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Water Quality in the Northern Colorado Plateau Network

Water Years 2016–2018 (Revised with Cost Estimate)

Natural Resource Report NPS/NCPN/NRR—2020/2184



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ON THE COVER

Collecting water samples at Courthouse Wash, Arches National Park.
NPS/Rebecca Weissinger.

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Acronyms and Abbreviations

Park acronyms

ARCH:	Arches National Park
BLCA:	Black Canyon of the Gunnison National Park
BRCA:	Bryce Canyon National Park
CANY:	Canyonlands National Park
CARE:	Capitol Reef National Park
CURE:	Curecanti National Recreation Area
DINO:	Dinosaur National Monument
GOSP:	Golden Spike National Historical Park
HOVE:	Hovenweep National Monument
NABR:	Natural Bridges National Monument
TICA:	Timpanogos Cave National Monument
ZION:	Zion National Park

General acronyms and abbreviations

303(d):	Section 303(d) of Clean Water Act, requiring a reporting of waters not meeting criteria
ab:	above
bl:	below
BLM-WSA:	Bureau of Land Management Wilderness Study Area
bndry:	boundary
cfu:	colony-forming units
ck:	creek
cnfl:	confluence
CO:	Colorado
DO:	dissolved oxygen
E. coli:	*Escherichia coli* bacteria
EPA:	U.S. Environmental Protection Agency
H-dep:	hardness-dependent
Hwy:	highway
mg/L:	milligrams per liter
MPN:	most probable number
NPS:	National Park Service
NCPN:	Northern Colorado Plateau Network
NM:	national monument
NP:	national park
nr:	near
NRA:	national recreation area
NWQL:	National Water Quality Laboratory
OHV:	off-highway vehicle
Rd:	road
SEUG:	Southeast Utah Group (includes ARCH, CANY, HOVE, and NABR)
SOP:	standard operating procedure
TDS:	total dissolved solids
TMDL:	total maximum daily load
µg/L:	micrograms per liter
UT:	Utah
UDWQ:	Utah Division of Water Quality
USGS:	U.S. Geological Survey

Colorado Designated Beneficial Use Codes

Ag:	Agricultural use
ALCW1:	Aquatic life cold-water class 1
ALWW1:	Aquatic life warm-water class 1
ALWW2:	Aquatic life warm-water class 2
BlueMesa:	Blue Mesa Reservoir water-temperature standard
DWS:	Drinking-water supply
RecE:	Existing primary-contact recreation
RecU:	Undetermined-use recreation
Res:	Reservoir-specific aquatic life standards

Standards for assessed Colorado stream segments within Colorado park units

LC3:	Lower Colorado River basin segment 3 aquatic life standard
LG1:	Lower Gunnison River basin segment 1 aquatic life standard
LG4c:	Lower Gunnison River basin segment 4c aquatic life standard
LYG2:	Lower Yampa/Lower Green River basin segment 2 aquatic life standard
LYG19a:	Lower Yampa/Lower Green River basin segment 19a aquatic life standard
UG2:	Upper Gunnison River basin segment 2 aquatic life standard
UG14:	Upper Gunnison River basin segment 14 aquatic life standard
UG26:	Upper Gunnison River basin segment 26 aquatic life standard
UG29b:	Upper Gunnison River basin segment 29b aquatic life standard

Utah Designated Beneficial Use Codes

1C:	Drinking-water supply
2A:	Primary-contact recreation
2B:	Secondary-contact recreation
3A:	Cold-water game fish
3B:	Warm-water game fish
3C:	Non-game fish
4:	Agricultural use
NoCrk:	Zion National Park North Creek TDS standard

Executive Summary

Water-quality monitoring in National Park Service units of the Northern Colorado Plateau Network (NCPN) is made possible through partnerships between the National Park Service Inventory & Monitoring Division, individual park units, the U.S. Geological Survey, and the Utah Division of Water Quality. This report evaluates data from site visits at 62 different locations on streams, rivers, and reservoirs in or near ten NCPN park units between October 1, 2015 and September 30, 2018. Data are compared to state water-quality standards for the purpose of providing information to park managers about potential water-quality problems. The National Park Service does not determine the regulatory status of surface waters; state water quality agencies determine whether waters comply with the Clean Water Act.

Evaluation of water-quality parameters relative to state water-quality standards indicated that 17,997 (96.8%) of the 18,583 total designated beneficial-use evaluations completed for the period covered in this report met state water-quality standards (Figure A). The most common exceedances or indications of impairment, in order of abundance, were due to elevated nutrients, elevated bacteria (*E. coli*), elevated water temperature, elevated trace metals, elevated total dissolved solids (and sulfate), elevated pH, and low dissolved oxygen (Figure B).

While some exceedances were recurring and may have been caused by human activities in the watersheds, many were due to naturally occurring conditions characteristic of the geographic setting. This is most apparent with phosphorus, which can be introduced into surface water bodies at elevated levels by natural weathering of the geologic strata found throughout the Colorado Plateau. Higher phosphorus concentrations could also be attributed to anthropogenic activities that can accelerate erosion and transport of phosphorus. Some activities that can increase erosional processes include grazing, logging, mining, pasture irrigation, and off-highway vehicle (OHV) use. Exceedances for total phosphorus were common occurrences at nine out of ten NCPN park units, where at least one site in each of these parks had elevated phosphorus concentrations. At these sites, high levels of nutrients have not led to algal blooms or other signs of eutrophication.

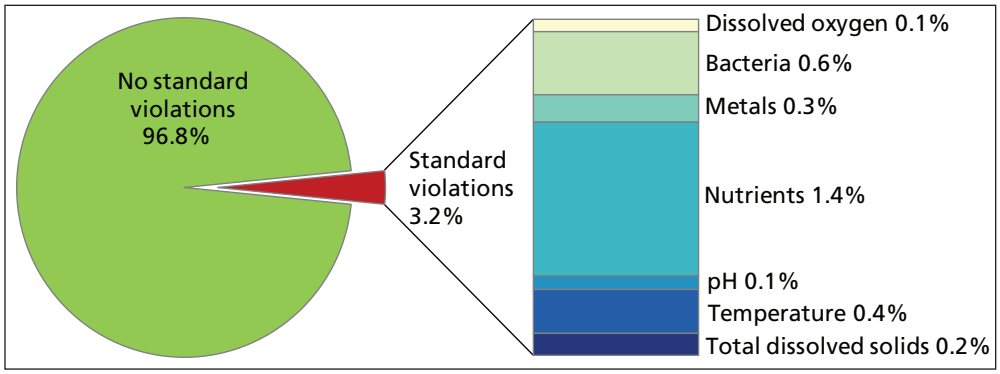


Figure A. Percentage of use evaluations that exceeded standards, and the causes of exceedances at selected sites sampled in NCPN park units, October 1, 2015–September 30, 2018.

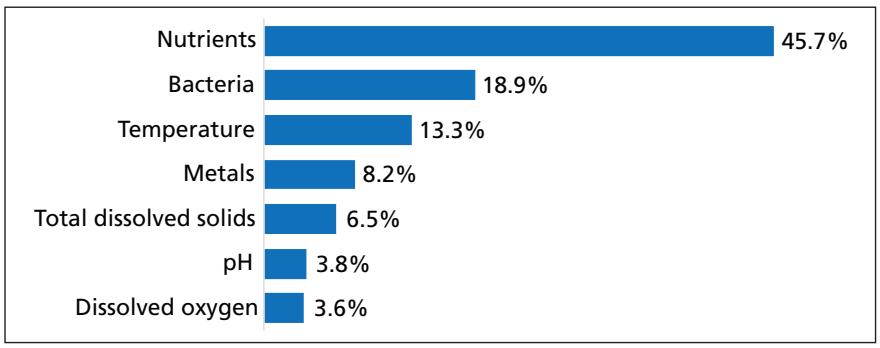


Figure B. Sources of water quality standard violations, as percentages of samples with an exceedance in NCPN park units, October 1, 2015–September 30, 2018.

Sites monitored in Arches National Park (NP), Black Canyon of the Gunnison NP (BLCA), Bryce Canyon NP (BRCA), Capitol Reef NP (CARE), Curecanti National Recreation Area (CURE), Dinosaur National Monument (DINO), and Zion NP (ZION) all had *E. coli* exceedances that could be addressed by management actions. While many of these sites already have management actions underway, some of the actions necessary to bring these waters into compliance are beyond the control of the National Park Service. Changes to agricultural practices to improve water quality involves voluntary participation by landowners and/or grazing permittees and their respective states. This could be the case with lands upstream of several parks with *E. coli* contamination issues, including Red Rock Canyon (BLCA); Sulphur, Oak, and Pleasant creeks (CARE); Blue Creek and Cimarron River (CURE); Brush and Pot creeks (DINO); and North Fork Virgin River (ZION). Issues with *E. coli* contamination at Yellow Creek (BRCA) seemed to be resolved after the park boundary fence downstream of the site was repaired, keeping cattle out of the park. At North Fork Virgin River, *E. coli* exceedances have been less frequent since the State of Utah worked with landowners and grazing permittees to modify agricultural practices. Continued coordination between the National Park Service, state agencies, and local landowners will be necessary to further reduce *E. coli* exceedances and, in turn, improve public health and safety in these streams.

Selenium concentrations in Red Rock Canyon (BLCA) continued to exceed the state aquatic-life standard at both the upstream and downstream sites. Although selenium weathers naturally from bedrock and soils in the Red Rock Creek drainage, upstream irrigation return flows could be carrying more of these sediments rich in selenium into the creek. Continued management action is needed to bring irrigation return flows in Red Rock Canyon into compliance with state water-quality standards.

In recent years, pH exceedances have declined at North Creek in Zion National Park. Only one exceedance for pH occurred during water years 2016–2018, as compared to seven exceedances in water years 2013–2015 and nine exceedances in water years 2010–2012. The reduction in pH exceedances at North Creek indicates that conditions may be stabilizing in North Creek after a wildfire burned much of the watershed in 2006.

Acknowledgements

David Thoma designed and implemented the water-quality monitoring program for the Northern Colorado Plateau Network (NCPN). Helen Thomas (NCPN) and Dean Tucker (National Park Service Water Resources Division) provided data management. Aneth Wight (NCPN) produced all of the maps for this report. Thanks to park staff at Southeast Utah Group, Black Canyon of the Gunnison National Park/Curecanti National Recreation Area (BLCA/CURE), and Timpanogos Cave National Monument for collecting water-quality data and samples. Additional thanks to Kim Hartwig (BLCA/CURE), Jim Roche and Sandy Borthwick (Capitol Reef National Park), Lisa Baldwin (Dinosaur National Monument), Robyn Henderek (Zion National Park), and Dusty Perkins (NCPN) for reviewing this document.

1 Introduction

1.1 Background

The Northern Colorado Plateau Network (NCPN) consists of 16 National Park Service units in Utah, Colorado, Arizona, and Wyoming (Figure 1-1). The water-dependent ecosystems in these unique landscapes are protected by the National Park Service (NPS) Organic Act, NPS Management Policies (NPS 2006), and the Clean Water Act. Through comprehensive scoping processes, water quality and quantity were identified as vital signs that should be monitored by the network (O'Dell et al. 2005).

Under authority of the U.S. Environmental Protection Agency (EPA), states have developed a regulatory system under the Clean Water Act that provides for specific concentrations or measures for water-quality constituents that protect designated uses. The protected designated uses vary by state, but generally include irrigated agriculture, domestic water supply, cold-water aquatic life, warm-water aquatic life, and water-based recreation.

Water-quality monitoring in National Park Service units of the Northern Colorado Plateau Network (NCPN) is made possible through partnerships between the National Park Service Inventory & Monitoring Division, individual park units, the U.S. Geological Survey, and the Utah Division of Water Quality.

1.2 Program justification

To mitigate past impacts and future threats to water resources, park managers need objective information on status and trends in surface-water quality and quantity. Section 4.3.6 of NPS Management Policies (NPS 2006) establishes expectations for park managers regarding water resources:

> *The pollution of surface waters and groundwaters by both point and nonpoint sources can impair the natural functioning of aquatic and terrestrial ecosystems and diminish the utility of park waters for visitor use and enjoyment. The Service will determine the quality of park surface and groundwater resources and avoid, whenever possible, the pollution of park waters by human activities occurring within and outside the parks. The Service will*
>
> *a) work with appropriate governmental bodies to obtain the highest possible standards available under the Clean Water Act for the protection for park waters;*
>
> *b) take all necessary actions to maintain or restore the quality of surface waters and groundwaters within the parks consistent with the Clean Water Act and all other applicable Federal, State, and local laws and regulations; and*
>
> *c) enter into agreements with other agencies and governing bodies, as appropriate, to secure their cooperation in maintaining or restoring the quality of park water resources.*

1.3 Long-term monitoring objectives

Measurable objectives of this long-term monitoring program focus on status and trends in water-quality parameters. They include the following:

- Establish range and variability of water quality parameters under base flow conditions as they vary seasonally using descriptive statistics.
- Determine status and trends in selected water quality parameters as a function of flow, season, and climatic conditions, using trend-analysis techniques.
- Compare water quality data against state criteria for acute and chronic exceedance.
- Analyze long-term data for designation as Outstanding National Resource Waters.
- Determine point and non-point sources of pollution within watersheds via association with ancillary data or knowledge of land-management practices or activities in the watersheds.

Water-Quality Monitoring Sites, 2016–2018

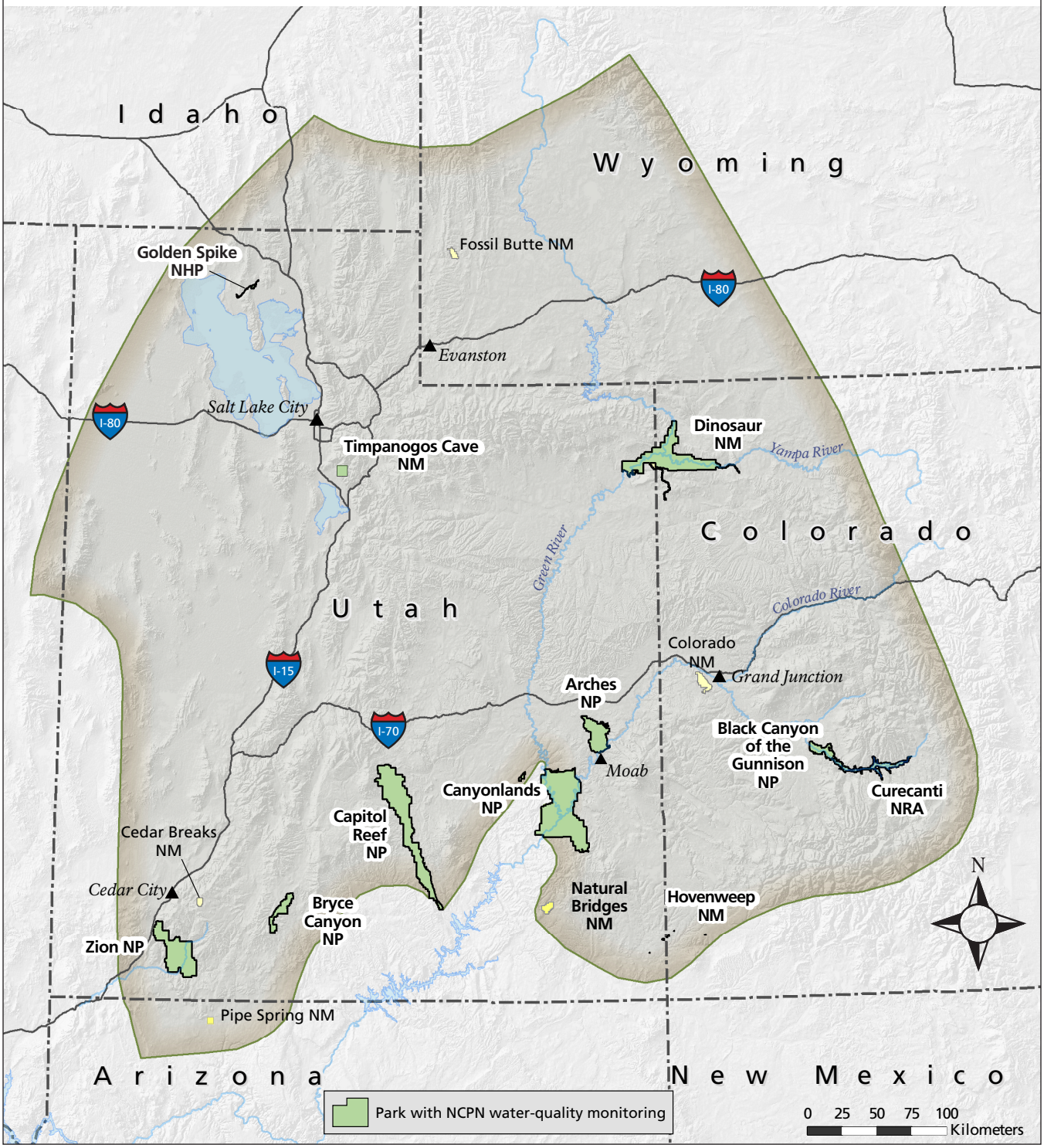


Figure 1-1. National Park Service units of the Northern Colorado Plateau Network. Parks where the NCPN monitors water quality are highlighted.

1.4 Management outcomes

The knowledge gained by achieving the measurable objectives of this monitoring will be used to evaluate and report on the condition of water bodies in NCPN park units. Additionally, it can be used to inform park managers about water resources in order to:

- Maintain waters that vary within their natural chemical and biological ranges and meet applicable federal and state water-quality criteria.
  Justification: Waters that vary within their natural ranges can typically support healthy aquatic ecosystems and most beneficial uses.
- Demonstrate and maintain high water quality where it exists.
  Justification: The antidegradation provision of the Clean Water Act specifies that high-quality waters will be maintained (USEPA 2006, Section 303).

1.5 Report scope and objectives

This is the fifth report on activities and results of the NCPN water-quality monitoring program (Thoma et al. 2008; Van Grinsven et al. 2010; Hackbarth and Weissinger 2013; Hackbarth and Weissinger 2016). In total, these five reports provide information on 14 years of NCPN water quality (water years 2005–2018).

This report focuses on sites monitored by NCPN staff and by cooperating staff and agencies working in and near NCPN parks. Although long-term data records exist for some of these sites, this report evaluates data from site visits at 62 different locations on streams, rivers, and reservoirs in or near ten NCPN park units between October 1, 2015 and September 30, 2018. Data are compared to state water-quality standards for the purpose of providing information to park managers about potential water-quality problems. The National Park Service does not determine the regulatory status of surface waters; state water quality agencies determine whether waters comply with the Clean Water Act.

The objectives of this report are to:

- compare data to state water-quality standards,
- provide descriptive statistics for water quality data,
- identify and characterize potential sources of water quality contamination, and
- provide resource managers with pertinent information about these data.

2 Methods

2.1 Target population

The target population for NCPN water-quality monitoring is a subset of potential daytime water-quality measurements in perennial streams and rivers, selected through a judgmental or targeted process involving the participation of park resource managers, NCPN staff, U.S. Geological Survey (USGS) staff, and other water-quality specialists (O'Dell et al. 2005; Thoma et al. 2017).

Specific water sources were selected based on the following hierarchy:

- 303(d)-listed waters, where previous sampling indicated that one or more parameters regularly approached or exceeded criteria or recommended levels.
- Waters with demonstrated threat levels, where an analysis of available data indicated that measured conditions regularly approached or exceeded criteria or recommended levels, but where the frequency of exceedance or the quality of the data did not support a 303(d) listing.
- Data gaps: Waters identified as important, but where little or no water quality information existed.
- Waters of management concern, where past sampling may not have indicated constituent values of concern, but where anthropogenic activities indicated that contamination was a significant threat.
- Other perennial waters with no specific threat.

Perennial waters were preferentially selected over ephemeral or seasonal water sources because they support year-round aquatic ecological process and function and have established criteria that allow monitoring for compliance with the Clean Water Act. Sixty-two sites in or near 10 NCPN units were sampled between October 1, 2015 and September 30, 2018 (see Appendix A).

2.2 Laboratory and field methods

Approximately 30 parameters were measured during each site visit. The core parameters, or those measured in the field, included dissolved oxygen, pH, temperature, specific conductance, and flow. Other parameters, measured in the laboratory from samples collected in the field, fell into general categories of metals, nutrients, total dissolved solids, and bacteria. Due to temporary limitations on the number of samples accepted by the Utah Public Health Laboratory during March–September 2018, samples were not collected for lab analyses at several parks, including Arches, Bryce Canyon, Capitol Reef, and Zion national parks.

Field methods used to collect data for this report are outlined in the NCPN Standard Operating Procedures (SOPs) for Water Quality (Thoma et al. 2017). Specifically, SOPs 3–11 outline the techniques for measurement of core parameters and sample collection and handling in the field.

Laboratory analytical methods are discussed in detail in SOPs 11–13 (Thoma et al. 2017). The NCPN ensures comparability of the laboratory data created by this monitoring program by using the USGS National Water Quality Laboratory (NWQL) methods for Colorado parks (SOP 12), and the EPA standard methods, or methods outlined in Standard Methods for Analysis of Water and Wastewater, for Utah parks (APHA 1998; SOP 13). Details of the quality-control process for NWQL and the Utah Public Health Laboratory are provided in SOP 7, Appendices A and B (Thoma et al. 2017).

2.2.1 Selenium

Results for selenium from the Utah Public Health Laboratory were not included in the water-quality standards analysis for this study period. At time of writing, the Utah Division of Water Quality was investigating discrepancies in lab methods and associated results for selenium. The NCPN decided to suspend reporting on those data until the review is complete.

