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U.S. Department of the Interior
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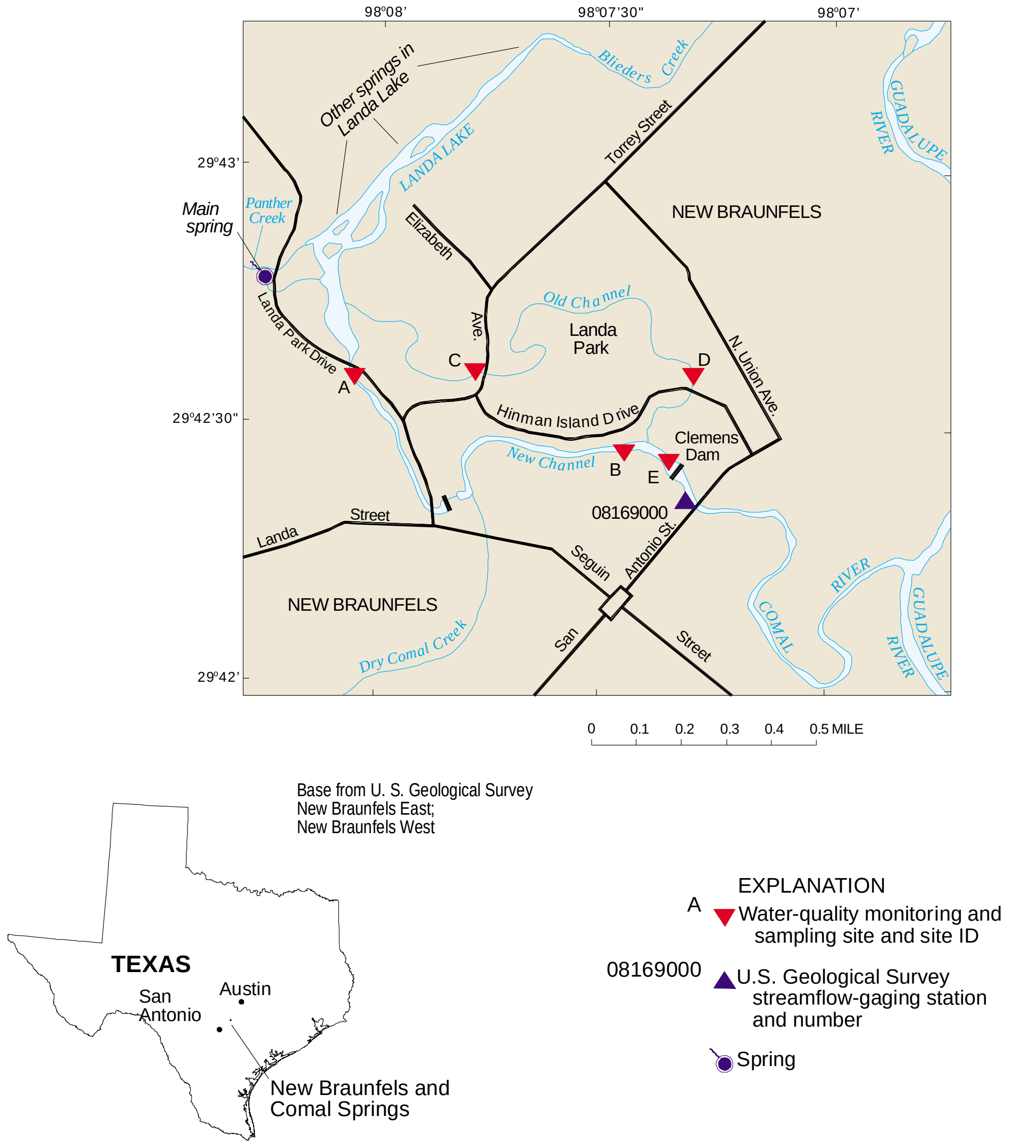
Water-Quality Assessment of the Comal Springs Riverine System, New Braunfels, Texas, 1993–94

