



Screening for Contaminants of Emerging Concern in the Northern Colorado Plateau Network, 2010 and 2012

Natural Resource Technical Report NPS/NCPN/NRTR—2013/802



ON THE COVER

Clockwise from top left: Yampa River, Dinosaur National Monument; Timpanogos Cave, Timpanogos Cave National Monument; Fremont River, Capitol Reef National Park; Courthouse Wash, Arches National Park. NPS photos.

Screening for Contaminants of Emerging Concern in the Northern Colorado Plateau Network, 2010 and 2012

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Acronyms

µg/L	micrograms per liter
CEC	contaminant of emerging concern
EDP	endocrine-disrupting potential
EPA	Environmental Protection Agency
J	estimated data
LC ₅₀	lethal concentration for 50% of organisms
LCMS	Liquid Chromatography – Mass Spectrometry
LOEL	lowest observed effect level
NCPN	Northern Colorado Plateau Network
ND	not detected
PAH	polycyclic aromatic hydrocarbon
PPCP	pharmaceutical and personal care products
QA/QC	quality assurance and quality control
RPD	relative percent difference
VOA	volatile organic analysis
WW	wastewater indicator

Executive Summary

Rivers and streams are the lifeblood of the Colorado Plateau, yet they can also serve to carry contaminants far away from their original sources. While NCPN parks generally lie far from metropolitan areas, human land-use activities within the parks and/or their watersheds include oil and gas development, livestock use, cultivated farmland, sparse to moderate human occupation, recreational use, and park management practices. Waters in the NCPN range from remote springs to inter-regional rivers and can be expected to have varying levels of exposure to these activities.

So-called contaminants of emerging concern (CECs)—compounds such as pesticides, pharmaceuticals, personal care products, and wastewater indicators—are pollutants that have not traditionally been tested for during water quality sampling and may not be adequately cleansed by current wastewater treatment methods. The effects of CECs are often just beginning to be assessed, yet regional studies have shown that these compounds can be found in waters throughout western North America, including remote locations with no direct anthropogenic source.

In 2010, in cooperation with the U.S. Environmental Protection Agency Region 8, Northern Colorado Plateau Network (NCPN) and park staff sampled a wide variety of network waters (30 sites selected by park staff in 11 parks) to identify potential hotspots for CECs. Follow-up sampling in 2012 focused on water bodies that were noted as hotspots during the 2010 sampling, either because multiple analytes were detected in a sample or because analytes were detected at levels of concern.

Overall, the majority of CEC analytes were never detected in any sampled NCPN water body, and one-third of site visits had no analytes detected. Plasticizers, herbicides, and fire retardants were the most commonly detected types of analytes. Solvents and disinfectants were not detected as frequently, but were detected in higher concentrations than other analyte types. Herbicides, while detected frequently, were found at relatively lower concentrations than other common analyte types.

In comparison to more urbanized watersheds, NCPN waters had fewer analytes and lower total analyte concentrations. However, some sites reported analytes at levels high enough to potentially affect aquatic ecosystems. The Yampa River (Dinosaur NM) remains a priority for NCPN sampling due to the high number of analytes detected despite its paucity of point sources. The Colorado River (Canyonlands NP) has chronic contamination by a few CECs and, in general, had more detections than the Green River (Canyonlands NP, Dinosaur NM). Sampling to further document the presence of CECs in NCPN waters will continue.

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1 Introduction

The Northern Colorado Plateau Network Inventory and Monitoring (NCPN) program serves 16 national park units in Utah, western Colorado, northern Arizona, and southern Wyoming. In cooperation with the U.S. Environmental Protection Agency Region 8 (EPA), NCPN and park staff screened a variety of waters for the presence of pesticides, pharmaceutical and personal care products (PPCPs), and other contaminants of emerging concern (CEC) found in wastewater. CECs are pollutants that have not traditionally been tested for during water quality sampling and may not be adequately cleansed by current wastewater treatment methods.

While NCPN parks generally lie far from metropolitan areas, human land-use activities within the parks and/or their watersheds include oil and gas development, livestock use, cultivated farmland, sparse to moderate human occupation, recreational use, and park management practices. Waters in the NCPN range from remote springs to inter-regional rivers and can be expected to have varying levels of exposure to these activities.

The effects of pesticides, PPCPs, and CECs found in wastewater are often just beginning to be assessed, yet regional studies have shown that these compounds can be found in waters throughout western North America, including remote locations with no direct anthropogenic source (Blais et al. 1998; Sprague and Bataglin 2004; Keteles 2011). Some of these compounds have been linked to the presence of intersex fishes (Lee et al. 2008; Writer et al. 2010) and even the complete collapse of fish populations (Kidd et al. 2007). In most cases, standards or benchmarks for acceptable levels of contamination have yet to be quantified.

1.1 Sampling locations

In 2010, NCPN and park staff sampled a wide variety of park waters (30 sites selected by park staff in 11 parks) to identify potential hotspots of contamination. Samples were collected at Arches, Bryce Canyon, Canyonlands, Capitol Reef, and Zion national parks (NP); Curecanti National Recreation Area (NRA); and Dinosaur, Hovenweep, Natural Bridges, Pipe Spring, and Timpanogos Cave national monuments (NM) from July to November 2010, in water bodies selected by each park unit (Figure 1-1; Table 1-1). Follow-up sampling in 2012 focused on water bodies that were noted as hotspots during the 2010 sampling, either because multiple analytes were detected in a sample or because analytes were detected at levels of concern. One additional location (Goodman Point, at Hovenweep NM) was sampled accidentally on one visit.

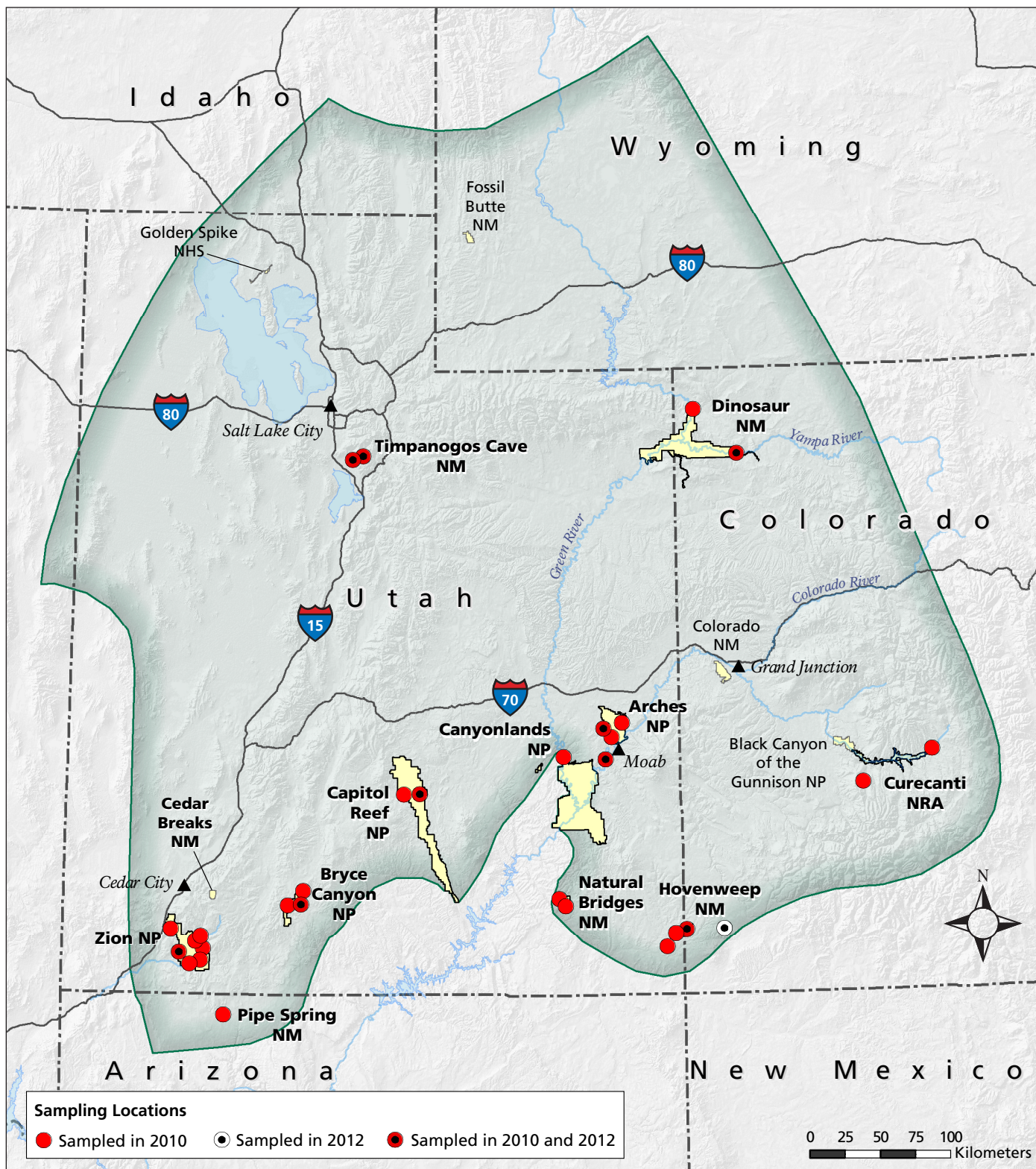


Figure 1-1. Northern Colorado Plateau Network parks sampled for contaminants of emerging concern in 2010 and 2012.

Table 1-1. Sampling sites for contaminants of emerging concern in NCPN parks, 2010 and 2012.

Park unit	Park code	State	Site	STORET/ NWIS ID	Water body type	2010	2012
Arches NP	ARCH	UT	Salt Wash	5995220	intermittent stream	X	
			Sleepy Hollow	5995250	spring	X	
			Courthouse Boundary	5995245	spring	X	X
Bryce Canyon NP	BRCA	UT	Mossy Cave	4951915	spring	X	
			Sheep Creek	4951855	perennial stream	X	
			Yellow Creek	4951857	perennial stream	X	X
Canyonlands NP	CANY	UT	Colorado River	4956290	inter-regional river	X	X
			Green River	4930150	inter-regional river	X	
Capitol Reef NP	CARE	UT	Fremont River	4954360	regional river	X	X
			Sulphur Creek	4954770	perennial stream	X	
Curecanti NRA	CURE	CO	Gunnison River	383103106594200	regional river	X	
			Lake Fork Gunnison River	381934107133500	regional river	X	
Dinosaur NM	DINO	CO	Green River	404417108524900	inter-regional river	X	
			Yampa River	09260050	regional river	X	X
Hovenweep NM	HOVE	UT	Cajon Spring	5995710	spring	X	
		CO	Goodman Point	n/a	spring		X
		CO	Hackberry Spring	5995720	spring	X	X
		UT	Square Tower	5995700	spring	X	
Natural Bridges NM	NABR	UT	Armstrong Canyon	5995310	intermittent stream	X	
			Owachomo Bridge	5995320	intermittent stream	X	
Pipe Spring NM	PISP	AZ	Tunnel Spring	PISP_NPS_TS	spring	X	
Timpanogos Cave NM	TICA	UT	Middle Cave bridge	n/a	cave	X	X
			Middle Cave off-trail	TICA_BYU_MCL	cave	X	X
Zion NP	ZION	UT	Grotto Spring	ZION_USGS_GR	spring	X	
			La Verkin Creek	4950800	perennial stream	X	
			Menu Falls Spring	n/a	spring	X	
			North Creek	4950920	perennial stream	X	X
			North Fork of the Virgin River at Temple of Sinawava	4951199	regional river	X	
			Temple of Sinawava Spring	ZION_USGS_TS	spring	X	
			Upper Emerald Pool	n/a	spring	X	

STORET = EPA Storage and Retrieval database, NWIS = U.S. Geological Survey National Water Information System, AZ = Arizona, CO = Colorado, UT = Utah

2 Methods

2.1 Field sampling

In 2010, pesticide and wastewater indicator samples were collected during each site visit. In 2012, PPCP testing was added. Pesticides and PPCPs were analyzed from the same sample, while wastewater indicators were analyzed from a separate sample. In 2012, wastewater indicator samples were not taken during every sampling visit due to limitations in laboratory processing availability.

