



Water Quality Monitoring for the Rito de los Frijoles and Capulin Creek in Bandelier National Monument

2014 Summary Report

Natural Resource Data Series NPS/SCPN/NRDS—2017/1133



ON THE COVER
Frijoles Creek in Bandelier National Monument, 2014.
Photography by SCPN

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Abstract

Water-related vital signs are fundamental components defining overall riparian and aquatic ecosystem integrity. The Southern Colorado Plateau Network (SCPN) has identified water quality as one of seven key vital signs used to determine the condition and long-term status of aquatic ecosystems in park streams. This report summarizes water quality core parameter data and bacteria, nutrient, major element, and trace metal data for water quality samples collected from the Rito de los Frijoles and Capulin Creek in Bandelier National Monument in 2014. In addition, it reports data on Contaminants of Emerging Concern found in water quality samples for an agreement with the U.S. EPA. The data presented in this report represent a snapshot of the water quality in these systems in 2014.

1 Introduction

The National Park Service Inventory and Monitoring Program was designed to determine the current status and monitor long-term trends in the condition of park natural resources, providing park managers with a scientific foundation for making decisions and working with other agencies and the public to protect park ecosystems. Hydrologic vital signs are the fundamental components that define overall riparian and aquatic ecosystem integrity. The Southern Colorado Plateau Network (SCPN) has identified 7 vital signs pertaining to riparian and spring ecosystems: 1) aquatic macroinvertebrates, 2) stream water quality, 3) stream flow and depth to groundwater, 4) spring water quality, 5) fluvial geomorphology, 6) riparian vegetation, composition, and structure, and 7) spring ecosystems. These vital signs are closely related and are all included in the Vital Signs Monitoring Plan for the Southern Colorado Plateau Network (Thomas et al. 2006). The context and ecological significance of these vital signs are further explained in Scott et al. (2005). In this report we focus on stream water quality.

Specific objectives for monitoring stream water quality in SCPN parks are

- Determine status and trends for selected core water quality parameters (water temperature, pH, specific conductance, dissolved oxygen, turbidity and discharge) at selected sites in priority streams within SCPN parks.
- Determine status and trends of selected water quality constituents, including bacteria, nutrients, major elements, and trace metals at selected sites in priority streams within SCPN parks.
- Compare water quality data against state standards for chronic exceedances. Multiple exceedances in a year typically indicate non-compliance.

1.1 Selecting potential water quality monitoring sites

We targeted SCPN streams and springs with potential for water quality monitoring by reviewing (1) water quality data inventory and analysis reports prepared by the Water Resources Division (WRD) of the National Park Service (NPS); (2) a USGS summary and review of available water quality data from streams in SCPN parks (Brown 2008); (3) data collected during a Level 1 water quality inventory of streams in SCPN parks (Macy and Monroe 2006); and (4) results of water quality monitoring planning meetings with park staff.

SCPN water bodies were selected for water quality monitoring based on the following criteria:

- 303(d) listed waters¹ — where previous sampling indicates one or more parameters regularly approach or exceed established water quality standards or recommended levels
- waters with demonstrated threat levels—where an analysis of existing data indicate that measured conditions regularly approach or exceed standards or recommended levels, but where the frequency of exceedances or the quality of the database do not support a 303(d) listing
- pristine waters—where there is no direct impact of human activities (provides baseline data)
- ecological significance—presence of unique species or species of concern
- waters of management concern—where past sampling may not indicate constituent values of concern, but where anthropogenic activities indicate that contamination is a significant threat
- historic data—waters identified as important, for which substantial historic water quality data are available
- data gaps—waters identified as important, but where little or no water quality information exists

Whenever possible, SCPN water quality monitoring sites are located where a history of water quality data collection exists, and co-located with SCPN aquatic macroinvertebrate monitoring sites.

¹ Under section 303(d) of the Clean Water Act, states, territories, and authorized tribes are required to develop lists of impaired waters— waters that are too polluted or otherwise degraded to meet the water quality standards set by states, territories, or authorized tribes (EPA 2011).

1.2 Water quality monitoring at Bandelier National Monument

The Rito de los Frijoles is a perennial stream that flows eastward from the Sierra de los Valles of the Jemez Mountains in north central New Mexico and into the Rio Grande. The entire length of this stream lies within the boundaries of BAND and much of its watershed is designated wilderness. The watershed is bordered by lands administered by Los Alamos National Laboratory, Valles Caldera National Preserve, and Santa Fe National Forest. The monument's visitor center and numerous archeological sites are located adjacent to the Rito de los Frijoles and, as a result, the riparian area around the stream is heavily impacted by visitor use. In recent years several large fires have affected areas in and around this watershed. In 1977 the La Mesa Fire burned about 58% of the Frijoles watershed (Vieira et al 2004); in 2000, the Cerro Grande Fire ignited in the upper portion of the watershed, and in June 2011 the Las Conchas Fire severely burned about 35% of Frijoles Canyon, including much of the riparian vegetation. Since then, the frequency and severity of flooding has increased, and several large flood events have deposited massive amounts of sediment and debris into the stream channel and on the floodplain. Water quality concerns in this stream include fecal coliform bacteria, turbidity, water temperature, DDT in fish tissue, and aluminum. Because of these issues, the stream has been included on New Mexico's 303(d) list of impaired surface waters since 1998 (New Mexico Environment Department, Surface Water Quality Board (NMED SWQB 1998–2016)).

Capulin Creek is a perennial stream that flows through the southwestern portion of BAND and joins the Rio Grande approximately 8 km south of the Rito de los Frijoles. The upper portion of its watershed lies within the Santa Fe National Forest, while the remainder lies within BAND. Most of the watershed is a designated wilderness area, managed for recreational use within park boundaries. The U.S. Forest Service manages land in the upper reaches of the watershed for recreation and timber harvest. In 1996 the Dome Fire burned approximately 90% of the Capulin watershed (Vieira et al 2004), and in 2011, during the Las Conchas Fire, approximately 32% of the watershed was burned with moderate or high severity fire and much of the riparian vegetation was destroyed. As was the case with the Rito de los Frijoles, several large floods have drastically altered the channel morphology and introduced large amounts of sediment and woody debris into the stream channel and floodplain.

In 2010 SCPN implemented long-term water quality monitoring at three sites in BAND:

- *Rito de los Frijoles near Visitor Center* (BANDRIT01), identified in this report as RIT01, is located adjacent to a streamflow gaging station (Los Alamos National Laboratory LANL-E350, USGS #08313350, Rito de los Frijoles in Bandelier Nat Mon, NM) and is co-located with a SCPN aquatic macroinvertebrate monitoring site.
- *Rito de los Frijoles at Upper Crossing* (BANDRIT02), identified in this report as RIT02, is located at the Upper Crossing Trail intersection, 9.5 km upstream from RIT01, and is co-located with a SCPN aquatic macroinvertebrate monitoring site.
- *Capulin Creek at Base Camp Gaging Station* (BANDCAP01), identified in this report as CAP01, is located less than 0.3 km upstream from the backcountry ranger cabin at a discontinued U.S. Geological Survey streamflow gaging station (Capulin Canyon at Ranger Cabin, station #083133655). This site is co-located with a SCPN aquatic macroinvertebrate monitoring site.

SCPN visits CAP02 once per year to sample aquatic macroinvertebrates and only collects core water quality parameter measurements at this site.

- *Capulin Creek above Painted Cave* (BANDCAP02), identified in this report as CAP02, is located 1.8 km up canyon from the Painted Cave and 2.6 km downstream from CAP01. This site is co-located with a SCPN aquatic macroinvertebrate monitoring site.

An additional site, RIT03, was established in 2011 in order to help address the effects that visitor activity was having on levels of *E. coli* and contaminants of emerging concern in Rito de los Frijoles. This site was also visited

on a quarterly basis in 2014:

- Rito de los Frijoles above Wilderness Boundary (BANDRIT03), identified in this report as RIT03, is located approximately 2.8 km upstream from RIT01. It is upstream from the Ceremonial Cave and the majority of visitor activity at BAND.

Also, to assess spatial variability of water quality core parameters along the Rito de los Frijoles, SCPN crew visited ten sites along the length of the stream, extending from the headwaters to the monument visitor center on May 15–16 (Figure 1). In this report these measurements are compared to data collected from the same sites in 2013.

SCPN conducts water quality monitoring site visits at RIT01, RIT02, and CAP01 quarterly. However, winter visits to CAP01 are often skipped because it is difficult to access this site during winter conditions. In 2014, RIT01 and RIT02 were sampled four times, in February, May, July, and October. CAP01 was sampled three times—the February site visit was skipped.

This report contains the results for all of SCPN’s water quality sampling activities at BAND during 2014. Table 1 summarizes the types of data collected at each site.

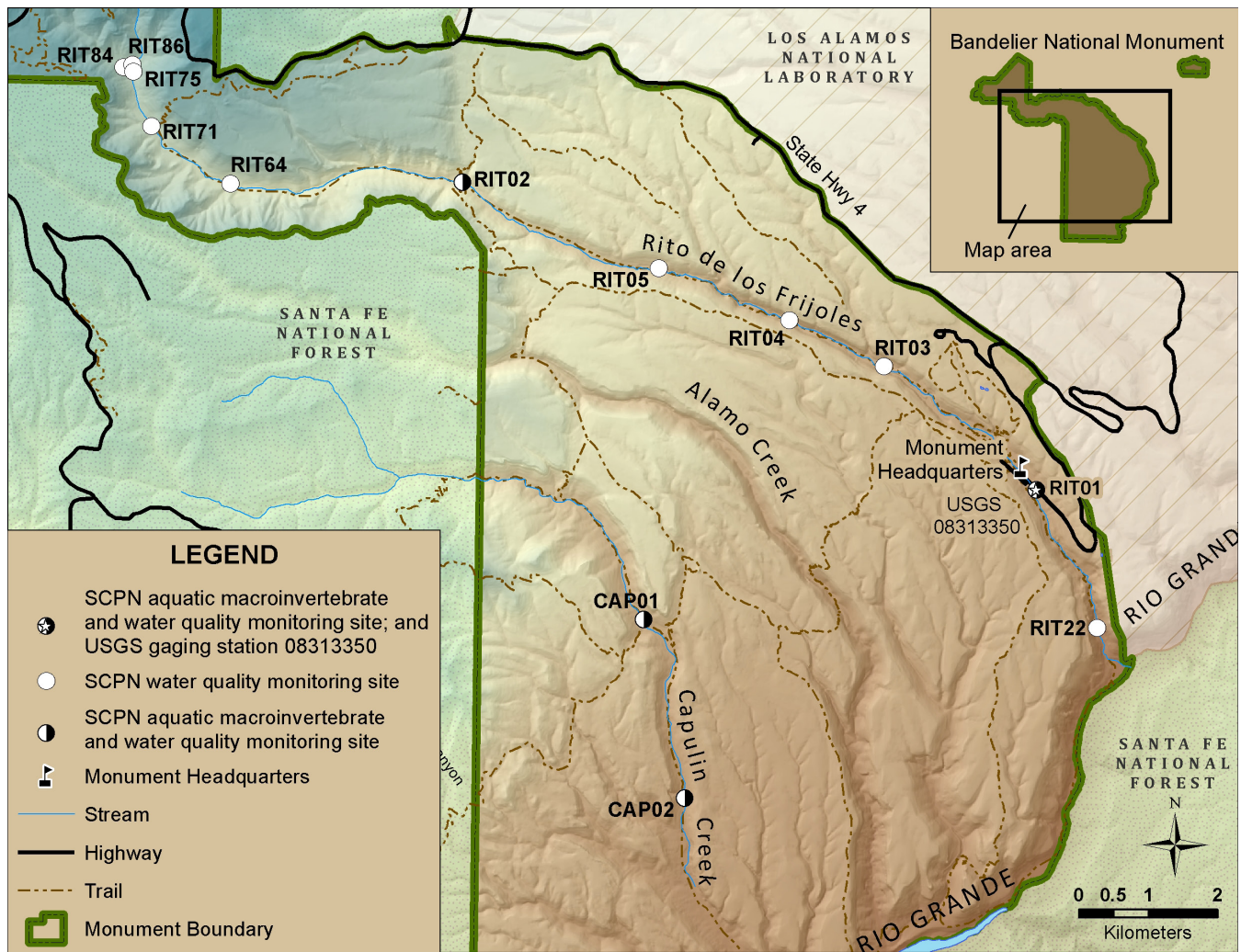


Figure 1. Map of water quality sites on the Rito de los Frijoles and Capulin Creek in Bandelier NM. CAP01, RIT01 and RIT02 are the long-term monitoring sites. See Appendix A for more details about these sites.

Table 1. Summary of site visits made and data collected in Bandelier NM, 2014. An "X" indicates that no data was collected for the category. See Appendix A for a description of SCPN water quality sites in Bandelier NM.

Site	Core parameters	Long-term temperature ^a	Bacteria	Nutrients, major elements, trace metals	Contaminants of emerging concern
RIT01 ^b	4	Complete	4	4	2
RIT02 ^b	4	X	4	4	1
RIT03	4	X	4	X	3
CAP01	3	X	3	3	1
CAP02	1	X	X	X	X
RIT04 ^b	1	X	X	X	X
RIT05 ^b	1	X	X	X	X
RIT22 ^b	1	X	X	X	X
RIT64 ^b	1	X	X	X	X
RIT71 ^b	1	X	X	X	X
RIT75 ^b	1	X	X	X	X
RIT84 ^b	1	X	X	X	X
RIT86 ^b	1	X	X	X	X

a Data for long-term temperature are continuous data recorded by a temperature logger.

b Data collected to characterize spatial variability in core parameters along Rito de los Frijoles.