2.3 Partnerships

The NCPN water-quality monitoring program is a collaborative venture between the NCPN, Black Canyon of the Gunnison National Park (NP), Curecanti National Recreation Area (NRA), the Southeast Utah Group (SEUG), Timpanogos Cave National Monument (NM), the USGS, and the Utah Division of Water Quality (UDWQ). Personnel from the NCPN, SEUG, and Timpanogos Cave NM conduct field work and deliver samples to the Utah Public Health Laboratory according to a partnership agreement between the NPS and the UDWQ. Staff from Black Canyon of the Gunnison NP and Curecanti NRA conduct field work and have laboratory analysis conducted at the NWQL, in Lakewood, Colorado, via agreements with the USGS. Sites at Dinosaur NM are visited by USGS staff, who deliver samples to the NWQL for laboratory analysis. Other nearby sites (outside park boundaries) routinely monitored by the states of Colorado and Utah are also considered when they will help determine water quality flowing into or out of the park. Regardless of which entity performed the field work or laboratory analysis, the data were stewarded through the NPSTORET database v.1.88, which was used for this analysis.

2.4 Data quality

Samples collected by staff from the USGS, Black Canyon of the Gunnison NP, and Curecanti NRA are evaluated for data quality by those staff. Quality-control data for these sites are not available for this report. For sites sampled by NCPN and SEUG staff and analyzed by the Utah Public Health Laboratory, up to 18 field blanks were submitted between October 1, 2015 and September 30, 2018. The number of field blanks varied by parameter due to sampling constraints at the laboratory in 2018 (Appendix B). For the parameters evaluated in this report, concentrations were detected in 18 of 145 blank analyses. The Utah Public Health laboratory reduced reporting limits for many parameters during this time period, likely increasing the number of detections in our blanks. Most of these detections were near or at the analytical detection limit and well below the assessment criteria and should not affect evaluations. Three of eighteen ammonia blanks were above the detection limit and in the range of concentrations reported from environmental samples. Ammonia is assessed using a temperature- and pH-dependent formula, and a high bias is possible in some samples. However, there were no exceedances of the Utah ammonia standards for environmental samples in this report. Nineteen replicate samples were submitted for major constituents and nutrients. Fourteen replicate samples were submitted for trace metals. The median replicate percent difference was 0.5% (interquartile range 0–3.8%, range 0–117%).

2.5 Understanding water quality and standards

The sampling methodology used in the NCPN water-quality monitoring program has implications for data interpretation used for management. Monthly grab samples represent conditions at the point and time of sampling; they do not represent the condition of the entire water body, spatially or temporally. Samples are routinely collected several times per year in order to build a database that represents the range of conditions that occur, with a focus on base flow conditions. Thus, rare and short-term events are often not captured.

This report contains terminology that may not be readily understood by non-specialists. For clarification purposes, various terms and concepts that may cause confusion will be defined here. A water-quality standard refers to an individual parameter and its associated beneficial-use designation, in conjunction with a criterion, which is the numeric component against which a result is compared. For example, the standard for chronic selenium (parameter) for cold-water game fish (beneficial-use designation) is 4.6 µg/L (numeric criterion).

One site visit yields approximately 30 water-quality parameter measurements or results. Each result is then evaluated against a water-quality standard; this is referred to as a “use evaluation” in this report. Each beneficial-use designation may contain distinct criteria for one parameter, and each site

may contain up to four distinct beneficial-use designations. Therefore, one parameter measurement from one site visit may result in multiple use evaluations.

Over the course of the study period, one site may have a different number of results for each parameter. For example, the NCPN may have visited one monitoring site 24 times during the period covered in this report, but not all parameters may have been measured during each site visit. This is especially true for metals results. Laboratory analysis for metal concentrations is typically performed quarterly, whereas other parameters, such as nutrients and dissolved oxygen, are determined for each site visit. For a complete list of beneficial uses and associated water-quality standards used in this report, see Appendices C and D.

2.5.1 Chronic and acute standards

For a single parameter, numeric criteria for water-quality standards address potential effects of both chronic exposure over an extended period of time (months) and acute exposure over a short period of time (hours or days). Permitted levels are much lower for chronic exposure than for acute exposure. Criteria for chronic exposure are not directly comparable to the results obtained from a one-time monthly grab sample. From a compliance standpoint, the acute instantaneous criteria afford the only direct comparison for such data. However, from a resource-conservation standpoint, instantaneous grab-sample data, when compared against more stringent chronic criteria, can provide a means of early warning and an indication of a problem that may require more attention. Exceedances in this report, therefore, are meant to inform managers of potential problems, rather than conform to a regulatory definition.

For these reasons, parameter results were compared against the chronic standards to create the graphical and tabular data included in this report. Each exceedance was then re-evaluated against the less-stringent acute criteria. If a chronic exceedance also exceeded the acute standard, then documentation was provided in the results section for that individual site.

2.5.2 Phosphorus as an indicator of impairment

The State of Utah does not have a water-quality standard for total phosphorus. Rather, the value of 0.05 mg/L is used as an indication of impairment meant to be considered with other parameters, such as dissolved oxygen. If low dissolved-oxygen concentrations were observed commensurate with elevated total-phosphorus concentrations (above 0.05 mg/L), then the collective results might indicate impairment due to eutrophication. Corroborating evidence may include other chemical parameters associated with eutrophication—such as elevated nutrient concentrations or low dissolved-oxygen concentrations—and bioassessments.

In 2012, the State of Colorado established interim values for total phosphorus that are scheduled to come into effect in 2022. For state regulatory purposes, total phosphorus is evaluated as an annual median value or average summer value, depending on the type of water body. For purposes of this report, any individual value that exceeded the designated total-phosphorus interim value was reported as an exceedance.

2.5.3 Rules for applying standards

When criteria for a parameter differed by designated beneficial use, or within a use class by aquatic-life stage, the more-stringent (chronic) standard was used as the basis for comparison in this report. Results that exceeded the chronic standard were then compared against the less-stringent (acute) standard. The goal is to provide advance warning of an impending problem before it becomes severe—not to meet regulatory definitions of impairment.

2.5.4 Frequency of exceedances for reporting

This report presents beneficial-use evaluation exceedances only if they occurred for more than 10% of results. This approach minimizes reporting of short-duration changes in water chemistry that may result from natural variability associated with weather events and may not be of manage-

ment concern. It also follows the assessment guidelines used by the UDWQ in preparing their list of impaired water bodies.

Summary statistics displayed at the beginning of each results section refer to the number of use evaluations performed for all sites in or near that NPS unit. The term "evaluation" is used throughout this report in connection with exceedance analyses. Thus, tables and results sections for individual sites refer to "evaluations" instead of "site visits." The total number of evaluations is synonymous with the total number of site visits when an individual parameter is compared against an individual beneficial-use designation at one monitoring site.

2.5.5 Regulatory authority

The National Park Service does not have regulatory authority to establish water-quality standards or assign beneficial-use designations over waters in U.S. For that reason, this report compares water-quality data to designated beneficial-use criteria without stating whether a designated beneficial-use was attained. Those designations are left to the states, in their triennial 305(b) reports to Congress. However, the NPS participates with states in collecting data used in the protection of water bodies under state jurisdiction. These assessments can provide early warning or evidence of evolving conditions.

2.6 Site-specific standards and triennial reviews

A triennial review process allows stakeholders to provide feedback about water-quality standards, criteria, and designated beneficial uses. Through this process, the regulatory agencies may re-classify a water body's designated use or set standards appropriate for the use. This process is especially relevant where uses were not assigned, due either to a lack of use data or a situation in which natural conditions precluded a water body from meeting its designated beneficial use. For instance, a use-attainability analysis may indicate that a water body cannot achieve its designated beneficial use due to naturally elevated parameter concentrations observed in that stream or stream segment. If the historical data record is not long enough or reasonable supporting evidence does not exist, then the state may choose not to change a water-quality standard, or reclassify a designated use during the triennial review, but may provide guidance on how to further investigate the particular issue.

Some NCPN water-quality monitoring sites may be suitable candidates for a use-attainability analysis and site-specific criteria, due to naturally elevated concentrations of total phosphorus or total dissolved solids that may be derived from soil and bedrock weathering. If commensurate measurements, such as dissolved oxygen or nitrogen concentrations at a site, do not indicate that elevated total-phosphorus concentrations are causing eutrophication of the water body, then the water body may be considered for a different use classification or a water body-specific standard.

Results displayed in this report highlight and characterize such scenarios, but do not necessarily contain the breadth of supporting documentation required for submission to the triennial review process. Completion of long-term trend-analysis reports, such as Weissinger and Sharrow (2018) and Weissinger and Gibney (2018), will significantly improve the NCPN's ability to determine which candidate sites and associated water-quality standards merit inclusion in a use-attainment assessment.

3 Results

3.1 Overall results

Evaluation of water-quality parameters relative to state water-quality standards indicated that 17,997 (96.8%) of the 18,583 total designated beneficial-use evaluations completed for the period covered in this report met state water-quality standards (Figure 3-1). The most common exceedances or indications of impairment, in order of abundance, were due to elevated nutrients, elevated bacteria (*E. coli*), elevated water temperature, elevated trace metals, elevated total dissolved solids (and sulfate), elevated pH, and low dissolved oxygen (Figure 3-2).

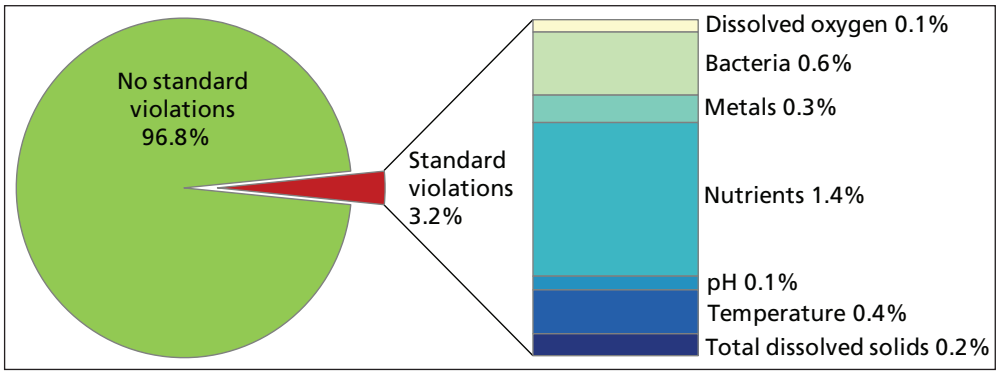


Figure 3-1. Percentage of use evaluations that exceeded standards, and the causes of exceedances at selected sites sampled in NCPN park units, October 1, 2015–September 30, 2018.

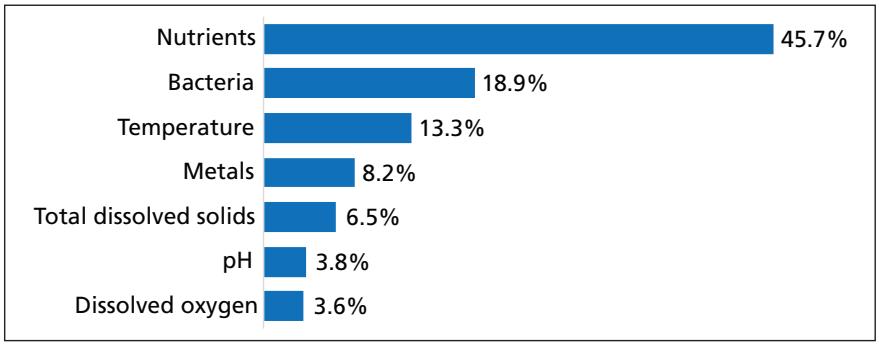


Figure 3-2. Sources of water quality standard violations, as percentages of samples with an exceedance in NCPN park units, October 1, 2015–September 30, 2018.

3.2 Arches National Park

3.2.1 Water-quality summary

A total of 1,604 designated beneficial-use evaluations were completed for water-quality results obtained at six sites in or near Arches National Park between October 1, 2015 and September 30, 2018. Of those 1,604 evaluations, 57 (3.6%) exceeded water-quality standards or indications of impairment (Figure 3-3). Standards were exceeded for five constituent categories—most commonly, nutrients, total dissolved solids, and *E. coli*.

3.2.2 Reportable exceedances

The Colorado River near Cisco, Utah, did not have any exceedances based upon 66 evaluations. At this site, the only parameters that could be compared against water-quality standards were water temperature, fluorides, and total dissolved solids. Courthouse Wash above the Colorado River had one exceedance for dissolved oxygen, which accounted for 10% of evaluations. The remaining sites discussed below had exceedances of Utah water-quality standards or indications of impairment for more than 10% of evaluations (Figure 3-4, Table 3-1).

3.2.2.1 Colorado River near Colorado/Utah State Line

This site, located in the State of Colorado, is subject to Colorado state water-quality standards. Total-phosphorus levels exceeded the aquatic life warm-water class 1 interim standard for 33% of evaluations.

3.2.2.2 Courthouse Wash at Spring

This report marks the second set of evaluations for this site, which was initiated in October 2013. Previous monitoring near this location occurred downstream, but as the channel changed, sufficient surface water was no longer available for sampling at the previous site. This site had exceedances for dissolved oxygen, *E. coli*, total phosphorus, and total dissolved solids. Dissolved-oxygen levels exceeded the chronic standard for warm-water game fish for 30% of evaluations, and the acute standard of 3.0 mg/L was exceeded on two occasions. *E. coli* concentrations exceeded the standard for primary-contact recreation and drinking-water supply for 20% of evaluations. Total phosphorus exceeded the indication-of-impairment criteria for primary-contact recreation and warm-water game fish for 67% of evaluations. Total dissolved solids exceeded the standard for agricultural use for 33% of evaluations.

3.2.2.3 Dolores River near Cisco, UT

At this site, the only parameters that can be compared against water-quality standards are water temperature and total dissolved solids. Total dissolved solids exceeded the standard for agricultural use for 31% of evaluations.

3.2.2.4 Salt Wash at Wolfe Ranch

Total dissolved solids exceeded the standard for agricultural use for 100% of evaluations at this site.

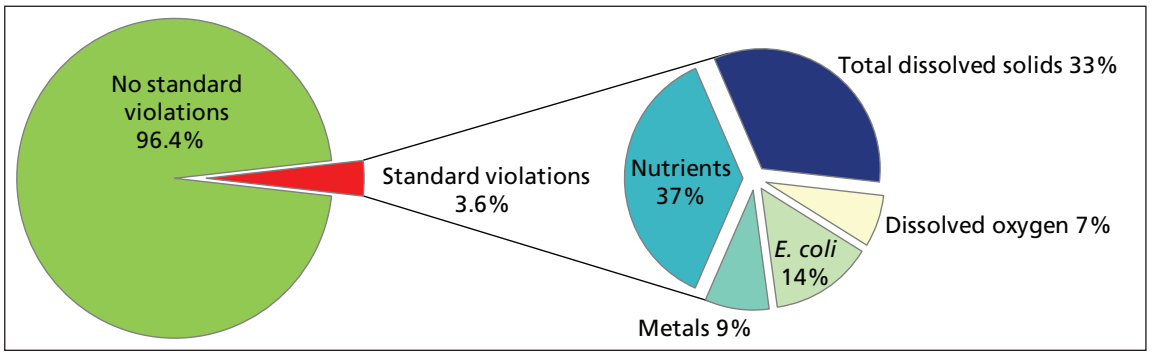


Figure 3-3. Percentage of use evaluations that exceeded standards, and the causes of exceedances as percentages of samples with an exceedance, Arches National Park, October 1, 2015–September 30, 2018.

Arches National Park
Utah

National Park Service
U.S. Department of the Interior
Northern Colorado Plateau Network

Water-Quality Monitoring Sites, 2016–2018

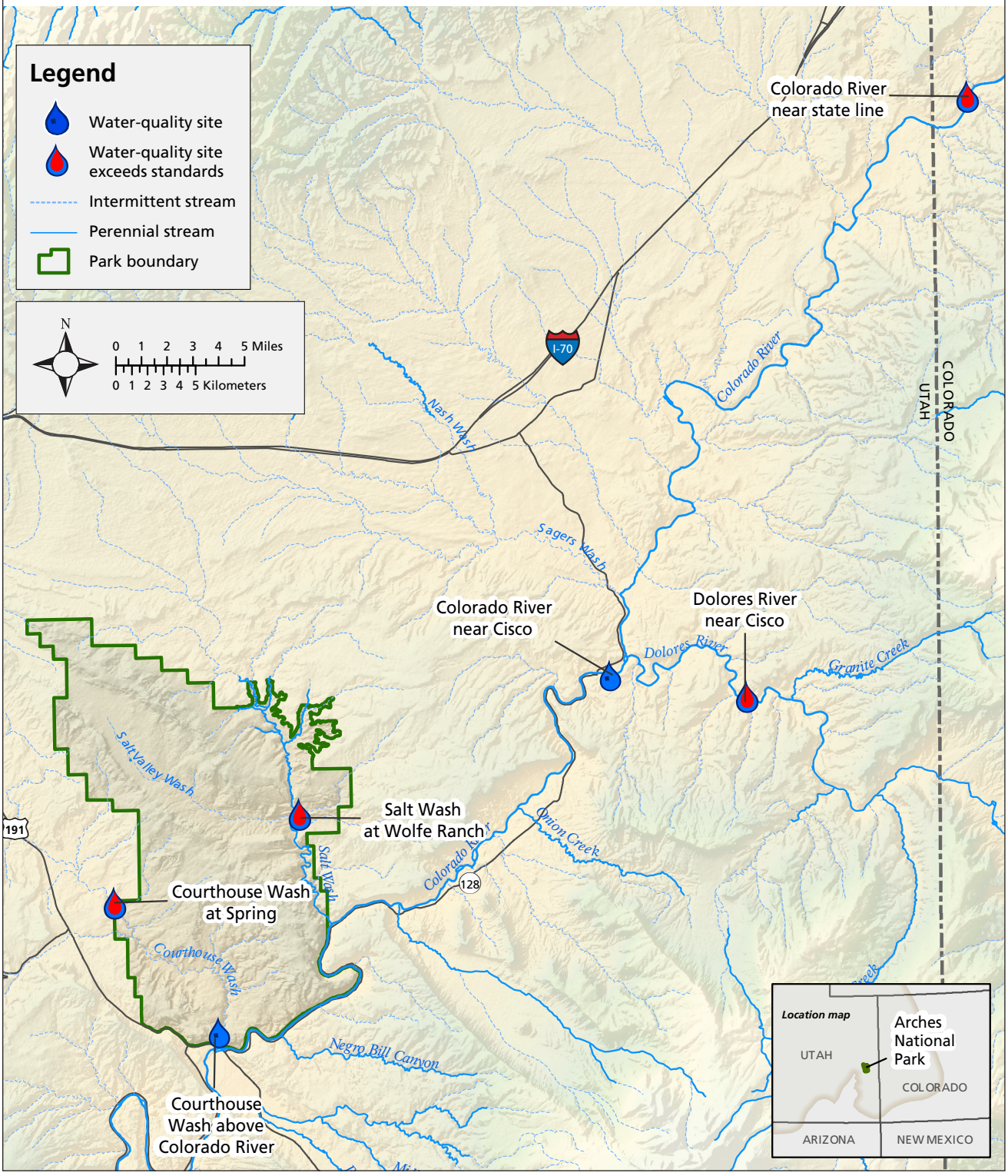


Figure 3-4. Water-quality monitoring locations in and near Arches National Park. Sites that exceeded standards for more than 10% of evaluations for one or more parameters are marked with a red symbol.

Table 3-1. Sites with exceedances of surface water-quality standards for more than 10% of evaluations in or near Arches National Park, October 1, 2015–September 30, 2018.

Site	Use code[A]	Parameter	Standard	Total evaluations	Exceedances	Percent exceedances
Colorado River near CO/UT State Line	ALWW1	Phosphorus, total	0.17 mg/L	52	17	33
Courthouse Wash at Spring	3B	Dissolved oxygen	5.5 mg/L	10	3	30
	2A	*E. coli* (chronic)	126 MPN/100mL	10	2	20
	1C	*E. coli* (chronic)	206 MPN/100mL	10	2	20
	2A	*E. coli* (acute)	409 MPN/100mL	10	2	20
	1C	*E. coli* (acute)	668 MPN/100mL	10	2	20
	2A, 3B	Phosphorus, total	0.05 mg/L	3	2	67
	4	Total dissolved solids	1,200 mg/L	3	1	33
Dolores River near Cisco, UT	4	Total dissolved solids	1,200 mg/L	26	8	31
Salt Wash at Wolfe Ranch	4	Total dissolved solids	1,200 mg/L	10	10	100

[A]Use codes: ALWW1 = aquatic life warm-water class 1 (Colorado standard); 2A = primary-contact recreation; 3B = warm-water game fish; 1C = drinking-water supply; 4 = agricultural use

3.2.3 Discussion and management implications

Many of the water-quality exceedances in Arches NP were likely due to naturally occurring conditions, and resulted from the application of use designations intended to protect the Colorado River and its tributaries. Because many monitoring sites in Arches NP are low-flow, intermittent, or ephemeral tributaries to the Colorado River, the applicable use designations, specifically 3B (warm-water game fish), do not necessarily account for their biogeochemical nature.



Figure 3-5. Courthouse Wash at Spring water-quality site on August 8, 2018. The water-quality site is the smaller pool on the right, indicated by the arrow.

Most of the monitoring sites in Arches NP are candidates for use-attainability assessments because of their geologic setting. The geologic conditions of small springs with large groundwater components, and predominantly intermittent streams that may episodically contribute naturally elevated constituent loads, distinguish them from other perennial tributaries to the Colorado River. After two decades of water-quality monitoring, the Southeast Utah Group has re-evaluated their site-selection criteria and moved toward monitoring sites with more-specific resource threats.

3.2.3.1 Dissolved oxygen

Low dissolved-oxygen concentrations at the Courthouse Wash at Spring site can be attributed to its hydrologic setting. The sample site is a small, spring-fed pool at the base of a slickrock slope with no measurable flow; therefore, the water is poorly mixed (Figure 3-5). These stagnant conditions can cause depleted oxygen concentrations, especially during times when there are turbid conditions in the pool, which was the case when these exceedances were recorded.