Sample bottles and coolers were provided by the EPA laboratory. Park personnel put on clean gloves for each sample, dipped and rinsed the sample bottles in source water twice, then collected grab samples of the source water. Sample bottles were labeled and immediately placed on ice. Samples were packed in ice and shipped overnight to the EPA lab as soon as possible after sampling (maximum hold time of five days).

2.2 Laboratory analysis

Laboratory analysis methods used are shown in Table 2-1. Pesticide and PPCP samples were filtered and the dissolved fraction was analyzed. Wastewater samples were not filtered and the total sample was analyzed. Samples were analyzed for 73 pesticide analytes, 102 PPCP analytes, and 83 wastewater analytes. A schedule of all analytes, and the lowest concentration at which they can be reported (the reporting limit), is provided in Appendix A.

2.2 Quality assurance and quality control

2.2.1 Field sampling

Field-sampling quality assurances improved during the course of the study. The NCPN water quality staff had complete turnover of personnel between the 2010 and 2012 sampling seasons, leading to the repetition of some errors between years.

Out of 65 sample visits in 2010, eight (12%) were flagged as out of the recommended temperature range (i.e., they arrived at the lab too warm). These eight samples all came from Dinosaur or Timpanogos Cave NMs; half of their 2010 data were flagged on that basis.

In 2012, the temperature range was exceeded for samples collected on 11 of 30 (37%) pesticide and PPCP visits and 7 of 19 (37%) wastewater indicator visits. Yampa River (Dinosaur NM) data were flagged for four of seven (57%) visits. Samples from two of three visits to Yellow Creek (Bryce Canyon NP) and three of four visits to the Fremont River (Capitol Reef NP) were also flagged. Estimated data from samples that exceeded holding times (9 of 267 detections) and/or recommended temperature ranges (46 of 267 detections) are included in data summaries.

2.2.2 Field blanks

Field blank samples are processed at the field site using de-ionized water in the same

Table 2-1. Analysis methods and sample requirements for the EPA Region 8 laboratory.

Parameter/Analytical method	Sample volume	Container size and type	Preservation	Maximum holding time
Pesticides by Liquid Chromatography – Mass Spectrometry (LCMS), EPA Method 8321A, EPA R8 Laboratory SOP ORGM-550	40 ml	Sterile 40-ml amber glass volatile organic analysis (VOA) vials	Ice to 2–6°C	7 Days
PPCPs by LCMS EPA Method 1694 EPA R8 Laboratory SOP LCMS PPCPs Electrospray Ionization (ESI)+ and LCMS PPCPs ESI-	40 ml	Sterile 40-ml amber glass VOA vials	Ice to 2–6°C	7 Days
Waste Water Indicator Compounds by Gas Chromatography – Mass Spectrometry, EPA R8 Laboratory SOP ORGM-006	250 ml	Sterile 250-ml amber glass VOA vials	Ice to 2–6°C	7 days to extraction

manner and using the same equipment as the environmental samples. The purpose of a field blank is to determine whether contamination is being introduced during sample collection and handling. Field blanks are evaluated with the benchmark of no detection for every parameter.

Field blanks were submitted for 3 of 30 of pesticide/PPCP samples (10%) and 1 of 19 wastewater indicator samples (5.3%), beginning in September 2012. Field blanks for pesticide/PPCPs and wastewater indicators submitted by the NCPN in September 2012 had several analyte contaminants. Most of these contaminants were not detected in the source-water sample and did not compromise source-water sampling results (Table 2-2). However, caffeine was detected in both the blank and the source water, and the source-water detection was set to Not Detected (i.e., the data were removed from analysis). Field blanks for pesticide/PPCPs submitted by Dinosaur NM in October and November 2012 met the quality assurance/quality control (QA/QC) goal of having no detections.

2.2.3 Replicate samples

Replicate samples are collected concurrently with environmental samples and processed in the same lab. The purpose of a replicate is to determine the variability introduced from collection, processing, shipping, and laboratory handling. Replicate samples are evaluated with the benchmark that all detected parameters are within 30% relative percent difference (RPD) of those detected in the environmental samples. RPD is calculated as the percent difference between the detected amounts, divided by the average of the amounts: $(A-B)/((A+B)/2)*100$.

A non-detected parameter in the environmental sample should also be non-detected in the replicate sample. If a parameter is detected in one sample but not the other, then the detected result should be within 30% of the reporting limit. When original samples and their replicates are entirely composed of non-detects, it is assumed that the analyses are falling within the desired precision. Of the 2010 samples, two pesticide and three wastewater indicator samples were entirely non-detects. Of the 2012 samples, five pesticide/PPCP and two wastewater indicator samples were entirely non-detects.

Of 72 site visits in 2010, replicate samples were opportunistically taken during four pesticide (6%) and four wastewater indicator (6%) visits in 2010. Systematic replicate sampling was instituted at the beginning of the 2012 field season in May, with a goal of taking replicates for 10% of samples. Replicate samples were taken for 7 of 30 (23%) pesticide/PPCP samples and 4 of 19 (21%) wastewater indicator samples in 2012. Replicate samples in excess of the 10% goal were taken to ensure that sampling visits by different observers at different locations were adequately covered.

Analytes detected in both the environmental and the replicate samples (n=46 replicates) were compared to determine whether the analysis met the precision goal. Analytes for which one replicate had a detected amount and the other was a non-detect (n=30 replicates) were compared by adding 30% to the reporting limit and seeing if the detected amount fell within this range. The analytes in Table 2-3 did not meet the 30% RPD goal (18 of 76 replicates with at least one detected amount).

2.2.4 Laboratory measures

Laboratory QA/QC measures include laboratory (1) blanks that test for contamination during the analysis process, (2) spikes in which an analyte of known concentration is analyzed, and the percent recovery of the known amount is recorded¹, and (3) duplicates that test for precision. For pesticides,

¹For example, if 50 ng/L of caffeine was added to a sample and the analyzed result said 52.3 ng/L, then the “percent recovery” would be 104.6%.

Table 2-2. Analytes detected in a contaminated blank sample from North Creek (ZION) in September 2012.

Analyte	Detected amount (µg/L)	Reporting limit (µg/L)
Acetophenone	1.140	0.0500
Benzophenone	0.788	0.0500
Caffeine	0.0259	0.0100
Camphor	0.149	0.0500
DEET	4.080 J	0.0100
Phenol	5.390	0.100

J = outside of quantitation range

Table 2-3. Analytes with greater than 30% relative percent difference (RPD) between replicate samples.

Date	Park	Site	Analyte	RPD
7/2010	CURE	Gunnison River	2,4-D	46%
7/2010	CURE	Gunnison River	Acetophenone	>30% (non-detect)
7/2010	CURE	Gunnison River	Triphenyl phosphate	>30% (non-detect)
7/2010	DINO	Yampa River	Phenol	>30% (non-detect)
7/2010	DINO	Yampa River	Triclosan	>30% (non-detect)
7/2010	PISP	Tunnel Spring	Neburon	>30% (non-detect)
5/2012	DINO	Yampa River	Tri (2-butoxyethyl) phosphate	>30% (non-detect)
11/2012	CANY	Colorado River	Bisphenol A	>30% (non-detect)
11/2012	CANY	Colorado River	Caffeine	51%

See Table 1-1 for park codes.

the acceptance criteria are +/- 20% of the matrix blanks, spikes, and duplicates. For PPCPs and wastewater indicators, the acceptance criteria are +/- 30% of the matrix blanks, spikes, and duplicates.

Forty-one of 267 detected analytes were flagged for analytical reasons. Of those, 33 were analyzed in the same batch as a contaminated laboratory blank. For these analytes, the detected amount was compared to the amount falsely reported for the laboratory blank. If the detected amount in the source-water sample was within 2× the amount reported for the blank, then the data were set to Not Detected. If the amount in the source water was greater than 2× the amount reported for the contaminated blank, then the data were reported as estimated with a J-flag.

In eight cases, analytes were flagged as having greater than 120–130% recovery of a spike. If the detected amount in the source-water sample was within 130% of the reporting limit, then these data were set to Not Detected. If the source-water detection was greater

than 130% of the reporting limit, then the data were reported as estimated with a J-flag.

The remaining analytically flagged data were reported as estimated with a J-flag. In four cases, analytes were flagged for low recovery (<70–80%). One analyte was detected outside the calibrated range for the test, and two analytes had a flag of unknown origin.

Analytes that could not be estimated were not included in results provided by the laboratory, but were included in the QA/QC summaries provided with each dataset. In addition, some analytes were added to or removed from the analyte suite during the course of sampling.

In 2010, out of 66 pesticide and 48 wastewater indicator analytes (114 total) per analysis, the analytes shown in Table 2-4 were not reported.

In 2012, all 223 total analytes (68 pesticide, 53 wastewater indicator, and 102 PPCP), were reported.

Table 2-4. Analytes not reported in 2010 due to failure to meet laboratory QA/QC goals or additions or deletions to the analyte suite.

Analysis date	Analytes excluded	% excluded	Park data affected
7/17/10	3-Hydroxycarbofuran, Bendiocarb, Methiocarb	3	ARCH, CANY, CURE, HOVE, PISP, TICA
8/7/10	3-Hydroxycarbofuran, Methiocarb, Oxamyl	3	DINO
8/13/10	Methiocarb	<1	ARCH, CANY, CURE, PISP, TICA
8/20/10	None	0	CARE, ZION
9/10/10	None	0	BRCA, CARE, CURE, DINO, PISP, TICA, ZION
9/17/10	None	0	ARCH, BRCA, NABR
10/8/10	Acetochlor	<1	ARCH, CURE, DINO, PISP, TICA
10/15/10	Acetochlor	<1	ZION
10/29/10	Acetochlor	<1	CARE
11/5/10	Acetochlor	<1	PISP
11/12/10	2,4,5-T; 2,4,5-TP; 2,4,5-D; Acetochlor, Acetochlor OA, Alachlor OA, Bentazon, Bromoxynil, Dacthal monoacid, Dichloroprop, Dimethenamid OA, MCPA, MCPP, Metolachlor OA, Oryzalin, Propachlor OA, Triclopyr	15	CURE, DINO, TICA
11/18/10	Acetochlor	<1	ARCH, BRCA, HOVE, ZION

See Table 1-1 for park codes.

3 Results

There were 76 sample visits in 2010 and 32 sample visits in 2012, for a total of 108 visits. Of those 108 visits, no analytes were detected at 45 (42%) visits, only one analyte was detected at 28 (26%) visits, and two or more analytes were detected at 35 (32%) visits. The median number of analyte detections per visit was 1. Of the 30 sites sampled, 10 had no compounds detected during any visit, 3 had only one analyte detected, and 17 had two or more analytes detected over the course of all visits. Nine of the 10 non-detect sites were locally spring-fed (at or near a spring source with little to no runoff component). The remaining site was a perennial stream with a local watershed contained entirely on public lands.

Forty-six unique analytes were detected throughout the course of this study, including 10 pesticides, 5 PPCPs (two of which are also wastewater indicators), and 33 wastewater indicators (two of which are also PPCPs; see Table 3-1). The majority of analytes were not detected at any site, including 63 of 73 pesticide compounds (86%), 97 of 102 PPCPs (95%), and 22 of 55 wastewater indicators (40%). Due to the large number of analytes, only detected analytes are presented in this report. For a full schedule of analytes and their reporting limits, see Appendix A.

In most cases, because of their emerging status, no water quality benchmarks or standards apply to contaminants of emerging concern. For the limited number of analytes for which state water quality or national aquatic life benchmarks have been determined, no exceedances were found. In addition to possible direct toxicity, many of the analytes included in the analysis suite are known or suspected endocrine disruptors, which can have harmful effects on aquatic vertebrates. The endocrine-disrupting potential (EDP)

of detected analytes is described in Table 3-1. Analytes included in the tested suite may also be ecologically benign but serve as indicators of persistent synthetic compounds in the natural environment.

