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

2012–2013 Summary Report

Natural Resource Data Series NPS/SCPN/NRDS—2016/1218

ON THE COVER
El Rito de los Frijoles in Bandelier National Monument, 2012.
Photography by SCPN

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2012–2013 Summary Report

Natural Resource Data Series NPS/SCPN/NRDS—2016/1218

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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 waters[1] — 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

El Rito de los Frijoles is a perennial stream flowing eastward from the Sierra de los Valles of the Jemez Mountains in north central New Mexico into the Rio Grande. The entire length of this stream lies within the boundaries of Bandelier National Monument (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 in the lower portion of the watershed, resulting in high levels of visitor use of the riparian area around the stream. 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 1998–2014).

Capulin Creek is a perennial stream that flows through the southwestern portion of BAND and joins the Rio Grande approximately 8 km south of El 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 El 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 four sites in BAND. In addition to regular water quality monitoring, SCPN sometimes collects additional samples to address park-specific water quality concerns. This report summarizes water quality data collected at BAND during 2012-2013. Information describing SCPN water quality sites and activities is provided below and in Appendix A.

- *El Rito de los Frijoles at Headquarters* (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.
- *El 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.
- *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.

SCPN conducts water quality monitoring site visits at regular intervals throughout the year. Water quality samples are analyzed by SCPN staff and by a qualified contract laboratory. During 2012 SCPN staff completed

seven site visits spaced approximately six weeks apart to RIT01, RIT02, and RIT03. Only four site visits were made to CAP01 due to the difficulty in accessing this site during winter conditions. SCPN made one site visit to CAP02 in October 2012 during aquatic macroinvertebrate sampling, and only took water quality core parameter measurements. One site visit to ALA01 occurred in May 2012 to collect samples for radionuclide analysis. To assess spatial variability of water quality core parameters along Rito de los Frijoles, SCPN visited ten sites along the length of the stream extending from the headwaters to the monument visitor center in May 2012 and June 2013. In this report these measurements are compared to data collected at the same sites from 2006-2010, prior to the Las Conchas Fire.

In 2013, we revised our monitoring schedule to quarterly visits spaced at three month intervals throughout the year. Four site visits were completed at RIT01, RIT02, and RIT03. CAP01 was visited three times. CAP02 was not sampled in 2013. This report documents and summarizes all of SCPN's water quality sampling activities at BAND during 2012 and 2013. Table 1 summarizes the site visits to BAND in 2012 and 2013 and the data collected. Previous water quality data from Capulin Creek and El Rito de los Frijoles are summarized in Brown 2008.

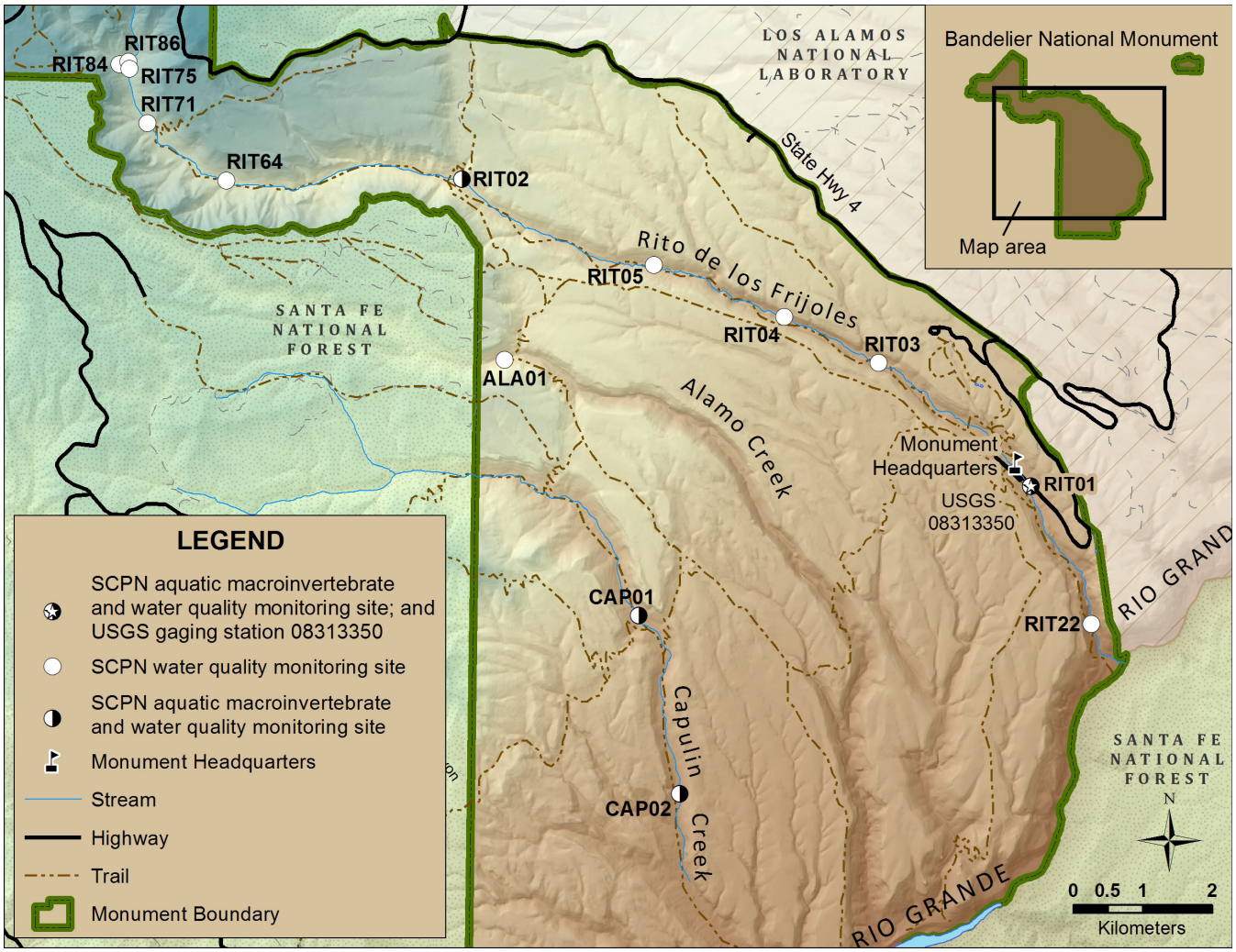


Figure 1. Map of water quality sampling sites on the Rito de los Frijoles, Capulin Creek, and Alamo Creek in Bandelier NM.

Table 1. Summary of site visits made and data collected in Bandelier NM, 2012–2013. "X" indicates that no data was collected for the category. See Appendix A for a description of SCPN water quality sites.

Site	Core parameter measurements		Long-term temperature[1]		Bacteria		Nutrients, major elements, trace metals		Contaminants of emerging concern		Radionuclide samples	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
ALA01	1	X	X	X	1	X	X	X	X	X	1	X
RIT01	7	5	Partial	Complete	6	4	7	4	3	3	1	X
RIT02	7	5	X	Partial	7	4	7	4	X	X	1	X
RIT03	7	5	X	X	4	4	X	X	3	3	X	X
CAP01	4	3	Partial	Partial	4	3	4	3	X	X	1	X
CAP02	1	X	X	X	X	X	X	X	X	X	X	X
RIT04	1[2]	1[2]	X	X	X	X	X	X	X	X	X	X
RIT05	1[2]	1[2]	X	X	X	X	X	X	X	X	X	X
RIT22	X	X	X	X	X	X	X	X	X	X	X	X
RIT64	1[2]	1[2]	X	X	X	X	X	X	X	X	X	X
RIT71	1[2]	1[2]	X	X	X	X	X	X	X	X	X	X
RIT75	1[2]	1[2]	X	X	X	X	X	X	X	X	X	X
RIT84	1[2]	1[2]	X	X	X	X	X	X	X	X	X	X
RIT86	1[2]	1[2]	X	X	X	X	X	X	X	X	X	X

[1] Data for long-term temperature are continuous data recorded by a temperature logger. "Partial" indicates that the data are incomplete due to a disruption of the data logger as a result of fire or flood.

[2] Data collected to characterize spatial variability along the 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. in preparation).

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 is 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.), a Pygmy Meter and AquaCalc Pro (Rickly Inc. and JBS Instruments), or a Marsh McBirney Flo-Mate 2000 (Hach Inc.).
- Water and air temperatures were recorded at 15-minute intervals by a HOBO Pendant (Onset Computer Corporation) deployed at RIT01, RIT02, and CAP01. Maintaining data loggers at the monitoring sites was challenging due to flooding and quickly changing stream channels caused by effects from the Las Conchas fire; this was particularly true at RIT02 and CAP01. Data from these sites has been extremely limited and we stopped deploying loggers at them in the summer of 2013, but have included the data in this report. Temperature is still recorded at RIT01. For most of 2012, RIT01 temperature data were recorded with a pressure transducer (Solinst Levelogger; Solinst Canada Limited); this was replaced by a HOBO Pendant for the remainder of 2012 and for all of 2013.

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 water quality core parameters on El Rito de los Frijoles, SCPN collected measurements at 10 sites distributed along the entire length of the stream in May 2012 and June 2013. The objective was to collect all data during a base flow period. A mutiparameter sonde was placed at RIT01 to record temperature, pH, specific conductance, and dissolved oxygen at 15-minute intervals from June 5–7, 2013 in order to compare to the upstream sites.

2.2 Water quality samples

During each site visit, SCPN staff collected samples to analyze for bacteria, nutrients, major elements and trace metals. Bacteria samples were collected by dipping a sterile sample bottle at the center of flow. Staff then analyzed the sample for total coliforms and *E. coli* using the Quanti-Tray® 2000 system (IDEXX Inc.). Samples for other analytes were filtered and/or acid-treated (as required), kept on ice, and shipped to the contract laboratory. During 2012–2013, SCPN contracted with the USGS National Water Quality Lab (NWQL) in Denver, Colorado for analyses of selected water quality constituents. These analyses fall into three categories: nutrients, trace metals, and major elements (Table 2). Information documenting NWQL methods is included in the SCPN water quality monitoring protocol (Monroe et al. in preparation).

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
Radionuclides	72-hour and 30-day gross alpha, beta, and gamma; U-234, 235, and 238, and radium 226/228

2.2.1 Sampling for special projects.

After the Las Conchas Fire in 2011, the Los Alamos National Laboratory (LANL) obtained water samples during a storm event that caused concern because of elevated alpha radiation levels that exceeded drinking water standards (LANL 2013, NMED 2013). To further investigate, SCPN conducted one sampling event for radionuclides at 2 sites in December 2011 (Dyer and Monroe 2013) and one sampling event at 4 sites in May 2012. Stream water and streambed sediment samples from RIT01, RIT02, CAP01, and ALA01 were analyzed by Eberline Services in Richmond, California, for gross alpha, beta, and gamma radiation, as well as isotopic uranium and radium 226/228. Stream water was collected in 1-L acid-cleaned polyethylene bottles, while bed sediment samples were collected in 250 mL polyethylene jars. Water samples were not filtered, ensuring that both dissolved and particulate fractions were included in the analyses. Immediately after they were collected, samples were preserved with nitric acid and shipped overnight to the laboratory. Gross alpha and beta analyses were conducted twice: within 72 hours of collection and again after 30 days.

Also in 2012–2013, SCPN continued its partnership with the U.S. Environmental Protection Agency (EPA) to sample for contaminants of emerging concern in selected SCPN parks. The categories of contaminants include pharmaceuticals, personal care products, waste indicators, and pesticides (see Appendix H). The goal is to develop a baseline dataset documenting the occurrence of these contaminants within SCPN parks. We followed the procedures described in NPS 2013. We conducted six sampling events at RIT01 and RIT03 from May to October in 2012 and 2013. Samples were kept on ice and sent to the EPA Region 8 Laboratory in Golden, Colorado for analysis within seven days of collection, as required.

2.3 Data handling and analysis

All SCPN water quality data are entered in NPSTORET, v.1.83, a Microsoft Access database created by the Water Resources Division of the National Park Service. All multiparameter sonde and flow meter electronic data files are stored on the SCPN server.

In this report, we only include the median values of a subset of seven consecutive multiparameter sonde measurements taken close to the time of sample collection. Similarly, only the median values for each set of turbidity triplicate samples are presented.

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 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); however, 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 the 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 which contains the most stringent criterion. 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.

For *E. coli*, water quality criteria are expressed as the number of colony forming units per 100 mL (cfu/100 mL). SCPN bacteria data are expressed as a most probable number (MPN) per 100 mL. 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 (IDEXX Inc.). Although the New Mexico criteria are expressed as cfu/100 mL and do not assume an estimation, the two units are comparable.

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

3.1 El Rito de los Frijoles

Data collected by SCPN staff during water quality monitoring site visits on El Rito de los Frijoles in BAND in 2012 and 2013 are presented below. See Table 1 for summary of 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 2012–2013 site visits are presented in Table 3. The core parameter data include water temperature, pH, specific conductance, dissolved oxygen, turbidity, and discharge. The 2010 and 2011 data are included for comparison. Data are also compared to the state of New Mexico's high quality coldwater and Bandelier-specific water quality criteria (NMED 2013). Complete results for 2012–2013 are provided in Appendices B–D.

Median pH results were very similar among the three sites and also were similar between the two years. The range of all measurements during our site visits to RIT01, RIT02, and RIT03 was 7.4–8.5, which did not fall outside the water quality criteria. Specific conductance, which had increased after the 2011 Las Conchas fire, was higher in many of the 2012–2013 measurements than they were before the fire at all three sites. Measurements were approximately 100 µS/cm higher after the fire. However, between precipitation events, RIT02 tended to return closer to pre-fire conditions than RIT01 and RIT03, which are downstream. Median results for RIT02 in 2012 and 2013 were 148 and 139 µS/cm. In contrast, median results for RIT01 were 198 and 193 µS/cm, and for RIT03 were 174 and 153 µS/cm. None of the measurements exceeded the 300 µS/cm water quality criterion.

Turbidity varied greatly for the three sites throughout 2012–2013, depending on when the last precipitation event occurred. Generally turbidity readings tended towards pre-fire conditions in the late spring, but were higher during other times of the year. Median turbidity was lowest at RIT02; in 2012 and 2013 it was 7.9 and 3.4 NTU. At RIT01, median turbidity was 116 and 38 NTU, and at RIT03 it was 98 and 45 NTU. Prior to the fire, turbidity samples were usually below 4 NTU, with the exception of samples collected during periods of high streamflow. Turbidity was extremely high in August 2013 due to a large flood which had occurred three weeks earlier.

Dissolved oxygen measurements were near 100% saturation at all site visits in 2012–2013. Measurements ranged from 6.7 to 11.9 mg/L at RIT01, 6.2 to 10.3 mg/L at RIT02, and 6.6 to 11.9 mg/L at RIT03. All measurements were above the high quality coldwater criterion of 6 mg/L.

Stream discharge at RIT01 during the site visits ranged from 0.3 to 1.9 cfs. Discharge at RIT03 was usually slightly higher than RIT01 and ranged from 0.5 to 2.5 cfs. Discharge at RIT02 ranged from 0.8 to 1.7 cfs. None of the site visits occurred during a high flow event. A streamflow gage was installed at RIT01 by the USGS in July 2012, which recorded data intermittently from July 5, 2012 until October 17, 2013. These data are plotted below in Figure 2, along with stream turbidity. This gage documented several large flows on El Rito de los Frijoles, which normally maintained base flows of less than 1 cfs. In 2012, the maximum flow was 461 cfs which occurred on July 11 and was only several minutes in duration. Several smaller flow events occurred during July–September but these were less than 100 cfs. In 2013 the monsoon season was much more active, with three flow events over 1000 cfs: July 26 (4900 cfs), September 12 (2140 cfs) and September 13 (9500 cfs)(USGS 2016). Also shown in Figure 2 are turbidity results for samples collected at RIT01. Turbidity tended to be lower in the spring; was much higher during the monsoon seasons; and remained elevated for several months after.

Stream and air temperatures are logged at RIT01 at 15-minute intervals; daily minimum, maximum, and average temperatures from 2009–2013 are presented in Figure 3. Stream temperatures recorded during site visits are also shown, along with the water temperature criteria for high-quality coldwater streams. For air temperatures, numerous data points are omitted due to sun exposure of the instrument. This was particularly an issue after 2011, when floods removed sources of shade for the logger and resulted in temperatures that were too high. In these instances, only the daily minimum temperatures are plotted. Areas where the data are missing entirely were

Table 3. Summary of water quality core parameter data from RIT01, RIT02, and RIT03 on the Rito de los Frijoles in Bandelier NM, 2012–2013. The associated New Mexico water quality criteria are indicated for each parameter; a "nc" indicates that no water quality criteria exists for a parameter.

		2009–2011			2012			2013			
Core parameter	**Site**	# of measure-ments	Median	Range	# of measure-ments	Median	Range	# of measure-ments	Median	Range	N.M. state criteria
Water temperature (°C)	RIT01	21	9.1	0.2–21.8	7	10.8	1.3–23.1	5	16.7	0.0–19.7	Max. temp <23°, 4T3 = 20°[a]
	RIT02	18	8.1	1.6–17.6	7	14.6	3.3–22.4	5	15.5	5.7–23.3	
	RIT03	7	15.3	0.2–18.4	7	11.6	1.8–20.0	5	12.7	-0.3–22.5	
pH	RIT01	21	7.9	7.6–8.4	7	8.1	7.7–8.3	5	8.0	7.8–8.2	>6.6 and <8.8
	RIT02	18	8.0	7.7–8.2	7	8.1	8.1–8.5	5	8.1	8.1–8.2	
	RIT03	7	8.1	7.7–8.4	7	8.1	7.4–8.3	5	8.1	7.9–8.2	
Specific conductance (µS/cm)	RIT01	21	111	98–318	7	198	165–230	5	193	156–266	<300
	RIT02	18	109	94–302	7	148	130–204	5	139	113–227	
	RIT03	7	190	97–352	7	174	144–217	5	153	118–257	
Dissolved oxygen (mg/L)	RIT01	21	8.6	6.5–11.5	7	8.6	6.7–11.0	5	7.3	7.1–11.9	>6
	RIT02	18	8.8	7.1–10.5	7	7.7	6.5–10.3	5	7.8	6.2–9.3	
	RIT03	7	7.5	7.3–11.4	7	8.4	7.2–10.9	5	8.2	6.6–11.9	
Turbidity (NTU)	RIT01	21	3.4	1.8–370	7	116	17–490	5	38	2.1–4160	nc
	RIT02	17	2.7	1.4–250	7	7.9	2.4–300	5	3.4	2.6–1460	
	RIT03	7	88	1.8–241	6	98	5.3–590	5	45	2.4–920	
Discharge (cfs)	RIT01	21	0.7	0.0–9.9	7	0.6	0.3–1.9	5	1.0	0.3–1.7	nc
	RIT02	17	1.3	0.9–6.6	5	1.4	1.2–1.7	4	1.2	0.8–1.7	
	RIT03	4	0.8	0.3–1.2	6	0.9	0.7–2.5	5	0.7	0.5–1.2	

[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.