Comal Springs of Central Texas are the largest springs in the southwestern United States. The long-term average flow of the Comal River, which essentially is the flow from Comal Springs, is 284 cubic feet per second (ft^3/s). The artesian springs emerge at the base of an escarpment formed by the Comal Springs fault. The Comal River (fig. 1) is approximately 2 miles (mi) long and is a tributary of the Guadalupe River. Most of the Comal River follows the path of an old mill race, here referred to as New Channel, then flows through a channel carved by a tributary stream (Dry Comal Creek), eventually rejoining its original watercourse. The original watercourse, here referred to as Old Channel, has been reduced to a small stream, the source of which is water diverted from Landa Lake and several springs in the channel. In addition to being an important economic resource of the region, the springs and associated river system are home to unique aquatic species such as the endangered fountain darter (*Etheostoma fonticola*). The Comal Springs riffle beetle (*Heterelmis comalensis*), which exists in the springflow channel upstream of Landa Lake, has been proposed for listing as endangered. The Comal Springs dryopid beetle (*Stygoparmus comalensis*) and the Peck's cave amphipod (*Stygobromus pecki*) are two subterranean species associated with Comal Springs also proposed for endangered listing.



Base from U. S. Geological Survey New Braunfels East; New Braunfels West

Figure 1. Comal Springs riverine system, New Braunfels, Texas.

The population in the region has increased 20 to 30 percent per decade for the last 3 decades. This increase in population has correspondingly increased the use of both surface- and groundwater resources in the region, which in turn has prompted concern for habitats of endangered species that depend on the spring water. To better understand the environmental needs of threatened or endangered species, the U.S. Fish and Wildlife Service (USFWS) undertook an intensive ecological assessment of the Comal Springs riverine system. One component of the study involved the effects of varied springflows on water chemistry and aquatic-species habitat in the riverine system. For that study component, the U.S. Geological Survey (USGS) provided continuous monitoring of selected water-quality properties and collected discrete water samples for analysis at selected sites along the Comal Springs riverine system. The purpose of this fact sheet is to summarize the principal results of the USGS water-quality monitoring, sampling, and analyses for selected properties, major ions, nutrients, trace elements, and pesticides during selected periods in the summer and winter of 1993–94. Only high flow (greater than 300 ft^3/s) occurred during the monitoring periods; therefore, effects of lesser flows on water quality were not measured. Data collected from this study and subsequent monitoring can be used to evaluate instream flow habitat requirements of the fountain darter and other aquatic species.

During the monitoring periods, the New Channel received approximately 92 percent of the total volume of springflow by way of Landa Lake. New Channel has a uniform stream channel and higher velocities than Old Channel. In the upper reach of New Channel, west of Landa Park Drive, stream velocities are lowest and the bottom is predominantly large gravel and cobbles. In the lower reach, from Landa Park Drive to Clemens Dam, the velocities are highest and the streambed predominantly is bedrock and large gravel. In contrast, Old Channel received about 8 percent of the total volume of springflow. Old Channel has the meandering characteristics of a natural stream. In the upper reach of Old Channel, from Landa Lake to Elizabeth Avenue, are intermittent riffles and pools and a streambed of silt and assorted gravels. Downstream of Elizabeth Avenue, the stream mostly comprises slow runs and pools with very little riffle habitat; water velocities are minimal and the water appears turbid. The streambed is mostly coarse sediment and mud.

Collection of Water-Quality Data

Site selection and data collection were designed to evaluate physical and chemical properties of the riverine system. Five sites were selected for monitoring the upper and lower reaches of the two stream channels. These sites were evaluated to ensure uniform mixing of water and that monitoring points were representative of the sites. Two sites were selected on New Channel. Site A is at the Landa Lake outfall into New Channel. This site represents the start of the riverine system and a composite of the spring-fed lake waters. Site B is immediately upstream of the confluence of Old and New Channels. This site was selected to monitor changes to water chemistry that might have occurred as water passed through New Channel. Within Old Channel, two sites also were selected. Site C is immediately upstream of Elizabeth Avenue and represents a composite of spring-fed lake water as it enters Old Channel. Site D is on Old Channel upstream of Hinman Island Drive and the confluence of Old and New Channels. Data from site E, downstream of the confluence of the two channels and on the Comal River immediately upstream of Clemens Dam, represent the cumulative effects of Old and New Channels.