The ecological effects of these compounds are often uncertain. A range of known effect levels can be represented by (1) the lowest observed effect level (LOEL) for freshwater organisms (which can include effects not only on mortality, but also on ecologically relevant variables, such as biochemistry, behavior, and morphology), and (2) the acute toxicity rating at which 50% of tested organisms die (lethal concentration for 50% of organisms, LC_{50})¹. Table 3-2 shows the detected analytes and their LOEL or LC_{50} thresholds and indicates whether those thresholds were exceeded in NCPN waters. A list of all analytes detected and the values at which they were detected, with exceedances noted, is provided as Electronic Appendix A.

PPCPs and wastewater contaminants tend to have the strongest effects on vertebrates, while pesticides affect the foundations of the aquatic food chain, such as invertebrates and algae. Micro-organisms can also be impacted; there is concern that the presence of antibiotic compounds may hasten the development of drug resistance in the wild. Endocrine-disrupting chemicals, in particular, can be bioactive at very low concentrations that may not be captured by an LOEL. For example, studies indicate that Bisphenol A concentrations as low as 1 µg/L can have endocrine-disrupting effects on aquatic organisms, and a conservative estimate adopted by Canada of a safe level for no effect is 0.175 µg/L (EPA 2010). As such, the mere presence of potential endocrine disruptors in aquatic systems may be of concern.

The most frequently detected compounds all occurred at low concentrations (less than 1 µg/L) (Figure 3-1).

¹ While provided for comparison with levels detected in NCPN waters, the LOEL and LC_{50} are standardized tests that can be misleading because (1) the values are usually developed based on laboratory tests with static water conditions, rather than flowing natural environments, (2) information is often not available for every taxonomic group (e.g., amphibians, fish, invertebrates including zooplankton, vascular plants, non-vascular plants including phytoplankton), (3) some of the values are derived from thousands of studies while others are derived from only a handful, and (4) the LOEL is highly dependent on instrument sensitivity. Note that pharmaceuticals are not expected to occur at levels that will affect aquatic life, but are included in this table to provide context.

Table 3-1. Analytes detected at one or more sampling location by indicator type, 2010 and 2012.

Analyte	CAS #	EDP ²	Example source(s)
Pesticides			
2,4-D	94-75-7	K ⁴	herbicide
Acetochlor	34256-82-1	S ³	herbicide
Bendiocarb	22781-23-3	K ⁴	insecticide
Diuron	330-54-1	K ⁴	herbicide
Hexazinone	51235-04-2	--	herbicide
Metalaxyl	57837-19-1	--	fungicide
Metolachlor ESA	947601-85-6	--	herbicide breakdown product
Propachlor OA	70628-36-3	--	herbicide breakdown product
Tebuthiuron	34014-18-1	--	herbicide
Triclopyr	55335-06-3	--	herbicide
Pharmaceutical and personal care products			
DEET	134-62-3	--	insecticide, mosquito repellent
Naproxen	22204-53-1	--	anti-inflammatory medication, nonprescription drug
Sulfamethoxazole	723-46-6	--	antibiotic medication
Wastewater indicators			
17beta-Estradiol	50-28-2	K	livestock feed supplement, hormone
3-Methyl-1H-indole (skatole)	83-34-1	--	fecal matter, fragrance
4-Cumylphenol (PCP)	599-64-4	K ³	plastic and rubber polymers, plasticizer
4-n-Octylphenol (POP)	1806-26-4	K ³	surfactant, resin, detergent metabolite
Acetophenone	98-86-2	--	resin, coating, ink, adhesive, fragrance , beverage additive
Benzophenone	119-61-9	S ³	fixative for fragrances and soaps
Bisphenol A	80-05-7	K ³	plastics, plasticizer
Bromacil	314-40-9	K ⁴	herbicide
Camphor	76-22-2	--	plasticizer , antimicrobial, moth repellent, flavor, odorant
Carbaryl	63-25-2	K ³	insecticide
Chlorpyrifos	2921-88-2	K ³	insecticide
DCPA (Dacthal)	1861-32-1	K ⁴	herbicide
Dichlorvos	62-73-7	K ⁴	insecticide
Estrone	53-16-7	K	human hormone
Ethinyl estradiol	57-63-6	K	birth control pills, hormone
Fluoranthene	206-44-0	--	byproduct of combustion, PAH
Galaxolide	1222-05-5	K ⁴	fragrance
Isoquinoline	119-65-3	--	solvent , dyes, insecticides, antifungals, paints, pharmaceuticals
Menthol	89-78-1	--	cigarettes, cough drops, liniment, mouthwash, fragrance
Metolachlor	51218-45-2	K ⁴	herbicide
Nonylphenol	25154-52-3	K ³	nonionic detergent or metabolite
p -Cresol	106-44-5	K ⁴	deodorizers, insecticide, disinfectant, solvent , wood preservative
Phenol	108-95-2	K ⁴	broad use: plastics, nylon, detergent, sunscreen, herbicide, pharmaceuticals, disinfectant
Prometon	1610-18-0	--	herbicide
Pyrene	129-00-0	--	dyes, combustion product, coal tar, asphalt, PAH
Tri(2-butoxyethyl) phosphate (TBEP)	78-51-3	--	flame retardant
Tri(2-chloroethyl) phosphate (TCEP)	115-96-8	S ³	flame retardant
Tri(dichloroisopropyl) phosphate (TDCP)	13674-87-8	S ³	flame retardant

Table 3-1. Analytes detected at one or more sampling location, 2010 and 2012, cont.

Analyte	CAS #	EDP ²	Example source(s)
Tributyl phosphate	126-73-8	--	extractant, plasticizer , hydraulic fracturing
Triethyl citrate	77-93-0	--	food additive, plasticizer
Triphenyl phosphate	115-86-6	K ⁴	plasticizer , flame retardant
Wastewater indicators/Pharmaceutical and personal care products			
Caffeine	58-08-2	K ⁴	beverages, diuretic, nonprescription drug
Triclosan	3380-34-5	K ⁴	antimicrobial, disinfectant

Bolded sources are categories used for subsequent data summaries (see Figure 3-2).

EDP = endocrine disrupting potential

PAH = Polycyclic aromatic hydrocarbon

² K = known; S = suspected; -- = no data found

³ as summarized in Lee and others (2008).

⁴ TEDX database, October 2011 version <http://www.endocrinedisruption.com/endocrine.TEDXList.overview.php>.

Table 3-2. Summary of the lowest level (µg/L) of each detected analyte found to impact a freshwater organism represented by standardized tests for lowest observed effect level (LOEL) and acute toxicity (lethal concentration for 50% of organisms, LC₅₀).

Analyte	Organism (LOEL)	Organism (LC ₅₀)
17beta-Estradiol	amphibians, fish (0.1) ¹	invertebrates (45) ¹
2,4-D	vascular plants (2) ¹	vascular plants (13.1) ²
3-Methyl-1H-indole (skatole)	--	fish (8,840) ³
4-Cumylphenol (PCP)	invertebrates (1,100) ⁴	fish (1,500) ⁴
4-n-Octylphenol (POP)	amphibians (0.206) ³	non-vascular plants (82) ⁴
Acetochlor	--	fish (380) ⁵
Acetophenone	--	fish (170,750) ¹
Bendiocarb	--	invertebrates (6.7) ¹
Benzophenone	--	fish (6,650) ³
Bisphenol A	invertebrates (1) ¹	invertebrates (200) ¹
Bromacil	non-vascular plants (0.1) ¹	non-vascular plants (6.8) ²
Caffeine	amphibians (0.05) ¹	amphibians (0.27) ¹
Camphor	--	invertebrates (500,000) ¹
Carbaryl	invertebrates (0.09) ¹	invertebrates (0.85) ²
Chlorpyrifos	invertebrates (0.03) ¹	invertebrates (0.05) ²
DCPA (Dacthal)	--	fish (6,600) ³
DEET	--	fish (71,250) ³
Dichlorvos	none < acute noted	invertebrates (0.035) ²
Diuron	non-vascular plants (0.02) ¹	non-vascular plants (2.4) ²
Estrone	fish (0.0033) ¹	invertebrates (100) ¹
Ethinyl estradiol	fish (0.0005) ¹	invertebrates (100) ¹
Fluoranthene	invertebrates (1.4) ¹	invertebrates (17.4) ¹
Galaxolide	invertebrates (205) ⁶	fish (452) ⁶
Hexazinone	fish (79.8) ³	fish (75,000) ³
Isoquinoline	--	fish (14,000) ³
Menthol	--	--
Metalaxyl	invertebrates (1,000) ¹	invertebrates (10,800) ¹

Table 3-2. Summary of the lowest level (µg/L) of each detected analyte found to impact a freshwater organism represented by standardized tests for lowest observed effect level (LOEL) and acute toxicity (lethal concentration for 50% of organisms, LC₅₀), cont.

Analyte	Organism (LOEL)	Organism (LC ₅₀)
Metolachlor	amphibians (7.4) ¹	non-vascular plants (8) ²
Metolachlor ESA	--	--
Naproxen	invertebrates (22,360) ³	invertebrates (62,500) ⁷
Nonylphenol	--	invertebrates (20.7) ³
p -Cresol	--	fish (7,250) ¹
Phenol	none < acute noted	invertebrates (5.51)¹
Prometon	none < acute noted	non-vascular plants (98) ²
Propachlor OA	--	--
Pyrene	invertebrates (5.8) ¹	invertebrates (8) ¹
Sulfamethoxazole	--	invertebrates (26,270) ³
Tebuthiuron	--	fish (106,000) ³
Tri(2-butoxyethyl) phosphate (TBEP)	--	fish (6,800) ⁸
Tri(2-chloroethyl) phosphate (TCEP)	--	non-vascular plants (5,000) ⁹
Tri(dichloroisopropyl) phosphate (TDCP)	--	fish (1,100) ¹⁰
Tributyl phosphate	none < acute noted	invertebrates (1,000) ¹
Triclopyr	none < acute noted	fish (260) ³
Triclosan	non-vascular plants (0.01)¹	amphibian (152)¹¹
Triethyl citrate	--	--
Triphenyl phosphate	fish (1.4) ³	fish (240) ³

Yellow highlights indicate that at least one detected concentration in our study surpassed the LOEL. Red highlights indicate that at least one detected concentration surpassed the LC₅₀.

µg/L = micrograms per liter.; -- = no data found.

¹ www.pesticideinfo.org, 1/5/12.

² EPA Aquatic Life Benchmarks (draft) http://www.epa.gov/oppefed1/ecorisk_ders/aquatic_life_benchmark.htm, 1/4/12.

³ EPA, Ecotoxicity database, <http://cfpub.epa.gov/ecotox/>, 2/15/13.

⁴ General Electric Company (2005).

⁵ EPA (1994).

⁶ EPA (2008).

⁷ Blaise and others (2006).

⁸ WHO (2000).

⁹ Environment Canada (2009).

¹⁰ EPA (2005).

¹¹ Brausch and Rand (2011).

3.1 Overall patterns

Plasticizers, herbicides, and fire retardants were the most commonly detected types of analytes (Figure 3-2). Solvents and disinfectants were not detected as frequently, but were detected in higher concentrations than other analyte types. Herbicides, while detected frequently, were found at relatively lower concentrations than other common analyte types. In comparison to more urbanized watersheds, as presented in Kolpin and others (2002), NCPN watersheds had proportionally fewer detections of pharmaceuticals and detergent metabolites and more detections of pesticides and flame retardants.

Few analytes were detected in most samples with CEC detections (median detections = 2; Figure 3-3), and most of the total concentrations were lower than 1 µg/L (median concentration = 0.2585 µg/L). Total concentrations tended to increase as the number of analytes increased (Spearman's rank correlation coefficient = 0.67, $p < 0.001$). The number of analytes detected and the total concentration of contaminants was much lower than in urbanized watersheds (Kolpin et al. 2002).

