Prepared in cooperation with City of Cedar Rapids Utilities Water Division

Selected Water-Quality Data from the Cedar River and Cedar Rapids Well Fields, Cedar Rapids, Iowa, 2017–22

Data Report 1224

U.S. Department of the Interior
U.S. Geological Survey

Front cover. Photograph of the Cedar River in Cedar Rapids, Iowa, taken from Mt. Trashmore on June 22, 2025, by Steve Kalkhoff, U.S. Geological Survey.

Back cover. Photograph showing U.S. Geological Survey hydrologists collecting a water sample from the Cedar River at Blairs Ferry Road at Palo, Iowa, on October 27, 2022, by Shannon Meppelink, U.S. Geological Survey.

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	0.000039	micrometer (µm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Volume	
fluid ounce (oz)	0.0338	milliliter (mL)
gallon (gal)	3.7854	liter (L)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
square feet per day (ft^2/d)	0.0929	square meter per day (m^2/d)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)

Datums

Horizontal coordinate information is referenced to the Universal Transverse Mercator projection, Zone 15, North American Datum of 1983.

Supplemental Information

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Concentrations of chemical constituents in water are given in milligrams per liter (mg/L), micrograms per liter (µg/L), or nanograms per liter (ng/L).

Abbreviations

CRM	Cedar Rapids Monitoring
HCW	horizontal collector wells
IBW	inorganic blank water
LC–MS/MS	liquid chromatography–tandem mass spectrometry
LRL	laboratory reporting limit
OBW	organic blank water
QA	quality assurance
QC	quality control
RPD	relative percent difference
TP	transformation product
USGS	U.S. Geological Survey

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Abstract

The Cedar River alluvial aquifer is the source of drinking water in Cedar Rapids, Iowa. Production wells are completed in the alluvial aquifer approximately 40 to 80 feet below land surface. The City of Cedar Rapids and the U.S. Geological Survey have studied the groundwater-flow system and water quality of the aquifer in the vicinity of Cedar Rapids since 1992. Results of these studies documented hydrologic conditions, water quality, and geochemistry of the alluvial aquifer and interactions with the Cedar River. Water-quality samples were collected for studies involving well field monitoring, trends, source-water protection, groundwater geochemistry, surface-water–groundwater interaction, and pesticides in groundwater and surface water. Water quality was analyzed for dissolved major ions (boron, bromide, calcium, chloride, fluoride, iron, magnesium, manganese, potassium, silica, sodium, sulfate, and total dissolved solids), dissolved nutrients (ammonia as nitrogen, ammonia plus organic nitrogen as nitrogen, nitrite plus nitrate as nitrogen, nitrite as nitrogen, orthophosphate as phosphorus, and phosphorus), dissolved organic carbon, and selected pesticides. Physical characteristics (alkalinity, dissolved oxygen, pH, specific conductance, and water temperature) were measured on site and recorded for each water sample collected. This report presents the results of routine water-quality data-collection activities from October 2017 through September 2022. Methods of data collection, quality assurance, water-quality analyses, and statistical procedures are presented. Data include the results of water-quality analyses from quarterly sampling from monitoring wells, production wells, two water treatment plants, and the Cedar River at Blairs Ferry Road at Palo, Iowa, streamgage (U.S. Geological Survey station number 05464420), as well as monthly nutrient sampling from the Cedar River and Morgan Creek near Covington, Iowa, streamgage (U.S. Geological Survey station number 05464475).

Introduction

The City of Cedar Rapids, in Linn County, Iowa, obtains its drinking water supply from a shallow alluvial aquifer adjacent to the Cedar River. Forty-five vertical wells and six horizontal collector wells (HCW) are completed at about 40 to 80 feet (ft) below land surface. Vertical wells gradually are being replaced by higher-yielding HCWs, but many of the vertical wells are used regularly or are in standby operation. Adequate quantities of generally high-quality water have been obtained from the alluvial aquifer since the resource was developed in 1962.

Population growth and industrial development have increased the demand for water; Cedar Rapids pumped an average of 39.3 million gallons per day (Mgal/d) from the alluvial aquifer in 2018, 38.0 Mgal/d in 2019, 36.7 Mgal/d in 2020, 40.0 Mgal/d in 2021, and 38.7 Mgal/d in 2022. A record high daily demand of 53.73 Mgal/d was recorded on June 16, 2021 (C. Knapp, City of Cedar Rapids Water Department, written commun., June 2023). To document the quantity and quality of water available from the Cedar River and the alluvial aquifer, the City of Cedar Rapids and the U.S. Geological Survey (USGS) carried out a multidiscipline study of the Cedar River alluvial aquifer flow system and its interaction with the underlying Silurian-Devonian aquifer and adjacent Cedar River in the vicinity of the Cedar Rapids well fields since 1992. Additionally, the cooperative study was intended to document the physical extent of the aquifer, model flow into the aquifer from the adjacent Cedar River and underlying bedrock aquifers, and document how use of water from the aquifer affects the quality of water in the aquifer.

Previous Investigations

Results from the long-term multidiscipline cooperative study between the City of Cedar Rapids Water Department and the USGS have been published in data and interpretative reports. Water-quality data collected as part of this study were previously summarized at 5-year intervals in data reports by Schulmeyer and others (1995), Schnoebelen and Schulmeyer (1996), Boyd and others (1999), Littin and Schnoebelen (2010), Littin (2012), and Meppelink and others (2019).

Data collected during this study were used to understand the hydrology and water-quality characteristics of the alluvial aquifer and the interaction of aquifer water with the Cedar River. Schulmeyer (1995) analyzed the effect of the Cedar River on the quality of groundwater near the well fields. Schnoebelen and Schulmeyer (1996) documented hydrogeologic data collected and compiled from October 1992 to March 1996. Schulmeyer and Schnoebelen (1998) described the hydrogeology near the well fields, documented a groundwater-flow model constructed to simulate regional groundwater flow under steady-state conditions, identified sources of water to the well fields, and assessed temporal and spatial variations of selected water-quality constituents and properties. Boyd (1998) characterized groundwater flow near the well fields using selected environmental isotopes and tracers. Boyd (2000) evaluated the occurrence and distribution of concentrations of selected pesticides in the alluvial aquifer and Cedar River following springtime application of these pesticides to upstream cropland areas.

Kalkhoff (2018) documented spatial and temporal differences in nitrogen and phosphorus transport from the Cedar River Basin during 2000 to 2015 that can assist in documenting progress of efforts by the City of Cedar Rapids in the Middle Cedar Partnership Project, the Iowa Department of Natural Resources Watershed Management Authority in the upper and middle Cedar River, and the University of Iowa Watershed Approach in the middle Cedar River Basin to reduce downstream flooding and improve water quality. Garrett (2021) developed and documented a model based on real-time turbidity measurements that provided information to evaluate progress of nutrient reduction efforts in the Cedar River Basin. Most recently, Kalkhoff (2021) summarized the effect of pumping on spatial and temporal hydrologic and water-quality variability of the Cedar River alluvial aquifer in Linn County, Iowa, from 1990 to 2019.

During water years 2018 through 2022, geophysical data (Deszcz-Pan and others, 2018; Johnson and others, 2020) were collected to refine the lithology and extent of the aquifer (Valder and others, 2018), and an updated groundwater-flow model to simulate effects of drought on water availability was developed (Haj and others, 2021).

Purpose and Scope

This report presents the results of water-quality data-collection activities in water years 2018 through 2022 (October 2017 through September 2022) for a multidiscipline study of the Cedar River alluvial aquifer completed by the USGS, in cooperation with the City of Cedar Rapids Utilities Water Division. Selected water-quality constituents were monitored continuously in the Cedar River and Morgan Creek, and water levels were monitored continuously in selected wells during the 2018–22 period (USGS, 2023a). Only water-quality data from periodic samples are summarized in this report; all data are publicly available in the USGS Water Data for the Nation database (USGS, 2023a). Data presented in this report include results of water-quality analyses and physical characteristics of surface water flowing into Cedar Rapids from the Cedar River and Morgan Creek. Water quality within the Cedar River alluvial aquifer was determined by periodically sampling two monitoring wells, seven production wells in the Cedar Rapids well fields, and raw water entering the two drinking water treatment plants. Samples were analyzed for selected physical characteristics at the time of collection, constituents that included nitrate as nitrogen, selected pesticides of interest for drinking water supply, and major ions to document the basic water chemistry in the surface and groundwater in the study area.

Description of the Study Area

Cedar Rapids is within Linn County in east-central Iowa. Water for the City of Cedar Rapids is supplied from three well fields (Seminole, East, and West) along the Cedar River (fig. 1). The City of Cedar Rapids had a population of about 137,700 in 2020 (U.S. Census Bureau, 2023). The Cedar River flows from the northwest to the southeast in the study area (fig. 1) and drains 6,342 square miles upstream from the Cedar River at Blairs Ferry Road at Palo, Iowa, streamgage (USGS station number 05464420; hereafter referred to as “CRPalo streamgage”; fig. 1). Morgan Creek flows from the southwest to northeast in the study area and drains 16.7 square miles in Linn and Benton Counties upstream from the Morgan Creek near Covington, Iowa, streamgage (USGS station number 05464475; hereafter referred to as “MorgCr streamgage”). Morgan Creek flows into the Cedar River upstream from the Seminole well field (fig. 1). Upstream land use in the Cedar River and Morgan Creek Basins is greater than 90 percent agriculture, which is dominated by corn and soybean production (Iowa Department of Natural Resources, 2006). Livestock raised in Cedar River and Morgan Creek Basins upstream from the study area include cattle and hogs. Annual precipitation in the Cedar Rapids, Iowa, area was as follows: 26.09 in. (2017), 40.65 in. (2018), about 37.5 in. (2019), 31.55 in. (2020), 23.69 in. (2021), and 28.36 in. in 2022 (National Oceanic and Atmospheric Administration, 2025).

Extreme daily mean flows recorded at the CRPalo streamgage during this reporting period were a maximum of 61,700 cubic feet per second (ft^3/s) on March 18, 2019, and minimum of 525 ft^3/s on December 26, 2017 (U.S. Geological Survey, 2023a). These extreme flows compare to the long-term (1903–2022) maximum daily mean flow of 138,000 ft^3/s on June 13, 2008, and minimum of 140 ft^3/s on November 18, 1989, at the downstream streamgage at Cedar Rapids (USGS station number 05464500) (U.S. Geological Survey, 2023a).

Hydrogeologic units in and near the Cedar Rapids well fields include unconsolidated surficial deposits of loess, glacial till, and Cedar River alluvium (alluvial aquifer), underlain by Silurian and Devonian carbonate bedrock. The Cedar River

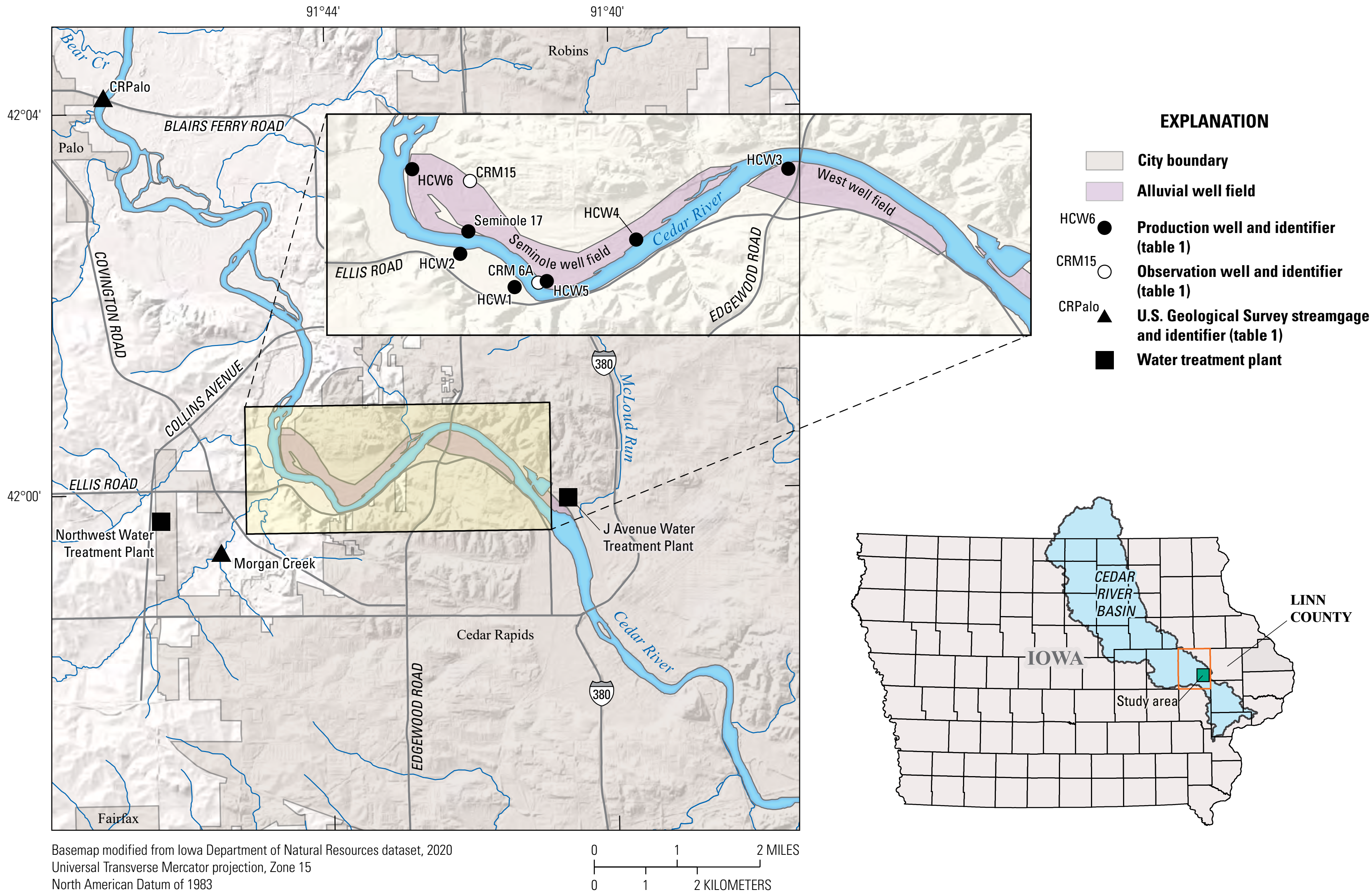

Figure 1. Map showing study area with alluvial well fields and locations of well, stream, and water treatment plant sampling sites, Cedar Rapids, Iowa, 2017–22.

floodplain ranges between about 1,000 and 3,300 ft wide in the study area and is bounded by steep bluffs that rise nearly 200 ft above the river valley, exposing bedrock in some places. The upland topography is characterized by rolling hills of low relief typically formed in loess and glacial till. The alluvial aquifer ranges from 5 to 95 ft thick near the well fields, with the thickest parts nearest to the present-day location of the Cedar River and the thinnest alluvium adjacent to the valley walls. The alluvial aquifer is characterized by a sequence of coarse sand and gravel at the base, grading upward to fine sand, silt, and clay near the surface. Bedrock in the study area consists primarily of jointed and fractured Paleozoic limestone and dolomite, with interbedded chert and shale (Schulmeyer and Schnoebelen, 1998). The buried bedrock surface has its own complicated erosional topography with multiple superimposed incised channel networks reflecting the area's glacial history. This Silurian-Devonian sequence has a maximum thickness of about 700 ft in the study area, and although no production wells have been completed in this aquifer, it is used locally for private and industrial water supply. The unconsolidated surficial deposits in the Cedar River Valley, underlying Devonian and Silurian carbonate bedrock, and deeper hydrogeologic units are described in detail by Hansen (1970), Wahl and Bunker (1986), and Schulmeyer and Schnoebelen (1998).

