



Water Quality Monitoring for the Escalante River and Coyote Gulch in Glen Canyon National Recreation Area

2011–2013 Summary Report

Natural Resource Data Series NPS/SCPN/NRDS—2016/1219



ON THE COVER

Water quality monitoring at Coyote Gulch, Glen Canyon National Recreation Area.
Photography by SCPN

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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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 to

- 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 Glen Canyon National Recreation Area

The Escalante River watershed covers 5,244 km² in southern Utah, with 97% of the watershed managed by the U.S. Forest Service, Bureau of Land Management (BLM), and the National Park Service (NPS) (Macfarlane and Wheaton 2013). The river is primarily fed by several perennial tributaries originating from the Aquarius Plateau north of Boulder, Utah. The mainstem of the river flows northwest to southeast, from outside of Escalante and through the arid canyonlands of Grand Staircase-Escalante National Monument and Glen Canyon National Recreation Area (GLCA) for approximately 145 km before emptying into Lake Powell. The small towns of Escalante and Boulder lie within the northern portion of the watershed.

Coyote Gulch, where one of SCPN's water quality monitoring sites is located, is a perennial tributary that is located in the southeastern tip of the Escalante Watershed and enters the Escalante River near Lake Powell. It is an extremely popular hiking destination. The upper portion of the Coyote Gulch watershed is located in the Grand Staircase-Escalante National Monument and is managed for multiple uses by the BLM. However, most of the canyon and stream lies within GLCA and is managed by the NPS for recreational use.

Water sampling by SCPN in GLCA began in 2011 when samples were collected for Contaminants of Emerging Concern (CECs) on the Escalante River. Prior to 2011, core parameter measurements (temperature, pH, specific conductance, dissolved oxygen, turbidity, and discharge) were collected during aquatic macroinvertebrate site visits on Coyote Gulch and the Escalante River. In 2013 SCPN implemented long-term monitoring of water quality at two sites in GLCA (Figure 1), which were to be visited on a quarterly basis:

- *Escalante River above Coyote Gulch* (GLCAESC02), identified in this report as ESC02 (see Appendix A for site location), is located just upstream from the confluence with Coyote Gulch.
- *Coyote Gulch above Crack-in-the-Wall Trail* (GLCACOY01) is identified in this report as COY01. The site is located in the lower portion of Coyote Gulch, approximately 1.6 km upstream from the confluence of the Escalante River. This site is co-located with an SCPN aquatic macroinvertebrate monitoring site, where limited water quality data has been collected since 2008.

From 2010–2011, limited water quality data was collected at

- *Escalante River below Steven's Canyon* (GLCAESC01), identified in this report as ESC01. This site is located less than 0.5 km downstream from the confluence of Steven's Canyon and the Escalante River, and was an SCPN aquatic macroinvertebrate monitoring site in 2010. It is 1.6 km upstream from ESC02.

This report contains results from all water quality samples collected by SCPN at GLCA since 2011. This includes the CEC samples collected from 2011–2013 and the samples collected for bacteria, nutrients, major ions, and trace metals in 2013. Also included are summaries of the core parameter data collected at ESC01 since 2010 and COY01 since 2008 as part of aquatic macroinvertebrate sample collection. A summary of SCPN water quality site visits to GLCA is in Table 1.

Table 1. Summary of site visits made and data collected during water quality monitoring at Glen Canyon NRA, 2010–2013.

Site	Core parameter measurements				Bacteria		Nutrients, major elements, trace metals		Contaminants of emerging concern		
	2010	2011	2012	2013	2012	2013	2012	2013	2011	2012	2013
ESC01	1	1	X	X	X	X	X	X	2	X	X
ESC02	X	X	2	3	X	3	X	3	X	2	2
COY01	X	X	2	4	X	4	X	4	X	2	2

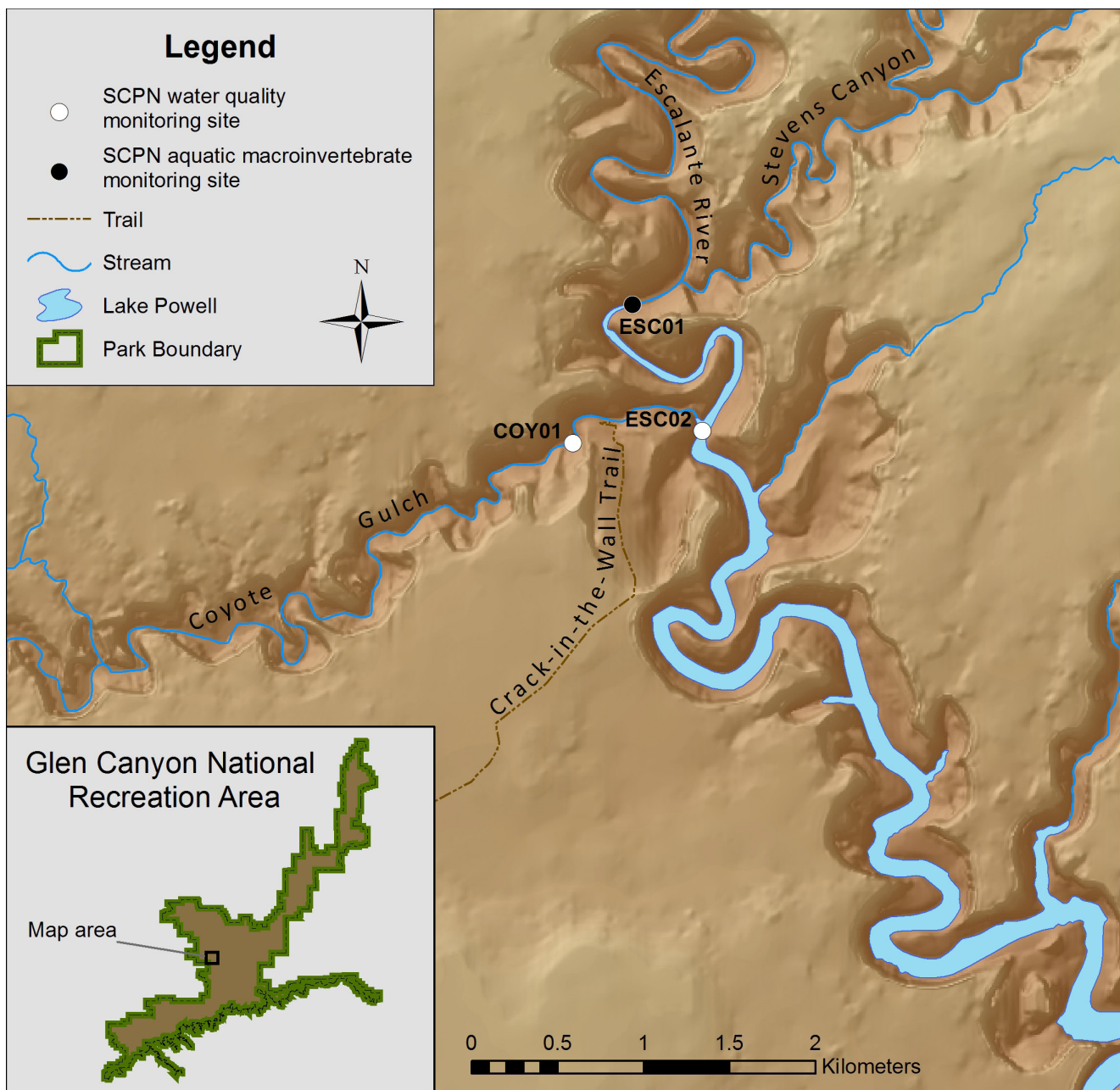


Figure 1. SCPN water quality monitoring sites in the Escalante River and Coyote Gulch at Glen Canyon NRA.