3.2 Park-specific results

3.2.1 Arches National Park

Salt Wash at Wolfe Ranch is a perennial reach of an intermittent stream fed by the shallow alluvial aquifer underlying Salt Wash. The sampling location is directly adjacent to one of the most popular hiking trails in the park. Pit toilets are located approximately 100 m upslope from the sampling location. Despite the busy location, little off-trail traffic occurs at the sampling site. No analytes were detected in pesticide and wastewater indicator samples taken in July, September, and November 2010.

Courthouse Boundary Spring is a perennial spring located just outside the park boundary fence. Age-dating indicates that this spring has a mixture of younger (<30 years) and older water (Masbruch et al. 2010). Livestock and off-highway vehicle use regularly impact the spring. Courthouse Boundary Spring was sampled in 2010 and 2012 (Table 3-3). Phenol surpassed known acute toxicity levels on one occasion. 17beta-Estradiol and ethynyl estradiol surpassed levels of known effect.

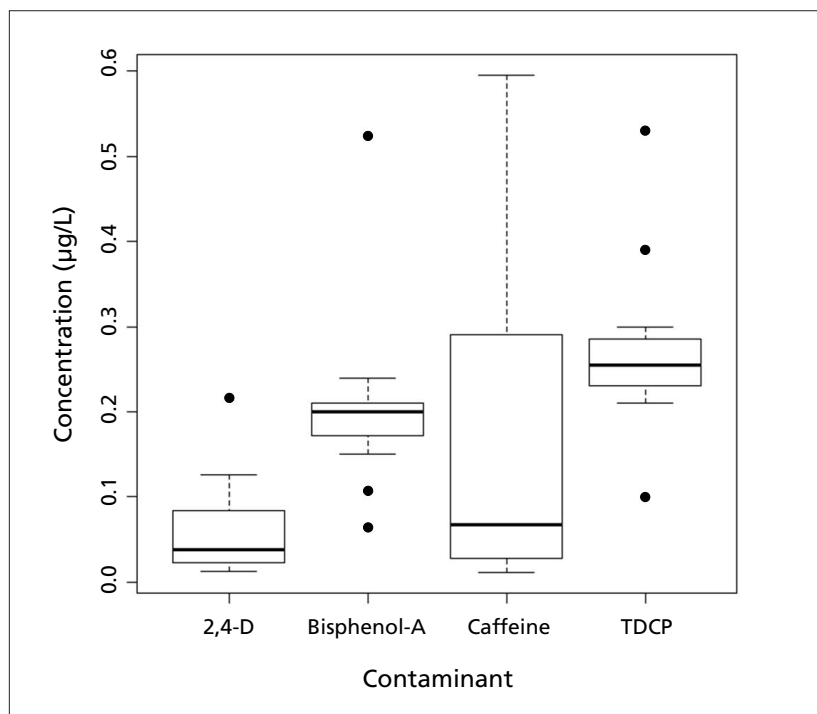


Figure 3-1. Comparison of concentrations for analytes with more than 10 detections. Boxes show the median (middle data point) and interquartile range (25–75% of data), while whiskers and points indicate the entire range of concentrations reported. Estimated data are included in this figure.

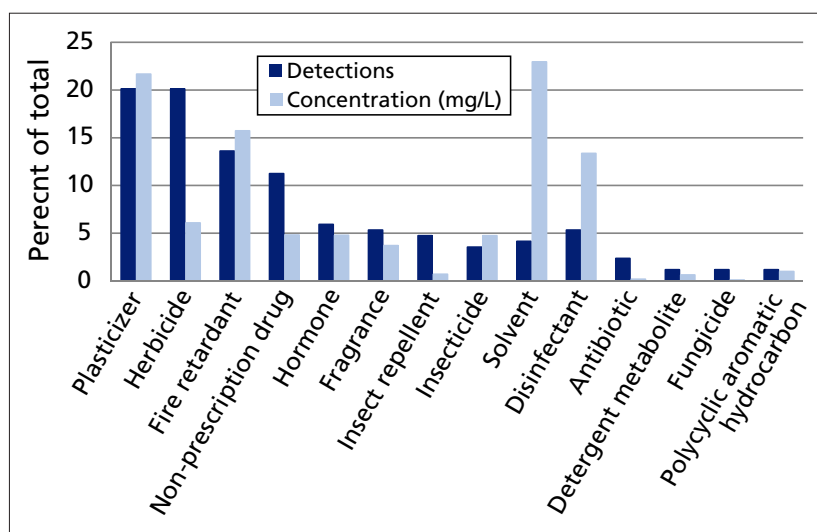


Figure 3-2. Relative frequency of detections and relative concentrations of analyte categories, expressed as percent of the total number of detections and total concentration of detected analytes.

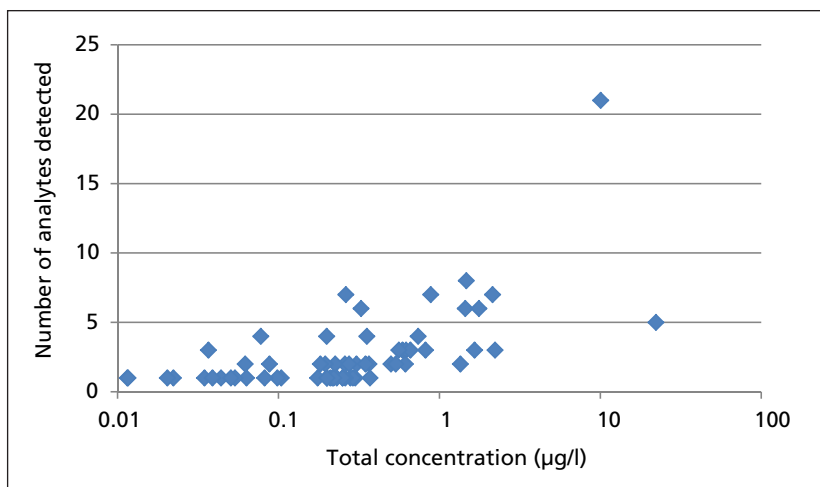


Figure 3-3. Relationship between total concentration (summation of all detections) and number of contaminants found per sample in samples with detected analytes.

Table 3-3. Detected analytes (µg/L) in Courthouse Boundary Spring, 2010 and 2012.

Analyte	2010		2012		
	Aug.	Oct.	May	July	Sept. ^a
17beta-Estradiol	ND	0.260	ND	ND	ND
3-Methyl indole	0.820	ND	ND	ND	ND
Bisphenol A	ND	0.210	ND	ND	ND
Caffeine	ND	0.310	ND	ND	ND
Camphor	3.020	0.710	ND	ND	1.5200
Ethynyl estradiol	ND	0.230	ND	ND	ND
Menthol	ND	ND	0.0798	ND	ND
p-Cresol	11.9 J	ND	0.2850	ND	0.6400
Phenol	5.910	ND	ND	ND	ND
Tri(2-butoxyethyl) phosphate	0.510	ND	ND	ND	0.0555
Tri(dichloroisopropyl) phosphate	ND	0.220	ND	ND	ND
Triclosan	ND	0.200	ND	ND	ND

Yellow highlights indicate a concentration that surpassed the LOEL. Red highlighted cells surpassed the LC₅₀.

J = estimated data; ND = not detected.

All dates in 2010 included pesticide and wastewater sampling and all dates in 2012 included pesticide, PPCP, and wastewater sampling unless noted in a footnote.

^a No pesticide/PPCP sample

Table 3-4. Detected analytes (µg/L) in Sleepy Hollow Spring, 2010.

Analyte	Aug.	Oct.
Bisphenol A	0.200	ND
Tri(dichloroisopropyl) phosphate	ND	0.300
All dates included pesticide and wastewater sampling. ND = not detected.		

Triclosan also surpassed a level of known effect, and camphor may be a chronic contaminant at Courthouse Boundary Spring.

Sleepy Hollow Spring is a perennial spring that is recharged from a shallow local aquifer dated to <30 years old (Masbruch et al. 2010). Hikers infrequently visit the site. There are no contaminant sources known for this location, and few analytes were detected during sampling in 2010 (Table 3-4).

3.2.2 Bryce Canyon National Park

Mossy Cave is a perennial spring located on a popular hiking trail. There is possible contamination from tourism development and septic systems in Bryce Canyon City via natural geologic fracturing. No pesticide or wastewater contaminants were detected during a single visit in September 2010.

Sheep Creek is a perennial stream whose spring-fed headwaters and watershed lie entirely within Bryce Canyon National Park. A backcountry campsite is located about 0.75 km upstream of the sampling location at the park boundary. The boundary is fenced, but trespass cattle regularly intrude on the area. Few analytes were detected (Table 3-5).

Table 3-5. Detected analytes (µg/L) in Sheep Creek, 2010.

Analyte	Jul.	Sept.	Nov.
Bisphenol A	ND	ND	0.150
Isoquinoline	ND	ND	0.230 J
Metolachlor	ND	ND	0.210

All dates included pesticide and wastewater sampling.

J = estimated data; ND = not detected.

Yellow Creek is a perennial stream whose spring-fed headwaters and watershed lie entirely within Bryce Canyon National Park. A group backcountry campsite is located approximately 1.5 km upstream from the sampling location at the park boundary. Trespass cattle are an occasional problem at this site. Yellow Creek was sampled at the park boundary in 2010 and 2012 (Table 3-6). Carbaryl and estrone surpassed levels of known effect on one occasion at Yellow Creek.

3.2.3 Canyonlands National Park

The Colorado River was sampled at the Potash boat ramp in 2010 and 2012 (Table 3-7). This sampling location is approximately 14 river miles downstream from the effluent outflow for Moab, a town of about 4,000 year-round residents and a much larger seasonal and tourist population. Campgrounds with pit toilets occur every few miles on the 45-mile stretch from Dewey Bridge to the Potash boat ramp, and the boat ramp has pit toilets on site. Septic systems and agricultural activities also occur in the nearby watershed. The boat ramp at this site is located at a large eddy where motorized boats sometimes idle while departing and arriving. Attempts were made to take samples outside the eddy, but because of accessibility limitations, they were taken very near the eddy.

Total caffeine surpassed acute toxicity (wastewater analysis, Aug. 2012) and dissolved caffeine surpassed levels of known effect (PPCP analysis, Aug. and Oct. 2012). Replicate caf-

Table 3-6. Detected analytes (µg/L) in Yellow Creek, 2010 and 2012.

Analyte	2010	2012			
	Nov.	July	Aug.	Sept. ^a	Oct. ^b
Bisphenol A	0.170	0.107 J	ND	ND	--
Caffeine	ND	0.0122 J	0.0439 J	ND	ND
Carbaryl	0.160	ND	ND	ND	--
Estrone	0.190	ND	ND	ND	--
Isoquinoline	0.190	ND	ND	ND	--
Metolachlor	0.220	ND	ND	ND	--
Nonylphenol	ND	0.121 J	ND	ND	--
p-Cresol	0.210	ND	ND	ND	--
Tri(2-chloroethyl) phosphate	0.160	ND	ND	ND	--
Tributyl phosphate	0.170	0.114 J	ND	ND	--

Yellow highlights indicate a concentration that surpassed the LOEL.

All dates in 2010 included pesticide and wastewater sampling and all dates in 2012 included pesticide, PPCP, and wastewater sampling unless noted in a footnote. Blank cells indicate an analyte was not sampled.

J = estimated data; ND = not detected.

^a No pesticide/PPCP sample

^b No wastewater indicator sample

Table 3-7. Detected analytes (µg/L) in the Colorado River, 2010 and 2012.