The Cedar River is in direct hydraulic connection with the alluvial aquifer (Turco and Buchmiller, 2004), and the alluvial aquifer is recharged by infiltration from the river, as well as by precipitation and seepage from underlying and adjacent hydrogeologic units. In areas affected by production well pumping, groundwater flows from the Cedar River toward the well fields, whereas in other areas, groundwater generally flows toward the river. Hansen (1970) calculated an approximate transmissivity of the alluvial aquifer to be about 20,000 square feet per day (ft^2/d), whereas Schulmeyer (1995) determined that transmissivity varies between 1,500 and 19,000 ft^2/d, depending on the physical properties of the alluvium. In May 2006, a contractor to the City of Cedar Rapids performed an aquifer test using Seminole 10 (an abandoned well located on the edge of the riverbank) that yielded a transmissivity value of approximately 15,000 ft^2/d (R. Hesemann, Cedar Rapids Water Department, oral commun., March 2007).

Methods of Study

Samples for water-quality analysis were collected from the Cedar River, monitoring wells within the well fields, production wells, and the two Cedar Rapids drinking water treatment plants (table 1). Data include results of water-quality analyses and physical characteristics measured at the time of sample collection. Well locations used for sampling are shown in figure 1. Summary statistics were compiled for water-quality samples. In addition, methods of quality assurance (QA) of samples are discussed, and data on quality-control (QC) samples are presented.

Well Construction and Nomenclature

Wells sampled during the study included 2-inch outer-diameter monitoring wells. The monitoring wells were installed using hollow-stem auger drilling techniques and completed with polyvinyl-chloride flush-joint casing. Bentonite grout was installed around the casing 6 to 8 ft below land surface, and the wells were capped with a cement pad at the surface. Well depths ranged from 18 to 97 ft. Well-construction information for all wells is listed in table 1.

Monitoring wells are named according to a convention that includes the year the well was installed (for example, 1993), the agency identifier (USGS), the local project identifier (CRM, for Cedar Rapids Monitoring), and a unique incremental number (beginning with number 1). For example, well 1993USGS CRM–3 is the third monitoring well installed by the USGS for this project. For convenience in this report, all sites have been given a short name (table 1).

Table 1. Information on water-quality data collection sites, Cedar Rapids, Iowa, 2017–22.

[ID, U.S. Geological Survey site identification number; S, surface water; C, common ions and trace elements; N, nutrients; P, pesticides; --, no data or not applicable; H, Ranney well; A, alluvial; M, monitoring well; SD, Silurian Devonian; T, treatment plant inflow; V, vertical well]

Site ID	Site name	Short name	Site type	Type of water-quality samples collected	Quarterly samples collected	Monthly nutrient samples	Period of record	Total depth (feet below land surface)	Casing diameter	Screened interval top/bottom (feet below land surface)	Land-surface elevation (feet above mean sea level)	Aquifer
05464420	Cedar River at Blairs Ferry Road at Palo, Iowa	CRPalo	S	C,N,P	17	30	2017–22	--	--	--	--	--
05464475	Morgan Creek near Covington, Iowa	MorgCr	S	C,N	--	48	2017–22	--	--	--	--	--
415952091440400	083N08W13CBCB 1994Cedar Rapids Ranney 1	Ranney 1	H	C,N,P	16	--	2017–22	59.5	--	--	721.6	A
415954091435101	083N08W13 CBDA 2020Cedar Rapids Smnl Ranney 5	Ranney 5	H	C,N,P	8	--	2020–22	55.0	--	--	727.0	A
420004091442300	083N08W14ADCC 1995Cedar Rapids Ranney 2	Ranney 2	H	C,N,P	10	--	2017–22	49.6	--	--	724.9	A
420010091431801	083N08W13ACAD 56471 2002Cedar Rapids Smnl Ranney 4	Ranney 4	H	C,N,P	16	--	2017–22	64.0	--	--	720.6	A
420035091422301	083N07W07DCBC 56470 2002Cedar Rapids West Ranney 3	Ranney 3	H	C,N,P	16	--	2017–22	67.0	--	--	734.6	A
420036091444001	083N08W11DCBC 2013Cedar Rapids Ranney 6	Ranney 6	H	C,N,P	16	--	2017–22	74.3	--	--	726.8	A
415954091435302	083N08W13ADBC 2010USGS CRM-6A	CRM6A	M	C,N,P	1	--	2018	97.0	2	90.0/95.0	727.9	SD
420031091441801	083N08W11DDC 1996USGS CRM-15	CRM15	M	C,N,P	11	--	2020–22	18.0	2	15.5/18.0	725.1	A
415956091461701	Cedar Rapids Northwest Water Treatment Plant	NWWTP	T	C,N,P	16	--	2017–22	--	--	--		--
420002091403200	Cedar Rapids Water Division (raw composite water)	JAve	T	C,N,P	16	--	2017–22	--	--	--		--
420013091442000	083N08W14ADBB 43186 1991Cedar Rapids Seminole 17	Seminole 17	V	C,N,P	16	--	2017–22	58.0	30	34.0/54.0	723.5	A

Water-Quality Sampling

Water-quality samples were collected from the Cedar River, Morgan Creek, monitoring wells, production wells, and inflow to two Cedar Rapids drinking water treatment plants (raw water composites from multiple production wells). Water-quality samples were collected from October 2017 through September 2022 and included quarterly water samples and monthly nutrient sampling at the Cedar River and, starting in October 2018, monthly samples at Morgan Creek. Samples were collected from HCWs, vertical wells, and monitoring wells on a quarterly basis. Samples that were a composite of water from vertical wells and HCWs were also collected quarterly at the Cedar Rapids Water Division (hereafter referred to as the "J Avenue plant" and Cedar Rapids Northwest (hereafter referred to as the "Northwest plant") water treatment plants.

This reporting period was one of transition for some sites and the overall project. Historically, Cedar River samples were collected downstream from Seminole Park at either the Edgewood Road bridge or at a jetty at Mohawk Park. Mohawk Park is approximately 1 river mile downstream from the Edgewood Road bridge. Starting in September 2016, Cedar River sample collection was moved upstream from the city to the CRPalo streamgage. Water quality at the CRPalo streamgage is representative of that flowing into the Cedar Rapids metropolitan area, whereas water in the Cedar River at Mohawk Park or Edgewood Road may have been affected by urban runoff. The first sample collected at the CRPalo streamgage was a flood sample; subsequent samples were either full quarterly samples or monthly nutrient-only samples. During this period, Ranney 5 became operational and was added to the sampling effort. The construction of Ranney 5, however, caused damage to CRM–6A, which removed it from the sampling plan after a single sample and replicate had been collected in November 2018. To offset that loss, a monitoring well, CRM–15, located in a recharge area near the edge of the Cedar River alluvial aquifer that is minimally affected by production well pumping (fig. 1) was added to the sampling plan in February 2020.

The two treatment plants have different operating capacities, and the number of wells sampled by the USGS per plant is not equal. The Northwest plant operates at roughly one-half the scale of the J Avenue plant. The J Avenue plant has a maximum daily output capacity of 40 Mgal/d, whereas the Northwest plant maximum daily output capacity is 20 Mgal/d. Of the production wells sampled for this project, Ranneys 1, 2, and 6 and Seminole 17 are valved to the Northwest plant. Ranneys 3, 4, and 5 are valved to the J Avenue plant. As necessary, Ranney 6 can be valved to the J Avenue plant instead of the Northwest plant for water-quality or water-quantity issues (C. Knapp, City of Cedar Rapids Water Department, written commun., April 2024). For the purposes of this report, because Ranney 6 is typically valved to the Northwest plant, data for Ranney 6 are included in the data tables grouped with data from the Northwest plant. Likewise, because Ranney 5 is typically valved to the J Avenue plant, data for Ranney 5 are in the data tables grouped with data for the J Avenue plant.

Before collecting water samples, monitoring wells are pumped to remove approximately three wellcasing volumes of water. Water samples were collected using either a stainless-steel submersible Fultz pump with fluoropolymer tubing or a Geopump peristaltic pump with C-Flex tubing. All samples were collected after field measurements of dissolved oxygen, pH, specific conductance, turbidity, and water temperature stabilized. These field measurements are summarized in table 2, along with alkalinity, bicarbonate, and carbonate data. Field values were measured in a flow-through chamber for all groundwater sites. Production wells were sampled after they had been pumping for at least 1 hour to obtain a representative sample from the aquifer. Samples from production wells were obtained from a spigot near the pump. Raw combined water samples were collected from the water treatment plants.

Surface-water samples were collected according to protocols detailed in U.S. Geological Survey (variously dated, 2023b) and Wilde (2002) and are summarized here. At the CRPalo streamgage, water-quality samples were collected using equal-width increment methods (U.S. Geological Survey, variously dated) to ensure the sample was representative of water in the entire cross section of the river. Field measurements were collected at a minimum of 10 equidistant points at the surface across the width of the river using a multiparameter sonde. Measurements were made across the total width to document potential variability. Field measurements were obtained using a multiparameter Yellow Springs Instruments EXO2, Eureka Manta 2, or a Eureka Manta 35 sonde. The recorded sample value of dissolved oxygen, pH, specific conductance, turbidity, and water temperature were the median value of the measurements made at the 10 points. Samples were collected at the same points of the cross section where the sonde measurements were made. All samples were combined into a churn splitter for sample processing. For Morgan Creek, all field measurements and samples were vertical center of flow because the stream is narrow, shallow, and well-mixed.

Groundwater samples were collected according to protocols detailed in U.S. Geological Survey (variously dated; 2023b) and Wilde (2002), with the following adaptations. To maintain sampling consistency across the history of the project, all groundwater samples were not processed with clean hands/dirty hands techniques utilizing a sampling chamber and two individuals. Instead, deviation from the standard protocol was that a single person collected, processed, and preserved samples. Raw (unfiltered) samples and pesticides were collected from the pump outlet or production well tap. Filtered samples were collected by connecting a filter directly to the pump outlet tubing and were filtered in situ. Samples from wells were collected to ensure the sample water was representative of that in the aquifer, which meant that production wells had been pumping an

Table 2. Physical characteristics, nutrients and dissolved organic carbon, and major ions analyzed for in water-quality samples from Morgan Creek, Cedar River, and Cedar Rapids wells, 2017–22.

[Data are from the U.S. Geological Survey Water Data for the Nation database (U.S. Geological Survey, 2023a); CASRN, Chemical Abstract Service Registry Number; LRL, laboratory reporting level; $CaCO_3$, calcium carbonate; --, not applicable; mg/L, milligram per liter; µS/cm, microsiemen per centimeter; N, nitrogen; P, phosphorus; µg/L, microgram per liter]

Constituent name	CASRN number[1]	LRL	Unit
Physical characteristics			
Alkalinity (as $CaCO_3$)	--	--	mg/L
Dissolved oxygen	--	--	mg/L
pH	--	--	standard units
Specific conductance	--	--	µS/cm at 25 degrees Celsius
Temperature, water	--	--	degrees Celsius
Bicarbonate	3983-19-5	0.02	mg/L
Carbonate	471-34-1	0.02	mg/L
Turbidity	--	--	FNU
Dissolved nutrients and dissolved organic carbon			
Ammonia, NH_3 + NH_4+ (as N)	7664-41-7	0.04	mg/L
Nitrite (as N)	14797-65-0	0.002	mg/L
Nitrite plus nitrate (as N)	--	0.08	mg/L
Orthophosphate (as P)	14265-44-2	0.008	mg/L
Ammonia plus organic nitrogen (as N)	17778-88-0	0.14	mg/L
Phosphorus	7723-14-0	0.04	mg/L
Dissolved organic carbon	--	0.6	mg/L
Dissolved major ions			
Boron	7440-42-8	4	µg/L
Bromide	24959-67-9	0.02	mg/L
Calcium	7440-70-2	0.04	mg/L
Chloride	16887-00-6	0.1	mg/L
Fluoride	16984-48-8	0.02	mg/L
Iron	7439-89-6	10	µg/L
Magnesium	7439-95-4	0.02	mg/L
Manganese	7439-96-5	0.4	µg/L
Potassium	7440-09-7	0.6	mg/L
Silica (as SiO_2)	7631-86-9	0.1	mg/L
Sodium	7440-23-5	0.4	mg/L
Sulfate	14808-79-8	0.04	mg/L
Total dissolved solids	--	20	mg/L

[1]This report contains CAS Registry Numbers, which is a Registered Trademark of the American Chemical Society. CAS recommends the verification of the CASRNs through CAS Client Services.

extended time before sample collection and that monitoring wells were pumped to remove about three well casing volumes of water before the sample was collected.