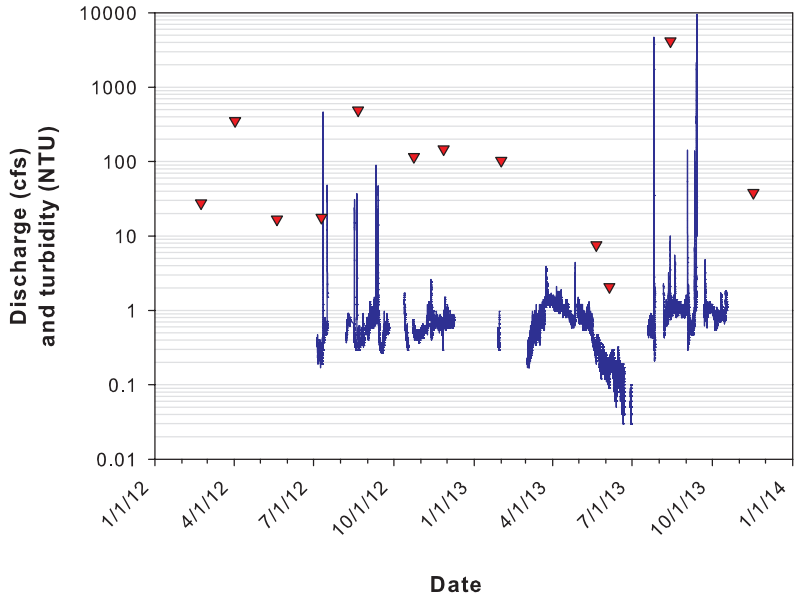


Figure 2. Streamflow for USGS gaging station 08313350 near RIT01 on the Rito de los Frijoles near the visitor center, Bandelier NM, 2012–2013 (USGS 2016). Turbidity is shown in red.

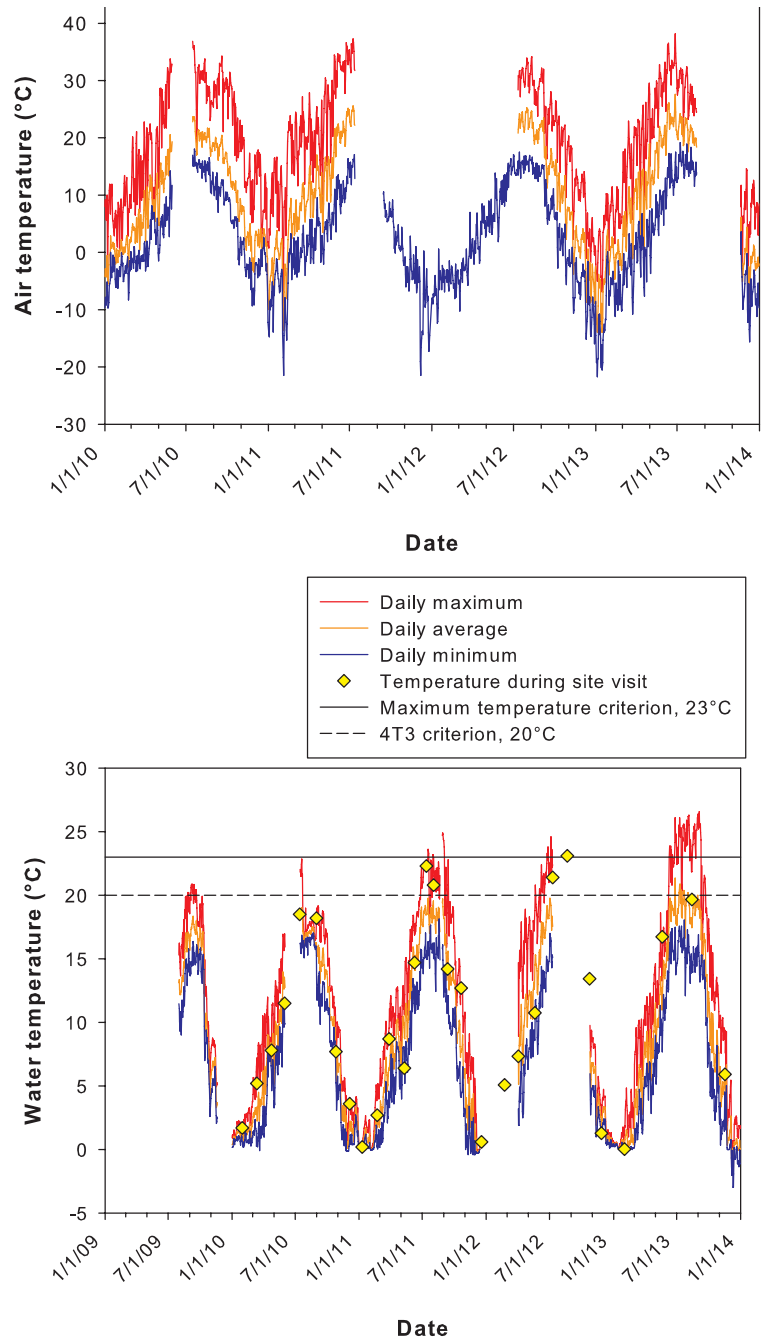


Figure 3. Stream temperature and air temperature data for RIT01 on the Rito de los Frijoles near the visitor center, Bandelier NM, 2009–2013. Water and air temperatures were recorded at 15-minute intervals by either a HOBO Tidbit or HOBO Pendant (Onset Computer Corporation). Data are missing in sections because data loggers were lost due to fire or floods.

a result of floods that washed away the trees which held the logger.

Water temperatures at RIT01 in 2012–2013 continued to exceed the water temperature criteria, which is a maximum of 23°C, not to be exceeded at any time, as well as the 4T3 criterion of 20°C, not to be exceeded for four or more consecutive hours on more than three consecutive days (NMED 2013). Only limited water temperature data are available for 2012. The 23°C criterion was exceeded on 5 days, though data are missing between 7/11/12 and 10/24/12. The maximum recorded temperature in 2012 was 24.6°C. In 2012, the 4T3 criterion was exceeded from 6/12–6/15 and 6/18–7/6/12. In 2013, water temperatures were recorded for the entire year. The 23°C criterion was exceeded on 74 days between early June and early September. The maximum recorded temperature that year was 26.3°C. In 2013, the 4T3 criterion was exceeded from 6/9–7/1, 7/3–7/14, 7/16–8/13, and 8/15–9/9—a total of 90 days.

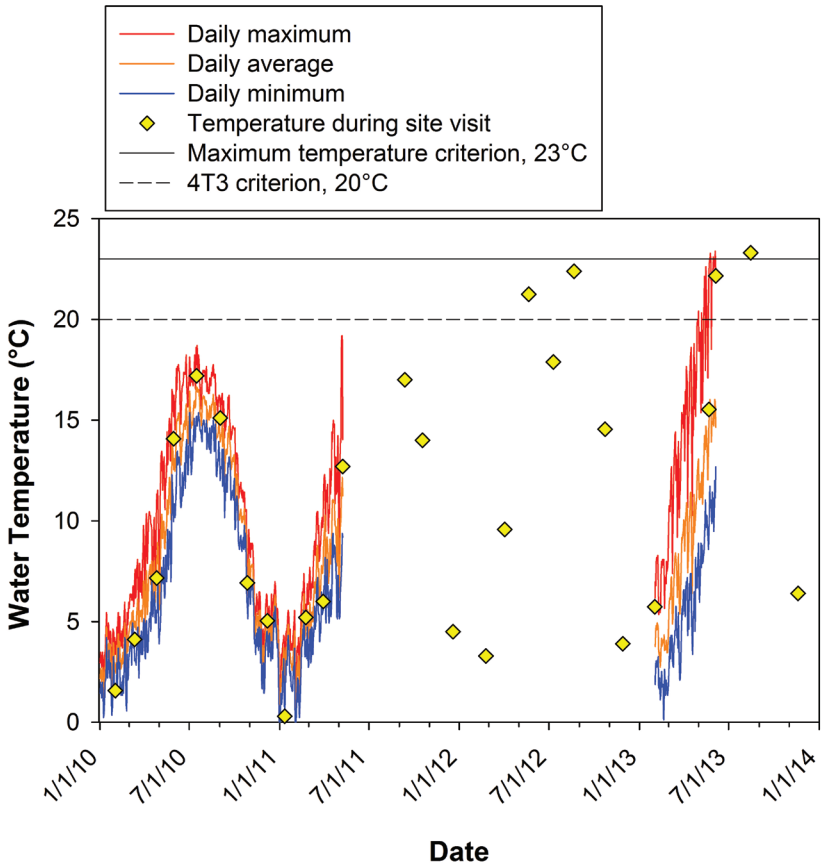


Figure 4. Daily maximum, average, and minimum temperatures for RIT02 on the Rito de los Frijoles, Bandelier NM, 2010–2013. Water temperatures were recorded at 15-minute intervals by a HOBO Pendant (Onset Computer Corporation). Water temperatures recorded by SCPN during site visits are included. Data are missing because data loggers were lost in floods.

Daily minimum, maximum, and average stream temperatures recorded at RIT02 from 2010–2013 are displayed in Figure 4, along with temperature criteria for high-quality coldwater streams and measurements collected by SCPN during site visits. Data for this site are very limited due to multiple losses of the loggers caused by the fire and several floods. For this reason, the only 15-minute logger data are from 2/1–6/5/13 and prior to 5/9/11. There are no logger data for 2012; the only post-fire temperature measurements were obtained during site visits. Although the 2013 data stops on June 5, the 23°C maximum was exceeded on four days, and one more exceedance was recorded at a site visit on 8/15 at 11:10. The 4T3 criterion was exceeded from 5/22–5/26 and from 5/30–6/4. Even with this limited data, stream temperatures recorded after the 2011 fire were higher than those recorded prior to the fire.

3.1.2 Precipitation

Data from the early warning system weather stations Ponderosa C.G. (#31507) and Dome Road (#31508) (OneRain 2015) are shown in Figures 5 and 6. The Ponderosa C.G. rain gage, located 2 km north from RIT02, started collecting data on June 29, 2012, and continued through 2013. Significant precipitation did not occur until July 23, 2012, when the gage recorded wet periods several days in length, followed by dry periods several days in length. This pattern continued through September. About 151 mm of rainfall fell during the monsoon months of July, August, and September, but over half of this (86 mm) fell in September. The total precipitation recorded from June–December 2012 was 210 cm.

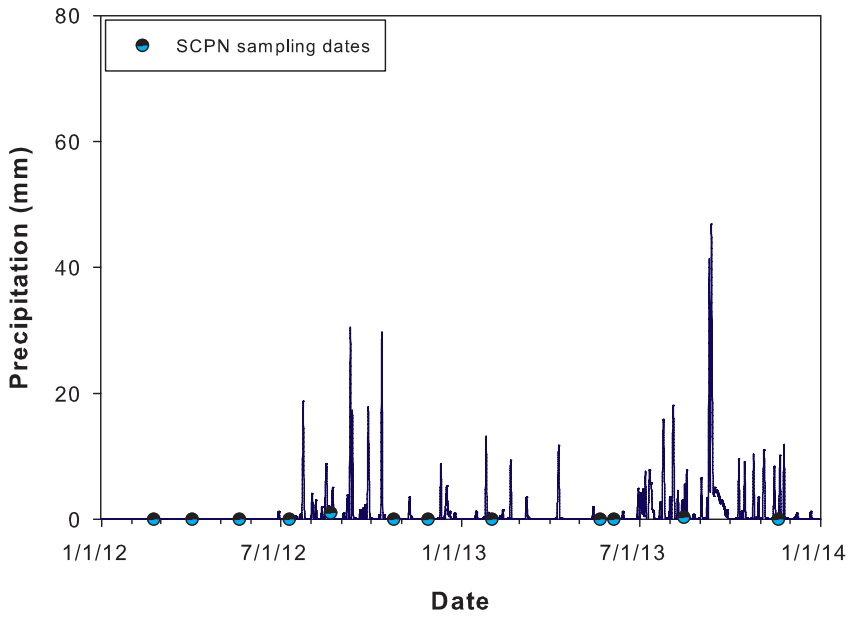


Figure 5. Daily precipitation from the rain gage (#31057) at Ponderosa C.G. in Bandelier NM, 2012–2013.

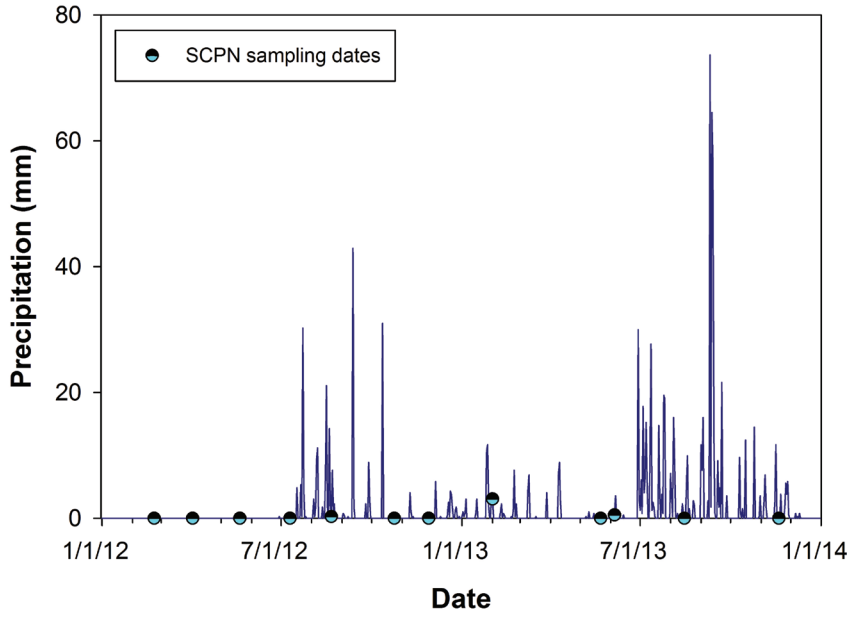


Figure 6. Daily precipitation from the Dome Road rain gage (#31058) in Bandelier NM, 2012–2013.

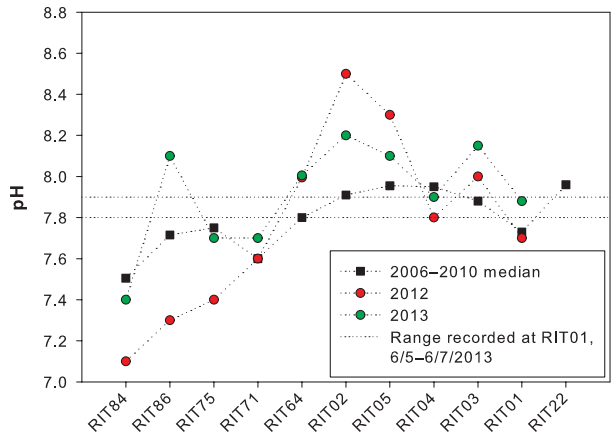
In 2013, a total of 456 mm of precipitation was recorded at the rain gage. The first six months of the year were fairly dry without any large storms. Two-thirds of the total precipitation for 2013 occurred during the months of July, August, and September, though September was a particularly wet month with 171 mm of rain.

The Dome Road rain gage is located approximately 7.7 km west of RIT02 near the Frijoles Canyon headwaters. The gage began recording data on June 29, 2012 and continued through 2013. Total precipitation recorded in the last half of 2012 was 249 mm; similar to the amount recorded by the gage at Ponderosa C.G. During the monsoon months of July, August, and September, 190 mm of rain fell. There was one larger rain event in October, but otherwise the end of 2012 was dry with several small precipitation events.

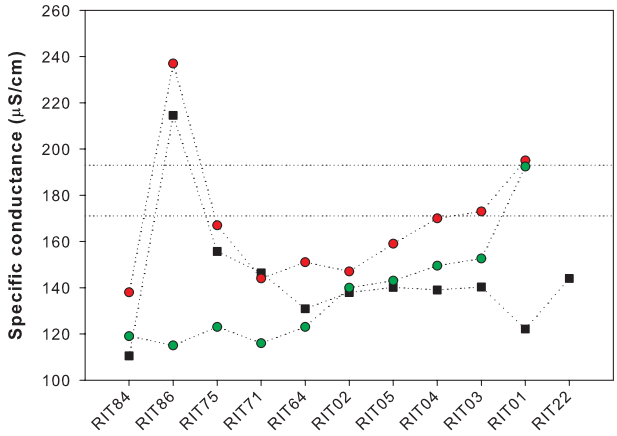
In 2013, the Dome Road gage recorded 737 mm of precipitation. As was the case with the Ponderosa Campground gage, two-thirds (512 mm) of the precipitation occurred during July, August, and September, with September alone receiving 288 mm of rain. Several more significant precipitation events occurred during October and November, followed by a very dry December. In contrast with the abundant monsoonal precipitation, the winter and spring months were dry and precipitation was infrequent except for the end of January.