2 Methods

A brief description of water quality data collection and processing procedures followed by SCPN staff at GLCA during 2011–2013 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:

- 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 Marsh-McBirney FloMate (Hach, Inc.), a Hach FH950, or a FlowTracker Acoustic Doppler Velocimeter (SonTek Inc.).

2.2 Water quality samples

In 2013, SCPN began collecting water quality samples at GLCA to analyze for bacteria, nutrients, major elements and trace metals, as well as core parameter samples, during each quarterly site visit. Bacteria samples were collected by dipping a sample bottle into the center of flow. SCPN staff then analyzed the sample for total coliforms and *E. coli* using the Quanti-Tray® 2000 system (IDEXX Inc.). We collected samples to be tested for other analytes in a similar manner. Sample water was filtered and/or acid-treated (as required), kept on ice, and shipped to the contract laboratory. In 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 2). This is the same laboratory that had been used to analyze samples collected at other SCPN parks. Information documenting NWQL methods is included in SOP #8 of the SCPN water quality monitoring protocol (Monroe et al. in preparation).

Also, in 2011, SCPN began a partnership with the U.S. Environmental Protection Agency (EPA) to sample for Contaminants of Emerging Concern (CECs) in water sources in selected SCPN parks. The contaminants include pharmaceuticals, personal care products, waste indicators, and pesticides (see Appendix C). We followed the procedures described in NPS 2013. The purpose was to develop a baseline dataset documenting the occurrence of these contaminants within SCPN parks. Two samples were collected at ESC01 in 2011, two were collected at

Table 2. 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

ESC02 and COY01 in 2012, and two were collected at ESC02 and COY01 in 2013.

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 and discharge files are stored on the SCPN server. In this report, we include the median values of a subset of seven consecutive multiparameter sonde measurements. Similarly, only the median values for each set of turbidity samples are presented. For total coliforms and *E. coli* samples, most-probable numbers (MPN/100 mL) are reported; these were determined using a lookup table provided by the manufacturer of Quanti-Tray 2000, the method used by SCPN to analyze bacteria in stream samples (IDEXX Inc.).

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.

Where applicable, we compared our results against the state of Utah's Department of Environmental Quality 2014 water quality standards (Utah DEQ 2014). We noted any exceedances 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.

The Utah DEQ has developed water quality standards and criteria to meet requirements of the Federal Clean Water Act. This report includes water quality standards and criteria applicable to the Escalante River and Coyote Gulch. A water quality standard refers to a specific parameter and its associated beneficial use, in conjunction with a criterion, which is the numeric component against which a result is compared. For example, the standard for dissolved selenium (parameter) for warm water aquatic life (beneficial use) is a one-hour average of 18.4 µg/L (numeric criterion) (UDEQ 2014).

All SCPN sample results are for the dissolved concentration, meaning that samples are filtered through a 0.45µm filter to remove the particulate component of the sample before it is shipped for analysis of the dissolved fraction. All aquatic life criteria for metals are based on the dissolved fraction. This method more accurately addresses the form of metals that is most toxic to aquatic life while excluding less toxic forms. However, for some analytes, such as ammonia, the Utah water quality standards are based on the total 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 note when dissolved concentrations exceed the criteria for total concentrations.

As tributaries to Lake Powell, the Escalante River and Coyote Gulch have the following beneficial uses: infre-

quent primary contact recreation, warm water aquatic life, and irrigation and stock watering. The aquatic life criteria are often dependent upon water hardness, which varies at 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*, data are obtained using the Quanti-Tray 2000 procedure (IDEXX, Inc.). The results 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. The Utah water quality standards state that the Quanti-Tray 2000 procedure is approved as a method for water quality assessment.

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 and acute exposure over a short period of time. In Utah, the criteria are expressed as either 4-day average or 1-hour average concentrations. Criteria are much lower for chronic exposure than for acute exposure and are not directly comparable to the results obtained from a single sample due to the multiple samples required over a 4-day period. From a compliance standpoint, the acute 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 a means of early warning and an indication of a problem that may require more attention. Therefore, we have identified when results are outside the chronic criteria 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 jurisdiction.

3 Results

This section summarizes data collected by SCPN from the Escalante River in 2010–2013 and Coyote Gulch in 2008–2013. Starting in 2013, long-term monitoring of core parameters, bacteria, and the full suite of analytes in Table 2 began on a quarterly basis at ESC02 and COY01. Prior to this, only limited water quality data was collected at these sites. All data collected at ESC01, ESC02, and COY01, including dates and sample times, are included in Appendix B.

3.1 Escalante River below Steven’s Canyon

3.1.1 Water quality core parameter data

On October 29 2011, one set of core parameter measurements was collected at ESC01 when this site was sampled for CECs. These data are displayed below in Table 3 along with data collected in 2010 during aquatic macroinvertebrate sampling. The Utah water quality criteria are included; none of the results exceeded these criteria.

3.1.2 Contaminants of emerging concern

Two sets of samples were collected and analyzed by the USEPA Region 8 Laboratory for contaminants of emerging concern, which are split into three categories: pesticides, pharmaceuticals and personal care products, and waste water indicators. The samples were collected on June 10 and October 29, 2011; a summary of the seven detected contaminants and their uses is in Table 4. These contaminants included herbicides, endocrine disruptors, and flame retardants. Each contaminant was detected only once. There are no water quality standards for

Table 3. Summary of water quality core parameter data from ESC01 in Glen Canyon NRA, 2010–2011, and the associated Utah water quality criteria (n=1 for both years). A “nc” means that no criteria exist for a specific parameter. A “nd” means that data was not collected for a specific parameter.

Core parameters	2010	2011	Utah state aquatic life criteria
Water temperature (°C)	21.1	7.3	≤ 27.0
pH	8.5	8.5	>6.5–<9.0
Specific conductance (µS/cm)	576	407	nc
Dissolved oxygen (mg/L)	nd	10.5	>5.0
Turbidity (NTU)	21	220	nc
Discharge (cfs)	26.1	nd	nc

Table 4. Summary of detections of contaminants of emerging concern in samples collected at ESC01 in Glen Canyon NRA, 2011.

Contaminant	Use	Number of detections
Pesticides		
Propachlor OA	Breakdown product of the herbicide Propachlor	1
Triclopyr	Herbicide	1
Pharmaceuticals and Personal Care Products - no detections		
Waste Indicators		
Bisphenol A	Used in plastic; contains hormone properties	1
Estrone	A form of estrogen	1
Pentachlorophenol	Pesticide and disinfectant; used as a preservative in utility poles and railroad ties	1
Tri(dichloroisopropyl) phosphate	Flame retardant	1
Triphenyl phosphate	Flame retardant	1

these contaminants. The concentrations of each detected contaminant and their reporting levels are in Appendix B. The full list of analytes and reporting levels is in Appendix C.

3.2 Escalante River above Coyote Gulch

3.2.1 Water quality core parameter data

In 2012–2013, ESC02 was visited five times and core parameter measurements were collected at each site visit. In 2012, the site was visited in June and September. In 2013, it was visited at quarterly intervals in April, June, and September; in December, snow prevented access to the site. Table 5 presents medians and ranges for the core parameter data, along with the Utah water quality criteria; none of the results for temperature, pH, and dissolved oxygen exceeded these criteria. The complete results, along with dates of site visits, are in Appendix B.