Analyte	2010		2012			
	Jul.	Aug.	Jun.	Aug.	Oct. ^a	Nov.
2,4-D	0.104	0.585	0.116 J 0.137 J	0.0647	0.0372	0.0114 0.0124
Caffeine	ND	ND	0.0275 0.0269	0.196 0.596 ^b	0.101	Detect ^c Detect ^c
DEET	--	--	0.0526 0.0429	ND	ND	ND
Hexazinone	ND	ND	0.0102 J <0.0100 J	ND	ND	ND
Metolachlor ESA	ND	ND	0.0207 J <0.0200 J	0.0456	0.0353	0.0256 0.0268
Naproxen	--	--	0.0149 0.0156 J	ND	ND	ND
Sulfamethoxazole	--	--	0.0132 0.0163	0.0228	0.0256	0.0237 0.0236
Tri(dichloroisopropyl) Phosphate	ND	ND	ND	0.0994	--	ND
Triclopyr	ND	ND	ND	0.0315	ND	ND
Triethyl citrate	ND	0.200	ND	ND	--	ND

Yellow highlights indicate a concentration that surpassed the LOEL. Red highlighted cells surpassed the LC₅₀.

All dates in 2010 included pesticide and wastewater sampling and all dates in 2012 included pesticide, PPCP, and wastewater sampling unless noted in a footnote. Blank cells indicate an analyte was not sampled.

Cells with dual values indicate replicate samples.

J = estimated data; Detect = quality flagged data; ND = not detected.

^a No wastewater indicator sample

^b Total caffeine. The upper number is dissolved caffeine.

^c Replicates were not within 30% RPD.

feine samples returned results with an RPD of >30% on another occasion (Nov. 2012, presented as “Detect” in Table 3-7). There appears to be chronic contamination by 2,4-D, caffeine, Metolachlor ESA, and sulfamethoxazole in the Colorado River at the Potash boat ramp.

The Green River in Canyonlands NP was sampled on two occasions in 2010, at Mineral Bottom (Table 3-8). The local watershed is primarily agricultural, with sparse livestock grazing and some irrigated cropland. The nearest effluent outflow is approximately 68 river miles upstream at the town of Green River, which has about 1,000 residents.

Table 3-8. Detected analytes (µg/L) in the Green River at Mineral Bottom, 2010.

Analyte	Jul.	Aug.
Acetophenone	0.370	ND
Tri(dichloroisopropyl) phosphate	ND	0.210
All dates included pesticide and wastewater sampling.		
ND = not detected.		

3.2.4 Capitol Reef National Park

The Fremont River was sampled at Hickman Bridge in 2010 and 2012 (Table 3-9). This perennial river passes through several small towns before reaching Capitol Reef NP, the nearest being Torrey (pop. 200), about 10 miles upstream of the sampling location. The watershed has irrigated cropland and livestock grazing and a history of water quality exceedances for nutrients, total dissolved solids, and fecal coliforms. Within the park, the Fremont River passes by orchards and horse pastures that are flood-irrigated and treated with pesticides. The sampling location is along a popular hiking trail located just downstream of a parking area with pit toilets. The location is also downstream of the confluence with Sulphur Creek. Most of the samples taken in 2012 were out of the acceptable temperature range for analysis.

Sulphur Creek is a perennial stream with headwaters on U.S. Forest Service land. A hiking route follows the creek for about two miles upstream of the park visitor center. The creek then passes the visitor center and park residential area, with parking areas, septic systems, and a leach field. Sulphur Creek was sampled near the Ripple Rock Nature Center in 2010 (Table 3-10). The sampling location is in the middle of the park’s developed area.

Table 3-9. Detected analytes (µg/L) in the Fremont River, 2010 and 2012.

Analyte	2010			2012 ^a			
	Jul.	Sep.	Oct.	Jun.	Jul.	Aug.	Oct.
2,4-D	ND	ND	ND	ND	0.216 J	ND	ND
Bisphenol A	ND	ND	0.210	--	--	--	--
Caffeine	ND	ND	ND	0.0128 J <0.0100 J	ND	ND	ND
DEET	--	--	--	0.0136 J 0.0119 J	ND	ND	ND
Metalaxyl	ND	ND	ND	0.014 J 0.0112 J	ND	ND	ND
Tri(2-butoxyethyl) phosphate	ND	ND	0.400	--	--	--	--
Triclosan	--	--	--	ND	ND	0.0123 J <0.0100 J	ND

Yellow highlights indicate a concentration that surpassed the LOEL.

All dates in 2010 included pesticide and wastewater sampling and all dates in 2012 included pesticide and PPCP sampling.

Blank cells indicate an analyte was not sampled. Cells with dual values indicate replicate samples.

J = estimated data; ND = not detected.

^a No wastewater indicator sample

Table 3-10. Detected analytes (µg/L) in Sulphur Creek, 2010.

Analyte	Aug.	Oct.
Bisphenol A	ND	0.200
All dates included pesticide and wastewater sampling. ND = not detected.		

3.2.5 Curecanti National Recreation Area

The Gunnison River was sampled at County Road 32 in 2010 (Table 3-11). This location is just downstream of the effluent outflow for the town of Gunnison, with about 6,000 year-round residents. The watershed also has agricultural inputs.

The Lake Fork of the Gunnison River passes through a small community of 400 residents served by a <100:1 dilution wastewater treatment plant before reaching its sampling location above Blue Mesa Reservoir. Several ranches and other landowners upstream of the site are primarily on septic systems. The watershed also has agricultural inputs. Estrone and triclosan surpassed known levels of effect on one occasion in the Lake Fork of the Gunnison River (Table 3-12).

3.2.6 Dinosaur National Monument

The Green River at Gates of Lodore was sampled in 2010 (Table 3-13). This section of the Green River has a regulated hydrograph due to Flaming Gorge Dam. Possible contamination sources include effluent and agricultural inputs. The sampling site is located at a popular boat ramp with camping and pit toilets. Most samples in 2010 were out of the acceptable temperature range for analysis.

The Yampa River at Deerlodge Park was sampled in 2010 and 2012 (Table 3-14). A high proportion of intersex fish, potentially caused by the presence of endocrine-disrupting chemicals, have previously been found in the Yampa River (Hinck et al. 2007). The local watershed has septic-system and agricultural inputs, and the nearest effluent outflow is in the town of Craig, Colorado (pop. 9,200), approximately 100 river miles upstream. The sampling site is located at a popular boat ramp with camping and pit toilets.

Table 3-11. Detected analytes (µg/L) in the Gunnison River, 2010.

Analyte	Jul.	Aug.	Sep.	Oct.	Nov.
2,4-D	Detect Detect ^a	ND	ND	ND	ND
Acetochlor	ND	0.0222 J	ND	ND	ND
All dates included pesticide and wastewater sampling. J = estimated data; Detect = Quality-flagged data; ND = not detected. ^a Replicates not within 30% RPD					

Table 3-12. Detected analytes (µg/L) in the Lake Fork of the Gunnison River, 2010.

Analyte	Jul.	Aug.	Sep.	Oct.	Nov.
Bisphenol A	ND	ND	ND	0.200	ND
Estrone	ND	ND	ND	0.220	ND
Triclosan	ND	ND	ND	0.200	ND
Triethyl citrate	ND	ND	0.280	ND	ND
Yellow highlights indicate a concentration that surpassed the LOEL. All dates included pesticide and wastewater sampling. ND = not detected.					

Table 3-13. Detected analytes (µg/L) in the Green River, 2010.

Analyte	Jul.	Aug.	Sep.	Oct.	Nov.
Bisphenol A	ND	ND	ND	0.200 J	ND
Tri(dichloroisopropyl) phosphate	ND	ND	ND	0.260 J	ND
Triclosan	0.200 <0.150	ND	ND	ND	ND
Triethyl citrate	ND	ND	ND	0.200 J	ND
All dates included pesticide and wastewater sampling. J = estimated data. ND = not detected. Cells with dual values indicate replicate samples.					

Of all water bodies tested in the NCPN, the Yampa River had the highest number of analytes detected, with 31. At the November 2010 sampling event, in particular, measurements of several analytes were above known levels of effect for acute toxicity. Many of the samples in 2010 and 2012 were out of the acceptable temperature range for analysis. There was no relationship between discharge, as recorded at the U.S. Geological Survey (USGS) gaging station on site, and the total number or concentration of analytes present (Figure 3-4).

Table 3-14. Detected analytes (µg/L) in the Yampa River, 2010 and 2012.

Analyte	2010					2012						
	Jul.	Aug.	Sep.	Oct.	Nov.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.
17beta-Estradiol	ND	ND	0.25 J	ND	0.25	ND	ND	ND	ND	ND	ND	ND
2,4-D	0.0203 0.0200	ND	ND	0.0254 J	ND	ND	ND	ND	ND	0.0121	0.0389 J	ND
4-Cumylphenol	ND	ND	ND	ND	0.24	ND	ND	ND	ND	ND	ND	ND
4-n-Octylphenol	ND	ND	ND	ND	0.23	ND	ND	ND	ND	ND	ND	ND
Acetophenone	ND	ND	ND	ND	ND	ND	0.067 J	ND	ND	ND	ND	ND
Benzophenone	ND	ND	ND	ND	ND	ND	0.0528 J	ND	ND	ND	ND	ND
Bisphenol A	0.2 <0.15	ND	0.21 J	0.2 J	ND	0.0642 0.0622	ND	ND	ND	ND	ND	ND
Bromacil	ND	ND	ND	ND	0.57	ND	ND	ND	ND	ND	ND	ND
Caffeine	ND	ND	ND	ND	0.28	ND	0.0397 J	ND	ND	ND	ND	ND
Camphor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0984
Carbaryl	ND	ND	ND	ND	0.4	ND	ND	ND	ND	ND	ND	ND
Chlorpyrifos	ND	ND	ND	ND	1.73	ND	ND	ND	ND	ND	ND	ND
Dacthal	ND	ND	ND	ND	0.34	ND	ND	ND	ND	ND	ND	ND
Dichlorvos	ND	ND	ND	ND	0.23	ND	ND	ND	ND	ND	ND	ND
Estrone	ND	ND	0.22 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethinyl estradiol	ND	ND	ND	ND	0.27	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	ND	ND	ND	ND	0.25	ND	ND	ND	ND	ND	ND	ND
Galaxolide	ND	ND	ND	ND	0.31	ND	ND	ND	ND	ND	ND	ND
Metalaxyl	ND	0.0248	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Metolachlor	ND	ND	ND	ND	0.39	ND	ND	ND	ND	ND	ND	ND
p-Cresol	ND	ND	ND	ND	ND	ND	0.0519 J	ND	ND	ND	ND	ND
Prometon	ND	ND	ND	ND	0.33	ND	ND	ND	ND	ND	ND	ND
Propachlor OA	ND	0.0592 J	0.0578 J	0.0512 J	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND	0.32	ND	ND	ND	ND	ND	ND	ND
Tri(2-butoxyethyl) Phosphate	ND	1.57	ND	0.69 J	1.53	ND	ND	ND	ND	0.213	ND	ND
Tri(2-chloroethyl) Phosphate	ND	ND	ND	ND	0.41	ND	ND	ND	ND	ND	ND	ND
Tri(dichloroisopropyl) phosphate	ND	ND	ND	0.27 J	0.53	ND	ND	ND	ND	ND	ND	ND
Tributyl phosphate	ND	ND	ND	0.21 J	0.36	ND	0.0554 J	ND	ND	ND	ND	ND
Triclosan	ND	ND	ND	ND	0.48	ND	ND	ND	ND	ND	ND	ND
Triethyl citrate	ND	ND	ND	ND	ND	ND	0.0592 J	ND	ND	ND	ND	ND
Triphenyl phosphate	ND	ND	ND	ND	0.6	ND	ND	ND	ND	ND	ND	ND

Yellow highlights indicate a concentration that surpassed the LOEL. Red highlighted cells surpassed the LC₅₀.

All dates in 2010 included pesticide and wastewater sampling and all dates in 2012 included pesticide, PPCP and wastewater sampling. Due to space limitations, not all significant digits are shown. Cells with dual values indicate replicate samples. J = estimated data; ND = not detected.