All surface-water samples from the Cedar River and Morgan Creek were collected and processed using clean hands/dirty hands techniques, except for samples collected between March 2020 and June 2020 owing to restrictions placed on personnel as a result of the COVID–19 pandemic. As indicated in the “Quality Assurance and Quality Control” section of this report, the adaptation for groundwater sampling did not adversely affect the samples.

Sample Preparation and Laboratory Analysis

Water samples for analysis of nutrients and major ions were filtered through a 0.45-micrometer (µm) pore size Aquaprep polycarbonate disk or Pall capsule filter in the field. Water samples for pesticide analysis in 2018 and 2019 were filtered through a 47-millimeter (mm) diameter, 0.7-µm pore size glass-fiber filter in a Teflon filter holder into a 1-liter (L) baked glass bottle. Starting in 2020, pesticide samples were filtered using a 25-mm diameter, 0.7-µm pore size borosilicate glass-fiber syringe tip filter into a baked glass 20 milliliter (mL) vial. After collection, water samples were kept chilled until shipped overnight to the USGS National Water-Quality Laboratory in Denver, Colorado, for analysis.

Samples were analyzed to determine nutrient concentrations using colorimetric methods (Patton and Kryskalla, 2011) for dissolved species and alkaline persulfate digestion (Patton and Kryskalla, 2003) for unfiltered samples. Analytical methods used for major ions are described by Fishman (1993). Inductively coupled plasma–atomic emission spectrometry was used to determine boron concentrations (Struzeski and others, 1996). The high-temperature combustion method was used to determine the total organic carbon concentration in samples (ASTM International, 2019).

Nutrients, dissolved organic carbon, physical characteristics, and major ions from water-quality samples, the Chemical Abstract Service Registry Number, laboratory reporting limits (LRL), and reporting units are listed in table 2. Pesticides from water-quality samples, followed by the Chemical Abstract Service Registry Number, and LRLs are listed in table 3. The LRL is used to specify the lowest quantifiable value for constituents listed in tables 2 and 3. The LRL is defined more rigorously by statistics than the older minimum reporting level that it replaces (Oblinger Childress and others, 1999).

During this period of record, the analytical method for pesticides was changed from a C–18 solid-phase extraction and gas chromatography/mass spectrometry method (Sandstrom and others, 2001) to direct aqueous-injection liquid chromatography–tandem mass spectrometry (LC–MS/MS) in December 2019 (Sandstrom and others, 2015). The analysis was changed to analyze for a broader range of constituents at a lower LRL (table 3). The LC–MS/MS analytical method includes more than 200 fungicides, herbicides, insecticides, and associated transformation products (TPs) with results at similar or lower concentrations than previously available methods. The pesticides represent a broad range of chemical classes and were selected based on criteria such as current-use intensity, probability of occurrence in streams and groundwater, and toxicity to humans or aquatic organisms (Sandstrom and others, 2015)

Quality Assurance and Quality Control

To properly interpret water-quality data and to verify these data are reliable and accurate, QA procedures are followed and QC samples are collected in addition to the environmental samples. In general, QA includes using correct procedures and protocols, proper documentation (log books and field sheets) and approved analytical methods. The QC samples typically are used in the estimation of the magnitude of bias and variability of the environmental samples. Bias is systematic error that can “skew” results in either a positive or negative direction. The most common source of positive bias in water-quality studies is contamination of samples from airborne gases and particulates or inadequately cleaned sampling equipment between uses and locations. Variability is the degree of random error of independent measurements of the sample quantity. Variability may be the result of errors in laboratory analytical procedures or in collection of samples in the field. The QA/QC procedures are followed to ensure the data collected meet standards of reliability and accuracy.

The QA/QC procedures for the study followed USGS protocols (U.S. Geological Survey, variously dated) and other USGS guidelines (Mueller and others, 1997) and included documenting any deviations made in the field. Approximately 5 percent of the total samples collected for the study were analyzed for QC including equipment blanks, field blanks, and replicates. Generally, field blanks are used to estimate sample bias, whereas replicates are used to estimate sample variability.

A field blank is a water sample that is intended to be free of the analytes of interest. Two types of commercially available blank waters were used for equipment and field blanks. Organic blank water (OBW) and inorganic blank water (IBW) are certified by the manufacturer (Ricca) to be free of either organic compounds (OBW) or inorganic compounds (IBW). In the case of equipment blanks, blank water was passed through all sampling equipment in a “clean environment,” such as the laboratory, to examine the cleanliness of the equipment before sampling. A field blank is a specific type of blank sample collected in the field and is used to demonstrate that (1) equipment has been adequately cleaned to remove contamination introduced by samples obtained at the previous site; (2) sample collection and processing have not resulted in contamination; and (3) sample handling, transport, and laboratory analysis have not introduced contamination (Mueller and others, 1997). Field

Table 3. Selected pesticides analyzed in water-quality samples from the Cedar River and Cedar Rapids wells, 2017–22.

[Data are from the U.S. Geological Survey Water Data for the Nation database (U.S. Geological Survey, 2023a); CASRN, Chemical Abstract Service Registry Number; LRL, laboratory reporting level; GC/MS, analytical method gas chromatograph/mass spectrometry (Sandstrom and others, 2001); µg/L, microgram per liter; LC–MS/MS, analytical method liquid chromatography /tandem mass spectrometry (Sandstrom and others, 2015);] ng/L, nanogram per liter; --, not applicable

Compound name	Compound class	CASRN number[1]	LRL	
			GC/MS (µg/L)	LC–MS/MS (ng/L)
1H-1,2,4-Triazole	Transformation product	288-88-0	--	22
1-Naphthol	Transformation product	90-15-3	0.050	--
2-(1-Hydroxyethyl)-6-methylaniline (HEMA)	Transformation product	196611-19-5	--	160
2,4-D	Herbicide	94-75-7	--	62
2,6-Diethylaniline	Reagent	579-66-8	0.006	--
2-[(2-Ethyl-6-methylphenyl)amino]-1-propanol	Transformation product	61520-53-4	--	5
2-Aminobenzimidazole	Transformation product	934-32-7	--	9
2-Amino-N-isopropylbenzamide	Transformation product	30391-89-0	--	4
2-Chloro-2,6-diethylacetanilide	Transformation product	6967-29-9	0.010	5
[2]-Chloro-4-isopropylamino-6-amino-*s*-triazine (CIAT)	Transformation product	6190-65-4	0.010	--
2-Chloro-6-ethylamino-4-amino-*s*-triazine (CEAT)	Transformation product	1007-28-9	--	--
2-Chloro-N-(2-ethyl-6-methylphenyl)acetamide	Transformation product	32428-71-0	--	5
2-Ethyl-6-methylaniline	Transformation product	24549-06-2	0.010	--
2-Hydroxy-4-isopropylamino-6-amino-*s*-triazine (OIAT)	Transformation product	19988-24-0	--	4
2-Hydroxy-6-ethylamino-4-amino-*s*-triazine (OEAT)	Transformation product	7313-54-4	--	100
2-Hydroxyatrazine (OIET)	Transformation product	2163-68-0	--	8
3,4-Dichloroaniline	Transformation product	95-76-1	0.006	--
3,4-Dichlorophenylurea	Transformation product	2327-02-08	--	108
3,5-Dichloroaniline	Transformation product	626-43-7	0.006	--
3-Hydroxycarbofuran	Transformation product	16655-82-6	--	16
3-Phenoxybenzoic acid	Transformation product	3739-38-6	--	61
4-(Hydroxymethyl) pendimethalin	Transformation product	56750-76-6	--	114
4-Chloro-2-methylphenol	Transformation product	1570-64-5	0.008	--
4-Chlorobenzylmethyl sulfoxide	Transformation product	24176-68-9	--	3.2
4-Hydroxychlorothalonil	Transformation product	28343-61-5	--	42
4-Hydroxyhexazinone A	Transformation product	72576-13-7	--	3
Acephate	Insecticide	30560-19-1	--	10
Acetochlor	Herbicide	34256-82-1	0.01	10
Acetochlor OA	Herbicide	194992-44-4	--	65
Acetochlor SA	Herbicide	187022-11-3	--	320
Acetochlor SAA	Herbicide	618113-86-3	--	176
Alachlor	Herbicide	15972-60-8	0.008	27
Alachlor OA	Herbicide	171262-17-2	--	60
Alachlor SA	Herbicide	142363-53-9	--	840
Aldicarb	Insecticide	116-06-3	--	8
Aldicarb sulfone	Insecticide	1646-88-4	--	20
Aldicarb sulfoxide	Insecticide	1646-87-3	--	2.2
alpha-Endosulfan	Transformation product	959-98-8	0.010	--
Ametryn	Herbicide	834-12-8	--	2.6

Table 3. Selected pesticides analyzed in water-quality samples from the Cedar River and Cedar Rapids wells, 2017–22.—Continued

[Data are from the U.S. Geological Survey Water Data for the Nation database (U.S. Geological Survey, 2023a); CASRN, Chemical Abstract Service Registry Number; LRL, laboratory reporting level; GC/MS, analytical method gas chromatograph/mass spectrometry (Sandstrom and others, 2001); µg/L, microgram per liter; LC–MS/MS, analytical method liquid chromatography /tandem mass spectrometry (Sandstrom and others, 2015);] ng/L, nanogram per liter; --, not applicable

Compound name	Compound class	CASRN number[1]	LRL	
			GC/MS (µg/L)	LC–MS/MS (ng/L)
Asulam	Herbicide	3337-71-1	--	24
Atrazine	Herbicide	1912-24-9	0.008	6.8
Azinphos-methyl	Insecticide	86-50-0	0.120	8
Azinphos-methyl oxon	Transformation product	961-22-8	0.042	15
Azoxystrobin	Fungicide	131860-33-8	--	3
Benfluralin	Herbicide	1861-40-1	0.014	--
Bentazon	Herbicide	25057-89-0	--	9
Bifenthrin	Insecticide	82657-04-3	--	19
Bromacil	Herbicide	314-40-9	--	5.6
Bromoxynil	Herbicide	1689-84-5	--	60
Butralin	Herbicide	33629-47-9	--	5
Butylate	Herbicide	2008-41-5	--	10
Carbaryl	Insecticide	63-25-2	0.060	5.6
Carbendazim	Fungicide	10605-21-7	--	10
Carbofuran	Insecticide	1563-66-2	0.060	5
Chlorimuron-ethyl	Herbicide	90982-32-4	--	8.8
Chlorpyrifos	Insecticide	2921-88-2	0.010	3
Chlorpyrifos oxon	Transformation product	--	--	4.4
Chlorpyrifos oxygen analog	Transformation product	5598-15-2	0.080	--
Chlorsulfuron	Herbicide	64902-72-3	--	50
cis-Cyhalothric acid	Intermediate	68127-59-3	--	105
cis-Permethrin	Insecticide	61949-76-6	0.010	4.2
cis-Propiconazole	Transformation product	60207-90-1	0.008	--
Cyanazine	Herbicide	21725-46-2	0.022	50
Cyfluthrin	Insecticide	68359-37-5	0.016	--
Cypermethrin	Insecticide	52315-07-8	0.020	--
DCPA (dacthal)	Herbicide	1861-32-1	0.008	--
DCPA monoacid (Chlorthal-monomethyl)	Herbicide	887-54-7	--	700
Dechlorofipronil	Transformation product	--	--	3.8
Dechlorometolachlor	Transformation product	126605-22-9	--	2
Deethylatrazine (CIAT)	Transformation product	6190-65-4	--	11
Deiodo flubendiamide	Transformation product	1016160-78-3	--	10
Deisopropylatrazine (CEAT)	Transformation product	1007-28-9	--	20
Demethyl fluometuron	Transformation product	3032-40-4	--	3.6
Demethyl hexazinone B	Transformation product	56611-54-2	--	3
Demethyl norflurazon	Transformation product	23576-24-1	--	4
Desamino metribuzin (Metribuzin DA)	Transformation product	35045-02-4	--	9
Desamino-diketo metribuzin	Transformation product	52236-30-3	--	200
Desulfinylfipronil	Transformation product	205650-65-3	0.012	3.8

Table 3. Selected pesticides analyzed in water-quality samples from the Cedar River and Cedar Rapids wells, 2017–22.—Continued

[Data are from the U.S. Geological Survey Water Data for the Nation database (U.S. Geological Survey, 2023a); CASRN, Chemical Abstract Service Registry Number; LRL, laboratory reporting level; GC/MS, analytical method gas chromatograph/mass spectrometry (Sandstrom and others, 2001); µg/L, microgram per liter; LC–MS/MS, analytical method liquid chromatography /tandem mass spectrometry (Sandstrom and others, 2015);] ng/L, nanogram per liter; --, not applicable