ESC02 was visited during spring, summer and fall. Turbidity was the most variable parameter, ranging from 3.3–30,400 NTU. The highest result was measured on September 5, 2012, a day after rain fell in the area and the river was still flowing very muddy. The lowest turbidity results occurred in June and were also associated with the lowest discharge measurements. Except for very large flows, a variety of flow conditions were sampled; discharge ranged from 14.3–81.3 cfs.

Table 5. Summary of water quality core parameter data from ESC02 in Glen Canyon NRA, 2012–2013, and the associated Utah water quality criteria. A “nc” means that no criteria exist for a specific parameter.

Core parameters	2012 (n=2)		2013 (n=3)		Utah state aquatic life criteria
	Median	Range	Median	Range	
Water temperature (°C)	19.7	18.6–20.9	16.9	15.1–22.4	≤ 27.0
pH	7.9	7.8–8.1	8.6	8.3–8.6	>6.5–<9.0
Specific conductance (µS/cm)	531 ^a	531 ^a	531	502–673	nc
Dissolved oxygen (mg/L)	6.7	5.7–7.7	8.3	6.8–9.1	>5.0
Turbidity (NTU)	15200	3.3–30400	13	5.2–300	nc
Discharge (cfs)	23.9	18.2–23.9	64.6	14.3–81.3	nc

^a Specific conductance was only measured on one of the two sampling visits in 2012

3.2.2 Precipitation

The National Oceanic and Atmospheric Administration/National Climatic Data Center operates weather stations in the upper Escalante watershed in the towns of Escalante (#422592, 63 km away) and Boulder, Utah (#481930, 67 km away) (NOAA/NCDC 2015). Daily precipitation for 2012–2013 is plotted in Figure 2 for both stations.

Both stations received considerably less precipitation in 2012 than they did in 2013. Slightly more precipitation fell in Boulder in both years. In 2012, the Boulder station recorded 248 mm, and the Escalante station recorded 222 mm. In 2013, the Boulder station recorded 440 mm and the Escalante station recorded 368 mm.

A third NOAA weather station (421020, NOAA/NCDC 2015), located near Lake Powell at Bullfrog, UT is 24km northeast of ESC02 and COY01. This is the closest active weather station to the monitoring sites. In 2012, only 72 mm of precipitation was recorded, and almost all of the precipitation events occurred after July (Figure 3). In 2013, 196 mm of precipitation was recorded. Almost all of the precipitation occurred after July, in particular, during two multi-day events in early September and in mid-November.

3.2.3 Total coliforms and *E. coli*

Starting in 2013, SCPN began sampling for total coliforms and *E. coli* at ESC02. Three samples were collected

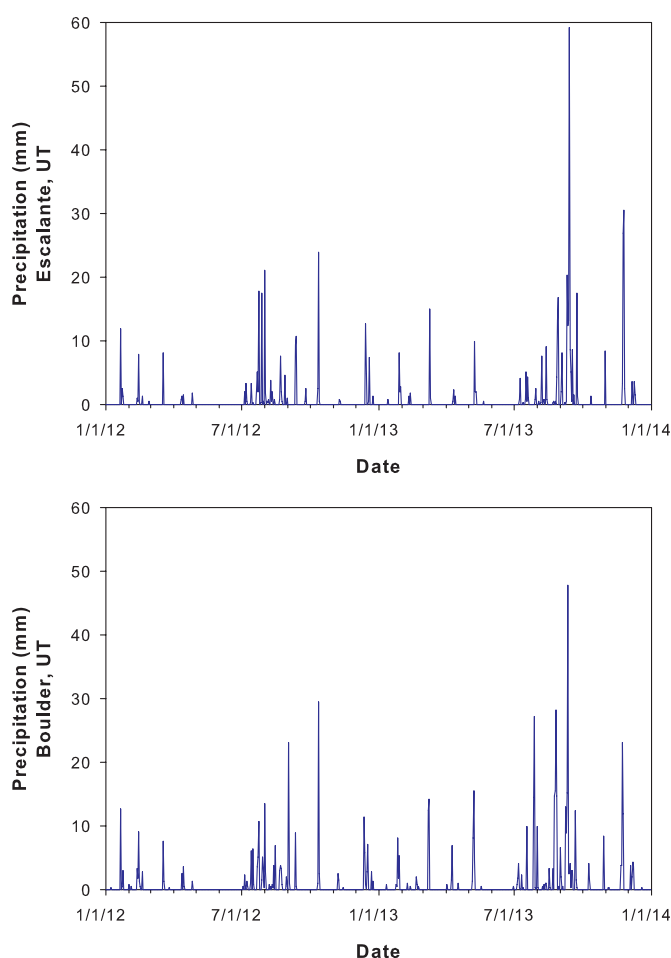


Figure 2. Daily precipitation from the NOAA/NCDC weather stations 422592 in Escalante, UT (top) and 481930 in Boulder, UT (bottom), located in the upper Escalante watershed, 2012–2013.

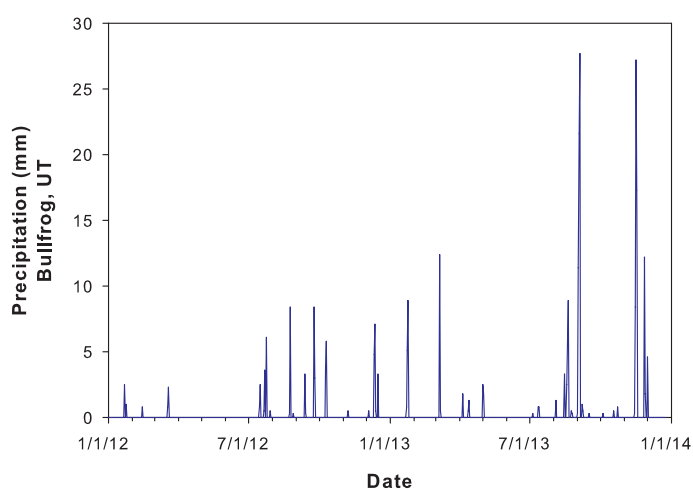


Figure 3. Daily precipitation from the NOAA/NCDC weather stations 421020 in Bullfrog Basin, UT, located 24 km north-east of ESC01 and COY01, 2012–2013.

on April 4, June 13, and September 26. Results are presented in Figure 4 and listed in Appendix B. The Escalante River is protected for infrequent primary contact recreation (UDEQ 2014), meaning that recreational use of the stream is presumed to be primarily through secondary contact recreation, such as wading or fishing, and there is a low likelihood that water will be ingested through activities such as swimming or rafting. For the Escalante River, Utah's criteria for *E. coli* is a single-sample maximum of 668 MPN/100 mL or a 5-sample monthly geometric mean of 206 MPN/100 mL. None of the samples exceeded these criteria; the results were <1, 7, and 59 MPN/100 mL in the April, June, and September samples.

Total coliforms, which include *E. coli* and many other types of bacteria, are also included in the analyses. They are indicators of the presence of all coliform groups of bacteria, both vegetative and fecal in origin. Total coliforms are used in drinking water testing because their presence indicates contamination of a water supply by an outside source. There are no water quality criteria for total coliforms. At ESC02, total coliform levels were 205, >2400, and >2400 MPN/100 mL in the April, June, and September samples.

3.2.4 Water quality laboratory data

Nutrients, major element, and trace metal results from the three water samples collected at ESC02 on April 4, June 13, and September 26, 2013 are presented in Tables 5–7. All results are compared to the Utah water quality standards applicable to ESC02 (UDEQ 2014).

Nutrient data are presented in Table 6. There are aquatic life criteria for ammonia, however these are based on the total ammonia concentration and our results are based on the dissolved concentration. Ammonia was not detected in the samples above the laboratory reporting limit of 0.0100 mg/L. Nitrite concentrations were low and only detected in one sample. Nitrite+nitrate concentrations were also low, ranging from <0.040 to 0.115 mg/L, and well below the water quality criterion for nitrate, which is 4 mg/L. Orthophosphate concentrations were also very low, ranging from <0.00400 to 0.00832 mg/L.