The properties of pH, temperature, specific conductance, and dissolved oxygen were monitored continuously during selected periods in the summer and winter of 1993–94. Continuous monitoring of water properties required use of a four-parameter monitoring probe, which was connected to a data storage device and powered by a solar battery. The sites are inaccessible and required use of portable, self-contained floating shelters. To ensure data quality, the instruments were calibrated before and periodically during operation. Monitors measured and logged parameters at 30-minute intervals for periods of 3 to 8 weeks, depending on the site. Property data at the New Channel sites were monitored in the summer from August 20 to September 20, 1993, and in the winter from January 4 to February 3, 1994. Property data at the Old Channel sites were monitored in the summer from June 30 to August 18, 1993, and in the winter from

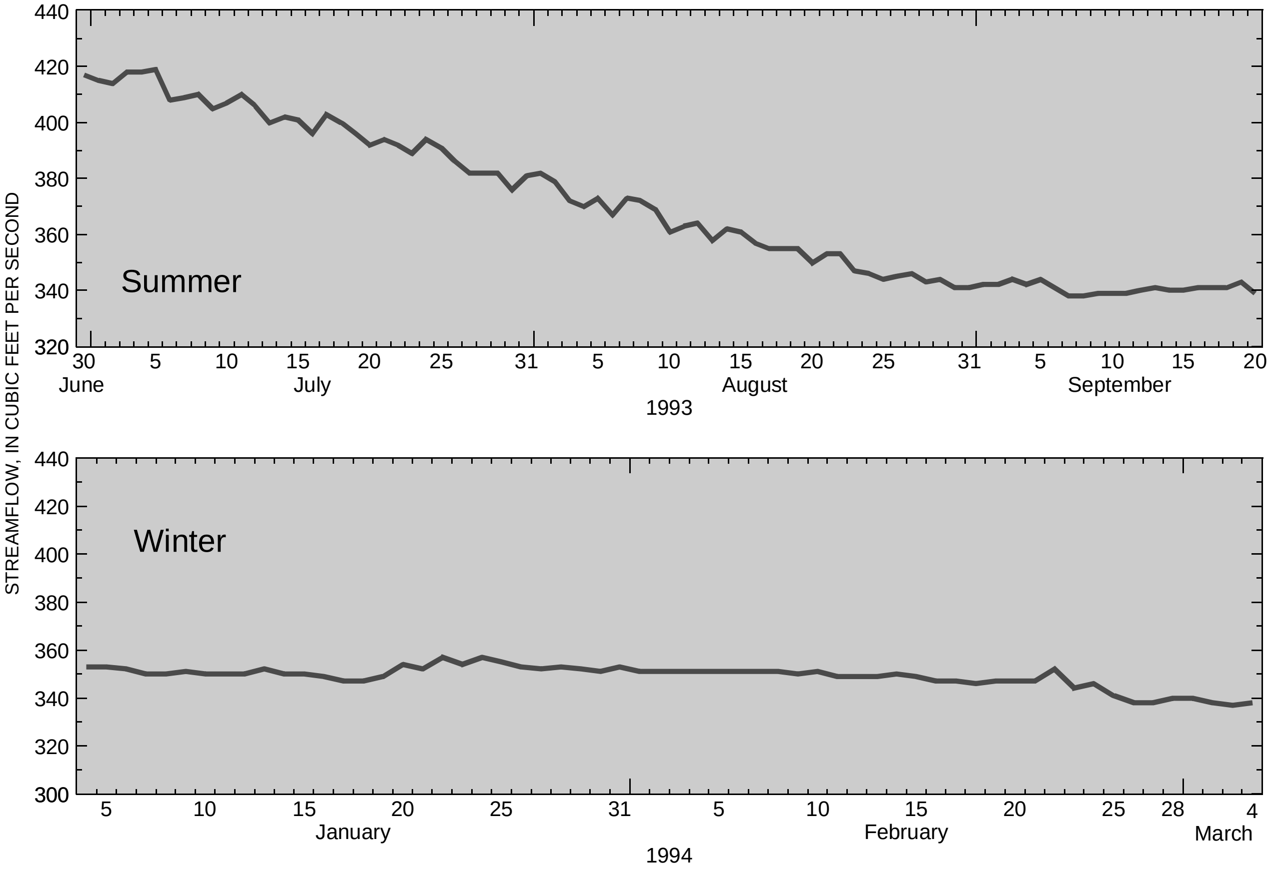


Figure 2. Daily mean streamflow, Comal River at New Braunfels, Texas, during water-quality monitoring periods, 1993–94.

February 7 to March 4, 1994. Property data at the Comal River site were monitored during all four periods. Periodic water-quality samples were collected at each of the five sites. Samples from New Channel and the Comal River were collected near the end of the monitoring periods on September 20, 1993, and February 3, 1994. Samples from Old Channel and the Comal River were collected on August 20, 1993, and March 3, 1994. Samples for major ions, nutrients, and trace elements were collected using a depth-integrated method at multiple intervals along the cross section, then composited. Samples for pesticides were collected using a depth-integrated method at a single interval at the midpoint of the stream.

Table 1. Water properties and major ion concentrations, Comal Springs riverine system, New Braunfels, Texas, 1993–94