Compound name	Compound class	CASRN number[1]	LRL	
			GC/MS (µg/L)	LC–MS/MS (ng/L)
Desulfinylfipronil amide	Transformation product	1115248-09-3	0.029	10
Diazinon	Insecticide	333-41-5	0.006	6.4
Diazinon oxygen analog	Transformation product	962-58-3	0.012	--
Diazoxon	Transformation product	--	--	4
Dicamba	Herbicide	1918-00-9	--	800
Dichlorvos	Insecticide	--	0.040	52
Dicrotophos	Insecticide	141-66-2	0.080	4
Didealkylatrazine (CAAT)	Transformation product	3397-62-4	--	24
Didemethyl hexazinone F (Hexazinone TP F)	Transformation product	56611-55-3	--	10
Dieldrin	Insecticide	60-57-1	0.012	--
Diflubenzuron	Insecticide	35367-38-5	--	6
Diflufenzopyr	Herbicide	109293-97-2	--	72
Diketonitrile-isoxaflutole	Transformation product	143701-75-1	--	10
Dimethenamid	Herbicide	87674-68-8	--	3
Dimethenamid OA	Transformation product	380412-59-9	--	85
Dimethenamid SA	Transformation product	205939-58-8	--	79
Dimethoate	Insecticide	60-51-5	0.010	4.6
Disulfoton	Insecticide	298-04-4	0.040	11
Disulfoton oxon	Transformation product	126-75-0	--	2
Disulfoton oxon sulfone	Transformation product	2496-91-5	--	6
Disulfoton oxon sulfoxide	Transformation product	2496-92-6	--	6
Disulfoton sulfone	Transformation product	2497-06-5	0.010	9
Disulfoton sulfoxide	Transformation product	2497-07-6	--	4
Diuron	Herbicide	330-54-1	--	5
Endosulfan sulfate	Transformation product	1031-07-8	0.016	--
EPTC	Herbicide	759-94-4	0.006	206
EPTC R248722	Transformation product	65109-69-5	--	4
Ethion	Insecticide	563-12-2	0.005	--
Ethion monoxon	Transformation product	17356-42-2	0.021	--
Ethoprop	Insecticide	13194-48-4	--	5
Ethoprophos	Insecticide	13194-48-4	0.016	--
Etoxazole	Insecticide	153233-91-1	--	4.2
Fenamiphos	Insecticide	22224-92-6	0.030	4.6
Fenamiphos sulfone	Transformation product	31972-44-8	0.054	5
Fenamiphos sulfoxide	Transformation product	31972-43-7	0.080	5
Fenbutatin oxide	Transformation product	13356-08-6	--	500
Fentin	Fungicide	668-34-8	--	30
Fipronil	Insecticide	120068-37-3	0.018	4
Fipronil amide	Transformation product	205650-69-7	--	9.2

Table 3. Selected pesticides analyzed in water-quality samples from the Cedar River and Cedar Rapids wells, 2017–22.—Continued

[Data are from the U.S. Geological Survey Water Data for the Nation database (U.S. Geological Survey, 2023a); CASRN, Chemical Abstract Service Registry Number; LRL, laboratory reporting level; GC/MS, analytical method gas chromatograph/mass spectrometry (Sandstrom and others, 2001); µg/L, microgram per liter; LC–MS/MS, analytical method liquid chromatography /tandem mass spectrometry (Sandstrom and others, 2015);] ng/L, nanogram per liter; --, not applicable

Compound name	Compound class	CASRN number[1]	LRL	
			GC/MS (µg/L)	LC–MS/MS (ng/L)
Fipronil sulfide	Transformation product	120067-83-6	0.016	4.2
Fipronil sulfonate	Transformation product	209248-72-6	--	44
Fipronil sulfone	Transformation product	120068-36-2	0.024	5.6
Flubendiamide	Insecticide	272451-65-7	--	4.4
Flumetsulam	Herbicide	98967-40-9	--	38
Fluometuron	Herbicide	2164-17-2	--	10
Fonofos	Insecticide	944-22-9	0.005	11
Halosulfuron-methyl	Transformation product	100784-20-1	--	12
Hexazinone	Herbicide	51235-04-2	0.012	3.6
Hexazinone TP C	Transformation product	72585-88-7	--	2
Hexazinone TP D	Transformation product	30243-77-7	--	294
Hexazinone TP E	Transformation product	72576-14-8	--	76
Hexazinone TP G	Transformation product	--	--	22
Hydroxy didemethyl fluometuron	Transformation product	--	--	50
Hydroxy monodemethyl fluometuron	Transformation product	--	--	12
Hydroxyacetochlor	Transformation product	60090-47-3	--	20
Hydroxyalachlor	Transformation product	56681-55-1	--	6
Hydroxydiazinon	Transformation product	29820-16-4	--	11
Hydroxymetolachlor	Transformation product	131068-72-9	--	2.4
Hydroxyphthalazinone	Transformation product	--	--	28
Hydroxysimazine	Transformation product	2599-11-3	--	120
Imazamox	Herbicide	114311-32-9	--	30
Imazaquin	Herbicide	81335-37-7	--	10
Imazethapyr	Herbicide	81335-77-5	--	8
Imidacloprid	Insecticide	138261-41-3	--	16
Indoxacarb	Insecticide	173584-44-6	--	5.2
Iprodione	Fungicide	36734-19-7	0.014	--
Isofenphos	Insecticide	25311-71-1	0.014	--
Isoxaflutole	Herbicide	141112-29-0	--	18
Isoxaflutole Acid RPA 203328	Transformation product	142994-06-7	--	9.2
Kresoxim-methyl	Fungicide	143390-89-0	--	5
Lactofen	Herbicide	77501-63-4	--	10
lambda-Cyhalothrin	Insecticide	91465-08-6	0.014	--
Linuron	Herbicide	330-55-2	--	5.6
Malaoxon	Transformation product	1634-78-2	0.022	54
Malathion	Insecticide	121-75-5	0.016	5.4
MCPA	Herbicide	94-74-6	--	95
Metalaxyl	Fungicide	57837-19-1	0.014	6
Metconazole	Fungicide	125116-23-6	--	5

Table 3. Selected pesticides analyzed in water-quality samples from the Cedar River and Cedar Rapids wells, 2017–22.—Continued

[Data are from the U.S. Geological Survey Water Data for the Nation database (U.S. Geological Survey, 2023a); CASRN, Chemical Abstract Service Registry Number; LRL, laboratory reporting level; GC/MS, analytical method gas chromatograph/mass spectrometry (Sandstrom and others, 2001); µg/L, microgram per liter; LC–MS/MS, analytical method liquid chromatography /tandem mass spectrometry (Sandstrom and others, 2015);] ng/L, nanogram per liter; --, not applicable

Compound name	Compound class	CASRN number[1]	LRL	
			GC/MS (µg/L)	LC–MS/MS (ng/L)
Methamidophos	Insecticide	10265-92-6	--	10
Methidathion	Insecticide	950-37-8	0.012	8.4
Methomyl	Insecticide	16752-77-5	--	3
Methomyl oxime	Transformation product	13749-94-5	--	8000
Methoxyfenozide	Insecticide	161050-58-4	--	2.2
Methyl paraoxon	Transformation product	950-35-6	--	19
Methyl parathion	Insecticide	298-00-0	0.008	--
Metolachlor	Herbicide	51218-45-2	0.012	3.2
Metolachlor hydroxy morpholinone	Transformation product	61520-54-5	--	10
Metolachlor OA	Transformation product	152019-73-3	--	149
Metolachlor SA	Transformation product	171118-09-5	--	68
Metribuzin	Herbicide	21087-64-9	0.012	20
Metribuzin DK	Transformation product	56507-37-0	--	236
Molinate	Herbicide	2212-67-1	0.008	28
Myclobutanil	Fungicide	88671-89-0	0.010	7
N-(3,4-Dichlorophenyl)-N-methylurea (DCPMU)	Transformation product	3567-62-2	--	5
Naled	Insecticide	300-76-5	--	56
Nicosulfuron	Herbicide	111991-09-4	--	12
Norflurazon	Herbicide	27314-13-2	--	3.4
Novaluron	Insecticide	116714-46-6	--	50
O-Ethyl O-methyl S-propyl phosphorothioate	Transformation product	76960-87-7	--	5
Omethoate	Insecticide	1113-02-6	--	2
Orthosulfamuron	Herbicide	213464-77-8	--	6
Oryzalin	Herbicide	19044-88-3	--	12
Oxamyl	Insecticide	23135-22-0	--	2
Oxamyl oxime	Transformation product	30558-43-1	--	5
Oxyfluorfen	Herbicide	42874-03-3	0.010	500
Paraoxon	Insecticide	311-45-5	--	3.4
Paraoxon-methyl	Transformation product	950-35-6	0.014	--
Pendimethalin	Herbicide	40487-42-1	0.012	10
Phorate	Insecticide	298-02-2	0.020	11
Phorate oxon	Transformation product	2600-69-3	0.027	55
Phorate oxon sulfone	Transformation product	2588-06-9	--	20
Phorate oxon sulfoxide	Transformation product	2588-05-8	--	7
Phorate sulfone	Transformation product	2588-04-7	--	36
Phorate sulfoxide	Transformation product	2588-03-6	--	4.6
Phosmet	Insecticide	732-11-6	0.140	--
Phosmet oxon	Transformation product	3735-33-9	0.051	--
Phthalazinone	Transformation product	90004-07-2	--	15

Table 3. Selected pesticides analyzed in water-quality samples from the Cedar River and Cedar Rapids wells, 2017–22.—Continued

[Data are from the U.S. Geological Survey Water Data for the Nation database (U.S. Geological Survey, 2023a); CASRN, Chemical Abstract Service Registry Number; LRL, laboratory reporting level; GC/MS, analytical method gas chromatograph/mass spectrometry (Sandstrom and others, 2001); µg/L, microgram per liter; LC–MS/MS, analytical method liquid chromatography /tandem mass spectrometry (Sandstrom and others, 2015);] ng/L, nanogram per liter; --, not applicable

Compound name	Compound class	CASRN number[1]	LRL	
			GC/MS (µg/L)	LC–MS/MS (ng/L)
Piperonyl butoxide	Transformation product	51-03-6	--	25
Profenofos	Insecticide	41198-08-7	--	3
Prometon	Herbicide	1610-18-0	0.012	4
Prometryn	Herbicide	7287-19-6	0.010	4.2
Pronamide (Propyzamide)	Herbicide	23950-58-5	--	2.4
Propanil	Herbicide	709-98-8	0.010	12
Propargite	Insecticide	2312-35-8	0.020	2
Propazine	Herbicide	139-40-2	--	3.2
Propiconazole	Transformation product	60207-90-1	--	6
Propoxur	Insecticide	114-26-1	--	3.2
Propyzamide	Herbicide	23950-58-5	0.008	--
Prosulfuron	Herbicide	94125-34-5	--	10
Pyraclostrobin	Fungicide	175013-18-0	--	2.4
Pyridaben	Insecticide	96489-71-3	--	2.4
Pyrimidinol (2-Isopropyl-6-methyl-4-pyrimidinol)	Transformation product	2814-20-2	--	8
Pyriproxyfen	Insecticide	95737-68-1	--	3
sec-Acetochlor OA	Transformation product	152019-74-4	--	55
Siduron	Herbicide	1982-49-6	--	5
Simazine	Herbicide	122-34-9	0.006	7.2
Sulfentrazone	Herbicide	122836-35-5	--	18
Sulfometuron-methyl	Transformation product	74222-97-2	--	4
Sulfosulfuron	Herbicide	141776-32-1	--	11
Tebuconazole	Fungicide	107534-96-3	0.020	15
Tebufenozide	Insecticide	112410-23-8	--	2
Tebupirimfos	Insecticide	96182-53-5	--	2
Tebupirimfos oxon	Transformation product	--	--	2
Tebuthiuron	Herbicide	34014-18-1	0.028	3
Tebuthiuron TP 104	Transformation product	59962-53-7	--	5.6
Tebuthiuron TP 108	Transformation product	39222-73-6	--	10
Tebuthiuron TP 109 (OH)	Transformation product	139888-73-6	--	38
Tebuthurion TP 109	Transformation product	59962-54-8	--	11
Tefluthrin	Insecticide	79538-32-2	0.014	--
Terbacil	Herbicide	5902-51-2	--	21
Terbufos	Insecticide	13071-79-9	0.018	6.8
Terbufos oxon	Transformation product	56070-14-5	--	4
Terbufos oxon sulfone	Transformation product	56070-15-6	--	11
Terbufos oxon sulfoxide	Transformation product	56165-57-2	--	4
Terbufos oxygen analog sulfone	Transformation product	56070-15-6	0.045	--
Terbufos sulfone	Transformation product	56070-16-7	--	32

Table 3. Selected pesticides analyzed in water-quality samples from the Cedar River and Cedar Rapids wells, 2017–22.—Continued

[Data are from the U.S. Geological Survey Water Data for the Nation database (U.S. Geological Survey, 2023a); CASRN, Chemical Abstract Service Registry Number; LRL, laboratory reporting level; GC/MS, analytical method gas chromatograph/mass spectrometry (Sandstrom and others, 2001); µg/L, microgram per liter; LC–MS/MS, analytical method liquid chromatography /tandem mass spectrometry (Sandstrom and others, 2015);] ng/L, nanogram per liter; --, not applicable

Compound name	Compound class	CASRN number[1]	LRL	
			GC/MS (µg/L)	LC–MS/MS (ng/L)
Terbufos sulfoxide	Transformation product	10548-10-4	--	3
Terbuthylazine	Herbicide	5915-41-3	0.008	3.6
Tetraconazole	Fungicide	112281-77-3	--	7
Thiobencarb	Herbicide	28249-77-6	0.016	4.2
trans-Permethrin	Insecticide	61949-77-7	--	3.8
trans-Propiconazole	Transformation product	60207-90-1	0.018	--
Triallate	Herbicide	--	--	12
Tribufos	Defoliant	78-48-8	0.018	--
Tribuphos	Defoliant	78-48-8	--	2
Triclopyr	Herbicide	55335-06-3	--	88
Trifloxystrobin	Fungicide	141517-21-7	--	2.8
Trifluralin	Herbicide	1582-09-8	0.018	--

[1]This report contains CAS Registry Numbers, which is a Registered Trademark of the American Chemical Society. CAS recommends the verification of the CASRNs through CAS Client Services.

blank samples of the OBW and IBW were collected by passing water through all pumps, filter holders, and filters to verify the cleanliness of sampling equipment and technique. Field blank sample concentrations of inorganic constituents typically were at or below the LRL. For this dataset, calcium, chloride, dissolved organic carbon, ammonia, nitrite as nitrogen, nitrite, and phosphorus were all detected in field blank samples. Of the 11 detections in field blank samples, eight of them were close to the reporting levels and three were unexplainable. There were no detections of organic constituents in field blank samples.