3.2.7 Hovenweep National Monument

Hovenweep National Monument consists of small, dispersed units located in a patchwork of agricultural and range lands. The recharge area of aquifers for springs in the units is unknown, but presumably is affected by land-use activities outside park boundaries. Square Tower and Cajon springs are located in areas with increasing oil and gas development activities. Hackberry House and Goodman Point springs are not known to have any contaminant sources.

No pesticides or wastewater indicators were detected at Square Tower Spring during the only site visit in July 2010. No pesticides or PPCPs were detected at Goodman Point Spring during the only site visit in July 2012 (wastewater indicators were not sampled).

Cajon Spring was sampled in 2010 (Table 3-15) and Hackberry House Spring was sampled in 2010 and 2012 (Table 3-16). Caffeine surpassed an acute toxicity level at Hackberry House Spring. Diuron also surpassed a known level of effect at Hackberry House Spring. (Note that subsequent sampling had a higher non-detect threshold for Diuron.)

Table 3-15. Detected pesticide and wastewater indicator analytes (µg/L) in Cajon Spring, 2010.

Analyte	Nov.
3-Methyl Indole	0.210
Camphor	1.140

Table 3-16. Detected analytes (µg/L) in Hackberry House Spring, 2010 and 2012.

Analyte	2010		2012 ^a	
	Jul.	Nov.	Aug.	Nov.
Caffeine	ND	ND	0.336	ND
DEET			0.0110	ND
Diuron	0.0204	ND	ND	ND

Yellow highlights indicate a concentration that surpassed the LOEL. Red highlighted cells surpassed the LC₅₀.

All dates in 2010 included pesticide and wastewater sampling, and all dates in 2012 included pesticide and PPCP sampling. Blank cells indicate an analyte was not sampled. ND = not detected.

^a No wastewater indicator sample

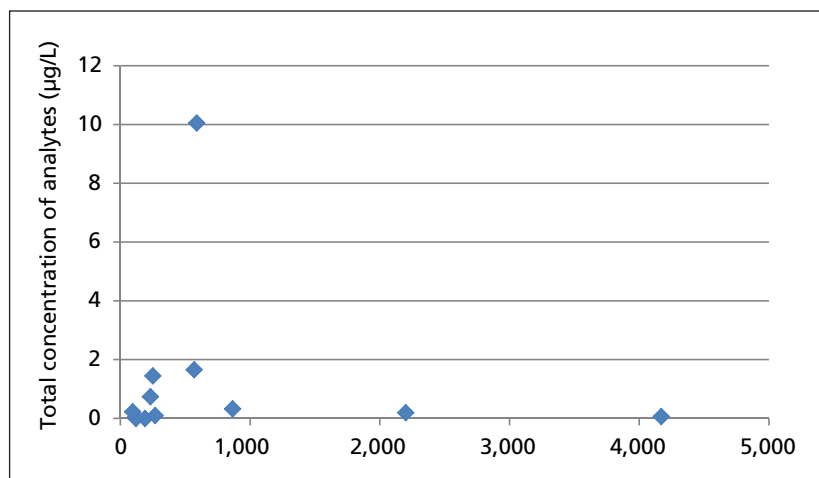


Figure 3-4. Relationship of daily mean discharge of the Yampa River at Deerlodge Park (USGS Station 09260050) and the total concentration of analytes in that day's sample.

3.2.8 Natural Bridges National Monument

Both Owachomo Bridge and Armstrong Canyon near Kachina Bridge are perennial pools fed by spring flow, runoff, and shallow alluvial aquifer inputs. A hiking route passes through the wash near these sites, but no contaminant sources are known. No pesticides or wastewater indicators were detected at Owachomo Bridge during the only site visit in September 2010, and only one analyte was detected at Armstrong Canyon near Kachina Bridge (Table 3-17).

Table 3-17. Detected pesticide and wastewater indicator analytes (µg/L) in Armstrong Canyon, 2010.

Analyte	Sep.
Bisphenol A	0.230

3.2.9 Pipe Spring National Monument

Tunnel Spring is a perennial spring that has been developed by boring a tunnel into the bedrock. It is one of the primary spring sources at Pipe Spring National Monument and is located in the developed area. Aquifer drawdown has decreased flow to this spring, and there is possible aquifer contamination from nearby communities on septic systems. Tunnel Spring was sampled in 2010 (Table 3-18).

Table 3-18. Detected analytes (µg/L) in Tunnel Spring, 2010.

Analyte	Jul.	Aug.	Sep.	Oct.	Nov.
Bromacil	ND	ND	ND	0.230	ND
Tri(dichloroisopropyl) phosphate	ND	ND	0.250	0.390	ND
Tributyl phosphate	ND	ND	ND	0.200	ND

Yellow highlights indicate a concentration that surpassed the LOEL.

All dates included pesticide and wastewater sampling. ND = not detected.

3.2.10 Timpanogos Cave National Monument

Timpanogos Cave sits high in the watershed of the American Fork River. The source water for the cave is unknown, but pristine water quality is needed to maintain the integrity of the cave ecosystem. The Middle Cave Lake Bridge (visitor use area) and off-trail areas were sampled in 2010 and 2012 (Tables 3-19 and 3-20). The off-trail area was intended to serve as an unimpacted control site in comparison to the visitor area. However, the sampling locations are less than 100 m apart, and flow patterns between the sites are unknown. Many of the samples were out of the acceptable temperature range for laboratory analysis.

In the visitor use area, caffeine surpassed levels of known effect and acute toxicity. The same analytes were detected in the off-trail area. Despite the proximity of the sampling locations, it is interesting to note that levels of concern did not always occur during the same sampling occasions (see Tables 3-19 and 3-20). A high level of Dichlorvos was

also detected in the off-trail area on one occasion. DEET may be a chronic contaminant in the visitor use area.

3.2.11 Zion National Park

Menu Falls Spring, Temple of Sinawava Spring, and the Grotto are perennial springs that emerge from the east side of Zion Canyon. Age-dating indicates that these springs include a mixture of recent water and ancient water between 2,000 and 4,000 years old (Kimball and Christensen 1996). The Grotto is used for the park's water supply. Menu Falls and Temple of Sinawava had no pesticide or wastewater indicator detections during their single sampling event in October 2010. The Grotto spring had no detections in July 2010 and November 2010.

Upper Emerald Pool is a perennial spring with much younger water that flows from the west side of Zion Canyon. This site is located along a popular hiking trail. No pesticide or wastewater contaminants were found during sampling in October 2010.

Table 3-19. Detected analytes (µg/L) in the Middle Cave visitor use area, 2010 and 2012.

Analyte	2010					2012 ^a			
	Jul.	Aug.	Sep.	Oct.	Nov.	Jun.	Jul.	Sep.	Nov.
Caffeine	ND	0.29	ND	ND	ND	0.099	0.464 0.464	0.031 J	ND
DEET						0.083	0.162 0.140	0.031 J	ND
Diuron	0.054 J	ND	ND	ND	ND	ND	ND	ND	ND
Tebuthiuron	ND	ND	ND	ND	ND	ND	ND	ND	0.012
Tri(2-butoxyethyl) phosphate	ND	ND	ND	0.22 J	ND				
Tri(dichloroisopropyl) phosphate	ND	ND	0.26 J	ND	ND				
Triethyl citrate	ND	ND	ND	0.28 J	ND				

Yellow highlights indicate a concentration that surpassed the LOEL. Red highlighted cells surpassed the LC₅₀. All dates in 2010 included pesticide and wastewater sampling, and all dates in 2012 included pesticide and PPCP sampling as noted in a footnote. Blank cells indicate an analyte was not sampled. Cells with dual values indicate replicate samples. J = estimated data. ND = not detected. Due to space limitations not all significant digits are shown. ^a No wastewater indicator sample.

Table 3-20. Detected analytes (µg/L) in the Middle Cave off-trail area, 2010 and 2012.

Analyte	2010					2012 ^a		
	Jul.	Aug.	Sep.	Oct.	Nov.	Jun.	Sep.	Nov.
Acetophenone	0.2 J	ND	ND	ND	ND	--	--	--
Bendiocarb	--	0.0348	ND	ND	ND	--	--	--
Caffeine	ND	ND	ND	ND	ND	0.0533	0.08 J	ND
DEET	--	--	--	--	--	0.0345	ND	ND
Dichlorvos	ND	ND	ND	0.22 J	ND	--	--	--
Diuron	0.03 J	ND	ND	ND	ND	ND	ND	ND
Tri(dichloroisopropyl) phosphate	ND	0.24	0.25 J	ND	ND	--	--	--
Triclosan	0.33 J	ND	ND	ND	ND	--	--	--

Yellow highlights indicate a concentration that surpassed the LOEL. Red highlighted cells surpassed the LC₅₀.

All dates in 2010 included pesticide and wastewater sampling and all dates in 2012 included pesticide and PPCP sampling as noted in a footnote. Blank cells indicate an analyte was not sampled.

J = estimated data. ND = not detected. Due to space limitations, not all significant digits are shown.

^a No wastewater indicator sample

La Verkin Creek is a perennial creek whose upper watershed lies outside park boundaries in a U.S. Forest Service protected wilderness zone. Dispersed livestock grazing occurs in the watershed, but there are no point sources for contaminants. No pesticide or wastewater contaminants were found during sampling in September 2010.

North Creek is a perennial creek whose watershed lies entirely within park boundaries. Several of the tributaries to North Creek are very popular hiking routes. A fire in 2006 burned much of the watershed, and the area was treated with fire retardants during the fire and post-fire aerial applications of herbicides (Imazapic and glyphosate) in 2006 and 2008 to control invasive annual brome grasses. The herbicide formulations would have included several organic compounds that were inactive ingredients. Multiple analytes were detected in August 2010, including propachlor OA, described as an herbicide breakdown product, but subsequent sampling showed little contamination (Table 3-21). Samples from several sampling events did not meet temperature acceptance criteria for laboratory analyses.

The North Fork Virgin River is a regional river whose headwaters lie on national forest land. The sampling location is downstream of a very popular wading hike and a park shuttle destination with a parking area and pit toilets. Livestock grazing and flood-irrigation practices upstream of the park

boundary have resulted in exceedances of fecal indicator bacteria, and a 303(d) listing for noncompliant waters. Only one analyte was found during two sampling events at the Temple of Sinawava (Table 3-22).

Table 3-21. Detected analytes (µg/L) in North Creek, 2010 and 2012.

Analyte	2010	2012		
	Aug.	Jul.	Sep.	Nov.
17beta-Estradiol	0.470	ND	ND	ND
Benzophenone	ND	ND	ND	0.0506
Bisphenol A	0.240	0.524 J	ND	ND
Caffeine	ND	0.0109 J	ND	ND
Estrone	0.440	ND	ND	ND
Propachlor OA	0.0501 J	ND	ND	ND
Tri(2-chloroethyl) phosphate	0.210	ND	ND	ND
Triclosan	0.350	ND	ND	ND

Yellow highlights indicate a concentration that surpassed the LOEL.

All dates in 2010 included pesticide and wastewater sampling and all dates in 2012 included pesticide, PPCP, and wastewater indicator sampling.

J = estimated data. ND = not detected.

Table 3-22. Detected analytes (µg/L) in North Fork Virgin River at the Temple of Sinawava, 2010.

Analyte	Jul.	Oct.
Triclosan	0.200 J	ND

Yellow highlights indicate a concentration that surpassed the LOEL.

All dates included pesticide and wastewater indicator sampling.

J = estimated data. ND = not detected.

4 Discussion

The majority of CEC analytes were never detected in any sampled NCPN water body, and no analytes were detected on one-third of site visits. NCPN waters had fewer analytes detected, and lower total analyte concentrations, than more urbanized watersheds. However, some CECs occurred at levels known to affect aquatic ecosystems.