3.2.3.2 *E. coli*

The primary-contact recreation and drinking-water supply standards for *E. coli* were exceeded at Courthouse Wash at Spring on two occasions. This site is located at the edge of the western boundary of Arches National Park, adjacent to public land that allows for off-highway vehicle (OHV) use and cattle grazing. Even though the site is located within the park boundary, the fence to keep OHV travel and cattle out of the park is downstream of the site; therefore, cattle frequently visit this small, spring-fed pool and OHVs drive directly through the site. Possible sources of *E. coli* contamination could be wildlife, domestic animals, humans, or a combination thereof. At the time of each of the exceedances at this site, cow manure was noted in and around the site, which could be a reasonable cause of these exceedances.

3.2.3.3 Nutrients

Due to temporary limitations on the number of samples accepted by the Utah Public Health Laboratory, only 1–2 samples from each site monitored at Arches NP were tested for nutrients. Because this sample set was so small, other exceedances during this sample period may not have been captured. Two of three samples at Courthouse Wash at Spring exceeded the indication-of-impairment criteria for phosphorus. Natural sources of phosphorus likely occur within the Courthouse Wash watershed. Furthermore, accelerated weathering from grazing and OHV use may contribute to the observed total phosphorus levels. Elevated total phosphorus concentrations in Courthouse Wash are consistent with 16 years of data from 1990–2006 (Brown and Thoma 2012).

The Colorado River near Colorado/Utah State Line site continued to have exceedances for Colorado's interim phosphorus standard. Elevated phosphorus levels are most likely due to natural sources.

3.2.3.4 Total dissolved solids

As in past years, concentrations of total dissolved solids (TDS) at Salt Wash at Wolfe Ranch exceeded standards. They likely have a geologic origin, as there are few human activities near Salt Wash that could contribute to such high TDS levels. Elevated TDS concentrations in surface water and groundwater are not uncommon in the Moab area, resulting from the underground weathering of the near-subsurface salt dome (Baars and Doelling 1987; Chaffin 2002). Mineral-rich clay and shale deposits of the Morrison and Mancos formations exposed near the sample site may also contribute TDS to Salt Wash during overland flow events. The results presented are consistent with decades of sampling in Arches NP, as described by Schelz and Moran (2004), Van Grinsven and others (2010), and Hackbarth and Weissinger (2013 and 2016). Elevated TDS concentrations in Courthouse Wash are most likely from the same sources as at Salt Wash.

The presence of salt-bearing geologic layers near the surface results in conditions that may be cause for exemption or re-classification of the total dissolved solids standard for Salt Wash. In fact, the UDWQ is reviewing water bodies across the state that may need to be re-classified as a result of natural conditions, such as salt-bearing geologic layers, that cause elevated TDS concentrations.

3.3 Black Canyon of the Gunnison National Park

3.3.1 Water-quality summary

A total of 822 designated beneficial-use evaluations were completed for water-quality results obtained at three sites in Black Canyon of the Gunnison NP between October 1, 2015 and September 30, 2018. Of those 822 evaluations, 33 (4.0%) exceeded water-quality standards or criteria (Figure 3-6). Water-quality standards were exceeded for four constituent categories—most commonly, metals, *E. coli*, and nutrients.

3.3.2 Reportable exceedances

The Gunnison River below the Gunnison Tunnel had no water-quality exceedances or indications of impairment based upon 257 total evaluations. The following discussion focuses on the two sites that had exceedances of Colorado water-quality standards for more than 10% of evaluations (Figure 3-7, Table 3-2).

3.3.2.1 Red Rock Canyon at Mouth near Montrose, CO

This site had exceedances for *E. coli*, selenium, and sulfate. *E. coli* levels exceeded the existing primary-contact recreation standard for 18% of evaluations. Dissolved-selenium concentrations exceeded the chronic (4.6 µg/L) standard for aquatic life warm-water class 2 for 100% of evaluations and the acute (18.4 µg/L) standard for 57% of evaluations. The drinking-water standard for sulfate was exceeded for 18% of evaluations.

3.3.2.2 Red Rock Canyon near NPS Boundary near Montrose, CO

This site had exceedances for *E. coli*, manganese, phosphorus, and selenium. *E. coli* levels exceeded the existing primary-contact recreation standard for 55% of evaluations. Two *E. coli* evaluations exceeded the drinking-water supply standard. Dissolved-manganese concentrations exceeded the drinking-water supply standard for 43% of evaluations. Total-phosphorus levels exceeded the interim standard for aquatic life warm-water class 2 for 27% of evaluations. Dissolved-selenium concentrations exceeded the chronic (4.6 µg/L) and acute (18.4 µg/L) standards for aquatic life warm-water class 2 for 100% of evaluations.

3.3.3 Discussion and management implications

3.3.3.1 *E. coli*

Both sites at Red Rock Canyon had exceedances for *E. coli* during the study period. This is not a new concern for the sites within this canyon and is consistent with previous years of sampling (Van Grinsven et al. 2010; Hackbarth and Weissinger 2013; Hackbarth and Weissinger 2016; Weissinger and Gibney 2019). As in previous years, the majority of *E. coli* exceedances occurred during average flow and clear water conditions. Because episodic storm events were not related to the observed *E. coli* exceedances, a continuous source may exist upstream. *E. coli* exceedances occurred during the summer months, when recreational activity in Red Rock Canyon was at its peak. Cooperation

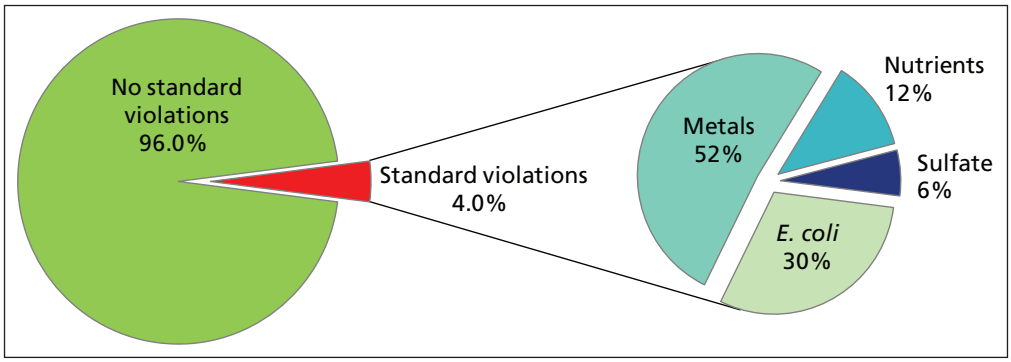


Figure 3-6. Percentage of use evaluations that exceeded standards, and the causes of exceedances as percentages of samples with an exceedance, Black Canyon of the Gunnison NP, October 1, 2015–September 30, 2018.

Black Canyon of the Gunnison National Park
Colorado

National Park Service
U.S. Department of the Interior
Northern Colorado Plateau Network

Water-Quality Monitoring Sites, 2016–2018

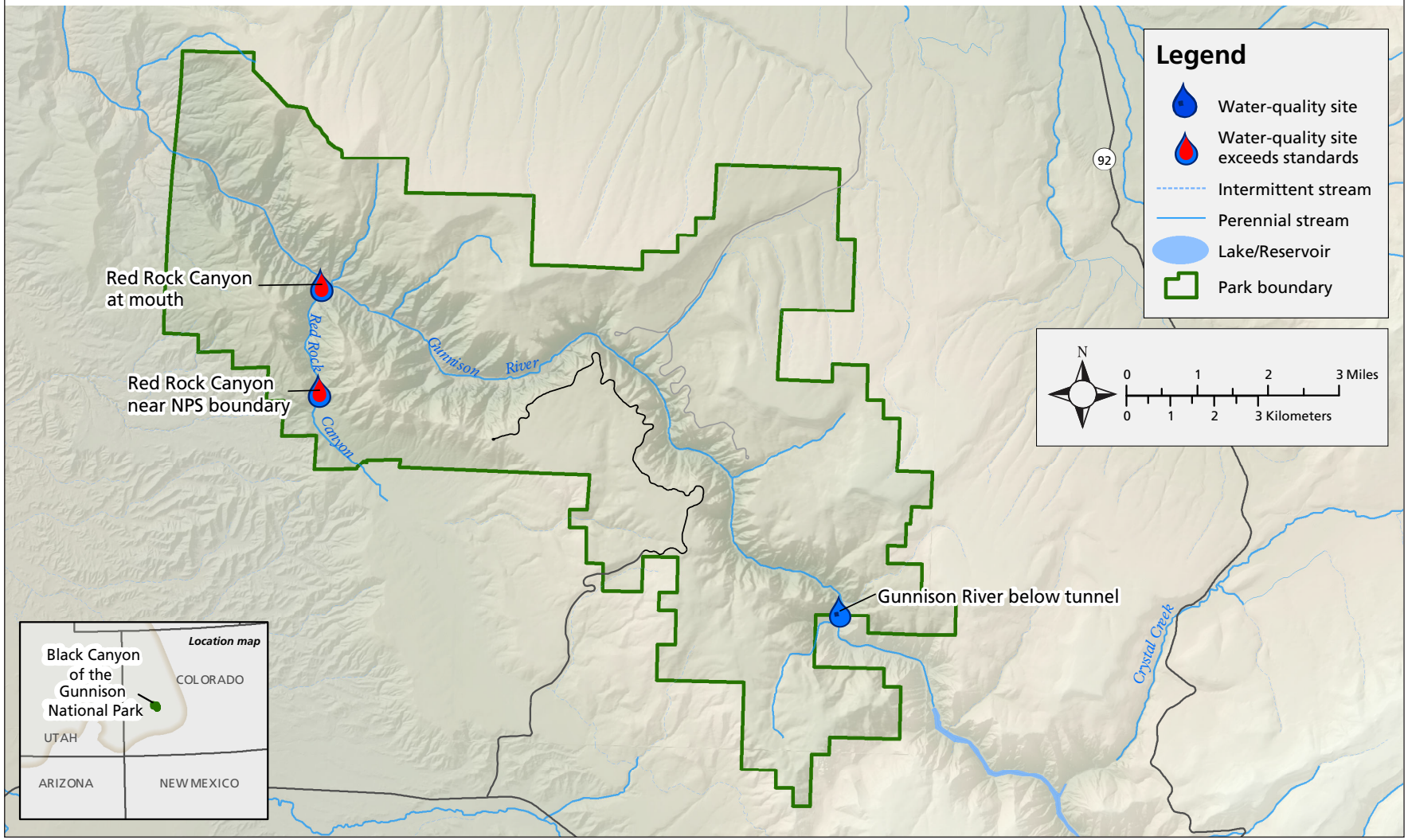


Figure 3-7. Water-quality monitoring locations in Black Canyon of the Gunnison National Park. Sites that exceeded standards for more than 10% of evaluations for one or more parameters are marked with a red symbol.

Table 3-2. Sites with exceedances of surface water-quality standards for more than 10% of evaluations in Black Canyon of the Gunnison National Park, October 1, 2015–September 30, 2018.

Site	Use code[A]	Parameter	Standard	Total evaluations	Exceedances	Percent exceedances
Red Rock Canyon at Mouth near Montrose, CO	RecE	*E. coli*	126 MPN/100mL, 126 cfu/100mL	11	2	18
	ALWW2	Selenium, dissolved	4.6 µg/L	7	7	100
	DWS	Sulfate	250 mg/L	11	2	18
Red Rock Canyon near NPS Boundary near Montrose, CO	RecE	*E. coli*	126 MPN/100mL, 126 cfu/100mL	11	6	55
	DWS	*E. coli*	630 MPN/100mL, 630 cfu/100mL	11	2	18
	DWS	Manganese, dissolved	50 µg/L	7	3	43
	ALWW2	Phosphorus, total	0.17 mg/L	11	3	27
	ALWW2	Selenium, dissolved	4.6 µg/L	7	7	100

[A]Use codes: ALWW2 = aquatic life warm-water class 2; RecE = existing primary-contact recreation; DWS = drinking-water supply

with the State of Colorado may be needed to determine the source(s) of bacteria in the area.

3.3.3.2 Metals

All samples tested for selenium at sites in Red Rock Canyon exceeded the chronic aquatic-life standard during water years 2016–2018. These exceedances were consistent with a recent trend report that documented selenium exceedances for 98% of site visits at Red Rock Canyon at Mouth and 100% of site visits at Red Rock Canyon near NPS Boundary for data collected from 2001 to 2014 (Weissinger and Gibney 2019). Selenium exceedances in Red Rock Canyon have been extensively documented, and the tributary was previously included on the 303(d) list of impaired waters in Colorado. In 2011, an assessment for total maximum daily load (TMDL) was completed for selenium for the Gunnison River and tributaries, including Red Rock Creek. The TMDL indicates that non-point sources in Red Rock Creek will need to be reduced by over 90% in order to meet selenium standards (CDPHE 2011). Although selenium weathers naturally from bedrock and soils in the Red Rock Creek drainage, statewide debate exists about the impact of irrigation on this weathering. The majority of discharge from Red Rock Creek is return flow from an upstream irrigation headgate. Downstream loading of selenium in the Gunnison River watershed has been decreasing for several decades (Henneberg 2016).

The chronic manganese standard for drinking-water supply was exceeded on three occasions at Red Rock Canyon near NPS Boundary. It is likely that the source of manganese is natural weathering. It should also be noted that the concentration of manganese did not exceed criteria for aquatic life, and that the drinking-water supply standard of 50 µg/L is for odor, color, and staining—not human health.

3.3.3.3 Nutrients

The total-phosphorus interim standard for Colorado warm-water rivers and streams, scheduled to be implemented in 2022, is analyzed as an annual median value of 0.17 mg/L (CDPHE 2008). For purposes of this report, any individual total-phosphorus value for Colorado warm-water rivers or streams that exceeded 0.17 mg/L was included as an indicator of a potential problem.

Three of eleven evaluations at Red Rock Canyon near NPS Boundary exceeded the total-phosphorus interim standard. At Red Rock Canyon at Mouth, there was one exceedance for total phosphorus (9% of evaluations). Elevated total-phosphorus values in Red Rock Canyon are consistent with 10 years of data collected from 1996

to 2006 (Brown and Thoma 2012). A recent trend analysis of data collected from 2001 to 2014 showed an overall decrease in total phosphorus in Red Rock Canyon (Weissinger and Gibney 2019). Natural sources of phosphorus likely occur within Red Rock Canyon and the surrounding area.

3.3.3.4 Inorganics

This was the first study period when sulfate was tested at Red Rock Canyon and compared against water-quality standards. There were two occurrences at Red Rock Canyon at Mouth that exceeded the drinking-water supply standard. The upstream site, Red Rock Canyon near NPS Boundary, did not have any exceedances for sulfate, indicating there may be a source of sulfate between these two sites. The source is likely natural weathering.

Exceedances for sulfate do not raise significant concerns, because the drinking-water supply standard of 250 mg/L is based on secondary drinking-water standards, and is not health-based. These standards are based upon "welfare" impacts, such as taste, odor and discoloration of laundry or fixtures, and are established by EPA as goals for public water supplies.

3.4 Bryce Canyon National Park

3.4.1 Water-quality summary

A total of 1,105 designated beneficial-use evaluations were completed for water-quality results obtained at four sites in Bryce Canyon NP between October 1, 2015 and September 30, 2018. Of those 1,105 evaluations, five (0.5%) exceeded water-quality standards or criteria (Figure 3-8). Water-quality standards were exceeded for two constituent categories: *E. coli* and nutrients.

3.4.2 Reportable exceedances

Sheep Creek (514 evaluations), Mossy Cave Spring (178 evaluations), and Tropic Ditch (100 evaluations) did not have any water-quality exceedances. The following discussion focuses on the site that did have exceedances of Utah water-quality standards for more than 10% of evaluations: Yellow Creek (Figure 3-9, Table 3-3).

3.4.2.1 Yellow Creek

E. coli exceeded the chronic standard for secondary-contact recreation for 17% of evaluations. Total phosphorus exceeded the indication-of-impairment criteria for secondary-contact recreation for 17% of evaluations.

3.4.3 Discussion and management implications

3.4.3.1 *E. coli*

Two of eighteen samples at Yellow Creek exceeded the chronic *E. coli* standard (206 MPN), with one of these samples also exceeding the acute standard (668 MPN). On each of these visits, in June and July 2017, cattle tracks and fresh cattle manure were noted at the site. After these visits, monsoonal storms washed out the manure in the area, and *E. coli* concentrations decreased. Trespass cattle were still noted, however. The park boundary fence, just downstream of the Yellow Creek site, was rebuilt in the spring of 2018, which should help to prohibit cattle from entering the park. The infrequent *E. coli* exceedances that occurred during the study period do not warrant concern from a human-health perspective. Potential physical and biological damage to the riparian corridor and degradation of water quality from cattle trespass is not being measured but may be a management concern.

3.4.3.2 Nutrients

Elevated total-phosphorus levels at Yellow Creek have been previously documented (Hackbarth and Weissinger 2013), and are not uncommon. Total-phosphorus exceedances may result from rock weathering, airborne deposition, or soil erosion. Phosphorus comes in several forms, including a form sorbed to soil particles that may be transported to water bodies where dissolution can occur, resulting in bioavailable phosphorus. Trespass cattle in and around Yellow Creek may contribute to soil erosion and increased total-phosphorus levels. It is also possible that the phosphorus has a geologic origin and is naturally occurring at high levels due to weathering (Reynolds et al. 2001). A better understanding of phosphorus source, transport, and biological effect in these watersheds would help determine potential management actions for restoration, including the possibility of reclassifying or providing site-specific classifications for water bodies based on natural conditions.

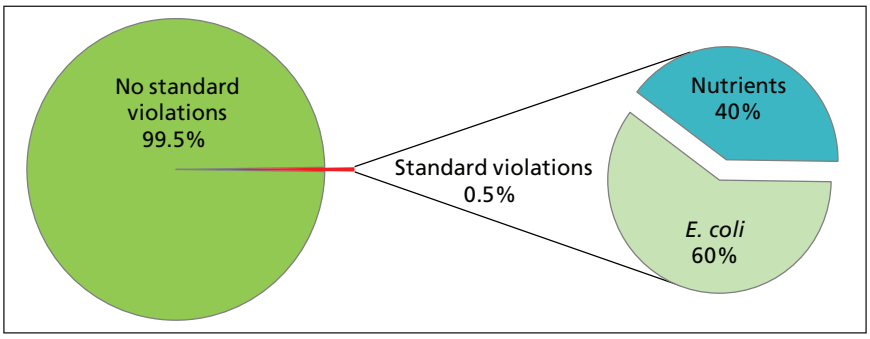


Figure 3-8. Percentage of use evaluations that exceeded standards, and the causes of exceedances as percentages of samples with an exceedance, Bryce Canyon National Park, October 1, 2015–September 30, 2018.

Water-Quality Monitoring Sites, 2016–2018

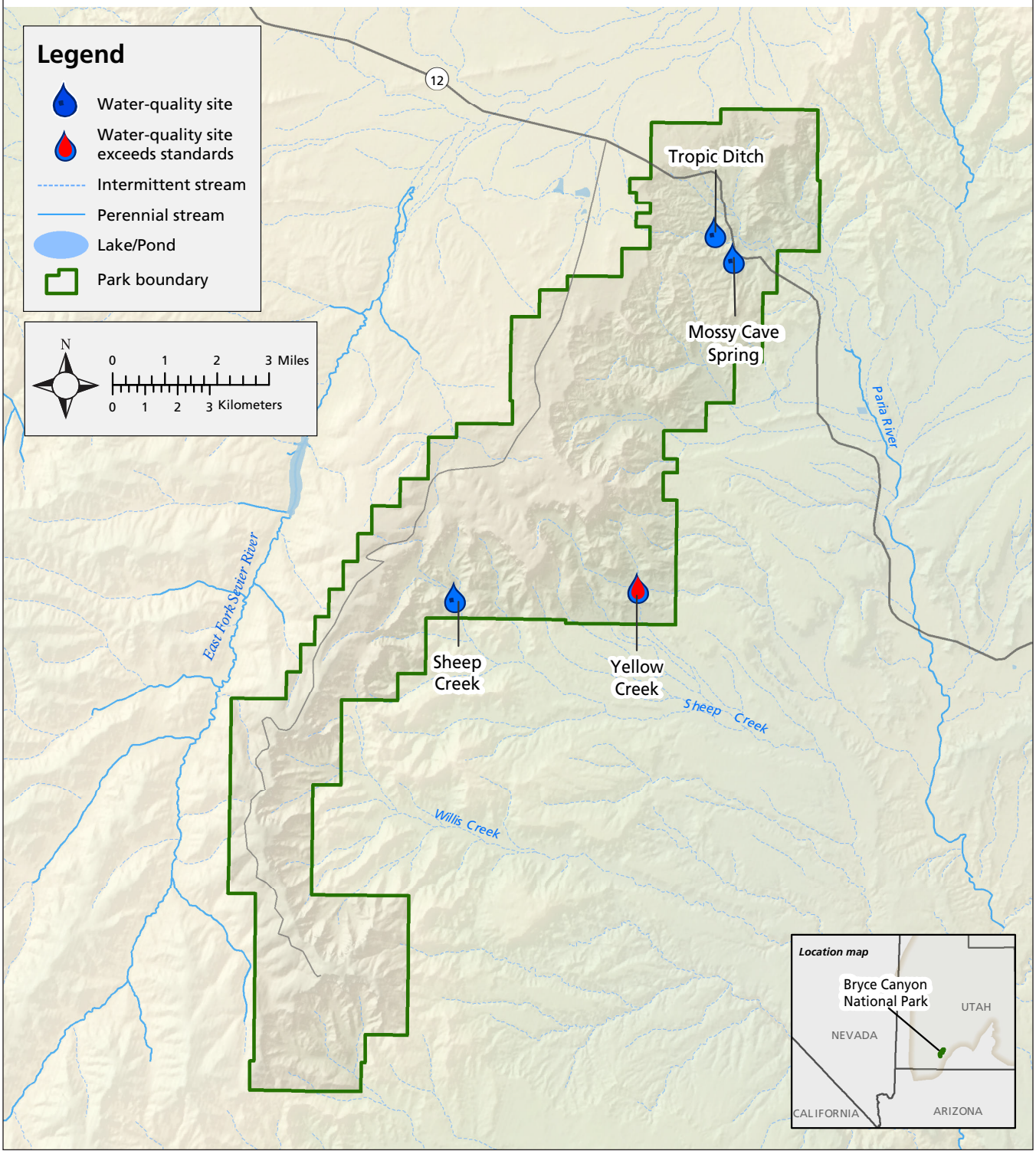


Figure 3-9. Water-quality monitoring locations in Bryce Canyon National Park. Sites that exceeded standards for more than 10% of evaluations for one or more parameters are marked with a red symbol.

