



Water Quality Monitoring for the Mancos River in Mesa Verde National Park

2012–2013 Summary Report

Natural Resource Data Series NPS/SCPN/NRDS—2016/1221



ON THE COVER

Mancos River in Mesa Verde National Park, February 2014

Photography by SCPN

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

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

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

1.2 Water quality monitoring at Mesa Verde National Park

The Mancos River is a perennial stream flowing from the La Plata Mountains in southwestern Colorado to its confluence with the San Juan River in northwestern New Mexico. Approximately 6 km of the river flow along the eastern boundary of Mesa Verde National Park (MEVE). Upstream from the park, Jackson Gulch Dam and numerous diversions in the Mancos Valley reduce the amount of Mancos River flow that reaches the park (Colorado Water Trust 2011). In August of 2000, the NPS, in cooperation with the United States Geological Survey (USGS), installed a streamflow gaging station on the Mancos River within MEVE (Figure 1).

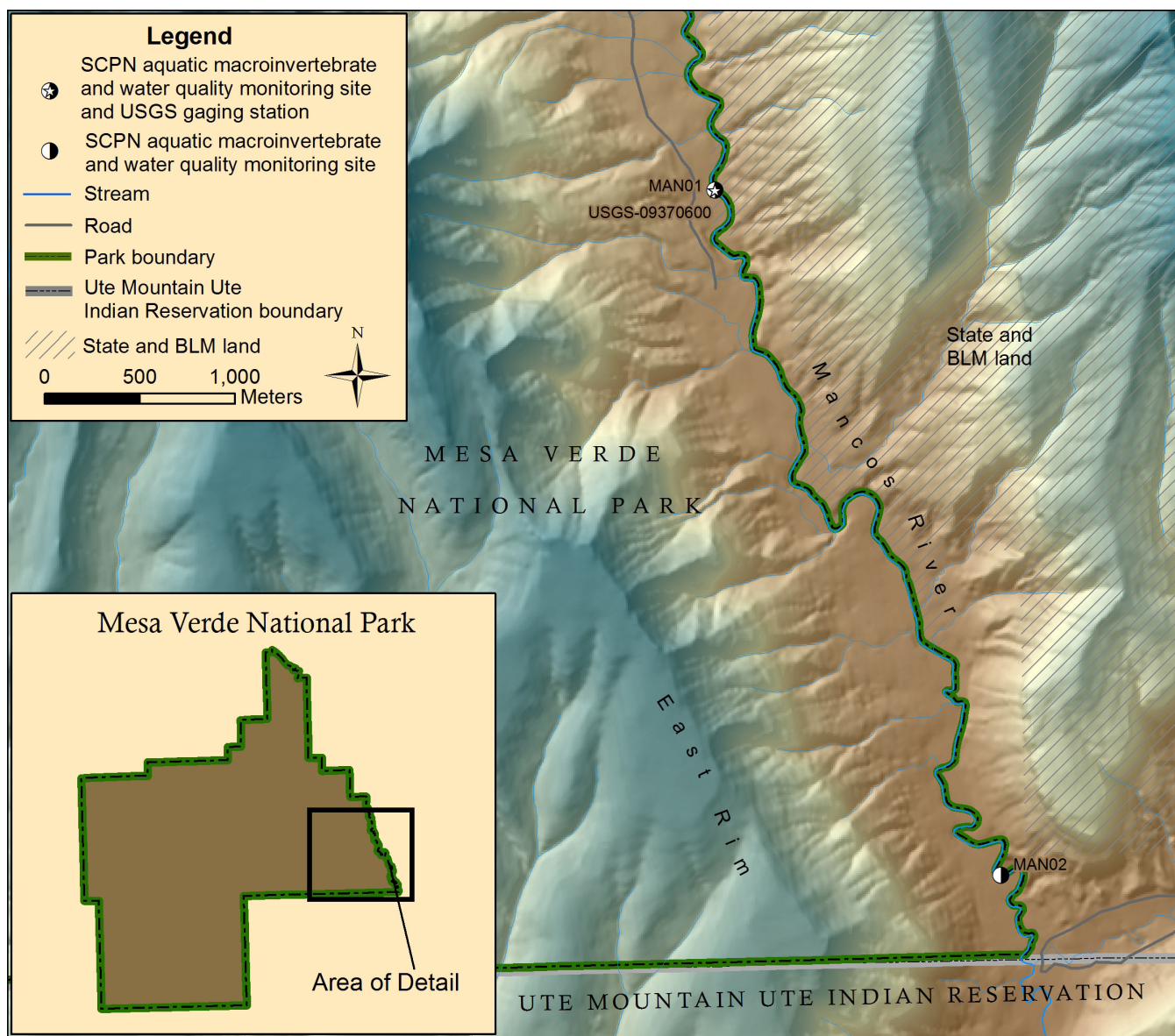


Figure 1. Map of the Mancos River, Mesa Verde NP, Colorado, with the location of Southern Colorado Plateau Network's aquatic macroinvertebrate and water quality monitoring sites MAN01 and MAN02 visited in 2012 and 2013.

Water quality concerns within the park include insecticide, algicide, and herbicide applications (Brown 2008). Adjacent agriculture and sewage-treatment facilities have been sources of nutrient and bacterial contamination (Thomas et al. 2006). Irrigation practices along the Mancos River and its tributaries may be contributing to their elevated salinity levels (Yochum 2004). Drought and wildfire have also affected the river. In 2000, a high-intensity

fire burned portions of the watershed in MEVE; fire retardant drops during the fire resulted in fish kills in the Mancos River (San Miguel, G., Natural Resource Manager, Mesa Verde NP, personal communication, 28 July 2011). For more than a century mining activities in the Mancos River watershed have potentially mobilized metals and other contaminants into the river. Most recently an illegal gold processing mill near the Town of Mancos released large quantities of mercury and other contaminants into the environment close to the Mancos River (Weston Solutions, Inc. 2014). In 2012, the Weber Fire burned 10,000 acres outside nearby Mancos, CO. The Ute Mountain Ute Tribe has been restocking an average of 12,000 native fish each year to the Mancos River downstream from MEVE since 2003 (Larrick and Ashmore 2014).

Data documenting water quality conditions in the Mancos River are sparse. The most recent samples collected in the park were part of a Level 1 water quality inventory of water bodies in SCPN parks completed by the USGS in 2005 and 2006 (Macy and Monroe 2006). An assessment of the functional condition of the Mancos River conducted in 2006 found high concentrations of algal blooms, a possible indicator of poor water quality (Stacey 2007), and probably caused by a combination of high solar exposure and the wide, shallow channel near MAN01. The Ute Mountain Ute Tribe conducted a water quality assessment of nutrients, metals, *E. coli*, stream habitat, and macroinvertebrates for 2011–2012 in the Mancos River downstream from MEVE, which included samples of post-fire runoff. Occasional high levels of selenium, aluminum, iron, copper, and *E. coli* were found (Larrick and Ashmore 2014).

In 2010, SCPN implemented water quality monitoring at two sites on the Mancos River in MEVE:

- *Mancos River at Gage* (MEVEMAN01), identified in this report as MAN01 (Appendix A), was established in 2010 as SCPN's primary water quality monitoring site. The site is co-located with a SCPN aquatic macroinvertebrate monitoring site and the USGS streamflow gaging station Mancos River at Anitas Flat below Mancos, CO (USGS 09370600).
- *Mancos River above Downstream Park Boundary* (MEVEMAN02), identified in this report as MAN02, is co-located with a SCPN aquatic macroinvertebrate monitoring site. NPS core water quality are collected here once each year, concurrently with SCPN aquatic macroinvertebrate monitoring. The site is on a large bend in the river near the downstream park boundary.

SCPN collects core water quality data and water quality samples at regular intervals throughout the year. Diurnal variation in NPS core water quality parameters are characterized by deploying a multi-parameter sonde to collect data for as many days as possible during base flows. Water quality samples are analyzed by SCPN staff and by a qualified contract laboratory.