No CECs were detected in several springs at Arches NP, Bryce Canyon NP, Hovenweep NM, Natural Bridges NM, and Zion NP. However, potential problem spots were found to exist in other, “pristine,” spring-fed waters, such as Middle Cave (Timpanogos Cave NM) and Sleepy Hollow Spring (Arches NP). Relatively small watersheds, such as Yellow Creek (Bryce Canyon NP) and North Creek (Zion NP), had high numbers of detections compared to other sites on a few occasions.

Expert reviewers with the CEC programs in the EPA (J. Lazorchak) and U.S. Geological Survey (P. Bradley) indicated that levels of some hormones and caffeine were unexpectedly high. In most cases, these high levels occurred only once and should be interpreted with caution. Overall, however, locating the source(s) of contamination should be a high priority so that park managers can assess how to reduce contaminant inputs. Repeated high levels of hormones and caffeine could have catastrophic effects on aquatic vertebrate communities.

Because of limited QA/QC during the course of sampling, it is impossible to rule out sampling

contamination as a source for the unexpectedly high detections of hormones and caffeine. Based on our experience with the initial phases of this project, we have developed improved QA/QC measures for future sampling, including more frequent field blanks, an established Quality Assurance Plan, and the use of larger coolers and more ice during hot sampling months, to strengthen sampling results.

The Yampa River (Dinosaur NM) remains a high priority for NCPN sampling due to the high number of analytes detected despite its paucity of point sources. The Colorado River (Canyonlands NP) has chronic contamination by a few CECs and, in general, had more detections than the Green River (Canyonlands NP, Dinosaur NM). Further investigations of NCPN locations with frequent or high CEC detections could begin to incorporate biological samples to trace the fate of these analytes in the ecosystem. Sediment sampling for CECs would also provide valuable information on the accumulation and persistence of CECs in NCPN aquatic systems.

Temporally, analytes often occurred in waves, with multiple analytes detected during single visits and few or none found on other visits. These results suggest that CEC contamination in NCPN waters can be “flashy,” rather than chronic in nature. Waves of wastewater contaminants may be linked to overflow events during which contaminant-rich sediment is mobilized or wastewater systems are bypassed. However, discharge and analyte concentrations did not appear to be correlated at the Yampa River. In the future, linking analyte detections and concentrations to discharge or precipitation events could be helpful.

5 Literature Cited

- Blais, J. M., D. W. Schindler, G. C. G. Muir, L. E. Kimpe, D. B. Donald, and B. Rosenberg. 1998. Accumulation of persistent organochlorine compounds in mountains of western Canada. *Nature* 395:585–588.
- Blaise, C., F. Gagne, P. Eullaffroy, and J. F. Ferard. 2006. Ecotoxicity of certain pharmaceuticals of urban origin discharge to the Saint Lawrence River (Quebec, Canada): A review. *Brazilian Journal of Aquatic Science and Technology* 10:29–51.
- Brausch, J., and G. Rand. 2011. A review of personal care products in the aquatic environment: Environmental concentrations and toxicity. *Chemosphere* 82:1518–1532.
- Environment Canada. 2009. Screening assessment for the challenge: Ethanol, 2-chloro-, phosphate (3:1) (Tris(2-chloroethyl) phosphate [TCEP]), Chemical Abstracts Service Registry Number 115-96-8. Accessed January 20, 2012, at http://www.ec.gc.ca/substances/ese/eng/challenge/batch5/batch5_115-96-8_en.pdf.
- General Electric Company. 2005. U.S. high production volume (HPV) chemical challenge program robust summary: p-Cumylphenol (CAS NO. 599-64-4). Accessed January 20, 2012, at <http://www.epa.gov/hpv/pubs/summaries/plastics/12614b1rt.pdf>.
- Hinck, J., V. Blazer, N. Denslow, K. Echols, T. Gross, T. May, P. Anderson, J. Coyle, and D. Tillitt. 2007. Chemical contaminants, health indicators, and reproductive biomarker responses in fish from the Colorado River and its tributaries. *Science of the Total Environment* 378:376–402.
- Keteles, K. 2011. Screening for pesticides in high elevation lakes in federal lands. EPA Region 8, Denver, Colorado.
- Kidd, K. A., P. J. Blanchfield, K. H. Mills, V. P. Palace, R. E. Evans, J. M. Lazorchak, and R. W. Flick. 2007. Collapse of a fish population after exposure to a synthetic estrogen. *Proceedings of the National Academy of Sciences* 104(21):8897–8901.
- Kimball, B. A., and P. Christensen. 1996. Residence time of water discharging from the hanging gardens of Zion National Park. *Journal of the American Water Resources Association* 32(3):531–540.
- Kolpin, D. W., E. T. Furlong, M. T. Meyer, E. M. Thurman, S. D. Zaugg, L. B. Barber, and H. T. Buxton. 2002. Pharmaceuticals, hormones, and other organic wastewater contaminants in U.S. streams, 1999–2000: A reconnaissance. *Environmental Science and Technology* 36:1202–1211.
- Lee, K. E., C. S. Yaeger, N. D. Jahns, and H. L. Schoenfuß. 2008. Occurrence of endocrine active compounds and biological responses in the Mississippi River: Study design and data, June–August 2006. U.S. Geological Survey Data Series 368. U.S. Geological Survey, Reston, Virginia.
- Masbruch, M. D., D. K. Solomon, and J. Harte. 2010. Groundwater age dating in and near Arches National Park, Utah. Unpublished report to the Southeast Utah Group, National Park Service.
- Sprague, L. A., and W. A. Battaglin. 2004. Wastewater chemicals in Colorado's streams and ground water. U.S. Geological Survey Fact Sheet 2004-3127. Accessed December 28, 2011, at <http://pubs.usgs.gov/fs/2004/3127/>.
- U.S. Environmental Protection Agency (EPA). 1994. Acetochlor herbicide: New chemical science chapter. Memo to EPA registration division. Accessed February 15, 2013, at http://www.epa.gov/pesticides/chem_search/cleared_reviews/csr_PC-121601_25-Jan-94_130.pdf.
- . 2005. Furniture flame retardancy partnership: Environmental profiles of chemical flame-retardant alternatives for low-density polyurethane foam. Vol. 2. Accessed December 29, 2011, at <http://www.epa.gov/dfe/pubs/flameret/altrep-v2/altrept-v2.pdf>.

- . 2008. Screening-level hazard characterization of high production volume chemicals: Sponsored chemical 1,3,4,6,7,8-Hexahydro-4,6,6,7,8,8-hexamethylcyclopenta[g]-2-benzopyran (HHCB), (CAS No. 1222-05-5), [9th CI Name: Cyclopenta[g]-2-benzopyran, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-]: Interim report. Accessed January 20, 2012, at http://www.epa.gov/hpvis/hazchar/1222055_HHCB_HC_INTERIM_February%202008.pdf.
- . 2010. Bisphenol A action plan. Accessed at December 28, 2011, at http://www.epa.gov/oppt/existingchemicals/pubs/actionplans/bpa_action_plan.pdf.
- World Health Organization (WHO). 2000. Flame retardants: tris (2-butoxyethyl) phosphate, tris(2-ethlyhexyl) phosphate and tetrakis(hydroxymethyl) phosphonium salts. Geneva, Switzerland. Accessed January 5, 2012, at http://whqlibdoc.who.int/ehc/WHO_EHC_218.pdf.
- Writer, J. H., L. B. Barber, G. K. Brown, H. E. Taylor, R. L. Kiesling, M. L. Ferry, N. D. Jahns, S. E. Bartell, and H. L. Schoenfuss. 2010. Anthropogenic tracers, endocrine disrupting chemicals, and endocrine disruption in Minnesota lakes. *Science of the Total Environment* 409:100–111.

Appendix A. List of Analytes

Table A-1. Pesticide analytes, Chemical Abstract Services (CAS) registry number, and reporting limits (µg/L) in 2010 and 2012.

Analyte	CAS number	2010		2012	
		Reporting limit (µg/L)	Analyzed?	Reporting limit (µg/L)	Analyzed?
2,4,5-T	93-76-5	0.0200	Yes	0.0100	Yes
2,4,5-TP	93-72-1	0.0100	Yes	0.0100	Yes
2,4-D	94-75-7	0.0200	Yes	0.0100	Yes
3-Hydroxycarbofuran	16655-82-6	0.0200	Yes	0.0100	Yes
Acetochlor	34256-82-1	0.0200	Yes	0.0200	Yes
Acetochlor OA	194992-44-4	0.0200	Yes	0.0200	Yes
Alachlor	15972-60-8	0.0500	Yes	0.0200	Yes
Alachlor OA	171262-17-2	0.0200	Yes	0.0500	Yes
Aldicarb	116-06-3	0.0100	Yes	0.0100	Yes
Aldicarb sulfone	1646-88-4	0.0200	Yes	0.0200	Yes
Aldicarb sulfoxide	1646-87-3	0.0100	Yes	0.0100	Yes
Atraton	1610-17-9	NA	No	0.0100	Yes
Atrazine	1912-24-9	0.0200	Yes	0.0100	Yes
Atrazine de-ethyl	6190-65-4	0.0100	Yes	0.0200	Yes
Atrazine de-isopropyl	1007-28-9	0.0200	Yes	0.0200	Yes
Azoxystrobin	131860-33-8	0.0200	Yes	0.0200	Yes
Bendiocarb	22781-23-3	0.0200	Yes	NA	No
Bentazon	25057-89-0	0.0200	Yes	0.0100	Yes
Bromacil	314-40-9	0.0500	Yes	0.0500	Yes
Bromoxynil	1689-84-5	0.0100	Yes	0.0100	Yes
Butachlor ESA		0.0100	Yes	0.0100	Yes
Carbaryl	63-25-2	NA	No	0.0100	Yes
Carbofuran	1563-66-2	0.0200	Yes	0.0100	Yes
Chlorimuron ethyl	90982-32-4	0.0500	Yes	0.0200	Yes
Cyanazine	21725-46-2	0.0200	Yes	0.0100	Yes
Dacthal monoacid	887-54-7	0.0500	Yes	0.0200	Yes
Diazinon	333-41-5	0.0100	Yes	0.0500	Yes
Dichloroprop	120-36-5	0.0100	Yes	0.0100	Yes
Dimethachlor	50563-36-5	0.0100	Yes	0.0100	Yes
Dimethenamid	87674-68-8	0.0100	Yes	0.0100	Yes
Dimethenamid ESA	205939-58-8	0.0200	Yes	0.0200	Yes
Dimethenamid OA		0.0100	Yes	NA	No
Disulfoton sulfone	2497-06-5	0.0500	Yes	0.0200	Yes
Diuron	330-54-1	0.0200	Yes	0.0500	Yes
Diuron Metabolite	3567-62-2	NA	No	0.0200	Yes
EPTC	759-94-4	0.0200	Yes	0.0200	Yes
Ethoprop	13194-48-4	0.0100	Yes	0.0100	Yes
Fipronil	120068-37-3	NA	No	0.0200	Yes
Fipronil sulfide	120067-83-6	NA	No	0.0100	Yes
Hexazinone	51235-04-2	0.0100	Yes	0.0100	Yes
Imazaquin	81335-37-7	0.0200	Yes	0.0200	Yes
Imazethapyr	81335-77-5	0.0200	Yes	0.0100	Yes

Table A-1. Pesticide analytes, Chemical Abstract Services (CAS) registry number, and reporting limits (µg/L) in 2010 and 2012, cont.

