 shows potential agencies that could contribute funding or resources to the implementation effort.

Table 23. Potential funding opportunities for nonpoint source projects

Entity	Grant program
Utah Division of Water Quality	Section 319 Grant Funding, Utah Nonpoint Source Pollution Grants
Natural Resource Conservation Service	Environmental Quality Incentives Program, National Water Quality Initiative Program
Utah Department of Agriculture and Food	Utah Conservation Commission Grants, Grazing Improvement Program Grants
Utah Department of Natural Resources	Watershed Restoration Initiative

Technical assistance will be needed in addition to funding for actual project implementation to ensure projects are properly planned and installed. This assistance can include soliciting grant funding, working with landowners to identify proper practices, obtaining proper permits, and writing reports highlighting the restoration activities. In general, much of this technical assistance will be provided by DWQ, NRCS, or UDAF employees, but in some instances, contractors may be required to develop designs or other critical planning components. The cost of this assistance should be calculated when determining the cost to implement this TMDL.

7.6 Implementation Schedule and Milestones

A schedule with milestones is a key element to any plan. These milestones should clearly identify activities and timelines to ensure transparency and help agencies plan ahead with funding proposals and reporting.

Table 24. Implementation schedule and milestones

Activity	Milestones	Agency Responsible	Timeline
Develop Local Watershed Group		UDWQ	2020
Begin project monitoring	Sampling Analysis Plan developed in coordination with the Local Working Group	DWQ with assistance from USU Extension, UDAF, and CRNP	Ongoing through recreation seasons. TBD for specific projects
Septic System Loading	Work with the local watershed group to develop an information and education strategy about the importance of septic inspections and maintenance.	DWQ, local watershed coordinator, or UDAF	Ongoing beginning in 2020
	Obtain funding for septic outreach campaign		Submit NPS application to DWQ Spring 2021
	Implement septic outreach campaign with the goal of having at least 10 septic systems inspected and maintained annually		Ongoing beginning in 2020
	Capitol Reef National Park septic system upgrade	CRNP	Planned for 2020
Feedlot Improvements	Identify landowners willing to relocate or make corrections to existing feedlots.	DWQ,UDAF, Local Conservation District	Ongoing beginning in 2020

	Solicit funding for Phase 2 of the Fremont River Implementation Project	Local Conservation District	Submit NPS application to DWQ Spring 2021
	Address runoff issues from feedlots in the Fremont River Watershed	DWQ, UDAF, Local Conservation District	Ongoing as funding is available
Grazing and Irrigation Water Management	Identify landowners (both public and private) willing to implement BMPs that will limit cattle access and improve grazing and/or flood irrigation practices along the Fremont River and tributaries	DWQ,UDAF, USFS, BLM, SITLA, Local Conservation District	Ongoing beginning in 2020
	Solicit funding for Phase 3 of the Fremont River TMDL Implementation plan	Local Conservation District	Submit NPS application to DWQ Spring 2021
	Reduce *E. coli* loading into the Fremont River and tributaries by installing grazing and irrigation related practices where necessary	DWQ, UDAF, USFS, BLM, SITLA, Local Conservation District	Ongoing as funding is available
Ongoing: Evaluation of Watershed Plan/TMDL	All interested stakeholders		Every 5 years beginning in 2025

8.0 FUTURE MONITORING

Follow-up monitoring is required to ensure implementation efforts result in the attainment of water-quality standards. DWQ, in collaboration with other stakeholders, will continue to collect *E. coli* samples when and where appropriate to evaluate the effectiveness of pollution-control efforts.

E. coli monitoring will continue at established monitoring locations. Sites previously identified as impaired on the Utah 303(d) list will be monitored until full-support status is reached in order for the AU to be delisted for *E. coli*. Those sites include:

- 4954390: Fremont River at U12 Crossing
- 4954480: Fremont River at Campground in Fruita

After the 2018/2020 Integrated Report is released these sites will also include:

- 4955310: Spring Creek at U24 Crossing
- 4955330: Fremont River at Big Rocks Rd

Ideally, samples can be collected twice per month throughout the recreation season so results can be compared to the recreation season geo-mean standard, which requires 10 or more samples collected between May and October (See Appendix A for specific assessment scenarios). This effort will depend on available resources, specifically monitoring staff availability, for collecting samples at that increased frequency.

Many pathogen studies include a microbial source tracking (MST) component to determine through genetic analysis the sources of bacteria in the river. MST techniques can often help determine if the source is human, wildlife, or domestic animals. Microbial source tracking monitoring will be a priority in this watershed. Ideally, samples could be collected during multiple flow regimes including spring runoff, precipitation events, and base-flow conditions. MST analysis is expensive, so stakeholders will have to develop the most efficient strategy to collect this type of data.

9.0 PUBLIC INVOLVEMENT

Stakeholder participation for this TMDL process was achieved through meetings and site visits with state and federal agency representatives and local landowners. Fremont River stakeholders include:

- Utah Division of Water Quality
- Utah Department of Agriculture and Food
- Fremont River Conservation District

- Capitol Reef National Park
- Utah State University Extension
- Bureau of Land Management
- US Forest Service
- Central Utah Health Department
- Natural Resources Conservation Service
- Private landowners

A TMDL kickoff meeting was held on August 29, 2018, at the Bicknell Community Center. DWQ water quality assessments and TMDL basics were discussed, as well as the specifics of the Fremont River *E. coli* impairment. The draft TMDL was presented virtually to stakeholders April 27, 2020 and emailed to them for their review and feedback.

Several site visits, monitoring runs, and watershed tours were conducted between 2017 and 2020 to help with development of this study. Some were with agency staff and others were with local landowners. An article discussing the kickoff meeting and TMDL process was posted in The Insider newspaper on September 6, 2018. This publication serves Wayne and Garfield counties.

Stakeholders were given the opportunity to provide feedback on the TMDL as part of the initial review process, as well as during rulemaking when the study is posted for a 30-day public review.

REFERENCES

Barcina, I. J.;Gonzalez, M.; Iriberri, J.; Egea L. (1990) Survival Strategies of *Escherichia coli* and *Enterococcus faecalis* in Illuminated fresh and Marine systems. *J. Appl. Bacter*. **68**,189-198.

Benham, B.L.; Baffaut, C.; Zeckoski, R.W.; Mankin, K.R.; Pachepsky, Y.A.; Sadeghi, A.M.; Brannan, K.M.; Soupir, M.L.; Habersack, M.J. (2006) Modeling Bacteria Fate and Transport in Watersheds to Support TMDLs. *Transactions of the ASABE*. **49**(4):987-1002.

Chronic, Halka. 1990. *Roadside Geology of Utah*. Mountain Press Publishing Company: Missoula, Montana.

Colorado Department of Public Health and Environment. March 13, 2019. Template for Developing a Total Maximum Daily Load Assessment in Colorado.