Replicates are two or more samples collected or processed so that the samples are considered essentially identical in composition. All replicate samples for groundwater and surface-water point samples were collected as sequential samples (that is, they were collected one after the other, utilizing the same techniques and filters, as necessary). All composited surface-water samples were collected as split replicates (that is, they were collected in and processed from the same container but were processed as replicates at the laboratory). For the purposes of this report, the terms “environmental sample” and “replicate sample” are used to identify a particular sample in a replicate pair.

One objective of collecting replicate pairs was to estimate the precision of constituent concentrations determined by sample processing and analysis. Analytical results of organic constituents generally are more variable than those of inorganic constituents. Replicate pairs were compared by using relative percent differences (RPD). The RPD between sample pairs was calculated using the following equation:

$$RPD = \left(\frac{abs(S1 - S2)}{\frac{(S1 + S2)}{2}} \right) \cdot 100 \qquad (1)$$

where

abs is the absolute value;

$S1$ is equal to the concentration in the environmental sample, in micrograms per liter or milligrams per liter; and

$S2$ is equal to the concentration in the replicate sample, in the same units as $S1$.

A large relative percent difference can indicate greater variability between samples. Variability for all constituents in the replicate samples generally was within 10 percent of the environmental samples. As shown in table 4, the maximum RPD for nutrients ranged from 0.00 to 7.14 percent, the maximum RPD for organic carbon and major ions ranged from 0.46 to 49.0 percent, and the maximum RPD for pesticides ranged from 0.46 to 104 percent. It should be noted that when comparing low concentrations between replicate pairs, the RPD can appear relatively large because slight differences (common at the lowest detection levels) can result in higher RPDs. For example, an environmental value of 0.029 milligram per liter (mg/L) for bromide with a replicate value of 0.024 mg/L has an RPD of 9.4 percent, although the absolute difference between the pair was 0.005 mg/L. The median RPD for nutrients ranged from 0.00 to 1.14, the median RPD for organic carbon and major ions ranged from 0.00 to 14.0, and the median RPD for pesticides ranged from 0.00 to 18.3.

Surrogates were added to all environmental and quality-control samples for pesticide analysis before sample preparation in the laboratory. A surrogate has physical and chemical properties similar to those of the analytes of interest but is not normally present in environmental samples. Surrogates provide QC by monitoring matrix effects and gross processing errors (Wershaw and others, 1987) and help control for bias, either positive or negative. Surrogate recoveries of organic chemicals are expressed in percent and typically range from 80 to 120 percent. Three surrogates—carbendazim-d4, 2,4-D-d3, and alachlor-d13—had a combined 14 recoveries of 0. The minimum median recovery for all sites and surrogates was 48.8, and the maximum was 110.5. Surrogate recoveries that consistently are less than 70 percent may indicate that many targeted compounds may be present in greater concentrations than reported. Minimum, maximum, and median surrogate percent recoveries are listed in table 5.

Table 4. Replicate water-quality data for nutrients, major ions, and pesticides in groundwater and surface-water samples, Cedar Rapids, Iowa, 2018–22.

[Data are from the U.S. Geological Survey Water Data for the Nation database (U.S. Geological Survey, 2023a); N, nitrogen; P, phosphorus; SiO2, silicon dioxide; $CaCO_3$, calcium carbonate]

Constituent	Number of replicate samples	Relative percent difference		
		Minimum	Maximum	Median
Nutrients				
Ammonia (as N)	5	0.00	7.14	0.00
Nitrite plus nitrate (as N)	5	0.00	2.02	0.92
Nitrite (as N)	5	0.00	0.00	0.00
Orthophosphate (as P)	5	0.00	4.76	1.14
Carbon and major ions				
Organic carbon	3	2.31	23.5	7.84
Boron	5	0.00	4.44	0.00
Bromide	5	3.39	18.9	9.52
Calcium	5	0.13	2.76	0.57
Chloride	5	0.00	1.83	0.00
Fluoride	5	0.00	5.41	0.00
Iron	5	0.00	49.0	1.79
Magnesium	5	1.42	3.29	2.06
Manganese	5	1.85	11.2	2.40
Potassium	5	0.00	3.20	0.93
Silica (as SiO_2)	5	0.94	3.92	1.83
Sodium	5	0.21	2.35	0.93
Sulfate	5	0.00	0.46	0.41
Total Dissolved Solids	5	0.98	4.07	2.44
Alkalinity (as $CaCO_3$)	5	0.00	1.69	0.84
Bicarbonate	5	0.00	1.39	0.69
Carbonate	5	0.00	28.6	14.0
Pesticides and transformation products				
1H-1,2,4-Triazole	3	0.00	30.4	0.00
2-Chloro-4-isopropylamino-6-amino-*s*-triazine (CIAT)	4	0.00	30.1	13.8
2-Chloro-6-ethylamino-4-amino-*s*-triazine (CEAT)	3	0.00	41.7	2.51
2-Hydroxy-4-isopropylamino-6-amino-*s*-triazine (OIAT)	3	0.00	29.9	0.00
2-Hydroxyatrazine (OIET)	3	2.63	19.6	8.54
Acetochlor	4	0.00	64.3	6.84
Acetochlor ethanesulfonic acid (ESA)	3	5.26	19.1	14.1
Acetochlor oxanilic acid (OA)	3	1.41	10.1	8.60
Atrazine	4	0.00	20.7	8.90
Azoxystrobin	3	3.59	17.2	13.6
Bentazon	3	0.00	14.5	0.00
Dechlorometolachlor	3	0.70	21.4	16.7
Didealkylatrazine (CAAT)	3	1.67	48.9	7.64
Diketonitrile-isoxaflutole	3	0.00	21.7	6.72
Dimethenamid	3	2.43	17.0	2.71
Fipronil amide	3	0.00	104	0.00

Table 4. Replicate water-quality data for nutrients, major ions, and pesticides in groundwater and surface-water samples, Cedar Rapids, Iowa, 2018–22.—Continued

[Data are from the U.S. Geological Survey Water Data for the Nation database (U.S. Geological Survey, 2023a); N, nitrogen; P, phosphorus; SiO2, silicon dioxide; $CaCO_3$, calcium carbonate]

Constituent	Number of replicate samples	Relative percent difference		
		Minimum	Maximum	Median
Pesticides and transformation products—Continued				
Hydroxymetolachlor	3	0.93	25.9	18.3
Imazethapyr	3	7.92	86.6	12.0
Imidacloprid	3	0.00	22.8	0.00
Metalaxyl	4	0.00	0.44	0.00
Metolachlor	4	0.00	7.24	1.88
Metolachlor ethanesulfonic acid (ESA)	3	1.00	3.28	3.18
Metolachlor oxanilic acid (OA)	3	3.96	19.6	9.94
Metribuzin	4	0.00	48.3	0.00
Prometon	4	0.00	52.8	5.40
Propazine	3	0.00	54.1	5.13
Propiconazole	3	0.00	0.78	0.00
Sulfentrazone	3	7.03	20.4	7.81
Sulfometuron-methyl	3	0.00	103	0.00

Table 5. Analytical recovery of selected pesticide surrogates for Cedar River and groundwater samples, Cedar Rapids, Iowa, 2017–22.

[Data are from the U.S. Geological Survey Water Data for the Nation database (U.S. Geological Survey, 2023a); NWWTP, Cedar Rapids Northwest Water Treatment Plant; JAve, Cedar Rapids Water Division (raw composite water); GC/MS, gas chromatograph/mass spectrometry (Sandstrom and others, 2001); Min, minimum; --, not applicable; Max, maximum; Med, median; LC–MS/MS, liquid chromatography/tandem mass spectrometry (Sandstrom and others, 2015)]

Surrogate	Analytical method	Statistic	Cedar River (percent)	Groundwater (percent)										
				Selected wells pumped to NWWTP					Inflow to NWWTP	Selected wells pumped to JAve		Inflow to JAve	Monitoring wells	
				Ranney 1	Ranney 2	Ranney 3	Ranney 6	Seminole 17		Ranney 4	Ranney 5		CRM6A	CRM15
alpha-HCH-d6	GC/MS	Min	92.0	94.3	105	84.8	84.5	91.6	91.7	83.5	--	81.1	--	--
		Max	119	110.0	--	113	91.3	105	106	100	--	107	108	--
		Med	107	103.0	--	96.6	87.5	97.0	100	90.4	--	98.3	--	--
Diazinon-d10	GC/MS	Min	77.8	84.4	117	65.5	78.2	76.9	81.0	64.0	--	68.7	--	--
		Max	130	132	--	118	119	116	123	122	--	129	84.4	--
		Med	107	104	--	91.2	90.6	98.6	94.4	87.4	--	95.5	--	--
Malathion-d10	LC–MS/MS	Min	16.1	97.1	76.9	86.6	52.8	77.8	66.1	82.1	83.9	46.3	--	73.9
		Max	96.8	109	110	123	124	108	101	115	113	123	--	125
		Med	77.0	94.5	92.2	93.3	94.1	98.1	91.4	96.0	92.8	87.8	--	99.2
cis-Permethrin-13C6	LC–MS/MS	Min	34.8	35.0	28.5	30.9	29.6	38.2	21.3	28.7	47.1	30.4	--	24.4
		Max	103	88.5	68.5	103	107	80.9	68.0	112	82.1	114	--	111
		Med	56.3	50.4	49.7	51.6	58.8	56.1	54.9	57.6	54.3	53.8	--	48.8
Carbaryl-d7	LC–MS/MS	Min	24.5	81.1	81.3	89.1	54.6	86.0	81.3	85.4	80.8	56.3	--	85.7
		Max	113	141	103	113	144	134	117	120	144	143	--	133
		Med	85.5	94.3	95.9	103	92.9	101	90.8	98.5	91.0	96.4	--	99.6
Nicosulfuron-d6	LC–MS/MS	Min	55.8	57.0	91.5	45.9	51.1	58.2	48.6	61.2	60.9	50.5	--	50.4
		Max	109	119	115.0	107	131	121	111	126	107	108	--	125
		Med	102	97.3	98.7	97.1	97.8	98.0	96.8	96.6	95.5	99.9	--	95.6
Metolachlor-d6	LC–MS/MS	Min	92.1	91.8	85.5	85.7	83.5	88.2	89.6	97.4	98.8	92.9	--	83.7
		Max	106	124	114	104	116	107	105	116	112	109	--	110
		Med	101	101	104	100	102	103	99.6	101	102	97.9	--	99.5
Diflubenzuron-d4	LC–MS/MS	Min	93.1	83.9	85.2	83.0	79.7	80.4	76.8	79.7	84.3	79.3	--	80.3
		Max	126	128	119	111	146	146	135	136	150	129	--	109
		Med	101	102	104	102	111	104	102	102	101	100	--	97.5

Table 5. Analytical recovery of selected pesticide surrogates for Cedar River and groundwater samples, Cedar Rapids, Iowa, 2017–22.—Continued

[Data are from the U.S. Geological Survey Water Data for the Nation database (U.S. Geological Survey, 2023a); NWWTP, Cedar Rapids Northwest Water Treatment Plant; JAve, Cedar Rapids Water Division (raw composite water); GC/MS, gas chromatograph/mass spectrometry (Sandstrom and others, 2001); Min, minimum; --, not applicable; Max, maximum; Med, median; LC–MS/MS, liquid chromatography/tandem mass spectrometry (Sandstrom and others, 2015)]

Surrogate	Analytical method	Statistic	Cedar River (percent)	Groundwater (percent)										
				Selected wells pumped to NWWTP					Inflow to NWWTP	Selected wells pumped to JAve		Inflow to JAve	Monitoring wells	
				Ranney 1	Ranney 2	Ranney 3	Ranney 6	Seminole 17		Ranney 4	Ranney 5		CRM6A	CRM15
Diuron-d6	LC–MS/MS	Min	94.6	92.8	91.2	91.3	89.1	92.5	89.2	95.4	96.6	94.1	--	93.9
		Max	146	144	113	127	144	149	136	146	152	138	--	122
		Med	102	100	103	102	102	101	98.1	101	101	102	--	103
Acetochlor-d11	LC–MS/MS	Min	88.7	85.5	85.0	86.1	86.3	88.1	86.8	80.6	96.2	89.6	--	75.5
		Max	123	134	121	109	123	116	134	145	111	114	--	123
		Med	98.8	106	97.3	95.8	102	101	96.8	104	104	99.4	--	95.9
Linuron-d6	LC–MS/MS	Min	95.7	96.4	94.4	92.9	91.1	94.5	94.4	94.1	96.4	99.2	--	94.0
		Max	112	123	116	112	114	114	107	114	117	109	--	108
		Med	102	101	104	102	104	102	102	102	105	103	--	103
Carbofuran-d3	LC–MS/MS	Min	75.7	97.0	92.6	96.5	89.8	99.5	92.6	98.2	94.7	98.5	--	94.2
		Max	123	131	112	118	112	124	114	130	142	114	--	112
		Med	98.2	105	106	102	105	105	102	105	105	102	--	103
Alachlor-d13	LC–MS/MS	Min	81.4	89.2	81.8	81.4	90.5	80.9	86.1	88.0	93.3	0.00	--	80.2
		Max	117	121	120	106	122	132	107	119	121	108	--	108
		Med	98.1	104	99.4	95.4	100	101	95.4	98.2	101	95.0	--	97.6
Deethylatrazine-d6	LC–MS/MS	Min	77.0	84.5	83.5	84.3	84.9	79.6	89.4	91.0	87.3	82.9	--	86.5
		Max	116	107	108	109	120	103	107	125	120	110	--	110
		Med	96.4	96.7	97.4	97.8	95.7	99.4	92.8	97.8	100	97.0	--	95.9
Carbendazim-d4	LC–MS/MS	Min	94.9	95.7	101	98.3	95.7	94.1	0.00	99.2	98.3	0.00	--	0.00
		Max	125	139	124	123	139	126	136	126	130	121	--	147
		Med	106	109	109	105	108	108	105	104	106	103	--	105
Dimethachlor SA	LC–MS/MS	Min	67.9	69.6	94.2	63.8	63.1	73.3	70.7	63.5	71.3	60.5	--	77.2
		Max	129	141	149	111	126	123	130	114	133	125	--	125
		Med	103	102	100	104	104	101	99.1	102	101	98.6	--	103