In 2012, SCPN staff made seven water quality sampling visits to MAN01 and one to MAN02. In 2013, water quality sampling visits to MAN01 were reduced to four quarterly visits. MAN02 was not visited in 2013. This report documents SCPN water quality monitoring activities at MEVE in 2012 and 2013 and summarizes the data collected.

2 Methods

A brief description of water quality data collection and processing procedures followed by SCPN staff at MEVE during 2012 and 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, The SCPN Water Resources field crew noted the hydrologic conditions and collected water quality core parameter data using the following methods:

- Water and air temperatures are recorded at 15-minute intervals by a HOBO Pendant Temperature/Alarm Logger #UA-001-64, and a HOBO TidbiT v2 Water Temperature Data Logger, #UTBI-001 (Onset Computer Corporation) deployed at each monitoring site. The sensors were downloaded and maintenance was performed during each site visit.
- As soon as possible after arriving at the site, SCPN water resources crew calibrated and deployed a multi-parameter sonde (Hydrolab-MS5; Hach Inc.) 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 kept on ice for a maximum time of 24 hours, then analyzed with a HACH 2100P Portable Turbidimeter (Hach Inc.).
- Discharge was measured using a FlowTracker Acoustic Doppler Velocimeter (SonTek Inc.).

In addition, we obtained streamflow data from the USGS website (USGS 2014) for the streamflow gaging station Mancos River at Anitas Flat below Mancos CO (09370600) which documented discharge at 15-minute intervals throughout the year. Per an Interagency Agreement between Mesa Verde NP and the USGS, we provided the USGS data for discharge measurements made during each of our site visits. We attempted to obtain all measurements and samples as close in time to one another as possible.

In addition to the regular site visits, which were usually less than two hours, SCPN deployed a multiparameter sonde at MAN01 from October 5–12, 2012 to collect temperature, pH, specific conductance, and dissolved oxygen data at 30-minute intervals in order to characterize temporal variability.

2.2 Water quality samples

During each site visit, SCPN crew also collected samples to analyze for bacteria; nutrients, major elements and trace metals, and contaminants of emerging concern. We collected bacterial samples by dipping a sample bottle into the center of flow. SCPN staff analyzed the sample for total coliforms and *E. coli* using the Quanti-Tray® 2000 system (IDEXX Inc.).

We collected samples for other analyses in a similar manner. Sample water was filtered and/or acid-treated (as required), kept on ice, and shipped to the contract laboratory. In 2012–2013 SCPN continued an Interagency Agreement with the USGS National Water Quality Laboratory (NWQL) in Denver, Colorado for analysis of water samples for selected water quality constituents (Table 1). Information documenting NWQL methods is included in SOP #8 of the SCPN water quality monitoring protocol (Monroe et al. in preparation).

In 2011, SCPN entered into a partnership with the U.S. Environmental Protection Agency (EPA) to sample at MEVE, GLCA, GRCA, and BAND for a suite of contaminants of emerging concern (CEC), which include pharmaceuticals, personal care products, waste water indicators, and pesticides (Appendix C). We followed the procedures in National Park Service (2013). The purpose is to develop a baseline dataset documenting the occurrence of these contaminants within SCPN parks. This was continued in 2012 and 2013 with three sampling

Table 1. USGS 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	pharmaceuticals, personal care products, waste water indicators, pesticides

events each year between the months of April and November. Samples were kept on ice and analyzed at the EPA Region 8 Laboratory in Golden, Colorado 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 electronic data, discharge, and temperature logger files are stored on the SCPN server. In this report, we include the median values of a subset of seven consecutive multiparameter sonde measurements, with the exception of the data presented in Table 4. Similarly, only the median values for each set of turbidity triplicate samples are presented.

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

Where applicable, we compared our results against the State of Colorado's 2013 surface water quality standards and the standards specific to the Mancos River (Colorado Department of Public Health and Environment [CDPHE] 2013 and 2014). We noted any exceedences of the applicable standards.

2.4 Understanding water quality data and standards

The NPS Natural Resource Challenge (NRC) provides funding for water quality monitoring in NPS park units. This funding is intended to advance NPS's long-term goals to protect pristine water quality and improve impaired water quality in parks by supporting Clean Water Act protections and provisions for designated unimpaired and impaired waters. Preliminary analysis of data available through the water quality data synthesis (Brown 2008), a Level 1 water quality inventory (Macy and Monroe 2006), and SCPN 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 quarterly to document the range of hydrologic conditions that occur in network parks. Thus, rare and short-term events may not be captured. These "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 Colorado has developed statewide water quality standards and criteria for surface waters, as well as specific additional criteria relevant to the reach of the Mancos River within MEVE (CDPHE 2013 and 2014). This report includes all water quality standards and criteria applicable to the Mancos River. A water quality standard refers to a specific parameter and its associated beneficial-use designation, in conjunction with a criterion, which is the numeric component against which a result is compared. For example, the standard for chronic selenium (parameter) for aquatic life (beneficial use designation) is 4.6 µg/L (numeric criterion). This criterion is for dissolved samples.

All of SCPN samples are filtered through a 0.45 µm filter to remove the particulate component of the sample before it is shipped for analysis of the dissolved fraction. Most aquatic life criteria for metals are based on the dissolved fraction. This method more accurately measures the form of metals that is most toxic to aquatic life while excluding less toxic forms. However, not all Colorado state water quality criteria are based on dissolved samples—the criteria for agriculture, domestic water supply, some metals, and others are for the total sample, 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. Because of this, only the criteria for dissolved parameters are listed in the Results section of this report. However, we note when concentrations of dissolved samples exceed the criterion for total concentration samples.

For this report, results for each water quality parameter measurement were evaluated against applicable water quality standards as defined by the State of Colorado. Colorado surface waters can have up to five beneficial use classifications. Four beneficial uses are identified for the relevant reach of the Mancos River and are discussed in this report: Class 1 warm water aquatic life and agriculture, water supply, and recreation (Class N from Nov. 1 to April 30, and Class E from May 1 to Oct. 31) (CDPHE 2014). Each beneficial use may have different criteria for one parameter. In this report, we present only the lowest applicable criteria.

For *E. coli*, we compared our results against the criteria for Class N (not primary contact use) and Class E (existing primary contact use) recreation, depending upon the time of year the samples were collected. The Colorado 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 Colorado 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). Acute criteria are based on either a single sample or an average of samples collected during a one-day period. 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. This is because chronic standards are based on either a single representative sample or the average of all samples collected during a thirty-day period (CDPHE 2013); the exact number of samples is not specified. When determining whether or not a sample meets 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 criteria, can provide evidence of a problem that may require more attention. Therefore, we have identified when results are outside the chronic criterion 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 beneficial use. This report compares water quality data to deneficial use criteria without stating whether a beneficial 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 jurisdiction.

3 Results

3.1 Mancos River

3.1.1 Water quality core parameter data

Summary statistics for water quality core parameter data collected at MAN01 and MAN02 during 2012 and 2013 are presented in Table 2 and Table 3; 2010 and 2011 data for both sites are included for comparison. Complete results for MAN01, 2012–2013, are provided in Appendix B. Measurements at MAN02 were collected on October 4 and were similar to those collected at MAN01 on October 5. At MAN01, the data exhibited considerable within- year variability for several parameters (Table 2), but there were no exceedances of Colorado state water quality standards at MAN01 or MAN02 during our site visits (CDPHE 2013, 2014).

Water and air temperature data from temperature loggers at MAN01 in 2012 and 2013 are summarized here and shown in Figure 2, along with the data for 2010 and 2011. The water temperatures indicate the Mancos River thawed on January 24, 2012 and froze on December 22, 2012. In 2013, the river thawed on February 2 and froze for a few days in the beginning of December. In 2012, the maximum water temperature was 31.1°C, occurring on July 19, and the average water temperature was 10.0°C. In 2013, the maximum water temperature was 32.4°C,

Table 2. Summary of water quality core parameter data from site visits to MAN01 on the Mancos River in Mesa Verde NP in 2012 (n=7) and 2013 (n=4, except for discharge, where n=3). Associated Colorado State aquatic life criteria are indicated for each parameter; “nc” means that no criteria have been developed for a specific parameter. Data from 2009–2011 (n=19, except for turbidity and discharge, for which n=17) are included for comparison.