Easton, J. H.; Gauthier J. J.; Lalor, M.; Pitt, R. E. (2005) Die-off of Pathogenic *E. coli* in Sewage Contaminated Waters. *AWRA Journal of the American Water Resources Association*, **41**, 1187-1193.

Environmental Protection Agency. 2012 Recreational Water Qulaity Criteria. https://www.epa.gov/sites/production/files/2015-10/documents/rwqc2012.pdf

Environmental Protection Agency. 2017 New Homebuyers Guide to Septic Systems
https://www.epa.gov/sites/production/files/2017-08/documents/170803-homebuyerssepticguide_508c.pdf

Environmental Protection Agency. 2018 Septic Systems Overview
https://www.epa.gov/septic/septic-systems-overview

Francy, D.S., D. Myers , and K.D. Metzker (1993) Escherichia coli and fecal-coliform bacteria as indicators of recreational water quality. Water-Resources Investigations Report 93-4083

Hackbarth, C., and R. Weissinger. 2018. Escherichia coli concentrations in Fremont River tributaries at Capitol Reef National Park, 2008–2017. Natural Resource Report NPS/NCPN/ NRR—2018/1698. National Park Service, Fort Collins, Colorado.

Jamieson, R. C.; Joy, D. M.; Lee, H.; Kostaschuk, R.; Gordon, R. J. (2004) Persistence of Enteric Bacteria in Alluvial Streams. *J. Environ. Eng. Sci.*, **3**, 203–212.

Kistemann, T.; ClaBen, T.; Koch, C.; Dangerndorf, F.; Fischeder, R.; Gebel, J.; Vacata V.; Exner, M. (2002) Microbial Load of Drinking Water Reservoir Tributaries during Extreme Rainfall and Runoff. *Appl. Environ. Microbiology.*, **68**, 2188-2197

Kolpin, et al. 2002. Pharmaceuticals, hormones, and other organic wastewater contaminants in U.S. streams, 1999-2000: a national reconnaissance. Environmental Science and Technology. 2002 March 15; 36(6): 1202-11.

Leclerc, H.; Mossel, D. A. A.; Edberg, S. C.; Struijk, C. B. (2001) Advances in the Bacteriology of the Coliform Group: Their Suitability as Markers of Microbial Water Safety. *Annual Review of Microbiology*, **55**, 201-234.

Rose, J.B.; Sun, G.; Allen, C.P., and N.A. Sinclair. Microbial Quality and Persistence of Enteric Pathogens in Graywater from Various Household Sources. Journal of Water Resources, Volume 25, No 1. 1991.

U.S. Department of Agriculture. Natural Resources Conservation Service. 2019 Expanded Fremont River Watershed Coordinated Resource Management Plan. .

Utah Department of Environmental Quality, Division of Water Quality. Utah Bacteriological Monitoring Program: Bacteriological Standards. http://www.waterquality.utah.gov/Monitoring/Bac/methods.htm.
Utah Department of Environmental Quality, Division of Water Quality, 2013 Utah Nonpoint Source Pollution Management Plan, Appendix C, Utah Nonpoint Source Information and Education Strategy.

Utah Department of Environmental Quality (2016) Utah's 2016 Integrated Report and 303(d) List of Impaired Waters. Department of Environmental Quality, Division of Water Quality, https://deq.utah.gov/ProgramsServices/programs/water/monitoring-reporting/assessment/docs/2016/chapter-3-river-and-stream-assessments-final2016ir-v2-1.pdf

Utah Division of Administrative Rules (2005) R317-2: Standards of Quality for Waters of the State. Utah State Bulletin, Vol. 2005, No. 1.

Utah Division of Administrative Rules (2005) R317-2: Standards of Quality for Waters of the State. Utah Administrative Code: Effective February 1, 2006. http:/./www.rules.utah.gov/publicat/code/r317/r317-002.htm#T15.

Utah Division of Wildlife Resources. 2017. Utah Big Game Annual Report. Publication No. 18-21.

World Health Organization (WHO). 2001. Water Quality: Guidelines, Standards and Health. Edited by Lorna Fewtrell and Jamie Bartram. Published by IWA Publishing, London, UK.

Zeckoski, R. W., Benham, B. L., Shah, S. B., Wolfe, M. L., Brannan, K. M., Al-Smadi, M., Dillaha, T. A., Mostaghimi, S., and C.D. Heatwole. 2005. BSLC: A Tool for Bacteria Source Characterization for Watershed Management. American Society of Agricultural Engineers ISSN 0883-8542. Vol. 21(5): 879-889.

Appendix A: Utah Division of Water Quality Listing Methodology for *E. coli*

Surface waters designated for 2A recreational use in Utah are assessed for *E. coli* using the water quality standards (Table 3) and the assessment methodology presented below.

The following rules provide an interpretation of Utah's *E. coli* criteria based on the number of samples collected during the most recent six years of sampling. AUs that fail to meet any of these criteria will be included on Utah's 303(d) list of impaired waters. However, exceptions may be made to these rules if a single collection event represents an outlier that biases results.

Scenario A: Seasonal assessment against maximum criterion

For each AU with ≥5 collection events in any recreation season, no more than 10% of samples collected from May 1st through October 30th may exceed 409 MPN/100 mL for 2A waters or 668 MPN/100 mL for 1C/2B waters throughout the most recent six years.