Table 5. Analytical recovery of selected pesticide surrogates for Cedar River and groundwater samples, Cedar Rapids, Iowa, 2017–22.—Continued

[Data are from the U.S. Geological Survey Water Data for the Nation database (U.S. Geological Survey, 2023a); NWWTP, Cedar Rapids Northwest Water Treatment Plant; JAve, Cedar Rapids Water Division (raw composite water); GC/MS, gas chromatograph/mass spectrometry (Sandstrom and others, 2001); Min, minimum; --, not applicable; Max, maximum; Med, median; LC–MS/MS, liquid chromatography/tandem mass spectrometry (Sandstrom and others, 2015)]

Surrogate	Analytical method	Statistic	Cedar River (percent)	Groundwater (percent)										
				Selected wells pumped to NWWTP					Inflow to NWWTP	Selected wells pumped to JAve		Inflow to JAve	Monitoring wells	
				Ranney 1	Ranney 2	Ranney 3	Ranney 6	Seminole 17		Ranney 4	Ranney 5		CRM6A	CRM15
Hexazinone-d6	LC–MS/MS	Min	92.2	98.7	93.6	90.8	89.2	90.8	94.5	95.3	100	89.4	--	93.0
		Max	109	115	116	106	117	116	110	118	126	113	--	111
		Med	101	102	106	101	101	103	98.2	101	105	99.5	--	100
Thiobencarb-d10	LC–MS/MS	Min	89.7	93.0	84.0	91.1	89.9	86.8	90.7	92.4	94.8	91.5	--	89.7
		Max	110	116	111	106	119	117	117	114	125	109	--	106
		Med	102	101	103	98.7	102	98.1	98.0	97.7	102	99.2	--	96.0
Butachlor SA	LC–MS/MS	Min	67.7	68.5	70.7	73.8	71.0	72.6	59.7	67.4	71.1	59.7	--	71.2
		Max	121	128	123	125	118	125	117	112	122	119	--	127
		Med	92.8	100	98.0	98.3	97.4	100	99.1	95.7	100	97.1	--	94.8
3-Phenoxybenzoic acid-13C6	LC–MS/MS	Min	89.2	90.7	93.5	87.6	89.8	87.9	90.0	88.1	91.7	88.1	--	87.8
		Max	121	124	119	106	111	107	113	110	125	124	--	115
		Med	97.7	101	98.2	99.6	98.8	97.1	98.1	96.6	99.2	98.4	--	98.0
2,4-D-d3	LC–MS/MS	Min	0.00	0.00	84.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	--	0.00
		Max	106	113	105	98.1	95.8	96.9	101	101	112	103	--	103
		Med	86.2	90.5	89.6	88.5	87.8	87.2	85.9	89.3	90.6	88.3	--	83.1
Diazinon-d10	LC–MS/MS	Min	90.4	89.9	87.4	89.8	79.9	84.7	90.8	97.2	93.7	96.5	--	88.7
		Max	137	132	119	130	124	121	120	141	137	138	--	142
		Med	99.7	111	104	98.3	105	104	99.6	101	104	103	--	101
Tebuconazole-d6	LC–MS/MS	Min	95.2	63.7	71.3	66.7	67.8	74.8	64.5	62.6	72.7	61.6	--	68.7
		Max	113	118	110	111	124	119	111	123	115	110	--	108
		Med	105	98.7	100	102	104	101	96.6	99.7	100	102	--	99.1

Water-Quality Data for Cedar River and Cedar Rapids Well Fields

The results of the water-quality samples collected from October 2017 through September 2022 are summarized in tables 6–8. Data compiled are from samples collected from the Cedar River, production wells, monitoring wells, and the two water treatment plants with quarterly monitoring. Other water-quality data were obtained from monthly nutrient sampling on the Cedar River and Morgan Creek.

Water-quality data were used to assess the quality of water in the Cedar River alluvial aquifer and the Cedar River. The Cedar River is the major influence on water quality in the Cedar River alluvial aquifer because of induced infiltration from the river because of the pumping of wells (Schulmeyer and Schnoebelen, 1998; Boyd and others, 1999; Turco and Buchmiller, 2004; Kalkhoff, 2021; Haj and others, 2023). Agricultural chemicals (nutrients and pesticides) are of concern because of the predominance of agricultural land use (90 percent and greater) in the Cedar River Basin. An 11.6-mile reach of the Cedar River between the confluence with Bear Creek, which is upstream from the CRPalo streamgage, and the confluence with McLoud Run in Cedar Rapids, is shown on the Iowa Department of Natural Resources 2022 water quality assessments impaired waters map (Iowa Department of Natural Resources, 2025). For this segment of the river, a total maximum daily load limit was established for nitrate by the Iowa Department of Natural Resources (2006).

Physical Characteristics, Nutrients, and Major Ions

Physical characteristics were measured at each sampling site when a water-quality sample was collected. Physical characteristics reported include temperature, pH, dissolved oxygen, specific conductance, turbidity, alkalinity, bicarbonate, and carbonate. Summary statistics for the physical characteristics of sample water from individual sites are listed in table 6.

Nutrient data were compiled for ammonia as nitrogen, nitrite as nitrogen, nitrite plus nitrate as nitrogen, orthophosphate as phosphorus, ammonia plus organic nitrogen as nitrogen, and phosphorus. Dissolved organic carbon data are summarized with the nutrient data. Major ion data were compiled for total dissolved solids, iron, manganese, fluoride, calcium, magnesium, silica, sodium, chloride, sulfate, boron, potassium, and bromide. Major ion data are required for characterization of water chemistry and geochemical modeling. Nutrient and major ion concentration summary statistics for surface water and groundwater are listed in table 7.

Pesticides

Pesticides are used to control unwanted vegetation, insects, and other pests in agricultural and urban areas. Typically, large amounts (thousands of pounds per year) of common herbicides are applied during the growing season in the Cedar River Basin to corn and soybean crops (Schnoebelen and others, 2003). In 2019, the most recent pesticide-use data available indicated glyphosate, acetochlor, atrazine, and metolachlor were the most commonly used herbicides in Iowa (U.S. Geological Survey, 2024). Insecticides are detected less often in water, most likely because they are used in smaller amounts than herbicides, have shorter persistence, and are selectively applied during periods of reduced runoff (Schnoebelen and others, 2003). Pesticide TPs are formed when a parent pesticide compound breaks down or degrades. TPs often have been detected at higher concentrations than their parent compounds (Kolpin and others, 2000, 2004; Schnoebelen and others, 2003). There were 123 TPs analyzed using the gas chromatography/mass spectrometry and LC–MS/MS analytical methods during the 2017 to 2022 time period. The complete list of pesticides and TPs analyzed are included in table 4. Summary statistics for pesticides detected in samples are summarized in table 8.

Table 6. Summary statistics for physical characteristics of surface-water and groundwater samples Cedar Rapids, Iowa, 2017–22.

[Data are from the U.S. Geological Survey Water Data for the Nation database (U.S. Geological Survey, 2023a); NWWTP, Cedar Rapids Northwest Water Treatment Plant; JAve, Cedar Rapids Water Division (raw composite water); °C, degrees Celsius; Min, minimum; --, not applicable; Max, maximum; Med, median; mg/L, milligram per liter; <, less than; µS/cm, microsiemen per centimeter at 25 degrees Celsius; FNU, formazin nephelometric units; $CaCO_3$, calcium carbonate. Shortened names for sites defined in table 1]

Constituent	Statistic	Surface water		Groundwater										
				Selected wells pumped to NWWTP					Inflow to NWWTP	Selected wells pumped to JAve		Inflow to JAve	Monitoring wells	
		Cedar River	Morgan Creek	Ranney 1	Ranney 2	Ranney 5	Ranney 6	Seminole 17		Ranney 3	Ranney 4		CRM6A	CRM15
Temperature (°C)	Min	−0.10	0.00	3.90	3.00	6.90	4.70	6.00	4.30	4.80	3.70	5.40	--	8.70
	Max	27.9	24.4	21.9	22.6	22.8	22.3	17.7	20.9	21.1	22.1	20.2	12.4	13.7
	Med	11.0	9.15	14.5	14.2	14.3	13.8	12.3	13.5	14.1	14.9	13.5	--	10.2
pH (standard units)	Min	7.40	7.50	7.20	7.10	7.20	7.20	7.00	7.50	7.20	7.20	7.00	--	6.80
	Max	8.80	8.70	7.50	7.60	7.60	7.50	7.40	7.90	7.50	7.60	7.50	7.30	7.40
	Med	8.20	8.00	7.30	7.50	7.40	7.40	7.30	7.70	7.40	7.35	7.30	--	6.90
Dissolved Oxygen (mg/L)	Min	5.90	6.80	0.10	0.10	0.20	0.10	0.10	1.30	0.10	0.10	0.10	--	2.70
	Max	16.0	15.3	6.90	7.70	2.80	7.80	2.80	12.2	6.90	7.10	8.10	<0.10	8.20
	Med	12.0	11.5	1.05	1.70	1.25	2.45	0.20	9.60	0.55	1.00	0.30	--	4.60
Specific Conductance (µS/cm)	Min	260	420	497	466	461	454	509	481	435	441	493	--	630
	Max	681	1100	614	644	592	627	592	620	613	641	626	443	752
	Med	516	609	524	516	546	526	537	524	562	521	545	--	718
Turbidity (FNU)	Min	0.80	0.70	<0.10	0.70	0.90	0.20	0.80	0.20	<0.10	0.70	<0.10	--	0.50
	Max	97.0	150	11.0	2.60	2.00	3.70	3.70	6.60	1.70	2.50	11.0	--	12.0
	Med	20.0	3.25	0.90	1.00	1.30	1.00	1.20	1.25	1.00	0.90	1.50	--	2.70
Alkalinity (mg/L as $CaCO_3$)	Min	96.0	99.6	187	164	166	167	188	23.8	181	181	177	--	324
	Max	261	251	264	238	234	263	261	295	264	247	301	238	364
	Med	190	220	214	192	199	207	223	209	218	211	212	--	356
Bicarbonate (mg/L)	Min	117	121	227	199	202	203	228	28.9	220	220	215	--	394
	Max	317	305	322	289	285	320	318	358	321	301	366	289	443
	Med	229	266	260	234	241	251	271	254	265	257	259	--	434
Carbonate (mg/L)	Min	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.10	0.10	0.10	0.10	--	0.10
	Max	8.50	2.40	0.40	0.90	0.40	0.60	0.40	1.20	0.50	0.50	0.50	0.40	0.20
	Med	1.40	0.80	0.20	0.30	0.20	0.30	0.30	0.50	0.25	0.25	0.25	--	0.20

Table 7. Summary statistics for nutrient and major ion concentrations in surface-water and groundwater water samples, Cedar Rapids, Iowa, 2017–22.

[Data are from the U.S. Geological Survey Water Data for the Nation database (U.S. Geological Survey, 2023a); NWWTP, Cedar Rapids Northwest Water Treatment Plant; JAve, Cedar Rapids Water Division (raw composite water); N, nitrogen; mg/L, milligram per liter; Min, minimum; <, less than; --, not applicable µg/L, microgram per liter; Max, maximum; Med, median; E, estimated. Shortened names for sites defined in table 1]

Constituent	Statistic	Surface water		Groundwater										
				Selected wells pumped to NWWTP					Inflow to NWWTP	Selected wells pumped to JAve		Inflow to JAve	Monitoring wells	
		Cedar River	Morgan Creek	Ranney 1	Ranney 2	Ranney 5	Ranney 6	Seminole 17		Ranney 3	Ranney 4		CRM6A	CRM15
Nutrients														
Ammonia, NH_3 + NH_4+ as N (mg/L)	Min	0.01	<0.013	0.01	<0.01	<0.026	0.03	<0.026	0.02	0.04	<0.013	0.04	--	<0.013
	Max	0.42	0.53	0.18	0.11	0.94	0.09	0.61	0.10	2.78	0.80	1.38	0.34	<0.026
	Med	0.06	0.04	0.03	0.08	0.07	0.05	0.08	0.03	0.42	0.13	0.13	--	<0.026
Nitrite as N (mg/L)	Min	0.01	0.01	0.001	< 0.001	<0.001	<0.001	0.001	0.002	0.001	0.003	0.004	--	<0.001
	Max	0.17	0.11	0.01	0.01	0.004	0.04	0.03	0.02	0.01	0.02	0.05	<0.001	0.004
	Med	0.02	0.02	0.003	0.004	0.003	0.004	0.01	0.01	0.003	0.01	0.02	--	<0.001
Nitrite + nitrate as N (mg/L)	Min	0.40	1.15	0.08	0.52	<0.04	0.22	0.68	0.44	0.23	0.27	0.19	--	0.44
	Max	10.3	10.4	7.12	7.34	7.34	6.58	0.37	6.92	5.54	5.69	4.97	<0.04	2.20
	Med	5.02	5.29	3.15	3.87	2.25	3.24	0.20	3.47	1.92	3.09	2.79	--	1.43
Orthophosphate as P (mg/L)	Min	<0.004	0.01	0.07	0.07	0.01	0.01	0.05	0.03	0.05	0.09	0.05	--	0.06
	Max	0.38	0.73	0.13	0.10	0.03	0.07	0.10	0.10	0.12	0.13	0.09	0.01	0.07
	Med	0.11	0.03	0.09	0.08	0.02	0.05	0.07	0.06	0.09	0.10	0.08	--	0.06
Ammonia + organic nitrogen as N (mg/L)	Min	0.28	0.11	0.01	<0.01	<0.02	0.02	<0.02	0.02	0.03	<0.01	0.03	--	<0.01
	Max	2.40	2.60	0.14	0.09	0.73	0.07	0.47	0.08	2.16	0.62	1.07	0.27	<0.02
	Med	0.91	0.29	0.02	0.06	0.05	0.04	0.07	0.02	0.33	0.10	0.12	--	<0.02
Phosphorus (mg/L)	Min	0.08	<0.02	--	--	--	--	--	--	--	--	--	--	--
	Max	0.67	1.18	--	--	--	--	--	--	--	--	--	--	--
	Med	0.19	0.05	--	--	--	--	--	--	--	--	--	--	--
Dissolved organic carbon (mg/L)	Min	1.91	--	1.29	1.34	1.33	1.41	1.47	1.40	1.52	1.40	1.49	--	0.88
	Max	6.54	--	1.88	1.95	1.79	1.92	2.28	1.90	2.11	1.86	1.94	0.45	1.18
	Med	2.55	--	1.53	1.40	1.52	1.59	1.73	1.60	1.67	1.60	1.70	--	1.07
Major ions														
Total dissolved solids (mg/L)	Min	190	349	280	260	272	258	295	274	251	255	286	--	298
	Max	369	595	349	362	340	356	345	355	351	366	364	241	477
	Med	303	376	309	289	305	298	312	302	319	303	310	--	450