[µS/cm, microsiemens per centimeter at 25 °C; °C, degrees Celsius; mg/L, milligrams per liter; $CaCO_3$, calcium carbonate; <, less than; NA, not available; ft^3/s, cubic feet per second]

Constituent	New Channel				Comal River[1]	
	Site A		Site B		Site E	
	Summer (9/20/93)	Winter (2/3/94)	Summer (9/20/93)	Winter (2/3/94)	Summer (9/20/93)	Winter (2/3/94)
Specific conductance (µS/cm)	548	509	547	509	544	514
pH (standard units)	7.6	7.4	7.8	7.3	7.8	7.1
Temperature (°C)	24.0	23.0	24.0	22.5	24.5	22.0
Dissolved oxygen (mg/L)	7.2	8.2	9.0	9.5	9.0	9.4
Calcium, dissolved (mg/L)	83	82	81	82	80	82
Magnesium, dissolved (mg/L)	16	16	16	16	16	16
Sodium, dissolved (mg/L)	9.9	9.7	11	10	10	10
Potassium, dissolved (mg/L)	.70	1.3	.70	1.3	.70	1.3
Alkalinity (mg/L as $CaCO_3$)	230	230	230	230	240	230
Sulfate, dissolved (mg/L)	23	24	24	24	23	24
Chloride, dissolved (mg/L)	15	16	15	16	15	16
Fluoride, dissolved (mg/L)	.20	.20	.20	.20	.20	.20
Silica, dissolved (mg/L)	12	11	12	11	12	11
Dissolved solids, sum of constituents (mg/L)	307	309	308	309	307	310

Constituent	Old Channel				Comal River[1]	
	Site C		Site D		Site E	
	Summer (8/20/93)	Winter (3/3/94)	Summer (8/20/93)	Winter (3/3/94)	Summer (8/20/93)	Winter (3/3/94)
Specific conductance (µS/cm)	552	529	565	523	547	541
pH (standard units)	7.7	6.9	7.5	7.3	7.6	7.3
Temperature (°C)	24.0	21.5	25.5	20.5	26.0	23.0
Dissolved oxygen (mg/L)	8.1	11.4	4.4	11.8	9.2	12.0
Calcium, dissolved (mg/L)	83	82	85	81	84	81
Magnesium, dissolved (mg/L)	16	16	16	16	16	16
Sodium, dissolved (mg/L)	9.6	10	10	11	9.5	11
Potassium, dissolved (mg/L)	1.9	1.3	1.6	1.3	<.10	1.3
Alkalinity (mg/L as $CaCO_3$)	230	240	240	240	230	240
Sulfate, dissolved (mg/L)	25	24	26	24	25	24
Chloride, dissolved (mg/L)	16	15	16	16	16	15
Fluoride, dissolved (mg/L)	.30	.20	.20	.20	.20	.20
Silica, dissolved (mg/L)	12	12	11	10	12	11
Dissolved solids, sum of constituents (mg/L)	309	310	314	310	NA	309