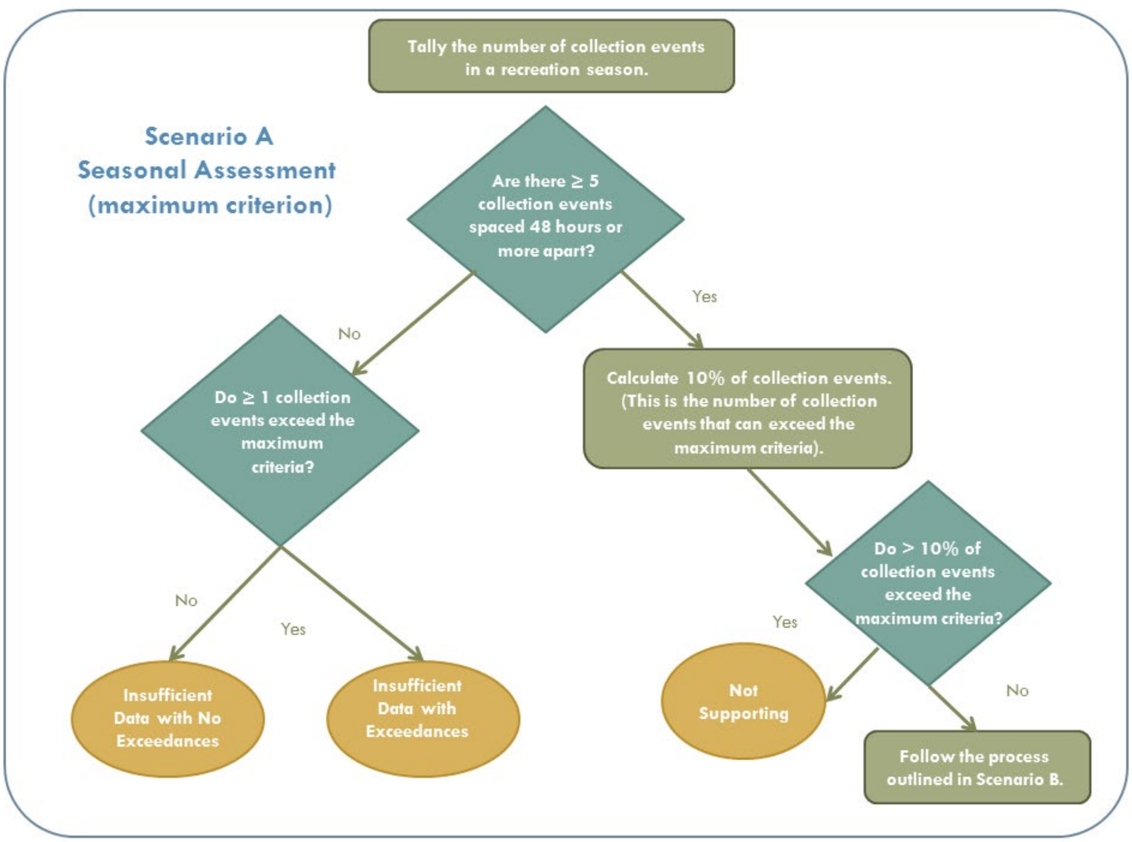


Figure 42. Seasonal assessment against maximum criterion

If less than 10 percent of collection events exceed the maximum criterion, the site is then assessed using the 30-day geometric mean criterion (Figure 4). There must be a minimum of five collection events in 30 days, with at least 48 hours between collection events, to assess against the 30-day geometric mean criterion directly. This ensures that collection events are adequately spaced and are representative of ambient conditions.

Scenario B: 30-day geometric mean assessment

For each AU with ≥5 collection events in any recreation season, no 30-day interval geometric means should exceed 126 MPN/100 mL for 2A waters or 206 MPN/100 mL for 1C/2B waters throughout the most recent six years.

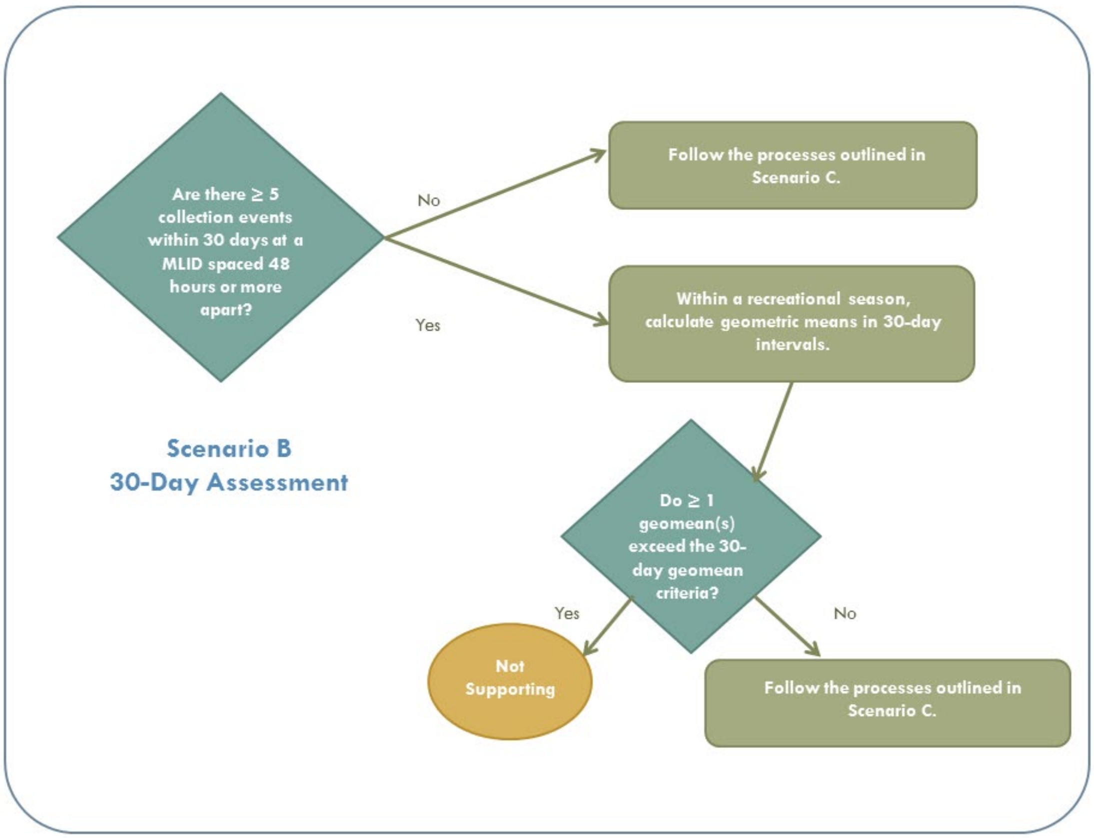


Figure 43. 30-day assessment against geometric mean

If adequate (at least five samples) and/or representative data spaced apart by at least 48 hours are not available to assess against the 30-day geometric mean, DWQ will assess *E. coli* data for the recreation season provided there are at least five collection events during the season (May - October). Exceedances of the geometric mean criterion will result in the site being classified either as impaired (minimum of 10 collection events in a recreation season) or as insufficient data (sample size is more than five but less than 10).

Scenario C: Seasonal geometric mean assessment

For each AU with ≥10 collection events in any recreation season, the geometric mean of all samples should not exceed 126 MPN/100 mL for 2A waters or 206 MPN/100 mL for 1C/2B waters throughout the most recent six years of recreation seasons.