3.1.3 Spatial variability of water quality core parameter data from El Rito de los Frijoles in BAND

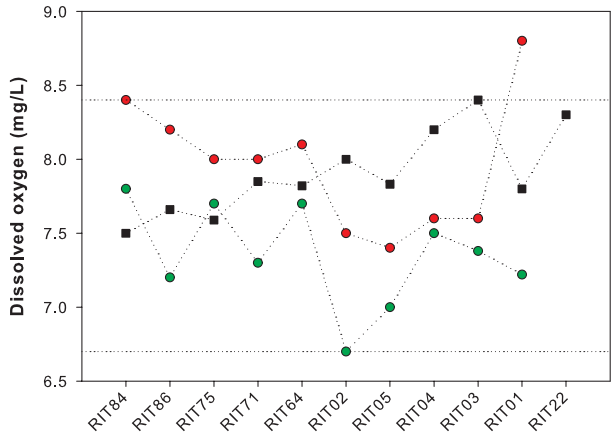
From 2006 to 2013, SCPN staff collected core water quality measurements at 11 locations on El Rito de los Frijoles, from the headwaters to below the Lower Falls



(a)



(b)



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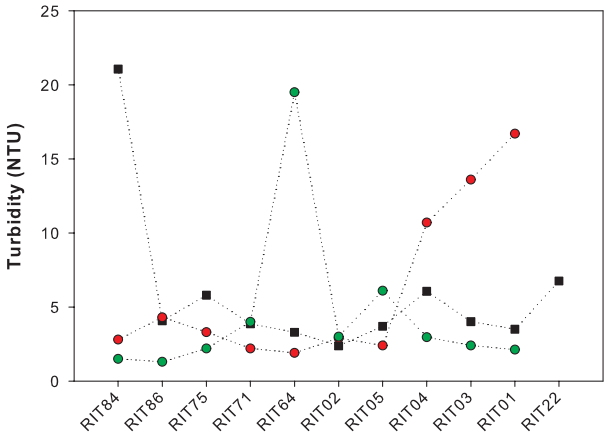
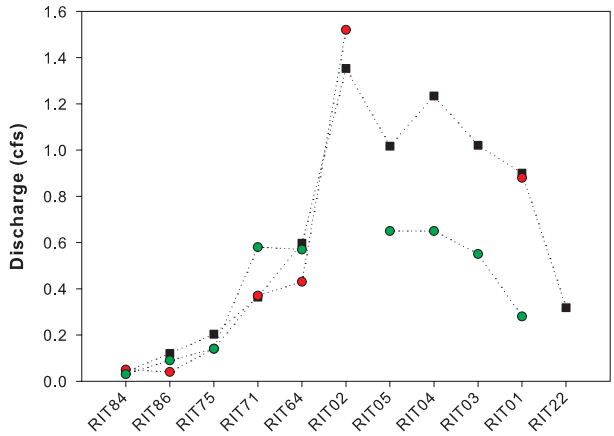


(d)



(e)

Figure 7. Spatial variability along the Rito de los Frijoles in Bandelier NM, 2012–2013. Values for core parameters measured during base flow conditions: (a) pH, (b) specific conductance, (c) dissolved oxygen, (d) turbidity, and (e) discharge. Median values measured from 2006–2010 are included for comparison.

near the Rio Grande, to assess the spatial variability of these parameters along the length of the stream. Values for all parameters measured during May 21–22, 2012 and June 5-6, 2013 are presented in Figure 7, along with median values for measurements taken from 2006–2010, which were taken during base flow conditions prior to the Las Conchas fire. In 2013, a multiparameter sonde recorded temperature, pH, specific conductance, and dissolved oxygen data at RIT01 from June 5–7. The ranges of these values are plotted in Figure 7 so that the upstream sites can be compared to RIT01. Sites are listed in order from upstream to downstream, except for RIT84 and RIT86 which represent two forks of El Rito de los Frijoles shortly before they converge just upstream of RIT75. The data used in Figure 7 are in Appendix G.

Values for pH ranged from 7.1–8.5 in 2012 and 2013. There was a slight upward trend from upstream to downstream in the pre-fire pH readings. This trend did not appear as clearly in the 2012 or 2013 data—in both years the pH readings increased from the headwaters until RIT02, then decreased from RIT02 until RIT01.

Specific conductance ranged from 115–237 μS/cm in 2012 and 2013. Prior to the fire, measurements did not appear to change at different locations in the canyon, except that the two forks of El Rito de los Frijoles were quite different from one another. After the fire, readings at RIT84 and RIT86 in 2012 were very different from one another, but were similar in 2013. As for the remaining sites, there appears to be an upward trend in the 2012–2013 specific conductance measurements from upstream to downstream which was not present before the fire.

Dissolved oxygen values ranged between 6.7 and 8.8 mg/L in 2012–2013. Values tended to increase from upstream to downstream in the 2006–2010 data, but this trend was not present in the recent dataset.

Turbidity was usually low across all the sites and the 2012 and 2013 measurements, which ranged from 1.3–19.5 NTU, were similar to the 2006–2010 medians, with a few exceptions.

Stream discharge in 2012–2013 continued a pattern similar to the 2006–2010 data, where discharge was lowest near the headwaters and increased until the middle of the canyon. However, due to flow meter malfunctions, our recent data are incomplete, particularly in 2013. In 2012, the discharge measurements were similar to the 2006–2010 medians until RIT64 (RIT02 was not measured this year), then decreased.

Median temperatures from 2006–2010 were between 8.6 and 13.2°C at all the sample sites, and varied little between the sites. The 2012 and 2013 temperatures were usually higher than the 2006–2010 medians, particularly at RIT02 where the median temperature was 10.3° before the fire and 21.7° and 22.3° after the fire. RIT02 was the only site where the measured temperatures exceeded 20°.

3.1.4 Total coliforms and E. coli

Bacteria data for samples collected by SCPN at RIT01, RIT02, and RIT03 in 2012–2013 are plotted in Figure 8; 2010 and 2011 data are included for comparison. Numeric results for 2012–2013 are presented in Appendices B–D. In 2012, seven bacteria samples were collected each from RIT01 and RIT02, and four were collected from RIT03. Four samples were collected at each of the sites in 2013. SCPN's data are expressed as a most probable number (MPN), a statistical estimate of the number of bacteria per 100 mL of stream water. Water quality criteria are expressed as colony forming units (cfu) per 100 mL and do not assume an estimation, but the two units are comparable. The *E. coli* criteria applicable at Bandelier are a monthly geometric mean of 126 cfu/100 mL or a single-sample maximum of 235 cfu/100 mL. We analyze our samples for total coliforms because theoretically they are indicators of the presence of all coliform groups of bacteria, both vegetative and fecal in origin. For drinking water, total coliforms are still the standard test because their presence indicates contamination of a water supply by an outside source. There are no water quality criteria for total coliforms.

Median total coliform levels at RIT01, RIT02, and RIT03 were 2000, 940, and 2200 MPN/100 mL, respectively. The two downstream sites, RIT01 and RIT03, were higher than RIT02, which is located 9.5 km upstream from RIT01.

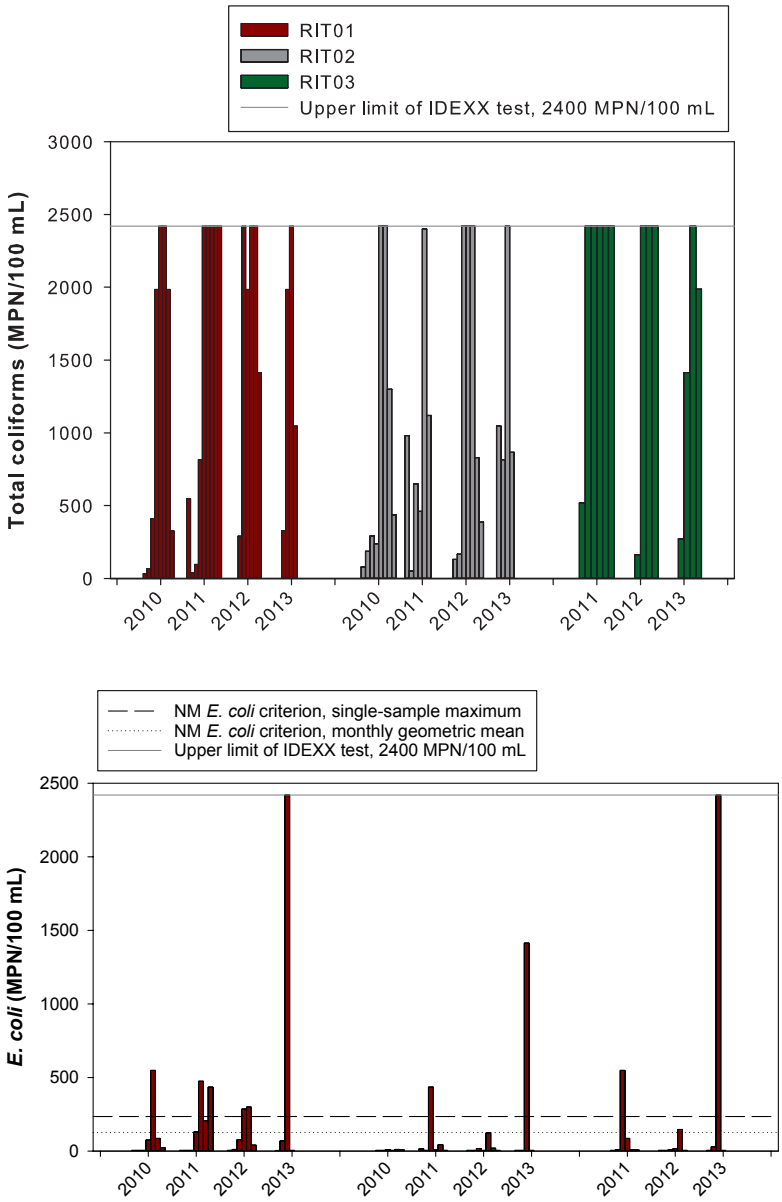


Figure 8. Total coliforms (top) and *E. coli* data (bottom) in samples collected from RIT01, RIT02, and RIT03 on the Rito de los Frijoles in Bandelier NM, 2010–2013.

Median results for *E. coli* were higher at RIT01 than the other two sites in 2012–2013. At RIT01, the median was 73 MPN/100 mL, while RIT02 was 1 MPN/100 mL and RIT03 was 8 MPN/100 mL. However, all three sites had at least one sample that exceeded the water quality criteria for *E. coli*. At RIT01, three samples exceeded the single-sample maximum of 235 cfu/100 mL; two of these samples were from 2012 (290 and 300 MPN/100 mL) and one was from 2013 (>2400 MPN/100 mL). All three samples were collected in July or August. One sample from RIT02 exceeded the water quality criteria; this sample was collected in August 2013 and was 1400 MPN/100 mL. One sample from RIT03 exceeded the water quality criteria and was also collected in August 2013. This sample result was 2400 MPN/100 mL. A second sample from August 2012 was 150 MPN/100 mL, which exceeded the chronic criterion of 126 cfu/100 mL.

3.1.5 Water quality laboratory data

Samples for nutrients, major elements, and trace metals were collected by SCPN at RIT01 and RIT02 and analyzed by the NWQL. Seven samples were collected at each site in 2012 and four were collected at each site in 2013; sample collection was spaced evenly throughout the year. Laboratory results for these samples are summarized in Tables 4-6. The lowest water quality standards are noted for each parameter for the designated uses applicable to streams in BAND: domestic water supply, primary contact, wildlife habitat, and high-quality coldwater aquatic life. Irrigation and livestock watering standards were not evaluated because these uses are not occurring at the streams in BAND. Complete results are presented in Appendices B–C.

Nutrient results are summarized in Table 4. Dissolved ammonia was only detected in one of the eleven samples from RIT01, but was detected in all but two samples from RIT02 (reporting level is 0.0100 mg/L). However, the ammonia levels at RIT02 were still very low, with a median concentration of 0.0117 mg/L. New Mexico chronic aquatic life criteria are based on the total ammonia concentrations so the results are not directly comparable; however all of the dissolved ammonia levels were far below the aquatic life criteria.

Nitrite concentrations were also very low at both sites, with median concentrations of 0.00143 mg/L at RIT01 and 0.00210 mg/L at RIT02. There are no water quality criteria for nitrite. Nitrite + nitrate concentrations were also low, with medians of 0.106 mg/L at RIT01 and 0.163 mg/L at RIT02. There are no water quality standards for

Table 4. Summary of nutrient data collected from RIT01 (n=11) and RIT02 (n=11) at on El Rito de los Frijoles in Bandelier NM, 2012–2013. There are no dissolved criteria for these analytes. Results that were lower than the NWQL reporting levels are noted as "<[reporting level]".

Nutrient (dissolved)	Site	Minimum (mg/L)	Maximum (mg/L)	Median (mg/L)	Standard deviation
Ammonia	RIT01	<0.0100	0.0104	-[a]	-
	RIT02	<0.0100	0.0489	0.0138	0.0117
Nitrite + nitrate as N	RIT01	<0.040	0.591	0.106	0.158
	RIT02	<0.040	0.806	0.163	0.212
Nitrite as N	RIT01	<0.00100	0.00621	0.00143	0.00170
	RIT02	<0.00100	0.0177	0.00210	0.00500
Orthophosphate as P	RIT01	0.0935	0.308	0.129	0.0645
	RIT02	0.104	0.256	0.129	0.0491

[a] Missing values were not calculated because >70% of results were below the laboratory reporting level.

Table 5. Summary of major element data, acid neutralizing capacity and total dissolved solids in samples collected at RIT01 (n=11) and RIT02 (n=11) on the Rito de los Frijoles in Bandelier NM, 2012–2013. There are no New Mexico water quality criteria for these analytes.

Major element (dissolved)	Site	Minimum (mg/L)	Maximum (mg/L)	Median (mg/L)	Standard deviation
Calcium	RIT01	15.6	26.7	21.2	4.02
	RIT02	11.2	25.2	14.7	3.75
Chloride	RIT01	2.59	8.12	3.39	1.53
	RIT02	2.03	5.08	2.62	0.914
Fluoride	RIT01	0.189	0.294	0.217	0.0429
	RIT02	0.159	0.225	0.177	0.0249
Magnesium	RIT01	4.79	7.42	5.97	0.771
	RIT02	3.18	5.71	4.13	0.706
Potassium	RIT01	2.69	7.67	3.57	1.81
	RIT02	2.26	6.81	3.18	1.27
Silica	RIT01	25.9	60.7	53.8	9.85
	RIT02	32.3	60.4	56.4	9.31
Sodium	RIT01	12.4	19.2	14.0	1.96
	RIT02	7.46	12.3	11.3	1.38
Sulfate	RIT01	1.70	5.75	2.62	1.40
	RIT02	1.56	6.08	2.18	1.31
Acid neutralizing capacity, as $CaCO_3$ (unfiltered)	RIT01	75.2	136	105	19.3
	RIT02	60.4	115	74.0	15.2
Total dissolved solids	RIT01	144	218	175	22.3
	RIT02	101	181	149	26.3

nitrite + nitrate in BAND.

Orthophosphate was detected in all samples at RIT01 and RIT02 and ranged from 0.0935–0.308 mg/L at RIT01 and 0.104–0.256 mg/L at RIT02. This is a continued departure from the twelve samples collected at each site prior to the 2011 Las Conchas fire, when orthophosphate concentrations never exceeded 0.100 mg/L, and were usually less than half that concentration. In 2012–2013, median concentrations were 0.129 mg/L at RIT01 and RIT02. There are no water quality standards for orthophosphate in New Mexico.

Major elements, acid neutralizing capacity, and total dissolved solids results for samples collected at RIT01 and RIT02 in 2012–2013 are summarized in Table 5. There are no New Mexico water quality standards for these analytes. The relative concentrations of eight major ions from both sites are plotted in Figure 9. The dominant cation was calcium, then sodium plus potassium, and finally magnesium. The dominant anions were almost entirely carbonate/bicarbonate. The proportions of anions and cations did not differ by much between sites or between site visits.

Trace metal results from RIT01 and RIT02 in 2012–2013 are summarized in Table 6, along with the lowest applicable water quality standards. In cases where the water quality criteria are dependent on water hardness, they are expressed as a range

of values. None of the metals concentrations were high enough to exceed the water quality criteria. Aluminum, iron, and manganese had the highest concentrations; they also tended to vary between samples. The highest aluminum concentrations occurred during the monsoon season at both sites. This pattern was not observed with iron or manganese. Several metals were either not detected or only detected in one or two samples; these included beryllium, cadmium, chromium, mercury, silver, and zinc.

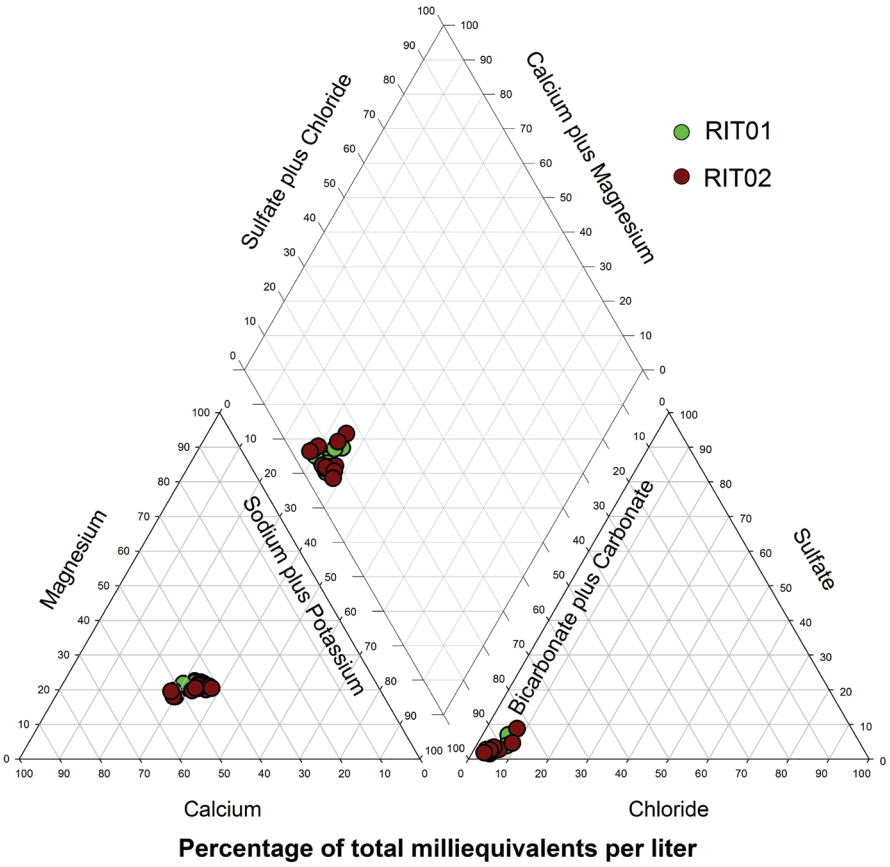


Figure 9. Major ion composition from samples collected at RIT01 and RIT02 on the Rito de los Frijoles in Bandelier NM, 2012–2013.