2 Methods

A brief description of water quality data collection and processing methods followed by SCPN staff at BAND during 2012–2013 is presented here. Detailed descriptions of these procedures will be available in the *Water Quality Monitoring Protocol for Streams and Springs in the Southern Colorado Plateau Network* (Monroe et al. 2016).

2.1 Water quality core parameters

National Park Service core water quality parameters include water temperature, pH, specific conductance, dissolved oxygen, turbidity, and discharge. During each site visit, which was generally less than two hours long, SCPN crew noted the hydrologic conditions and collected water quality core parameter data using the following methods:

- As soon as possible after arrival at the site, a multiparameter sonde (Hydrolab-MS5; Hach Inc.) was calibrated and deployed in a well-mixed part of the stream channel, logging temperature, pH, specific conductance, and dissolved oxygen data at 5-second intervals. The sonde was left stationary in the stream for the entire site visit.
- Turbidity samples were collected and analyzed with a HACH 2100P Portable Turbidimeter (Hach Inc.) as soon as possible after collection.
- Discharge was measured using a Hach FH950 (Hach, Inc.).
- Water temperatures were recorded at 15-minute intervals by a HOBO Pendant (Onset Computer Corporation) deployed at RIT01.

A streamflow gaging station was installed at this site by the USGS in 1983 and was operated by the agency until 1996. The gage was maintained by Los Alamos National Laboratory from 1998 until 2011 when it was destroyed by a flood. In 2012 USGS re-installed the gage and continues to operate it with support from NPS.

To characterize spatial variability of NPS core water quality parameters on the Rito de los Frijoles, SCPN collected measurements at 10 sites distributed along the entire length of the stream on May 15–16, 2014. The objective was to collect all data during a base flow period when the stream water was not being influenced by runoff from the surrounding watershed. A multiparameter sonde was placed at RIT01 to record temperature, pH, specific conductance, and dissolved oxygen at 15-minute intervals from May 14–16 in order to compare to the upstream sites. Discharge and turbidity were also measured at each site.

2.2 Water quality samples

SCPN collects water quality samples during each quarterly site visit to BAND to analyze for bacteria, nutrients, major elements and trace metals. Bacteria samples were collected by dipping a sterile sample bottle into the center of flow. SCPN staff then analyzed the sample for total coliforms and *E. coli* using the Quanti-Tray® 2000 system (IDEXX Inc.). Samples for nutrients, major elements, and trace metals were filtered directly from the stream. Sample water was then acid-treated (as required), kept on ice, and shipped to the contract laboratory.

In 2014, SCPN contracted with the USGS National Water Quality Lab (NWQL) in Denver, Colorado for analyses of water quality samples for selected water quality constituents: nutrients, major elements, and trace metals (Table 2). Sample collection methods and NWQL analysis methods are described in the SCPN water quality monitoring protocol (Monroe et al. 2016).

In 2014, SCPN continued to sample for contaminants of emerging concern (CECs) in selected SCPN parks through a partnership with the U.S. Environmental Protection Agency (EPA) which began in 2011. The categories of contaminants include pesticides, pharmaceuticals, personal care products, and waste indicators. The list of 265 analytes is provided in Appendix C. The goal of the project is to develop a baseline dataset documenting the occurrence of these contaminants in SCPN parks. We followed the sample collection and shipping procedures

Table 2. National Water Quality Laboratory and U.S. Environmental Protection Agency Laboratory sample analytes.

Analytical group	Analytes
Nutrients	ammonia, nitrite, nitrite + nitrate, orthophosphate
Major elements	calcium, chloride, fluoride, magnesium, potassium, silica, sodium, sulfate, acid neutralizing capacity (ANC; as CaCO ₃), total dissolved solids
Trace metals	aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron lead, manganese, mercury, molybdenum, nickel, selenium, silver, uranium, vanadium, zinc
Contaminants of emerging concern	pesticides, pharmaceuticals and personal care products, waste indicators (see Appendix H for a complete list)

described in NPS 2013. In 2014, we collected two of these samples at RIT01, one at RIT02, three at RIT03, and one at CAP01. Samples were kept on ice and sent to the EPA Region 8 Laboratory in Golden, Colorado for analysis within seven days of collection.

2.3 Data handling and analysis

All water quality data are entered into SCPN's water quality database. All multiparameter sonde electronic data and discharge files are stored on the SCPN server. In this report, we include the median values of a subset of seven consecutive multiparameter sonde measurements. Similarly, only the median values for each set of turbidity samples are presented. For total coliforms and *E. coli* samples, most-probable numbers (MPN/100 mL) are reported; MPN is a statistical estimate of the number of bacteria per unit volume of a sample, determined by using a lookup table provided by the manufacturer of Quanti-Tray 2000, the method used by SCPN to analyze bacteria in stream samples (IDEXX Inc.). Although the New Mexico criteria are expressed as cfu/100 mL and do not assume an estimation, the two units are comparable.

All results from the NWQL and EPA are presented as they were reported from the lab. In cases where analytes were not detected, we present the applicable laboratory reporting level, which is the lowest concentration that can be reliably quantified by a given analytical method. For the NWQL data, results which are below the laboratory reporting level but above the method detection level are noted to indicate that the analyte was detected, but the concentration was not high enough to report.

Where applicable, we compared our results against the State of New Mexico's 2016 surface water quality standards and to the standards specific to streams in BAND (New Mexico Environment Department [NMED] 2013). We noted any exceedances of the applicable water quality standards.

2.4 Understanding water quality data and standards

The NPS Natural Resource Challenge (NRC) provides funding for water quality monitoring in NPS park units. Water quality monitoring supports efforts to attain NPS's long-term goal to protect pristine water quality and improve impaired water quality by complying with Clean Water Act protections and provisions for designated unimpaired and impaired waters. Preliminary analysis of data available through water quality data synthesis (Brown 2008), a Level 1 water quality inventory (Macy and Monroe 2006), and monitoring indicate that water quality conditions at many SCPN parks exceed established USEPA, State, or Tribal standards.

The SCPN water quality monitoring program collects samples several times per year at regular intervals in order to document the range of hydrologic conditions that occur in network parks. Thus, rare and short-term events are often not captured. 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.

To meet requirements of the Federal Clean Water Act (Clean Water Act of 1972), the state of New Mexico has developed statewide water quality standards and criteria for surface waters and additional criteria specific to streams in BAND (NMED 2013). This report includes all water quality standards and criteria applicable to the streams in BAND. A water quality standard refers to a specific parameter and its associated designated use, in conjunction with a criterion, which is the numeric component against which a result is compared. For example, the standard for chronic mercury (parameter) for aquatic life (designated use) is 0.77 µg/L (numeric criterion). This is a criterion for dissolved samples.

All SCPN sample results are for the dissolved concentration, meaning that samples are filtered through a 0.45 µm filter in order to remove the particulate component of the sample before it is shipped to the contract laboratory and analyzed for the dissolved fraction. In New Mexico, most water quality criteria for metals are based on the dissolved fraction. This method more accurately measures the form of metals that is most toxic to humans, livestock, or aquatic life, while excluding less toxic forms. However, not all water quality criteria are based on dissolved samples—the aquatic life criteria for selenium are for the total sample concentration, which includes the portion of the analyte bound to particulates. Because our samples exclude the particulate component, our data are not necessarily comparable to criteria based on the total sample. Therefore, only the criteria for dissolved parameters are listed in the Results section of this report. However, we compare dissolved sample concentrations to the total concentration criteria and note when exceedances occur.

In this report, results for each parameter are evaluated against applicable water quality standards as defined for each stream by the state of New Mexico. Six designated uses are identified for the BAND streams discussed in this report: domestic water supply, high quality coldwater aquatic life, irrigation, livestock watering, wildlife habitat, and primary contact (NMED 2013). We did not evaluate the standards for irrigation and livestock watering because these uses are not occurring on these streams. Because of the multiple designated uses that apply to BAND streams, each parameter may have multiple standards. In these cases we only list the most stringent criterion for each parameter in the Results section, along with the designated use for which the most stringent criterion applies. Also, aquatic life criteria are often dependent upon water hardness, which varies for each site visit. In these cases, the criteria are expressed as a range encompassing the lowest and highest values for the year.

2.4.1 Chronic and acute standards

Numeric criteria for aquatic life water quality standards address potential effects of both chronic exposure to a parameter over an extended period of time (months), and acute exposure over a short period of time (hours or days). New Mexico has two types of aquatic life criteria—one is intended to protect aquatic life, and the other is intended to protect human health in waters where fish or other aquatic organisms to be consumed are caught. Compliance with acute criteria is determined from a single grab sample, and compliance with chronic criteria is determined from the mean of consecutive-day samples, or the results of individual grab samples collected during hydrologically stable conditions (NMED 2014). Criteria are much lower for chronic exposure than for acute exposure and are not necessarily comparable to the results obtained from a one-time grab sample. When determining attainment of both acute and chronic standards, the representative nature of the data must be considered. From a compliance standpoint, the acute instantaneous criteria afford the only direct comparison for such data because they apply to a single sample. However, from a resource conservation standpoint, instantaneous grab-sample data, when compared against more stringent chronic criterion, can provide a means of early warning and an indication of a problem that may require more attention. Therefore, we have identified chronic exceedances in the Results section of this report.

2.4.2 Regulatory authority

The National Park Service does not have regulatory authority over waters in the U.S., or even the authority to

make assessments for designated use. This report compares water quality data to designated-use criteria without stating whether a designated use was attained. Those designations are reported by the states or tribes in their triennial 305(b) reports to Congress. However, the NPS cooperates with states and tribes in collecting data used in the protection of water bodies under state and tribal jurisdiction.

3 Results

This section summarizes data collected by SCPN from the Rito de los Frijoles and Capulin Creek in Bandelier NM in 2014. We made four quarterly site visits to RIT01, RIT02, and RIT03 on the Rito de los Frijoles in February, May, July and October 2014. We made three site visits to Capulin Creek, in May, July, and October.

3.1 Rito de los Frijoles

Data collected by SCPN staff during water quality monitoring site visits to the Rito de los Frijoles in BAND in 2014 are presented below and compared to the New Mexico water quality standards that apply. These include standards for high-quality coldwater streams and Bandelier-specific water quality standards (NMED 2013). See Table 1 for a summary of data collected during site visits.

3.1.1 Water quality core parameter data

Summary statistics for water quality core parameter data collected at RIT01, RIT02, and RIT03 during the 2014 site visits are presented in Table 3. The core parameter data include water temperature, pH, specific conductance, dissolved oxygen, turbidity, and discharge. The 2013 data are included for comparison. Complete results for 2014 are provided in Appendix B.

Table 3. Summary of water quality core parameter data from RIT01, RIT02, and RIT03 on the Rito de los Frijoles in Bandelier NM, 2014. The associated New Mexico water quality criteria are indicated for each parameter; an “n/c” indicates that no water quality criteria exists for a parameter.

Core parameter	Site	2013			2014			N.M. state criteria
		<i>n</i>	Median	Range	<i>n</i>	Median	Range	
Water temperature (°C)	RIT01	5	16.7	0.0–19.7	5	11.7	1.7–23.2	Max. temp <23°, 4T3 = 20 ^{oa}
	RIT02	5	15.5	5.7–23.3	5	14.8	6.8–23.7	
	RIT03	5	12.7	-0.3–22.5	5	15.8	4.2–20.4	
pH	RIT01	5	8	7.8–8.2	5	7.8	7.6–8.1	>6.6 and <8.8
	RIT02	5	8.1	8.1–8.2	5	7.8	7.6–8.3	
	RIT03	5	8.1	7.9–8.2	5	7.8	7.6–8.1	
Specific conductance (µS/cm)	RIT01	5	193	156–266	5	250	151–331	<300
	RIT02	5	139	113–227	5	142	130–152	
	RIT03	5	153	118–257	5	181	166–224	
Dissolved oxygen (mg/L)	RIT01	5	7.3	7.1–11.9	5	8.4	6.2–11.2	>6
	RIT02	5	7.8	6.2–9.3	5	7.7	6.2–9.1	
	RIT03	5	8.2	6.6–11.9	5	7.5	6.7–10.2	
Dissolved oxygen (%)	RIT01	5	96.7	94.5–101	5	97.0	93.6–98.6	nc
	RIT02	5	97.4	90.6–101	5	97.0	94.1–97.5	
	RIT03	5	97.8	93.8–101	5	95.6	92.5–97.9	
Turbidity (NTU)	RIT01	5	38	2.1–4150	5	67	2.0–450	nc
	RIT02	5	3.4	2.6–1460	5	5.7	3.3–100	
	RIT03	5	45	2.4–920	5	35.4	2.8–58.4	
Discharge (cfs)	RIT01	5	1.0	0.3–1.7	5	0.8	0.3–1.1	nc
	RIT02	4	1.2	0.8–1.7	4	1.1	0.6–1.5	
	RIT03	5	0.7	0.5–1.2	5	0.7	0.5–1.0	

^a“4T3” criteria is the water temperature not to be exceeded for four or more consecutive hours in a 24-hour period on more than three consecutive days.

In the data from the four site visits to Rito de los Frijoles in 2014 water temperature ranged from 1.0 to 23.2°C at RIT01; from 6.8 to 23.7°C at RIT02; and from 4.2 to 20.4°C at RIT03. Water temperature exceeded the acute criterion of < 23°C for high-quality coldwater streams at both RIT01 (23.2°C) and RIT02 (23.7°C) on 23 July.