Core parameter	2009–2011		2012		2013		CO State aquatic life criteria
	Median	Range	Median	Range	Median	Range	
Water temperature (°C)	7.3	0.0–25.2	6.1	0.5–18.0	11.1	(-)0.3–21.8	^a
pH	8.2	7.9–8.6	8.2	8.0–8.4	8.3	8.2–8.5	>6.5 or <9
Specific conductance (µS/cm)	1260	282–2210	1410	535–2190	1840	1530–1970	nc
Dissolved oxygen (mg/L)	9.4	6.8–11.4	9.74	7.4–11.4	9.2	7.5–11.1	>5
Turbidity (NTU)	14.5	1.7–150	21	1.7–19,850	9.9	3.6–171	nc
Discharge (cfs)	20.7	4.6–269	8.8	0.6–37.8	3.5	1.3–7.9	nc

^a See section 3.1 for an explanation of CO water temperature criteria.

Table 3. Water quality core parameter data from site visits to MAN02 on the Mancos River in Mesa Verde NP in 2010 and 2011 (n=2), and concurrently with the collection of aquatic macroinvertebrate monitoring on October 4, 2012 (n=1). The associated Colorado state aquatic life criteria are indicated for each parameter; “nc” indicates that no criterion has been developed for a specific parameter.

Core parameter	2010–2011	2012	CO State aquatic life criterion
Water temperature (°C)	13.4–14.4	11.0	^a
pH	8.3–8.4	8.4	>6.5 or <9
Specific conductance (µS/cm)	1280–1330	1990	nc
Dissolved oxygen (mg/L)	8.5–8.6	9.2	>5
Turbidity (NTU)	9–18	3.1	nc
Discharge (cfs)	10.4–10.8	0.8	nc

^a See section 3.1 for an explanation of CO water temperature criteria

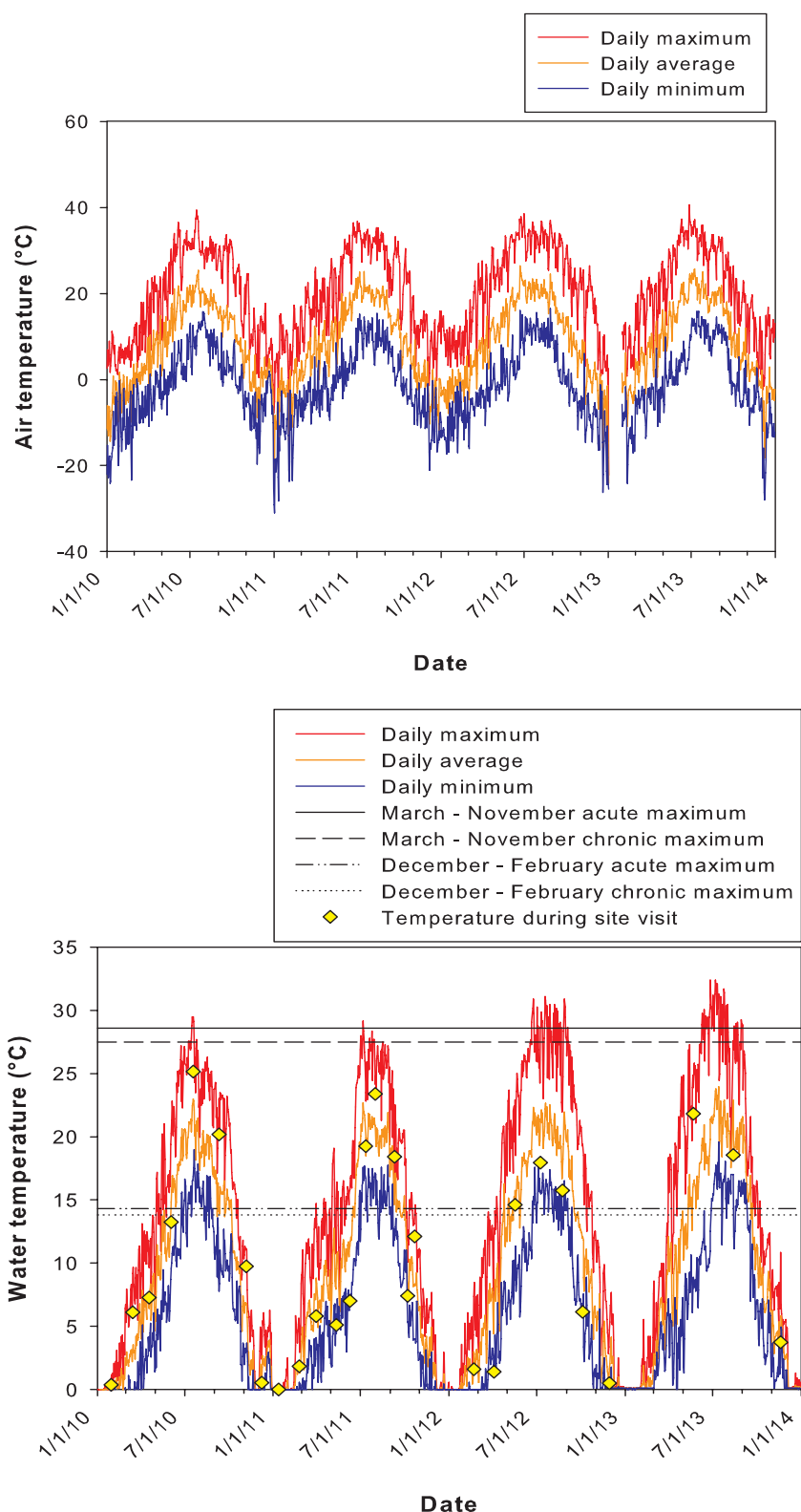


Figure 2. Daily maximum, average, and minimum air temperatures (top) and water temperatures (bottom) at MAN01 at the Mancos River in Mesa Verde NP, 2010–2013. Air temperature data are missing from 1/3–1/30/13 due to battery failure.

occurring on June 27, and the average was 9.8°C.

In 2012, the maximum air temperature was 38.5°C on July 1, while the minimum temperature of -26.2°C occurred on December 20. The average air temperature for the year was 8.8°C. In 2013, the maximum air temperature was 40.6°C on June 27, and the minimum temperature was -27.9°C, which occurred on December 9. However most of the January data was not recorded because the batteries failed on the temperature logger, and so the yearly average was not calculated.

This section of the Mancos River is designated by the State of Colorado as a Class 1–Warm Water Biota stream. There are three “tiers” of temperature standards, depending on the assemblage of fish species expected to occur. The Mancos River is subject to the Tier II criteria, which include both acute and chronic standards (CDPHE 2013, 2014). The acute criteria are 14.3°C from December through February and 28.6°C from March through November. The lower acute criterion was not exceeded, but the higher criterion was exceeded on 20 days between June and August in 2012, and on 32 days between June and August in 2013. The chronic criteria are 13.8°C from December through February, and 27.5°C from March through November. River temperatures did not exceed the chronic criteria in 2012 or 2013.

Measured pH at MAN01 was relatively consistent over the two years, ranging from 8.0 to 8.5. All measurements were within the Colorado state water quality criteria of >6.5 and <9.0 (CDPHE 2013).

Specific conductance at MAN01 ranged between 528 and 2190 $\mu\text{S}/\text{cm}$, with median values of 1410 $\mu\text{S}/\text{cm}$.