[1] Daily mean flow, 08169000 Comal River at New Braunfels: 350 ft^3/s - 8/20/93, 339 ft^3/s - 9/20/93, 351 ft^3/s - 2/3/94, 337 ft^3/s - 3/3/94.

Streamflow

Continuous streamflow data (fig. 2) were collected from USGS streamflow-gaging station 08169000 Comal River at New Braunfels during the water-quality monitoring periods. Initial daily mean streamflow of the Comal River for the summer monitoring period was 417 ft^3/s on June 30, 1993, and ending streamflow was 339 ft^3/s on Sept. 20, 1993. A peak flow of 419 ft^3/s occurred on July 5, 1993, and a minimum flow of 338 ft^3/s occurred on Sept. 7 and 8, 1993. Initial daily mean streamflow for the winter monitoring period was 353 ft^3/s on January 4, 1994, and ending streamflow was 338 ft^3/s on March 4, 1994. A peak flow of 357 ft^3/s occurred on January 22 and 24, 1994, and a minimum flow of 337 ft^3/s occurred on March 3, 1994.

Water Quality

Water Properties

Boxplots summarize the distributions of continuously monitored water-property data at the five sites (fig. 3). In some instances, the median is the same as the 25th or 75th percentile. Data were edited to correct for instrument drift and to exclude instrument malfunction. The number of data values per property per site ranged from 1,054 to 2,644.

For New Channel and Comal River, summer median specific conductance shows little variability along the reach, ranging from 547 to 551 microsiemens per centimeter at 25 °C (µS/cm). Winter median specific conductance shows more variability than summer, ranging from 525 µS/cm at site A to 551 µS/cm at site E. Summer median pH increases downstream from 7.3 at site A to 7.6 at sites B and E. Similarly during winter, median pH increases from 7.2 to 7.5. Summer median water temperature increases downstream from 23.5 degrees Celsius (°C) at sites A and B to 23.7 °C at site E.