Table 7. Summary statistics for nutrient and major ion concentrations in surface-water and groundwater water samples, Cedar Rapids, Iowa, 2017–22.—Continued

[Data are from the U.S. Geological Survey Water Data for the Nation database (U.S. Geological Survey, 2023a); NWWTP, Cedar Rapids Northwest Water Treatment Plant; JAve, Cedar Rapids Water Division (raw composite water); N, nitrogen; mg/L, milligram per liter; Min, minimum; <, less than; --, not applicable µg/L, microgram per liter; Max, maximum; Med, median; E, estimated. Shortened names for sites defined in table 1]

Constituent	Statistic	Surface water		Groundwater										
				Selected wells pumped to NWWTP						Selected wells pumped to JAve			Monitoring wells	
		Cedar River	Morgan Creek	Ranney 1	Ranney 2	Ranney 5	Ranney 6	Seminole 17	Inflow to NWWTP	Ranney 3	Ranney 4	Inflow to JAve	CRM6A	CRM15
Major ions—Continued														
Iron (µg/L)	Min	<5.00	<5.00	<5.00	<5.00	10.1	34.3	<5.00	5.90	<10.0	<5.00	8.80	--	<5.00
	Max	67.3	91.0	<10.0	<10.0	321	598	212	80.7	702	131	200	86.4	64.6
	Med	11.0	9.10	<5.00	<5.00	95.3	312	93.9	27.5	174	77.2	34.9	--	28.7
Manganese (µg/L)	Min	0.60	32.5	7.48	2.38	91.0	39.3	6.39	25.3	42.8	15.1	84.2	--	<0.20
	Max	34.6	92.9	39.7	16.9	810	240	476	100	1450	325	729	11.8	5.21
	Med	3.04	71.4	16.1	7.36	194	137	256	57.9	264	91.0	246	--	0.41
Fluoride (mg/L)	Min	0.17	0.16	0.15	0.16	0.15	0.15	0.16	0.15	0.17	0.15	0.16	--	0.05
	Max	0.22	0.19	0.24	0.23	0.23	0.23	0.21	0.23	0.23	0.25	0.23	0.28	0.07
	Med	0.20	0.18	0.20	0.20	0.22	0.19	0.20	0.20	0.19	0.20	0.20	--	0.07
Calcium (mg/L)	Min	40.7	83.5	65.3	51.3	54.0	53.4	65.3	57.8	60.6	61.1	65.2	--	125
	Max	83.8	97.0	81.7	78.3	80.6	83.7	79.8	82.3	82.3	81.8	80.2	58.2	152
	Med	72.0	89.7	71.8	65.6	68.9	70.9	74.1	71.0	73.0	71.5	71.7	--	143
Magnesium (mg/L)	Min	11.0	19.4	18.7	17.9	17.1	17.2	19.8	18.1	17.2	17.0	20.2	--	10.7
	Max	24.4	21.9	26.7	28.5	24.4	25.3	23.7	25.9	25.3	28.4	26.5	24.0	13.3
	Med	21.9	20.8	20.4	21.6	21.3	20.2	21.2	20.6	22.5	21.0	21.7	--	12.2
Silica (mg/L)	Min	1.49	4.11	10.8	8.43	8.78	8.98	10.2	9.46	11.1	10.8	11.4	--	24.2
	Max	15.8	13.1	81.7	14.7	12.1	13.5	16.0	14.7	19.0	16.0	16.3	14.1	28.4
	Med	11.0	11.0	13.4	9.92	10.9	11.4	12.6	11.7	13.7	13.7	12.6	--	26.6
Sodium (mg/L)	Min	4.23	11.2	7.65	8.41	9.49	7.38	8.44	7.58	8.26	7.21	8.55	--	4.25
	Max	18.2	101	14.6	17.1	15.0	14.9	13.9	15.0	16.3	15.6	25.5	4.23	6.93
	Med	10.8	14.8	10.5	12.5	12.9	11.0	10.4	10.9	13.3	11.6	12.3	--	6.15
Chloride (mg/L)	Min	9.78	34.9	16.4	18.4	22.2	16.7	18.0	16.8	17.9	16.3	18.3	--	3.66
	Max	32.3	198	29.1	21.7	29.5	29.0	28.3	29.5	33.2	31.0	32.0	0.54	13.8
	Med	22.8	40.0	23.3	26.5	26.2	23.5	21.9	23.0	27.5	23.3	25.5	--	11.0

Table 7. Summary statistics for nutrient and major ion concentrations in surface-water and groundwater water samples, Cedar Rapids, Iowa, 2017–22.—Continued

[Data are from the U.S. Geological Survey Water Data for the Nation database (U.S. Geological Survey, 2023a); NWWTP, Cedar Rapids Northwest Water Treatment Plant; JAve, Cedar Rapids Water Division (raw composite water); N, nitrogen; mg/L, milligram per liter; Min, minimum; <, less than; --, not applicable µg/L, microgram per liter; Max, maximum; Med, median; E, estimated. Shortened names for sites defined in table 1]

Constituent	Statistic	Surface water		Groundwater										
				Selected wells pumped to NWWTP					Inflow to NWWTP	Selected wells pumped to JAve		Inflow to JAve	Monitoring wells	
		Cedar River	Morgan Creek	Ranney 1	Ranney 2	Ranney 5	Ranney 6	Seminole 17		Ranney 3	Ranney 4		CRM6A	CRM15
Major ions—Continued														
Sulfate (mg/L)	Min	12.1	26.9	19.2	21.2	24.4	20.9	20.4	20.6	17.0	17.9	21.5	--	22.9
	Max	37.3	47.8	34.9	37.7	37.3	35.6	32.6	35.8	34.6	38.1	36.0	7.15	36.1
	Med	26.9	31.8	26.6	29.4	30.4	28.1	23.7	26.3	25.3	26.0	26.0	--	28.9
Boron (µg/L)	Min	15.0	13.0	14.0	15.0	22.0	18.0	18.0	18.0	19.0	18.0	27.0	--	23.0
	Max	49.0	26.0	36.0	35.0	37.0	35.0	33.0	35.0	40.0	41.0	44.0	42.0	27.0
	Med	28.0	17.0	26.0	28.5	27.0	27.0	26.0	26.5	25.5	30.0	33.5	--	25.0
Potassium (mg/L)	Min	1.64	0.93	1.73	1.87	1.93	1.90	2.18	1.82	1.94	1.71	2.10	--	0.82
	Max	4.52	3.59	3.28	2.75	3.43	2.88	3.13	3.03	3.36	3.29	3.03	1.26	1.22
	Med	2.27	1.17	2.39	2.32	2.27	2.47	2.55	2.52	2.63	2.51	2.51	--	0.93
Bromide (mg/L)	Min	0.01	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	--	<0.01
	Max	0.06	0.05	0.06	0.06	0.05	0.05	0.05	0.05	0.06	0.07	0.06	E0.01	0.02
	Med	0.03	0.04	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.03	--	0.02

Table 8. Summary statistics for detected pesticides in Cedar River and groundwater samples, Cedar Rapids, Iowa, 2017–22.

[Data are from the U.S. Geological Survey Water Data for the Nation database (U.S. Geological Survey, 2023a); NWWTP, Cedar Rapids Northwest Water Treatment Plant; JAve, Cedar Rapids Water Division (raw composite water); Max, maximum detected concentration, in nanograms per liter; --, not applicable; E, estimated; Detect, frequency of detection; refer to table 3 for laboratory reporting levels; pesticides analyzed using liquid chromatography/tandem mass spectrometry (Sandstrom and others, 2015). Shortened names for sites defined in table 1]

Constituent	Statistic	Cedar River	Groundwater										
			Selected wells pumped to NWWTP					Inflow to NWWTP	Selected wells pumped to JAve		Inflow to JAve	Monitoring wells	
			Ranney 1	Ranney 2	Ranney 5	Ranney 6	Seminole 17		Ranney 3	Ranney 4		CRM6A	CRM15
1H-1,2,4-Triazole	Max	--	E27.5	E28.2	E26.4	E28.9	E23.8	--	E14.3	E28.0	E20.2	--	--
	Detect	0/12	2/12	3/9	2/8	3/12	11/12	0/12	1/12	3/12	2/12	--	0/11
2,4-D	Max	572	--	53.4	--	45.7	28.5	--	32.3	62.5	--	--	--
	Detect	5/12	0/12	1/9	0/8	1/12	1/12	0/12	11/12	1/12	0/12	--	0/11
Acetochlor	Max	756	26.1	44.1	E40.4	51.6	25.0	44.5	85.3	66.5	59.6	--	--
	Detect	14/16	6/16	5/10	4/8	9/16	4/16	7/16	6/16	4/16	12/16	0/1	0/11
Acetochlor ESA	Max	E2450	E1780	E1170	E791	E1230	E1620	E1560	E1440	E1580	E1040	--	--
	Detect	7/12	9/12	5/9	5/8	9/12	7/12	9/12	7/12	10/12	6/12	--	0/11
Acetochlor OA	Max	E2660	E1180	E560	E591	E490	E880	E467	E550	E887	E515	--	--
	Detect	12/12	12/12	9/9	8/8	12/12	12/12	12/12	12/12	12/12	12/12	--	0/11
Atrazine	Max	704	611	226	E205	295	E316	216	267	E306	E259	--	--
	Detect	16/16	16/16	10/10	8/8	16/16	16/16	16/16	16/16	16/16	16/16	0/1	0/11
Azoxystrobin	Max	24.8	8.42	10.4	8.44	25.6	6.76	15.5	10.9	9.95	18.9	--	--
	Detect	10/12	8/12	7/9	6/8	8/12	7/12	10/12	7/12	10/12	8/12	--	0/11
Bentazon	Max	E249	16.4	11.6	8.05	E67.3	20.3	E34.2	E42.7	10.1	E32.8	--	--
	Detect	7/12	8/12	5/9	5/8	9/12	11/12	9/12	9/12	8/12	10/12	--	0/11
Bromacil	Max	E4.51	--	--	--	--	--	--	E2.44	--	--	--	--
	Detect	1/12	0/12	0/9	0/8	0/12	0/12	0/12	1/12	0/12	0/12	--	0/11
Didealkylatrazine (CAAT)	Max	277	E336	E228	163	E272	126	178	170	E273	170	--	36.2
	Detect	9/12	9/12	7/9	7/8	8/12	10/12	9/12	9/12	9/12	10/12	--	2/11
Carbaryl	Max	4.11	--	--	--	--	--	--	--	--	--	--	--
	Detect	2/16	0/16	0/10	0/8	0/16	0/16	0/16	0/16	0/16	0/16	0/1	0/11
Carbendazim	Max	E7.38	E7.32	--	--	--	--	--	--	--	--	--	--
	Detect	2/12	2/12	0/9	0/8	0/12	0/12	0/12	0/12	0/12	0/12	--	0/11
2-Chloro-6-ethylamino-4-amino-*s*-triazine (CEAT)	Max	E103	67.3	30.9	E53.6	32.3	43.5	E33.5	E33.0	58.3	E21.4	--	--
	Detect	4/12	5/12	4/9	4/8	6/12	6/12	6/12	4/12	4/12	5/12	--	0/11

Table 8. Summary statistics for detected pesticides in Cedar River and groundwater samples, Cedar Rapids, Iowa, 2017–22.—Continued

[Data are from the U.S. Geological Survey Water Data for the Nation database (U.S. Geological Survey, 2023a); NWWTP, Cedar Rapids Northwest Water Treatment Plant; JAve, Cedar Rapids Water Division (raw composite water); Max, maximum detected concentration, in nanograms per liter; --, not applicable; E, estimated; Detect, frequency of detection; refer to table 3 for laboratory reporting levels; pesticides analyzed using liquid chromatography/tandem mass spectrometry (Sandstrom and others, 2015). Shortened names for sites defined in table 1]