Major element data are summarized in Table 7,

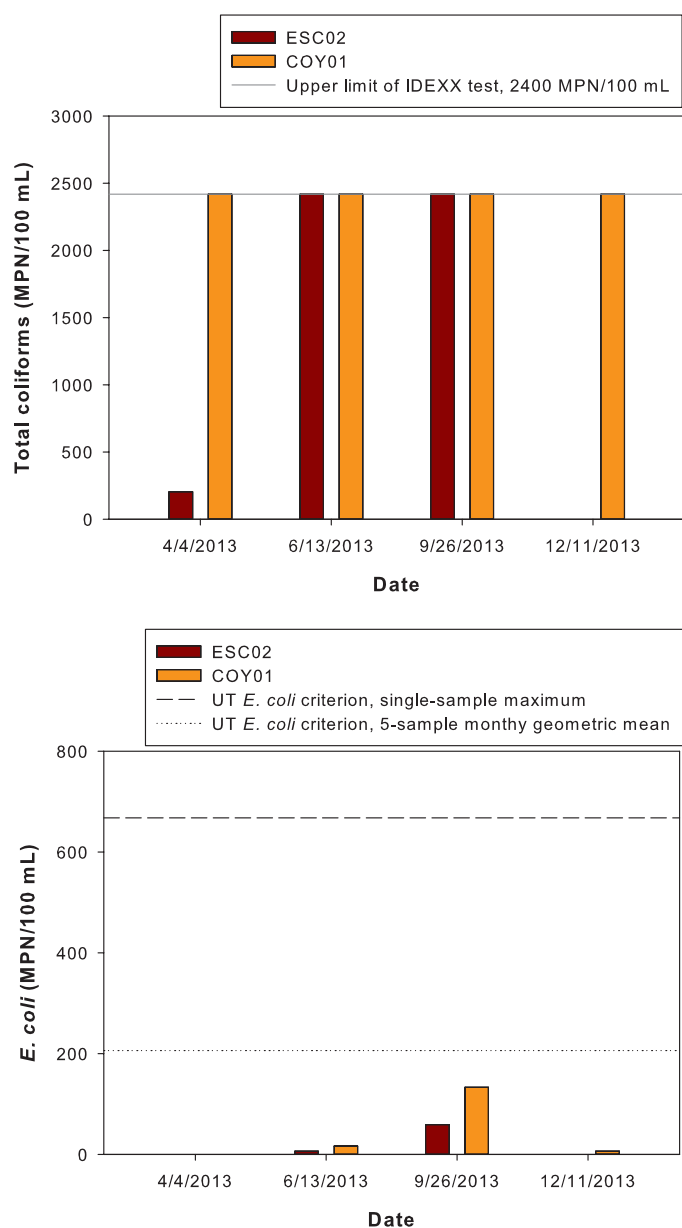


Figure 4. Total coliforms (top) and *E. coli* results (bottom) for samples collected at ESC02 and COY01 in Glen Canyon NRA in 2013. There were no detections of *E. coli* on 4/4/2013; samples were not collected at ESC02 on 12/11/2013.

Table 6. Nutrient data from ESC02 at Glen Canyon NRA, 2013. A “nc” indicates that no Utah state criteria have been developed for a particular nutrient, and a “ndc” indicates that there is no dissolved criterion. Results lower than the National Water Quality Laboratory reporting levels are noted as “[reporting level]”.

Nutrient (mg/L)	Sample collection date and time			Most stringent criterion	# of exceedances	Beneficial use
	4/4/2013 15:00	6/13/2013 6:40	9/26/2013 13:30			
Ammonia as N	<0.0100	<0.0100	<0.0100	ndc	ndc	ndc
Nitrite + nitrate as N	0.115	<0.040	0.055	4 (NO ₃ only)	0	recreation
Nitrite as N	<0.00100	<0.00100	0.00276	nc	nc	nc
Orthophosphate as P	0.00832	<0.00400	0.00805	nc	nc	nc

along with acid neutralizing capacity and total dissolved solids. The major ions are plotted in Figure 5, showing that ion composition did not change much among the three samples collected in 2013. Anions were between 50–60% bicarbonate, with approximately 30% sulfate and 10–20% chloride. Cations were approximately 50% calcium, 30–40% magnesium, and 20% sodium plus potassium. Acid neutralizing capacity ranged from 141–221 mg/L, and total dissolved solids ranged from 307–443 mg/L.

Trace metal data are presented in Table 8, along with the water quality criteria applicable to ESC02. Trace metal concentrations did not vary much between samples. Of the 21 analytes, six were not detected in the three samples: beryllium, cadmium, chromium, mercury, silver, and zinc. There were no exceedances of the warm water aquatic life criteria; metals that were detected in these samples were present at levels well below these criteria.

3.2.5 Contaminants of emerging concern

In 2012–2013, six samples were collected at ESC02 to be analyzed for contaminants of emerging concern by the USEPA Region 8 lab. Two pesticide/PPCP samples were collected each year in June and September, and two waste indicator samples were collected in 2013. The five detected contaminants are summarized in Table 9; the complete dataset, including concentrations and reporting levels, is in Appendix B. The complete list of over 250 analytes is in Appendix C.

3.3 Coyote Gulch above Crack-in-the-Wall Trail

3.3.1 Water quality core parameter data

Table 7. Major element data from ESC02 at Glen Canyon NRA, 2013. All analytes are dissolved except for acid neutralizing capacity, which was measured in unfiltered samples. There are no Utah state water quality criteria for these analytes.

Major element (mg/L)	Sample collection date and time		
	4/4/2013 15:00	6/13/2013 6:40	9/26/2013 13:30
Calcium	50.1	48.9	78.8
Chloride	29.9	32.3	35.7
Fluoride	0.180	0.245	0.196
Magnesium	19.3	23.1	26.2
Potassium	2.79	4.19	4.37
Silica	16.7	9.06	16.7
Sodium	26.4	26.0	33.8
Sulfate	73.7	89.0	121
Acid neutralizing capacity, as CaCO ₃ (unfiltered)	149	141	221
Total dissolved solids	307	340	443

Table 8. Trace metal data from samples collected at ESC02 in Glen Canyon NRA, 2013, and the water quality criteria for each trace metal. A "nc" indicates that no criteria have been developed for a particular trace metal. Results that were lower than the NWQL reporting levels are noted as "<[reporting level]".

Trace metal (µg/L)	Sample collection date and time			Most stringent criterion (µg/L)	# of exceedances	Beneficial use
	4/4/2013 15:00	6/13/2013 6:40	9/26/2013 13:30			
Aluminum	6.90	3.41	7.58	750, chronic	0	warm water aquatic life
Antimony	0.0541	0.0777	0.154	640	0	warm water aquatic life (consumption)
Arsenic	2.86	3.69	4.09	150, chronic	0	warm water aquatic life
Barium	86.9	108	127	nc	nc	nc
Beryllium	<0.040	<0.040	<0.040	nc	nc	nc
Boron	35.3	46.5	47.1	nc	nc	nc
Cadmium	<0.060	<0.060	<0.060	47.4–65.2, chronic	0	warm water aquatic life
Chromium	<0.600	<0.600	<0.600	Cr (III), 133–185; Cr (VI), 11, chronic	0	warm water aquatic life
Cobalt	0.102	<0.100 ^a	0.231	nc	nc	nc
Copper	<0.800	0.899	0.906	16.5–23.2, chronic	0	warm water aquatic life
Iron	13.4	10.4	11.2	nc	nc	nc
Lead	0.0914	0.714	<0.080	5.44–8.26, chronic	0	warm water aquatic life
Manganese	4.73	5.38	5.45	nc	nc	nc
Mercury	<0.005	<0.005	<0.005	0.012, chronic	0	warm water aquatic life
Molybdenum	0.751	0.896	1.08	nc	nc	nc

Table 8. (continued) Trace metal data from samples collected at ESC02 in Glen Canyon NRA, 2013, and the water quality criteria for each trace metal. A “nc” indicates that no criteria have been developed for a particular trace metal. Results that were lower than the NWQL reporting levels are noted as “<[reporting level]”.