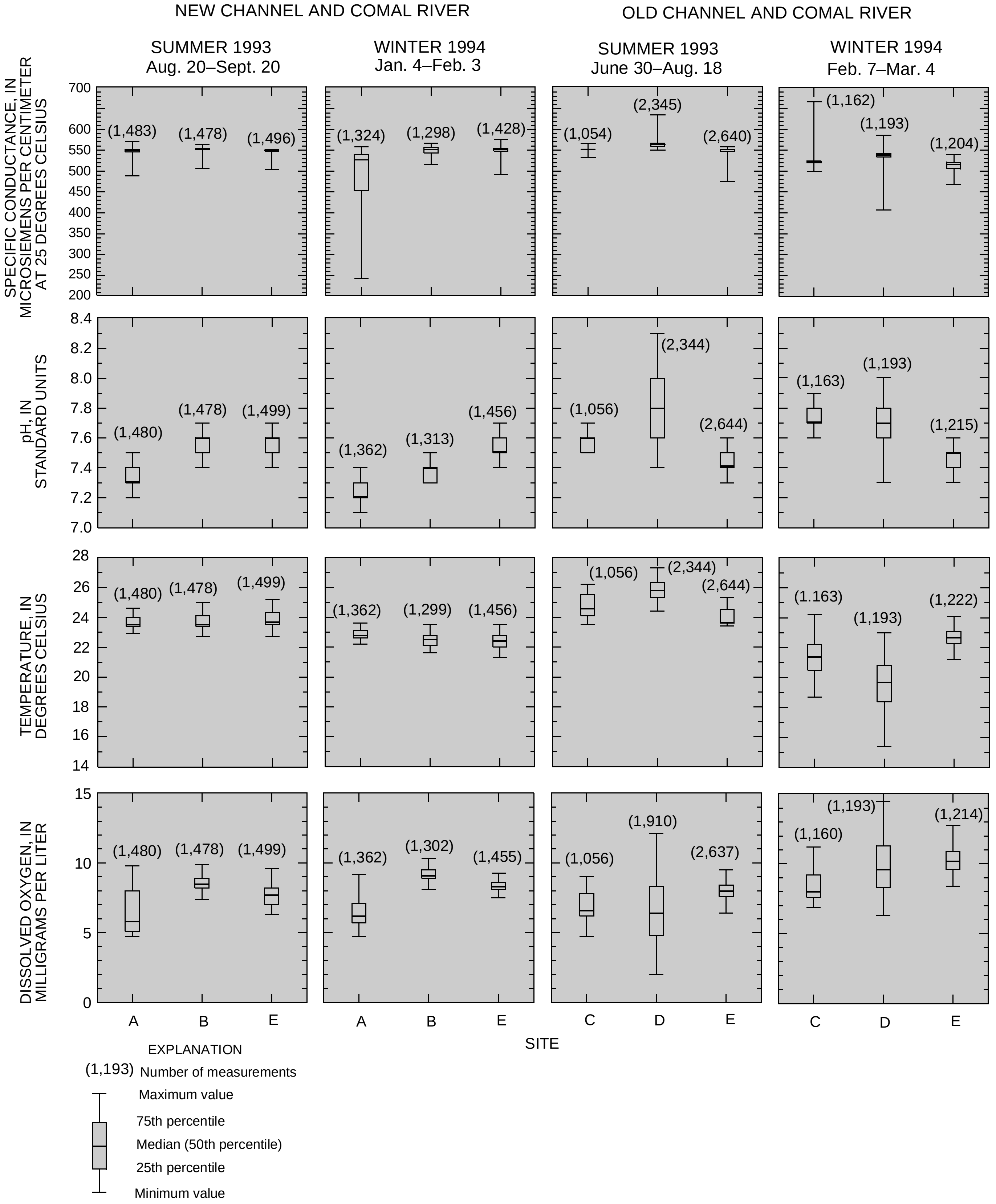


Figure 3. Distributions of specific conductance, pH, temperature, and dissolved oxygen, Comal Springs riverine system, New Braunfels, Texas, 1993–94.

Conversely, winter median water temperature decreases from 22.8 to 22.4 °C. Summer median dissolved oxygen increases downstream from 5.8 milligrams per liter (mg/L) at site A to 8.5 mg/L at site B and subsequently decreases to 7.7 mg/L at site E.

Table 2. Nutrient concentrations, Comal Springs riverine system, New Braunfels, Texas, 1993–94

[mg/L, milligrams per liter; NA, not available; <, less than; ft^3/s, cubic feet per second]

Constituent (mg/L)	New Channel				Comal River[1]	
	Site A		Site B		Site E	
	Summer (9/20/93)	Winter (2/3/94)	Summer (9/20/93)	Winter (2/3/94)	Summer (9/20/93)	Winter (2/3/94)
Nitrogen, nitrate, dissolved	NA	1.87	NA	1.87	NA	2.38
Nitrogen, nitrite, dissolved	<0.010	.030	<0.010	.030	<0.010	.020
Nitrogen, ammonia, dissolved	.030	.020	.030	.030	.030	.050
Nitrogen, organic, dissolved	NA	NA	NA	NA	NA	NA
Phosphorus, dissolved	<.010	<.010	<.010	<.010	<.010	<.010
Phosphorus, ortho, dissolved	NA	NA	NA	NA	.03	NA
Phosphate, ortho, dissolved (as P)	<.010	<.010	<.010	<.010	.010	<.010