Table 6. Summary of trace metal data collected from RIT01 (n=11) and RIT02 (n=11) on the Rito de los Frijoles in Bandelier N.M., 2012–2013. 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 designated uses evaluated in this report. "ndc" = no dissolved criteria. Results that were lower than the NWQL reporting levels are noted as "<[reporting level]".

Trace metal (µg/L)	Site	Minimum	Maximum	Median[a]	Standard deviation[a]	Most stringent criteria (µ/L)	# of exceed-ances	Beneficial use[b]
Aluminum	RIT01	22.6	461	83.0	134	661–1246, chronic	0	Aquatic life
	RIT02	9.74	271	53.6	88.1	416–1380, chronic	0	Aquatic life
Antimony	RIT01	<0.0619	0.335	0.0858	0.0833	6	0	DWS
	RIT02	0.0488	0.154	0.0627	0.0362	6	0	DWS
Arsenic	RIT01	1.04	2.97	1.42	0.689	9	0	HH-OO
	RIT02	0.902	2.55	1.15	0.476	9	0	HH-OO
Barium	RIT01	16.7	62.4	26.2	13.9	2000	0	DWS
	RIT02	13.9	69.7	21.8	15.7	2000	0	DWS
Beryllium	RIT01	<0.040	0.136	-	-	4	0	DWS
	RIT02	<0.040	0.0776	-	-	4	0	DWS
Boron	RIT01	11.7	25.7	15.7	4.51	nc	nc	nc
	RIT02	10.0	19.9	12.1	2.83	nc	nc	nc

Table 6. (*continued*) Summary of trace metal data collected from RIT01 (n=11) and RIT02 (n=11) on the Rito de los Frijoles in Bandelier NM, 2012–2013. 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 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	Site	Minimum (μg/L)	Maximum (μg/L)	Median[a] (μg/L)	Standard deviation[a]	Most stringent criteria	# of exceed-ances	Designated use[b]
Cadmium	RIT01	<0.060	0.239	-	-	0.22–0.39, chronic	0	Aquatic life
	RIT02	<0.060	<0.060	-	-	0.22–0.37, chronic	0	Aquatic life
Chromium	RIT01	<0.600	<0.600	-	-	11, Cr(VI); 37–70, Cr(III), chronic	0	Aquatic life
	RIT02	<0.600	<0.600	-	-	11, Cr(VI); 36–66, Cr(III), chronic	0	Aquatic life
Cobalt	RIT01	0.207	1.70	0.501	0.442	nc	nc	nc
	RIT02	0.113	1.58	0.354	0.444	nc	nc	nc
Copper	RIT01	<0.800	2.68	1.00	0.758	4.3–8.4, chronic	0	Aquatic life
	RIT02	<0.800	2.1	-	-	4.3–7.9, chronic	0	Aquatic life
Iron	RIT01	85.5	379	163	80.3	nc	nc	nc
	RIT02	108	264	157	46.5	nc	nc	nc
Lead	RIT01	0.0305	0.992	0.297	0.309	1.0–2.3, chronic	0	Aquatic life
	RIT02	<0.080	0.855	0.389	0.256	1.0–2.2, chronic	0	Aquatic life
Manganese	RIT01	21.8	1100	145	310	1236–1612, chronic	0	Aquatic life
	RIT02	39.7	567	99.3	177	1235–1572, chronic	0	Aquatic life
Mercury	RIT01	<0.005	<0.005	-	-	0.77, chronic	0	Aquatic life
	RIT02	<0.005	<0.005	-	-	0.77, chronic	0	Aquatic life
Molybdenum	RIT01	2.07	73.0	3.38	21.0	ndc	ndc	ndc
	RIT02	1.54	5.67	2.12	1.19	ndc	ndc	ndc
Nickel	RIT01	0.425	1.94	0.801	0.453	25–49, chronic	0	Aquatic life
	RIT02	<0.400	2.78	-	-	25–46, chronic	0	Aquatic life
Selenium	RIT01	<0.100	0.378	0.117	0.0947	5	0	DWS
	RIT02	0.119	1.34	0.143	0.360	5	0	DWS
Silver	RIT01	<0.040	<0.040	-	-	0.7–2.9, acute	0	Aquatic life
	RIT02	<0.040	<0.040	-	-	0.7–2.5, acute	0	Aquatic life
Uranium	RIT01	0.133	3.25	0.324	0.932	30	0	DWS
	RIT02	0.147	3.45	0.257	0.964	30	0	DWS
Vanadium	RIT01	1.21	4.27	2.35	0.969	nc	nc	nc
	RIT02	0.829	4.61	3.17	1.06	nc	nc	nc
Zinc	RIT01	<4.00	<4.00	-	-	55–114, chronic	0	Aquatic life
	RIT02	<4.00	<4.00	-	-	55–106, chronic	0	Aquatic life

[a] Values that are not reported were not calculated because >70% of results were below the laboratory reporting level.

[b] 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)

3.1.6 Contaminants of emerging concern

During 2012–2013, SCPN staff collected samples from the Rito de los Frijoles and sent them to the EPA Region 8 Laboratory to be analyzed for approximately 250 contaminants of emerging concern (Appendix H). The contaminants are grouped into three categories: pesticides, pharmaceuticals and personal care products, and waste indicators. The sample sites included RIT01, which is located downstream from most park facilities, and RIT03, which is located upstream from the park facilities and upstream from where most of the visitor usage takes place. Six samples for pesticides, pharmaceuticals, and personal care products were collected each at RIT01 and RIT03 during 2012–2013. Five waste indicator samples were collected at RIT01 during this time and three were collected at RIT03.

Table 7 summarizes the six contaminants which were detected in El Rito de los Frijoles; the complete results with concentrations are in Appendices B and D. Pesticides were not detected in any of the samples. Three contaminants, caffeine, Tri(2-butoxyethyl) Phosphate, and *p*-cresol, were detected at both sites, and three were detected only at RIT01. Caffeine was the only compound that was detected twice at both sites; one sample from RIT01 contained caffeine, acetaminophen, and the two related compounds theobromine and theophylline. There are no water quality standards for the contaminants listed in Table 7.

Table 7. Summary of contaminants of emerging concern detected in samples collected at RIT01 (n=3) and RIT03 (n=6) on the Rito de los Frijoles in Bandelier NM, 2012–2013.

		No. of detections	
Contaminant	**Use**	**RIT01**	**RIT03**
Pesticides		0	0
Pharmaceuticals and personal care products			
Caffeine	Stimulant drug	2	2
Acetaminophen	Pain reliever / fever reducer	1	0
Theobromine	Found in cocoa beans and tea; similar to caffeine	1	0
Theophylline	Found in cocoa beans; used for respiratory diseases	1	0
Waste indicators			
Tri(2-butoxyethyl) Phosphate	Flame retardant, plasticizer, used in floor polishes	1	1
p-Cresol	Solvent, disinfectant, and chemical intermediate	1	1

3.1.7 Radionuclides

Samples for radionuclides in stream water and in streambed sediment were collected at RIT01 and RIT02 on May 20 and 21, 2012. Unfiltered water samples were collected and analyzed for gross alpha, gross beta, isotopic uranium, radium 226/228, and gamma emitters. The gross alpha and beta samples were analyzed twice: once within 72 hours of collection, and again 30 days after collection. The complete results are in Appendices B and C.

For the stream water samples, only gross alpha and Radium 226/228 have water quality standards. The standards are 15 pCi/L for gross alpha and 5 pCi/L for Ra 226+228; these are drinking water standards (NMED 2013). The water results were well below these criteria: the gross alpha results were 2.08 pCi/L (72 hour) and 1.97 pCi/L (30 day) at RIT01, and 0.427 pCi/L (72 hour) and 0.414 pCi/L (30 day) at RIT02. The gross beta results were 4.56 pCi/L (72 hour) and 4.78 pCi/L (30 day) at RIT01. Gross beta results at RIT02 were 3.24 (72 hour) and 3.50 pCi/L (30 day). Several types of uranium isotopes were present but in small quantities. The uranium isotopes are alpha emitters, but results were low and indicate that uranium is not a large contributor to the gross alpha in samples from these sites. Radium 226, which is also an alpha emitter, was detected at RIT01 at 0.010 pCi/L, but was not detected at RIT02. Radium 228, which is a beta emitter, was detected at RIT01 at 0.281 pCi/L, but was not detected at RIT02. The radium 226+228 results did not exceed the water quality criteria.

For streambed sediment samples, gross alpha results at RIT01 were 10.6 pCi/g (72 hour) and 9.53 pCi/g (30 day). At RIT02, gross alpha was 17.3 pCi/g (72 hour) and 14.3 pCi/g (30 day). Gross beta results at RIT01 were 24.5

pCi/g (72 hour) and 25.3 pCi/g (30 day). At RIT02, gross beta results were 27.1 pCi/g (72 hour) and 25.5 pCi/g (30 day). Uranium isotopes represented a small portion of the alpha radioactivity present in both sediment samples. Radium 226 was 0.823 pCi/g at RIT01 and 0.974 pCi/g at RIT02. Radium 228 was 0.978 pCi/g at RIT01 and 1.37 pCi/g at RIT02, representing a small portion of the gross beta radioactivity at both sites. Gamma emitters at both sites were primarily in the form of potassium-40, a naturally occurring radioisotope, with much smaller amounts of bismuth, lead, and thorium.

3.2 Capulin Creek

3.2.1 Water quality core parameter data

A summary of NPS core parameter results from site visits completed in 2012–2013 at CAP01 is presented in Table 8. Data collected from 2008–2011 are also summarized for comparison. CAP02 was only visited in autumn during aquatic macroinvertebrate sampling, which occurred once per year from 2008–2012 (Table 8) and did not occur in 2013. CAP01 is normally visited multiple times per year except during winter months when access is not possible. Because of this, SCPN site visits occurred between May and November in 2012–2013. The complete results for CAP01 are in Appendix E.

Four visits to CAP01 were completed in 2012 and three were completed in 2013. Water temperature measurements ranged from 7.8–23.4°C, and two of these exceeded the maximum stream temperature criterion of 23°C. These measurements were collected on August 20, 2012 at 1200 hours and August 14, 2013 at 1130 hours. These high temperatures were not observed in Capulin Creek prior to the Las Conchas fire.

All other core parameter measurements at CAP01 were within the water quality criteria applicable to streams in BAND. Specific conductance was elevated when compared to pre-fire levels. Measurements ranged from 172–257 µS/cm and were similar in 2012 and 2013, with medians of 213 µS/cm in 2012 and 218 µS/cm in 2013. Measurements were below the 300 µS/cm water quality criterion. pH ranged did not vary much between any of the site visits and ranged from 8.0–8.3. All measurements were within the water quality criteria of 6.6–8.8. Despite the higher water temperatures, dissolved oxygen was always above the 6.0 mg/L criterion; measurements ranged from 6.5–9.3 mg/L.

Turbidity at CAP01 varied greatly between site visits, depending on when the last precipitation occurred. It ranged from 9.6–1550 NTU in 2012 and 5.8–770 in 2013. The 1550 and 770 NTU measurements occurred in August 2012 and August 2013. Discharge was low during all site visits and ranged from 0.3–0.7 cfs.

Water quality core parameter data collected at CAP02 are also in Table 8. The measurements displayed represent measurements collected at approximately 12:00 during October macroinvertebrate sample events from 2008–2012. None of the measurements exceeded the water quality criteria.

Daily minimum, maximum, and average stream temperatures recorded by temperature loggers at CAP01 from 2010–2013 are displayed in Figure 10, along with temperature criteria for high-quality coldwater streams and measurements collected by SCPN during site visits. The temperature standards applicable to Capulin Creek are a maximum temperature of 23°C, meaning the stream temperature is not to exceed 23°C at any time, and a 4T3 criterion of 20°C, , which is the temperature that the stream cannot exceed for more than four consecutive hours on more than three consecutive days (NMED 2013). As with RIT02, temperature data for this site are very limited due to multiple data losses caused by the fire and several floods which dislodged the logger from the stream. Even with the limited dataset, it is clear that stream temperatures have been much higher than before the Las Conchas fire. In 2012, data are available until 6/7, from 8/20–8/26, and from 10/27-12/4. Despite the limited dataset, the 23°C maximum temperature was exceeded on 22 days during 2012. The maximum recorded stream temperature was 28.5°C. In 2012, the 4T3 criterion was exceeded from 5/21–5/26, 5/28–6/3, and 8/20–8/25. In 2013, data are only available for 5/21–6/5. During this time, the water temperature exceeded 23° on fourteen of these sixteen days, and the maximum recorded temperature was 26.1°C. This criterion was also exceeded during a site visit on 8/14. The 4T3 criterion was exceeded on thirteen of these days.

Table 8. Summary of water quality core parameter data from CAP01 and CAP02 on Capulin Creek in Bandelier NM, 2008–2013. The associated New Mexico water quality criteria are indicated for each parameter; "nc" indicates that no criteria exist for a specific parameter. "nd" indicates that data was not collected in 2013.

		2008–2011			2012			2013			
Core parameter	**Site**	# of measure-ments	Median	Range	# of measure-ments	Median	Range	# of measure-ments	Median	Range	**N.M. state criteria**
Water temperature (°C)	CAP01	17	12.0	0.1–23.6	4	17.6	7.8–23.2	3	19.1	9.1–23.4	Max. temp <23°, 4T3 = 20°[a]
	CAP02	4	11.5	9.7–18.9	1	17.2	-	nd	nd	nd	
pH	CAP01	17	8.0	7.8–8.3	4	8.2	8.1–8.3	3	8.2	8.1–8.3	>6.6 and <8.8
	CAP02	4	7.8	7.7–8.3	1	8.6	-	nd	nd	nd	
Specific conductance (µS/cm)	CAP01	17	139	107–398	4	213	172–249	3	218	183–257	<300
	CAP02	4	169	157–314	1	214	-	nd	nd	nd	
Dissolved oxygen (mg/L)	CAP01	16	8.0	6.5–11.3	4	7.4	6.5–9.3	3	7.3	6.6–9.0	>6
	CAP02	4	8.3	7.5–10.6	1	7.5	-	nd	nd	nd	
Turbidity (NTU)	CAP01	17	2.7	0.51–300	4	30	9.6–1550	3	9.1	5.8–770	nc
	CAP02	4	2.6	1.6–79	1	210	-	nd	nd	nd	
Discharge (cfs)	CAP01	15	0.4	0.1–12.0	4	0.4	0.3–0.5	3	0.5	0.4–0.7	nc
	CAP02	4	0.3	0.1–0.4	1	0.4	-	nd	nd	nd	

[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.

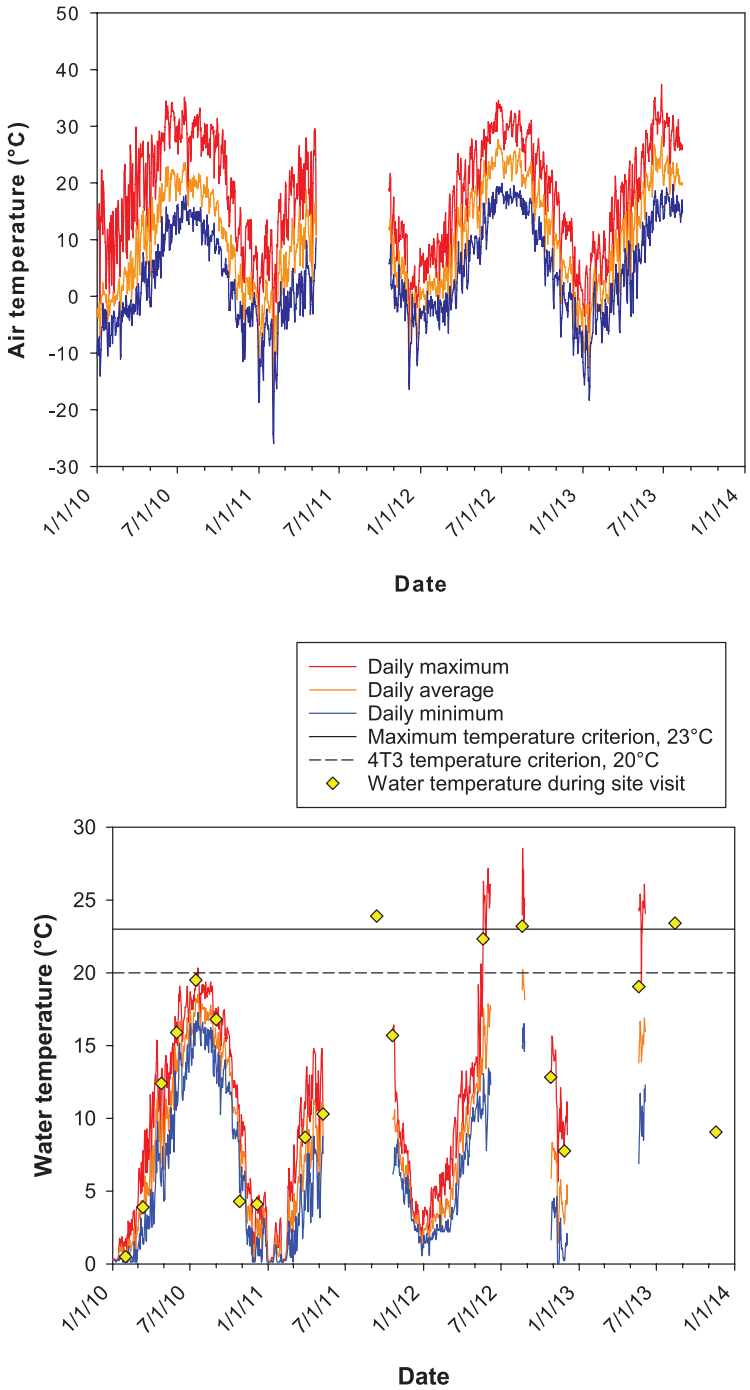


Figure 10. Daily maximum, average, and minimum air temperatures (top) and water temperatures (bottom) recorded at 15-minute intervals by HOBO Pendants (Onset Computer Corporation) at CAP01 on Capulin Creek in Bandelier NM, 2010–2013. Water temperatures recorded during SCPN site visits are also shown. There are several periods of missing data due to flooding.