Median values for pH were identical between RIT01, RIT02, and RIT03. The median was 7.8, and pH for all sites ranged from 7.6–8.3, which is within the aquatic life criteria of >6.6 and <8.8. Specific conductance remained elevated compared to levels prior to the 2011 Las Conchas Fire, and also increased from upstream to downstream. In order from upstream to downstream, median values for RIT02, RIT03, and RIT01 were 142, 181, and 251 µS/cm. This trend was also observed in 2013. One measurement on 17 October 2014 at RIT01 was 331 µS/cm, which exceeds the 300 µS/cm aquatic life criterion.

Dissolved oxygen was near 100% saturation during all site visits. Measurements ranged from 6.2–11.2 mg/L at RIT01, 6.2–9.1 mg/L at RIT02, and 6.7–10.2 mg/L at RIT03. These results meet the high quality cold water criterion of 6.0 mg/L. However, dissolved oxygen concentrations are inversely proportional to water temperature, and the maximum water temperature recorded during our site visits was 23.7°C (at RIT02), while the dissolved oxygen concentration at this site visit was 6.2 mg/L. Our temperature logger deployed at RIT01 recorded a maximum water temperature of 29.0°C, which indicates that dissolved oxygen levels likely do not meet the water quality criteria at times on the Rito de los Frijoles.

Turbidity varied greatly between site visits, depending on when recent precipitation had occurred. Readings were lowest in the May 15–16 samples. During this time of year precipitation is typically sparse and infrequent. The highest measurements occurred in July and October. The precipitation in July usually consists of monsoonal thunderstorms, a pattern that typically occurs from July–September. During these months, heavy rains wash sediments from the watershed into the stream. Because much of the vegetation in the watershed burned in 2011, much more sediment moves into the stream after heavy rain events than in pre-fire conditions. Like specific conductance, turbidity increased from upstream to downstream. Median values were 5.8, 36, and 67 NTU for RIT02, RIT03, and RIT01. The highest turbidity was 450 NTU, measured at RIT01.

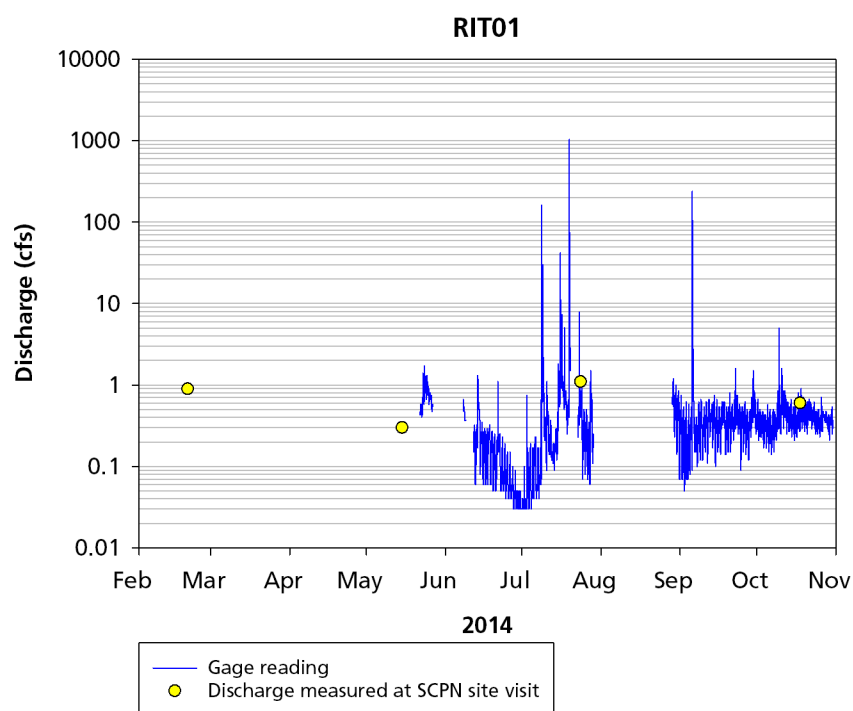


Figure 2. Streamflow for USGS gaging station 08313350 at RIT01 on the Rito de los Frijoles near the visitor center, Bandelier NM, 2014 (USGS 2016).

None of the water quality site visits occurred during a high flow event. Median stream discharge at RIT02 was 1.2 cfs, while median discharge at RIT03 and RIT01 was 0.8 cfs. A streamflow gage, operated by the USGS (USGS 2016), has been recording data at RIT01 since July 2012. These data are plotted below in Figure 2, along with the dates of SCPN site visits. The gage recorded limited data between May and October, and there is no information for most of August, which is one of the months that monsoonal rains typically occur. The peak streamflow recorded was 1040 cfs, recorded on 19 July. Two other streamflow events >100 cfs occurred this year: 162 cfs on 8 July, and 241 cfs on 5 September. Normal base flows for this creek are less than 1 cfs.

3.1.2 Continuous temperature data at RIT01

At RIT01, we logged stream and air temperatures at 15-minute intervals throughout the year; the daily minimum, maximum, and average temperatures from 2014 are plotted in Figure 3. Data collected prior to 20 February, from 28 June–1 July, and after 13 November are omitted because the changing streambed left the logger exposed to the air during those dates. Stream temperatures recorded during site visits are also shown, along with the New Mexico water temperature criteria for high-quality coldwater streams. There are two temperature criteria: an acute criterion of 23°C, which is not to be exceeded at any time, and a 4T3 criterion of 20°C. The 4T3 criterion is not to be exceeded for four or more consecutive hours for more than three consecutive days (NMED 2013).

Water temperatures at RIT01 continue to regularly exceed both water temperature criteria, as they have in the years since the 2011 Las Conchas fire. In 2014, the acute criterion was exceeded on 66 days from mid-June through August. The maximum temperature recorded was 29.0°C. The chronic criterion was exceeded regularly in the late spring and summer. From 27 May until 9 September, the chronic criterion was exceeded on 94 of the 102 days during this period.

3.1.3 Precipitation

Data from the early warning system weather stations Ponderosa C.G. (#31507) and Dome Road (#31508) (OneRain 2016) are shown in Figures 4 and 5. The Ponderosa C.G. gage is located 2 km north from RIT02. It recorded 40.5 cm of precipitation in 2014, and over half this amount (24.1 cm) occurred during the monsoon months from July through September. Precipitation events were smaller and distributed evenly through the remaining months; 2014 lacked the prolonged dry period that has occurred in previous years.

The Dome Road rain gage is located 7.7 km west of RIT02 near the Frijoles Canyon headwaters. The gage

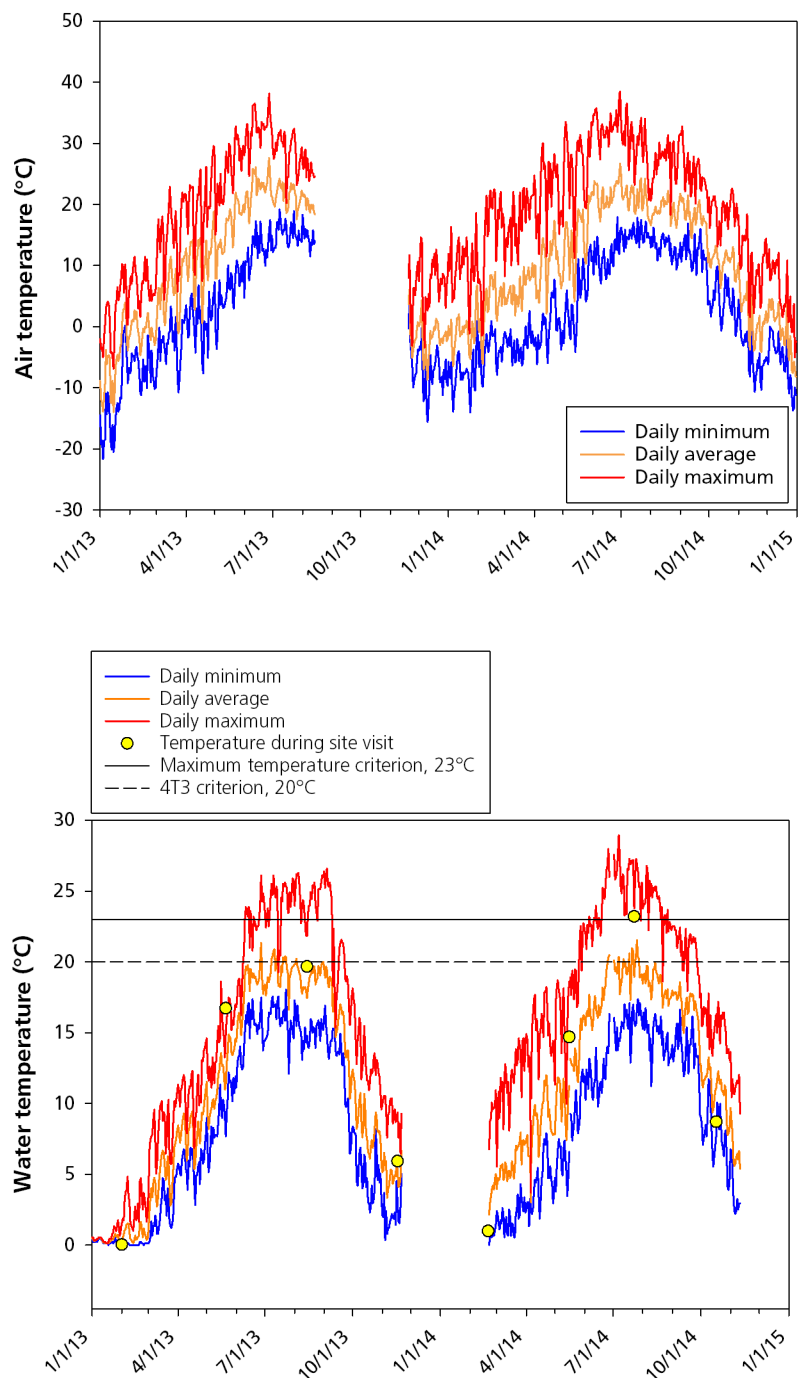


Figure 3. Air (top) and water (bottom) temperature data for RIT01 on the Rito de los Frijoles, Bandelier NM, 2013–2014, with the New Mexico temperature criteria for high-quality coldwater streams. Temperatures were recorded at 15-minute intervals.

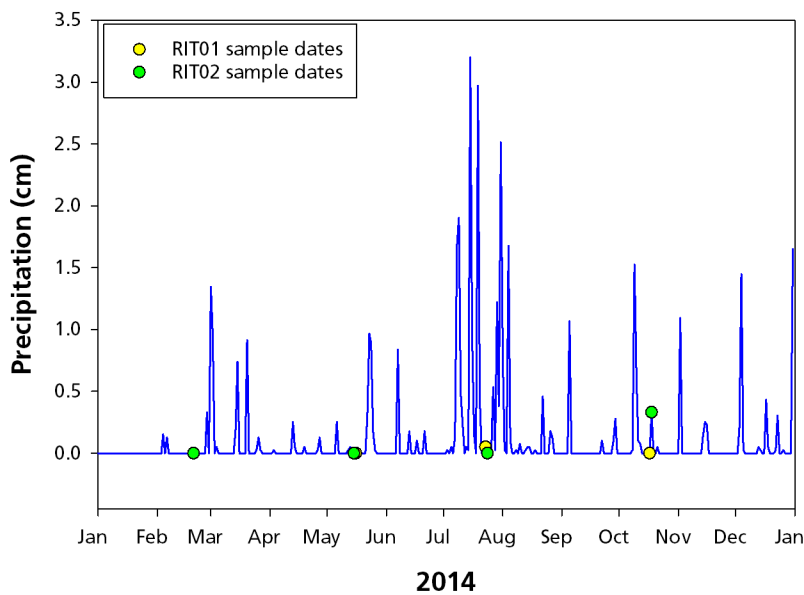


Figure 4. Precipitation data from the early warning system weather station Ponderosa C.G. (#31507).

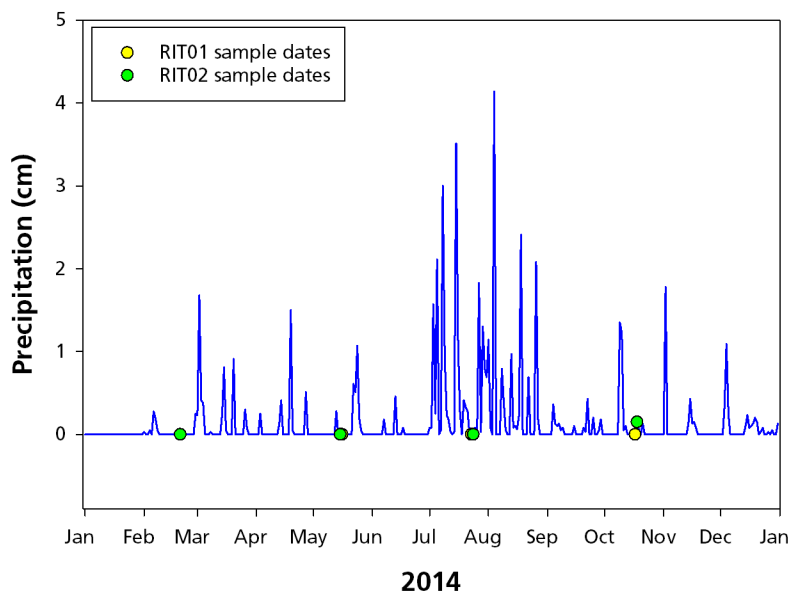


Figure 5. Precipitation data from the early warning system weather station Dome Road (#31508).

recorded 55.4 cm of precipitation, and 34.4 cm occurred in numerous rain events from July through September. As with what was recorded on the Ponderosa C.G. gage, precipitation was distributed evenly through the non-monsoonal months, except that the beginning and end of the year was dry.