Table 3-3. Sites with exceedances of surface water-quality standards for more than 10% of evaluations in Bryce Canyon National Park, October 1, 2015–September 30, 2018.

Site	Use code[A]	Parameter	Standard	Total evaluations	Exceedances	Percent exceedances
Yellow Creek	2B	*E. coli* (chronic)	206 MPN/100mL	18	2	11
	2B	Phosphorus, total	0.05 mg/L	12	2	17

[A]Use code: 2B = secondary-contact recreation

3.5 Canyonlands National Park

3.5.1 Water-quality summary

A total of 1,651 designated beneficial-use evaluations were completed for water-quality results obtained at seven sites in or near Canyonlands National Park between October 1, 2015 and September 30, 2018. Of those 1,651 evaluations, 119 (7.2%) exceeded water-quality standards or criteria (Figure 3-10). Water-quality standards were exceeded for two constituent categories: nutrients and temperature. It is important to note that Colorado River sites upstream of the confluence with the Green River have a history of selenium impairment (Hackbarth and Weissinger 2016). Selenium results were not evaluated in this report due to an ongoing project evaluating the Utah Public Health Laboratory's analytical method.

3.5.2 Reportable exceedances

Green River at Ouray, Utah, did not have any exceedances based upon 26 evaluations of water temperature only. Green River at Green River, Utah, did not have any exceedances based upon 84 evaluations of four parameters: water temperature, fluorides, pH, and total dissolved solids. All other sites had exceedances of Utah water-quality standards for more than 10% of evaluations (Figure 3-11, Table 3-4).

3.5.2.1 Colorado River above Confluence with Green River

This site exceeded the indication-of-impairment criteria for total phosphorus for primary-contact recreation and warm-water game fish for 100% of evaluations.

3.5.2.2 Colorado River at Potash Boat Ramp

This site exceeded the indication-of-impairment criteria for total phosphorus for primary-contact recreation and warm-water game fish for 100% of evaluations.

3.5.2.3 Colorado River below Big Drop #3 Rapids

This site exceeded the indication-of-impairment criteria for total phosphorus for primary-contact recreation and warm-water game fish for 100% of evaluations.

3.5.2.4 Green River above Confluence with Colorado River

This site exceeded the indication-of-impairment criteria for total phosphorus for primary-contact recreation and warm-water game fish for 100% of evaluations.

3.5.2.5 Green River at Mineral Bottom

This site had exceedances for total phosphorus and water temperature. Total phosphorus exceeded the indication-of-impairment criteria for primary-contact recreation and warm-water game fish for 100% of evaluations. Water temperature exceeded the standard for warm-water game fish for 20% of evaluations.

3.5.3 Discussion and management implications

3.5.3.1 Nutrients

All sample sites where phosphorus was measured in and around Canyonlands National Park had exceedances for 100% of samples. Elevated total phosphorus concentrations on the Colorado and Green Rivers were

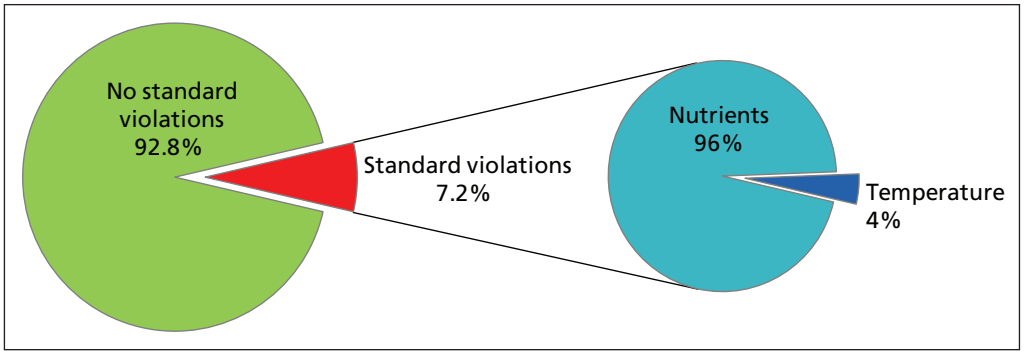


Figure 3-10. Percentage of use evaluations that exceeded standards, and the causes of exceedances as percentages of samples with an exceedance, Canyonlands National Park, October 1, 2015–September 30, 2018.

Water-Quality Monitoring Sites, 2016–2018

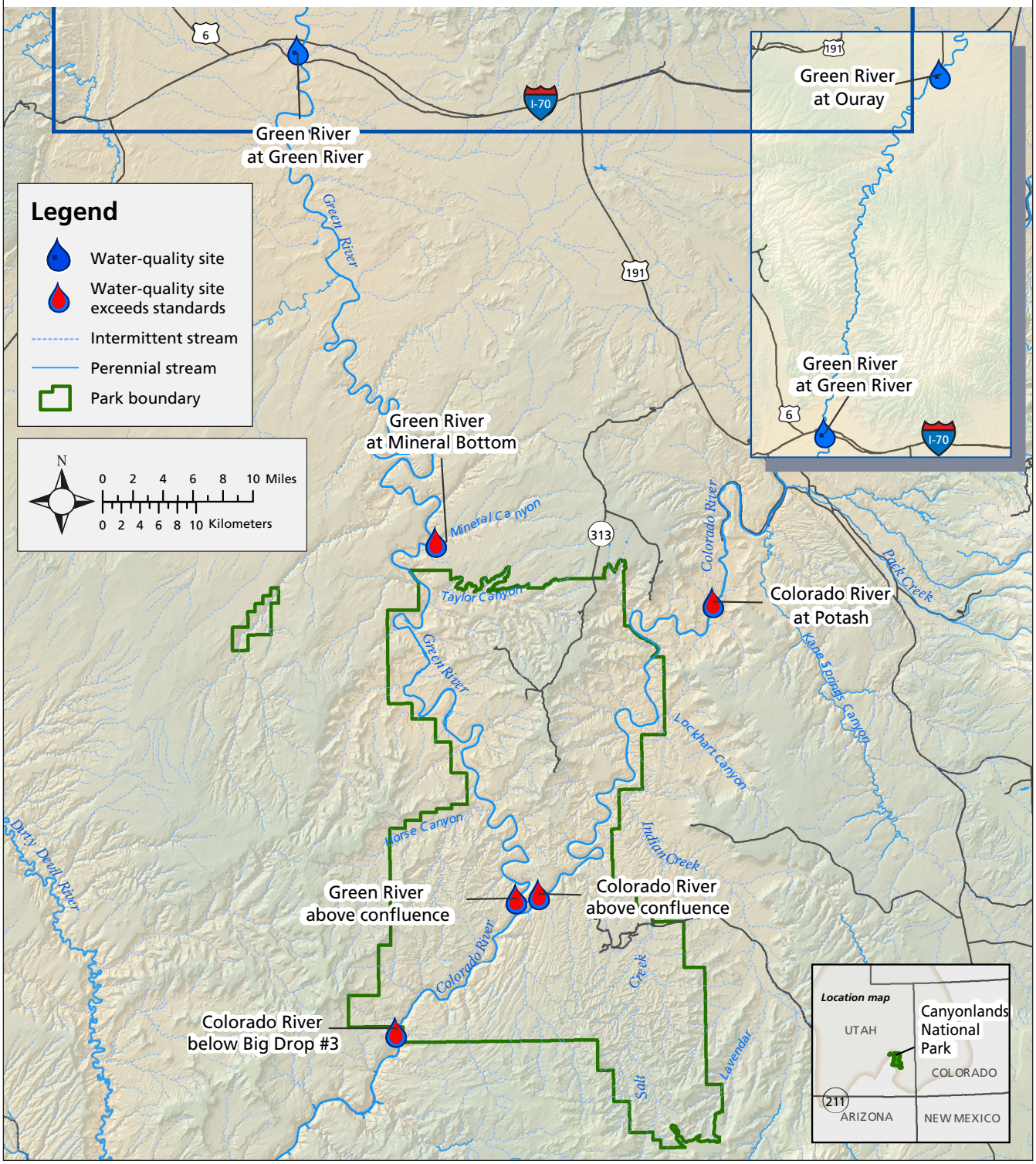


Figure 3-11. Water-quality monitoring locations in and near Canyonlands National Park. Sites that exceeded standards for more than 10% of evaluations for one or more parameters are marked with a red symbol.

Table 3-4. Sites with exceedances of surface water-quality standards for more than 10% of evaluations in or near Canyonlands National Park, October 1, 2015–September 30, 2018.

Site	Use code[A]	Parameter	Standard	Total evaluations	Exceedances	Percent exceedances
Colorado River above Confluence with Green River	2A, 3B	Phosphorus, total	0.05 mg/L	13	13	100
Colorado River at Potash Boat Ramp	2A, 3B	Phosphorus, total	0.05 mg/L	14	14	100
Colorado River below Big Drop #3 Rapids	2A, 3B	Phosphorus, total	0.05 mg/L	12	12	100
Green River above Confluence with Colorado River	2A, 3B	Phosphorus, total	0.05 mg/L	13	13	100
Green River at Mineral Bottom	2A, 3B	Phosphorus, total	0.05 mg/L	5	5	100
	3B	Water temperature	27°C	5	1	20

[A]Use codes: 2A = primary-contact recreation; 3B = warm-water game fish

consistent with decades of data (Brown and Thoma 2012; Van Grinsven et al. 2010; Hackbarth and Weissinger 2013; and Hackbarth and Weissinger 2016).

Total-phosphorus exceedances in rivers may result from rock weathering, airborne deposition, or soil erosion. Phosphorus comes in several forms, including a form sorbed to soil particles that may be transported to water bodies where dissolution can occur, resulting in bioavailable phosphorus. In the headwater areas of Canyonlands NP stream basins, soil erosion on uplands may have been accelerated due to grazing, and may continue at an accelerated pace if soil-surface crusts have not stabilized despite the absence of grazing for many years (Reynolds et al. 2005). Although speculative, this scenario may have important management implications. It is also possible that the phosphorus has a geologic origin and is naturally occurring at high levels due to weathering (Reynolds et al. 2001). A better understanding of phosphorus source, transport, and biological effect in these watersheds would help determine potential management actions for restoration, including the possibility of reclassifying or providing site-specific classifications for water bodies based on natural conditions.

3.5.3.2 Water temperature

Temperature exceedances were infrequent and occurred during the middle of the summer. Lower flow conditions, combined with hot summer air temperatures, cause periodic surface-water temperature exceedances. Water temperatures are expected to increase as human-caused climate change increases air temperatures and decreases surface-water flows in the U.S. Southwest (Seager et al. 2012).

3.6 Capitol Reef National Park

3.6.1 Water-quality summary

A total of 2,110 designated beneficial-use evaluations were completed for water-quality results obtained at six sites in or near Capitol Reef National Park between October 1, 2015 and September 30, 2018. Of those 2,110 evaluations, 92 (4.4%) exceeded water-quality standards or criteria (Figure 3-12). Water-quality standards were exceeded for five constituent categories—most commonly, *E. coli*, nutrients, and temperature.

3.6.2 Reportable exceedances

Temperature was the only water-quality parameter evaluated at the Fremont River near Bicknell site; there was only one exceedance based upon 23 evaluations (4% evaluations exceeded standard). The other five sites had exceedances of Utah water-quality standards for more than 10% of evaluations (Figure 3-13, Table 3-5).

3.6.2.1 Halls Creek below Narrows

At Halls Creek, total phosphorus exceeded the indication of impairment for secondary-contact recreation and warm-water game fish for 13% of evaluations.

3.6.2.2 Oak Creek above Sandy Ranch Dam

Oak Creek exceeded the chronic standard for *E. coli* for secondary-contact recreation and drinking-water supply (206 MPN) for 11% of evaluations. Total phosphorus exceeded the indication of impairment for primary-contact recreation and cold-water game fish for 23% of evaluations. Water temperature exceeded the standard for cold-water game fish for 39% of evaluations.

3.6.2.3 Pleasant Creek South of Sleeping Rainbow Ranch

Pleasant Creek exceeded the chronic drinking-water supply and secondary-contact recreation standards for *E. coli* for 11% of evaluations. Total phosphorus exceeded the indication-of-impairment criteria for secondary-contact recreation and cold-water game fish for 15% of evaluations. The water-temperature standard for cold-water game fish was exceeded for 35% of evaluations.

3.6.2.4 Sulphur Creek above Confluence with Fremont River

This site exceeded the chronic standard for *E. coli* for primary-contact recreation (126 MPN) for 25% of evaluations and drinking-water supply (206 MPN) for 20% of evaluations. One evaluation exceeded the acute *E. coli* standard for primary-contact recreation (409 MPN). Total phosphorus exceeded the indication-of-impairment criteria for primary-contact recreation and cold-water game fish for 15% of evaluations. Total dissolved solids exceeded the agricultural-use standard for 20% of evaluations. The water-temperature standard for cold-water game fish was exceeded for 25% of evaluations.

3.6.2.5 Sulphur Creek below Road to Goosenecks Overlook

This site exceeded the chronic standards for *E. coli* for primary-contact recreation (126 MPN) for 30% of evaluations and drinking-water supply (206 MPN) for 15% of evaluations. One evaluation exceeded the acute *E.*

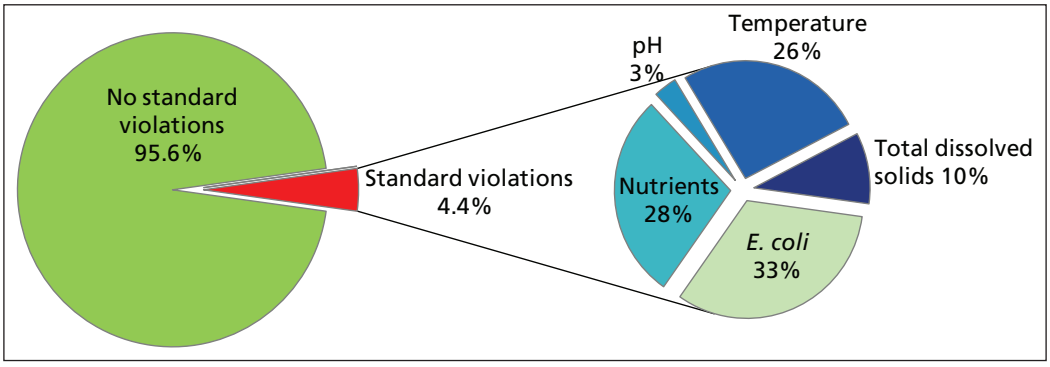


Figure 3-12. Percentage of use evaluations that exceeded standards, and the causes of exceedances as percentages of samples with an exceedance, Capitol Reef National Park, October 1, 2015–September 30, 2018.

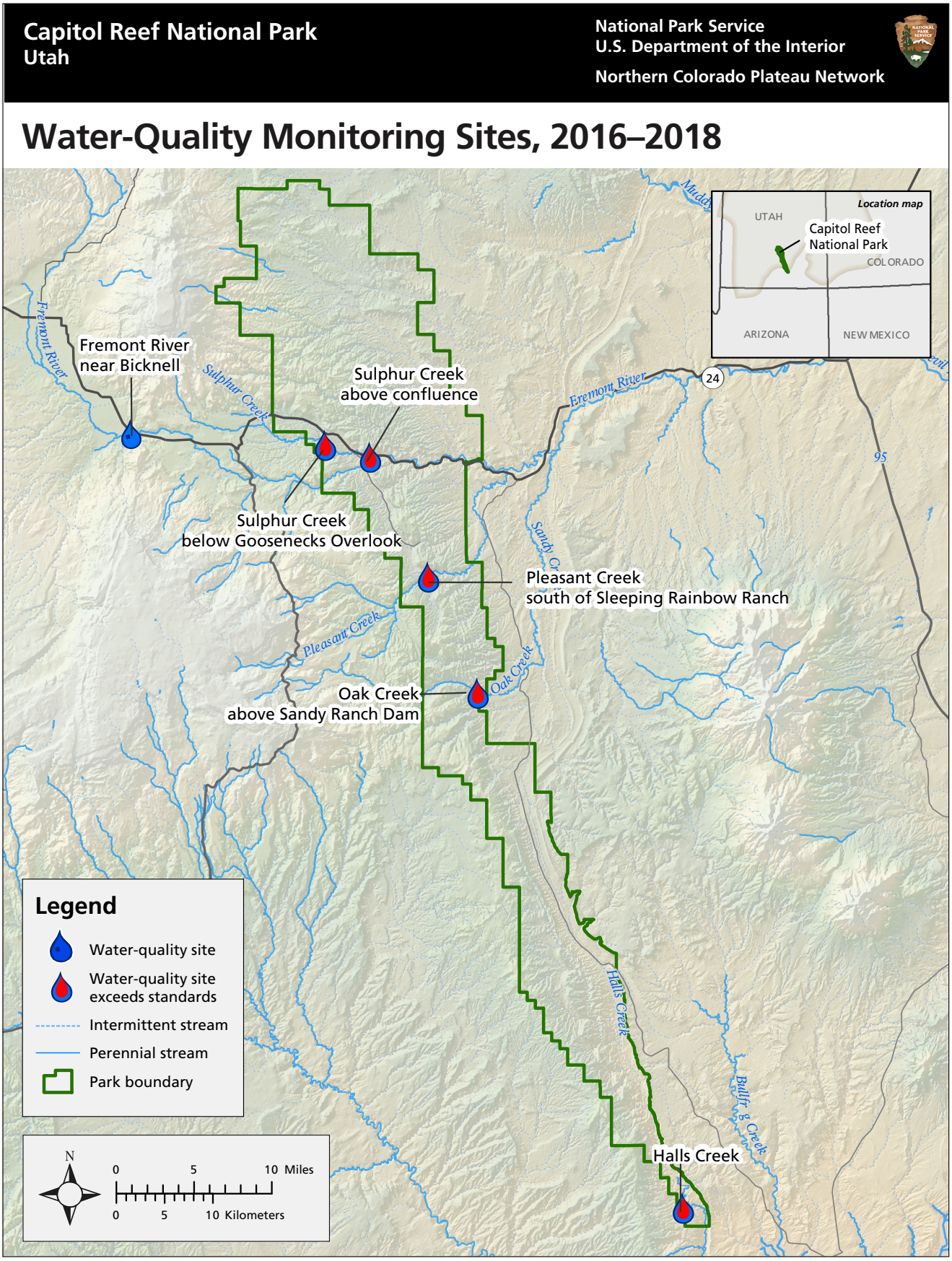


Figure 3-13. Water-quality monitoring locations in and near Capitol Reef National Park. Sites that exceeded standards for more than 10% of evaluations for one or more parameters are marked with a red symbol.

Table 3-5. Sites with exceedances of surface water-quality standards for more than 10% of evaluations in or near Capitol Reef National Park, October 1, 2015–September 30, 2018.

Site	Use code[A]	Parameter	Standard	Total evaluations	Exceedances	Percent exceedances
Halls Creek below Narrows	2B, 3B	Phosphorus, Total	0.05 mg/L	8	1	13
Oak Creek above Sandy Ranch Dam	1C, 2B	*E. coli* (chronic)	206 MPN/100mL	18	2	11
	2B, 3A	Phosphorus, total	0.05 mg/L	13	3	23
	3A	Water temperature	20°C	18	7	39
Pleasant Creek South of Sleeping Rainbow Ranch	1C, 2B	*E. coli* (chronic)	206 MPN/100mL	19	2	11
	2B, 3A	Phosphorus, total	0.05 mg/L	13	2	15
	3A	Water temperature	20°C	20	7	35
Sulphur Creek above Confluence with Fremont River	2A	*E. coli* (chronic)	126 MPN/100mL	20	5	25
	1C	*E. coli* (chronic)	206 MPN/100mL	20	4	20
	2A, 3A	Phosphorus, total	0.05 mg/L	20	3	15
	4	Total dissolved solids	1,200 mg/L	20	4	20
	3A	Water temperature	20°C	20	5	25
Sulphur Creek below Road to Goosenecks Overlook	2A	*E. coli* (chronic)	126 MPN/100mL	20	6	30
	1C	*E. coli* (chronic)	206 MPN/100mL	20	3	15
	2A, 3A	Phosphorus, total	0.05 mg/L	20	4	20
	4	Total dissolved solids	1,200 mg/L	20	5	25
	3A	Water temperature	20°C	20	3	15

[A]Use codes: 2A = primary-contact recreation; 2B = secondary-contact recreation; 3A = cold-water game fish; 3B = warm-water game fish; 1C = drinking-water supply; 4 = agricultural use

coli standard for primary-contact recreation (409 MPN). Total phosphorus exceeded the indication-of-impairment criteria for primary-contact recreation and cold-water game fish for 20% of evaluations. Total dissolved solids exceeded the agricultural-use standard for 25% of evaluations. The water-temperature standard for cold-water game fish was exceeded for 15% of evaluations.