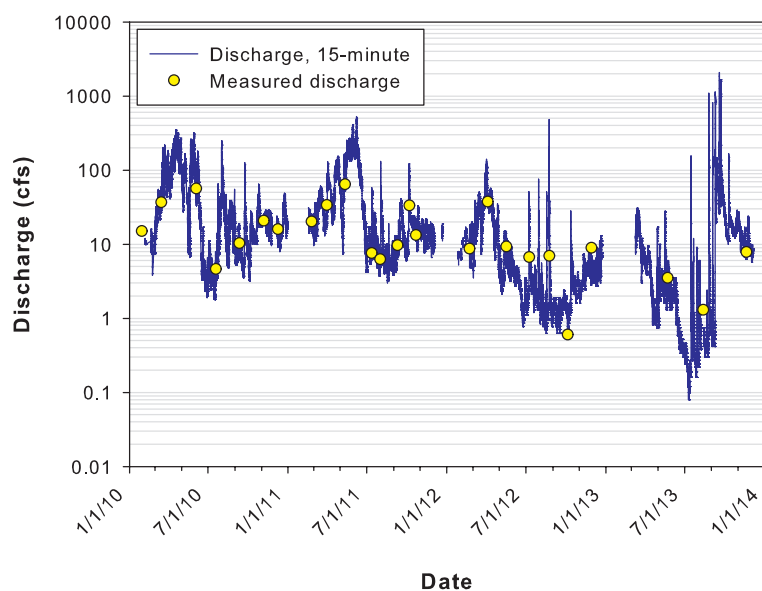


Figure 3. 15-minute discharge data from the streamflow gaging station Mancos River at Anitas Flat below Mancos, CO (09370600) at MAN01 on the Mancos River in Mesa Verde NP, 2012–2013. SCPN measured discharge is in yellow. The gaps in the data were due to the river being frozen during the winter months.

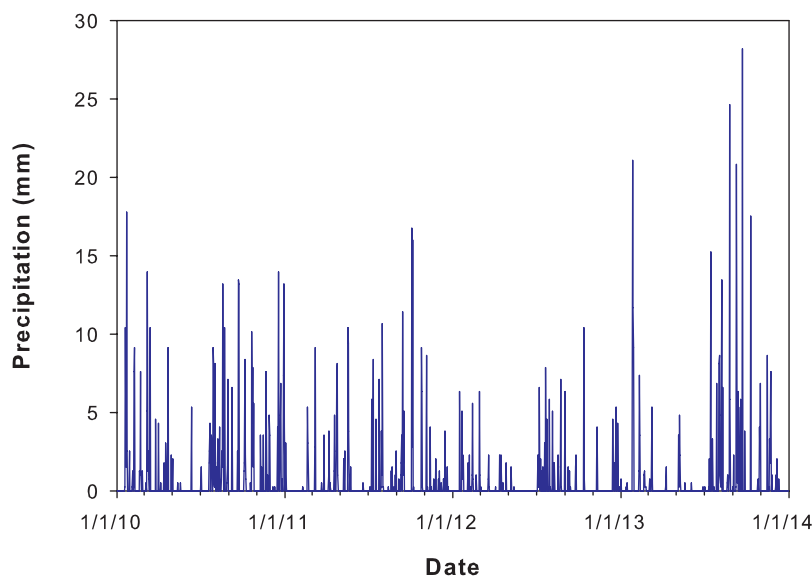


Figure 4. Daily precipitation from the CSU/USDA weather station (MNC01) at Mancos, Colorado, 2011–2013; and NOAA/NCDC weather station (055327), 2010.

3.1.2 Precipitation

Precipitation data was obtained from Colorado State University and the USDA Agricultural Research Service

cm in 2012 and 1840 $\mu\text{S}/\text{cm}$ in 2013. The lowest measurement corresponded with a snowmelt period where stream discharge was slightly higher than normal. The highest measurement occurred when stream discharge was much lower than normal.

Dissolved oxygen ranged between 7.4 and 11.4 mg/L, well above the minimum warm-water standard applicable to MAN01 (5 mg/L, CDPHE 2013). All measurements were close to 100% saturation. The highest measurements occurred when the river was close to freezing, while the lowest occurred during the spring and summer months.

Turbidity levels ranged between 1.7 and approximately 19,850 NTU; the highest measurement occurred on August 24, 2012, a day after a thunderstorm and flash flooding occurred in the Mancos Valley. Median values were 21 NTU in 2012 and 9.9 NTU in 2013.

We measured the discharge of the Mancos River during each water quality sampling visit, with the exception of our sampling visit on 1/31/2013 when the river was frozen. Measured flows ranged from 0.6 to 37.8 cfs in 2012, and 1.3 to 7.8 cfs in 2013. Figure 3 shows stream discharge for 2012 and 2013. The hydrograph from the gaging station shows a period of higher flow in March and April 2012, and flows exceeded 100 cfs during portions of four days. No such snowmelt period was observed in 2013, and discharge fell below 1 cfs for much of the summer, with the exception of brief increases caused by rain. In contrast, the snowmelt periods in 2010 and 2011 continued well into June and featured several weeks of discharge exceeding 100 cfs. The highest discharge each year was 486 cfs on August 23, 2012 and 2080 cfs on September 18, 2013.

Water Management Unit, which together operate a weather station in the town of Mancos (MNC01), approximately 8 km from MAN01. Daily precipitation for 2010–2013 is plotted in Figure 4. The 2010 data was obtained from a National Oceanic and Atmospheric Administration/National Climatic Data Center weather station (055327) (NOAA/NCDC 2011) in the town of Mancos. The 2011–2013 data was obtained from Colorado State University and the USDA Agricultural Research Service Water Management Unit, which together operate a weather station in the town of Mancos (MNC01), approximately 8 km from MAN01 (CoAgMet Data Access 2014). For 2012 the station recorded only 160 mm of precipitation. Most of the precipitation occurred in the winter and summer seasons, and only one precipitation event exceeded 10 mm. In contrast, there was 330 mm of precipitation in 2013 with several large precipitation events occurring in the summer and fall. That year, eight precipitation events exceeded 1 cm. In both years, the bulk of the precipitation occurred in the summer.

3.1.3 Temporal variability of water quality core parameter data from the Mancos River in Mesa Verde NP

To assess temporal variability in core water quality parameters at MAN01, a multi-parameter sonde was placed in the stream to record data at 30-minute intervals from October 5–12, 2012. These data are shown in Figure 5 along with the stream gage data. Diel fluctuations in temperature averaged 12.1°C during this time period. Fluctuations in pH averaged only 0.1. Specific conductance measurements were higher than the field measurements taken at other sites during both years—the overall range during the deployment was 1960–2270, and daily ranges averaged 111 µS/cm. These measurements coincided with a period of time where base flows in the Mancos River were much lower than those encountered during other site visits in 2012 and 2013. Median discharge was only 1.2 cfs during this week. Daily changes in dissolved oxygen averaged only 2.3 mg/L. Table 4 summarizes the variability in water temperature, dissolved oxygen, pH, and specific conductance during the 7-day deployment.

Table 4. Summary of water quality core parameter temporal variability at MAN01 on the Mancos River in Mesa Verde NP, October 5–12, 2012.

Core parameter	Minimum	Maximum	Median
Water temperature (°C)	1.7	18.8	10.0
Dissolved oxygen (mg/L)	7.8	10.9	8.8
pH	8.1	8.3	8.2
Specific conductance (µS/cm)	1960	2270	2130
Discharge (cfs)	0.6	4.8	1.2

3.1.4 Total coliforms and *E. coli*

Bacteria data collected at MAN01 in 2012 and 2013 are presented in Figure 6 and listed in Appendix B; data from 2010 and 2011 are included in Figure 6 for comparison. 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 Colorado state criteria values for *E. coli* are based on the geometric mean of at least four evenly-distributed samples collected over a 60-day period. The criteria applicable at MAN01 are 126 cfu/100 mL from May through October and 630 cfu/100 mL from November through April (CDPHE 2014). Total coliforms are also included in the IDEXX analyses. 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 the standard diagnostic test because their presence indicates contamination of a water supply by an outside source. There are no water quality criteria for total coliforms.