3.1.4 Spatial variability of water quality core parameters in the Rito de los Frijoles

Beginning in 2006, SCPN staff has collected core water quality measurements at 11 locations along the Rito de los Frijoles to assess the variability of these parameters. The 11 sites are spaced along the stream from the headwaters to below the Lower Falls near the Rio Grande. In 2014, these measurements were collected on 15–16 May, however the Lower Falls site (RIT22) was not visited because repeated flooding since the Las Conchas fire has made this site inaccessible. A multiparameter sonde was placed at RIT01 to record measurements for pH, dissolved oxygen, temperature, and specific conductance at 15-minute intervals so that the upstream sites can be compared to RIT01; however the data for specific conductance were not useable due to sediments affecting the sensor.

Values for temperature, pH, specific conductance, dissolved oxygen, and turbidity are plotted for 10 sites on the Rito de los Frijoles in Figure 6. Sites are listed in order from upstream to downstream, except for RIT84 and RIT86 which represent two forks of the Rito de los Frijoles shortly before they converge just upstream of RIT75. The data used in Figure 6 are in Appendix B.

Temperature ranged from 7.4–18.0°C at sites in BAND during 2014. Since stream temperature is highly dependent on the time of day, the site visits for RIT86 through RIT02 occurred on 15 May from 11:37 to 18:00, and RIT05 through RIT01 were visited on 16 May from 11:51 to 18:30. Despite site visits occurring during similar times of day, the temperatures at the lower sites were higher than those from the upper sites. These measurements were within the range recorded at RIT01, which was 4.6–18.1°C.

Values for pH ranged from 7.2–8.1; the three lowest values (7.2–7.5) were in the upper portion of the stream, while higher values began at RIT64 and continued downstream. The pH at RIT01 ranged from 7.9–8.1 during the two days. The pH values at RIT86 (the West Fork of the Rito de los Frijoles), RIT64, and RIT02 were within this range; all other pH values were below 7.9.

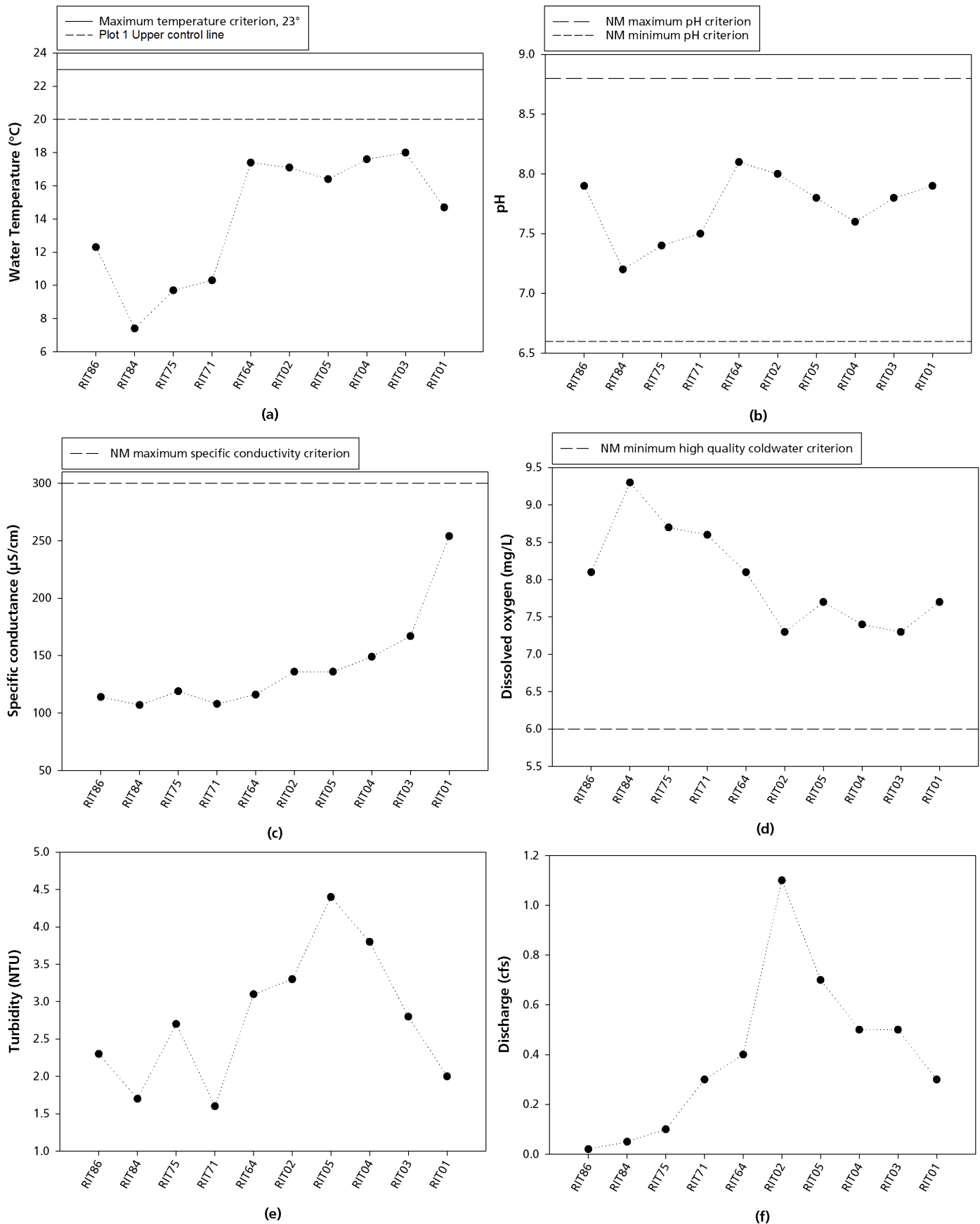


Figure 6. Spatial variability for core parameters along the Rito de los Frijoles in Bandelier NM, 2014. Measurements were obtained during base flow conditions for: (a) water temperature, (b) pH, (c) specific conductance, (d) dissolved oxygen, (e) turbidity, and (f) discharge.

Specific conductance ranged from 107–254 $\mu\text{S}/\text{cm}$, and generally increased from upstream to downstream. A large increase was observed between RIT03 and RIT01 in 2014.

Dissolved oxygen ranged from 7.3–9.3 mg/L. As was the case with temperature, measurements tended to decrease from upstream to downstream. Measurements were within the range recorded at RIT01, which was 7.2–10.0 mg/L.

Turbidity ranged from 1.6–4.4 NTU, and discharge ranged from <0.1–1.1 cfs. Stream discharge increased until RIT02, which was 1.1 cfs. Then, stream discharge decreased from RIT02 until RIT01, which was 0.3 cfs. The largest increase in discharge occurred between RIT64 and RIT02, where the stream increased from 0.4 to 1.1 cfs.

3.1.5 Total coliforms and *E. coli*

Bacteria results from RIT01, RIT02, and RIT03 in 2014 are plotted in Figure 7. Numeric results with dates and times for 2014 are presented in Appendix B. Four samples were collected at each site. Total coliforms include bacteria that are both vegetative and fecal in origin, and are indicators of the presence of all coliform groups of bacteria. While there are no surface water quality criteria for total coliforms, they are used in drinking water testing to indicate contamination from an outside source. Total coliforms were highest at RIT01; results ranged from 1400 to greater than 2400 MPN/100 mL and three of the four samples exceeded 2400 MPN/100 mL, which is the upper limit of the IDEXX test. At RIT02, the range was 550 to greater than 2400 MPN/100 mL. At RIT03, the range was 290 to greater than 2400 MPN/100 mL. At both these sites, one sample exceeded 2400 MPN/100 mL.

E. coli are a type of coliform bacteria which exist in the intestines of warm-blooded animals and can cause illness when ingested. They occur in streams where human or wildlife fecal matter enters the water. The water quality criteria for *E. coli* applicable at BAND is a monthly geometric mean of 126 cfu/100 mL or a single-sample maximum of 235 cfu/100 mL. Levels at all sites were highest in the July samples and lowest in February. *E. coli* levels at RIT01 ranged from less than 1 to 1200 MPN/100 mL; the sample taken on 23 July exceeded the single-sample maximum criterion. *E. coli* levels at RIT02 and RIT03 ranged from less than 1 to 110 MPN/100 mL and less than 1 to 190 MPN/100 mL, respectively. The sample taken at RIT03 on 25 July exceeded the chronic criterion level; however additional samples would have been needed to assess compliance with this criterion.

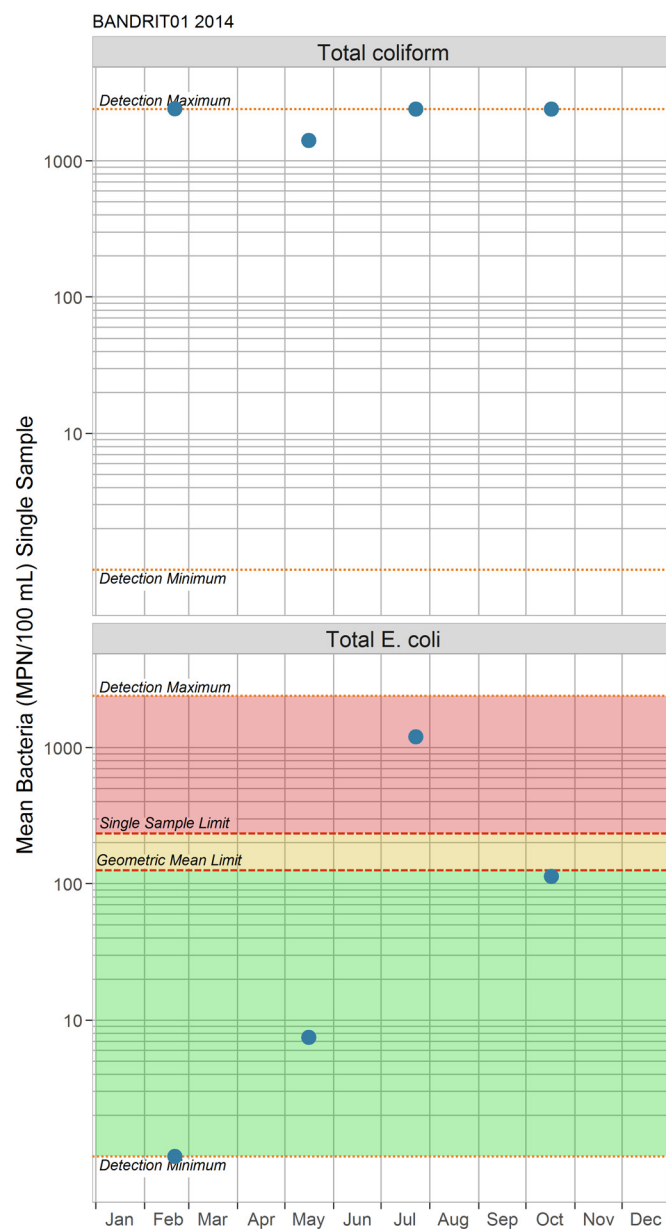


Figure 7a
See caption next page.



Figure 7. Total coliforms (top) and *E. coli* (bottom) in samples collected from RIT01 (7a), RIT02 (7b), and RIT03 (7c) on the Rito de los Frijoles in Bandelier NM, 2014. *E. coli* results were <1 MPN/100 mL in the following samples: RIT01, 11/17/13 and 2/20/14; RIT02, 2/1/13, 5/22/13, 2/20/14, 5/15/14; RIT03, 2/2/13 and 2/20/14.

3.1.6 Water quality laboratory data

Four samples were collected at RIT01 and at RIT02 to be analyzed for nutrients, major elements, and trace metals by the NWQL; the data are presented in Tables 4–6. The most stringent water quality standards for the designated uses that apply to streams in BAND are noted for each analyte. Designated uses include domestic water supply, primary contact, wildlife habitat, and high-quality cold water aquatic life. Compliance for irrigation and livestock watering were not evaluated because these uses are not occurring in the streams in BAND. All results represent dissolved analytes, except for acid neutralizing capacity, which was measured in the whole water sample.

Nutrient results for RIT01 and RIT02 are provided in Table 4. Dissolved ammonia was not detected at either site

above the reporting level of 0.0020 mg/L. Nitrite was detected once at each site but concentrations were very low (0.00442 mg/L at RIT01 and 0.00266 mg/L at RIT02). Nitrite + nitrate was not detected at RIT01, but was detected in three samples at RIT02 at low concentrations, ranging from <0.080–0.208 mg/L. Orthophosphate was present in all samples and concentrations have remained elevated since the Las Conchas Fire; results ranged from 0.0712–0.139 mg/L at RIT01 and 0.101–0.176 mg/L at RIT02.

Table 4. Nutrient data collected from RIT01 and RIT02 on the Rito de los Frijoles in Bandelier NM, 2014. There are no dissolved criteria for these analytes. Results that were lower than the NWQL reporting levels are noted as "<[reporting level]".