Constituent	Statistic	Cedar River	Groundwater										
			Selected wells pumped to NWWTP					Inflow to NWWTP	Selected wells pumped to JAve		Inflow to JAve	Monitoring wells	
			Ranney 1	Ranney 2	Ranney 5	Ranney 6	Seminole 17		Ranney 3	Ranney 4		CRM6A	CRM15
Chlorimuron-ethyl	Max	--	--	--	2.02	--	--	--	--	--	--	--	--
	Detect	0/10	0/9	0/7	1/5	0/9	0/9	0/9	0/9	0/9	0/9	--	0/8
Chlorpyrifos	Max	2.07	--	--	--	--	--	--	--	--	--	--	--
	Detect	1/16	16/16	0/10	0/8	0/16	0/16	0/16	0/16	0/16	0/16	0/1	0/11
Deethylatrazine (CIAT)	Max	240	132	88.4	113	82.6	86.5	95.1	74.8	112	80.9	--	--
	Detect	16/16	15/16	10/10	7/8	16/16	16/16	16/16	15/16	15/16	15/16	0/1	0/11
cis-Permethrin	Max	--	--	E2.30	--	--	--	--	--	--	--	--	--
	Detect	0/16	0/16	1/10	0/8	0/16	0/16	0/16	0/16	0/16	0/16	0/1	0/11
cis-Propiconazole	Max	E13.0	--	--	--	E2.00	--	E2.00	E2.00	--	E2.00	--	--
	Detect	1/4	0/4	0/1	--	1/4	0/4	2/4	1/4	0/14	2/4	0/1	--
DCPA	Max	2.90	--	--	--	--	--	--	--	--	--	--	--
	Detect	2/4	0/4	0/1	--	0/4	0/4	0/4	0/4	0/4	0/4	0/1	--
Dechlorometolachlor	Max	46.7	51.9	55.9	54.8	42.3	65.2	48.0	84.3	70.0	71.2	--	--
	Detect	10/12	12/12	9/9	8/8	11/12	12/12	12/12	12/12	12/12	12/12	--	0/11
Desulfinylfipronil	Max	--	--	--	--	--	--	--	7.00	--	--	--	--
	Detect	0/16	0/16	0/10	0/8	0/16	0/16	0/16	1/16	0/16	0/16	0/1	0/11
Dicamba	Max	E499	--	--	--	--	--	--	--	--	--	--	--
	Detect	1/12	0/12	0/9	0/8	0/12	0/12	0/12	0/12	0/12	0/12	--	0/11
Dichlorvos	Max	--	--	--	--	--	--	--	--	42.9	--	--	--
	Detect	0/16	0/16	0/10	0/8	0/16	0/16	0/16	0/16	1/16	0/16	0/1	0/11
Diketonitrile-isoxaflutole	Max	119	18.3	9.90	8.30	10.4	13.0	24.6	30.6	14.6	25.0	--	--
	Detect	8/12	6/12	5/9	6/8	7/12	6/12	5/12	8/12	5/12	7/12	--	0/11
Dimethenamid	Max	E313	52.7	213	E73.1	243	48.8	153	249	149	176	--	--
	Detect	12/12	12/12	9/9	8/8	12/12	12/12	12/12	12/12	12/12	12/12	--	0/11
Diuron	Max	5.12	--	--	--	--	--	--	8.15	--	--	--	--
	Detect	1/12	0/12	0/9	0/8	0/12	0/12	0/12	1/12	0/12	0/12	--	0/11

Table 8. Summary statistics for detected pesticides in Cedar River and groundwater samples, Cedar Rapids, Iowa, 2017–22.—Continued

[Data are from the U.S. Geological Survey Water Data for the Nation database (U.S. Geological Survey, 2023a); NWWTP, Cedar Rapids Northwest Water Treatment Plant; JAve, Cedar Rapids Water Division (raw composite water); Max, maximum detected concentration, in nanograms per liter; --, not applicable; E, estimated; Detect, frequency of detection; refer to table 3 for laboratory reporting levels; pesticides analyzed using liquid chromatography/tandem mass spectrometry (Sandstrom and others, 2015). Shortened names for sites defined in table 1]

Constituent	Statistic	Cedar River	Groundwater										
			Selected wells pumped to NWWTP					Inflow to NWWTP	Selected wells pumped to JAve		Inflow to JAve	Monitoring wells	
			Ranney 1	Ranney 2	Ranney 5	Ranney 6	Seminole 17		Ranney 3	Ranney 4		CRM6A	CRM15
Fipronil	Max	2.31	2.25	1.19	--	1.46	1.43	--	1.52	--	0.86	--	--
	Detect	3/16	1/16	2/10	0/8	2/16	1/16	0/16	1/16	0/12	1/16	0/1	0/11
Fipronil amide	Max	2.49	4.72	--	--	--	--	--	3.17	0.86	1.45	--	--
	Detect	1/12	2/12	0/9	0/8	0/12	0/12	0/12	1/12	1/12	1/12	--	0/11
Fipronil sulfide	Max	--	4.00	--	--	--	--	--	--	--	--	--	--
	Detect	0/16	1/16	0/10	0/8	0/16	0/16	0/16	0/16	0/16	0/16	0/1	0/11
Hydroxymetolachlor	Max	41.5	23.9	42.8	31.1	30.3	25.6	29.1	36.7	42.8	33.0	--	--
	Detect	12/12	11/12	8/9	8/8	9/12	12/12	10/12	11/12	11/12	12/12	--	0/11
Hydroxysimazine (EEOT)	Max	--	--	--	--	--	--	--	--	--	E16.2	--	--
	Detect	0/12	0/12	0/9	0/8	0/12	0/12	0/12	0/12	0/12	1/12	--	0/11
Imazethapyr	Max	E121	54.9	24.8	8.66	24.5	29.9	E46.3	E40.6	29.2	E34.3	--	12.0
	Detect	7/12	7/12	4/9	6/8	7/12	11/12	9/12	6/12	5/12	8/12	--	1/11
Imidacloprid	Max	E29.3	8.66	14.2	9.42	12.5	--	13.7	E9.53	5.52	E9.33	--	--
	Detect	4/12	2/12	3/9	1/8	0.167	0/12	5/12	2/12	1/12	1/12	--	0/11
Metalaxyl	Max	E8.30	1.90	E3.89	--	2/12	0.73	E4.52	E4.45	E2.60	E3.35	--	--
	Detect	2/16	1/16	1/10	0/8	1/16	1/16	1/16	1/16	2/16	1/16	0/1	0/11
Methoxyfenozide	Max	4.69	--	0.67	--	--	--	--	--	--	--	--	--
	Detect	2/12	0/12	2/9	0/8	0/12	0/12	0/12	0/12	0/12	0/12	--	0/11
Metolachlor	Max	1350	418	862	448	780	343	594	565	476	487	6.00	--
	Detect	16/16	16/16	10/10	8/8	16/16	16/16	16/16	16/16	16/16	16/16	1/1	0/11
Metolachlor ESA	Max	2490	2480	1640	2680	2650	2240	2310	2380	2660	2520	--	35.4
	Detect	12/12	12/12	9/9	8/8	12/12	12/12	12/12	12/12	12/12	12/12	--	3/11
Metolachlor OA	Max	E753	E755	E577	E739	E613	E828	E592	E749	E975	E717	--	--
	Detect	11/12	11/12	8/9	7/8	12/12	11/12	12/12	10/12	11/12	11/12	--	0/11
Metribuzin	Max	179	14.0	--	--	16.5	10.0	50.4	34.4	22.0	37.3	--	--
	Detect	1/16	2/16	0/10	0/8	5/16	4/16	3/16	3/16	2/16	4/16	0/1	0/11

Table 8. Summary statistics for detected pesticides in Cedar River and groundwater samples, Cedar Rapids, Iowa, 2017–22.—Continued

[Data are from the U.S. Geological Survey Water Data for the Nation database (U.S. Geological Survey, 2023a); NWWTP, Cedar Rapids Northwest Water Treatment Plant; JAve, Cedar Rapids Water Division (raw composite water); Max, maximum detected concentration, in nanograms per liter; --, not applicable; E, estimated; Detect, frequency of detection; refer to table 3 for laboratory reporting levels; pesticides analyzed using liquid chromatography/tandem mass spectrometry (Sandstrom and others, 2015). Shortened names for sites defined in table 1]

Constituent	Statistic	Cedar River	Groundwater										
			Selected wells pumped to NWWTP					Inflow to NWWTP	Selected wells pumped to JAve		Inflow to JAve	Monitoring wells	
			Ranney 1	Ranney 2	Ranney 5	Ranney 6	Seminole 17		Ranney 3	Ranney 4		CRM6A	CRM15
2-Hydroxy-4-isopropylamino-6-amino-*s*-triazine (OIAT)	Max	E13.3	E2.66	--	E2.60	E5.80	--	3.80	--	--	--	--	--
	Detect	6/12	1/12	0/9	1/8	6/12	0/12	3/12	0/12	0/12	0/12	--	0/11
2-Hydroxy-6-ethylamino-4-amino-*s*-triazine (OEAT)	Max	110	E216	E187	E155	E186	E212	E175	E233	E248	E225	--	--
	Detect	10/12	12/12	9/9	8/8	12/12	12/12	12/12	11/12	12/12	10/12	--	0/11
Piperonyl butoxide	Max	--	--	--	--	--	--	--	21.9	--	--	--	--
	Detect	0/12	0/12	0/9	0/8	0/12	0/12	0/12	2/12	0/12	0/12	--	0/11
Prometon (XIIT)	Max	32.0	5.26	8.11	8.01	5.59	5.71	8.51	7.43	8.28	7.34	--	--
	Detect	7/16	10/16	9/10	6/8	11/16	14/16	13/16	15/16	10/16	13/16	0/1	0/11
Propazine (CIIT)	Max	9.70	10.9	5.68	8.39	5.23	4.69	4.80	5.11	6.89	7.73	--	--
	Detect	7/12	4/12	5/9	5/8	3/12	4/12	2/12	2/12	5/12	9/12	--	0/11
Propiconazole	Max	10.8	5.64	6.30	26.4	E5.62	4.13	8.90	4.90	7.31	10.3	--	--
	Detect	5/12	4/12	4/9	3/8	2/12	2/12	4/12	2/12	4/12	5/12	--	0/11
Propoxur	Max	1.77	--	--	--	--	--	--	1.18	--	--	--	--
	Detect	1/12	0/12	0/9	0/8	0/12	0/12	0/12	1/12	0/12	0/12	--	0/11
Pyraclostrobin	Max	16.3	--	--	--	--	--	--	--	--	--	--	--
	Detect	4/16	0/12	0/9	0/8	0/12	0/12	0/12	0/12	0/12	0/12	--	0/11
Simazine	Max	8.56	6.96	0.63	--	E6.00	--	4.81	13.1	7.33	7.07	--	--
	Detect	2/16	1/16	1/10	0/8	1/16	0/16	2/16	5/16	2/16	3/16	0/1	0/11
Sulfentrazone	Max	541	163	69.3	55.9	86.2	125	172	176	109	130	--	--
	Detect	10/12	10/12	7/9	6/8	10/12	11/12	11/12	11/12	11/12	11/12	--	0/11
Sulfometuron-methyl	Max	--	--	--	--	--	1.80	1.61	--	--	1.71	--	--
	Detect	0/12	0/12	0/9	0/8	0/12	2/12	1/12	0/12	0/12	1/12	--	0/11
Tebuconazole	Max	E2.00	2.17	--	--	--	--	--	1.39	--	--	--	--
	Detect	1/16	1/16	0/10	0/8	0/16	0/16	0/16	1/16	0/16	0/16	0/1	0/11

Table 8. Summary statistics for detected pesticides in Cedar River and groundwater samples, Cedar Rapids, Iowa, 2017–22.—Continued

[Data are from the U.S. Geological Survey Water Data for the Nation database (U.S. Geological Survey, 2023a); NWWTP, Cedar Rapids Northwest Water Treatment Plant; JAve, Cedar Rapids Water Division (raw composite water); Max, maximum detected concentration, in nanograms per liter; --, not applicable; E, estimated; Detect, frequency of detection; refer to table 3 for laboratory reporting levels; pesticides analyzed using liquid chromatography/tandem mass spectrometry (Sandstrom and others, 2015). Shortened names for sites defined in table 1]

Constituent	Statistic	Cedar River	Groundwater										
			Selected wells pumped to NWWTP					Inflow to NWWTP	Selected wells pumped to JAve		Inflow to JAve	Monitoring wells	
			Ranney 1	Ranney 2	Ranney 5	Ranney 6	Seminole 17		Ranney 3	Ranney 4		CRM6A	CRM15
Tebuthiuron	Max	--	4.04	0.97	0.45	1.50	--	3.82	2.44	4.08	4.84	--	--
	Detect	0/16	4/16	1/10	1/8	2/16	0/16	1/16	14/16	3/16	4/16	0/1	0/11
Tefluthrin	Max	--	--	--	--	--	--	--	--	E1.00	--	--	--
	Detect	0/4	0/4	0/1	--	0/4	0/4	0/4	0/4	1/4	0/4	0/1	--
Tetraconazole	Max	--	E1.39	--	--	--	--	--	--	--	--	--	--
	Detect	0/12	1/12	0/9	0/8	0/12	0/12	0/12	0/12	0/12	0/12	--	0/11
trans-Permethrin	Max	--	--	--	--	--	--	--	--	--	E1.67	--	--
	Detect	0/12	0/12	0/9	0/8	0/12	0/12	0/12	0/12	0/12	1/12	--	0/11
trans-Propiconazole	Max	E19.0	3.00	--	--	4.00	2.00	4.00	6.00	3.00	E2.00	--	--
	Detect	2/4	1/4	0/1	--	2/4	1/4	2/4	1/4	1/4	1/4	0/1	--
Trifloxystrobin	Max	0.68	--	--	--	--	--	--	--	--	--	--	--
	Detect	1/12	0/12	0/9	0/8	0/12	0/12	0/12	0/12	0/12	0/12	--	0/11

Summary

The Cedar River alluvial aquifer is the primary source of drinking water in Cedar Rapids, Iowa. Production wells are completed in the alluvial aquifer about 40 to 80 feet below land surface. A cooperative effort began in 1992 between the U.S. Geological Survey and the City of Cedar Rapids to study the groundwater-flow system and water quality of the aquifer. Water-quality samples were collected for studies involving well field monitoring, trends, source-water protection, groundwater geochemistry, surface-water–groundwater interaction, and pesticides in groundwater and surface water. Water-quality was analyzed for dissolved major ions (boron, bromide, calcium, chloride, fluoride, iron, magnesium, manganese, potassium, silica, sodium, sulfate, and total dissolved solids), dissolved nutrients (ammonia as nitrogen, ammonia plus organic nitrogen as nitrogen, nitrite plus nitrate as nitrogen, nitrite as nitrogen, orthophosphate as phosphorus, and phosphorus), dissolved organic carbon, and selected pesticides. Physical characteristics (alkalinity, dissolved oxygen, pH, specific conductance, turbidity, and water temperature) were measured onsite and recorded for each water sample collected. This report presents the results of routine water-quality data-collection activities from water years 2017 through 2022. Methods of data collection, quality assurance, water-quality analyses, and statistical procedures are presented. Data include the results of water-quality analyses from quarterly sampling of observation wells, production wells, and two drinking water treatment plants, and monthly nutrient sampling from the Cedar River and Morgan Creek.

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