3.6.3 Discussion and management implications

3.6.3.1 *E. coli*

Possible sources of *E. coli* contamination could be wildlife, domestic animals, humans, or a combination thereof. At Pleasant and Oak creeks, cattle trailing is permitted through the park. Cattle are moved from lower-elevation pastures up through Oak Creek to pastures on Boulder Mountain in late spring. In the fall, cattle are trailed back through Oak Creek over the course of one week and through Pleasant Creek for one day to return to lower elevations. Conditions after cattle trailing can cause damage to riparian areas and degrade water quality. Trespass cattle have been frequently noted along Oak Creek within the park outside of the permitted trailing times. Upstream of the park, cattle grazing occurs on U.S. Forest Service lands from early June through mid-October.

During high-discharge events, runoff from the watershed contributes large amounts of sediment and organic material to streams. Fecal matter and its microbial components, such as *E. coli*, are carried into streams, along with silts and sands eroded during overland-flow events. *E. coli* readily binds to benthic and suspended sediment in surface-water bodies, and is able to survive for prolonged periods when attached to sediments (Sampson et al. 2006). In addition, *E. coli* concentrations have been shown to be positively correlated with turbidity levels (Smith et al. 2008). Therefore, elevated *E.*

coli concentrations are more likely to occur during turbid, high-discharge events.

While some of these *E. coli* exceedances occurred during higher flows and turbid water, many of the exceedances were associated with low-to-normal flows and clear water. A recent report on Fremont River tributaries in Capitol Reef NP (Hackbarth and Weissinger 2018) compared *E. coli* data collected in 2008–2017 against streamflow and turbidity to look for patterns contributing to *E. coli* contamination. Although no significant relationship was found between the three parameters (suggesting that *E. coli* contamination was not always due to flood events), a seasonal pattern stood out: most exceedances occurred during the summer months, when activities upstream of the park (livestock grazing, recreation, agriculture, and wildlife use) could be introducing *E. coli* into the streams. The State of Utah is in the process of implementing a TMDL for *E. coli* exceedances in the Fremont River watershed. The TMDL can help to identify potential sources of *E. coli* contamination and, in turn, make recommendations for reducing *E. coli* loads, such as modifications to agricultural practices.

3.6.3.2 Nutrients

Five sites within Capitol Reef NP exceeded the indication of impairment for total phosphorus. Elevated total-phosphorus concentrations at these sites are consistent with data presented in previous reports (Van Grinsven et al. 2010; Hackbarth and Weissinger 2013; Hackbarth and Weissinger 2016). Rocks of volcanic origin are known to have naturally high levels of phosphorus (Brown and Thoma 2012). As they are common in the upper watersheds of these streams, a geologic source for these exceedances is likely. Anthropogenic activities, such as pasture irrigation, grazing, and OHV recreation, can accelerate erosion and transport of phosphorus (sorbed to sediment particles) to surface-water bodies. Further investigation is warranted to determine if the observed total-phosphorus concentrations are natural or anthropogenic in origin. If the observed total-phosphorus exceedances are strongly correlated with low dissolved-oxygen conditions, then management action could be warranted. At these sites, elevated total-phosphorus concentrations did not coincide with low dissolved-oxygen concentrations, indicating a low likelihood of eutrophication.

3.6.3.3 Total dissolved solids

Both sites monitored on Sulphur Creek exceeded the agricultural-use standard for total dissolved solids. Exceedances for total dissolved solids at Sulphur Creek are consistent with past data (Hackbarth and Weissinger 2013; Hackbarth and Weissinger 2016). Sulphur Creek runs primarily through the Moenkopi Formation, which is known to contribute naturally high levels of dissolved solids (Doelling et al. 1989). Irrigation inflows and runoff from agricultural activities upstream from and within Capitol Reef NP are a possible anthropogenic source of elevated TDS levels.

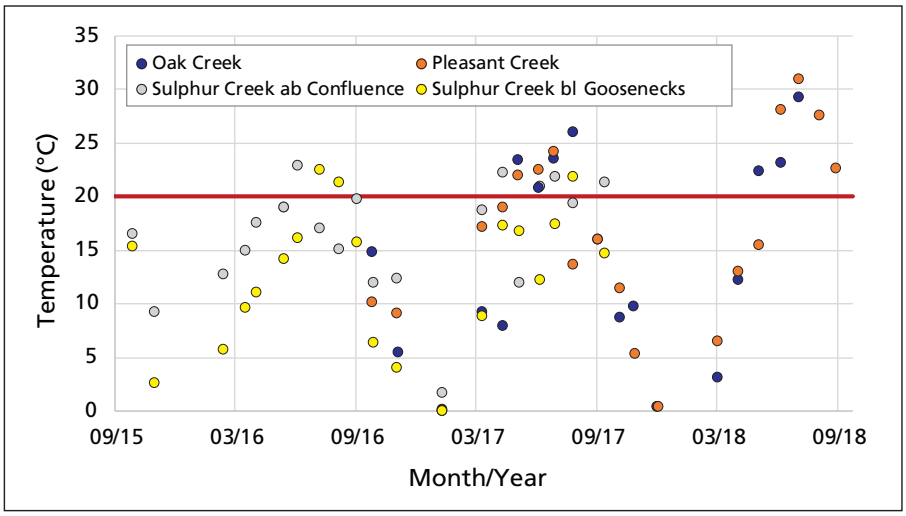


Figure 3-14. Water-temperature measurements at four sites in Capitol Reef National Park, October 1, 2015–September 30, 2018. The red line indicates the temperature standard for cold-water game fish of 20°C.

3.6.3.4 Water temperature

Elevated temperatures occurred at four sites within Capitol Reef National Park. Temperatures exceeded the State of Utah standard for cold-water game fish during the warmer summer months, usually from May through the beginning of September (Figure 3-14). Low-flow conditions, combined with hot summer air temperatures, cause periodic exceedances of surface-water temperature at these sites. Water temperatures are expected to increase as human-caused climate change increases air temperatures and decreases surface-water flows in the U.S. Southwest (Seager et al. 2012).

3.7 Curecanti National Recreation Area

3.7.1 Water-quality summary

A total of 5,108 designated beneficial-use evaluations were completed for water-quality results obtained at 20 sites in or near Curecanti National Recreation Area between October 1, 2015 and September 30, 2018. Of those 5,108 evaluations, 130 (2.5%) exceeded water-quality standards or indications of impairment for the State of Colorado (Figure 3-15). Water-quality standards were exceeded for six constituent categories—most commonly, nutrients, temperature, and *E. coli*.

3.7.2 Reportable exceedances

Six sites in or near Curecanti NRA did not have exceedances: Gunnison River at County Rd 32 below Gunnison (444 evaluations), Lake Fork Gunnison River below Gateview (272 evaluations), Crystal Reservoir at Crystal Creek (25 evaluations), Crystal Reservoir at Crystal Dam (57 evaluations), Morrow Point Reservoir below Blue Creek (49 evaluations), and Morrow Point Reservoir above Morrow Point Dam (54 evaluations). West Elk Creek below Forest Service Boundary and Soap Creek above Chance Creek had exceedances that accounted for less than 10% of evaluations. The following discussion focuses on the 11 sites that had exceedances of Colorado water-quality standards for more than 10% of evaluations (Figure 3-16, Table 3-6).

3.7.2.1 Beaver Creek at Hwy 50 near Gunnison

Total phosphorus exceeded the interim standard for aquatic life cold-water class 1 for 36% of evaluations.

3.7.2.2 Blue Creek at Hwy 50 near Sapinero

At this site, *E. coli* exceeded the undetermined-use recreation standard for 64% of evaluations.

3.7.2.3 Cebolla Creek at Powderhorn

This site exceeded standards for aluminum and total phosphorus. Aluminum exceeded the aquatic life cold-water class 1 standard for 31% of evaluations. Total phosphorus exceeded the interim standard for aquatic life cold-water class 1 for 11% of evaluations.

3.7.2.4 Cimarron River below Squaw Creek near Cimarron

E. coli exceeded the undetermined-use recreation standard for 78% of evaluations.

3.7.2.5 Curecanti Creek near Sapinero

Two samples for *E. coli* exceeded the undetermined-use recreation standard, with one of these samples also exceeding the drinking-water supply standard.

3.7.2.6 East Elk Creek near mouth near Sapinero

This site exceeded standards for total phosphorus and water temperature. Total phosphorus exceeded the interim standard for aquatic life cold-water class 1 for 73% of

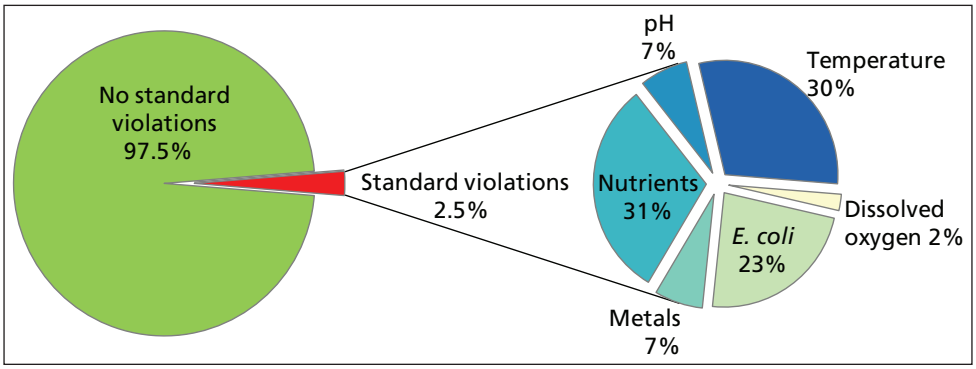


Figure 3-15. Percentage of beneficial-use evaluations that exceeded standards, and the causes of exceedances as percentages of samples with an exceedance, Curecanti National Recreation Area, October 1, 2015–September 30, 2018.

Curecanti National Recreation Area
Colorado

National Park Service
U.S. Department of the Interior
Northern Colorado Plateau Network

Water-Quality Monitoring Sites, 2016–2018

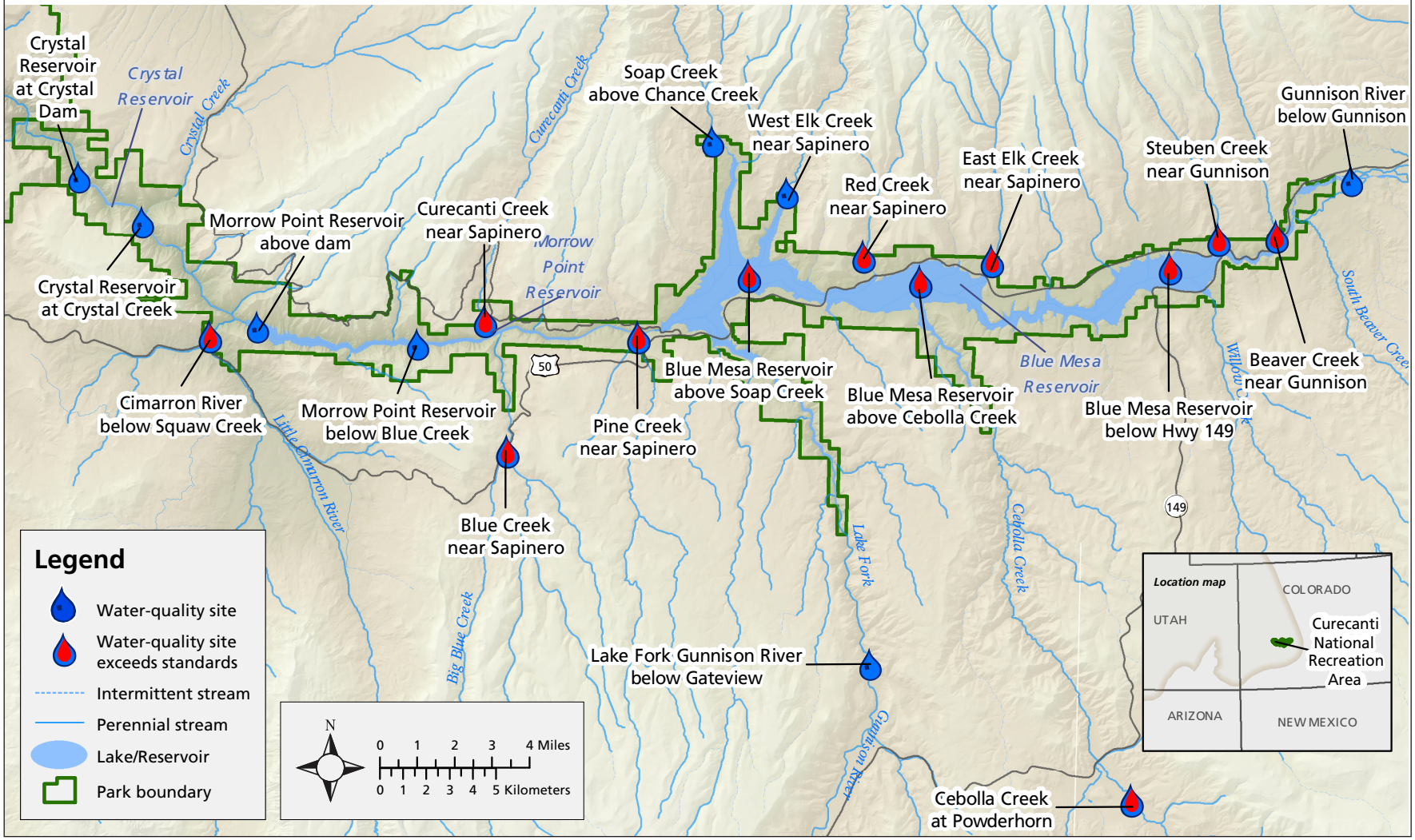


Figure 3-16. Water-quality monitoring locations in and near Curecanti National Recreation Area. Sites that exceeded standards for more than 10% of evaluations for one or more parameters are marked with a red symbol.

Table 3-6. Sites with exceedances of surface water-quality standards for more than 10% of evaluations in or near Curecanti National Recreation Area, October 1, 2015–September 30, 2018.

Site	Use code[A]	Parameter	Standard	Total evaluations	Exceedances	Percent exceedances
Beaver Creek at Hwy 50 near Gunnison	ALCW1	Phosphorus, total	110 µg/L	11	4	36
Blue Creek at Hwy 50 near Sapinero	RecU	*E. coli*	126 MPN/100mL, 126 cfu/100mL	11	7	64
Cebolla Creek at Powderhorn	ALCW1	Aluminum, total recoverable	H-dep µg/L	16	5	31
	ALCW1	Phosphorus, total	110 µg/L	19	2	11
Cimarron River below Squaw Creek near Cimarron	RecU	*E. coli*	126 MPN/100mL, 126 cfu/100mL	9	7	78
Curecanti Creek near Sapinero	RecU	*E. coli*	126 MPN/100mL, 126 cfu/100mL	9	2	22
	DWS	*E. coli*	630 MPN/100mL, 630 cfu/100mL	9	1	11
East Elk Creek near Mouth near Sapinero	ALCW1	Phosphorus, total	110 µg/L	11	8	73
	UG2	Water temperature	17.0°C (summer) 9.0°C (winter)	12	3	25
Pine Creek at Hwy 50 near Sapinero	RecU	*E. coli*	126 MPN/100mL, 126 cfu/100mL	10	3	30
	ALCW1	Phosphorus, total	110 µg/L	10	7	70
Red Creek near mouth near Sapinero	DWS	Manganese, dissolved	50 µg/L	7	2	29
	ALCW1	Phosphorus, total	110 µg/L	10	8	80
	UG2	Water temperature	17.0°C (summer) 9.0°C (winter)	13	3	23
Steuben Creek near Mouth near Gunnison	RecU	*E. coli*	126 MPN/100mL, 126 cfu/100mL	11	2	18
	ALCW1	Phosphorus, total	110 µg/L	11	2	18
Blue Mesa Reservoir above Cebolla Creek near Sapinero	BlueMesa	Water temperature	16.6°C (summer) 9.0°C (winter)	10	9	90
Blue Mesa Reservoir above Soap Creek near Sapinero	BlueMesa	Water temperature	16.6°C (summer) 9.0°C (winter)	10	9	90
Blue Mesa Reservoir below Hwy 149 near Gunnison	ALCW1, DWS, RecE	pH	9	10	2	20
	Reservoir	Phosphorus, total	25 µg/L	11	5	45
	BlueMesa	Water temperature	16.6°C (summer) 9.0°C (winter)	10	9	90

[A]Use codes: ALCW1 = aquatic life cold-water class 1; RecE = existing primary-contact recreation; RecU = undetermined use recreation; DWS = drinking-water supply; UG2 = Upper Gunnison River Basin segment 2 aquatic life standard; BlueMesa = Blue Mesa water-temperature standard; Res = reservoir-specific aquatic life standard

evaluations. Water temperature exceeded the Upper Gunnison River Basin segment 2 aquatic life standard for 25% of evaluations.

3.7.2.7 Pine Creek at Hwy 50 near Sapinero

This site exceeded standards for *E. coli* and total phosphorus. *E. coli* exceeded the undetermined-use recreation standard for 30% of evaluations. Total phosphorus exceeded the interim standard for aquatic life cold-water class 1 for 70% of evaluations.

3.7.2.8 Red Creek near mouth near Sapinero

At this site, exceedances were observed for manganese, total phosphorus, and water temperature. Dissolved-manganese concentrations exceeded the chronic standard for drinking-water supply for 29% of evaluations. There are no drinking-water supplies drawn from Red Creek within or outside Curecanti NRA. Total phosphorus exceeded the interim standard for aquatic life cold-water class 1 for 80% of evaluations. Water temperature exceeded the Upper Gunnison River Basin segment 2 aquatic life standard for 23% of evaluations.

3.7.2.9 Steuben Creek near mouth near Gunnison

This site exceeded standards for *E. coli* and total phosphorus. *E. coli* exceeded the undetermined-use recreation standard for 18% of evaluations. Total phosphorus exceeded the interim standard for aquatic life cold-water class 1 for 18% of evaluations.

3.7.2.10 Blue Mesa Reservoir above Cebolla Creek near Sapinero

Water temperature exceeded the Blue Mesa Reservoir-specific chronic standard for aquatic life cold-water for 90% of evaluations.

3.7.2.11 Blue Mesa Reservoir above Soap Creek near Sapinero

Water temperature exceeded the Blue Mesa Reservoir-specific chronic standard for aquatic life cold-water for 90% of evaluations.

3.7.2.12 Blue Mesa Reservoir below Hwy 149 near Gunnison

This site exceeded the standards for pH, total phosphorus, and water temperature. Two of ten samples exceeded pH standards for aquatic life cold-water class 1, drinking-water supply, and existing primary-contact recreation. Total phosphorus exceeded the interim standard for aquatic life cold-water in Colorado reservoirs for 45% of evaluations. Water temperature exceeded the Blue Mesa Reservoir-specific chronic standard for aquatic life cold-water for 90% of evaluations.

3.7.3 Discussion and management implications

3.7.3.1 *E. coli*

E. coli standards were exceeded at Blue Creek, Cimarron River, Curecanti Creek, Pine Creek, and Steuben Creek. Possible sources of *E. coli* contamination could be wildlife, domestic animals, humans, or a combination thereof. During high-discharge events, runoff from the watershed contributes large amounts of sediment and organic material to streams. Fecal matter and its microbial components, such as *E. coli*, are carried into streams, along with silts and sands eroded during overland-flow events. *E. coli* readily binds to benthic and suspended sediment in surface-water bodies, and is able to survive for prolonged periods when attached to sediments (Sampson et al. 2006). In addition, *E. coli* concentrations have been shown to be positively correlated with turbidity levels (Smith et al. 2008). Therefore, elevated *E. coli* concentrations are more likely to occur during turbid, high-discharge events.

The majority of *E. coli* exceedances in Curecanti NRA occurred when the water was relatively clear. Additionally, *E. coli* exceedances occurred during the summer months, when recreational activity in the park is at its peak. Because the risk of primary contact is greatest at the same time when the *E. coli* exceedances tend to occur, it is recommended that park staff warn visitors of potential bacterial contamination and increase the rate of sample collection if an exceedance is observed in the future.

3.7.3.2 Metals

The chronic-manganese standard for drinking-water supply was exceeded twice at the

Red Creek near Mouth near Sapinero site. Exceedances for the drinking-water supply standard do not raise significant concerns because there are no direct drinking-water intakes at Curecanti NRA. The tributaries drain areas of public land that are minimally impacted by human activities, and the source of manganese is likely natural weathering. It should also be noted that the concentration of manganese in these and other water bodies did not exceed criteria for aquatic life, and the drinking-water supply standard of 50 µg/L is for odor, color, and staining—not human health.

It may be possible to request exemptions or site-specific manganese criteria if sufficient evidence exists to make a strong case for naturally occurring conditions that exceed criteria, and no drinking-water source exists on the water bodies. Such a change would not improve water quality, but would make accounting for exceedances more straightforward, especially if these conditions are already recognized by the Colorado State Water Quality Control Commission.

Aluminum concentrations at Cebolla Creek exceeded the standard on five occasions. The majority of these exceedances occurred during higher discharges, when overland flow may have carried natural sources of aluminum into the creek.

3.7.3.3 Nutrients

The total phosphorus interim standard for Colorado cold-water rivers and streams, scheduled to be implemented in 2022, is analyzed as an annual median value of 0.11 mg/L (CDPHE 2008). For purposes of this report, any individual total-phosphorus value for Curecanti NRA rivers and streams that exceeded 0.11 mg/L was included in this report as an indicator of a potential problem. There is also an adopted interim standard for Colorado cold-water lakes and reservoirs, analyzed as an average value 0.025 mg/L for the summer months. Any individual total-phosphorus value for Curecanti NRA reservoirs that exceeded 0.025 mg/L was included in this report.