	Site	Sampling date and time			
	RIT01	2/20/14, 11:00	5/16/14, 18:30	7/23/14, 17:15	10/17/14, 15:39
Nutrient (dissolved)	RIT02	2/20/14, 15:00	5/15/14, 18:00	7/24/14, 16:45	10/18/14, 14:40
Ammonia	RIT01	<0.0200	<0.0200	<0.0200	<0.0200
	RIT02	<0.0200	<0.0200	<0.0200	<0.0200
Nitrite + nitrate as N	RIT01	<0.080 ^a	<0.080	<0.080 ^a	<0.080
	RIT02	0.138	<0.080	0.208	0.118
Nitrite as N	RIT01	<0.00200	<0.00200	0.00442	<0.00200 ^a
	RIT02	<0.00200	<0.00200 ^a	0.00266	<0.00200 ^a
Orthophosphate as P	RIT01	0.0712	0.0987	0.139	0.0918
	RIT02	0.101	0.106	0.176	0.133

a Result is above the Method Detection Level and below the Laboratory Reporting Level

Major elements, acid neutralizing capacity, and total dissolved solid results for RIT01 and RIT02 are provided in Table 5. There are no New Mexico water quality standards for these analytes. The eight major ions are plotted in Figure 8 as percentages of milliequivalents per liter. Ion chemistry between the two sites was similar and did not differ much between site visits. The dominant cation was calcium, followed by equal percentages of magnesium

Continued on page 18...

Table 5. Summary of major element data, acid neutralizing capacity and total dissolved solids in samples collected at RIT01 and RIT02 on the Rito de los Frijoles in Bandelier NM, 2014. There are no New Mexico water quality criteria for these analytes.

	Site	Sampling date and time			
	RIT01	2/20/14, 11:00	5/16/14, 18:30	7/23/14, 17:15	10/17/14, 15:39
Major element (dissolved)	RIT02	2/20/14, 15:00	5/15/14, 18:00	7/24/14, 16:45	10/18/14, 14:40
Calcium	RIT01	23.5	21.3	24.8	30.3
	RIT02	10.4	11.5	13.8	13.6
Chloride	RIT01	6.05	5.28	4.05	4.09
	RIT02	3.29	2.69	2.37	2.25
Fluoride	RIT01	0.310	0.404	0.366	0.404
	RIT02	0.191	0.203	0.231	0.198
Magnesium	RIT01	6.93	6.39	6.72	9.23
	RIT02	2.80	3.05	3.56	3.85
Potassium	RIT01	3.88	3.58	7.24	6.36
	RIT02	2.41	2.83	4.93	3.75

Table 5. Summary of major element data, acid neutralizing capacity and total dissolved solids in samples collected at RIT01 and RIT02 on the Rito de los Frijoles in Bandelier NM, 2014. There are no New Mexico water quality criteria for these analytes.

	Site	Sampling date and time			
	RIT01	2/20/14, 11:00	5/16/14, 18:30	7/23/14, 17:15	10/17/14, 15:39
Major element (dissolved)	RIT02	2/20/14, 15:00	5/15/14, 18:00	7/24/14, 16:45	10/18/14, 14:40
Silica	RIT01	51.3	52.4	55.8	62.0
	RIT02	47.1	54.7	61.6	59.6
Sodium	RIT01	18.6	19.0	15.9	19.8
	RIT02	8.81	10.6	10.2	10.8
Sulfate	RIT01	3.51	2.03	2.66	1.05
	RIT02	3.03	2.08	2.83	1.59
Acid neutralizing capacity, as CaCO_3 (unfiltered)	RIT01	125	130	125	160
	RIT02	63.2	64.6	69.4	73.7
Total dissolved solids	RIT01	199	213	202	226
	RIT02	175	142	148	136

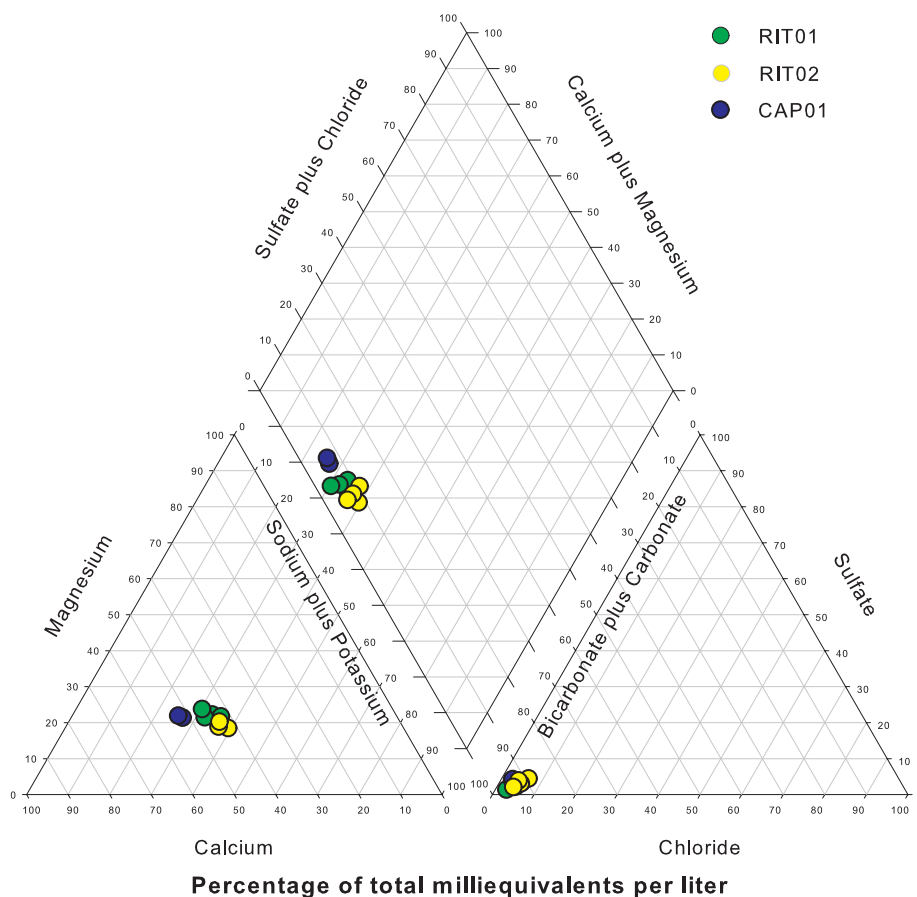


Figure 8. Major ion composition from water quality samples collected at RIT01, RIT02, and CAP01 on the Rito de los Frijoles and on Capulin Creek in Bandelier NM, 2014.

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and sodium plus potassium. Anions were primarily dominated by bicarbonate plus carbonate. In terms of concentrations, ions were generally twice as high at RIT01 as at RIT02, with the exception of sulfate. Acid neutralizing capacity was also twice as high at RIT01, ranging from 125–160 mg/L at that site and 63.2–73.7 mg/L at RIT02. Silica concentrations were similar between the two sites and between site visits, ranging from 47.1–62.0 mg/L. Total dissolved solids were higher at RIT01 and ranged from 199–226 mg/L; they ranged from 136–175 mg/L at RIT02.

Trace metal results from RIT01 and RIT02 in 2014 are in Table 6, along with the most stringent water quality standards that apply. In cases where the water quality criteria are dependent on water hardness, they are

Continued on page 20...

Table 6. Summary of trace metal data collected from RIT01 and RIT02 at the Rito de los Frijoles in Bandelier NM, 2014. Of the drinking water supply, aquatic life and wildlife habitat designated uses, only the most stringent criteria are listed. Because SCPN samples were filtered, only criteria based on dissolved samples were used. "nc" means there are no criteria for the analyte. Results that were lower than the NWQL reporting levels are noted as "<[reporting level]".

Trace metal (µg/L)	Site	Sampling date and time				Most stringent criteria	# of exceedances	Designated use ^a
	RIT01	2/20/14 11:00	5/16/14 18:30	7/23/14 17:15	10/17/14 15:39			
	RIT02	2/20/14 15:00	5/15/14 18:00	7/24/14 16:45	10/18/14 14:40			
Aluminum	RIT01	30.3	14.0	274	30.7	1002–1635	0	Aquatic life, chronic
	RIT02	26.5	19.1	205	36.4	358–528	0	Aquatic life, chronic
Antimony	RIT01	0.0889	0.0721	0.1650	0.0883	6	0	DWS
	RIT02	0.0661	<0.0540 ^b	0.0846	0.0581	6	0	DWS
Arsenic	RIT01	1.33	1.40	2.58	2.11	9	0	HH-OO
	RIT02	0.892	1.07	1.59	1.34	9	0	HH-OO
Barium	RIT01	24.6	18.8	31.6	23.4	2000	0	DWS
	RIT02	11.2	10.5	19.0	15.4	2000	0	DWS
Beryllium	RIT01	<0.040 ^a	<0.040 ^b	0.072	<0.040 ^b	4	0	DWS
	RIT02	<0.040	<0.040	0.060	<0.040	4	0	DWS
Boron	RIT01	14.0	15.0	25.7	25.7	nc	na ^c	nc
	RIT02	10.2	11.6	20.2	14.5	nc	na ^c	nc
Cadmium	RIT01	<0.060	<0.060 ^b	<0.060 ^b	<0.060	0.35–0.45	0	Aquatic life, chronic
	RIT02	<0.060	<0.060	<0.060	<0.060	0.20–0.25	0	Aquatic life, chronic
Chromium	RIT01	<0.60	<0.60	<0.60	<0.60	Cr(III) 61.4–82.4, Cr(VI) 11	0	Aquatic life, chronic
	RIT02	<0.60	<0.60 ^a	<0.60	<0.60	Cr(III) 33.2–41.9, Cr(VI) 11	0	Aquatic life, chronic
Cobalt	RIT01	0.651	0.379	1.03	0.746	nc	na ^c	nc
	RIT02	0.474	0.204	0.495	0.262	nc	na ^c	nc

Table 6. (continued) Summary of trace metal data collected from RIT01 and RIT02 at the Rito de los Frijoles in Bandelier NM, 2014.

Trace metal (µg/L)	Site	Sampling date and time					Most stringent criteria	# of exceedances	Designated use ^a
	RIT01	2/20/14 11:00	5/16/14 18:30	7/23/14 17:15	10/17/14 15:39				
	RIT02	2/20/14 15:00	5/15/14 18:00	7/24/14 16:45	10/18/14 14:40				
Copper	RIT01	<1.60	<1.60 ^b	<1.60 ^b	<1.60 ^b	7.37–10.0	0	Aquatic life, chronic	
	RIT02	<1.60	<1.60	<1.60	<1.60	3.88–4.94	0	Aquatic life, chronic	
Iron	RIT01	168	318	195	212	nc	na ^c	nc	
	RIT02	97.9	145	94.7	118	nc	na ^c	nc	
Lead	RIT01	0.135	0.110	0.452	0.106	1.96–2.89	0	Aquatic life, chronic	
	RIT02	0.080	<0.080 ^a	0.297	<0.080 ^a	0.85–1.17	0	Aquatic life, chronic	
Manganese	RIT01	450	142	87.7	366	1529–1722	0	Aquatic life, chronic	
	RIT02	150	121	72.7	214	1190–1308	0	Aquatic life, chronic	
Mercury	RIT01	<0.010	<0.010	<0.010	<0.010	0.77	0	Aquatic life	
	RIT02	<0.010	<0.010	<0.010	<0.010	0.77	0	Aquatic life	
Molybdenum	RIT01	3.17	4.15	7.32	6.49	ndc	ndc	ndc	
	RIT02	1.12	1.56	2.71	1.96	ndc	ndc	ndc	
Nickel	RIT01	0.956	1.34	1.52	1.09	42.9–58.0	0	Aquatic life	
	RIT02	0.456	0.527	0.872	0.306	22.7–28.9	0	Aquatic life	
Selenium	RIT01	0.134	0.124	0.215	0.139	5	0	DWS	
	RIT02	0.128	0.119	0.153	<0.100 ^b	5	0	DWS	
Silver	RIT01	<0.040	<0.040	<0.040	<0.040	2.17–4.01	0	Aquatic life, chronic	
	RIT02	<0.040	<0.040	<0.040	<0.040	0.60–0.97	0	Aquatic life, chronic	
Uranium	RIT01	0.344	0.235	0.590	0.476	30	0	DWS	
	RIT02	0.104	0.101	0.152	0.111	30	0	DWS	
Vanadium	RIT01	1.76	2.60	3.56	1.87	nc	na ^c	nc	
	RIT02	2.65	3.66	3.77	3.52	nc	na ^c	nc	
Zinc	RIT01	<4.00	<4.00 ^b	<4.00	<4.00	98.4–136	0	Aquatic life, chronic	
	RIT02	<4.00	<4.00	<4.00	<4.00	49.7–64.3	0	Aquatic life, chronic	

a Designated use codes: DWS = domestic water supply; HH-OO = Human health-organism only—HH-OO criteria are intended to protect human health when aquatic organisms are consumed. They are not intended for protection of the organisms themselves (NMED 2012).

b Result is above the Method Detection Level and below the Laboratory Reporting Level.

c “na” means not applicable because no criterion has been set for this analyte.

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expressed as a range of values. None of the trace metal concentrations were high enough to exceed the water quality criteria at either site. Aluminum concentrations at both sites were much higher in July after the watershed had received monsoon rainfall than they were during other times of the year, but levels were still below the water quality criteria. Six metals were not detected in any of the samples: cadmium, chromium, copper, mercury, silver, and zinc.

3.1.7 Contaminants of emerging concern

In 2014, SCPN staff collected six samples from the Rito de los Frijoles to be analyzed by the EPA Region 8 Laboratory for 265 contaminants of emerging concern (Appendix C). The contaminants are grouped in three categories: pesticides, pharmaceuticals and personal care products, and waste indicators. Waste indicators were not analyzed in every sample. Two samples were collected at RIT01, which is located downstream from most park facilities and areas with the highest visitor use. Three samples were collected at RIT03, which is located upstream from the park facilities and just upstream from where the majority of visitor usage occurs. One sample was collected at RIT02, which is located 6 miles upstream from the park facilities and experiences very little visitor use.