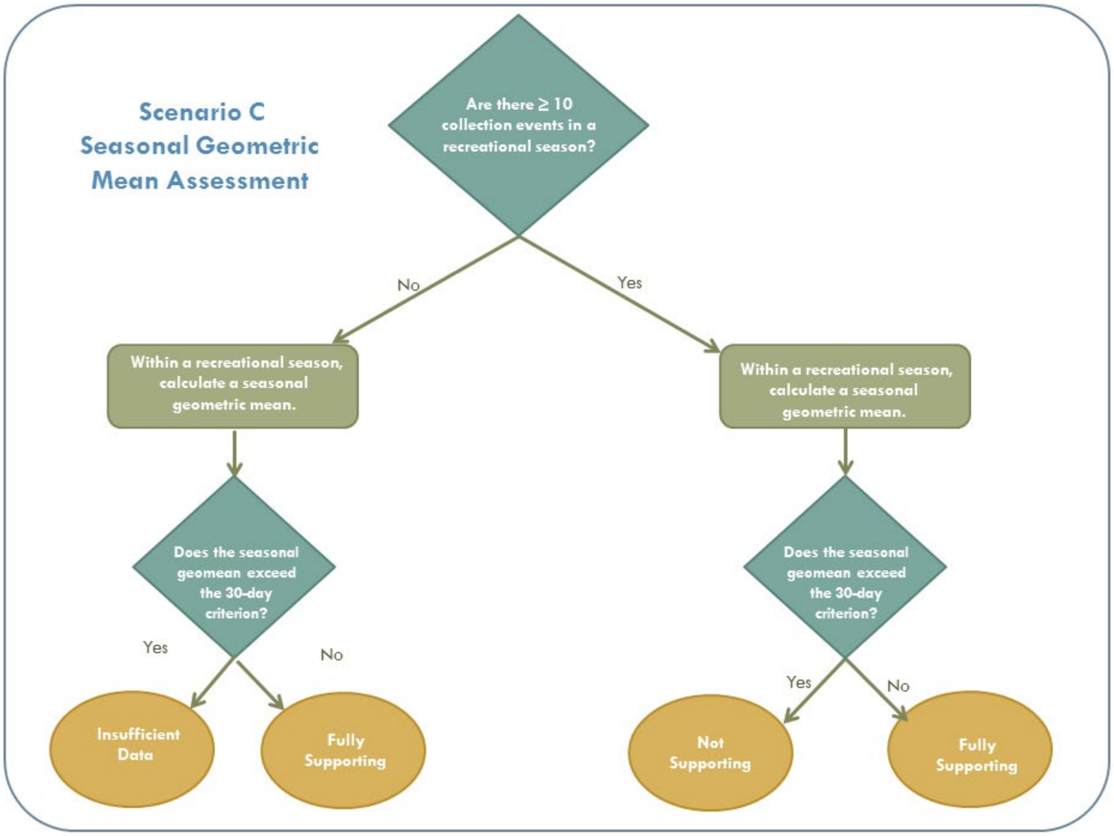


Figure 44. Seasonal geometric mean assessment

AUs with <5 samples in any recreation season will not be assessed for support of recreation uses. These sites will be prioritized for future sampling, particularly if limited data suggest a problem exists in the waterbody.

Sample collection and laboratory analysis are performed as prescribed in the approved DWQ protocols, which are consistent with EPA guidelines. All persons conducting sampling or analysis receive annual training by DWQ personnel. Replicates were collected for most of the Fremont River *E. coli* collection events. The geometric mean of samples is used to represent a single collection event for those results. Field blanks were also collected on each sampling run per DWQ monitoring protocol.

Assessment of Recreational and Drinking Water Uses

When determining the use attainment of a monitoring location with sampling results across multiple years, the following rules are applied in the following order.

Not Supporting (Category 5)

A waterbody is considered to be impaired (not meeting its designated beneficial uses) if any of the following conditions exist:

- A lake or reservoir with two or more posted health advisories or beach closures during any recreation season.
- Any monitoring location where *E. coli* concentrations from 10% or more of the collection events exceed the maximum criterion.
- Any monitoring location where the 30-day geometric mean exceeds the 30-day geometric mean criterion (minimum five collection events with at least 48 hours between collection events).
- Any monitoring location where the recreational season (May - October) geometric mean exceeds the 30-day geometric mean criterion (minimum of 10 collection events).

Insufficient Data or Information Assessment Considerations (Category 3A)

Sites with four or fewer samples in all seasons evaluated will be listed as not assessed, provided impairment is not suggested by a posted health advisory or beach closure. This applies to lakes and reservoirs only. All Category 3A sites will be prioritized for future monitoring, especially if limited data suggest impairment.

Fully Supporting (Category 1 or 2)

No evidence of impairment by any assessment approach for all recreation seasons over the most recent six years. A fully supporting determination can be made with a minimum of five collection events during the recreational season.

Appendix B: Bureau of Land Management Grazing Allotment Tables

(Information provided by Paul Caso, BLM Range Staff, email correspondence with DWQ on January 15, 2020)

Table 25: Bureau of Land Management grazing allotments in the Fremont River watershed

Allotment Name & Number	Public Acres	Livestock Number & Kind	Days in rec season	Start Date	End Date	Aums	% PL	Susp. AUMs
Bicknell (00700)	1,772	20 C	-	11/16	01/17	41	100	18
		28 C	-	11/01	01/15	32	46	88
		6 C	-	11/01	01/15	15	100	44
Bicknell Spring (00701)	26,559	175 S	34	05/22	06/30	19	41	
		175 S	46	09/16	10/31	22	41	
		200 S	34	05/22	06/30	7	14	
		200 S	46	09/16	10/31	25	41	
		200 S	34	05/22	06/30	22	41	
		200 S	46	09/16	10/31	25	41	
		100 S	36	05/16	06/20	5	19	
		100 S	39	09/16	10/25	5	19	
		128 C	15	05/16	06/01	64	90	
		510 S	43	05/18	06/30	60	41	
		510 S	46	09/16	10/31	63	41	
		62 C	30	05/16	06/15	42	67	
		50 C	30	05/16	06/15	51	100	
		290 C	30	05/16	06/15	248	84	
		69 C	30	05/16	06/15	70	100	
		13 C	15	06/16	06/30	6	100	
		69 C	30	05/16	06/15	70	100	
		13 C	14	06/16	06/30	6	100	
		94 C	30	05/16	06/15	96	100	
		13 C	14	06/16	06/30	6	100	
		311 S	34	05/22	06/30	43	52	
		311 S	46	09/16	10/31	49	52	
		1685 S	40	05/16	06/25	436	96	
		1685 S	58	09/04	10/31	617	96	
		22 C	31	05/16	06/16	23	100	
		1378 C	35	05/16	06/20	62	19	
		1378 C	31	09/14	10/14	53	19	
		95 C	30	05/16	06/15	65	67	
Bicknell Winter (00702)	25,447	175 C	-	11/01	01/09	70	87	
		200 S	-	11/01	01/09	43	47	
		200 S	-	11/01	01/09	92	100	