E. coli levels were highest in a sample collected on 8/24/12 and exceeded 2400 MPN/100 mL, the maximum detection level of the IDEXX test. This sample was collected one day after an intense thunderstorm occurred

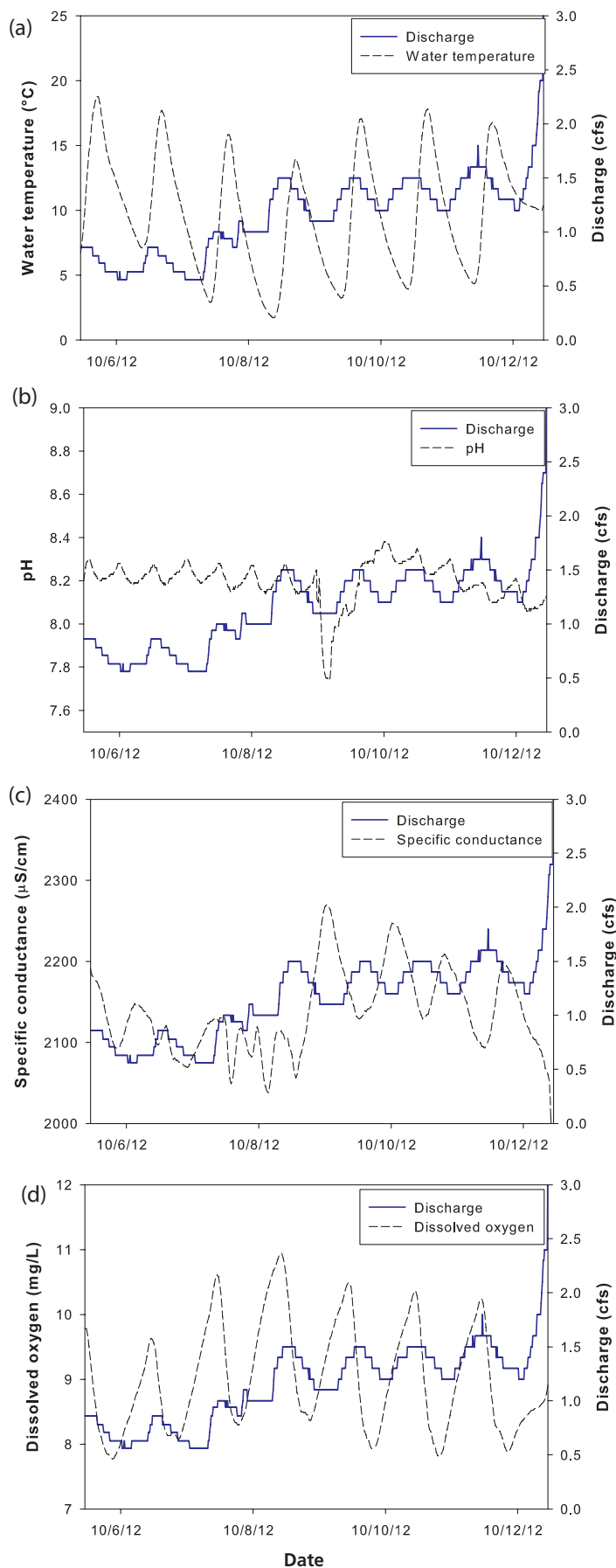


Figure 5. Multiparameter sonde data measured at 30-minute intervals during a 7-day period starting October 5, 2012 at MAN01 on the Mancos River in Mesa Verde NP: water temperature (a), pH (b), specific conductance (c), dissolved oxygen (d). Discharge data is from the streamflow gaging station Mancos River at Anitas Flat below Mancos, CO (09370600)(USGS 2014).

upstream from the sample site and resulted in a peak flow of 486 cfs, which drastically increased turbidity in the river. *E. coli* results exceeded the Colorado State criterion of 126 MPN/100 mL in three other instances, in July 2012, May 2013, and August 2013. However, our sampling was not frequent enough to assess compliance with the water quality standard because four samples are needed within a two month period. Total coliform results ranged from 108 MPN/100 mL to >2400 MPN/100 mL. Total coliforms exceeded 2400 MPN/100 mL in July 2012, August 2012, and August 2013.

3.1.5 Water quality laboratory data

SCPN collected seven water samples at MAN01 in 2012 and four in 2013 at regular intervals throughout the year. All samples were sent to the NWQL to be analyzed for a suite of analytes (Table 1). Laboratory results for water samples are summarized in Tables 5–7; complete results are presented in Appendix B.

Nutrient concentrations (Table 5) were very low at all times of the year and were usually not detected except during the winter months. When detected, levels were close to the laboratory reporting levels, which were 0.0100 for ammonia, 0.040 for nitrate plus nitrite, 0.00100 for nitrite, and 0.00400 orthophosphate. There were no exceedances of Colorado state standards for nutrients.

Major element data, which includes major ions, silica, acid neutralizing capacity, and total dissolved solids, are summarized for MAN01 in Table 6. Total dissolved solids, which mainly consist of the ions listed in Table 6 plus carbonate/bicarbonate, varied over the two years from 369 mg/L to 1690 mg/L, with a median concentration of 1250 mg/L. In 2014, a drinking water supply (DWS) designation was added to this reach of the Mancos River, which extends from US160 in Mancos to the Ute Reservation boundary. As a result of the DWS designation, the water+fish standards now apply.

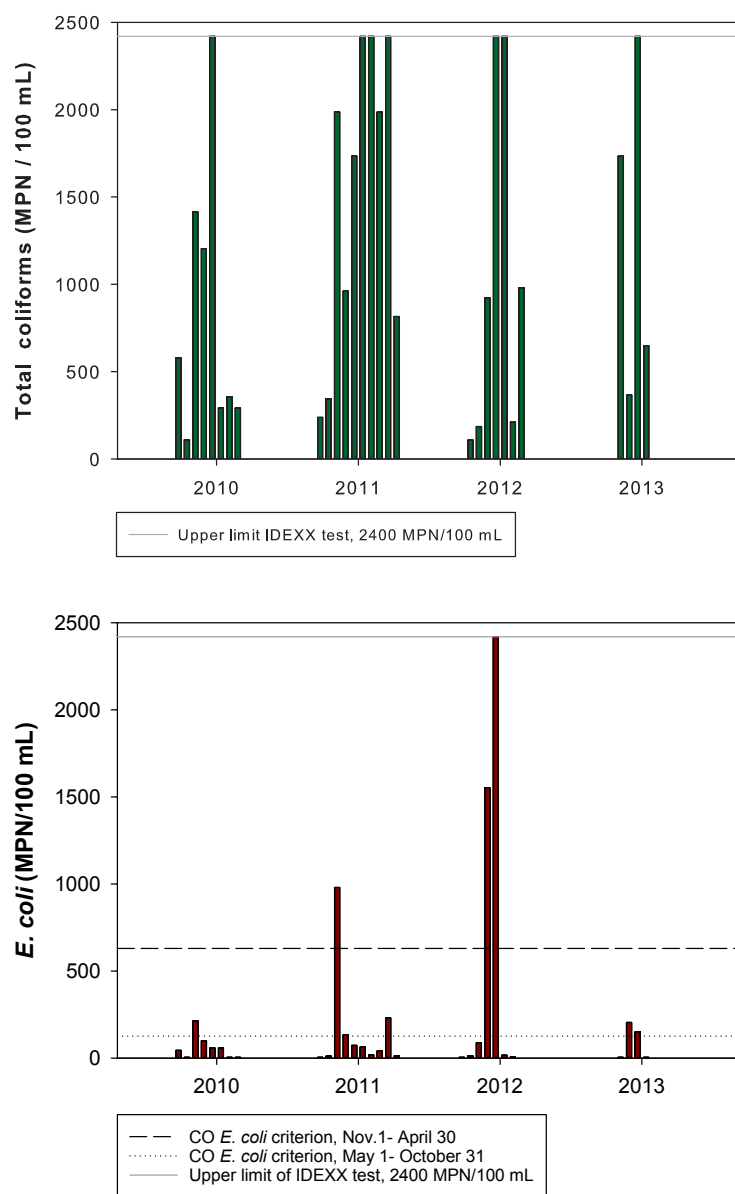


Figure 6. Total coliforms (top) and *E. coli* data (bottom) in samples collected from MAN01 on the Mancos River in Mesa Verde NP, 2010–2013.