Table 7 reports CEC detections from the Rito de los Frijoles. CECs were not detected in the sample collected at RIT02, and pesticides were not detected in any of the samples. DEET was the only contaminant detected at RIT01. Four contaminants were detected at RIT03: the flame retardant tri(2-butoxyethyl) phosphate, the estrogenic hormone 17-beta estradiol, caffeine, and the plastic component bisphenol A.

Table 7. Summary of contaminants of emerging concern detected in samples collected at RIT01 and RIT03 on the Rito de los Frijoles in Bandelier NM, 2014.

Contaminant		No. of detections	
		RIT01	RIT03
Pesticides		nondetect	nondetect
Deet	Insect repellent	nondetect	45.6 ^a
a Analyzed outside holding time, result may be biased low			

3.2 Capulin Creek

Data collected by SCPN staff during water quality monitoring site visits to Capulin Creek in BAND in 2014 are presented below and are compared to the New Mexico water quality standards applicable to Capulin Creek. These include standards for high-quality coldwater streams and Bandelier-specific water quality standards (NMED 2013). See Table 1 for a summary of data collected during site visits.

3.2.1 Water quality core parameter data

Water quality core parameter data collected at CAP01 and CAP02 during 2014 are summarized in Table 8. The 2013 data are included for comparison (CAP02 was not visited in 2013). Complete results for 2014 are provided in Appendix B.

Water temperatures measured at CAP01 and CAP02 exceeded the 23°C water quality criterion for aquatic life. At CAP01, the water temperature was 27.3°C at 12:00 p.m. on 24 July. At CAP02, the water temperature was 23.2°C at 12:00 p.m. on 15 October. The 20°C chronic criterion could not be evaluated because temperature data was only collected during the site visits; however the data from previous years indicate that high temperatures are a chronic issue on Capulin Creek.

Table 8. Summary of water quality core parameter data from CAP01 and CAP02 on Capulin Creek in Bandelier NM, 2014. The associated New Mexico water quality criteria are indicated for each parameter; an “nc” indicates that no water quality criteria exists for a parameter. An “na” indicates that range is not applicable for CAP02 since there was only one site visit in 2014.

Core parameter	Site	2013			2014			N.M. state criteria
		<i>n</i>	Median	Range	<i>n</i>	Median	Range	
Water temperature (°C)	CAP01	3	19.1	9.1–23.4	3	21.5	19.5–27.3	Max. temp <23°, 4T3 = 20°C ^a
	CAP02	nd	nd	nd	1	23.2	na	
pH	CAP01	3	8.2	8.1–8.3	3	8.3	8.0–8.7	>6.6 and <8.8
	CAP02	nd	nd	nd	1	8.1	na	
Specific conductance (µS/cm)	CAP01	3	218	183–257	3	243	224–281	<300
	CAP02	nd	nd	nd	1	283	na	
Dissolved oxygen (mg/L)	CAP01	3	7.3	6.6–9.0	3	7.2	6.2–7.4	>6
	CAP02	nd	nd	nd	1	6.6	na	
Dissolved oxygen (%)	CAP01	3	97.9	96.7–99.0	3	98.5	97.6–105	nc
	CAP02	nd	nd	nd	1	96.6	na	
Turbidity (NTU)	CAP01	3	9.1	5.8–770	3	9.9	4.1–160	nc
	CAP02	nd	nd	nd	1	30	na	
Discharge (cfs)	CAP01	3	0.5	0.4–0.7	3	0.3	0.3–0.5	nc
	CAP02	nd	nd	nd	1	0.2	na	

^a“4T3” criteria is the water temperature not to be exceeded for four or more consecutive hours in a 24-hour period on more than three consecutive days.

At both sites, pH was within the aquatic life criteria of 6.6–8.8; this parameter ranged from 8.0–8.7 at CAP01 and was 8.1 at CAP02. Specific conductance was also below the aquatic life criterion of 300 µS/cm, but measurements remain higher than they were prior to the Las Conchas fire. At CAP01, they ranged from 224–281 µS/cm, and the CAP02 measurement was 283 µS/cm. Dissolved oxygen, which is inversely related to temperature, did not fall below the 6 mg/L high-quality cold water aquatic life criterion. Measurements were near 100% saturation and ranged from 6.2–7.4 mg/L at CAP01; the CAP02 measurement was 6.6 mg/L.

Turbidity was highly variable depending on when precipitation had occurred in the watershed. At CAP01, turbidity ranged from 4.1–160 NTU; the highest result was obtained in July after an active rainfall period. The measurement at CAP02 was 30 NTU. Discharge ranged from 0.3–0.5 cfs at CAP01 and 0.2 cfs at CAP02.

3.2.2 Precipitation

Daily precipitation data for 2014 from the early warning system rain gage Headwaters of Cochiti and Capulin Canyon (#31045), located 8.5 km northwest from CAP01, are shown on Figure 9 (OneRain 2016). A total of 37.3 cm of precipitation fell in 2014. Over half (22.1 cm) of this was rainfall occurred during the months of July–September; with the largest rainfall event of the year (5.5 cm) occurring on 29 July. Except for the summer precipitation and a dry January and February, this gage recorded smaller, infrequent precipitation events for the remaining months.

3.2.3 Total coliforms and *E. coli*

Total coliforms and *E. coli* results from the three samples collected at CAP01 are displayed in Figure 10, with the New Mexico *E. coli* water quality criteria for Bandelier streams. The numeric results with sample dates and times are in Appendix B. Total coliforms in the 2014 samples ranged from 690–1600 MPN/100 mL. *E. coli* ranged from <1–71 MPN/100 mL, which is well below the water quality criteria.

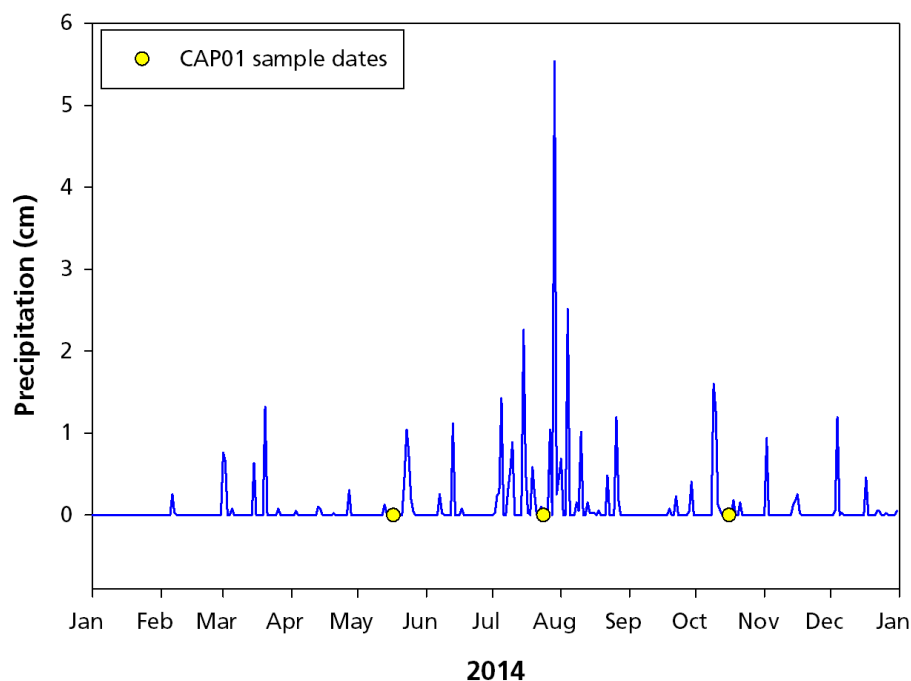


Figure 9. Daily precipitation from the rain gage Headwaters of Cochiti and Capulin Canyon (#31045) in Bandelier NM, 2014, with dates of SCPN water quality sampling site visits.

3.2.4 Water quality laboratory data

Three water samples from CAP01 were submitted to the NWQL in 2014 for analysis of nutrients, major elements, and trace metals. The results are in Tables 9–11, along with the lowest, most stringent applicable water quality standard for each analyte. None of the results exceeded the state of New Mexico acute or chronic water quality standards.

Nutrient results are presented in Table 9. Concentrations for the nitrogen species were very low: ammonia was not detected in the three samples, nitrite was only detected on one sample at 0.00213 mg/L, and nitrite + nitrate ranged from <0.080–0.176 mg/L. Orthophosphate ranged from 0.224–0.346 mg/L, results for this analyte are still elevated compared to pre-fire concentrations.

Major element results for CAP01 in 2014 are in Table 10. The major ions are plotted in Figure 8 (page 17), along with ion composition at RIT01 and RIT02. Only two samples are plotted because acid neutralizing capacity

was missing in the third sample.

In milliequivalents per liter, cation composition was approximately 50% calcium, followed by equal percentages of magnesium and sodium plus potassium. Anions almost entirely consisted of bicarbonate plus carbonate.

Table 9. Nutrient data collected from CAP01 on Capulin Creek in Bandelier NM, 2014. There are no dissolved criteria for these analytes. Results that were lower than the NWQL reporting levels are noted as "<[reporting level]".

Nutrient (dissolved)	Sampling date and time		
	5/17/2014 12:50	7/24/2014 12:00	10/16/2014 13:20
Ammonia	<0.0200	<0.0200	<0.0200
Nitrite + nitrate as N	<0.080	0.165	0.176
Nitrite as N	<0.00200 ^a	0.00213	<0.00200 ^a
Orthophosphate as P	0.224	0.346	0.286

a Result is above the Method Detection Level and below the Laboratory Reporting Level

Silica concentrations did not vary much between samples, ranging from 53.1–60.1 mg/L. Acid neutralizing was similar in the two samples where it was analyzed,

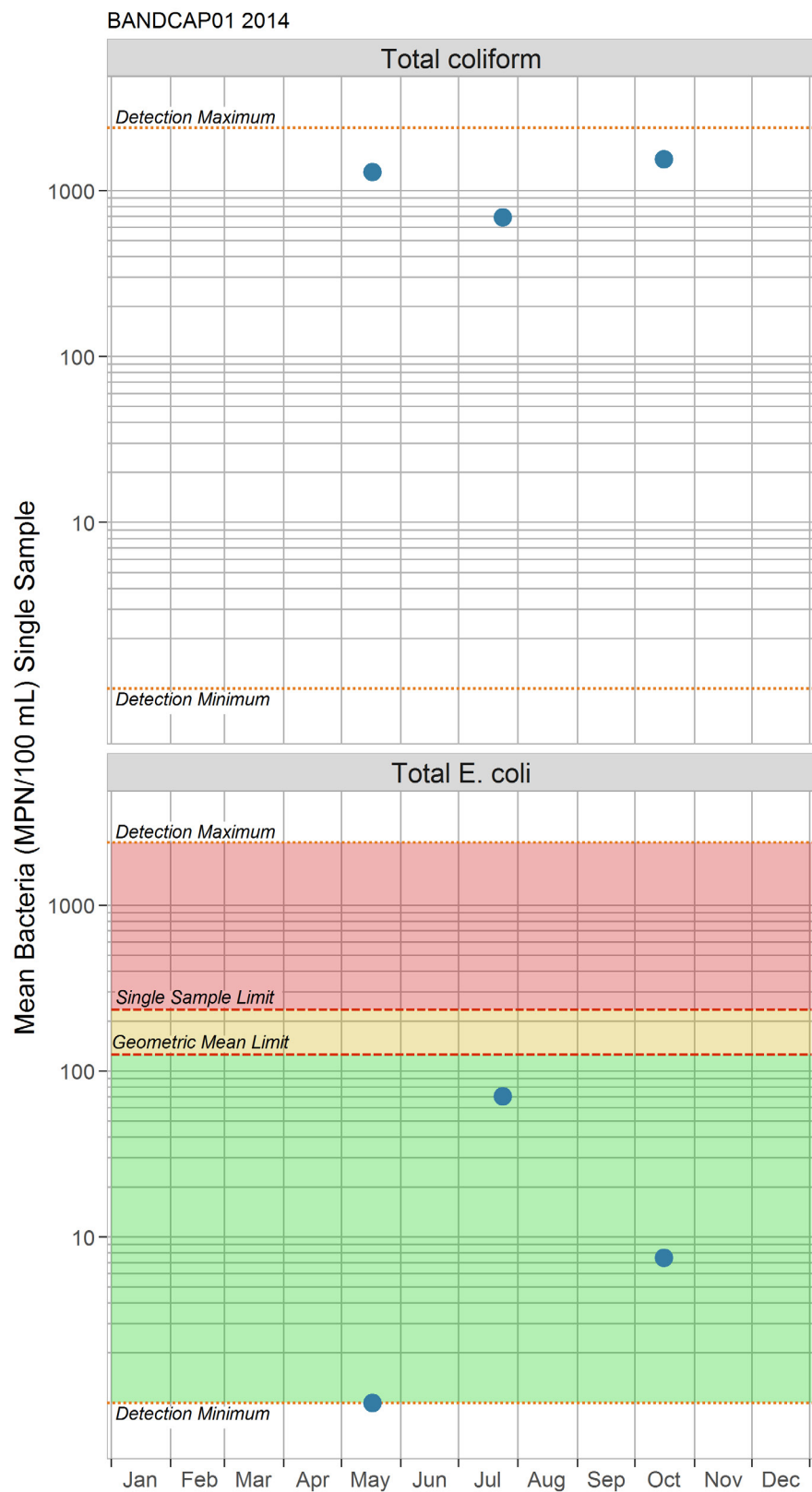


Figure 10. Total coliforms (top) and *E. coli* data (bottom) from samples collected at CAP01 on Capulin Creek in Bandelier NM, 2014. The *E. coli* result on 5/17/14 was <1 MPN/100 mL.