Allotment Name & Number	Public Acres	Livestock Number & Kind	Days in rec season	Start Date	End Date	Aums	% PL	Susp. AUMs
		27 C	60	09/01	11/30	81	100	
		100 S	-	11/01	02/28	79	100	
		34 C	45	09/01	10/15	49	98	
		32 C	-	04/16	04/30	16	100	
		56 C	16	04/16	05/16	57	100	
		118 C	15	04/26	05/15	76	98	
		137 S	-	12/01	02/28	81	100	
		20 C	-	12/01	03/31	80	100	
		104 C	15	04/26	05/15	47	69	
		127 C	60	09/01	10/30	238	95	
		221 C	15	04/15	05/15	203	90	
		72 C	15	04/16	05/15	71	100	
		72 C	15	04/16	05/15	71	100	
		100 C	15	04/16	05/15	99	100	
		215 S	-	11/01	01/10	87	87	
		871 S	-	11/01	01/09	381	95	
		36 C	16	04/15	05/16	38	100	
		99 C	15	05/01	05/15	48	98	
		20 C	60	09/01	02/28	119	100	
		2 C	60	09/01	01/01	8	100	
Cedar Grove (00705)	105,989	17 C	21	05/10	05/31	3	23	1
		82 C	46	05/16	06/30	29	23	43
		675 S	36	05/26	06/30	37	23	
		17 C	21	05/10	05/31	3	23	4
		12 C	20	05/10	05/30	5	23	
		171 C	52	05/10	06/30	67	23	51
		165 S	36	05/26	06/30	9	23	
		960 S	30	10/01	01/15	155	23	
		17 C	16	05/14	05/30	10	100	
		1340 S	36	05/26	06/30	73	23	19
		948 S	30	10/01	01/15	153	23	
Cyclone (00708)	5,235	6 C	30	05/01	05/31	6	100	
		52 C	30	05/01	05/30	9	17	
		36 C	31	05/01	05/31	7	19	

Allotment Name & Number	Public Acres	Livestock Number & Kind	Days in rec season	Start Date	End Date	Aums	% PL	Susp. AUMs
		58 C	31	05/01	05/31	17	29	
		48 C	31	05/01	05/31	10	21	
		205 C	31	05/01	05/31	36	17	
		977 S	21	10/11	12/07	71	19	
		977 S	37	05/16	06/21	45	19	
		600 S	-	01/05	02/22	193	100	
		16 C	31	05/01	05/31	3	19	
		60 C	31	05/01	05/31	9	15	
		77 S	31	10/01	11/18	15	60	
		63 C	31	05/01	05/31	12	19	
		83 C	31	05/01	05/31	15	18	
Government Creek (00713)	1,832	152 S	-	12/01	02/28	91	100	
Hector Hollow (00716)	1,955	41 C	31	05/01	05/31	42	100	
		37 C	31	05/01	05/31	38	100	
		99 S	-	11/16	02/12	58	100	
Horse Pasture (00717)	467	14 C	-	11/01	11/30	14	100	26
Lime Kiln (00720)	2,927	51 S	-	11/16	01/15	20	100	
		95 S	-	11/15	02/09	54	100	
		28 S	-	11/15	02/09	16	100	
		225 S	-	12/01	02/15	114	100	
		116 S	-	11/01	02/10	78	100	
		119 S	-	11/16	02/15	72	100	
Loa Winter (00721)	19,266	175 S	-	01/10	02/10	30	81	5
		200 S	-	01/10	02/10	34	81	9
		200 S	-	01/10	02/10	42	100	12
		275 S	-	11/10	01/03	99	100	68
		181 S	-	11/12	01/11	73	100	
		194 S	-	12/01	01/31	79	100	15
		195 S	-	01/10	02/10	33	81	
		130 C	-	11/01	12/17	181	90	72
		157 S	-	01/11	02/20	34	81	11
		730 S	-	01/01	01/31	119	80	32
		127 S	-	11/01	12/31	51	100	19
Lyman (00723)	2,020	279 S	-	10/01	11/11	77	100	

Allotment Name & Number	Public Acres	Livestock Number & Kind	Days in rec season	Start Date	End Date	Aums	% PL	Susp. AUMs
		47 C	-	12/01	12/31	48	100	48
Neff Ranch (00725)	1,602	128 S	-	01/07	02/28	45	100	62
		70 C	10	04/25	05/10	37	100	70
North Fremont (00726)	4,036	970 S	-	01/10	02/14	230	100	
Post Hollow (00727)	1,318	200 S	-	01/12	01/18	5	56	
		969 S	-	12/08	01/09	130	62	
		977 S	12	05/03	05/15	52	62	
		290 S	-	11/01	02/28	137	60	5
Sand Wash (00730)	676	41 C	-	01/01	01/24	32	100	21
Seven Mile (00731)	17,333	70 C	19	05/11	05/30	46	100	2
		87 C	19	05/11	05/30	53	93	2
		87 C	20	05/11	05/31	56	93	
		93 C	19	05/11	05/30	57	93	17
		101 C	19	05/11	05/30	62	93	
		27 C	19	05/11	05/30	17	93	22
		73 C	19	05/11	05/30	45	93	8
		62 C	19	05/11	05/30	38	93	
		111 C	19	05/11	05/30	68	93	3
		59 C	19	05/11	05/31	38	93	2
		46 C	19	05/11	05/30	28	93	5
		91 C	19	05/11	05/30	56	93	27
		28 C	19	05/11	05/30	17	93	
		178 C	20	05/11	05/31	123	100	
Teasdale Bench (00736)	1,118	20 C	-	11/01	11/30	20	100	
West Fremont (00742)	1,429	100 S	-	12/01	02/28	59	100	82
		16 C	-	01/10	02/15	19	100	