Constituent (mg/L)	Old Channel				Comal River[1]	
	Site C		Site D		Site E	
	Summer (8/20/93)	Winter (3/3/94)	Summer (8/20/93)	Winter (3/3/94)	Summer (8/20/93)	Winter (3/3/94)
Nitrogen, nitrate, dissolved	NA	NA	1.39	NA	NA	NA
Nitrogen, nitrite, dissolved	<0.010	<0.010	.010	<0.010	<0.010	<0.010
Nitrogen, ammonia, dissolved	.030	.020	.060	.030	.030	.010
Nitrogen, organic, dissolved	NA	NA	NA	0.27	NA	NA
Phosphorus, dissolved	<.010	.010	<.010	.050	<.010	.010
Phosphorus, ortho, dissolved	.03	NA	.06	NA	.03	NA
Phosphate, ortho, dissolved (as P)	.010	<.010	.020	<.010	.010	<.010

[1] Daily mean flow, 08169000 Comal River at New Braunfels: 350 ft^3/s - 8/20/93, 339 ft^3/s - 9/20/93, 351 ft^3/s - 2/3/94, 337 ft^3/s - 3/3/94.

Similarly, winter median dissolved oxygen increases from 6.2 mg/L at site A to 9.1 mg/L at site B, then decreases to 8.3 mg/L at site E.

For Old Channel and Comal River, summer median specific conductance increases from 550 µS/cm at site C to 562 µS/cm at site D, then decreases to 549 µS/cm at site E. Similarly, winter median specific conductance increases from 523 µS/cm at site C to 540 µS/cm at site D, then decreases to 517 µS/cm at site E. Summer median pH increases downstream from 7.6 at site C to 7.8 at site D, then decreases to 7.4 at site E. Winter median pH is 7.7 at sites C and D and 7.5 at site E. Summer median temperature increases from 24.6 °C at site C to 25.8 °C at site D and subsequently decreases to 23.8 °C at site E. Conversely, winter median temperature decreases from 21.4 °C at site C to 19.7 °C at site D, then increases to 22.7 °C at site E. Summer median dissolved oxygen decreases from 6.6. mg/L at site C to 6.4 mg/L at site D and increases to 8.0 mg/L at site E. Winter median dissolved oxygen increases from 8.0 mg/L at site C to 10.2 mg/L at site E.

In general, specific conductance, pH, temperature, and dissolved oxygen measured at the time of collection of discrete samples (table 1) fall within the range of measurements made by the continuous monitors.

Major Ions

Only slight variability in concentrations of major ions either along reaches or between seasons (along a reach) is observed for the periodic water-quality samples collected during high-flow conditions (table 1). For example, dissolved solids range from 307 to 309 mg/L for New Channel and from 309 to 314 mg/L for Old Channel.

Nutrients

Where measured, concentrations of nutrients and variations in concentrations (table 2) are small. For all sites, nitrate nitrogen concentrations range from 1.39 to 2.38 mg/L, nitrite nitrogen concentrations range from less than 0.010 to 0.030 mg/L, and ammonia concentrations range from 0.010 to 0.060 mg/L. Phosphorus concentrations range from less than 0.010 to 0.050 mg/L, orthophosphorus concentrations range from 0.03 to 0.06 mg/L, and orthophosphate concentrations range from less than 0.010 to 0.020 mg/L.

Trace Elements

Trace elements (table 3) show little variability in concentration either along the reaches or between seasons. Differences in concentrations between sites in the same reach and seasons are small, less than 5 micrograms per liter (µg/L), except for strontium in Old Channel, which decreases by 50 µg/L from site D to site E in both seasons and increases by 50 µg/L from summer to winter at site C. Concentrations of strontium (610 to 690 µg/L) are 1 to 2 orders of magnitude larger than that of other trace elements. Trace elements for which analyses were below detection limits are beryllium (less than 0.5 µg/L), cadmium (less than 1.0 µg/L), chromium (less than 5 µg/L), cobalt (less than 3 µg/L), copper (less than 10 µg/L), mercury (less than 0.1 µg/L), molybdenum (less than 10 µg/L), nickel (less than 10 µg/L), silver (less than 10 µg/L), and vanadium (less than 6 µg/L).