Table 5. Summary of dissolved nutrient data for water quality samples collected at MAN01 (n=11) on the Mancos River in Mesa Verde NP, 2012–2013, and number of times that the samples exceeded the applicable water quality criteria. A “nc” indicates that no criteria have been developed for a particular nutrient, and a “ndc” indicates there is no dissolved criterion. Results that were lower than the National Water Quality Laboratory reporting levels are noted as “<[reporting level]”.

Nutrients	Minimum (mg/L)	Maximum (mg/L)	Median ^a (mg/L)	Standard deviation ^a	Most stringent criterion (mg/L)	# of exceedances	Beneficial use
Ammonia as N	<0.0100	0.236	n/a	n/a	ndc	ndc	ndc
Nitrite + nitrate as N	<0.040	0.308	n/a	n/a	ndc	ndc	ndc
Nitrite as N	<0.00100	0.0228	n/a	n/a	0.05	0	aquatic life
Orthophosphate as P	<0.00400	0.0129	n/a	n/a	nc	nc	nc

^aMedians and standard deviations not calculated when more than 70% of the results fell below the reporting level

The DWS criteria are expressed as the total concentration and the SCPN water results represent the dissolved concentration. Our results for chloride and fluoride did not exceed the criteria, but because our results are based on the dissolved fraction they cannot be used to evaluate compliance with the DWS standard. However, our sulfate results exceeded the DWS criterion of 250 mg/L in 10 out of 11 samples. Results ranged from 182 mg/L to 1070 mg/L, with a median of 761 mg/L.

Figure 7 depicts the major ion composition at MAN01 as the percentage of total milliequivalents per liter, for all water sampling events. In all but one sample, anions consisted mainly of sulfate and, to a much lesser extent, bicarbonate. The one anomalous sample was collected on 8/24/12, one day after a flash flood on the Mancos River. In this sample, the majority of the anions consisted of bicarbonate. Cation composition was more evenly mixed, with calcium comprising the highest proportion, followed by magnesium, then sodium. Potassium was the least prevalent cation. With the exception of the 8/24/12 sample, these results were similar to those obtained in previous years.

Table 7 reports the dissolved trace metals analyzed in samples collected at MAN01 in 2012 and 2013. Most trace metals measured below the applicable water quality criteria except for arsenic and selenium (CDPHE 2014). In 2014, the water+fish standard was applied to the Mancos River, and the total recoverable arsenic criterion is 0.02 µg/L. The eleven results, which were based on dissolved

Table 6. Summary of dissolved major element data for water quality samples collected at MAN01 (n=11) on the Mancos River in Mesa Verde NP, 2012–2013. The Colorado state water quality criteria for these analytes are based on the total sample concentration. However, for sulfate, the dissolved concentration was much higher than the total sample criterion and data showed 10 exceedances of that criterion, so we have included it in this table. A “nc” indicates that no criterion has been developed for a particular analyte. A “ndc” indicates there is no dissolved criterion for the analyte. See section 2.4 for an explanation of water quality criteria.

Major elements	Minimum (mg/L)	Maximum (mg/L)	Median (mg/L)	Standard deviation	Lowest criteria	# of exceedances	Beneficial use
Calcium	66.5	277	193	55.6	nc	nc	nc
Chloride	3.55	23.1	13	4.93	ndc	ndc	ndc
Fluoride	<0.150	0.262	0.193	0.048	ndc	ndc	ndc
Magnesium	22.5	120	79.6	28.3	nc	nc	nc
Potassium	1.43	7.02	3.47	1.49	nc	nc	nc
Silica	6.86	10.4	7.81	1.21	nc	nc	nc
Sodium	20.2	119	74.7	27.1	nc	nc	nc
Sulfate	182	1070	761	252	250, 30-day (total)	10	domestic water supply
Acid neutralizing capacity, as CaCO ₃ (unfiltered)	103	941	222	226	nc	nc	nc
Total dissolved solids	369	1690	1250	368	nc	nc	nc

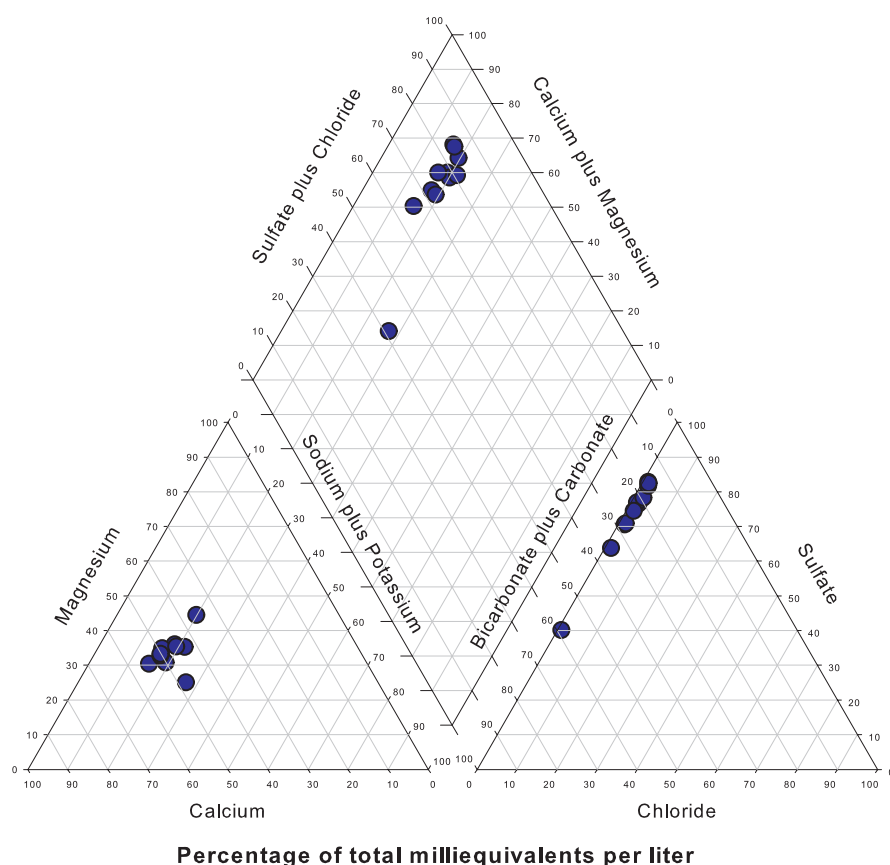


Figure 7. Major ion composition from samples collected at MAN01 on the Mancos River in Mesa Verde NP, 2012–2013.

Table 7. Summary of dissolved trace metal data from samples collected at MAN01 (n=11) on the Mancos River in Mesa Verde NP, 2012–2013, and number of times that the samples were outside the applicable water quality criteria. A “nc” indicates that no criteria have been developed for a particular trace metal. A “ndc” indicates there is no dissolved criterion for the trace metal. Results that were lower than the NWQL reporting levels are noted as “<[reporting level]”

Trace metal, dissolved	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Standard Deviation	Most stringent criterion	# of exceedances	Beneficial use
Aluminum	<2.20	57	n/a	n/a	ndc	ndc	ndc
Antimony	<0.108	0.319	0.129	0.068	5.6	0	water + fish
Arsenic	0.286	1	0.48	0.234	0.02	11	water + fish
Barium	37.7	141	42.6	30.0	ndc	ndc	ndc
Beryllium	<0.040	<0.040	n/a	n/a	ndc	ndc	ndc
Boron	18.8	127	67	26.0	ndc	ndc	ndc
Cadmium	<0.060	<0.060	n/a	n/a	0.87 - 1.20	0	aquatic life (chronic)
Chromium	<0.600	<0.600	n/a	n/a	162 - 231 (Cr III), 11 (Cr VI)	0	aquatic life (chronic)
Cobalt	0.205	2.8	0.712	0.699	nc	nc	nc
Copper	<0.800	6.27	1.86	1.70	20.2–29.3	0	aquatic life (chronic)
Iron	10.0	70.5	19.5	17.2	300	0	DWS (30-day)
Lead	<0.080	0.406	0.157	0.113	6.97–10.9	0	aquatic life (chronic)
Manganese	18.6	166	38.5	49.4	50,000	0	DWS (30-day)
Mercury	<0.005	<0.005	n/a	n/a	ndc	ndc	ndc
Molybdenum	0.888	5.05	2.85	1.01	ndc	ndc	ndc
Nickel	1.21	3.95	2.67	0.650	116–168	0	aquatic life (chronic)
Selenium	0.656	6.84	2.09	1.92	4.6	2	aquatic life (chronic)
Silver	<0.040	<0.040	n/a	n/a	1.65–3.47	0	aquatic life (chronic)
Uranium	1.45	8.70	5.22	2.44	4283–6915	0	aquatic life (chronic)
Vanadium	0.149	0.906	0.299	0.255	nc	nc	nc
Zinc	<4.00	<5.60	n/a	n/a	288–428	0	aquatic life (chronic)