Analyte	CAS number	2010		2012	
		Reporting limit (µg/L)	Analyzed?	Reporting limit (µg/L)	Analyzed?
Imidacloprid	138261-41-3	0.0500	Yes	0.0200	Yes
Linuron	330-55-2	0.0500	Yes	0.0200	Yes
Malathion	121-75-5	0.0100	Yes	0.0100	Yes
MCPA	94-74-6	0.0100	Yes	NA	No
MCPP	7085-19-0	0.0500	Yes	0.0200	Yes
Metalaxyl	57837-19-1	0.0200	Yes	0.0100	Yes
Methiocarb	2032-65-7	0.0100	Yes	0.0200	Yes
Methomyl	16752-77-5	0.0200	Yes	0.0200	Yes
Metolachlor	51218-45-2	0.0100	Yes	0.0100	Yes
Metolachlor ESA	947601-85-6	0.0200	Yes	0.0200	Yes
Metolachlor OA	152019-73-3	0.0200	Yes	NA	No
Metribuzin	21087-64-9	0.0200	Yes	0.0200	Yes
Monuron	150-68-5	0.0200	Yes	0.0100	Yes
Neburon	555-37-3	0.0200	Yes	0.0500	Yes
Oryzalin	19044-88-3	0.0200	Yes	0.0200	Yes
Oxamyl	23135-22-0	0.0100	Yes	0.0100	Yes
Pentachlorophenol	87-86-5	0.0100	Yes	NA	No
Prometon	1610-18-0	0.0100	Yes	0.0200	Yes
Propachlor	1918-16-7	0.0200	Yes	0.0100	Yes
Propachlor ESA	947601-88-9	NA	No	0.0200	Yes
Propachlor OA	70628-36-3	0.0500	Yes	0.0100	Yes
Propazine	139-40-2	0.0200	Yes	0.0500	Yes
Propiconazole	60207-90-1	0.0200	Yes	0.0200	Yes
Propoxur	114-26-1	0.0200	Yes	0.0100	Yes
Simazine	122-34-9	0.0200	Yes	0.0200	Yes
Sulfometuron methyl	74222-97-2	0.0200	Yes	0.0200	Yes
Tebuconazole	107534-96-3	NA	No	0.0500	Yes
Tebuthiuron	34014-18-1	0.0100	Yes	0.0100	Yes
Terbutylazine	5915-41-3	0.0100	Yes	0.0100	Yes
Thiamethoxam	153719-23-4	0.0200	Yes	0.0200	Yes
Triclopyr	55335-06-3	0.0200	Yes	0.0200	Yes

Table A-2. Pharmaceutical and personal care product (PPCP) analytes, Chemical Abstract Services (CAS) registry number, and reporting limits (µg/L) in 2012.

Analyte	CAS number	Reporting limit (µg/L)
(+/-)11-nor-9-carboxy-delta-THC		0.0100
Acebutolol	34381-68-5	0.0100
Albuterol	18559-94-9	0.0100
Alprazolam	28981-97-7	0.0100
Amitriptyline	549-18-8	0.0100
Amitriptyline (+/-)-E-10-hydroxylated	64510-05-4	0.0100
Atenolol	29122-68-7	0.0100
Atrazine	1912-24-9	0.0100
Benzoylecgonine	519-09-5	0.0100
Benzphetamine	5411-22-3	0.0100
Bezafibrate	41859-67-0	0.0100
Brombuterol	21912-49-2	0.0100
Bupropion	34841-39-9	0.0100
Butabarbital		0.0250
Butalbital		0.0100
Caffeine	58-08-2	0.0100
Cannabidiol		0.0250
Cannabinol		0.0250
Carbamazepine	298-46-4	0.0100
Chloramphenicol	716-61-0	0.0100
Chlordiazepoxide	438-41-5	0.0100
Chlorpheniramine	132-22-9	0.0100
Cimetidine	51481-61-9	0.0100
Clenbuterol	21898-19-1	0.0100
Clobazam	22316-47-8	0.0100
Clonazepam	1622-61-3	0.0100
Clonidine	4205-91-8	0.0100
Cocaethylene	529-38-4	0.0100
Cocaine	53-21-4	0.0100
Codeine	76-57-3	0.0100
DEET	134-62-3	0.0100
Diazepam	439-14-5	0.0100
Diclofenac	15307-86-5	0.0100
Diltiazem	33286-22-5	0.0100
Diphenhydramine	58-73-1	0.0100
Famotidine	76824-35-6	0.0100
Fenbendazole	43210-67-9	0.0100
Fenbufen	36330-85-5	0.0100
Fentanyl	437-38-7	0.0100
Flunitrazepam	1622-62-4	0.0100
Fluoxetine	54910-89-3	0.0100
Flurazepam	1172-18-5	0.0100
Furosemide	54-31-9	0.0100

Table A-2. Pharmaceutical and personal care product (PPCP) analytes, Chemical Abstract Services (CAS) registry number, and reporting limits (µg/L) in 2012, cont.

Analyte	CAS number	Reporting limit (µg/L)
Gemfibrozil	25812-30-0	0.0100
Glyburide	10238-21-8	0.0100
Hydrocodone	34195-34-1	0.0100
Hydromorphone	71-68-1	0.0100
Ibuprofen	15687-27-1	0.0100
Levorphanol	77-07-6	0.0100
Loratadine	79794-75-5	0.0100
Lorazepam	846-49-1	0.0100
MDEA	82801-81-8	0.0100
MDMA	42542-10-9	0.0100
Meperidine	57-42-1	0.0100
Mephobarbital	115-38-8	0.0250
Methaqualone		0.0100
Methypylon		0.0100
Metoprolol	37350-58-6	0.0100
m-Hydroxybenzoylecgonine	90899-22-2	0.0100
Morphine	57-27-2	0.0100
Naproxen	22204-53-1	0.0100
n-Butylparaben	94-26-8	0.0250
Nifedipine	21829-25-4	0.0100
Nifedipine oxidized		0.0100
Norfentanyl	1609-66-1	0.0100
Norverapamil	67812-42-4	0.0100
Omeprazole	73590-58-6	0.0100
Oxycodone	76-42-6	0.0100
Oxymorphone	76-41-5	0.0100
Paroxetine	61869-08-7	0.0100
Pentazocine		0.0100
Phenmetrazine	134-49-6	0.0100
Phenobarbital	50-06-6	0.0100
Phenytoin	57-41-0	0.0100
Pindolol	13523-86-9	0.0100
Prazepam	2955-38-6	0.0100
Progesterone	57-83-0	0.0100
Propranolol	525-66-6	0.0100
Secobarbital		0.0100
Sildenafil	171599-83-0	0.0100
Simvastatin	79902-63-9	0.0100
Sotalol	959-24-0	0.0100
Sulfamethazine	57-68-1	0.0100
Sulfamethoxazole	723-46-6	0.0100
Sumatriptan		0.0100
Talbutal		0.0250
Temazepam	846-50-4	0.0100

Table A-2. Pharmaceutical and personal care product (PPCP) analytes, Chemical Abstract Services (CAS) registry number, and reporting limits (µg/L) in 2012, cont.

Analyte	CAS number	Reporting limit (µg/L)
Testosterone	58-22-0	0.0100
THC		0.0250
Thebaine		0.0100
Thiabendazole	148-79-8	0.0100
Tramadol	27203-92-5	0.0100
Trazodone	19794-93-5	0.0100
Triamterene	396-01-0	0.0100
Triazolam	28911-01-5	0.0100
Triclocarban	101-20-2	0.0100
Triclosan	3380-34-5	0.0100
Trimethoprim	738-70-5	0.0100
Tylosin	1401-69-0	0.0100
Venlafaxine	93413-44-6	0.0100
Verapamil	52-53-9	0.0100
Warfarin	81-81-2	0.0100

Table A-3. Wastewater indicator analytes, Chemical Abstract Services (CAS) registry number, and reporting limits (µg/L) in 2010 and 2012.

Analyte	CAS number	2010		2012	
		Reporting limit (µg/L)	Analyzed?	Reporting limit (µg/L)	Analyzed?
1,4-Dichlorobenzene	106-46-7	0.150	Yes	0.0500	Yes
17beta-Estradiol	50-28-2	0.250	Yes	0.0500	Yes
1-Methylnaphthalene	90-12-0	0.150	Yes	0.0500	Yes
2,6-Dimethylnaphthalene	581-42-0	0.150	Yes	0.0500	Yes
2-Methylnaphthalene	91-57-6	0.150	Yes	0.0500	Yes
3-Methyl Indole	83-34-1	0.150	Yes	0.0500	Yes
4-Cumylphenol	599-64-4	0.150	Yes	0.0500	Yes
4-n-Octylphenol	1806-26-4	0.150	Yes	0.0500	Yes
4-tert-Octylphenol	140-66-9	0.150	Yes	0.0500	Yes
Acetophenone	98-86-2	0.150	Yes	0.0500	Yes
Benzophenone	119-61-9	0.150	Yes	0.0500	Yes
Bisphenol A	80-05-7	0.150	Yes	0.0500	Yes
Bromacil	314-40-9	0.150	Yes	0.0500	Yes
Butylated Hydroxyanisole	25013-16-5	0.150	Yes	0.0500	Yes
Caffeine	58-08-2	0.250	Yes	0.0500	Yes
Camphor	76-22-2	0.150	Yes	0.0500	Yes
Carbaryl	63-25-2	0.150	Yes	0.0500	Yes
Carbazole	86-74-8	0.150	Yes	0.0500	Yes
Celestolide	13171-00-1	NA	No	0.0500	Yes
Chlorpyrifos	2921-88-2	0.150	Yes	0.0500	Yes
Dacthal	1961-32-1	0.150	Yes	0.0500	Yes
Diazinon	333-41-5	0.100	Yes	0.0500	Yes
Dichlorvos	62-73-7	0.150	Yes	0.0500	Yes
Equilenin	517-09-9	NA	No	0.0500	Yes
Estrone	53-16-7	0.150	Yes	0.0500	Yes
Ethinylestradiol ¹	57-63-6	0.150	Yes	0.0500	Yes
Fluoranthene	206-44-0	0.150	Yes	0.0500	Yes
Galaxolide ²	1222-05-5	0.150	Yes	0.0500	Yes
Indole	120-72-9	0.150	Yes	0.0500	Yes
Isoborneol	124-76-5	0.150	Yes	0.0500	Yes
Isophorone	78-59-1	0.250	Yes	0.0500	Yes
Isoquinoline	119-65-3	0.150	Yes	0.0500	Yes
Menthol	89-78-1	0.250	Yes	0.0500	Yes
Methyl Salicylate	119-36-8	0.150	Yes	0.0500	Yes
Metolachlor	51218-45-2	0.150	Yes	0.0500	Yes
Musk ketone	81-41-1	NA	No	0.0500	Yes
Naphthalene	91-20-3	0.150	Yes	0.0500	Yes
Nonylphenol	25154-52-3	0.150	Yes	0.0500	Yes
p-Cresol	106-44-5	0.150	Yes	0.0500	Yes
Pentachlorophenol	87-86-5	0.500	Yes	0.0500	Yes
Phantolide	15323-35-0	NA	No	0.0500	Yes
Phenanthrene	85-01-8	0.150	Yes	0.0500	Yes
Phenol	108-95-2	0.250	Yes	0.0500	Yes
Prometon	1610-18-0	0.150	Yes	0.0500	Yes

Table A-3. Wastewater indicator analytes, Chemical Abstract Services (CAS) registry number, and reporting limits (µg/L) in 2010 and 2012.

Analyte	CAS number	2010		2012	
		Reporting limit (µg/L)	Analyzed?	Reporting limit (µg/L)	Analyzed?
Pyrene	129-00-0	0.150	Yes	0.0500	Yes
Tonalide	21145-77-7	NA	No	0.0500	Yes
Tri(2-butoxyethyl) Phosphate	78-51-3	0.150	Yes	0.0500	Yes
Tri(2-chloroethyl) Phosphate	115-96-8	0.150	Yes	0.0500	Yes
Tri(dichloroisopropyl) Phosphate	13674-87-8	0.150	Yes	0.0500	Yes
Tributyl Phosphate	126-73-8	0.150	Yes	0.0500	Yes
Triclosan	3380-34-5	0.150	Yes	0.0500	Yes
Triethyl Citrate	77-93-0	0.150	Yes	0.0500	Yes
Triphenyl phosphate	115-86-6	0.150	Yes	0.0500	Yes

¹ Reported under the name 17alpha-Ethynylestradiol in 2010.

² Reported under the name Hexahydrohexamethyl-cyclopentabenzopyran in 2010.

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