Pesticides

Of 29 pesticides for which samples were analyzed (table 4) only diazinon was detected during the summer at sites D and E, in concentrations of 0.01 and 0.02 µg/L, respectively.

Selected References

Brown, D.S., Petri, B.L., and Nalley, G.M., 1992, Compilation of hydrologic data for the Edwards aquifer, San Antonio area, Texas, 1991, with 1934–91 summary: San Antonio, Edwards Underground Water District Bulletin 51, 169 p.

Table 3. Trace element concentrations, Comal Springs riverine system, New Braunfels, Texas, 1993–94

[Constituents not detected include beryllium, cadmium, chromium, cobalt, copper, mercury, molybdenum, nickel, silver, and vanadium. µg/L, micrograms per liter; <, less than; ft^3/s, cubic feet per second]

Constituent (µg/L)	New Channel				Comal River[1]	
	Site A		Site B		Site E	
	Summer (9/20/93)	Winter (2/3/94)	Summer (9/20/93)	Winter (2/3/94)	Summer (9/20/93)	Winter (2/3/94)
Arsenic, dissolved	<1	<1	<1	<1	<1	<1
Barium, dissolved	51	51	52	51	52	51
Iron, dissolved	<3	<3	<3	<3	3	<3
Lead, dissolved	<10	<10	10	<10	<10	<10
Lithium, dissolved	7	6	8	6	7	7
Manganese, dissolved	<1	<1	<1	<1	<1	<1
Selenium, dissolved	1	<1	1	<1	1	<1
Strontium, dissolved	610	610	620	620	610	620
Zinc, dissolved	3	<3	<3	5	<3	<3

Constituent (µg/L)	Old Channel				Comal River[1]	
	Site C		Site D		Site E	
	Summer (8/20/93)	Winter (3/3/94)	Summer (8/20/93)	Winter (3/3/94)	Summer (8/20/93)	Winter (3/3/94)
Arsenic, dissolved	<1	2	<1	1	<1	1
Barium, dissolved	51	55	53	55	49	51
Iron, dissolved	3	<3	4	<3	<3	<3
Lead, dissolved	<10	10	<10	10	<10	<10
Lithium, dissolved	12	8	13	8	12	8
Manganese, dissolved	2	2	5	4	<1	2
Selenium, dissolved	<1	<1	<1	<1	<1	1
Strontium, dissolved	620	670	650	690	600	640
Zinc, dissolved	6	<3	4	<3	<3	5

[1] Daily mean flow, 08169000 Comal River at New Braunfels: 350 ft^3/s - 8/20/93, 339 ft^3/s - 9/20/93, 351 ft^3/s - 2/3/94, 337 ft^3/s - 3/3/94.

Table 4. Pesticide concentrations, Comal Springs riverine system, New Braunfels, Texas, 1993–94

[µg/L, micrograms per liter; compound in bold was detected]

Pesticide	Detection limit (µg/L)
PCB	0.1
Polychlorinated naphthalenes	.10
Aldrin	.010
Chlordane	.1
DDD	.010
DDE	.010
DDT	.010
Diazinon	.01
Dieldrin	.010
Disyston	.01
Endosulfan	.010
Endrin	.010
Ethion	.01
Heptachlor	.010
Heptachlor epoxide	.010
Lindane	.010
Malathion	.01
Methoxychlor	.01
Methylparathion	.01
Mirex	.01
Parathion	.01
Perthane	.1
Phorate	.01
Silvex	.01
Toxaphene	1
Trithion	.01
2,4-D	.01
2,4-DP	.01
2,4,5-T	.01

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Information on technical reports and hydrologic data related to this and other studies can be obtained from:

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