3.2.2 Precipitation

Daily precipitation data for 2012–2013 from the early warning system rain gage Headwaters of Cochiti and Capulin Canyon (#31045), located 8.5 km northwest from CAP01, are shown in Figure 11 (OneRain 2015). In 2012, a total of 272 mm of precipitation fell, while over half of this precipitation occurred during the monsoon season, from July through September. The months of January–April and October–December only experienced several very small precipitation events with long dry periods in between, except for one day in October when 24 mm of precipitation was recorded.

The precipitation received in 2013 was 587 mm, over twice the amount recorded in 2012. Half this amount (271 mm) was recorded in September, when large amounts of rain fell over a long duration in the middle of the month. As in 2012, the precipitation regime in the beginning of 2013 was characterized by several small precipitation events, with long dry periods in between. Most of the precipitation for the year (455 mm, 77%) fell during the monsoon months of July, August, and September.

3.2.3 Total coliforms and E. coli

Total coliforms and *E. coli* results from CAP01 are displayed in Figure 12, with 2010–2011 results for comparison. Total coliforms in the 2012–2013 samples ranged from 1600 to >2400 MPN/100 mL, with a median of 2000 MPN/100 mL. *E. coli* ranged from <1 to 2400 MPN/100 mL, with a median of 5 MPN/100 mL. One sample collected on 8/14/13 was 2400 MPN/100 mL, which exceeded the single sample maximum criterion of 235 cfu/100 mL. The stream was very turbid that day due to recent high flows from monsoon thunderstorms. Another sample from 8/20/12 was 210 MPN/100 mL, which is above the chronic criterion of 126 cfu/100 mL; however, more samples would be needed to confirm an exceedance of that criterion. These two results are the only summertime bacteria samples collected after the Las Conchas Fire.

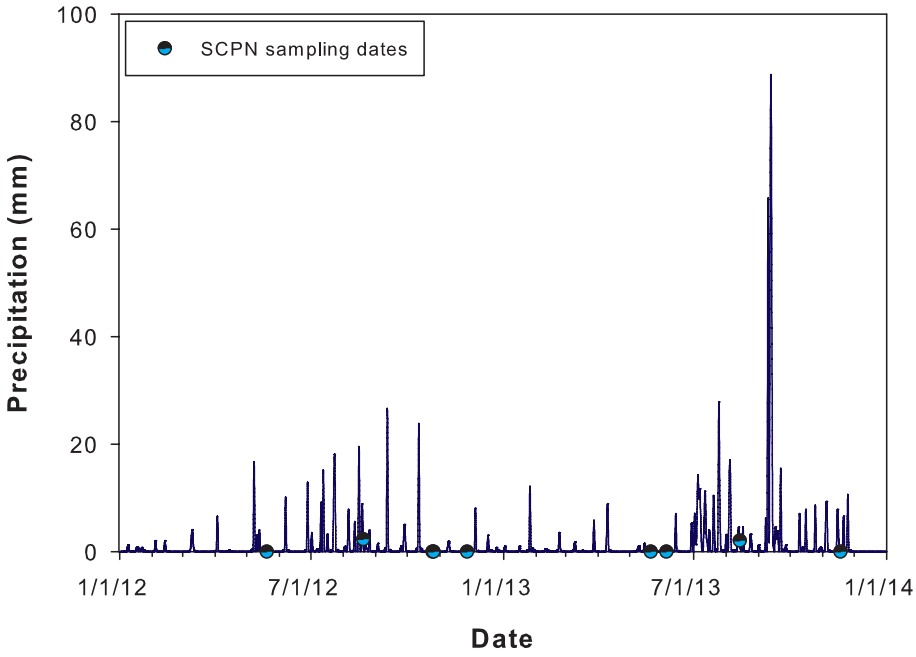


Figure 11. Daily precipitation from the rain gage (#31045) at the headwaters of Cochiti Canyon and Capulin Canyons in Bandelier NM, 2012–2013, with dates of SCPN water quality sampling visits.

3.2.4 Water quality laboratory data

Seven water samples were collected by SCPN at CAP01 and sent to the NWQL for analysis of nutrients, major elements, and trace metals. Four of these samples were collected in 2012 and three were collected in 2013. The results are summarized in Tables 9–11, along with the lowest applicable water quality standard for each parameter. Complete results are in Appendix E. None of the results exceeded state of New Mexico acute or chronic water quality standards for aquatic life.

Nutrient results are summarized in Table 9. Ammonia, nitrite+nitrate, and nitrite were present in most samples but at low concentrations. Orthophosphate was present in all samples at higher levels than those detected prior to the Las Conchas fire, and ranged from 0.178–0.454 mg/L.

Major element results for CAP01 in 2012–2013 are displayed in Table 10. Major ion composition is plotted in Figure 13, showing that anion composition is primarily bicarbonate/carbonate and that cation composition is mostly calcium, followed by sodium plus potassium, then magnesium. Ion composition did not vary much between samples.

Silica concentrations ranged from 35.9–63.5 mg/L. Acid neutralizing capacity ranged from 86.2–136 mg/L, while total dissolved solids ranged from 147–219 mg/L. The higher results for acid neutralizing capacity and total dissolved solids occurred in the August samples.

Results of trace metal analyses at CAP01 in 2012–2013 are summarized in Table 11. Of the 21 metals sampled, six were not present above the laboratory reporting levels: beryllium, cadmium, chromium, mercury, silver, and zinc. The metals which were detected in the samples did not exceed the water quality criteria applicable to Capulin

Table 9. Results of nutrient analyses of samples collected at CAP01 on Capulin Creek in Bandelier NM, 2012–2013 (n=7). The minimum, maximum and median values in mg/L are reported. There are no New Mexico state aquatic life criteria for these analytes. Results that were lower than the NWQL reporting levels are noted as "<[reporting level]".

Nutrient	Minimum	Maximum	Median	Standard deviation
Ammonia as N	<0.0100	0.0255	0.0111	0.0066
Nitrite + nitrate as N	<0.040	0.705	0.198	0.2119
Nitrite as N	<0.00100	0.0156	0.0018	0.0053
Orthophosphate as P	0.178	0.454	0.231	0.104

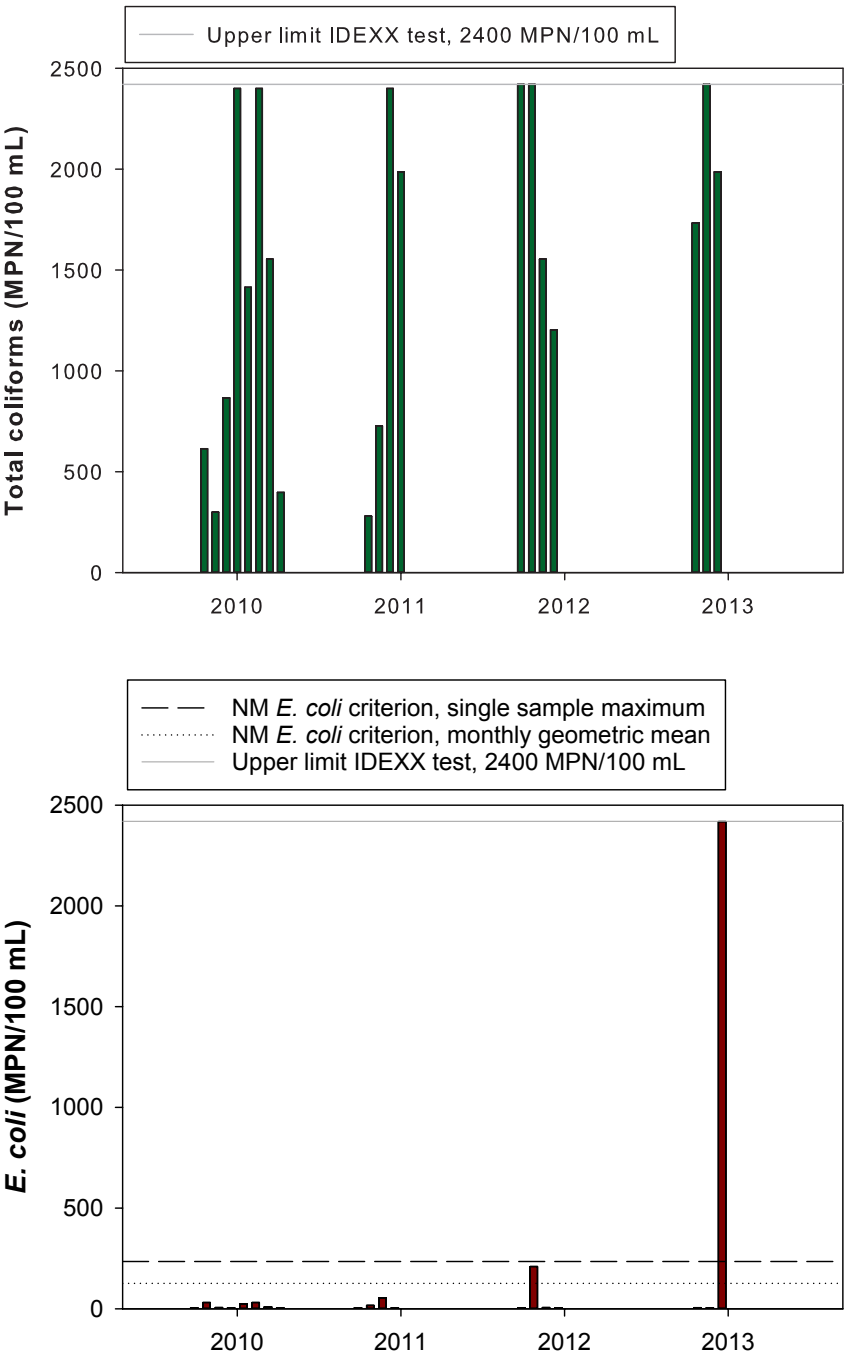


Figure 12. Total coliforms (top) and *E. coli* data (bottom) in samples collected from CAP01 on Capulin Creek in Bandelier NM, 2010–2013.

Creek. As was the case with El Rito de los Frijoles, aluminum and manganese concentrations varied between site visits. This was especially the case with aluminum, which ranged from 5.53–187µg/L. The two highest results occurred with the August samples.

3.2.5 Radionuclides

Radionuclide results for unfiltered stream water and streambed sediment samples collected at CAP01 on May 20, 2012 are in Appendix E. For the stream samples, the gross alpha results were well below the 15 pCi/L drinking water criterion (NMED 2013). Gross alpha results were 2.65 pCi/L after 72 hours and 1.47 pCi/L after 30 days from the collection date. Gross beta results were 5.37 pCi/L after 72 hours and 5.67 after 30 days. Uranium, an emitter of alpha radiation, was present in very small quantities. U-238 was 0.093 pCi/L and U-233/234 was 0.085 pCi/L. U-235 was not detected. Radium 226, an alpha emitter, was not detected while Radium-228, a beta emitter, was detected at 0.336 pCi/L. The radium results were well below the drinking water criterion of 5 pCi/L for Ra 226+228.

For the streambed sediment samples, gross alpha was 7.86 pCi/g after 72 hours and 8.61 pCi/g after 30 days. Gross beta results were 23.1 pCi/g after 72 hours and 22.4 pCi/g after 30 days. Uranium was detected in small quantities in the samples; results for U-238 were 0.332 pCi/g, U-235 was 0.0230 pCi/g, and U-233/234 was 0.383 pCi/g. Radium was present in small quantities as well; Ra-226 was 0.508 pCi/g and Ra-228 was 0.681 pCi/g. A scan for gamma emitters was also performed, the most prevalent being K-40 at 21.2 pCi/g. Low levels of isotopes of bismuth, lead, and thorium were found as well. Complete results are in Appendix E.

Table 10. Results of major element analyses from samples collected at CAP01 on Capulin Creek in Bandelier NM, 2012-2013 (n=7). The minimum, maximum and median values in mg/L are reported. There are no New Mexico state aquatic life criteria for these analytes.

Major element	Minimum	Maximum	Median	Standard deviation
Calcium	17.9	29.4	24.6	4.46
Chloride	2.55	3.30	2.76	0.254
Fluoride	0.210	0.307	0.272	0.0406
Magnesium	4.64	6.87	6.19	0.857
Potassium	3.00	7.50	4.55	1.80
Silica	35.9	63.5	53.6	11.4
Sodium	11.4	13.9	12.1	0.828
Sulfate	2.84	9.03	3.38	2.17
Acid neutralizing capacity, as $CaCO_3$ (unfiltered)	86.2	136	101	19.9
Total dissolved solids	147	219	178	26.0

Table 11. Results of trace metal analyses from samples collected at CAP01 on Capulin Creek in Bandelier NM, 2012-2013 (n=7) and number of times that the samples exceeded the New Mexico state aquatic life criteria. "nc" indicates that no criteria exists for a particular nutrient. All trace metals are dissolved. Results that were lower than the NWQL reporting levels are noted as "<[reporting level]".

Trace metal, µg/L, dissolved	Minimum	Maximum	Median[a]	Standard deviation[a]	Most stringent criteria	# of exceedances	Designated use[b]
Aluminum	5.53	187	24.9	71.1	741–1380	0	Aquatic life
Antimony	0.049	0.190	0.0685	0.0501	6	0	DWS
Arsenic	1.86	4.33	2.71	0.910	9	0	HH-OO
Barium	49.2	70.0	60.8	7.88	2000	0	DWS
Beryllium	<0.040	<0.040	-	-	4	0	DWS
Boron	11.9	22.4	14.3	4.47	nc	nc	nc
Cadmium	<0.060	<0.060	-	-	0.30–0.41, chronic	0	Aquatic life
Chromium	<0.600	0.397	-	-	11, Cr(VI) 44–51, Cr(III), chronic	0	Aquatic life
Cobalt	0.140	1.88	0.308	0.741	nc	nc	nc
Copper	<0.800	5.29	1.56	1.65	6.1–9.0, chronic	0	Aquatic life
Iron	23.3	145	97.8	39.2	nc	nc	nc
Lead	<0.080	1.36	0.384	0.487	1.5–2.5, chronic	0	Aquatic life
Manganese	57.3	230	75.5	76.1	1421–1652, chronic	0	Aquatic life
Mercury	<0.005	<0.005	-	-	0.77	0	Aquatic life
Molybdenum	1.51	4.76	2.11	1.29	ndc	ndc	ndc
Nickel	<0.400	1.09	0.663	0.277	36–52, chronic	0	Aquatic life
Selenium	0.179	0.368	0.269	0.0692	50	0	DWS
Silver	<0.040	<0.040	-	-	1.5–3.3, acute	0	Aquatic life
Uranium	0.114	1.21	0.178	0.460	30	0	DWS
Vanadium	3.99	5.65	4.54	0.634	nc	nc	nc
Zinc	<4.00	<4.00	-	-	81–122, chronic	0	Aquatic life

[a] Values that are not reported were not calculated because > 70% of results were below the laboratory reporting level.
[b] 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).

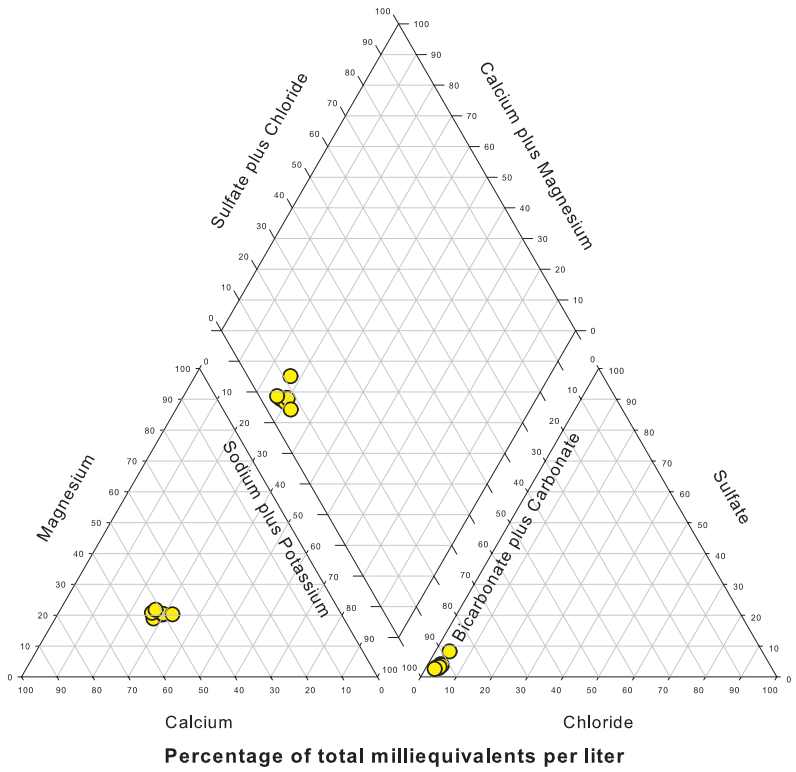


Figure 13. Major ion composition from samples collected at CAP01 on Capulin Creek in Bandelier NM, 2012–2013.

Table 12. Water quality core parameter and bacteria data from ALA01 on Alamo Creek in Bandelier NM, May 21, 2012. The associated New Mexico water quality criteria are indicated for each parameter; "nc" indicates that no criteria exist for a specific parameter.

Core parameter	5/21/12	N.M. state criteria
Water temperature (°C)	13.9	Max. temp <23°, 4T3 = 20°[a]
pH	7.8	>6.6 and <8.8
Specific conductance (µS/cm)	147	<300
Dissolved oxygen (mg/L)	8.0	>6
Turbidity (NTU)	3.6	nc
Discharge (cfs)	0.1	nc
Total coliforms (MPN/100 mL)	>2420	nc
E. coli (MPN/100 mL)	<1	235 (single sample maximum); 126 (monthly geometric mean)

[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.

3.3 Alamo Creek

A single visit was made to ALA01 on Alamo Creek on May 21, 2012, for the purpose of collecting radionuclide samples from the stream water and streambed sediment. NPS core parameters were measured and a bacteria sample was also collected. Results are presented below.