^aThe median was not calculated because more than 70% of the results fell below the reporting level

arsenic concentrations, ranged from 0.286 to 1.00 µg/L; all in exceedance of the criterion. Six metals—beryllium, cadmium, chromium, mercury, silver, and zinc—were not present above the laboratory reporting levels. Two selenium results exceeded the chronic aquatic life criterion of 4.6 µg/L. Table 7 provides a summary of results and values for the lowest applicable criteria. In some instances, the water quality criteria are based on hardness and, because hardness varied between samples, the actual numeric criteria are expressed as a range.

3.1.6 Contaminants of emerging concern

In 2012–2013, SCPN collected six water samples at MAN01 from April through November to be analyzed by the EPA Region 8 Laboratory for a suite of over 250 contaminants of emerging concern. The complete dataset is in Appendix B, and detections for 13 contaminants, all in ng/L concentrations, are summarized in Table 8. Of these, only the herbicide 2,4-D has a water quality standard, and our result was well below the numeric criterion.

Table 8. Summary of detections of contaminants of emerging concern in samples collected at MAN01 (n=6) on the Mancos River in Mesa Verde NP, 2012–2013.

Contaminant	Use	No. of detections
Pesticides		
2,4-D	herbicide	1
Triclopyr	herbicide	1
Pharmaceuticals and personal care products		
Caffeine	stimulant drug	2
Desmethylvenlafaxine	antidepressant	1
Gabapentin	anticonvulsant, painkiller	3
Hydrochlorothiazide	treats hypertension	1
Metformin	Type-2 diabetes drug used to control blood glucose	3
Sulfamethoxazole	antibiotic	1
Waste indicators		
Bisphenol A	used in the production of polycarbonate plastics and epoxy resins (hard plastic bottles and metal food cans)	1
1-methylnaphthalene	combustion product	1
2-methylnaphthalene	combustion product	1
Phenanthrene	combustion product, used in making drugs	1
Tri(2-butoxyethyl) phosphate	flame retardant, plasticizer in rubber and plastics, used in floor polishes	2

4 Quality Assurance/Quality Control

We followed the Quality Assurance/Quality Control (QA/QC) procedures described in Monroe et al. (in preparation) and in the Water Resources Inventory and Monitoring Program guidance (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.

Following QA/QC procedures, we collected a blank for the Contaminants of Emerging Concern at MEVE. The blank results were considered, as well as the QA/QC results provided by the EPA lab, when making decisions to flag or to exclude data.

5 Summary

In 2010, SCPN implemented long-term water-quality monitoring at MAN01 on the Mancos River in MEVE. Data collected during 11 site visits to MAN01 in 2012–2013 are summarized here and compared against the Colorado water quality standards applicable to this reach of the Mancos River (CDPHE 2013, 2014). Several exceedances were observed for the following parameters: temperature, *E. coli*, sulfate, and arsenic. Core parameter data was collected at MAN02 on 4 October 2012 and did not exceed water quality standards.

We made site visits at regular intervals throughout the year, capturing a variety of different seasonal and flow conditions. Discharge at the time of sample events ranged from 0.6 to 37.8 cfs, though discharge throughout the two years was generally very low with short periods of very high flow, particularly in 2013. Turbidity ranged from 1.7 to approximately 19,850 NTU. Specific conductance ranged from 535–2190 $\mu\text{S}/\text{cm}$. Dissolved oxygen measurements ranged from 7.4–11.4 mg/L. Measured pH was between 8.0 and 8.5. Water temperatures were logged at 15-minute intervals year-round and did not exceed the chronic water temperature criterion, but exceeded the acute criterion of 28.6°C for 20 days in 2012 and 32 days in 2013. A multiparameter sonde deployment at MAN01 during a hydrologically stable 7-day period in October showed regular diurnal patterns in water temperature, dissolved oxygen, pH and specific conductance with no exceedances of water quality criteria.

Results of SCPN's analyses for *E. coli* in 2012 and 2013 ranged from 2 MPN/100 mL to >2400 MPN/100 mL. Four samples exceeded the chronic *E. coli* criterion applicable to MAN01. However, SCPN's sampling strategy is not designed to assess compliance with water quality standards and additional samples would be needed to make a definite determination.

Laboratory-measured results for nutrients and trace metals were below applicable water quality criteria, except those for arsenic, which exceeded the criterion in every sample, and for sulfate, which exceeded the drinking water standard in 10 of 11 samples.

Six samples were collected to be analyzed for Contaminants of Emerging Concern. Thirteen of these contaminants were detected—various pharmaceuticals were the most common detections.

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 the Mancos River in Mesa Verde National Park.

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Appendix A. Southern Colorado Plateau Network Water Quality Monitoring Sites at Mesa Verde National Park, 2012–2013

Site code	Common name	Report name	UTM (NAD 83, Zone 12)		Elevation (m)
			X	Y	
MEVEMAN01	Mancos River at Gage	MAN01	734375	4126163	1933
MEVEMAN02	Mancos River above downstream boundary	MAN02	735878	4122566	1882

Appendix B. Water quality monitoring results for the Mancos River at Mesa Verde National Park, 2012–2013

Table B-1. Water quality core parameter data from MAN01 on the Mancos River in Mesa Verde NP, 2012–2013

Parameter	Unit	Sample collection date and time										
		2/22/12 11:05	4/4/12 12:00	5/17/12 11:00	7/9/12 10:30	8/24/12 12:25	10/5/12 16:45	11/29/12 13:15	1/31/13 12:20	5/23/13 13:30	8/13/13 12:00	11/20/13 11:00
Water temperature	°C	1.6	5.0	14.6	18.0	17.3	6.1	0.5	-0.3	21.8	18.6	3.7
pH	none	8.0	8.2	8.2	8.3	8.1	8.1	8.4	8.2	8.3	8.4	8.5
Specific conductance	µS/cm	1860	535	1170	1340	1410	2190	1690	1970	1960	1710	1530
Dissolved oxygen	mg/L	11.2	10.5	8.4	7.4	7.4	9.7	11.4	11.1	7.5	7.9	10.6
Turbidity	NTU	8.2	21	14	660	19850 ^a	1.7	36	170	4.9	15	3.6
Discharge	cfs	8.8	37.8	9.3	6.7	7.0	0.6	9.0	---- ^b	3.5	1.3	7.9

^a Turbidity result is an estimate

^b No measurement taken

Table B-2. Total coliforms and *E. coli* in samples collected at MAN01 on the Mancos River in Mesa Verde NP, 2012–2013

	Unit	Sample collection date and time										
		2/22/12 11:05	4/4/12 12:00	5/17/12 11:00	7/9/12 10:30	8/24/12 12:25	10/5/12 16:45	11/29/12 13:15	1/31/13 12:20	5/23/13 13:30	8/13/13 12:00	11/20/13 11:00
Total coliforms	MPN/ 100 mL	110	190	920	>2400 ^a	>2400	210	980	1700	370	>2400	650
<i>E. coli</i>	MPN/ 100 mL	2	13	88	1600	>2400	17	8	4	200	150	2

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

Table B-3. Results of laboratory analyses for samples collected from MAN01 on the Mancos River in Mesa Verde NP in 2012–2013. Samples were analyzed by the U.S. Geological Survey National Water Quality Laboratory (NWQL). Results that were lower than the NWQL reporting levels are noted as “<[reporting level]”. All analytes were dissolved, except acid neutralizing capacity..