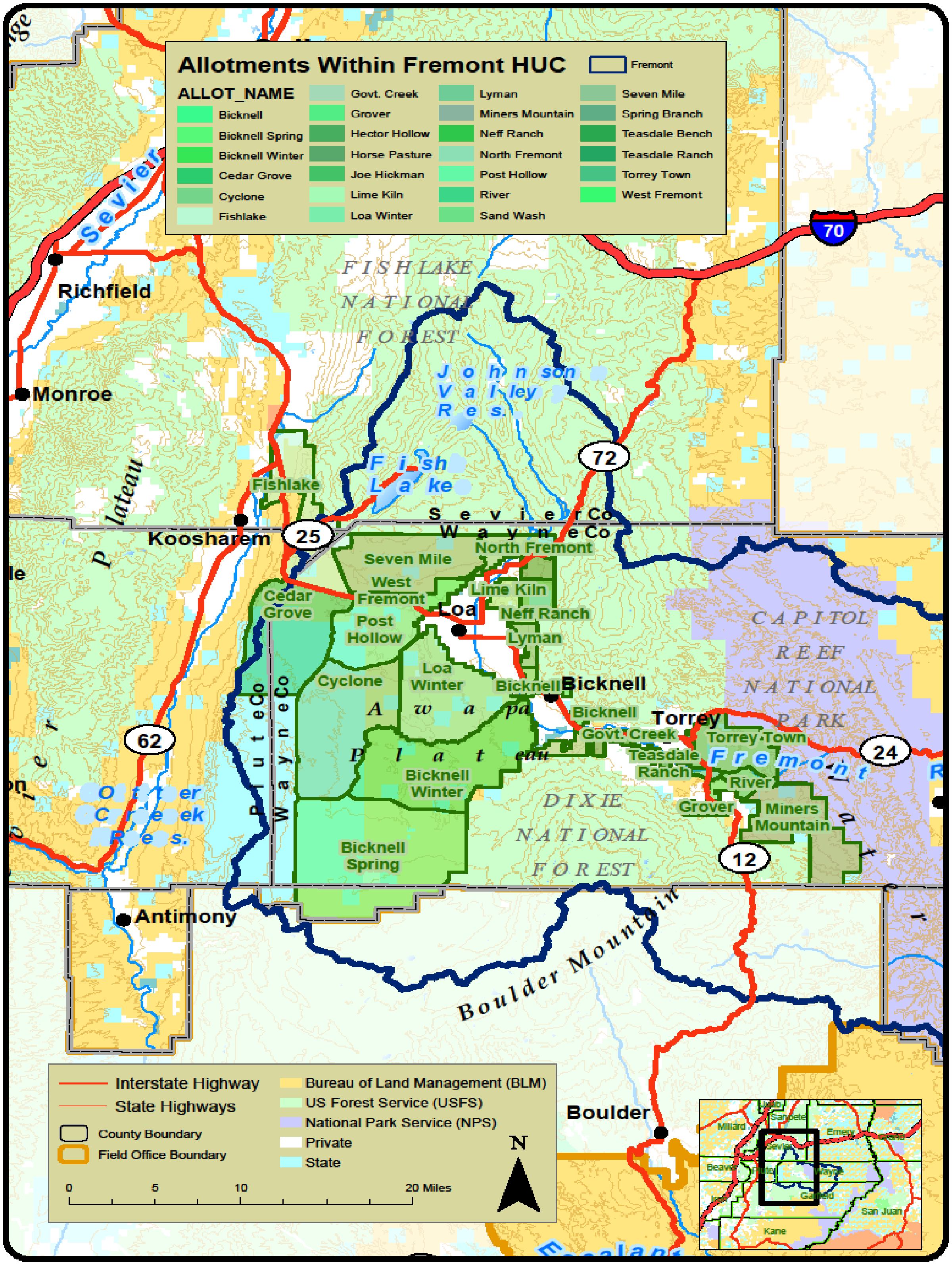


Figure 45. Map of BLM grazing allotments in the Fremont River watershed

Appendix C: SITLA Grazing Allotment Tables

(Information provided by Slate Stewart, Resource Specialist, email correspondence with DWQ on January 3, 2020)

Table 26: SITLA grazing allotments in the Fremont River watershed

Allotment Number	Acres	Total AUMs	Area	Season of Use	Animal Type
21198-E12	640	14	Loa	15 May - 15 Jun.	Cattle
21971-17	383	32	Bicknell	1 Oct. - 31 Jan.	Sheep
20420-00	67,093	6913	Bicknell	1 Jun. - 15 Oct.	Cattle
20608-10	3519	10	Bicknell (41% Inside watershed)	1 May - 31 May	Cattle
20608-10	3519	28	West & East of Capital Reef	1 Nov. - 31 May	Cattle
20608-A10	3519	10	West & East of Capital Reef	1 May - 31 May	Cattle
20608-A10	3519	28	West & East of Capital Reef	1 Nov. - 31 May	Cattle
20608-B10	3519	28	West & East of Capital	1 Nov. - 31 May	Cattle

			Reef		
20608-B10	3519	10	West & East of Capital Reef	1 May - 31 May	Cattle
21165-13	640	39	Bicknell	1 Nov. - 15 May	Sheep
21626-16	550	46	Pine Creek	15 Apr. - 15 May & 15 Oct. -15 Nov.	Cattle
22483-B11	2960	42	Pine Creek	1 Nov. - 1 Jan.	Sheep
22483-D11	2960	94	Pine Creek	15 Apr. - 15 Jun.	Cattle
22483-F12	3170	9	Pine Creek	16 Apr. - 15 May	Cattle
22483-G12	3170	10	Pine Creek	15 Apr. - 15 Jun.	Cattle
22535-10	480	15	Teasdale	1 Jan. - 31 Dec.	Cattle
22633-11	1312	30	Teasdale	21 Mar. - 21 Jun.	Sheep
22633-A11	1312	15	Bicknell	15 Jan. - 15 Feb.	Sheep
23000-11	1279	152	Pine Creek	1 Nov. - 31	Cattle

				May	
23295-13	120	11	Teasdale	1 Dec. - 15 May	Cattle

Appendix D: US Forest Service Grazing Allotments in Fremont River Watershed

Table 27: US Forest Service grazing allotments in the Fremont River watershed

	Allotment	Animal Numbers	AU	Season of Use	Percent in Watershed
Out of Study Area (Upper Watershed)	Hancock	1300 Sheep	3975	07/15 to 10/15	61.3% Upper Fremont River
	Daniels	25 Cattle	1694	07/01 to 09/30	4.3 % Upper Fremont River
	Seven Mile	1129 Cattle	5193	06/01 to 10/16	100% Upper Fremont River
	UM	815 Cattle	3749	06/01 to 10/16	99.7% Upper Fremont River
	Tidwell	670 Cattle	3417	06/01 to 10/31	90.3% Upper Fremont River
	Pin	614 Cattle	2906	06/01 to 10/20	0.9% Upper Fremont River
	Solomon	408 Cattle	2081	06/01 to 10/31	31.2% Upper Fremont River
Within Study Area	Thousand Lake	406 Cattle	1854	06/01 to 10/15	90.6% with 1/3 in the Upper Fremont River
	Dark Valley	1107 Cattle	4428	06/16 to 10/15	82.3% Upper Fremont River
	North Slope	275 Cattle	1182	06/06 to 10/15	100% Lower Fremont River
	Government Point	1393 Sheep	399	7/15 to 8/28	100% Lower Fremont River
	Surveyor's	1412 Sheep	424	7/16 to 09/01	83.4% Lower Fremont River
	Donkey Meadows	1387 Sheep	416	07/19 to 09/03	55.4 % Lower Fremont River
	Pleasant Creek	614 Cattle	2766	06/01 to 10/15	85.0% Lower Fremont River
	Oak Creek	1078 Cattle	4856	06/01 to 10/15	45.7% Lower Fremont River