Trace metal (µg/L)	Sample collection date and time			Most stringent criterion (µg/L)	# of exceedances	Beneficial use
	4/4/2013 15:00	6/13/2013 6:40	9/26/2013 13:30			
Nickel	<0.400 ^a	0.491	1.72	95.3–134, chronic	0	warm water aquatic life
Selenium	0.158	0.171	0.273	4.6, chronic	0	warm water aquatic life
Silver	<0.040	<0.040	<0.040	11.0–21.9, chronic	0	warm water aquatic life
Uranium	1.23	0.988	2.03	nc	nc	nc
Vanadium	1.76	1.83	2.39	nc	nc	nc
Zinc	<4.00	<4.00	<4.00	217–304, chronic	0	warm water aquatic life

^a Analyte was present above the Minimum Detection Level, but below the Laboratory Reporting level.

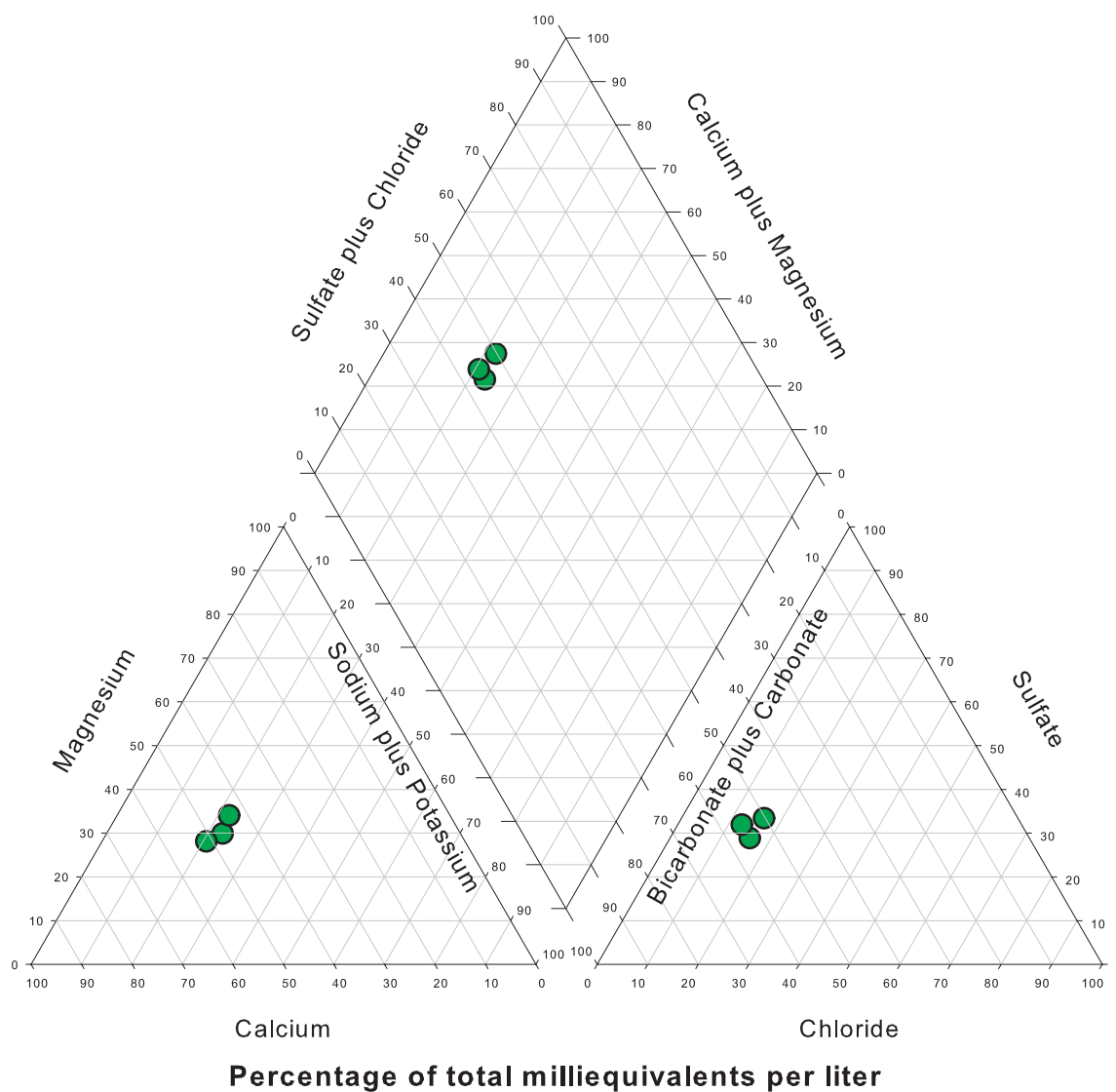


Figure 5. Major ion composition at ESC02 in Glen Canyon NRA, 2013.

Table 9. Summary of contaminants of emerging concern detections in 4 samples collected at ESC02 in Glen Canyon NRA, 2012–2013.

Contaminant	Use	Number of detections
Pesticides		
Triclopyr	Herbicide	2
Pharmaceuticals and Personal Care Products		
Caffeine	Stimulant drug	1
DEET	Insect repellent	2
Phenylpropanolamine	Discontinued decongestant; used in pet medicine	1
Triclocarban	Antibacterial agent in personal care products	1
Waste Indicators – none detected		

In 2012–2013, COY01 was visited six times, and core parameter measurements were collected at each of the site visits. In 2012, the site was visited in June and September on the same days as ESC02. In 2013, COY01 was visited four times. Medians and ranges for the core parameter data are displayed in Table 10, along with the Utah water quality criteria for aquatic life. The complete results, along with dates of site visits, are in Appendix B. Prior to 2012, COY01 was visited during SCPN aquatic macroinvertebrate sampling, which generally occurred in the spring and fall each year since 2008. These data are also summarized in Table 9 for comparison.

Turbidity was the most variable parameter, ranging from 3.2–3150 NTU during the 2012–2013 site visits. The highest results occurred during the summer monsoon season. pH did not vary much between site visits, ranging from 8.1–8.5, and specific conductance ranged from 261–513 $\mu\text{S}/\text{cm}$. Discharge ranged from 0.1–3.0 cfs; the lowest measurements occurred in June. Dissolved oxygen ranged between 6.9–12.6 mg/L. Temperature ranged from 0.1–21.1°C. All measurements for pH, dissolved oxygen, and temperature were within the Utah water quality criteria.

3.3.2 Total coliforms and *E. coli*

Sampling for total coliforms and *E. coli* began at COY01 in 2013. Four samples were collected; the results are presented in Figure 4 along with results for ESC02. Complete numeric results and sample times are in Appendix B. In all four samples, total coliforms either met or exceeded the maximum limit of the IDEXX, which is 2400 MPN/100 mL. There are no water quality criteria for total coliforms.