Total phosphorus exceeded the interim standard at Beaver Creek, Cebolla Creek, East Elk Creek, Pine Creek, Red Creek, Steuben Creek, and Blue Mesa Reservoir below Highway 149. These elevated phosphorus levels are consistent with decades of data from streams in and near Curecanti NRA (Brown and Thoma 2012; Weissinger and Gibney 2019). Rocks of volcanic origin, which commonly occur around the park, are known to contain relatively high amounts of phosphorus. Trend analyses indicate that total phosphorus is not increasing or decreasing (Brown and Thoma 2012; Weissinger and Gibney 2019), suggesting that phosphorus may be naturally occurring and of local geologic origin.

3.7.3.4 pH

Elevated pH levels were observed at one site on Blue Mesa Reservoir. Measurements for pH before and after these exceedances were within acceptable limits. Because these pH exceedances were infrequent, no immediate concern is warranted at this time.

3.7.3.5 Water temperature

Temperatures exceeded the State of Colorado standard for cold-water aquatic life at Red Creek, East Elk Creek, and at all three sites on Blue Mesa Reservoir. At Red Creek, one exceedance occurred in the middle of the summer. One exceedance occurred during each of the seasonal transition months of May and October, when the standard is 9° C as compared to 17°C during the summer months of June–September. Water temperatures at Red Creek never exceeded the acute standard for cold-water streams. At Elk Creek, exceedances occurred in July 2016 and May and September 2018. In July 2016, a water temperature of 23.1°C was recorded, which also exceeded the acute standard of 21.7°C.

At sites on Blue Mesa Reservoir, temperature was only measured in June–September. During the summer months, air temperatures heat the water surface, resulting in water temperatures above the chronic standard of 16.6°C. The temperature criteria for Blue Mesa Reservoir changed from 18.3°C to 16.6°C since the last report to protect lake trout from thermal impacts. Water temperatures at Blue Mesa Reservoir never exceeded the acute standard of 24.2°C, which is defined as the daily maximum temperature and

more comparable to the one-time monthly measurement at these sites. Reservoir data are based on samples collected at one meter below surface, but other temperature data not assessed here show typical cold-water refugia at depth. However, warm temperatures may have contributed to a harmful algal bloom event in 2018.

As climate change continues to warm higher-elevation areas more rapidly than lower-elevation areas, continued stream-temperature exceedances may threaten spawning habitat for fish. To reduce stress on game fish, managers at Yellowstone National Park have elected to close fisheries during periods of high-water temperatures—a management option that may also be helpful for cold-water tributaries at Curecanti NRA.

3.8 Dinosaur National Monument

3.8.1 Water-quality summary

A total of 2,326 designated beneficial-use evaluations were completed for water-quality results obtained at seven sites in or near Dinosaur National Monument between October 1, 2015 and September 30, 2018. Of those 2,326 evaluations, 82 (3.5%) exceeded water-quality standards or indications of impairment (Figure 3-17). Water-quality standards were exceeded for seven constituent categories—most commonly, nutrients, metals, and *E. coli*.

3.8.2 Reportable exceedances

The only water-quality criteria evaluated at the Green River near Jensen, Utah, was water temperature, and there were no exceedances based upon 20 evaluations. The following discussion focuses on the six sites that had exceedances of Colorado or Utah water-quality standards for more than 10% of evaluations (Figure 3-18, Table 3-7).

3.8.2.1 Brush Creek at U149 Crossing

At this site, exceedances were observed for *E. coli* and total phosphorus. All samples tested for *E. coli* during this study period exceeded the chronic standard for secondary-contact recreation (206 MPN), with one of the five samples also exceeding the acute standard (668 MPN). Total phosphorus exceeded the indication-of-impairment criteria for secondary-contact recreation and warm-water game fish for 67% of evaluations.

3.8.2.2 Green River above Gates of Lodore

Total recoverable iron concentrations exceeded aquatic life cold-water class 1 standard for 27% of evaluations.

3.8.2.3 Pot Creek above Matt Warner Reservoir

At this site, exceedances were observed for dissolved oxygen, *E. coli*, phosphorus, and water temperature. Dissolved-oxygen concentrations failed to meet the standard for cold-water game fish for 25% of evaluations. Two of five *E. coli* samples exceeded both the chronic and acute standard for secondary-contact recreation. Total phosphorus exceeded the indication-of-impairment criteria for secondary-contact recreation and cold-water game fish for 53% of evaluations. Water temperature exceeded the cold-water game fish standard for 12% of evaluations.

3.8.2.4 Yampa River at Deerlodge Park, CO

This site had exceedances for iron, manganese, and phosphorus. Total recoverable iron concentrations exceeded aquatic life warm-water class 1 standard for 42% of evaluations. Total recoverable manganese concentrations exceeded the agricultural-use standard for 17% of evaluations. Total phosphorus levels exceeded the aquatic life warm-water class 1 interim standard for 25% of evaluations.

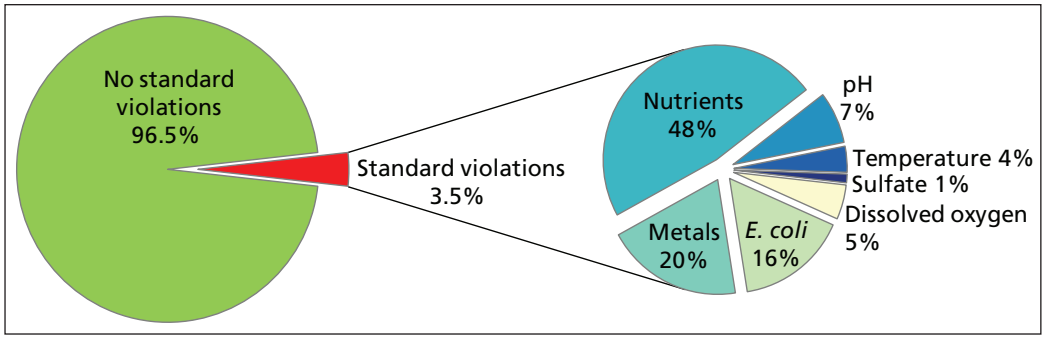


Figure 3-17. Percentage of use evaluations that exceeded standards, and the causes of exceedances as percentages of samples with an exceedance, Dinosaur National Monument, October 1, 2015–September 30, 2018.

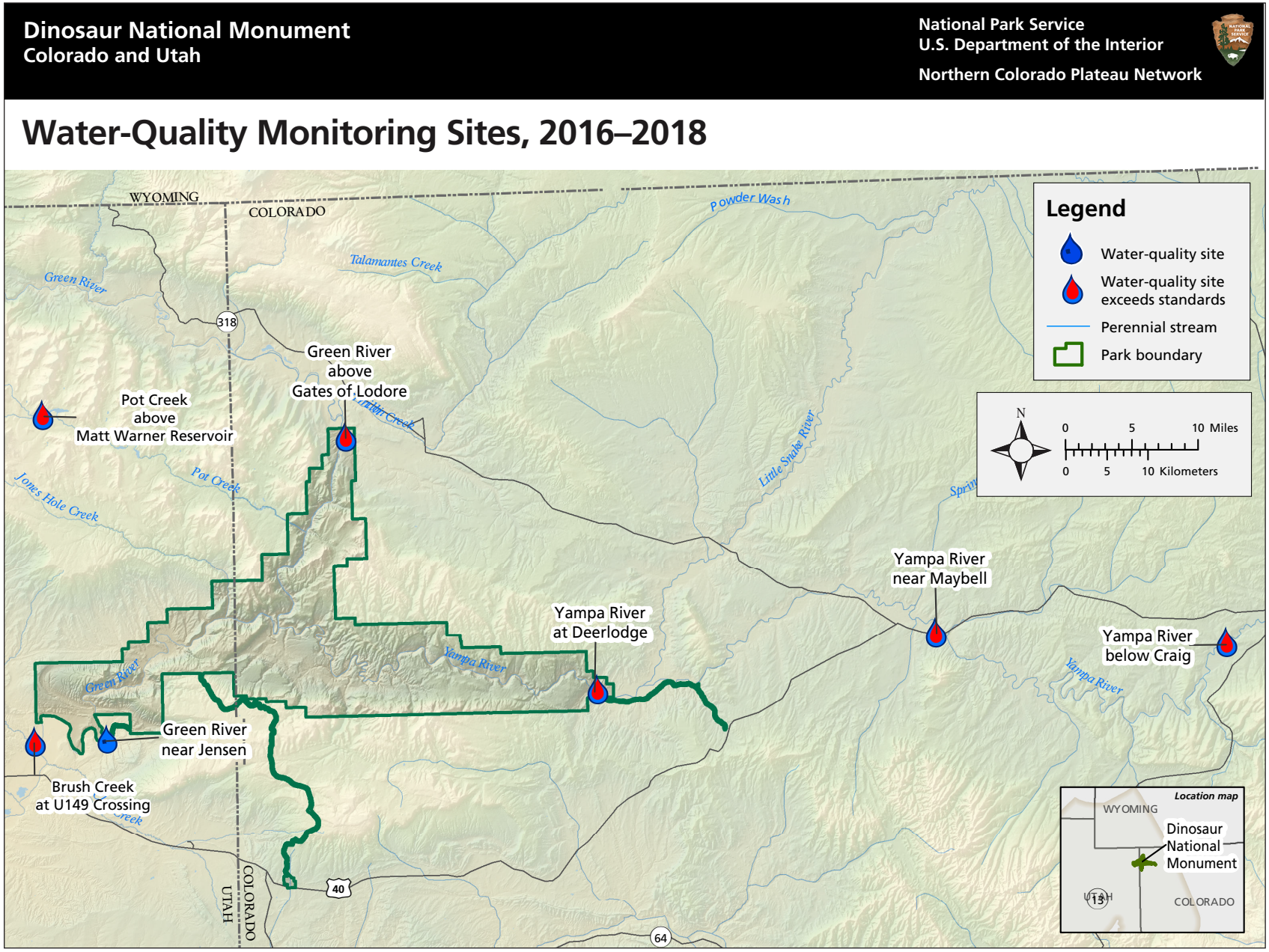


Figure 3-18. Water-quality monitoring locations in and near Dinosaur National Monument. Sites that exceeded standards for more than 10% of evaluations for one or more parameters are marked with a red symbol.

Table 3-7. Sites with exceedances of surface water-quality standards for more than 10% of evaluations in or near Dinosaur National Monument, October 1, 2015–September 30, 2018.

Site	Use code[A]	Parameter	Standard	Total evaluations	Exceedances	Percent exceedances
Brush Creek at U149 Crossing	2B	*E. coli* (chronic)	206 MPN/100mL	5	5	100
	2B	*E. coli* (acute)	668 MPN/100mL	5	1	20
	2B, 3B	Phosphorus, total	0.05 mg/L	12	8	67
Green River above Gates of Lodore	ALCW1	Iron, total recoverable	1,000 µg/L	11	3	27
Pot Creek above Matt Warner Reservoir	3A	Dissolved oxygen	6.5 mg/L	16	4	25
	2B	*E. coli* (chronic)	206 MPN/100mL	5	2	40
	2B	*E. coli* (acute)	668 MPN/100mL	5	2	40
	2B, 3A	Phosphorus, total	0.05 mg/L	17	9	53
	3A	Water temperature	20°C	17	2	12
Yampa River at Deerlodge Park	ALWW1	Iron, total recoverable	1,000 µg/L	12	5	42
	Ag	Manganese, total recoverable	200 µg/L	12	2	17
	ALWW1	Phosphorus, total	0.17 mg/L	12	3	25
Yampa River below Craig, CO	ALWW1	Iron, total recoverable	1,000 µg/L	12	3	25
	ALWW1, DWS, RecE	pH	9	12	2	17
Yampa River near Maybell, CO	RecE	*E. coli* (chronic)	126 cfu/100mL	8	2	25
	ALWW1	Iron, total recoverable	1,000 µg/L	8	2	25
	Ag	Manganese, total recoverable	200 µg/L	8	1	13
	ALWW1	Phosphorus, total	0.17 mg/L	8	1	13

[A]Colorado use codes: Ag = agricultural use; ALCW1 = aquatic life cold-water class 1; ALWW1 = aquatic life warm-water class 1; DWS = drinking-water supply; RecE = existing primary-contact recreation. Utah use codes: 2B = secondary-contact recreation; 3A = cold-water game fish; 3B = warm-water game fish

3.8.2.5 Yampa River below Craig, CO

Total recoverable iron concentrations exceeded the aquatic life warm-water class 1 standard for 25% of evaluations. The pH standard for aquatic life warm-water class 1, drinking-water supply, and primary-contact recreation was exceeded for 17% of evaluations.

3.8.2.6 Yampa River near Maybell, CO

At this site, exceedances were observed for *E. coli*, iron, manganese, and phosphorus. *E. coli* levels exceeded the chronic standard for primary-contact recreation for 25% of evaluations. Total recoverable iron concentrations exceeded aquatic life warm-water class 1 standard for 25% of evaluations. Total recoverable manganese concentrations exceeded the agricultural-use standard for 13% of evaluations. Total phosphorus levels exceeded the aquatic life warm-water class 1 interim standard for 13% of evaluations.

3.8.3 Discussion and management implications

3.8.3.1 Dissolved oxygen

Low dissolved-oxygen levels at Pot Creek were consistent with data collected in 2006–2007 (Van Grinsven et al. 2010). In low-flow conditions, the presence of stagnant, low or no-flow pools throughout the creek may produce the low dissolved-oxygen conditions observed.

3.8.3.2 *E. coli*

Exceedances for *E. coli* were observed at Brush Creek, Pot Creek, and the Yampa River near Maybell, Colorado. Possible sources of *E. coli* contamination could be wildlife, domestic animals, humans, or a combination thereof. The *E. coli* exceedances at Pot Creek and the Yampa River near Maybell were infrequent and do not warrant concern from a human-health perspective. *E. coli* contamination in the Brush Creek watershed has been documented previously. The segment for Brush Creek and tributaries from its confluence with the Green River to Red Fleet Dam was added to Utah's list of impaired waters in 2014 for *E. coli*. This is the first study period when we have reported on *E. coli* data collected by the State of Utah at the Brush Creek site. Samples were collected from May through September 2017, and ranged from 396.8 to 686.7 MPN. With this site's inclusion on the list of impaired waters, a total maximum daily load might be developed in the future which will help to identify possible sources of *E. coli* contamination and a plan to reduce levels.

3.8.3.3 Metals

Exceedances for iron and manganese in this area are not surprising. Elevated iron and manganese concentrations in the Yampa River have been well documented (Roehm 2004; Harza 2002; Thoma et al. 2017). Naturally occurring mineralization of iron and manganese minerals is prevalent in the watershed. Elevated concentrations may also be a result of runoff from mining operations throughout the basin. Iron and manganese exceedances have been regularly observed in the past, are included in two State of Colorado watershed management plans, and are not unique to the lower portions of the Yampa River watershed. In 2010, the Yampa River from Elkhead Creek to its confluence with the Green River was added to Colorado's 303(d) list for iron exceedances. As in past years, total recoverable iron concentrations in the Yampa River at Deerlodge Park, Colorado, were consistently higher than concentrations observed upstream at Craig, Colorado, indicating that there is a source of iron located between these two sites.

3.8.3.4 Nutrients

Total-phosphorus exceedances were observed at Brush Creek, Pot Creek, and two of the three sites on the Yampa River. Elevated total-phosphorus values on the Yampa River were consistent with 27–33 years of data, and total-phosphorus concentrations have not increased or decreased at these sites (Brown and Thoma 2012). Phosphorus exceedances at Pot Creek above Matt Warner Reservoir and Brush Creek at U149 Crossing have also been previously documented (Van Grinsven et al. 2010). In the Big Brush Creek Basin, upstream of the water-quality site on Brush Creek, there is a large commercial phosphate mine. Mining can contribute nutrients to surface water and groundwater from extraction of nitrogen and phosphorus-bearing source-rock materials. Naturally elevated phosphorus

conditions are common throughout the northern Colorado Plateau, and are suspected, in many cases, to be geologic in origin. Anthropogenic activities, such as logging, grazing, mining, and OHV recreation, can accelerate erosion and transport of phosphorus (sorbed to sediment particles) to surface-water bodies. Further investigation is warranted to determine if the observed total-phosphorus concentrations noted here are likely natural or anthropogenic in origin.

3.8.3.5 pH

The two pH exceedances observed at the Yampa River below Craig were infrequent, and both were measured at a pH of 9.1—only slightly above the pH standard of 9. These exceedances do not warrant management concern at this time.

3.8.3.6 Water temperature

Temperature exceedances observed at Pot Creek were infrequent, and both exceedances occurred during the summer. Low-flow conditions, combined with hot summer air temperatures, cause periodic surface-water temperature exceedances. Water temperatures are expected to increase as human-caused climate change increases air temperatures and decreases surface-water flows in the U.S. Southwest (Seager et al. 2012).

3.9 Golden Spike National Historical Park

No data were reported for the single station located near Golden Spike National Historical Park between October 1, 2015 and September 30, 2018. This site, Blue Creek at County Road 504, is sampled by the State of Utah.

3.10 Hovenweep National Monument

3.10.1 Water-quality summary

A total of 523 designated beneficial-use evaluations were determined for water-quality results obtained at one site in Hovenweep NM between October 1, 2015 and September 30, 2018. Of those 523 evaluations, 33 (6.3%) exceeded water-quality standards or indications of impairment (Figure 3-19). Water-quality standards were exceeded for four constituent categories: dissolved oxygen, *E. coli*, nutrients, and total dissolved solids.

3.10.2 Reportable exceedances

Square Tower Spring had exceedances of Utah water-quality standards for dissolved oxygen, *E. coli*, phosphorus, and total dissolved solids for more than 10% of evaluations (Figure 3-20, Table 3-8).

3.10.2.1 Square Tower Spring

Dissolved-oxygen concentrations failed to meet the chronic standard for warm-water game fish for 43% of evaluations. This site exceeded the chronic standards for *E. coli* for primary-contact recreation (126 MPN) for 25% of evaluations and drinking-water supply (206 MPN) for 19% of evaluations. Two evaluations exceeded the acute *E. coli* standards for primary-contact recreation (409 MPN) and drinking-water supply (668 MPN). Total phosphorus exceeded the indication-of-impairment criteria for primary-contact recreation and warm-water game fish for 14% of evaluations. Total dissolved solids exceeded the agricultural-use standard for 33% of evaluations.

3.10.3 Discussion and management implications

Springs in Hovenweep NM are protected for warm-water aquatic life. However, the isolated nature of these water bodies differentiates them from others nearby. The aquatic-life standards for Square Tower Spring were intended to protect the segment of the San Juan River and its tributaries between Lake Powell and the Colorado–Utah state line. These standards are applicable by law. However, the ephemeral and intermittent nature of this spring significantly differentiates it from the San Juan River. All water that enters the San Juan River from the park is derived from episodic or seasonal-driven events that likely do not reflect long-term water-quality conditions at this site. Comparison of water-quality results against long-term trends will better detect the timing and occurrence of degradation than comparison against water-quality standards designed for large water bodies, such as the San Juan River.

3.10.3.1 Dissolved oxygen

Consistent with past reports, low dissolved-oxygen levels were observed at Square Tower Spring during summer months. Square Tower Spring is a small, constant, spring-fed pool in the back of a protected alcove; the spring receives little direct influence from precipitation events. The oxygen-depleted groundwater discharged at this spring site is a natural phenomenon, indicating the water has been underground long enough

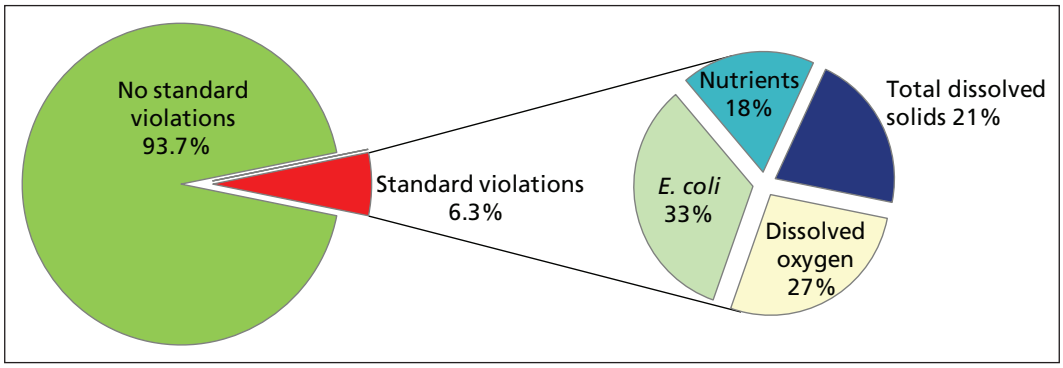


Figure 3-19. Percentage of use evaluations that exceeded standards, and the causes of exceedances as percentages of samples with an exceedance, Hovenweep National Monument, October 1, 2015–September 30, 2018.