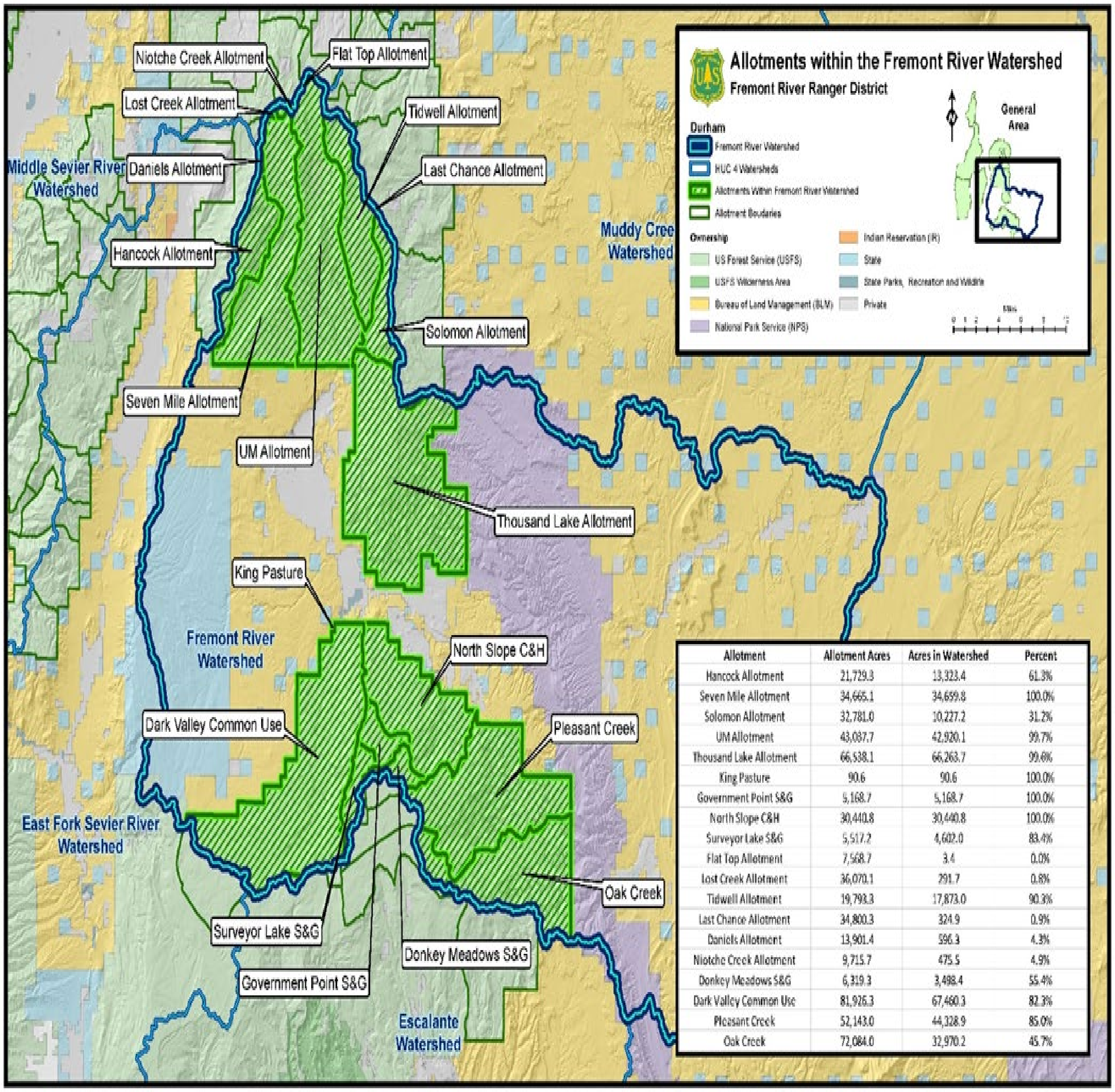


Figure 46. Map of current livestock grazing AUMs on Forest Service listed by allotment

Appendix E: U.S Fish and Wildlife Service List of Threatened and Endangered Species for Wayne County

(Source: USFWS website, August 2019)

Table 28: U.S Fish and Wildlife Service list of threatened and endangered species for Wayne County, UT

Group	Name	Status	Recovery Plan
Birds	California condor (*Gymnogyps californianus*)	Experimental Population, Non-Essential*	
	Yellow-billed Cuckoo (*Coccyzus americanus*)	Threatened	
	Mexican spotted owl (*Strix occidentalis lucida*)	Threatened	Final Recovery Plan for the Mexican Spotted Owl, First Revision (Strix occidentalis lucida)
	Southwestern willow flycatcher (*Empidonax traillii extimus*)	Endangered	Final Recovery Plan for the Southwestern Willow Flycatcher
Fish	Humpback chub (*Gila cypha*)	Endangered	Humpback Chub - 1990 2nd Revised Final Plan
	Colorado pikeminnow (*Ptychocheilus lucius*)	Endangered	Colorado Pikeminnow (Ptychocheilus lucius) Recovery Plan (Amendment and Supplement

			for Recovery Goals)
	Bonytail (*Gila elegans*)	Endangered	Bonytail Chub Revised Recovery Plan Goals
	Razorback sucker (*Xyrauchen texanus*)	Endangered	Razorback Sucker - Recovery Goals
Flowering Plants	Maguire daisy (*Erigeron maguirei*)	Recovery	Maguire Daisy (Erigeron maguirei) Recovery Plan
	Wright fishhook cactus (*Sclerocactus wrightiae*)	Endangered	Wright Fishhook Cactus
	Last Chance townsendia (*Townsendia aprica*)	Threatened	Last Chance Townsendia
	San Rafael cactus (*Pediocactus despainii*)	Endangered	Winkler cactus (Pediocactus winkleri) and San Rafael cactus (Pediocactus despainii)
	Winkler cactus (*Pediocactus winkleri*)	Threatened	Winkler cactus (Pediocactus winkleri) and San Rafael cactus (Pediocactus despainii)
	Barneby reed-mustard (*Schoenocrambe barnebyi*)	Endangered	Utah Reed-Mustards (3 spp.)

	Ute ladies'-tresses (*Spiranthes diluvialis*)	Threatened	Ute Ladies'-Tresses Draft Recovery Plan
Mammals	Utah prairie dog (*Cynomys parvidens*)	Threatened	Utah Prairie Dog (Cynomys parvidens) Revised Recovery Plan

*On the basis of the best available information, the experimental population is not essential for the continued existence of the species.