Table 10. Major element data, acid neutralizing capacity and total dissolved solids in samples collected at CAP01 on Capulin Creek in Bandelier NM, 2014. There are no New Mexico water quality criteria for these analytes. An “nd” indicates that data are not available.

Major element (dissolved)	Sampling date and time		
	5/17/2014 12:50	7/24/2014 12:00	10/16/2014 13:20
Calcium	23.3	28.3	29.9
Chloride	3.01	2.96	2.91
Fluoride	0.380	0.454	0.337
Magnesium	5.44	6.95	7.42
Potassium	4.66	6.30	6.34
Silica	53.1	60.1	53.8
Sodium	13.6	13.2	13.0
Sulfate	5.22	4.80	5.01
Acid neutralizing capacity, as CaCO ₃ (unfiltered)	nd	129	126
Total dissolved solids	181	210	192

results were 129 and 126 mg/L. Total dissolved solids ranged from 181–210 mg/L. There are no water quality criteria for these analytes.

Results for trace metal analyses at CAP01 in 2014 are in Table 11. Eight of these metals were not detected in the three samples: beryllium, cadmium, chromium, copper, lead, mercury, silver, and zinc. The remaining metals were present in concentrations well below the most stringent applicable water quality criteria.

3.4.5 Contaminants of emerging concern

One sample was collected at CAP01 to be analyzed for pesticides, pharmaceuticals and personal care products, and waste indicators. The sample was collected on 16 October 2014 at 13:20. Of the 265 analytes (Appendix C), none were detected in this sample.

Table 11. Trace metal data collected from CAP01 on Capulin Creek in Bandelier NM, 2014. Of the drinking water supply, aquatic life and wildlife habitat designated uses, only the most stringent criteria are listed. Because SCPN samples were filtered, only criteria based on dissolved samples were used. “ndc” means there are no dissolved criteria for the designated uses evaluated in this report. Results that were lower than the NWQL reporting levels are noted as “<[reporting level]”.

Trace metal (µg/L)	Sampling date and time			Most stringent criteria	# of exceed-ances	Designated use ^a
	5/17/2014 12:50	7/24/2014 12:00	10/16/2014 13:20			
Aluminum	8.80	33.3	18.9	1021–1471 (total)	0	Aquatic life, chronic
Antimony	0.0800	0.1370	0.0751	6	0	DWS
Arsenic	2.93	3.95	3.56	9	0	HH-OO
Barium	62.9	82.3	85.9	2000	0	DWS
Beryllium	<0.040	<0.040	<0.040	4	0	DWS
Boron	14.9	22.5	18.7	nc	na ^c	nc
Cadmium	<0.060	<0.060	<0.060	0.35–0.43	0	Aquatic life, chronic
Chromium	<0.60	<0.60	<0.60	Cr(III) 62.1–77.3, Cr(VI) 11	0	Aquatic life, chronic
Cobalt	0.240	0.771	0.369	nc	na ^c	nc
Copper	<1.60	<1.60 ^b	<1.60	7.45–9.36	0	Aquatic life, chronic
Iron	8.57	18.2	15.0	nc	na ^c	nc
Lead	<0.080	<0.080 ^a	<0.080	1.99–2.66	0	Aquatic life, chronic
Manganese	4.52	52.5	47.0	1535–1678	0	Aquatic life, chronic
Mercury	<0.010	<0.010	<0.010	0.77	0	Aquatic life
Molybdenum	2.62	3.84	3.59	ndc	ndc	ndc
Nickel	0.909	1.18	0.626	43.3–54.3	0	Aquatic life
Selenium	0.318	0.189	0.152	5	0	DWS
Silver	<0.040	<0.040	<0.040	2.22–3.51	0	Aquatic life, chronic
Uranium	0.519	0.527	0.546	30	0	DWS
Vanadium	9.77	7.02	5.68	nc	na ^c	nc
Zinc	<4.00	<4.00	<4.00	99.6–127	0	Aquatic life, chronic

a Designated use codes: DWS = domestic water supply; HH-OO = Human health-organism only—HH-OO criteria are intended to protect human health when aquatic organisms are consumed. They are not intended for protection of the organisms themselves (NMED 2012).

b Result is above the Method Detection Level and below the Laboratory Reporting Level.

c “na” means not applicable because no criterion has been set for this analyte.

4 Quality assurance/Quality control

We followed the Quality Assurance/Quality Control procedures described in Monroe et al. (2016) and in National Park Service 2013. To assure accuracy of the instruments, we calibrated and performed maintenance on the multiparameter sondes in an indoor laboratory several times per year, and instruments were also calibrated in the field prior to measurements. Current meters were checked according to manufacturer recommendations to ensure they were in working order, and the turbidimeter was calibrated quarterly in the lab. The turbidimeter was also checked for drift in the field prior to each measurement.

We collected five duplicate bacteria samples at several SCPN monitoring sites by filling two sample bottles in succession and comparing tray results after the incubation period. Two blank samples were processed using sterile water provided by IDEXX.

To verify the cleanliness of both the sampling equipment and the sample filtration process for nutrients, major elements, and trace metals, SCPN collected two sample sets of certified inorganic blank water at BAND on 5/16/14 and 10/17/14, and results were compared to the 2014 laboratory reporting levels (LRLs). Two analytes were detected in the 10/17/14 sample which affected the way the associated data were presented in this report: aluminum was detected at 6.54 µg/L (LRL was 6.00 µg/L), and cobalt was detected at 0.326 µg/L (LRL was 0.100 µg/L). These concentrations were compared to the stream samples collected from 10/16-10/18; if the stream sample results were within 5x the level found in the field blank, the result of the stream sample was used as the reporting level. The aluminum concentration at CAP01, which was 18.9 µg/L was within 5 times the concentration in the field blank, so it was changed to <18.9 µg/L. All values for cobalt were less than 5x the field blank concentration, so they were changed to <0.746 µg/L at RIT01, <0.262 µg/L at RIT02, and <0.369 µg/L at CAP01.

SCPN collected one set of blanks at BAND to be analyzed for pesticides, pharmaceuticals and personal care products, and waste indicators. The EPA lab also includes results for laboratory method blanks, blank spikes, matrix spikes, and other QA/QC checks in their reports to SCPN. In reporting the CEC detections, the results from both sets of QA/QC data were used to evaluate data quality.

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Appendices

Appendix A: Southern Colorado Plateau Network Water Quality Monitoring Sites in Bandelier National Monument

The Southern Colorado Plateau Network has four types of water quality sites at Bandelier NM:

1. Sites where a full suite of water quality samples and measurements are to be collected 4 times each year. These sites are BANDRIT01, BANDRIT02, and BANDCAP01.
2. Sites where water quality core parameters are measured in conjunction with aquatic macroinvertebrate sampling, once each year. These sites are BANDRIT01, BANDRIT02, BANDCAP01, and BANDCAP02.
3. Sites where water quality core parameters are measured once each year to assess spatial variability. These are BANDRIT01, BANDRIT02, BANDRIT03, BANDRIT04, BANDRIT05, BANDRIT22, BANDRIT64, BANDRIT71, BANDRIT75, BANDRIT84, and BANDRIT86.

Table A1. Southern Colorado Plateau Network (SCPN) water quality monitoring sites for Bandelier NM, 2014.

Site code	Common name	Report name	Easting (m) ¹	Northing (m) ¹	Elevation (m) ¹
BANDRIT86	Upper Frijoles – East Fork	RIT86	372361	3966007	2434
BANDRIT84	Upper Frijoles – West Fork	RIT84	372229	3965971	2433
BANDRIT75	Upper Frijoles – Confluence of East and West Forks	RIT75	372371	3965904	2434
BANDRIT71	Frijoles - Upper Upper Crossing	RIT71	372631	3965123	2366
BANDRIT64	Frijoles - Above Burn Area	RIT64	373770	3964295	2284
BANDRIT22	Rito de los Frijoles - Below Lower Falls	RIT22	386236	3957901	1684
BANDRIT02 ²	Rito de los Frijoles at Upper Crossing	RIT02	377109	3964316	2151
BANDRIT05	Frijoles - Narrows	RIT05	379932	3963074	2004
BANDRIT04	Frijoles - Hoodoo	RIT04	381806	3962327	1902
BANDRIT03	Rito de los Frijoles above Wilderness Boundary	RIT03	383164	3961664	1886
BANDRIT01 ²	Rito de los Frijoles near Visitor Center	RIT01	385363	3959889	1840
BANDCAP01 ²	Capulin Creek at Base Camp Gaging Station	CAP01	379713	3958026	1904
BANDCAP02	Capulin Creek above Painted Cave	CAP02	380300	3955457	1791

¹ Horizontal coordinates are reported in Universal Transverse Mercator (UTM) projection, Zone 13 North, North American Datum of 1983 (NAD 83). Vertical coordinates are referenced to the North American Vertical Datum of 1988 (NAVD 88).

² SCPN long-term water quality monitoring sites.

Appendix B. Water quality monitoring results for the Rito de los Frijoles and Capulin Creek at Bandelier National Monument, 2014

Table B1. Water quality core parameter data from RIT01 on the Rito de los Frijoles in Bandelier NM, 2014. An "nd" indicates no data are available.

Parameter	Sampling date and time			
	2/20/2014 11:00	5/16/2014 18:30	7/23/2014 17:15	10/17/2014 15:39
Water temperature (°C)	1.7	14.7	23.2	8.7
pH	8.1	7.9	7.6	7.7
Specific conductance (µS/cm)	246	254	151	331
Dissolved oxygen (mg/L)	11.0	7.7	6.2	9.2
Dissolved oxygen (% saturation)	98.6	96.1	93.6	97.8
Turbidity (NTU)	46	2.0	450	88
Discharge cfs	0.9	0.3	1.1	0.6

Table B2. Water quality core parameter data from RIT02 on the Rito de los Frijoles in Bandelier NM, 2014. An "nd" indicates no data are available.

Parameter	Sampling date and time			
	2/20/2014 15:00	5/15/2014 18:00	7/24/2014 19:00	10/17/2014 14:40
Water temperature (°C)	6.8	17.1	23.7	12.4
pH	8.3	8.0	7.6	7.5
Specific conductance (µS/cm)	130	136	152	147
Dissolved oxygen (mg/L)	9.1	7.3	6.2	8.11
Dissolved oxygen (% saturation)	96.5	97.5	94.1	97.6
Turbidity (NTU)	3.9	3.3	100	7.6
Discharge cfs	1.5	1.1	0.6	1.2

Table B3. Water quality core parameter data from RIT03 on the Rito de los Frijoles in Bandelier NM, 2014.

Parameter	Sampling date and time			
	2/20/2014 12:00	5/16/2014 14:45	7/25/2014 10:05	10/17/2014 17:24
Water temperature (°C)	4.2	18.0	20.4	13.6
pH	8.1	7.8	7.8	7.6
Specific conductance (µS/cm)	166	167	194	224
Dissolved oxygen (mg/L)	10.2	7.3	6.7	7.7
Dissolved oxygen (% saturation)	97.7	97.9	93.4	92.5
Turbidity (NTU)	29 ^a	2.8	42	58
Discharge cfs	1.0	0.5	0.9	0.6

^a Replicate turbidity measurements were not within 10% of one another for this sample

Table B4. Water quality core parameter data for spatial variability sites in Bandelier NM, 2014.

Site	Sampling date	Sampling time	Water temperature (°C)	pH	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Dissolved oxygen (% saturation)	Turbidity (NTU)	Discharge (cfs)
RIT86	5/15/2014	11:37	12.3	7.9	114	8.1	100	2.3	<0.1
RIT84	5/15/2014	12:05	7.4	7.2	107	9.3	103	1.7	0.1
RIT75	5/15/2014	12:30	9.7	7.4	119	8.7	102	2.7	0.1
RIT71	5/15/2014	13:51	10.3	7.5	108	8.6	101	1.6	0.3
RIT64	5/15/2014	15:24	17.4	8.1	116	8.1	112	3.1	0.4
RIT02	5/15/2014	18:00	17.1	8.0	136	7.3	97.5	3.3	1.1
RIT05	5/16/2014	11:51	16.4	7.8	136	7.7	99.7	4.4	0.7
RIT04	5/16/2014	13:14	17.6	7.6	149	7.4	98.3	3.8	0.5
RIT03	5/16/2014	14:45	18.0	7.8	167	7.3	97.9	2.8	0.5
RIT01	5/16/2014	18:30	14.7	7.9	254	7.7	96.1	2.0	0.3

Table B5. Total coliforms and *E. coli* in samples collected at RIT01 on the Rito de los Frijoles in Bandelier NM, 2014.

Parameter	Sampling date and time			
	2/20/2014 11:00	5/16/2014 18:30	7/23/2014 17:15	10/17/2014 15:39
Total coliforms, MPN/100mL	>2400 ^a	1400	>2400	>2400
<i>E. coli</i> , MPN/100mL	<1 ^b	8	1200	110

a Exceeded the maximum detection level of the IDEXX system, which is 2400 MPN/100 mL

b Below the minimum detection limit for the IDEXX system, which is less than 1MPN/100 mL

Table B6. Total coliforms and *E. coli* in samples collected at RIT02 on the Rito de los Frijoles in Bandelier NM, 2014.

Parameter	Sampling date and time			
	2/20/2014 15:00	5/15/2014 18:00	7/24/2014 19:00	10/18/2014 14:40
Total coliforms, MPN/100mL	730	550	>2400 ^a	≥2400
<i>E. coli</i> , MPN/100mL	<1 ^b	<1	110	17

a Exceeded the maximum detection level of the IDEXX system, which is 2400 MPN/100 mL

b Below the minimum detection limit for the IDEXX system, which is less than 1MPN/100 mL

Table B7. Total coliforms and *E. coli* in samples collected at RIT03 on the Rito de los Frijoles in Bandelier NM, 2014.