3.3.1 Water quality core parameter and bacteria data

A summary of the core parameter measurements taken at ALA01 is displayed in Table 12. Measurements were similar to the other Bandelier sites visited in May and were within the water quality criteria.

3.3.2 Radionuclides

On May 21, 2012, SCPN visited ALA01 to collect samples of unfiltered water and streambed sediment to be analyzed for a suite of radionuclides: gross alpha, gross beta, isotopic uranium, radium 226/228, and gamma emitters. The gross alpha and beta samples were analyzed twice: once within 72 hours of collection, and again 30 days after collection.

For the stream water samples, only gross alpha and Ra 226/228 have water quality standards. The standards are 15 pCi/L for gross alpha and 5 pCi/L for Ra 226/228; these are drinking water standards. The water results were well below these criteria: the 72-hour gross alpha result was 0.644 pCi/L, and it was not detected in the 30-day sample. Radium 226 was 0.012 pCi/L, and radium 228 was 0.283 pCi/L. Gross beta was 4.37 pCi/L in the 72-hour sample and 2.49 pCi/L in the 30-day sample. Of the uranium isotopes tested for, only U-238 was detected, at 0.017 pCi/L. Uranium 233/234 and 235 were not detected.

In the bed sediment samples, the

gross alpha was 25.3 and 22.0 pCi/g in the 72-hour and 30-day samples, respectively, The gross beta results were 20.6 and 19.4 pCi/g. Uranium isotopes only represented a small portion of the gross alpha levels. Uranium-238 was 0.822 pCi/g, uranium-235 was 0.0550 pCi/g, and uranium-233/234 was 0.736 pCi/g. Radium-226, an alpha emitter, was present at 0.875 pCi/g, while radium-228, a beta emitter, was present at 1.46 pCi/g. For gamma emitters, the most prevalent radionuclide was potassium-40, a naturally occurring radioisotope which was present at 22.4 pCi/g. Smaller amounts of bismuth, lead, and thorium isotopes were present as well. Complete results are presented in Appendix F.

4 Quality assurance/Quality control

We followed the Quality Assurance/Quality Control procedures described in Monroe et al. (in preparation) and in National Park Service 2013. To ensure accuracy of the instruments, we calibrated and performed maintenance on the multiparameter sondes in an indoor laboratory four times per year. We checked the current meters according to manufacturer recommendations to determine that they were in working order, and calibrated the turbidimeter quarterly in the lab. The turbidimeter was also checked for drift in the field prior to each measurement. We collected ten duplicate bacteria samples at several SCPN monitoring sites by filling two sample bottles in succession and comparing tray results after the incubation period. Three 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, NWQL analyzed three sample sets of certified inorganic blank water in 2012 and 2013. The results were compared against the 2014 reporting levels. To verify the cleanliness of the sample collection process for Contaminants of Emerging Concern, three blanks for pesticides, pharmaceuticals, and personal care products were collected at RIT01, and one blank sample was collected at RIT03. One waste indicators sample was collected at RIT01.

5 Summary

This report summarizes water quality monitoring activities at El Rito de los Frijoles, Capulin Creek, and Alamo Creek during 2012–2013 in BAND. Twelve site visits each to RIT01 and RIT02 on El Rito de los Frijoles were completed at regular intervals throughout the two years; seven site visits were completed at CAP01 on Capulin Creek; and twelve visits were completed at RIT03. A single visit was made to ALA01 on Alamo Creek to collect samples for radionuclide analysis; samples were also collected at CAP01, RIT01, and RIT02 in May 2012. This report summarizes the 2012–2013 activities at these sites and compares the results to the New Mexico water quality standards (NMED 2013).

We made site visits to Capulin Creek and El Rito de los Frijoles at regular intervals throughout the year when possible, capturing a variety of different seasonal and flow conditions as well as effects from the Las Conchas Fire. NPS core parameter measurements were recorded at all sites; measurements for pH, specific conductance, and dissolved oxygen were not outside the New Mexico water quality standards. Water temperatures exceeded the high-quality coldwater temperature criteria throughout most of the summer at RIT01. Temperature criteria compliance could not be fully assessed at CAP01 or at RIT02 because repeated flooding led to loss of data loggers. The temperature data that does exist for 2012–2013 indicate that the temperature criteria were not met at these sites either.

There are no New Mexico water quality standards for turbidity or discharge. Turbidity was highly variable at all sites, ranging from 2.4–4150 NTU, depending on when the last precipitation had occurred. The highest measurements were recorded during the summer. Discharge measurements ranged from 0.3–2.5 cfs.

E. coli levels exceeded the single-sample maximum of 235 cfu/100 mL once at CAP01, RIT02, and RIT03. All of these samples were collected during the same sampling trip when stream turbidities were particularly high. *E. coli* levels exceeded 235 cfu/100 mL three times at RIT01.

Some nutrient and trace metal concentrations were elevated compared to samples collected prior to the Las Conchas fire; however none of these analytes exceeded New Mexico water quality standards. Radionuclide results for samples collected in May 2012 at RIT01, RIT02, ALA01, and CAP01 were also below the water quality standards. Six contaminants of emerging concern were detected at RIT01 and RIT03. These contaminants were only detected once or twice per site.

The data in this report should be viewed as a snapshot of water quality conditions existing at the time that the

data was collected. Data and analyses in this report are provisional and are subject to change. When sufficient data are available, SCPN plans to produce an interpretive report which will include trend analysis of water quality data for El Rito de los Frijoles and Capulin Creek in Bandelier National Monument.

6 Literature cited

Brown, J. B. 2008. Review of Available Water-Quality Data for the Southern Colorado Plateau Network and Characterization of Water Quality in Five Selected Park Units in Arizona, Colorado, New Mexico, and Utah, 1925 to 2004: U.S. Geological Survey Scientific Investigations Report 2008–5130.

Dyer, Melissa, and Stephen. A. Monroe. 2013. Water quality monitoring for the Rito de los Frijoles and Capulin Creek in Bandelier National Monument: 2011 summary report. Natural Resource Data Series NPS/SCPN/NRDS—2013/566. National Park Service, Fort Collins, Colorado.

Macy, J. P., and S. A. Monroe. 2006. Water-quality data for selected National Park units in the Southern Colorado Plateau Network, Arizona, Utah, Colorado, and New Mexico, water years 2005 and 2006: U.S. Geological Survey Open-File Report 2006–1300.

Monroe, S. A., C. A. Bliss, and M. Dyer. (In preparation). Water quality monitoring protocol for the Southern Colorado Plateau Network. National Park Service.

National Park Service, Water Resources Division and Inventory and Monitoring Program. 2013. Quality Assurance Project Plan for surface water sampling for pesticides, pharmaceuticals, personal care products, waste water indicators in the National Park Service's Northern Colorado Plateau, Southern Colorado Plateau, Sierra Nevada, Sonoran Desert, and Southern Plains Inventory and Monitoring Networks. Unpublished report, Fort Collins, Colorado.

New Mexico Environment Department, Surface Water Quality Bureau (NMED SWQB). 1998-2012. State of New Mexico. Clean Water Act §303(d)/§305(b) Integrated List & Report. Available at http://www.nmenv.state.nm.us/swqb/303d-305b/.

New Mexico Environment Department, Surface Water Quality Bureau (NMED SWQB). 2013. Standards for interstate and intrastate surface waters. 20.6.4 NMAC. Available at: http://www.nmenv.state.nm.us/swqb/Standards/.

New Mexico Environment Department, Surface Water Quality Bureau. (NMED SWQB). 2014. Procedures for assessing water quality standards attainment for the State of New Mexico CWA 303(d) / 305(b) integrated report: assessment protocol. Available at: http://www.nmenv.state.nm.us/swqb/protocols.

OneRain Flood Early Warning System. Contrail online database. [Internet]. Rain gage data from Ponderosa C.G. (#31058), Dome Road (#31058), and Headwaters of Cochiti and Capulin Canyon (#31045) stations. Accessed January 2015 [No public access].

Scott, M. L., A. M. D Brasher, A. M. Caires, E. W. Reynolds, and M. E. Miller. 2005. The structure and functioning of riparian and aquatic ecosystems of the Colorado Plateau: Conceptual models to inform monitoring. Supplement III in Thomas, L. P., M. N. Hendrie, editor, C. L. Lauver, S. A. Monroe, N. J. Tancreto, S. L. Garman, and M. E. Miller. 2006. Vital signs monitoring plan for the Southern Colorado Plateau Network: Natural Resources Report NPS/SCPN/NRR-2006/002, National Park Service, Fort Collins, Colorado. Available at http://science.nature.nps.gov/im/units/scpn/assets/docs/Supplements/SuppIII_Riparian_Aquatic_Model.pdf (accessed 8 August 2011).

Thomas, L. P., M. N. Hendrie, editor, C. L. Lauver, S. A. Monroe, N. J. Tancreto, S. L. Garman, and M. E. Miller. 2006. Vital signs monitoring plan for the Southern Colorado Plateau Network: Natural Resources Report NPS/SCPN/NRR-2006/002, National Park Service, Fort Collins, Colorado. Available at http://science.nature.nps.gov/im/units/scpn/publications.cfm.

United States Environmental Protection Agency (EPA). 2011. Impaired waters and total maximum daily loads. Available at http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl (accessed 22 November 2011).

United States Geological Survey (USGS). 2016. National Water Information System: Web Interface. USGS, Denver, Colorado. Available at http://nwis.waterdata.usgs.gov/nm/nwis/inventory/?site_no=08313350&agency_cd=USGS (Accessed February 2016).

Vieira, N. K., Clements, W. H., Guevara, L. S., and Jacobs, B. F. 2004. Resistance and resilience of stream insect communities to repeated hydrologic disturbances after a wildfire. Freshwater Biology, 49: 1243–1259.

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.
4. Sites where SCPN has been collecting additional data, but not intended to be continued as long-term monitoring. This includes sites identified in #1 and #3, above. For example, SCPN has conducted sampling events for radionuclides after Los Alamos National Laboratory detected elevated alpha radiation levels in water samples collected after flood events post-Las Conchas Fire.

Table A1. Southern Colorado Plateau Network (SCPN) water quality monitoring sites for Bandelier NM, 2012–2013.

Site code	Common name	Report name	Northing (m)[1]	Easting (m)[1]	Elevation (m)[1]
BANDALA01	Upper Alamo Crossing	ALA01	3961711	377779	2012
BANDRIT86	Upper Frijoles – East Fork	RIT86	3966007	372361	2434
BANDRIT84	Upper Frijoles – West Fork	RIT84	3965971	372229	2433
BANDRIT75	Upper Frijoles – Confluence	RIT75	3965904	372371	2434
BANDRIT71	Upper Upper Crossing	RIT71	3965123	372631	2366
BANDRIT64	Above Burn	RIT64	3964295	373770	2284
BANDRIT02[2]	Rito de los Frijoles at Upper Crossing	RIT02	3964316	377109	2151
BANDRIT05	Narrows	RIT05	3963074	379932	2004
BANDRIT04	Hoodoo	RIT04	3962327	381806	1902
BANDRIT03	Rito de los Frijoles above Wilderness Boundary	RIT03	3961664	383164	1886
BANDRIT01[2]	Rito de los Frijoles near Visitor Center	RIT01	3959889	385363	1840
BANDRIT22	Below Lower Falls	RIT22	3957901	386236	1684
BANDCAP01[2]	Capulin Creek at Base Camp Gaging Station	CAP01	3958026	379713	1904
BANDCAP02	Capulin Creek above Painted Cave	CAP02	3955457	380300	1791

[1] Horizontal coordinates are reported in Universal Transverse Mercator (UTM) Projection, Zone 13, 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 data for RIT01 at Bandelier National Monument, 2006–2013

Table B-1. Water quality core parameter data from RIT01 on the Rito de los Frijoles in Bandelier NM, 2012–2013.

	Sampling date and time											
	2012							2013				
	2/23	4/2	5/20	7/10	8/21	10/24	11/27	2/1	5/21	6/5	8/14	11/17
Parameter	11:10	17:15	9:50	13:00	16:30	16:45	17:30	18:00	16:45	18:08	17:30	17:17
Water temperature (°C)	5.1	7.3	10.8	21.4	23.1	13.4	1.3	0.0	16.7	17.1	19.7	5.9
pH	7.9	8.2	7.7	8.1	8.2	8.3	8.0	8.1	7.8	7.9	8.2	8.0
Specific conductance (µS/cm)	187	165	194	198	230	215	198	156	178	193	233	266
Dissolved oxygen (mg/L)	10.0	9.4	8.6	6.9	6.7	7.9	11.0	11.9	7.3	7.2	7.1	9.6
Dissolved oxygen (% saturation)	100	99	96	98	98	95	97	101	95	97	97	96
Turbidity (NTU)	28	350	17	18	490	120	150	100	7.6	2.1	4150[a]	38
Discharge (cfs)	0.9	1.9	0.9	0.3	0.5	0.5	0.6	1.0	0.7	0.3	1.7	1.2

[a]Turbidity result is an estimate

Table B-2. Total coliforms and *E. coli* in samples collected at RIT01 on the Rito de los Frijoles in Bandelier NM, 2012–2013.

	Sampling date and time									
	2012						2013			
	2/23	4/2	5/20	7/10	8/21	11/27	2/1	5/21	8/14	11/17
Parameter	11:10	17:15	9:50	13:00	16:30	17:30	18:00	16:45	17:30	17:17
Total coliforms, MPN/100mL	290	>2400[a]	2000	>2400[a]	>2400[a]	1400	330	2000	>2400[a]	1000
E. coli, MPN/100mL	<1	11	77	290	300	40	4	69	>2400[a]	<1

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

Table B-3. Results of laboratory analyses of samples collected from RIT01 on the Rito de los Frijoles in Bandelier NM, 2012–2013. Results that were lower than the laboratory reporting levels are noted as "<[reporting level]". All analytes were dissolved, except for acid neutralizing capacity.

	Sampling date and time										
	2012							2013			
	2/23	4/2	5/20	7/10	8/21	10/24	11/27	2/1	5/21	8/14	11/17
Analyte	11:00	17:15	9:50	15:00	16:30	16:45	17:30	18:00	16:45	17:30	17:17
Nutrients (mg/L)											
Ammonia as N	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	0.0104	<0.0100
Nitrite + nitrate as N	0.112	0.591	0.054	<0.040	0.205	<0.040	0.106	0.176	<0.040	0.151	0.106
Nitrite as N	0.00376	0.00267	0.00164	0.00139	0.00621	<0.00100	0.00143	0.00136	<0.00100	0.00447	<0.00100
Orthophosphate as P	0.101	0.123	0.129	0.184	0.308	0.186	0.124	0.0935	0.130	0.222	0.111
Major elements (mg/L)											
Calcium	19.7	16.0	19.3	21.2	25.8	23.4	22.5	15.6	16.3	26.7	25.1
Chloride	3.39	4.03	4.36	3.81	3.16	3.39	2.96	2.75	2.59	3.28	8.12
Fluoride	0.219	0.195	0.217	0.275	0.200	0.189	0.189	0.189	0.294	0.277	0.281
Magnesium	5.97	4.85	5.80	6.30	5.43	6.04	6.14	4.79	4.98	6.17	7.42
Potassium	3.13	3.33	3.26	3.79	7.61	5.74	3.57	2.69	3.10	7.67	4.75
Silica	57.1	53.8	60.7	60.4	51.7	59.0	25.9	51.5	60.3	52.9	49.6
Sodium	14.5	13.3	15.0	15.5	12.6	15.1	14.0	12.4	13.4	12.5	19.2
Sulfate	2.69	5.75	2.74	1.70	2.34	2.41	1.96	2.62	1.81	3.65	5.52
Acid neutralizing capacity, as $CaCO_3$ (unfiltered)	95.9	75.2	99.9	110	113	111	105	81.4	88.1	136	133
Total dissolved solids	148	144	169	185	182	184	175	147	155	184	218
Trace metals (µg/L)											
Aluminum	42.3	85.3	30.6	105	283	113	61.9	83.0	22.6	461	45.3
Antimony	<0.0623	<0.0779	<0.0619	0.335	0.206	<0.124	<0.0919	0.0758	0.0676	0.144	0.0858
Arsenic	1.15	1.15	1.42	2.05	2.95	1.95	1.42	1.04	1.47	2.97	1.32
Barium	22.0	18.8	19.1	62.4	44.0	31.7	26.2	19.2	16.7	37.5	29.3
Beryllium	<0.040	<0.040[a]	<0.040[a]	<0.040	0.0523	<0.040[a]	<0.040[a]	<0.040[a]	<0.040	0.136	<0.040[a]
Boron	12.4	13.9	16.2	19.1	25.7	21.0	14.9	11.7	15.7	23.4	15.7
Cadmium	<0.060	<0.060	<0.060	0.239	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060[a]	<0.060
Chromium	<0.600	<0.600	<0.600	<0.600	<0.600	<0.600	<0.600	<0.600	<0.600	<0.600	<0.600
Cobalt	0.492	0.255	0.364	1.05	0.440	1.02	0.846	0.501	0.207	1.70	0.737
Copper	<0.800	<0.800	<0.800	1.16	2.06	2.68	2.64	1.74	<0.800	1.00	<0.80

Table B-3. (*continued*) Results of laboratory analyses of samples collected from RIT01 on the Rito de los Frijoles in Bandelier NM, 2012–2013. Results that were lower than the laboratory reporting levels are noted as "<[reporting level]". All analytes were dissolved, except for acid neutralizing capacity.

	Sampling date and time										
	2012							2013			
Analyte	2/23 11:00	4/2 17:15	5/20 9:50	7/10 15:00	8/21 16:30	10/24 16:45	11/27 17:30	2/1 18:00	5/21 16:45	8/14 17:30	11/17 17:17
Iron	197	85.5	158	260	160	136	154	163	263	379	163
Lead	0.184	0.167	0.0935	<0.080	0.754	0.620	0.539	0.511	0.159	0.992	0.297
Manganese	160	57.6	81.4	1100	21.8	94.9	304	159	145	85.5	447
Mercury	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Molybdenum	2.55	2.07	2.99	73.0	5.89	4.08	3.38	2.26	3.05	6.70	3.70
Nickel	0.526	0.425	1.94	0.804	0.839	0.801	0.679	0.529	0.470	1.18	1.29
Selenium	0.117	0.129	0.111	0.378	0.262	0.109	<0.100[a]	<0.100[a]	0.101	0.257	0.125
Silver	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
Uranium	0.307	0.235	0.190	3.25	0.969	0.421	0.324	0.221	0.133	1.53	0.505
Vanadium	2.23	2.56	2.63	1.21	4.27	2.35	1.66	2.00	3.07	4.21	1.95
Zinc	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00[a]	<4.00

[a] Analyte was present above the Minimum Detection Level, but below the Laboratory Reporting Level.