Analyte	Sample collection date and time										
	2/22/12 11:05	4/4/12 12:00	5/17/12 11:00	7/9/12 10:30	8/24/12 12:25	10/5/12 16:45	11/29/12 13:15	1/31/13 12:20	5/23/13 13:30	8/13/13 12:00	11/20/13 11:00
Nutrients (mg/L)											
Ammonia as N	0.0400	0.0313	0.0104	<0.0100	<0.0100	<0.0100	<0.0100	0.236	<0.0100	<0.0100	<0.0100
Nitrite + nitrate as N	0.168	0.070	<0.040	<0.040	0.308	<0.040	<0.040	0.190	<0.040	<0.040	<0.040
Nitrite as N	0.00303	0.00391	<0.00100	<0.00192	0.0228	<0.00100	<0.00100	0.00612	<0.00100	<0.00100	<0.00100
Orthophosphate as P	<0.00400	0.00486	<0.00400	<0.00400	0.0129	<0.00400	<0.00400	0.00910	<0.00400	<0.00400	<0.00400
Major elements (mg/L)											
Calcium	204	66.5	154	179	159	277	119	214	217	202	193
Chloride	16.3	3.55	8.41	11.0	13.0	13.6	11.3	23.1	16.4	11.8	13.1
Fluoride	0.208	0.140	0.166	0.195	0.262	0.107	0.133	0.193	<0.8	<0.15	0.209
Magnesium	98.5	22.5	60.0	66.7	50.5	120	90.0	106	103	79.6	77.7
Potassium	3.47	1.43	3.28	5.89	7.02	4.17	3.37	4.81	4.14	3.42	3.12
Silica	7.64	7.89	7.81	10.4	7.52	10.2	8.66	9.55	7.29	6.86	7.62
Sodium	94.2	20.2	58.7	74.0	98.3	102	74.0	119	104	74.7	70.4
Sulfate	808	182	490	589	616	1070	761	1000	940	784	679
Acid neutralizing capacity, as CaCO ₃ (unfiltered)	235	103	202	238	941	212	222	257	196	157	225
Total dissolved solids	1450	369	955	1120	1130	1690	1370	1640	1480	1250	1170
Trace metals (µg/L)											
Aluminum	<2.20	32.0	7.74	57.0	19.1	<2.20	<2.20	<2.20	<2.20	<2.20	<2.20
Antimony	<0.0973	<0.0720	<0.0962	0.162	0.319	0.148	0.129	0.148	0.145	<0.108	0.102
Arsenic	0.340	0.286	0.529	0.886	1.00	0.493	0.394	0.480	0.643	0.333	0.348
Barium	42.3	42.6	41.7	69.9	141	37.7	40.2	42.8	40.8	58.0	51.3
Beryllium	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
Boron	67.0	18.8	56.7	71.0	61.3	127	73.8	63.4	86.2	86.1	62.2
Cadmium	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<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	0.984	0.205	0.317	0.993	2.80	0.438	0.676	0.824	0.712	0.521	0.729

Table B-3 (continued) Results of laboratory analyses for samples collected from MAN01 on the Mancos River in Mesa Verde NP in 2012–2013. Samples were analyzed by the U.S. Geological Survey National Water Quality Laboratory (NWQL). Results that were lower than the NWQL reporting levels are noted as “<[reporting level]”. All analytes were dissolved, except CaCO₃.

Analyte	Sample collection date and time										
	2/22/12 11:05	4/4/12 12:00	5/17/12 11:00	7/9/12 10:30	8/24/12 12:25	10/5/12 16:45	11/29/12 13:15	1/31/13 12:20	5/23/13 13:30	8/13/13 12:00	11/20/13 11:00
Trace metals (µg/L)											
Copper	1.07	6.27	2.42	1.41	3.75	1.86	4.42	3.45	1.80	<0.80	1.25
Iron	36.3	20.2	10.6	70.5	31.6	12.8	19.5	22.9	19.3	10.0	19.2
Lead	<0.080	<0.080	<0.080	<0.080 ^a	0.203	0.157	0.406	0.202	0.338	0.248	0.104
Manganese	166	40.8	32.8	38.5	18.6	35.2	120	114	24.8	26.7	84.6
Mercury	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Molybdenum	2.44	0.888	2.15	2.97	5.05	2.85	3.06	3.19	3.13	2.48	2.05
Nickel	2.65	1.21	2.1	2.67	2.81	2.79	2.71	2.89	2.42	2.53	3.95
Selenium	2.09	0.656	1.16	1.31	2.75	5.47	2.05	6.84	3.66	2.77	1.33
Silver	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
Uranium	7.17	1.45	3.24	3.44	3.38	8.70	7.78	8.54	6.81	5.22	5.03
Vanadium	0.149	0.179	0.299	0.77	0.906	0.524	0.189	0.298	0.412	0.331	0.149
Zinc	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00

^aAnalyte was present above the MDL, but below the LRL.

Table B-4. Contaminant of Emerging Concern detections in samples collected at MAN01 on the Mancos River in MEVE, 2012–2013. In those instances where the analyte was not detected above the reporting level, the table cell is left blank. Only the pesticide 2,4-D had a Colorado water quality criterion, and it was not exceeded.

		Sample collection date and time					
Analyte	Reporting limit (ng/L)	4/4/2012 12:00	8/24/2012 12:25	10/5/2012 16:45	5/23/2013 13:30	8/13/2013 12:00	11/20/2013 11:00
Pesticides							
2,4-D ^a	10		14.6 ^b				
Triclopyr	20		92.9 ^b				
Pharmaceuticals and personal care products							
Caffeine	10	11.2					32
Desmethylvenlafaxine	10						10.3
Gabapentin	10				66.9	193	125
Hydrochlorothiazide	10						11.8
Metformin	10				21.4	14.7	32.8
Sulfamethoxazole	10						12.4
Waste indicators							
Bisphenol A	50						224
1-methylnaphthalene	50		64.2				
2-methylnaphthalene	50		77.6				
Phenanthrene	50		86.5				
Tri(2-butoxyethyl) phosphate	50				912		462 ^c

^aColorado state aquatic life criteria for 2,4-D in the water supply is 70,000 ng/L

^b Analyzed outside holding time, result may be biased low.

^cThis result is biased high

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

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

Analyte	Reporting limit (ng/L)	Analyte	Reporting limit (ng/L)
2,4,5-T	10	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	Terbutylazine	10
Diuron Metabolite	50	Thiamethoxam	20

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

Analyte	Reporting limit (ng/L)	Analyte	Reporting limit (ng/L)
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
Benzoyllecgonine	10.0	Hydrocodone	10.0
Benzphetamine	10.0	Hydromorphone	10.0
Bezafibrate	10.0	m-Hydroxybenzoyllecgonine	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	Methypyrrolon	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
diltiazem	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
Famotidine	10.0	Pentazocine	10.0
Fenbendazole	10.0	Phencyclidine	10.0

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

Analyte	Reporting limit (ng/L)	Analyte	Reporting limit (ng/L)
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 C-3. Target analytes and U.S. Environmental Protection Agency reporting limits for wastewater indicators

Analyte	Reporting limit (ng/L)	Analyte	Reporting limit (ng/L)
Acetophenone	50.0	Menthol	50.0
Benzophenone	50.0	3-Methyl Indole	50.0
Bisphenol A	50.0	Methyl Salicylate	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
Ethinylestradiol	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 D. Abbreviations, chemical formulas, and symbols used in this report

Term	Definition
ANC	acid neutralizing capacity of solutes plus particulates in an unfiltered water sample
CaCO ₃	chemical formula for calcium carbonate
cfs	cubic feet per second
cfu/100 ml	colony forming units, for bacteria sampling, a measure of the number of viable bacteria per 100 mL
LRL	laboratory reporting level
MDL	method detection level
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
P	chemical symbol for the element phosphorous

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