As a tributary to Lake Powell, Coyote Gulch is protected for infrequent primary contact recreation (UDEQ

Table 10. Summary of water quality core parameter data from COY01 in Glen Canyon NRA, 2012–2013, and the associated Utah water quality criteria. A “nc” means that no Utah state criteria exist for a specific parameter. Data from 2008–2011 are included for comparison.

Core parameters	2008–2011 (n=7)		2012–2013 (n=6)		Utah state aquatic life criteria
	Median	Range	Median	Range	
Water temperature (°C)	21.3	15.0–25.5	17.5	0.1–21.5	≤ 27.0
pH	8.6	8.4–8.7	8.2	8.1–8.5	>6.5 – <9.0
Specific conductance ($\mu\text{S}/\text{cm}$)	297	277–349	298 (n=5)	261–513	nc
Dissolved oxygen (mg/L)	7.4 (n=3)	7.1–11.3	8.1	6.8–12.6	>5.0
Turbidity (NTU)	39 (n=6)	3.6–360	39	3.2–3150	nc
Discharge (cfs)	1.9 (n=3)	1.2–1.9	1.7	0.1–3.0	nc

2014). The water quality criteria for *E. coli* are a single-sample maximum of 668 MPN/100 mL, or a 5-sample monthly geometric mean of 206 MPN/100 mL. None of the four samples exceeded these criteria; the range was <1–130 MPN/100 mL.

3.3.3 Water quality laboratory data

Nutrient, major element, and trace metal results from the four samples collected at COY01 in 2013 are presented in Tables 10–12, along with the Utah water quality standards applicable to COY01 (UDEQ 2014).

Nutrient data are presented in Table 11. Ammonia was not detected in any of the samples above the laboratory reporting limit of 0.0100 mg/L. Nitrite was not detected above the 0.00100 reporting level in three of the four samples, and the fourth sample was 0.00331 mg/L. Nitrite+nitrate concentrations were also very low and only detected in two of the four samples, with concentrations ranging from <0.040–0.081. The water quality criterion for nitrate is 4 mg/L. Orthophosphate was also detected in two of the four samples at very low concentrations ranging from <0.00400–0.00781 mg/L.

Major element data are summarized in Table 12. These include the major ions, silica, acid neutralizing capacity, and total dissolved solids. Major ions are plotted in Figure 6, showing that the majority of the anions consisted of bicarbonate, though this varied about 75–95% between samples. Sulfate comprised a lesser proportion of the anions. Cations mainly consisted of calcium, ranging from approximately 60–80%, and magnesium, which ranged from approximately 20–40%.

Acid neutralizing capacity and total dissolved solids did vary between samples; both analytes were higher in the September and December samples than they were in the April and June samples. Acid neutralizing capacity ranged from 147–266 mg/L, and total dissolved solids ranged from 159–273 mg/L.

Trace metal data are presented in Table 13, along with the water quality criteria applicable to COY01. Trace metal concentrations did not vary much between samples. Similar to ESC02 results, six of the 21 trace metals included in the analyses were not detected in the four samples: beryllium, cadmium, chromium, mercury, silver, and zinc. There were no exceedances of the warm water aquatic life criteria; metals that were detected in these samples were present at levels well below these criteria.

3.3.4 Contaminants of emerging concern

Table 14 contains a summary of contaminant of emerging concern detections found in four samples collected at COY01. Samples were analyzed for pesticides, pharmaceuticals, and personal care products. Waste indicators samples were not collected. The complete analyte list is in Appendix C. Samples for waste indicators were not collected at this site. Three contaminants were detected: caffeine, theobromine, and DEET. A list of detections with sample dates and concentrations is in Appendix B.

Table 11. Nutrient data from COY01 at Glen Canyon NRA, 2013. A “nc” indicates that no criteria have been developed for a particular nutrient, and a “ndc” indicates that there is no dissolved criterion. Results that were lower than the National Water Quality Laboratory reporting levels are noted as “<[reporting level]”.

Nutrient (mg/L)	Sample collection date and time				Most stringent criterion	# of exceedances	Beneficial use
	4/4/2013 13:00	6/13/2013 8:16	9/29/2013 15:30	12/11/2013 13:45			
Ammonia as N	<0.0100	<0.0100	<0.0100	<0.0100	ndc	ndc	ndc
Nitrite + nitrate as N	0.057	<0.040	<0.040	0.081	4 (NO ₃ only)	0	recreation
Nitrite as N	<0.00100	<0.00100	<0.00100	0.00331	nc	nc	nc
Orthophosphate as P	<0.00400	<0.00400	0.00781	0.00528	nc	nc	nc

Table 12. Major element data from COY01 at Glen Canyon NRA, 2013. All analytes are dissolved except for acid neutralizing capacity, which was measured in unfiltered samples. There are no Utah state water quality criteria for these analytes.

Major element (mg/L)	Sample collection date and time			
	4/4/2013 13:00	6/13/2013 8:16	9/29/2013 15:30	12/11/2013 13:45
Calcium	43.1	37.3	92.5	69.0
Chloride	2.00	1.67	3.35	3.80
Fluoride	0.145	0.156	0.185	0.182
Magnesium	11.8	13.0	14.7	17.8
Potassium	1.36	1.73	3.79	2.14
Silica	8.54	10.1	11.2	11.2
Sodium	2.58	2.78	3.87	4.60
Sulfate	7.78	4.86	80.1	27.7
Acid neutralizing capacity, as CaCO ₃ (unfiltered)	158	147	266	224
Total dissolved solids	192	159	273	249

Table 13. Trace metal data from samples collected at COY01 in Glen Canyon NRA, 2013, and the water quality criteria for each trace metal. A “nc” indicates that no Utah state criteria have been developed for a particular trace metal. Results that were lower than the National Water Quality Laboratory reporting levels are noted as “<[reporting level]”.

Trace metal (µg/L)	Sample collection date and time				Most stringent criterion (µg/L)	# of exceedances	Beneficial use
	4/4/2013 15:00	6/13/2013 6:40	9/26/2013 13:30	12/11/2013 13:45			
Aluminum	2.92	2.87	8.90	5.02	750, chronic	0	warm water aquatic life
Antimony	0.0632	0.0508	0.149	0.0706	640	0	warm water aquatic life (consumption)
Arsenic	0.79	1.44	2.49	0.777	150, chronic	0	warm water aquatic life
Barium	292	305	158	220	nc	nc	nc
Beryllium	<0.040	<0.040	<0.040	<0.040	nc	nc	nc
Boron	20.7	25.7	37.5	27.8	nc	nc	nc
Cadmium	<0.060	<0.060	<0.060	<0.060	36.1–63.0, chronic	0	warm water aquatic life
Chromium	<0.600	<0.600	<0.600	<0.600	Cr (III), 101–178; Cr (VI), 11, chronic	0	warm water aquatic life
Cobalt	0.714	<0.100 ^a	0.276	0.308	nc	nc	nc
Copper	<0.800	<0.800	<0.800	1.03	12.4–22.4, chronic	0	warm water aquatic life
Iron	12.7	46.8	6.22	6.86	nc	nc	nc
Lead	<0.080	0.409	<0.080	0.318	3.81–7.90, chronic	0	warm water aquatic life
Manganese	8.44	15.9	6.05	21.2	nc	nc	nc
Mercury	<0.005	<0.005	<0.005	<0.005	0.012, chronic	0	warm water aquatic life
Molybdenum	0.565	0.638	1.61	0.801	nc	nc	nc

Table 13. (*continued*) Trace metal data from samples collected at COY01 in Glen Canyon NRA, 2013, and the water quality criteria for each trace metal. A “nc” indicates that no Utah state criteria have been developed for a particular trace metal. Results that were lower than the National Water Quality Laboratory reporting levels are noted as “<[reporting level]”.