Table B-4: Contaminants of Emerging Concern (CEC) detected in samples collected at RIT01 on the Rito de los Frijoles in Bandelier NM, 2012–2013. There are no water quality standards for these analytes. Samples were collected for CECs on 6 occasions, but CECs were not detected above the reporting limit on 4/2/2012, 10/24/2012, and 8/14/2013. See Appendix H for a complete list of CECs.

		Sampling date and time		
CEC	Reporting limit, ng/L	8/21/2012 16:30	5/21/2013 16:45	11/17/2013 17:17
Pharmaceuticals and Personal Care Products (PPCPs)				
Caffeine	10	12.5	45	
Acetaminophen	10		19.7	
Theobromine	10		24.2	
Theophylline	10		11.1	
Waste Indicators				
Tri(2-butoxyethyl) Phosphate	50	61.4		
p-Cresol	50			97.4

Table B5. Radionuclide results for water and streambed sediment samples collected from RIT01 on the Rito de los Frijoles in Bandelier NM, May 20 2012. Results below the critical level are considered to be nondetections (ND). Gamma emitters were only reported for the streambed sediment samples; results for water samples were not included in the report from the lab. "nc" indicates that there are no NM state drinking water criteria for the analyte.

	Water samples, unfiltered			Sediment samples	
Analyte	Result (pCi/L)	Critical level (pCi/L)	N.M. state drinking water criteria (pCi/L)	Result (pCi/g)	Critical level (pCi/g)
Gross alpha, 72-hour	2.08	0.57	15	10.6	0.62
Gross alpha, 30-day	1.97	0.52	15	9.53	0.65
Gross beta, 72-hour	4.59	0.66	nc	24.5	0.95
Gross beta, 30-day	4.78	0.67	nc	25.3	1.2
U-233/234	0.216	0.013	nc	0.762	0.015
U-235	ND	0.0098	nc	0.0370	0.011
U-238	0.199	0.0081	nc	0.667	0.016
Ra-226	0.010	0.018	5 (Ra 226/228)	0.823	0.043
Ra-228	0.281	0.220	5 (Ra 226/228)	0.978	0.10
Gamma emitters					
Cs-137	ND	0.97	nc	ND	0.030
K-40	NR	-	nc	33.4	0.34
Be-7	NR	-	nc	ND	0.12
Co-60	NR	-	nc	ND	0.013
Nb-94	NR	-	nc	ND	0.0079
Ru-106	NR	-	nc	ND	0.12
Sb-125	NR	-	nc	ND	0.031
Eu-152	NR	-	nc	ND	0.036
Eu-154	NR	-	nc	ND	0.044
Eu-155	NR	-	nc	ND	0.050
Bi-212	NR	-	nc	0.849	0.071
Pb-212	NR	-	nc	0.992	0.040
Bi-214	NR	-	nc	0.847	0.045
Pb-214	NR	-	nc	0.947	0.047
Th-228	NR	-	nc	0.959	0.039
Th-232	NR	-	nc	0.973	0.099
Am-241	NR	-	nc	ND	0.055

Appendix C: Water Quality monitoring data for RIT02 at Bandelier National Monument, 2012–2013

Table C-1. Water quality core parameter data from RIT02 on the Rito de los Frijoles in Bandelier NM, 2012–2013.

	Sampling date and time											
	2012							2013				
	2/24	4/2	5/21	7/10	8/21	10/23	11/28	2/1	5/22	6/5	8/15	11/19
Parameter	9:20	12:22	12:30	9:15	11:50	14:45	9:45	13:15	10:30	12:30	11:10	9:58
Water temperature (°C)	3.3	9.6	21.3	17.9	22.4	14.6	3.9	5.7	15.5	22.2	23.3	6.4
pH	8.2	8.1	8.5	8.1	8.1	8.2	8.1	8.1	8.1	8.2	8.1	8.1
Specific conductance (µS/cm)	148	141	147	155	204	166	130	123	113	139	227	154
Dissolved oxygen (mg/L)	10.3	8.5	7.6	7.3	6.5	7.7	10.3	8.8	7.8	6.7	6.3	9.3
Dissolved oxygen (% saturation)	99	97	111	98	97	98	100	91	101	100	95	97
Turbidity (NTU)	3.1	7.9	2.7	10	300	130	2.4	57	2.6	3.1	1450[a]	3.4
Discharge cfs	1.2	-	1.5	1.4	1.3	1.7	-	1.2	0.8	-	1.7	1.3

[a]Turbidity result is an estimate

Table C-2. Total coliforms and *E. coli* in samples collected at RIT02 on the Rito de los Frijoles in Bandelier NM, 2012–2013.

	Sampling date and time										
	2012							2013			
	2/24	4/2	5/21	7/10	8/21	10/23	11/28	2/1	5/22	8/15	11/19
Parameter	9:20	12:22	12:30	9:15	11:50	15:30	9:45	13:15	10:30	11:10	9:58
Total coliforms, MPN/100mL	130	170	>2400[a]	>2400	>2400[a]	830	390	1000	820	>2400[a]	870
E. coli, MPN/100mL	<1	<1	17	4	120	20	<1	<1	<1	1400	1

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

Table C-3. Results of laboratory analyses of samples collected from RIT02 on the Rito de los Frijoles in Bandelier NM, 2012–2013. Results that were lower than the laboratory reporting levels are noted as "<[reporting level]". All analytes were dissolved, except for acid neutralizing capacity.

	Sampling date and time										
	2012							2013			
	2/24	4/2	5/21	7/10	8/21	10/23	11/28	2/1	5/22	8/15	11/19
Analyte	9:20	12:22	12:30	9:15	11:50	15:30	9:45	13:15	10:30	11:10	9:58
Nutrients (mg/L)											
Ammonia as N	0.0134	0.0152	0.0138	0.0124	0.0317	0.0195	0.0163	<0.0100	<0.0100	0.0489	0.0129
Nitrite + nitrate as N	0.265	0.806	<0.040	0.077	0.196	0.145	0.163	0.235	<0.040	0.140	0.253
Nitrite as N	0.00120	0.00398	0.00152	0.00228	0.0177	0.00415	0.00186	0.00208	<0.00100	0.00854	0.00159
Orthophosphate as P	0.124	0.118	0.156	0.187	0.256	0.185	0.121	0.104	0.129	0.211	0.109
Major elements (mg/L)											
Calcium	14.5	13.5	14.7	16.0	15.2	17.3	14.4	11.2	11.3	25.2	15.7
Chloride	2.58	3.98	3.61	2.79	2.68	2.45	2.31	2.27	2.03	2.62	5.08
Fluoride	0.193	0.166	0.190	0.216	0.171	0.163	0.159	0.177	0.222	0.225	0.165
Magnesium	4.33	4.00	4.13	4.61	3.18	4.43	3.95	3.38	3.36	5.71	4.27
Potassium	2.49	2.71	3.20	3.18	3.90	3.95	2.62	2.26	2.53	6.81	3.28
Silica	59.8	53.4	57.2	60.2	38.9	60.4	32.3	56.4	60.0	54.7	55.8
Sodium	11.9	10.6	12.3	12.2	7.46	11.7	11.0	9.95	10.2	11.5	11.3
Sulfate	2.14	6.08	2.23	1.56	2.67	1.81	1.79	2.21	1.73	2.18	3.69
Acid neutralizing capacity, as $CaCO_3$ (unfiltered)	74.3	60.4	74.0	86.3	80.3	83.8	72.5	62.4	64.3	115	72.0
Total dissolved solids	160	131	126	152	177	162	143	106	101	181	149
Trace metals (µg/L)											
Aluminum	22.7	119	19.7	65.0	271	53.6	9.74	54.6	15.2	217	24.0
Antimony	<0.061	<0.0697	<0.0597	0.154	0.128	0.0894	<0.0488	0.0532	0.0507	0.119	0.0627
Arsenic	1.14	1.05	1.70	0.971	1.52	1.59	1.15	1.03	1.38	2.55	0.902
Barium	19.2	22.1	15.2	69.7	25.8	24.8	19.9	14.6	13.9	33.3	21.8
Beryllium	<0.040	<0.040[a]	<0.040	<0.040	<0.040	<0.040[a]	<0.040	<0.040	<0.040	0.0776	<0.040[a]
Boron	10.8	12.1	13.8	15.1	15.1	14.8	11.2	10.0	11.5	19.9	12.1
Cadmium	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060[a]	<0.060
Chromium	<0.600[a]	<0.600[a]	<0.600	<0.600	<0.600	<0.600	<0.600	<0.600[a]	<0.600[a]	<0.600	<0.600
Cobalt	0.346	0.354	0.310	1.03	0.862	0.556	0.250	0.113	0.163	1.58	0.442

Table C-3. (*continued*) Results of laboratory analyses of samples collected from RIT02 on the Rito de los Frijoles in Bandelier NM, 2012–2013. Results that were lower than the laboratory reporting levels are noted as "<[reporting level]". All analytes were dissolved, except for acid neutralizing capacity.

	Sampling date and time										
	2012							2013			
	2/24	4/2	5/21	7/10	8/21	10/23	11/28	2/1	5/22	8/15	11/19
Analyte	9:20	12:22	12:30	9:15	11:50	15:30	9:45	13:15	10:30	11:10	9:58
Copper	<0.800	<0.800	<0.800	1.59	1.31	2.10	1.46	1.72	<0.800	<0.800	<0.80
Iron	157	173	201	264	147	108	125	108	141	180	200
Lead	0.106	0.290	0.0947	<0.080[a]	0.476	0.567	0.855	0.586	0.421	0.389	<0.080[a]
Manganese	273	99.3	81.1	39.7	95.4	229	336	95.0	98.0	567	475
Mercury	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Molybdenum	2.12	1.54	2.20	3.04	2.94	2.70	2.08	1.66	1.76	5.67	1.55
Nickel	<0.400[a]	<0.400[a]	<0.400[a]	2.78	0.586	0.413	<0.400[a]	<0.400[a]	<0.400	1.03	0.661
Selenium	0.150	0.183	0.143	1.34	0.138	0.119	0.126	0.150	0.135	0.235	0.135
Silver	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
Uranium	0.336	0.223	0.225	3.45	0.384	0.328	0.257	0.205	0.152	0.722	0.147
Vanadium	3.28	3.33	4.57	0.829	2.43	3.11	3.17	3.82	4.61	2.59	2.47
Zinc	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00

[a]Analyte was present above the Minimum Detection Level, but below the Laboratory Reporting Level

Table C-4. Radionuclide results for water and streambed sediment samples collected from RIT02 on the Rito de los Frijoles in Bandelier NM, May 20, 2012. Results below the critical level are considered to be nondetections (ND). Gamma emitters were only reported for the streambed sediment samples; results for water samples were not included in the report from the lab. "nc" indicates that there are now NM state drinking water criteria for the analyte.

	Water samples, unfiltered			Sediment samples	
Analyte	Result (pCi/L)	Critical level (pCi/L)	N.M. state drinking water criteria (pCi/L)	Result (pCi/g)	Critical level (pCi/g)
Gross alpha, 72-hour	0.427	0.29	15	17.3	0.65
Gross alpha, 30-day	0.414	0.43	15	14.3	0.53
Gross beta, 72-hour	3.24	0.51	nc	27.1	1.2
Gross beta, 30-day	3.50	0.62	nc	25.5	0.95
U-233/234	0.096	0.012	nc	1.02	0.013
U-235	ND	0.013	nc	0.0670	0.0093
U-238	0.080	0.0096	nc	0.948	0.011
Ra-226	ND	0.016	5 (Ra 226+228)	0.974	0.037
Ra-228	ND	0.23	5 (Ra 226+228)	1.37	0.103
Gamma emitters					
Cs-137	ND	0.47	nc	ND	0.020
K-40	NR	-	nc	24.0	0.28
Be-7	NR	-	nc	ND	0.11
Co-60	NR	-	nc	ND	0.015
Nb-94	NR	-	nc	ND	0.014
Sb-125	NR	-	nc	ND	0.024
Eu-152	NR	-	nc	ND	0.028
Eu-154	NR	-	nc	ND	0.038
Eu-155	NR	-	nc	ND	0.034
Bi-212	NR	-	nc	1.06	0.051
Pb-212	NR	-	nc	1.25	0.024
Bi-214	NR	-	nc	1.00	0.038
Pb-214	NR	-	nc	1.12	0.033
Th-228	NR	-	nc	1.21	0.024
Th-232	NR	-	nc	1.36	0.10
Am-241	NR	-	nc	ND	0.018

Appendix D: Water Quality monitoring data for RIT03 at Bandelier National Monument, 2012–2013

Table D-1. Water quality core parameter data from RIT03 on the Rito de los Frijoles in Bandelier NM, 2012–2013.

	Sampling date and time											
	2012							2013				
	2/23	4/3	5/18	7/10	8/22	10/24	11/28	2/2	5/20	6/5	8/15	11/19
Parameter	9:55	11:00	13:00	12:30	10:50	15:30	13:10	10:00	18:00	17:00	15:06	12:27
Water temperature (°C)	1.8	5.5	16.4	20.0	17.9	11.6	1.8	-0.3	12.7	17.3	22.5	7.3
pH	7.4	8.1	8.0	8.1	8.2	8.3	8.2	7.9	8.0	8.2	8.2	8.1
Specific conductance (µS/cm)	160	144	174	175	217	193	146	135	118	153	257	197
Dissolved oxygen (mg/L)	10.9	9.9	7.6	7.2	7.4	8.4	10.9	11.9	8.2	7.4	6.6	9.0
Dissolved oxygen (% saturation)	99	99	97	99	98	96	98	101	98	100	96	94
Turbidity (NTU)	11	490	14	5.4	590	180	-	52	3.2	2.4	920	45
Discharge cfs	1.1	2.5	-	0.8	1.0	0.7	0.8	0.7	0.5	0.6	0.9	1.2

Table D-2. Total coliforms and *E. coli* in samples collected at RIT03 on the Rito de los Frijoles in Bandelier NM, 2012–2013.

	Sampling date and time									
	2012						2013			
	2/24	4/3	5/18	7/10	8/22	11/28	2/2	5/20	8/15	11/19
Parameter	9:55	11:00	13:00	12:44	10:50	13:10	10:00	18:00	15:06	12:27
Total coliforms, MPN/100mL	160	>2400	1400	>2400[a]	>2400[a]	1700	270	1400	>2400[a]	2000
E. coli, MPN/100mL	<1	1	8	16	150	5	<1	29	2400	1

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

Table D-3: Contaminants of Emerging Concern (CEC) detected in samples collected at RIT03 on the Rito de los Frijoles in Bandelier NM, 2012–2013. There are no water quality standards for these analytes. Samples were collected for CECs on 6 occasions, but CECs were not detected above the reporting limit on 4/3/2012 and 8/22/2012. See Appendix H for the complete list of analytes.

		Sampling date and time					
		2012			2013		
		4/3	8/22	10/24	5/20	8/15	11/19
CEC	Reporting limit, ng/L	11:00	10:50	15:30	18:00	15:06	12:27
Pharmaceuticals and Personal Care Products (PPCPs)							
Caffeine	10				18	10.5	
Waste Indicators							
Tri(2-butoxyethyl) Phosphate	50			447			
p-Cresol	50						107

Appendix E: Water Quality monitoring data for CAP01 at Bandelier National Monument, 2012–2013

Table E-1. Water quality core parameter data from CAP01 on Capulin Creek in Bandelier NM, 2012–2013.

	Sampling date and time						
	2012				2013		
	5/20	8/20	10/26	11/27	5/21	8/14	11/18
Parameter	15:31	12:00	13:45	12:00	11:45	11:30	12:30
Water temperature (°C)	22.3	23.2	12.8	7.8	19.1	23.4	9.1
pH	8.1	8.3	8.2	8.3	8.1	8.2	8.3
Specific conductance (µS/cm)	229	249	196	172	183	257	218
Dissolved oxygen (mg/L)	6.5	6.6	8.2	9.3	7.3	6.6	9.0
Dissolved oxygen (% saturation)	94	97	97	97	99	97	98
Turbidity (NTU)	14	1550[a]	46	9.6	9.1	770	5.8
Discharge cfs	0.3	0.5	0.3	0.5	0.4	0.5	0.7

[a]Turbidity result is an estimate

Table E-2. Total coliforms and *E. coli* in samples collected at CAP01 on Capulin Creek in Bandelier NM, 2012–2013.

	Sampling date and time						
	2012				2013		
	5/20	8/20	10/26	11/27	5/21	8/14	11/18
Parameter	15:29	12:00	13:45	12:00	11:45	11:30	12:30
Total coliforms, MPN/100mL	>2400[a]	>2400[a]	1600	1200	1700	>2400[a]	2000
E. coli, MPN/100mL	1	210	6	<1	5	>2400	4

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

Table E-3. Results of laboratory analyses of samples collected from CAP01 on Capulin Creek in Bandelier NM, 2012–2013. Results that were lower than the laboratory reporting levels are noted as "<[reporting level]". All analytes were dissolved, except for acid neutralizing capacity.