Parameter	Sampling date and time			
	2/20/2014 12:00	5/16/2014 14:45	7/25/2014 10:05	10/17/2014 17:24
Total coliforms, MPN/100mL	290	1700	2000	>2400 ^a
<i>E. coli</i> , MPN/100mL	<1 ^b	5	190	120

a Exceeded the maximum detection level of the IDEXX system, which is 2400 MPN/100 mL

b Below the minimum detection limit for the IDEXX system, which is less than 1 MPN/100 mL

Table B8. Contaminants of Emerging Concern data for samples taken from RIT01 on the Rito de los Frijoles in Bandelier NM in 2014. An "nd" indicates that no data are available (analyte not detected).

Contaminant (ng/L)	Use	Reporting limit (ng/L)	Sampling date and time	
			5/16/2014 18:30	7/23/2014 17:15
Pesticides			nd	nd
Pharmaceuticals and personal care products			nd	
DEET	Insect repellant	10		45.6 ^a
Waste indicators			not sampled	nd

a Analyzed outside holding time; result may be biased low.

Table B9. Contaminants of Emerging Concern data for samples taken from RIT02 on the Rito de los Frijoles in Bandelier NM in 2014. An "nd" indicates that no data are available (analyte not detected).

Contaminant (ng/L)	Use	Reporting limit (ng/L)	Sampling date and time
			10/18/2014 14:40
Pesticides			nd
Pharmaceuticals and personal care products			nd
Waste indicators			not sampled

Table B10 Contaminants of Emerging Concern data for samples taken from RIT03 on the Rito de los Frijoles in Bandelier NM in 2014. An "nd" indicates that no data are available (analyte not detected).

Contaminant (ng/L)	Use	Reporting limit (ng/L)	Sampling date and time		
			5/16/2014 14:45	7/25/2014 10:05	10/17/2014 17:26
Pesticides			nd	nd	nd
Pharmaceuticals and personal care products			nd	nd	nd
Waste indicators					
Tri(2-butoxyethyl) Phosphate	Flame retardant, plasticizer, used in floor polishes	50	241	nd	nd
17beta-Estradiol	A naturally-occurring estrogen	100	753 ^a	nd	nd
Caffeine	Stimulant drug	50	63.8	nd	nd
Bisphenol A	Used in the production of polycarbonate plastics and epoxy resins (hard plastic bottles and metal food cans)	50		223	nd

a Blank spike (2000) resulted in a nondetect (<100).

Table B11. Water quality core parameter data from CAP01 on Capulin Creek in Bandelier NM, 2014. An "nd" indicates no data are available.

Parameter	Sampling date and time		
	5/17/2014 12:50	7/24/2014 12:00	10/16/2014 13:20
Water temperature (°C)	21.5	27.3	19.5
pH	8.7	8.3	8.0
Specific conductance (µS/cm)	224	281	243
Dissolved oxygen (mg/L)	7.4	6.2	7.2
Dissolved oxygen (% saturation)	105	97.6	98.5
Turbidity (NTU)	4.1	164	9.9
Discharge cfs	0.3	0.3	0.5

Table B12. Total coliforms and *E. coli* in samples collected at CAP01 on Capulin Creek in Bandelier NM, 2014.

Parameter	Sampling date and time		
	5/17/2014 12:50	7/24/2014 12:00	10/16/2014 13:20
Total coliforms, MPN/100mL	1300	690	1600
<i>E. coli</i> , MPN/100mL	<1	71	8

a Exceeded the maximum detection level of the IDEXX system, which is 2400 MPN/100 mL

b Below the minimum detection limit for the IDEXX system, which is less than 1MPN/100 mL

Appendix C: List of analytes and reporting limits for contaminants of emerging concern

Table C-1. Target analytes and U.S. Environmental Protection Agency reporting limits for pesticides

Analyte	Reporting limit (ng/L)	Analyte	Reporting limit (ng/L)
2,4,5-T	10.0	Ethoprop	10.0
2,4,5-TP	10.0	Fipronil	20.0
2,4-D	10.0	Fipronil sulfide	10.0
3-Hydroxycarbofuran	10.0	Fipronil sulfone	10.0
Acetochlor	20.0	Foramsulfuron	20.0
Acetochlor OA	20.0	Hexazinone	10.0
Alachlor	20.0	Imazaquin	20.0
Alachlor OA	50.0	Imazethapyr	20.0
Aldicarb	10.0	Imidacloprid	20.0
Aldicarb sulfone	20.0	Linuron	20.0
Aldicarb sulfoxide	10.0	Malathion	10.0
Atraton	10.0	MCPP	20.0
Atrazine	10.0	Metalaxyl	10.0
Atrazine de-ethyl	20.0	Methiocarb	20.0
Atrazine de-isopropyl	20.0	Methomyl	20.0
Azoxystrobin	20.0	Metolachlor	10.0
Bentazon	10.0	Metolachlor ESA	20.0
Bromacil	50.0	Metribuzin	20.0
Bromoxynil	10.0	Monuron	10.0
Butachlor ESA	10.0	Neburon	50.0
Carbaryl	10.0	Oryzalin	20.0
Carbofuran	10.0	Oxamyl	10.0
Chlorimuron ethyl	20.0	Prometon	20.0
Chlorsulfuron	20.0	Propachlor	10.0
Clothianidin	20.0	Propachlor ESA	20.0
Cyanazine	10.0	Propachlor OA	10.0
Dacthal monoacid	20.0	Propazine	20.0
Diazinon	20.0	Propiconazole	50.0
Dichloroprop	10.0	Propoxur	10.0
Dimethachlor	10.0	Simazine	20.0
Dimethenamid	10.0	Sulfometuron methyl	20.0
Dimethenamid ESA	20.0	Tebuconazole	50.0
Disulfoton sulfone	20.0	Tebuthiuron	10.0
Diuron	20.0	Terbuthylazine	10.0
Diuron Metabolite	20.0	Thiamethoxam	20.0
EPTC	20.0	Triclopyr	20.0

Table C-2. Target analytes and U.S. Environmental Protection Agency reporting limits for pharmaceuticals and personal care products

Analyte	Reporting limit (ng/L)	Analyte	Reporting limit (ng/L)
(+/-)11-nor-9-carboxy-delta-THC	10.0	Duloxetine	25.0
10,11-dihydro-10-hydroxycarbamazepine	10.0	Ecgonine Methyl Ester	10.0
6-Acetylmorphine	10.0	EDDP	10.0
Acebutolol	10.0	Erythromycin	10.0
Acetaminophen	10.0	Erythromycin-anhydro	10.0
Albuterol	10.0	Escitalopram	10.0
Amitriptyline	10.0	Famotidine	10.0
Amitriptyline (+/-)-E-10-hydroxylated	10.0	Fenbufen	25.0
Amphetamine	10.0	Fentanyl	10.0
Aripiprazole	10.0	Fluoxetine	10.0
Atenolol	10.0	Fluticasone propionate	10.0
Atorvastatin	10.0	Furosemide	10.0
Atrazine	10.0	Gabapentin	10.0
Benzoyllecgonine	10.0	Gemfibrozil	10.0
Bezafibrate	10.0	Glyburide	10.0
Buprenorphine	10.0	Hydrochlorothiazide	10.0
Bupropion	10.0	Hydrocodone	10.0
Caffeine	25.0	Hydromorphone	10.0
Carbamazepine	10.0	Hydroxybupropion	10.0
Carbamazepine 10,11 epoxide	10.0	Ibuprofen	25.0
Carisoprodol	10.0	Ketoprofen	10.0
Celecoxib	10.0	Lamotrigine	10.0
Chloramphenicol	10.0	Levorphanol	10.0
Chlorpheniramine	10.0	Lidocaine	10.0
Clenbuterol	10.0	Loratadine	10.0
Clopidogrel carboxylic acid	10.0	Lorazepam	25.0
Cocaethylene	10.0	MDA	10.0
Cocaine	10.0	MDEA	10.0
Codeine	10.0	MDMA	10.0
Cotinine	10.0	Mefenamic acid	10.0
DEET	10.0	Meperidine	10.0
Dehydroaripiprazole	10.0	Meprobamate	10.0
Desmethylcitalopram	10.0	Metformin	10.0
Desmethylvenlafaxine	10.0	Methadone	10.0
Dextromethorphan	10.0	Methamphetamine	10.0
Diclofenac	10.0	Methotrexate	10.0
Diclofenac 4-hydroxy	25.0	Methylparaben	25.0
Diltiazem	10.0	Methylphenidate	10.0
Diphenhydramine	10.0	Metoprolol	10.0
Disopyramide	10.0	Mevastatin	10.0
Donepezil	10.0	m-Hydroxybenzoyllecgonine	10.0

Table C-2. Target analytes and U.S. Environmental Protection Agency reporting limits for pharmaceuticals and personal care products, *continued*

Analyte	Reporting limit (ng/L)	Analyte	Reporting limit (ng/L)
Modafinil	10.0	Pregabalin	10.0
Modafinil acid	25.0	Primidone	25.0
Monoethylglycinexylidide	10.0	Propranolol	10.0
Montelukast	10.0	Pseudoephedrine	10.0
Morphine	10.0	Quetiapine	10.0
Naproxen	25.0	Ritalinic acid	10.0
n-Butylparaben	25.0	Sertraline	10.0
Nifedipine	10.0	Sildenafil	10.0
Nifedipine oxidized	10.0	Simvastatin	10.0
Norfentanyl	10.0	Sotalol	10.0
Norfluoxetine	10.0	Sulfamethazine	10.0
Normeperidine	10.0	Sulfamethoxazole	10.0
Norquetiapine	10.0	Sumatriptan	10.0
Norsertaline	10.0	Tadalafil	25.0
Norverapamil	10.0	Temazepam	10.0
Omeprazole	10.0	Thiabendazole	10.0
Oxazepam	10.0	Tramadol	10.0
Oxcarbazepine	10.0	Trazodone	10.0
Oxycodone	10.0	Triamterene	10.0
Oxymorphone	10.0	Triclocarban	10.0
Oxymorphone glucuronide	10.0	Triclosan	25.0
Paroxetine	10.0	Trimethoprim	10.0
Phenmetrazine	10.0	Tylosin	25.0
Phenobarbital	25.0	Valsartan	10.0
Phentermine	25.0	Venlafaxine	10.0
Phenylpropanolamine	10.0	Verapamil	10.0
Phenytoin	10.0	Warfarin	10.0
Pioglitazone	10.0	Zolpidem	10.0
Pravastatin	25.0	Zolpidem phenyl-4-carboxylic acid	10.0

Table C-3. Target analytes and U.S. Environmental Protection Agency reporting limits for wastewater indicators

Analyte	Reporting limit (ng/L)	Analyte	Reporting limit (ng/L)
1,4-Dichlorobenzene	50.0	Galaxolide	50.0
17beta-Estradiol	100	Indole	50.0
1-Methylnaphthalene	50.0	Isoborneol	50.0
2,6-Dimethylnaphthalene	50.0	Isophorone	50.0
2-Methylnaphthalene	50.0	Isoquinoline	50.0
3-Methyl Indole	50.0	Menthol	50.0
4-Cumylphenol	50.0	Methyl Salicilate	50.0
4-n-Octylphenol	50.0	Metolachlor	50.0
4-tert-Octylphenol	50.0	Musk ketone	50.0
Acetophenone	50.0	Naphthalene	50.0
Benzophenone	50.0	Nonylphenol	50.0
Bisphenol A	50.0	p-Cresol	50.0
Bromacil	50.0	Pentachlorophenol	100
Butylated Hydroxyanisole	100	Phantolide	50.0
Caffeine	50.0	Phenanthrene	50.0
Camphor	50.0	Phenol	50.0
Carbaryl	50.0	Prometon	50.0
Carbazole	50.0	Pyrene	50.0
Celestolide	50.0	Tonalide	50.0
Chlorpyrifos	50.0	Tri(2-butoxyethyl) Phosphate	50.0
Dacthal	50.0	Tri(2-chloroethyl) Phosphate	50.0
Diazinon	50.0	Tri(dichloroisopropyl) Phosphate	50.0
Dichlorvos	50.0	Tributyl Phosphate	50.0
Equilenin	100	Triclosan	50.0
Estrone	100	Triethyl Citrate	50.0
Ethinylestradiol	100	Triphenyl phosphate	50.0
Fluoranthene	50.0		

Appendix D. Abbreviations, chemical formulas, and symbols used in this report

Term	Definition
ANC	acid neutralizing capacity of solutes plus particulates in an unfiltered water sample
CaCO_3	chemical formula for calcium carbonate
cfs	cubic feet per second
cfu/100 ml	colony forming units, for bacteria sampling, a measure of the number of viable bacteria per 100 mL
LRL	laboratory reporting level
MDL	method detection level
$\mu\text{g/L}$	micrograms per liter
$\mu\text{S/cm}$	microsiemens per centimeter at 25°C, a measure of specific conductance
mg/L	milligrams per liter
Milliequivalents per liter	an expression of the concentration of substances that is chemically equivalent in terms atomic weight and electrical charge
MPN/100 mL	most probable number, for sampling bacteria, a statistical estimation of the number of coliform that would give the results shown by the laboratory examination
N	chemical symbol for the element nitrogen
ng/L	nanograms per liter
NTU	nephelometric turbidity unit, a measure of turbidity
P	chemical symbol for the element phosphorous

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