Trace metal (µg/L)	Sample collection date and time				Most stringent criterion (µg/L)	# of exceedances	Beneficial use
	4/4/2013 15:00	6/13/2013 6:40	9/26/2013 13:30	12/11/2013 13:45			
Nickel	<0.400 ^a	<0.400 ^a	1.91	1.68	71.9–129, chronic	0	warm water aquatic life
Selenium	<0.100 ^a	0.131	0.221	0.167	4.6, chronic	0	warm water aquatic life
Silver	<0.040	<0.040	<0.040	<0.040	6.22–20.3, acute	0	warm water aquatic life
Uranium	0.318	0.232	1.21	0.690	nc	nc	nc
Vanadium	0.361	0.744	3.61	0.735	nc	nc	nc
Zinc	<4.00	<4.00	<4.00	<4.00 ^a	164–293, acute	0	warm water aquatic life

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

Table 14. Summary of contaminants of emerging concern detections in 4 samples collected at COY01 in Glen Canyon NRA, 2012–2013.

Contaminant	Use	Number of detections
Pesticides - no detections		
Pharmaceuticals and Personal Care Products		
Caffeine	Stimulant drug	2
DEET	Insect repellent	1
Theobromine	Found in cocoa beans and tea; similar to caffeine	1
Waste Indicators – not collected		

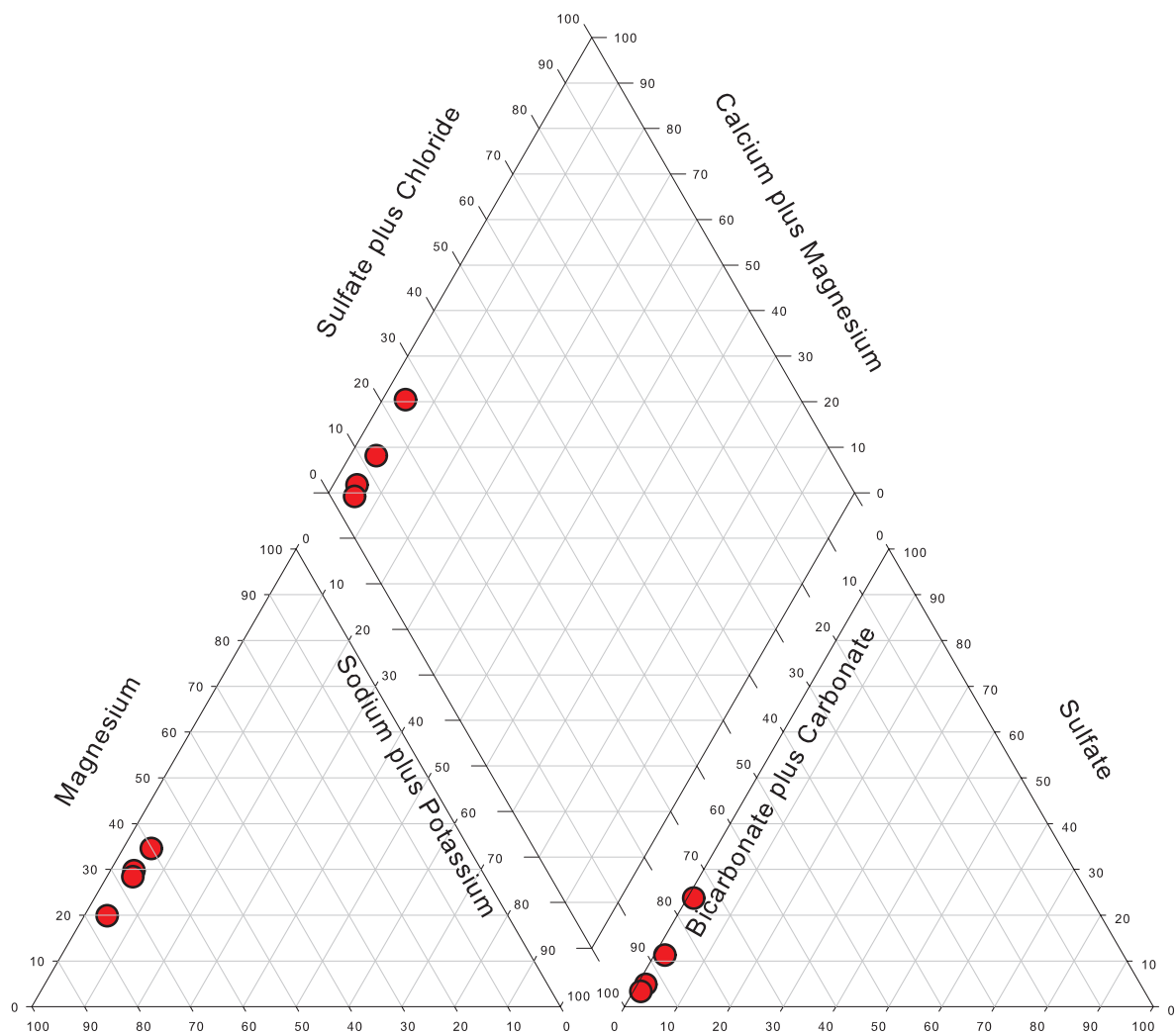


Figure 6. Major ion composition at COY01 in Glen Canyon NRA, 2013.

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.

In 2013, four duplicate bacteria samples were collected at several SCPN monitoring sites by filling two sample bottles in succession and comparing tray results after the incubation period. In addition, two blank samples were processed using sterile water provided by IDEXX.

To verify the cleanliness of both the sampling equipment and the sample filtration process for nutrients, major elements, and trace metals, NWQL analyzed two sample sets of certified inorganic blank water in 2013. The results were compared against the 2014 reporting levels. To verify the cleanliness of the sample collection process for Contaminants of Emerging Concern, two blank samples were collected at ESC02 for pesticides, pharmaceuticals, and personal care products in 2012–2013, and one blank was collected for waste indicators. At COY01, one blank was collected for pesticides, pharmaceuticals, and personal care products.

5 Summary

This report summarizes water quality monitoring activities at the Escalante River and Coyote Gulch during 2012–2013 in GLCA. Prior to 2012, limited water quality data was collected at these streams, but in 2013 ESC02 and COY01 became regular SCPN water quality monitoring sites to be visited on a quarterly basis. This report summarizes all activities at these sites since 2011 and compares the results to the Utah water quality standards (UDEQ 2014).

NPS core parameter measurements for water temperature, pH, specific conductance, dissolved oxygen, turbidity and discharge were recorded at all site visits. Measurements for temperature, pH, and dissolved oxygen were within the Utah state water quality criteria.

Starting in 2013, samples for *E. coli* and total coliform bacteria were collected during each of the quarterly site visits. Results for *E. coli* were well below the Utah state water quality criteria at ESC02 and COY01.

Nutrient and trace metal concentrations were low at both sites, and also below the Utah water quality criteria. A total of eleven contaminants of emerging concern were detected at the two monitoring sites on the Escalante River and three were detected at Coyote Gulch. These chemicals included herbicides, DEET, caffeine, endocrine disruptors, and flame retardants.

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 Escalante River and Coyote Gulch in Glen Canyon NRA.

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.
- Macfarlane, W.W., and J.M. Wheaton. 2013. Modeling the capacity of riverscapes to support dam-building beaver. Case study: Escalante River watershed. Utah State University, Ecogeomorphology & Topographic Analysis Laboratory. Available at http://etal.usu.edu/GCT/BRAT_Final_Report.pdf (accessed February

2015).