Hovenweep National Monument
Colorado and Utah

National Park Service
U.S. Department of the Interior
Northern Colorado Plateau Network

Water-Quality Monitoring Sites, 2016–2018

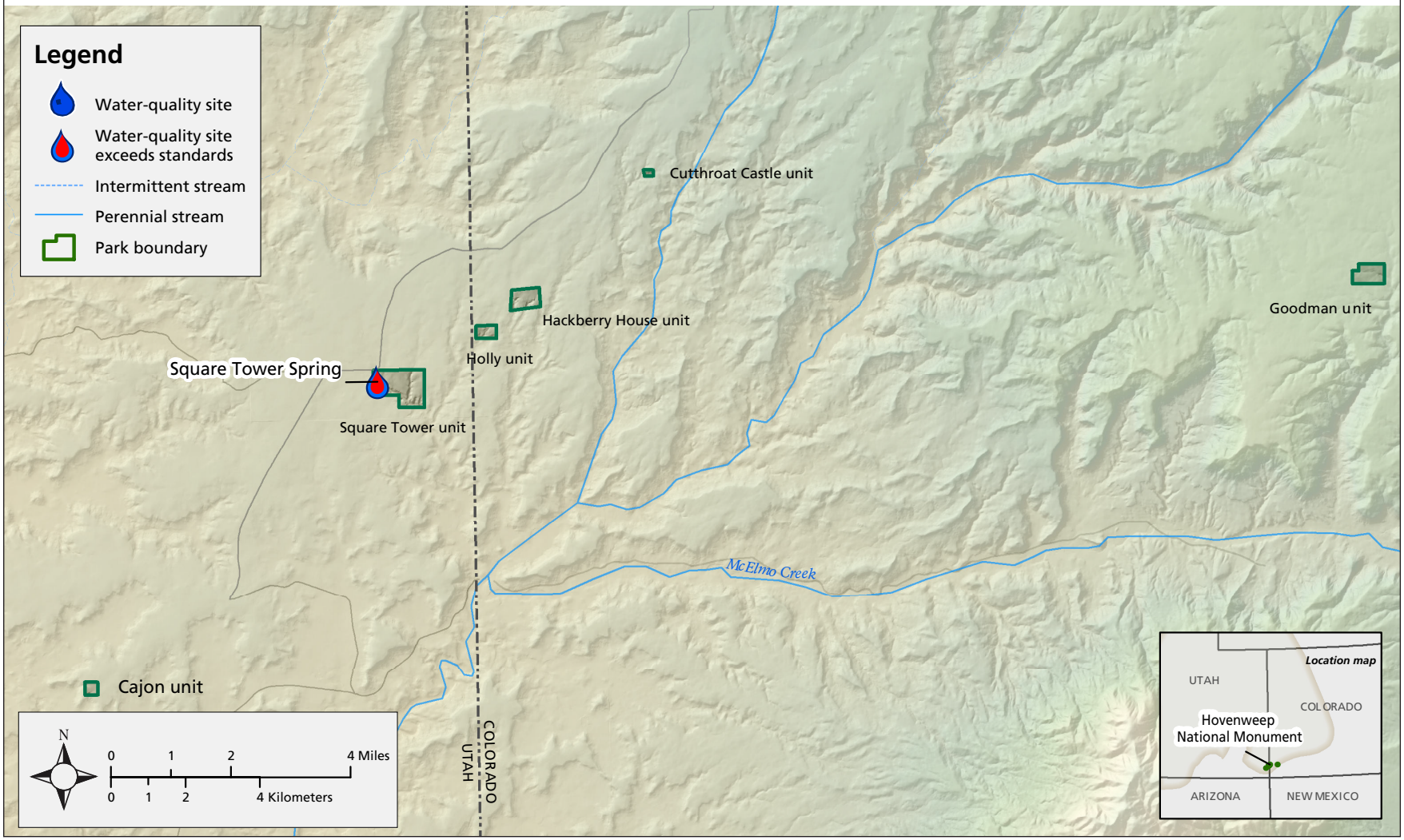


Figure 3-20. Water-quality monitoring locations in Hovenweep National Monument. Sites that exceeded standards for more than 10% of evaluations for one or more parameters are marked with a red symbol.

Table 3-8. Sites with exceedances of surface water-quality standards for more than 10% of evaluations in Hovenweep National Monument, October 1, 2015–September 30, 2018.

Site	Use code[A]	Parameter	Standard	Total evaluations	Exceedances	Percent exceedances
Square Tower Spring	3B	Dissolved oxygen	5.5 mg/L	21	9	43
	2A	*E. coli* (chronic)	126 MPN/100mL	16	4	25
	1C	*E. coli* (chronic)	206 MPN/100mL	16	3	19
	2A	*E. coli* (acute)	409 MPN/100mL	16	2	13
	1C	*E. coli* (acute)	668 MPN/100mL	16	2	13
	2A, 3B	Phosphorus, total	0.05 mg/L	21	3	14
	4	Total dissolved solids	1,200 mg/L	21	7	33

[A]Use codes: 1C = drinking-water supply; 2A = primary-contact recreation; 3B = warm-water game fish; 4 = agricultural use

to achieve complete or significant biological reduction of oxygen.

3.10.3.2 *E. coli*

During the period covered in this report, ravens were depositing decomposing animal parts in and around the spring. *E. coli* is found in the intestines of warm-blooded animals, and decomposing animal parts could have been a significant reason for these *E. coli* exceedances. *E. coli* concentrations decreased in the following months and remained at low to non-detectable levels for the remainder of the study period. It should be noted that high *E. coli* concentrations have not been observed in the past at this site. In that respect, the infrequent *E. coli* exceedances that occurred during the study period do not warrant concern from a human-health perspective.

3.10.3.3 Nutrients

Naturally elevated phosphorus conditions are common throughout the northern Colorado Plateau, and are suspected, in many cases, to be geologic in origin. Exceedances for total phosphorus at Square Tower Spring have been observed in the past (Schelz and Moran 2006; Hackbarth and Weissinger 2013), and are most likely due to natural sources.

3.10.3.4 Total dissolved solids

Square Tower Spring had exceedances for total dissolved solids, consistent with the data history of this site (Schelz and Moran 2006; Hackbarth and Weissinger 2013; Hackbarth and Weissinger 2016). The spring is situated in a well-protected alcove, and no direct anthropogenic influences are suspected at the site. The overlying Dakota Sandstone, which serves as a shallow aquifer for the spring, can have variable amounts of clays and silts, which can contribute to dissolved solid concentrations in springs.

3.11 Timpanogos Cave National Monument

3.11.1 Water-quality summary

A total of 1,357 designated beneficial-use evaluations were completed for water-quality results obtained at three sites in Timpanogos Cave National Monument between October 1, 2015 and September 30, 2018. Of those 1,357 evaluations, 2 (0.1%) exceeded water-quality standards.

Water quality at Timpanogos Cave NM never exceeded beneficial-use evaluations for more than 10% of results (Figure 3-21). Hansen Cave Spring did not have any water-quality exceedances based upon 461 total evaluations. At Hidden Lake, one sample exceeded the selenium standard for cold-water game fish (8% of evaluations). At Middle Cave Lake, one sample exceeded the dissolved oxygen standard for cold-water game fish (4% of evaluations). This report marks the first set of data for Middle Cave Lake, which was added in July 2015 to collect baseline data to include all three cave systems in the park.

3.11.2 Discussion and management implications

All of the exceedances observed at sites in Timpanogos Cave were only slightly outside the range for their respective standards; none poses immediate management concern. Continued water-quality monitoring is warranted for the purpose of long-term trend assessments. A trend assessment is likely a better method for evaluating condition than comparison against state water-quality standards protective of the American Fork River and its tributaries, and will provide early detection of degradation if it occurs.

Water-Quality Monitoring Sites, 2016–2018

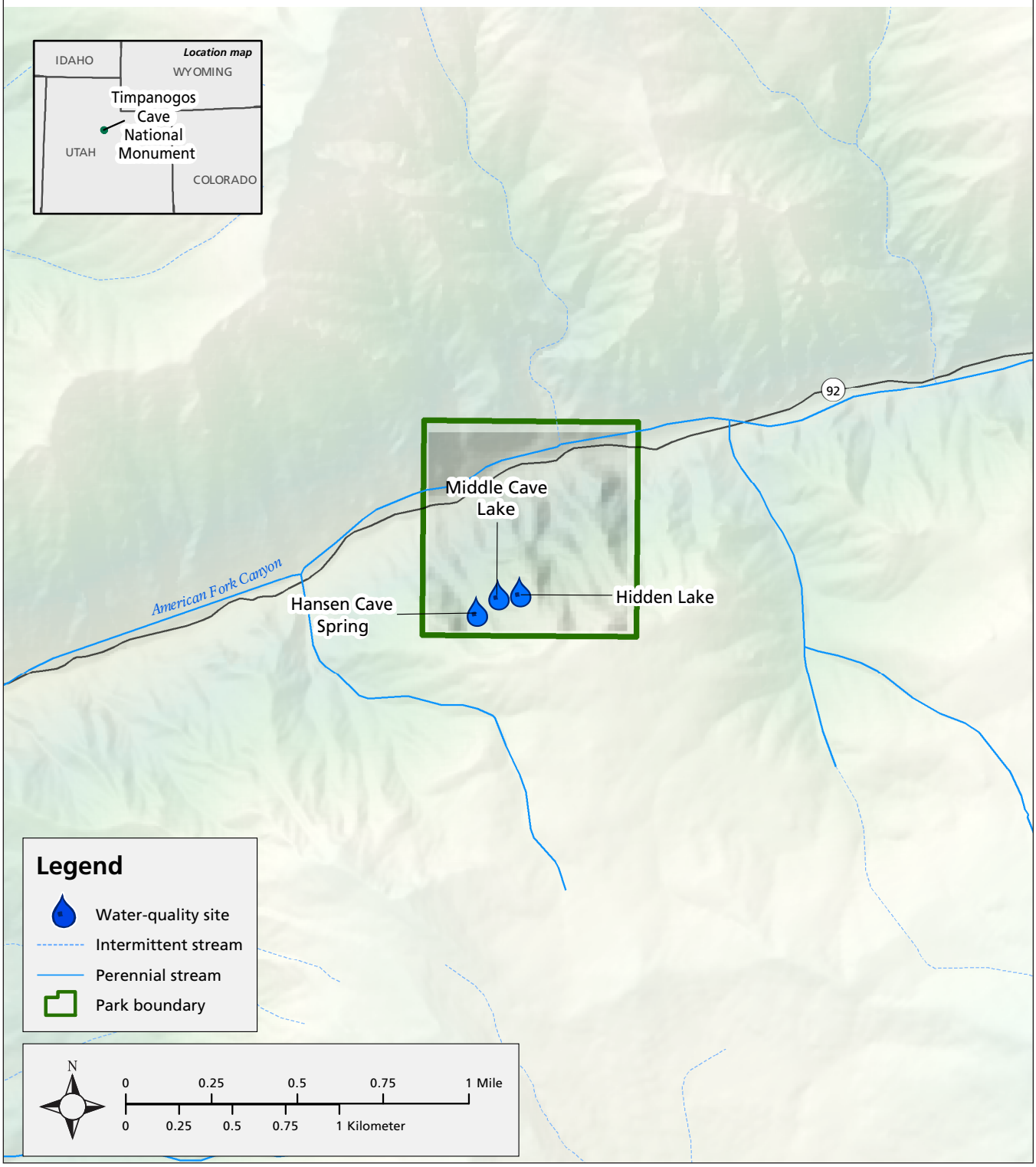


Figure 3-21. Water-quality monitoring locations in Timpanogos Cave National Monument.

3.12 Zion National Park

3.12.1 Water-quality summary

A total of 1,977 designated beneficial-use evaluations were completed for water-quality results obtained at five sites in or near Zion National Park between October 1, 2015 and September 30, 2018. Of those 1,997 evaluations, 33 (1.7%) exceeded water-quality standards or indications of impairment (Figure 3-22). Water-quality standards were exceeded for four constituent categories: pH, *E. coli*, nutrients, and temperature.

3.12.2 Reportable exceedances

The Virgin River at Virgin, UT site did not have any water-quality standards violations based on 26 evaluations (temperature and dissolved oxygen only). At North Fork Virgin River near Springdale, one measurement for water temperature exceeded the standard for cold-water game fish (5% of evaluations). North Creek at Planned Gage had exceedances for pH (3% of evaluations) and water temperature (10% of evaluations). The following discussion focuses on the two sites that had exceedances of Utah water-quality standards or indications of impairment for more than 10% of evaluations (Figure 3-23, Table 3-9).

3.12.2.1 La Verkin Creek at Lee Pass Trail

Total-phosphorus concentrations exceeded the State of Utah's indication of impairment for secondary-contact recreation and warm-water game fish for 26% of evaluations.

3.12.2.2 North Fork Virgin River at BLM-WSA boundary

At this site, three samples exceeded the chronic *E. coli* standard for primary-contact recreation (126 MPN). One of these samples exceeded the chronic standard for drinking-water supply (206 MPN) and the acute standard for primary-contact recreation (409 MPN). Water temperatures exceeded the standard for cold-water game fish for 13% of site visits.

3.12.3 Discussion and management implications

3.12.3.1 *E. coli*

In summer months, *E. coli* contamination in the North Fork Virgin River upstream from the Zion Narrows has occurred consistently since the NCPN started monitoring efforts in 2006 (Van Grinsven et al. 2010; Hackbarth and Weissinger 2013; Hackbarth and Weissinger 2016). Water-quality concerns in the North Fork Virgin River were first identified in a study conducted by Zion National Park staff that showed high fecal-coliform levels in 2000. Because of *E. coli* contamination, the North Fork Virgin River, from its confluence with Deep Creek to its headwaters, was added to Utah's 303(d) list of impaired waters in 2010. Exceedances of the standard were primarily driven by return flows from flood-irrigated pastures grazed by cattle and wildlife (Dickey and Adams 2017). During the summer recreational season, *E. coli* has been intensively monitored through cooperative sampling between the State of Utah, the National Park Service, and the Bureau of Land Management.

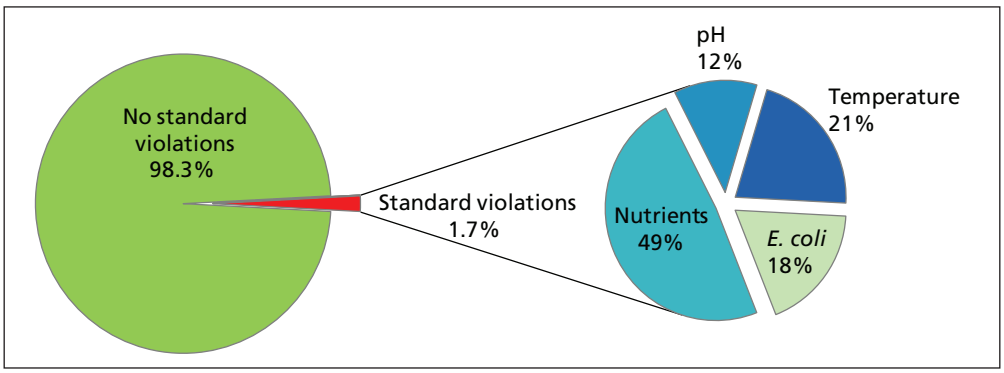


Figure 3-22. Percentage of use evaluations that exceeded standards, and the causes of exceedances as percentages of samples with an exceedance, Zion National Park, October 1, 2015–September 30, 2018.

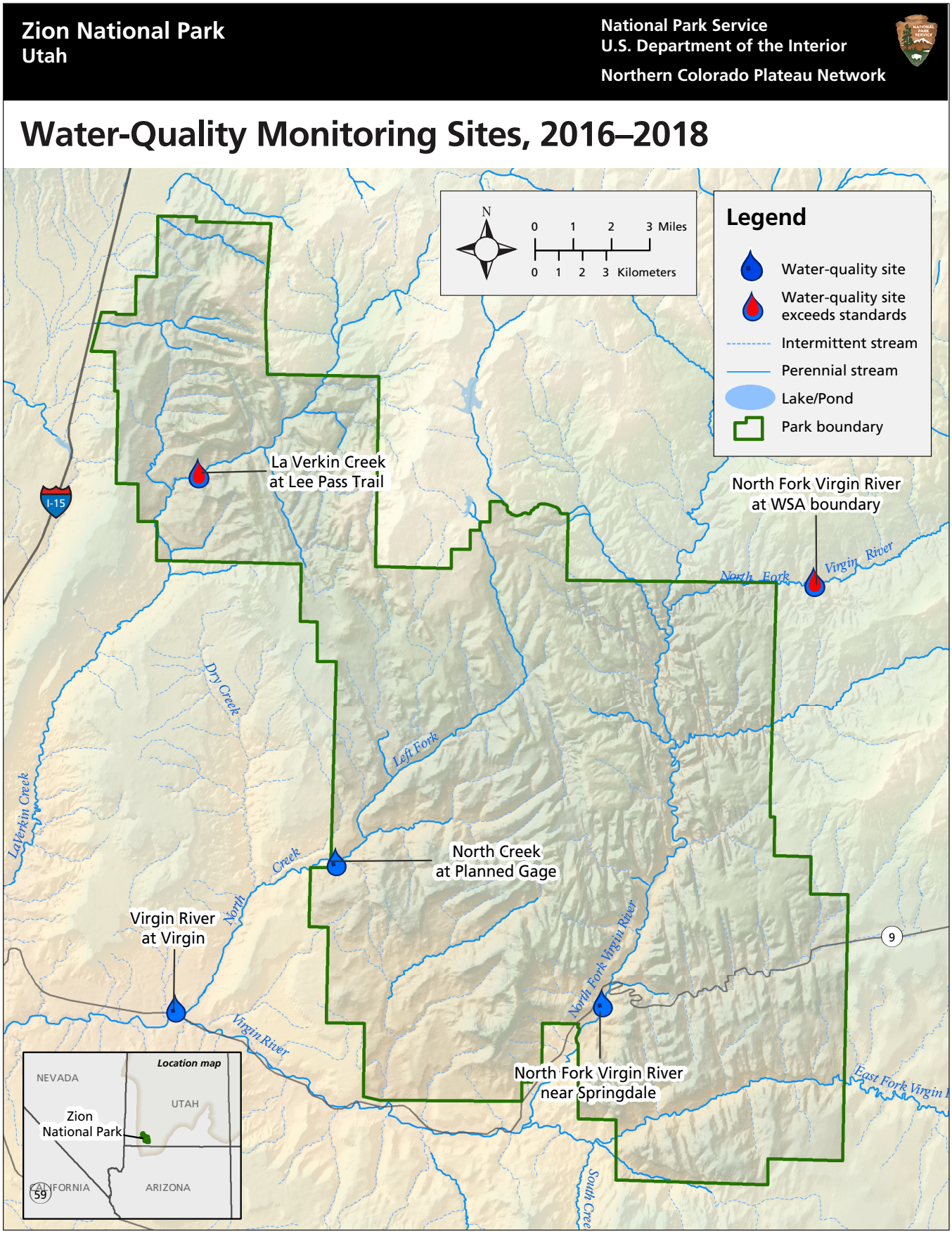


Figure 3-23. Water-quality monitoring locations in and near Zion National Park. Sites that exceeded standards for more than 10% of evaluations for one or more parameters are marked with a red symbol.

Table 3-9. Sites with exceedances of surface water-quality standards for more than 10% of evaluations in or near Zion National Park, October 1, 2015–September 30, 2018.

Site	Use code[A]	Parameter	Standard	Total evaluations	Exceedances	Percent exceedances
La Verkin Creek at Lee Pass Trail	2B, 3B	Phosphorus, total	0.05 mg/L	23	6	26
North Fork Virgin River at BLM-WSA Boundary	2A	*E. coli* (chronic)	126 MPN/100mL	24	3	13
	3A	Water temperature	20°C	24	3	13

[A]Use codes: 2A = primary-contact recreation; 2B = secondary-contact recreation; 3A = cold-water game fish; 3B = warm-water game fish

Since 2011, the State of Utah has collaborated with agencies and landowners to improve water quality in this area. Between 2011 and 2017, recreational-area improvements and best management practices were implemented, including the installation of a vault toilet at the trailhead where the Zion Narrows hike begins. In 2015, fences and gates along several pastures were improved to allow ease of hiker access while discouraging trespass cattle from grazing on actively irrigated pastures. In 2016, a control gate and flume were installed in one of the irrigation ditches in an attempt to limit the amount of water irrigating the pastures.

Results from NCPN monthly sampling have shown that the number of *E. coli* exceedances has been decreasing at the North Fork Virgin River at BLM-WSA Boundary site. Exceedances for the chronic *E. coli* standard for primary-contact recreation occurred for 36% of samples during water years 2010–2012, 26% of samples during water years 2013–2015, and 13% of samples during water years 2016–2018. It should also be noted that *E. coli* levels did not exceed the acute primary-contact recreation standard during the study period of this report (Figure 3-24), as compared to five exceedances during water years 2010–2015. Overall, water quality seems to be improving in the area due to the improvements mentioned above. Intensive monitoring will continue until the state removes this site from the 303(d) list of non-compliant waters. At that time, the NCPN will resume regular monitoring and monitoring by the park and state may be reduced or cease.

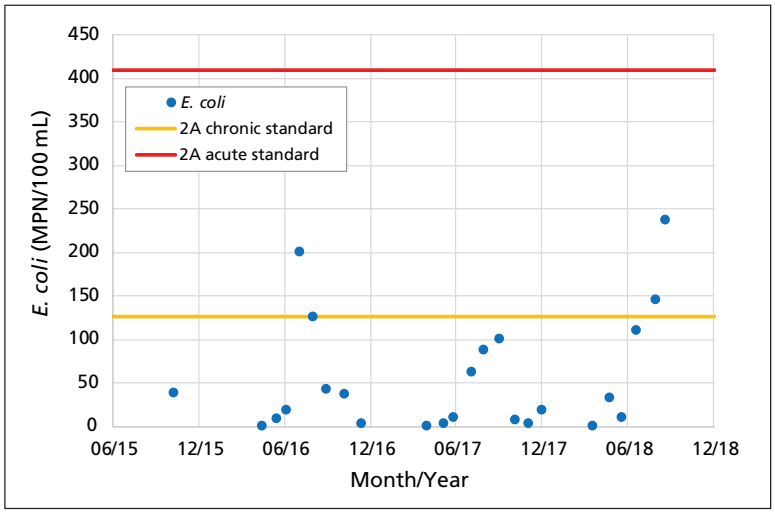


Figure 3-24. *E. coli* results for North Fork of the Virgin River at BLM-WSA Boundary, October 1, 2015–September 30, 2018.