	Sampling date and time						
	2012				2013		
	5/20	8/20	10/26	11/27	5/21	8/14	11/18
Analyte	15:29	12:00	12:00	12:00	11:45	11:30	12:30
Nutrients (mg/L)							
Ammonia as N	0.0138	0.0227	0.0111	<0.0100	<0.0100	0.0255	<0.0100
Nitrite + nitrate as N	0.198	0.230	0.166	0.173	<0.040	0.200	0.705
Nitrite as N	0.00626	0.0156	0.00176	0.00144	<0.00100	0.00650	0.00122
Orthophosphate as P	0.333	0.454	0.231	0.183	0.178	0.334	0.196
Major elements (mg/L)							
Calcium	25.4	29.4	21.7	19.4	17.9	28.9	24.6
Chloride	3.07	2.91	2.76	2.73	2.55	2.71	3.30
Fluoride	0.307	0.247	0.210	0.210	0.303	0.283	0.272
Magnesium	6.19	6.31	5.32	4.79	4.64	6.87	6.31
Potassium	5.11	7.5	3.85	3	3.5	7.33	4.55
Silica	62.4	38.5	63.5	35.9	61.6	51.6	53.6
Sodium	13.9	13	12.4	11.4	11.9	12.1	12
Sulfate	4.59	4.05	2.84	3.36	2.93	3.38	9.03
Acid neutralizing capacity, as $CaCO_3$ (unfiltered)	109	136	97.3	86.2	88.7	132	101
Total dissolved solids	196	219	168	147	170	213	178
Trace metals (µg/L)							
Aluminum	24.2	187	26.9	6.25	5.53	129	24.9
Antimony	<0.0767	0.19	<0.0685	<0.0597	0.049	0.126	0.0665
Arsenic	3.51	4.33	2.54	2.12	2.71	3.76	1.86
Barium	61.7	68.2	58.4	50.9	49.2	70	60.8
Beryllium	<0.040	<0.040[a]	<0.040	<0.040	<0.040	<0.040[a]	<0.040
Boron	19.3	22.4	13.7	11.9	13.3	22.3	14.3
Cadmium	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060
Chromium	<0.600	<0.600	<0.600[a]	<0.600[a]	<0.600	<0.600	<0.600[a]
Cobalt	0.308	1.88	0.333	0.286	0.140	1.64	0.208
Copper	<0.800	1.56	5.29	2.96	<0.800	1.82	<0.80
Iron	52.8	145	106	97.8	83	98.8	23.3
Lead	<0.080[a]	0.384	1.01	1.36	0.413	0.277	<0.080[a]
Manganese	75.5	57.3	217	230	73.3	77.2	59.2
Mercury	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Molybdenum	2.16	3.98	1.77	1.51	1.54	4.76	2.11
Nickel	0.663	1.05	0.549	0.477	<0.400[a]	1.09	0.859
Selenium	0.179	0.368	0.218	0.311	0.269	0.257	0.353
Silver	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
Uranium	0.178	1.21	0.176	0.153	0.114	1.02	0.624
Vanadium	5.65	4.54	3.99	4.42	5.48	4.17	4.82
Zinc	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0

[1]Analyte was present above the Minimum Detection Level, but below the Laboratory Reporting Level

Table E-4. Radionuclide results for water and streambed sediment samples collected from CAP01 on Capulin Creek in Bandelier NM, May 20, 2012. Results below the critical level are considered to be nondetections (ND). Gamma emitters were only reported for the streambed sediment samples; results for water samples were not included in the report from the lab. "nc" indicates that there are now NM state drinking water criteria for the analyte.

	Water samples, unfiltered			Sediment samples	
Analyte	Result (pCi/L)	Critical level (pCi/L)	N.M. state drinking water criteria (pCi/L)	Result (pCi/g)	Critical level (pCi/g)
Gross alpha, 72-hour	2.65	0.52	15	7.86	0.65
Gross alpha, 30-day	1.47	0.64	15	8.61	0.67
Gross beta, 72-hour	5.37	0.84	nc	23.1	1.0
Gross beta, 30-day	5.67	0.59	nc	22.4	0.89
U-233/234	0.085	0.012	nc	0.383	0.010
U-235	ND	0.012	nc	0.0230	0.0085
U-238	0.093	0.0078	nc	0.332	0.0079
Ra-226	ND	0.015	5 (Ra 226/228)	0.508	0.033
Ra-228	0.366	0.21	5 (Ra 226/228)	0.681	0.063
Gamma emitters					
Cs-137	ND	0.94	nc	ND	0.0074
K-40	NR	–	nc	21.2	0.23
Co-60	NR	–	nc	ND	0.014
Nb-94	NR	–	nc	ND	0.014
Ru-106	NR	–	nc	ND	0.077
Sb-125	NR	–	nc	ND	0.045
Eu-152	NR	–	nc	ND	0.025
Eu-155	NR	–	nc	ND	0.026
Bi-212	NR	–	nc	0.625	0.048
Pb-212	NR	–	nc	0.666	0.022
Bi-214	NR	–	nc	0.524	0.034
Pb-214	NR	–	nc	0.608	0.030
Th-228	NR	–	nc	0.643	0.021
Th-232	NR	–	nc	0.678	0.063
Am-241	NR	–	nc	ND	0.030

Appendix F: Radionuclide results for ALA01 at Bandelier National Monument, 2012

Table F-1. Radionuclide results for water and streambed sediment samples collected from ALA01 on Alamo Creek in Bandelier NM, May 21, 2012. Results below the critical level are considered to be nondetections (ND). Gamma emitters were only reported for the streambed sediment samples; results for water samples were not included in the report from the lab. "nc" indicates that there are no NM state drinking water criteria for the analyte.

	Water samples, unfiltered			Sediment samples	
Analyte	Result (pCi/L)	Critical level (pCi/L)	N.M. state drinking water criteria (pCi/L)	Result (pCi/g)	Critical level (pCi/g)
Gross alpha, 72-hour	0.644	0.29	15	25.3	0.68
Gross alpha, 30-day	ND	0.44	15	22.0	0.62
Gross beta, 72-hour	4.37	0.47	nc	20.6	0.91
Gross beta, 30-day	2.49	0.68	nc	19.4	0.94
U-233/234	ND	0.015	nc	0.736	0.0097
U-235	ND	0.012	nc	0.0550	0.0073
U-238	0.017	0.012	nc	0.822	0.0087
Ra-226	0.012	0.011	5 (Ra 226/228)	0.875	0.029
Ra-228	0.283	0.24	5 (Ra 226/228)	1.46	0.058
Gamma emitters					
Cs-137	ND	0.46	nc	ND	0.0085
K-40	NR	–	nc	22.4	0.20
Be-7	NR	–	nc	ND	0.35
Co-60	NR	–	nc	ND	0.018
Nb-94	NR	–	nc	ND	0.026
Ru-106	NR	–	nc	ND	0.12
Sb-125	NR	–	nc	ND	0.026
Eu-152	NR	–	nc	ND	0.026
Eu-154	NR	–	nc	ND	0.037
Eu-155	NR	–	nc	ND	0.037
Bi-212	NR	–	nc	1.28	0.049
Pb-212	NR	–	nc	1.49	0.022
Bi-214	NR	–	nc	0.901	0.030
Pb-214	NR	–	nc	1.06	0.028
Th-228	NR	–	nc	1.44	0.022
Th-232	NR	–	nc	1.45	0.058
Am-241	NR	–	nc	ND	0.037

Appendix G: Spatial variability of water quality core parameter data on the Rito de los Frijoles at Bandelier National Monument, 2006-2013

Table G-1. Spatial variability of water quality core parameter data from the Rito de los Frijoles in BAND, 2006–2013. Sites are listed in order from upstream to downstream.

Core parameter	Site name	Site code	2006–2010 median	2012	2013
pH	Upper Frijoles - East Fork	RIT86	7.5, n=8	7.1	7.4
	Upper Frijoles - West Fork	RIT84	7.7, n=8	7.3	8.1
	Upper Frijoles - Confluence	RIT75	7.8, n=7	7.4	7.7
	Upper Upper Crossing	RIT71	7.6, n=7	7.6	7.7
	Above Burn	RIT64	7.8, n=7	8.0	8.0
	Rito de los Frijoles at Upper Crossing	RIT02	7.9, n=5	8.5	8.2
	Narrows	RIT05	8.0, n=6	8.3	8.1
	Hoodoo	RIT04	8.0, n=5	7.8	7.9
	Rito de los Frijoles above Wilderness Boundary	RIT03	7.9, n=5	8.0	8.2
	Rito de los Frijoles near Visitor Center	RIT01	7.7, n=7	7.7	7.9
	Below Lower Falls	RIT22	8.0, n=4	—	—
Specific conductance	Upper Frijoles - East Fork	RIT84	111, n=8	138	119
	Upper Frijoles - West Fork	RIT86	215, n=8	237	115
	Upper Frijoles - Confluence	RIT75	156, n=7	167	123
	Upper Upper Crossing	RIT71	146, n=7	144	116
	Above Burn	RIT64	131, n=7	151	123
	Rito de los Frijoles at Upper Crossing	RIT02	138, n=5	147	140
	Narrows	RIT05	140, n=6	159	143
	Hoodoo	RIT04	139, n=5	170	150
	Rito de los Frijoles above Wilderness Boundary	RIT03	140, n=5	173	153
	Rito de los Frijoles near Visitor Center	RIT01	122, n=7	195	192
	Below Lower Falls	RIT22	144, n=4	—	—
Dissolved oxygen	Upper Frijoles - East Fork	RIT84	7.5, n=7	8.4	7.8

Table G-1. (*continued)* Spatial variability of water quality core parameter data from the Rito de los Frijoles in Bandelier NM, 2006–2013. Sites are listed in order from upstream to downstream.

Core parameter	Site name	Site code	2006–2010 median	2012	2013
	Upper Frijoles - West Fork	RIT86	7.7, n=7	8.2	7.2
	Upper Frijoles - Confluence	RIT75	7.6, n=7	8.0	7.7
	Upper Upper Crossing	RIT71	7.9, n=7	8.0	7.3
	Above Burn	RIT64	7.8, n=7	8.1	7.7
	Rito de los Frijoles at Upper Crossing	RIT02	8.0, n=5	7.5	6.7
	Narrows	RIT05	7.8, n=6	7.4	7.0
	Hoodoo	RIT04	8.2, n=5	7.6	7.5
	Rito de los Frijoles above Wilderness Boundary	RIT03	8.4, n=5	7.6	7.4
	Rito de los Frijoles near Visitor Center	RIT01	7.8, n=7	8.8	7.2
	Below Lower Falls	RIT22	8.3, n=4	—	—
Discharge	Upper Frijoles - East Fork	RIT84	0.0, n=7	0.1	0.0
	Upper Frijoles - West Fork	RIT86	0.1, n=7	0.0	0.1
	Upper Frijoles - Confluence	RIT75	0.2, n=7	0.1	0.1
	Upper Upper Crossing	RIT71	0.4, n=7	0.4	0.6
	Above Burn	RIT64	0.6, n=7	0.4	0.6
	Rito de los Frijoles at Upper Crossing	RIT02	1.4, n=5	1.5	—
	Narrows	RIT05	1.0, n=4	—	0.7
	Hoodoo	RIT04	1.2, n=4	—	0.7
	Rito de los Frijoles above Wilderness Boundary	RIT03	1.0, n=4	—	0.6
	Rito de los Frijoles near Visitor Center	RIT01	0.9, n=7	0.9	0.3
	Below Lower Falls	RIT22	0.3, n=4	—	—
Turbidity	Upper Frijoles - East Fork	RIT84	21.1, n=5	2.8	1.5
	Upper Frijoles - West Fork	RIT86	4.1, n=5	4.3	1.3
	Upper Frijoles - Confluence	RIT75	5.8, n=5	3.3	2.2
	Upper Upper Crossing	RIT71	3.9, n=5	2.2	4.0
	Above Burn	RIT64	3.3, n=5	1.9	19.5
	Rito de los Frijoles at Upper Crossing	RIT02	2.4, n=4	2.9	3.0
	Narrows	RIT05	3.7, n=3	2.4	6.1

Table G-1. (*continued)* Spatial variability of water quality core parameter data from the Rito de los Frijoles in Bandelier NM, 2006–2013. Sites are listed in order from upstream to downstream.

Core parameter	Site name	Site code	2006–2010 median	2012	2013
	Hoodoo	RIT04	6.1, n=4	10.7	3.0
	Rito de los Frijoles above Wilderness Boundary	RIT03	4.0, n=4	13.6	2.4
	Rito de los Frijoles near Visitor Center	RIT01	3.5, n=6	16.7	2.1
	Below Lower Falls	RIT22	6.8, n=5	—	—
Water temperature	Upper Frijoles - East Fork	RIT84	10.6, n=8	12.8	10.5
	Upper Frijoles - West Fork	RIT86	8.6, n=8	13.1	16.3
	Upper Frijoles - Confluence	RIT75	12.1, n=8	13.0	12.6
	Upper Upper Crossing	RIT71	12.4, n=7	14.9	13.6
	Above Burn	RIT64	12.2, n=7	16.6	14.0
	Rito de los Frijoles at Upper Crossing	RIT02	10.3, n=5	21.7	22.3
	Narrows	RIT05	12.5, n=6	18.3	18.6
	Hoodoo	RIT04	10.0, n=5	15.5	16.1
	Rito de los Frijoles above Wilderness Boundary	RIT03	10.8, n=5	16.4	17.3
	Rito de los Frijoles near Visitor Center	RIT01	9.9, n=7	10.8	17.1
	Below Lower Falls	RIT22	13.2, n=4	—	—

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

Table H-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	EPTC	20
2,4,5-TP	10	Ethoprop	10
2,4-D	10	Fipronil	20
3-Hydroxycarbofuran	10	Fipronil sulfide	10
Acetochlor	20	Hexazinone	10
Acetochlor OA	20	Imazaquin	20
Alachlor	20	Imazethapyr	10
Alachlor OA	50	Imidacloprid	20
Aldicarb	10	Linuron	20
Aldicarb sulfone	20	Malathion	10
Aldicarb sulfoxide	10	MCPP	20
Atrazine	10	Metalaxyl	10
Atrazine de-ethyl	20	Methiocarb	10
Atrazine de-isopropyl	20	Methomyl	20
Atraton	50	Metolachlor	10
Azoxystrobin	20	Metolachlor ESA	20
Bentazon	10	Metribuzin	20
Bromacil	50	Monuron	10
Bromoxynil	10	Neburon	50
Butachlor ESA	10	Oryzalin	20
Carbaryl	10	Oxamyl	10
Carbofuran	10	Pentachlorophenol	50
Chlorimuron ethyl	20	Prometon	10
Cyanazine	10	Propachlor	10
3-Hydroxycarbofuran	10	Propachlor ESA	20
Dacthal monoacid	20	Propazine	50
Diazinon	10	Propiconazole	20
Dichloroprop	10	Propoxur	10
Dimethachlor	10	Simazine	20
Dimethenamid	10	Sulfometuron methyl	20
Dimethenamid ESA	20	Tebuconazole	50
Disulfoton sulfone	20	Tebuthiuron	10
Diuron	50	Terbuthylazine	10
Diuron Metabolite	50	Thiamethoxam	20

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

Analyte	Reporting limit (ng/L)	Analyte	Reporting limit (ng/L)
Acebutolol	10.0	Fenbufen	10.0
Albuterol	10.0	Fentanyl	10.0
Alprazolam	10.0	Flunitrazepam	10.0
Amitriptyline	10.0	Furosemide	10.0
Amitriptyline, (+/-)-E-10-hydroxylated	10.0	Gabapentin	25.0
Amphetamine	10.0	Gemfibrozil	10.0
Atenolol	10.0	Glipizide	10.0
Atrazine	10.0	Glyburide	10.0
Benzoylecgonine	10.0	Hydrocodone	10.0
Benzphetamine	10.0	Hydromorphone	10.0
Bezafibrate	10.0	m-Hydroxybenzoylecgonine	10.0
Brombuterol	10.0	Ibuprofen	10.0
Butabarbital	25.0	Levorphanol	10.0
Butalbital	10.0	Loratadine	10.0
n-Butylparaben	25.0	Mefenamic acid 3-carboxy	10.0
Carbamazepine 10,11 epoxide	10.0	MDA	10.0
Caffeine	10.0	MDEA	10.0
Cannabidiol	25.0	MDMA	10.0
Cannabinol	25.0	Meperidine	10.0
Carbamazepine	10.0	Mephobarbital	25.0
Carisoprodol	10.0	Meprobamate	10.0
Chloramphenicol	10.0	Metformin	10.0
Chlordiazepoxide	10.0	Methamphetamine	10.0
Chlorpheniramine	10.0	Methaqualone	10.0
Cimetidine	10.0	Methylparaben	10.0
Clenbuterol	10.0	Methyprylon	10.0
Clobazam	10.0	Metoprolol	10.0
Clonazepam	10.0	Monensin	10.0
Clonidine	10.0	Morphine	10.0
Cocaethylene	10.0	Naproxen	10.0
Cocaine	10.0	Nifedipine	10.0
Codeine	10.0	Nifedipine oxidized	10.0
DEET	10.0	Nitrazepam	10.0
Dextromethorphan	10.0	Norfentanyl	10.0
Diazepam	10.0	Norfluoxetine	10.0
Diclofenac	10.0	Norverapamil	10.0
aDiltiazem	10.0	Omeprazole	10.0
Diphenhydramine	10.0	Oxycodone	10.0
Ecognine Methyl Ester	10.0	Oxymorphone	10.0
Erythromycin	10.0	Paroxetine	10.0

Table H-2. (*continued*) 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)
Famotidine	10.0	Pentazocine	10.0
Fenbendazole	10.0	Phencyclidine	10.0
Phendimetrazine	10.0	Talbutal	25.0
Phenmetrazine	10.0	Temazepam	10.0
Phenobarbital	10.0	Testosterone	10.0
Phentermine	10.0	(+/-)11-nor-9-carboxy-delta-THC	10.0
Phenylpropanolamine	10.0	THC	25.0
Phenytoin	10.0	Thebaine	10.0
Pindolol	10.0	Thiabendazole	10.0
Prazepam	10.0	Tramadol	10.0
Progesterone	10.0	Trazodone	10.0
Propranolol	10.0	Triamterene	10.0
Pseudoephedrine	10.0	Triazolam	10.0
Ranitidine	10.0	Triclocarban	10.0
Secobarbital	10.0	Triclosan	10.0
Sildenafil	10.0	Trimethoprim	10.0
Simvastatin	10.0	Tylosin	10.0
Sotalol	10.0	Venlafaxine	10.0
Sulfamethazine	10.0	Verapamil	10.0
Sulfamethoxazole	10.0	Warfarin	10.0
Sumatriptan	10.0		

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

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

Appendix I: 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
µg/L	micrograms per liter
µS/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
pCi/L	picocuries per liter, unit used for the intensity of radioactivity in a sample of radioactive material
pCI/g	picocuries per gram, unit used for the intensity of radioactivity in a sample of radioactive material
P	chemical symbol for the element phosphorous

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