- 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, Fort Collins, Colorado.
- National Oceanic and Atmospheric Administration/National Climatic Data Center (NOAA/NCDC). 2015. Daily Summaries Station Details page for Station ID: GHCND:USC00422592. Available at <http://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USC00422592/detail> (accessed February 2015).
- National Oceanic and Atmospheric Administration/National Climatic Data Center (NOAA/NCDC). 2015. Daily Summaries Station Details page for Station ID: GHCND:USC00420849. Available <http://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USC00420849/detail> (accessed February 2015).
- National Oceanic and Atmospheric Administration/National Climatic Data Center (NOAA/NCDC). 2015. Daily Summaries Station Details page for Station ID: GHCND:USC00421020. <http://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USC00421020/detail> (accessed February 2015).
- 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, Great Lakes, Heartland, Sonoran Desert and Southern Plains Inventory and Monitoring Networks. Unpublished report, Fort Collins, Colorado.
- 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 22 February 2015).
- 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>.
- Utah Department of Environmental Quality. 2015. Utah Administrative Code. Rule R317-2. Standards of Quality for Waters of the State. Accessed from <http://www.rules.utah.gov/publicat/code/r317/r317-002.htm>.

Appendices

Appendix A: Southern Colorado Plateau Network Water Quality Monitoring Sites in Glen Canyon National Recreation Area

Table A1. Southern Colorado Plateau Network (SCPN) water quality monitoring sites for Glen Canyon NRA, 2011–2013.

Site code	Common name	Report name	Northing (m) ^a	Easting (m) ^a	Elevation (m) ^a
GLCACOY01 ^b	Coyote Gulch above Crack-in-the-Wall Trail	COY01	500945	4142251	1147
GLCAESC01	Escalante River below Steven's Canyon	ESC01	501293	4143055	1134
GLCAESC02 ^b	Escalante River at Coyote Gulch	ESC02	501698	4142320	1129

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

^b SCPN long-term water quality monitoring sites.

Appendix B. Water quality monitoring results for the Escalante River and Coyote Gulch at Glen Canyon National Recreation Area, 2011–2013

Table B1. Contaminant of emerging concern detections from ESC01 on the Escalante River in Glen Canyon NRA, 2011. Analytes listed in this table were detected at least once during 2011. See Appendix C for a complete list of CECs.

CEC	Reporting limit (ng/L)	Sampling date and time	
		6/10/2011 5:40	10/29/2011 8:30
Pesticides			
Propachlor OA	10	17	
Triclopyr	20		60
Pharmaceuticals and Personal Care Products (PPCPs) - None detected			
Waste Indicators			
Bisphenol A	50	99.6 ^a	
Estrone	50		78.6
Pentachlorophenol	50		50.2
Tri(dichloroisopropyl) phosphate	50	126 ^a	
Triphenyl phosphate	50		59.2

^a QA/QC acceptance criteria not met; results are estimated.

Table B2. Water quality core parameter data from ESC02 on the Escalante River in Glen Canyon NRA, 2012–2013.

Parameter	Sampling date and time				
	6/6/2012 10:30	9/5/2012 10:47	4/4/2013 15:00	6/13/2013 6:40	9/26/2013 13:30
Water temperature (°C)	18.6	20.9	15.1	22.4	16.8
pH	8.1	7.9	8.6	8.3	8.6
Specific conductance (µS/cm)	527	-	502	534	673
Dissolved oxygen (mg/L)	7.7	5.7	9.1	6.8	8.3
Dissolved oxygen (% saturation)	93	87	103	90	99
Turbidity (NTU)	3.3	30400	13	5.2	300
Discharge cfs	18.2	29.7	64.6	14.3	81.3

Table B3. Total coliforms and *E. coli* in samples collected at ESC02 on the Escalante River in Glen Canyon NRA, 2013.

Parameter	Sampling date and time		
	4/4/13 15:00	6/13/13 06:40	9/26/13 13:30
Total coliforms, MPN/100mL	200	2400	>2400 ^a
<i>E. coli</i> , MPN/100mL	<1	6	59.1

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

Table B4. Contaminant of emerging concern detections from ESC02 on the Escalante River in Glen Canyon NRA, 2012–2013. Analytes listed in this table were detected at least once. See Appendix C for a complete list of CECs.

CEC	Reporting limit (ng/L)	Sampling date			
		6/6/2012 10:30	9/5/2012 10:47	6/13/2013 6:40	9/26/2013 13:30
Pesticides					
Triclopyr	20		926		258 ^a
Pharmaceuticals and Personal Care Products (PPCPs)					
Caffeine	10	18.3			
DEET	10	185 ^b		17.3 ^a	
Phenylpropanolamine	10				15.3 ^a
Triclocarban	10		18.2		
Waste Indicators - none detected					

^a Analyzed outside holding time, result is biased low

^b Method blank was contaminated (32.8 ng/L), result is biased high

Table B5. Water quality core parameter data from COY01 on the Escalante River in Glen Canyon NRA, 2012–2013.

Parameter	Sampling date and time					
	6/6/2012 8:15	9/5/2012 11:41	4/4/2013 13:00	6/13/2013 8:16	9/26/2013 15:30	12/11/2013 13:45
Water temperature (°C)	15.3	21.5	12.3	21.1	19.6	0.1
pH	8.1	8.2	8.5	8.2	8.5	8.2
Specific conductance (µS/cm)	261	-	298	282	513	421
Dissolved oxygen (mg/L)	8.6	6.9	9.7	7.1	7.7	12.6
Dissolved oxygen (% saturation)	96	101	104	92	98	100
Turbidity (NTU)	3.2	3150	13	4.3	450	66
Discharge cfs	0.1	1.3	3.0	0.2	2.0	3.0

Table B6. Total coliforms and *E. coli* in samples collected at COY01 on Coyote Gulch in Glen Canyon NRA, 2013.

Parameter	Sampling date and time			
	4/4/13 13:00	6/13/13 08:16	9/26/13 15:30	12/11/13 13:45
Total coliforms, MPN/100mL	>2400 ^a	2400	>2400 ^a	>2400 ^a
<i>E. coli</i> , MPN/100mL	<1	17	130	6

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

Table B7. Contaminant of emerging concern detections from COY01 on Coyote Gulch in Glen Canyon NRA, 2012–2013. Analytes listed in this table were detected at least once. Samples were collected for CECs on 4 occasions, but CECs were not detected above the reporting limit on 9/5/2012. See Appendix C for a complete list of CECs.

CEC	Reporting limit (ng/L)	Sampling date and time		
		6/6/2012 8:15	6/13/2013 08:16	9/26/2013 15:30
Pesticides				
Pharmaceuticals and Personal Care Products (PPCPs)				
Caffeine	10	21		15.3 ^a
DEET	10		1280 ^{a,b}	
Theobromine	10		24.4 ^a	
Waste Indicators - No detections				

^a Analyzed outside holding time, result is biased low.

^b Result is outside the quantitation range.

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	Terbuthylazine	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	Methypylon	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

Table C-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)
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 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
$\mu\text{g/L}$	micrograms per liter
$\mu\text{S/cm}$	microsiemens per centimeter at 25°C, a measure of specific conductance
mg/L	milligrams per liter
Milliequivalents per liter	an expression of the concentration of substances that is chemically equivalent in terms atomic weight and electrical charge
MPN/100 mL	most probable number, for sampling bacteria, a statistical estimation of the number of coliform that would give the results shown by the laboratory examination
N	chemical symbol for the element nitrogen
ng/L	nanograms per liter
NTU	nephelometric turbidity unit, a measure of turbidity
P	chemical symbol for the element phosphorous

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