Appendix F: Measured and modeled flow values used for loading calculations

Fremont River at Big Rocks Road				
4955330				
Date	**Measured Ecoli**	**USGS Flow (cfs)**	**Modeled Flows (cfs)**	**Observed Flows (cfs)**
1/26/2016	82.04	70.90	12.39	No flow measured
3/30/2016	51.94	76.10	15.31	No flow measured
4/29/2016	500.61	87.60	21.76	No flow measured
5/30/2016	23.29	65.90	9.58	No flow measured
6/30/2016	1367.08	62.40	7.62	No flow measured
7/29/2016	517.13	55.60	3.80	No flow measured
8/29/2016	290.93	66.00	9.64	No flow measured
9/27/2016	474.12	67.40	10.42	No flow measured
10/29/2016	178.21	67.20	10.31	No flow measured
12/12/2016	26.21	74.00	14.13	No flow measured
1/11/2017	276.89	80.30	17.66	No flow measured
3/23/2017	1756.40	75.60	15.03	No flow measured
4/27/2017	818.19	63.30	8.12	No flow measured
5/25/2017	108.27	51.70	1.61	No flow measured
7/19/2017	2047.64	49.80	0.55	0.922
8/30/2017	96.16	57.00	4.59	No flow measured
9/13/2017	112.83	64.90	9.02	No flow measured
11/7/2017	79.40	63.10	8.01	No flow measured
12/11/2017	119.83	61.60	7.17	No flow measured
1/4/2018	113.82	70.40	12.11	No flow measured
2/7/2018	112.93	76.10	15.31	15.6
3/13/2018	219.03	74.10	14.18	No flow measured
4/10/2018	166.59	71.20	12.56	No flow measured
5/8/2018	43.31	63.30	8.12	4.39
6/7/2018	1012.78	48.10	-0.41	1.315
7/11/2018	921.66	52.60	2.12	0.862
8/8/2018	2419.60	51.10	1.28	0.2186
9/20/2018	86.25	51.80	1.67	No flow measured
10/17/2018	1012.78	64.50	8.80	8.6498
11/27/2018	248.09	63.60	8.29	12.1199
12/11/2018	144.02	71.30	12.61	No flow measured

Fremont River at U12 Crossing				
4954390				
Date	**Measured Ecoli**	**USGS Flow (cfs)**	**Modeled Flows (cfs)**	**Observed Flows (cfs)**
8/22/2008	160.71	49.20	26.78	No flow measured
10/11/2008	24.05	60.70	47.30	No flow measured
11/18/2008	49.54	71.60	66.75	No flow measured
1/17/2009	9.60	78.50	79.07	No flow measured
3/13/2009	5.21	80.40	82.46	No flow measured
4/11/2009	1.00	73.10	69.43	No flow measured
5/2/2009	43.21	75.00	72.82	No flow measured
7/14/2009	461.00	49.40	27.14	No flow measured
8/15/2009	161.62	49.20	26.78	No flow measured
9/21/2009	150.01	57.00	40.70	No flow measured
10/10/2009	27.85	60.00	46.05	No flow measured
11/5/2009	57.31	67.50	59.44	No flow measured
12/10/2009	16.13	53.90	35.17	No flow measured
5/14/2010	34.51	67.60	59.62	No flow measured
6/13/2010	435.17	54.50	36.24	No flow measured
7/7/2010	435.17	49.60	27.49	No flow measured
7/15/2010	435.17	50.20	28.56	No flow measured
7/26/2010	387.32	52.20	32.13	No flow measured
8/2/2010	517.21	55.60	38.20	No flow measured
8/11/2010	726.99	57.30	41.23	No flow measured
8/23/2010	218.72	52.50	32.67	No flow measured
8/31/2010	113.70	55.00	37.13	No flow measured
9/9/2010	51.22	56.00	38.91	No flow measured
9/13/2010	121.12	55.30	37.67	No flow measured
9/21/2010	137.35	52.50	32.67	No flow measured
10/22/2010	248.09	74.90	72.64	No flow measured
11/18/2010	4.13	75.90	74.43	No flow measured
12/10/2010	17.31	81.40	84.24	No flow measured
3/11/2011	10.78	87.90	95.84	No flow measured
6/23/2011	174.39	62.60	50.69	No flow measured
7/14/2011	601.55	71.00	65.68	No flow measured
7/29/2011	442.94	56.30	39.45	No flow measured
8/11/2011	402.56	52.40	32.49	No flow measured
8/30/2011	331.55	60.00	46.05	No flow measured
9/20/2011	234.33	81.00	83.53	No flow measured
5/18/2012	79.64	66.90	58.37	No flow measured
6/12/2012	128.05	57.50	41.59	No flow measured

Date	Measured Ecoli	USGS Flow (cfs)	Modeled Flows (cfs)	Observed Flows (cfs)
7/19/2012	90.54	58.00	42.48	No flow measured
8/16/2012	250.71	67.20	58.90	No flow measured
9/24/2012	124.81	70.00	63.90	No flow measured
6/5/2013	225.73	48.10	24.82	No flow measured
7/15/2013	903.30	53.20	33.92	No flow measured
8/7/2013	362.30	56.10	39.09	No flow measured
9/25/2013	2419.57	76.70	75.86	No flow measured
5/5/2014	27.05	59.50	45.16	No flow measured
6/6/2014	86.42	52.80	33.20	No flow measured
7/15/2014	775.36	47.30	23.39	No flow measured
8/11/2014	291.21	51.60	31.06	No flow measured
9/17/2014	88.45	59.10	44.45	No flow measured
5/5/2015	56.23	65.30	55.51	No flow measured
6/1/2015	613.14	57.70	41.95	No flow measured
6/29/2015	668.00	48.60	25.71	No flow measured
9/10/2015	235.93	57.40	41.41	No flow measured
1/26/2016	12.81	70.90	65.51	No flow measured
3/30/2016	3.98	76.10	74.79	No flow measured
4/29/2016	64.45	87.60	95.31	No flow measured
5/30/2016	30.90	65.90	56.58	No flow measured
6/30/2016	355.37	62.40	50.34	No flow measured
7/29/2016	649.03	55.60	38.20	No flow measured
8/29/2016	48.17	66.00	56.76	No flow measured
9/27/2016	85.43	67.40	59.26	No flow measured
10/29/2016	39.49	67.20	58.90	No flow measured
12/12/2016	45.18	74.00	71.04	No flow measured
1/11/2017	24.22	80.30	82.28	No flow measured
3/23/2017	123.97	75.60	73.89	No flow measured
4/27/2017	42.08	63.30	51.94	20.1
5/25/2017	115.67	51.70	31.24	25.8
6/21/2017	217.79	48.90	26.24	40.2
7/19/2017	952.11	49.80	27.85	44.8
8/30/2017	233.32	57.00	40.70	No flow measured
9/13/2017	123.64	64.90	54.80	No flow measured
10/12/2017	105.42	63.60	52.48	42.8
11/7/2017	78.45	63.10	51.59	70.4
12/11/2017	15.69	61.60	48.91	64.1
1/4/2018	21.32	70.40	64.61	74.3
2/7/2018	27.83	76.10	74.79	77.68

Date	Measured Ecoli	USGS Flow (cfs)	Modeled Flows (cfs)	Observed Flows (cfs)
3/13/2018	31.00	74.10	71.22	75.49
4/10/2018	63.16	71.20	66.04	No flow measured
5/8/2018	37.09	63.30	51.94	28.28
6/7/2018	231.37	48.10	24.82	25.34
7/11/2018	1565.13	52.60	32.85	23.21
8/8/2018	225.77	51.10	30.17	22.94
9/20/2018	97.65	51.80	31.42	28.41
10/17/2018	102.00	64.50	54.08	39.5155
11/27/2018	45.11	63.60	52.48	70.0509
12/11/2018	58.85	71.30	66.22	71.3995