3.12.3.2 Nutrients

Naturally elevated phosphorus conditions are common throughout the northern Colorado Plateau, and are suspected, in many cases, to be caused by natural weathering of geologic strata containing phosphorus. Anthropogenic activities, such as pasture irrigation, grazing, and OHV recreation, can accelerate erosion and transport of phosphorus sorbed to sediment particles to surface-water bodies. Further investigation is warranted to determine if the observed total-phosphorus concentrations are likely natural or anthropogenic in origin. If the observed exceedances are strongly correlated with low dissolved-oxygen conditions, then management action could be warranted.

High total-phosphorus concentrations at La Verkin Creek tend to occur during high runoff events during the spring or after mon-

soonal storms in late summer. Consistent with previous reports, there is a correlation between stream turbidity and total phosphorus. Most of the time when the stream is significantly turbid (>100 NTU), total-phosphorus concentrations exceed the indication of impairment for the State of Utah.

In a recent trend analysis for data collected from 2006 to 2016, phosphorus exceedances were evaluated to determine whether additional indicators of impairment, such as low dissolved oxygen or high pH, were present, indicating potential nutrient enrichment (Weissinger and Sharrow 2018). It was concluded that associated indicators of nutrient enrichment had not been observed in La Verkin Creek, and that the presence of phosphorus in the stream is likely due to bedrock weathering.

3.12.3.3 Water temperature

Temperature exceedances in the North Fork Virgin River at the BLM Wilderness Study Area Boundary occurred during the hotter months of July and August, and exceeded the standard for cold-water game fish. Low-flow conditions, combined with hot summer air temperatures, cause periodic surface-water temperature exceedances. Downstream of this site, the North Fork Virgin River, from its confluence with the East Fork to Kolob Creek, was added to the state 303(d) list of impaired waters in 2010 for water-temperature exceedances. The State of Utah is considering whether the North Fork Virgin River might be more appropriately classified as a warm-water aquatic system.

4 Discussion

With 96.8% compliance with state standards, water quality in NCPN parks is good overall. While some exceedances were recurring and may have been caused by human activities in the watersheds, many were due to naturally occurring conditions characteristic of the geographic setting. This is most apparent with phosphorus, which can be introduced into surface-water bodies at elevated levels by natural weathering of the geologic strata found throughout the Colorado Plateau. Higher phosphorus concentrations could also be attributed to anthropogenic activities that can accelerate erosion and transport of phosphorus. Some activities that can increase erosional processes include grazing, logging, mining, pasture irrigation, and off-highway vehicle (OHV) use. Exceedances for total phosphorus were common occurrences at nine out of ten NCPN park units, where at least one site in each of these parks had elevated phosphorus concentrations. At these sites, high levels of nutrients have not led to algal blooms or other signs of eutrophication.

Sites monitored in Arches National Park (NP), Black Canyon of the Gunnison NP (BLCA), Bryce Canyon NP (BRCA), Capitol Reef NP (CARE), Curecanti National Recreation Area (CURE), Dinosaur National Monument (DINO), and Zion NP (ZION) all had *E. coli* exceedances that could be addressed by management actions. While many of these sites already have management actions underway, some of the actions necessary to bring these waters into compliance are beyond the control of the National Park Service. Changes to agricultural practices to improve water quality involves voluntary participation by landowners and/or grazing permittees and their respective states. This could be the case with lands upstream of several parks with *E. coli* contamination issues, including Red Rock Canyon (BLCA); Sulphur, Oak, and Pleasant creeks (CARE); Blue Creek and Cimarron River (CURE); Brush and Pot creeks (DINO); and North Fork Virgin River (ZION). Issues with *E. coli* contamination at Yellow Creek (BRCA) seemed to be resolved after the park boundary fence downstream of the site was repaired, keeping cattle out of the park. At North Fork Virgin River, *E. coli* exceedances have been less frequent since the State of Utah worked with landowners and grazing permittees to modify agricultural practices. Continued coordination between the National Park Service, state agencies, and local landowners will be necessary to further reduce *E. coli* exceedances and, in turn, improve public health and safety in these streams.

Selenium concentrations in Red Rock Canyon (BLCA) continued to exceed the state aquatic-life standard at both the upstream and downstream sites. Although selenium weathers naturally from bedrock and soils in the Red Rock Creek drainage, upstream irrigation return flows could be carrying more of these sediments rich in selenium into the creek. Continued management action is needed to bring irrigation return flows in Red Rock Canyon into compliance with state water-quality standards.

In recent years, pH exceedances have declined at North Creek in Zion National Park. Only one exceedance for pH occurred during water years 2016–2018, as compared to seven exceedances in water years 2013–2015 and nine exceedances in water years 2010–2012. The reduction in pH exceedances at North Creek indicates that conditions may be stabilizing in North Creek after a wildfire burned much of the watershed in 2006.

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Appendix A. Water-Quality Sites Reported, Water Years 2016–2018

Table A-1. Water-quality sites reported, water years 2016–2018.

Park	Station ID	Station name	Latitude	Longitude	Designated beneficial uses[A]
Arches NP	09180500	Colorado R nr Cisco, UT	38.811	-109.293	1C, 2A, 3B, 4
	09163500	Colorado R nr Colorado-Utah state line	39.133	-109.027	Ag, ALWW1, RecE, LC3
	5995240	Courthouse Wash .5 mi ab Colorado R at USGS CW-1	38.613	-109.579	1C, 2A, 3B, 4
	5995246	Courthouse Wash at spring inside Arches NP west bndry	38.687	-109.653	1C, 2A, 3B, 4
	09180000	Dolores R nr Cisco, UT	38.797	-109.195	2B, 3C, 4
	5995220	Salt Wash at Wolfe Ranch rd xing SW-3	38.735	-109.519	1C, 2A, 3B, 4
Black Canyon of the Gunnison NP	09128000	Gunnison R bl Gunnison Tunnel, CO	38.529	-107.649	Ag, ALCW1, DWS, RecE, LG1
	383537107471500	Red Rock Canyon at mouth nr Montrose, CO	38.594	-107.788	Ag, ALWW2, DWS, RecE, LG4c
	383418107471401	Red Rock Canyon nr NPS boundary nr Montrose, CO	38.572	-107.788	Ag, ALWW2, DWS, RecE, LG4c
Bryce Canyon NP	4951915	Mossy Cave Spring NW of Tropic	37.665	-112.115	2B, 3C, 4
	4951855	Sheep Ck bl Spring in Bryce Cyn NP	37.571	-112.201	2B, 3C, 4
	N/A	Tropic Ditch	37.665	-112.115	2B, 3C, 4
	4951857	Yellow Ck bl Spring in Bryce Cyn NP	37.574	-112.141	2B, 3C, 4
Canyonlands NP	4952400	Colorado R ab cnfl / Green R	38.193	-109.884	1C, 2A, 3B, 4
	4952380	Colorado R bl Big Drop #3 rapids	38.071	-110.046	1C, 2A, 3B, 4
	4956290	Colorado R at Potash Boat Ramp	38.467	-109.666	1C, 2A, 3B, 4
	4930010	Green R ab cnfl / Colorado R	38.190	-109.889	1C, 2A, 3B, 4
	4930150	Green R at Mineral Bottom	38.527	-109.993	1C, 2A, 3B, 4
	09315000	Green R at Green R, UT	38.896	-110.151	1C, 2A, 3B, 4
	09272400	Green R at Ouray, UT	40.085	-109.677	1C, 2A, 3B, 4
Capitol Reef NP	09330000	Fremont R nr Bicknell, UT	38.307	-111.517	1C, 2A, 3A, 4
	4954812	Halls Ck bl Narrows	37.615	-110.892	2B, 3B, 4
	4954795	Oak Creek above Sandy Ranch Dam	38.084	-111.140	1C, 2B, 3A, 4
	4954780	Pleasant Ck S of Sleeping Rainbow Ranch	38.180	-111.181	1C, 2B, 3A
	4954770	Sulphur Ck ab cnfl / Fremont R in picnic area	38.287	-111.247	1C, 2A, 3A, 4
	4954775	Sulphur Ck bl road to Goosenecks Overlook	38.307	-111.315	1C, 2A, 3A, 4

[A]See Acronyms and Abbreviations list for key to designated beneficial uses.

table continues on next page

Table A-1 (continued). Water-quality sites reported, water years 2016–2018.

Park	Station ID	Station name	Latitude	Longitude	Designated beneficial uses[A]
Curecanti National Recreation Area	382943107015300	Beaver Creek at HWY 50 nr Gunnison, CO	38.495	-107.032	Ag, ALCW1, DWS, RecU, UG2
	382418107242600	Blue Creek at HWY 50 nr Sapinero, CO	38.405	-107.408	Ag, ALCW1, DWS, RecU, UG26
	381633107054700	Cebolla Creek at Powderhorn, CO	38.276	-107.097	Ag, ALCW1, DWS, RecU, UG29b
	09127000	Cimarron R bl Squaw Creek nr Cimarron, CO	38.446	-107.556	Ag, ALCW1, DWS, RecU, UG26
	09125000	Curecanti Creek nr Sapinero, CO	38.488	-107.415	Ag, ALCW1, DWS, RecU, UG26
	382900107101600	East Elk Creek nr mouth nr Sapinero, CO	38.483	-107.172	Ag, ALCW1, DWS, RecU, UG2
	383103106594200	Gunnison R at County Rd 32 bl Gunnison, CO	38.517	-106.996	Ag, ALCW1, DWS, RecE, UG14
	381934107133500	Lake Fork Gunnison R bl Gateview, CO	38.326	-107.227	Ag, ALCW1, DWS, RecE, UG29b
	382702107203900	Pine Creek at HWY 50 nr Sapinero, CO	38.451	-107.345	Ag, ALCW1, DWS, RecU, UG26
	382902107140400	Red Creek nr mouth nr Sapinero, CO	38.484	-107.235	Ag, ALCW1, DWS, RecU, UG2
	383137107183600	Soap Creek ab Chance Creek nr Sapinero, CO	38.527	-107.311	Ag, ALCW1, DWS, RecU, UG26
	382937107033500	Steuben Creek nr mouth nr Gunnison, CO	38.494	-107.060	Ag, ALCW1, DWS, RecU, UG26
	383028107162200	West Elk Creek bl forest boundary nr Sapinero, CO	38.508	-107.273	Ag, ALCW1, DWS, RecU, UG2
	382829107122200	Blue Mesa Reservoir ab Cebolla Ck nr Sapinero, CO	38.475	-107.207	Ag, ALCW1, BlueMesa, DWS, RecE, Res
	382831107172600	Blue Mesa Reservoir ab Soap Ck nr Sapinero, CO	38.475	-107.291	Ag, ALCW1, BlueMesa, DWS, RecE, Res
	382856107050000	Blue Mesa Reservoir bl HWY 149 nr Gunnison, CO	38.482	-107.084	Ag, ALCW1, BlueMesa, DWS, RecE, Res
	382924107352300	Crystal Reservoir at Crystal Creek nr Cimarron, CO	38.490	-107.590	Ag, ALCW1, DWS, RecE, Res
	383024107371800	Crystal Reservoir at Crystal Dam nr Cimarron, CO	38.507	-107.622	Ag, ALCW1, DWS, RecE, Res
	382702107315400	Morrow Pt Reservoir ab Morrow Pt Dam nr Cimarron, CO	38.451	-107.532	Ag, ALCW1, DWS, RecE, Res
	382644107271000	Morrow Pt Reservoir bl Blue Ck nr Sapinero, CO	38.446	-107.453	Ag, ALCW1, DWS, RecE, Res
Dinosaur NM	4937760	Brush Creek at U149 crossing	40.408	-109.340	2B, 3B, 4
	404417108524900	Green R ab Gates of Lodore, CO	40.738	-108.880	Ag, ALCW1, DWS, RecE, LYG19a
	09261000	Green R nr Jensen, UT	40.409	-109.235	1C, 2A, 3B, 4
	5937880	Pot Creek ab Matt Warner Reservoir	40.769	-109.320	2B, 3A, 4
	09260050	Yampa R at Deerlodge Park, CO	40.452	-108.525	Ag, ALWW1, DWS, RecE, LYG2
	09247600	Yampa R bl Craig, CO	40.481	-107.614	Ag, ALWW1, DWS, RecE, LYG2
	09251000	Yampa R nr Maybell, CO	40.503	-108.033	Ag, ALWW1, DWS, RecE, LYG2
Hovenweep NM	5995700	Square Tower Spring	37.386	-109.081	1C, 2A, 3B, 4

[A]See Acronyms and Abbreviations list for key to designated beneficial uses.

table continues on next page

Table A-1 (continued). Water-quality sites reported, water years 2016–2018.

Park	Station ID	Station name	Latitude	Longitude	Designated beneficial uses[A]
Timpanogos Cave NM	4994970	Hansen Cave Spring in Timpanogos Cave	40.438	-111.711	2B, 3A, 4
	N/A	Hidden Lake at Timpanogos Cave	40.438	-111.709	2B, 3A, 4
	N/A	Middle Cave Lake	40.438	-111.711	2B, 3A, 4
Zion NP	4950800	La Verkin Ck at Lee Pass Trail	37.407	-113.176	2B, 3B, 4
	4950920	North Ck at planned gage in park	37.261	-113.106	1C, 2B, 3C, 4, NoCrk
	4951265	North Fork Virgin R at WSA bndry	37.371	-112.882	1C, 2A, 3A, 4
	09405500	North Fork Virgin R nr Springdale, UT	37.210	-112.979	1C, 2A, 3A, 4
	09406000	Virgin R at Virgin, UT	37.204	-113.181	1C, 2B, 3C, 4

[A]See Acronyms and Abbreviations list for key to designated beneficial uses.

Appendix B. Quality-Control Data

Table B-1. Quality-control data.

Parameter	Number of blank samples	Non-detects	Detects	Maximum blank concentration	Minimum LQL[A]	Maximum LQL[A]	Minimum environmental sample concentration	Minimum Utah standard
Aluminum, dissolved (µg/L)	5	5	0	ND[B]	2.86	10	5.57	87
Arsenic, dissolved (µg/L)	6	6	0	ND[B]	0.29	1	0.509	10
Barium, dissolved (µg/L)	6	6	0	ND[B]	0.146	100	16.7	100
Boron, dissolved (µg/L)	12	10	2	30	1.22	30	15	750
Cadmium, dissolved (µg/L)	6	6	0	ND[B]	0.023	0.1	0.082	0.25
Chromium, dissolved (µg/L)	6	5	1	2	0.239	2	0.515	50
Copper, dissolved (µg/L)	5	5	0	ND[B]	0.187	1	0.687	9
Iron, dissolved (µg/L)	12	12	0	ND[B]	1.62	30	1.94	1,000
Lead, dissolved (µg/L)	4	4	0	ND[B]	0.1	0.1	0.051	2.5
Mercury, dissolved (µg/L)	5	5	0	ND[B]	0.059	0.2	0.2	0.012
Nickel, dissolved (µg/L)	5	5	0	ND[B]	5	5	ND[B]	52
Nitrogen, ammonia as N (mg/L)	18	15	3	0.054	0.012	0.05	0.013	depends
Phosphorus, total (mg/L)	18	7	11	0.005	0.00277	0.003	0.0016	0.05
Selenium, dissolved (µg/L)	9	9	0	ND[B]	1	1	0.225	4.6
Silver, dissolved (µg/L)	6	6	0	ND[B]	0.092	0.5	ND[B]	1.6
Total dissolved solids (mg/L)	18	17	1	20	0	20	124	1,200
Zinc, dissolved (µg/L)	4	4	0	ND[B]	10	10	5.01	120

[A]LQL = lower quantification limit

[B]ND = non-detectable

Appendix C. Colorado Water-Quality Standards

Water-quality standards with applicable designated beneficial uses. These are the relevant standards for the parameters measured in the field and laboratory during water years 2016–2018.

Table C-1. Colorado water-quality standards.

Parameter	Ag	ALCW1	ALWW1	ALWW2	DWS	RecE	RecU	Res
Dissolved oxygen (mg/L) (minimum)	3.0	7.0	5.0	5.0	3.0	3.0	3.0	–
Escherichia coli (per 100 mL)	–	–	–	–	630	126	126	–
pH	–	6.5–9.0	6.5–9.0	6.5–9.0	5.0–9.0	6.5–9.0	6.5–9.0	–
Water temperature (°C), summer	–	17.0 (CS-I), 18.3 (CS-II)	27.5 (WS-II)	28.7 (WS-III)	–	–	–	18.3, 16.6 (BlueMesa)
Water temperature (°C), winter	–	9.0	13.8	14.3	–	–	–	9.0
Ammonia, dissolved (mg/L)	–	pH dep	pH dep	pH dep	–	–	–	–
Boron, dissolved (mg/L)	0.75							
Chloride, dissolved (mg/L)	–	–	–	–	250	–	–	–
Chlorophyll a (µg/L)	–	–	–	–	–	–	–	8
Fluoride, dissolved (mg/L)	–	–	–	–	2.0	–	–	–
Nitrate, dissolved (mg/L)	100	–	–	–	10	–	–	–
Nitrite, dissolved (mg/L)	10	0.02 (UG2), 0.05 (UG26)	0.05	0.5 (LG4c)	1.0	–	–	0.05
Phosphorus, total (mg/L) (interim)	–	0.110	0.170	0.170	–	–	–	0.025
Sulfate, dissolved (mg/L)	–	–	–	–	250	–	–	–
Aluminum, total recoverable (µg/L)	–	HD	HD	HD	–	–	–	–
Arsenic, dissolved (µg/L)	–	150	150	150	–	–	–	–
Barium, total recoverable (µg/L)	–	–	–	–	1000	–	–	–
Cadmium, dissolved (µg/L)	–	HD	HD	HD	–	–	–	–
Copper, dissolved (µg/L)	–	HD	HD	HD	–	–	–	–
Iron, dissolved (µg/L)	–	–	–	–	300	–	–	–
Lead, dissolved (µg/L)	–	HD	HD	HD	–	–	–	–
Manganese, dissolved (µg/L)	–	HD	HD	HD	50	–	–	–
Manganese, total recoverable (µg/L)	200	–	–	–	–	–	–	–
Mercury, total (µg/L)	–	0.01	0.01	0.01	–	–	–	–
Selenium, dissolved (µg/L)	–	4.6	4.6	4.6	–	–	–	–
Silver, dissolved (µg/L)	–	HD	HD	HD	–	–	–	–
Zinc, dissolved (µg/L)	–	HD	HD	HD	–	–	–	–

Ag = agricultural use; ALCW1 = aquatic life cold-water class 1; ALWW1 = aquatic life warm-water class 1; ALWW2 = aquatic life warm-water class 2; DWS = drinking-water supply; RecE = existing primary-contact recreation; RecU = undetermined use recreation; Res = reservoir-specific aquatic life standard; CS-I = cold stream tier I temperature standard for UG2 and UG26*; CS-II = cold stream tier II temperature standard for UG14, UG29b, LG1, LYG19a*; WS-II = warm stream tier II temperature standard for LC3 and LYG2*; WS-III = warm stream tier III temperature standard for LG4c*; pH dep = standard is dependent on concurrently measured pH value; HD = standard is dependent on concurrently measured hardness concentration.

*See Acronyms and Abbreviations list for key to additional designated beneficial uses.

Appendix D. Utah Water-Quality Standards

Water-quality standards with applicable designated beneficial uses. These are the relevant standards for the parameters measured in the field and laboratory during water years 2016–2018.

Table D-1. Utah water-quality standards.

Parameter	Beneficial use[A]						
	1C	2A	2B	3A	3B	3C	4
Dissolved oxygen (mg/L) (minimum)	–	–	–	6.5	5.5	5.0	–
Escherichia coli (MPN/100 mL), acute	668	409	668	–	–	–	–
Escherichia coli (MPN/100 mL), chronic	206	126	206	–	–	–	–
pH	6.5–9	6.5–9	6.5–9	6.5–9	6.5–9	6.5–9	6.5–9
Water temperature (°C)	–	–	–	20	27	27	–
Total dissolved solids (mg/L)	–	–	–	–	–	–	1200
Ammonia, total (mg/L)	–	–	–	pH dep[B]	pH dep[B]	pH dep[B]	–
Boron, dissolved (µg/L)	–	–	–	–	–	–	750
Phosphorus, total (mg/L)	–	0.05	0.05	0.05	0.05	0.05	–
Aluminum, dissolved (µg/L)	–	–	–	87	87	87	–
Arsenic, dissolved (µg/L)	10	–	–	150	150	150	100
Barium, dissolved (µg/L)	1000	–	–	–	–	–	–
Beryllium, dissolved (µg/L)	4	–	–	–	–	–	–
Cadmium, dissolved (µg/L)	10	–	–	HD[C]	HD[C]	HD[C]	10
Chromium, dissolved (µg/L)	50	–	–	HD[C]	HD[C]	HD[C]	100
Copper, dissolved (µg/L)	–	–	–	HD[C]	HD[C]	HD[C]	200
Iron, dissolved (µg/L)	–	–	–	1,000	1,000	1,000	–
Lead, dissolved (µg/L)	15	–	–	HD[C]	HD[C]	HD[C]	100
Mercury, dissolved (µg/L)	2	–	–	0.012	0.012	0.012	–
Nickel, dissolved (µg/L)	–	–	–	HD[C]	HD[C]	HD[C]	–
Selenium, dissolved (µg/L)	50	–	–	4.6	4.6	4.6	50
Silver, dissolved (µg/L)	50	–	–	HD[C]	HD[C]	HD[C]	–
Zinc, dissolved (µg/L)	–	–	–	HD[C]	HD[C]	HD[C]	–

[A]1C = drinking-water supply; 2A = primary-contact recreation; 2B = secondary-contact recreation; 3A = cold-water game fish; 3B = warm-water game fish; 3C = non-game fish; 4 = agricultural use

[B]pH dep = standard is dependent on concurrently measured pH value

[C]HD = standard is dependent on concurrently measured hardness concentration

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