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Water Quality in the Rio Grande Valley

Colorado, New Mexico, and Texas, 1992–95

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

Circular 1162

A COORDINATED EFFORT

Coordination among agencies and organizations is an integral part of the NAWQA Program. We thank the following agencies and organizations who directly participated in the Rio Grande Valley program.

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•City of Sante Fe
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•Colorado State University
•International Boundary and Water Commission
•Middle Rio Grande Conservancy District
•Natural Resources Conservation Service
•New Mexico Game and Fish Department
•New Mexico State Engineer
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•Rio Grande Water Conservation District
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•Colorado Division of Wildlife
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•Pueblo of Santa Clara
•Texas Natural Resources Conservation Commission
•University of New Mexico
•U.S. Fish and Wildlife Service

Front cover: Rio Grande at Taos Junction Bridge near Taos, New Mexico.
(Photograph by Lisa F. Carter, U.S. Geological Survey)
Back cover: Electro fishing on the Rio Grande near Del Norte, Colorado.
(Photograph by Denis F. Healy, U.S. Geological Survey)
Installing monitoring wells in the Rincon Valley, New Mexico.
(Photograph by Scott K. Anderholm, U.S. Geological Survey)

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Information on the NAWQA Program is also available on the Internet via the World Wide Web. You may connect to the NAWQA home page using the Universal Resources Locator (URL):
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Water Quality in the Rio Grande Valley, Colorado, New Mexico, and Texas, 1992-95

By Gary W. Levings, Denis F. Healy, Steven F. Richey, and Lisa F. Carter

U.S. GEOLOGICAL SURVEY CIRCULAR 1162

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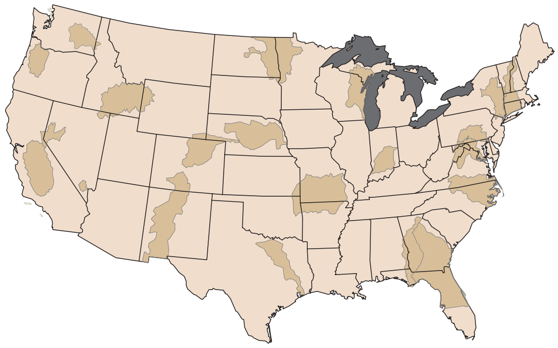
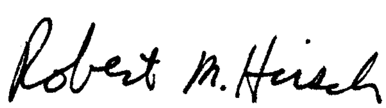


Knowledge of the quality of the Nation's streams and aquifers is important because of the implications to human and aquatic health and because of the significant costs associated with decisions involving land and water management, conservation, and regulation. In 1991, the U.S. Congress appropriated funds for the U.S. Geological Survey (USGS) to begin the National Water-Quality Assessment (NAWQA) Program to help meet the continuing need for sound, scientific information on the areal extent of the water-quality problems, how these problems are changing with time, and an understanding of the effects of human actions and natural factors on water quality conditions.

The NAWQA Program is assessing the water-quality conditions of more than 50 of the Nation's largest river basins and aquifers, known as Study Units. Collectively, these Study Units cover about one-half of the United States and include sources of drinking water used by about 70 percent of the U.S. population. Comprehensive assessments of about one-third of the Study Units are ongoing at a given time. Each Study Unit is scheduled to be revisited every decade to evaluate changes in water-quality conditions. NAWQA assessments rely heavily on existing information collected by the USGS and many other agencies as well as the use of nationally consistent study designs and methods of sampling and analysis. Such consistency simultaneously provides information about the status and trends in water-quality conditions in a particular stream or aquifer and, more importantly, provides the basis to make comparisons among watersheds and improve our understanding of the factors that affect water-quality conditions regionally and nationally.

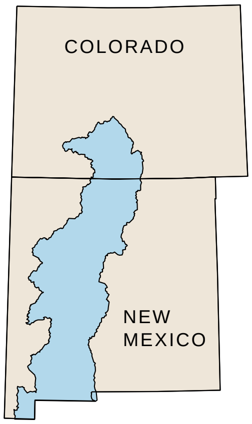
This report is intended to summarize major findings that emerged between 1992 and 1995 from the water-quality assessment of the Rio Grande Valley Study Unit and to relate these findings to water-quality issues of regional and national concern. The information is primarily intended for those who are involved in water-resource management. Indeed, this report addresses many of the concerns raised by regulators, water-utility managers, industry representatives, and other scientists, engineers, public officials, and members of stakeholder groups who provided advice and input to the USGS during this NAWQA Study-Unit investigation. Yet, the information contained here may also interest those who simply wish to know more about the quality of water in the rivers and aquifers in the area where they live.



Robert M. Hirsch, Chief Hydrologist

"In New Mexico, we are particularly pleased with the NAWQA effort on the Rio Grande. We were in great need of reliable, scientific data from which to assess the health of the river system. Now we are able to use these data to improve our management of this vital water resource."

Bobby J. Creel,
Assistant Director,
New Mexico Water Resources Research Institute



Issue: Ground water is the main source of drinking water in the Rio Grande Valley Study Unit; its quality is a major concern.

A variety of chemicals used in human activities, including pesticides, volatile organic compounds (VOCs), and nitrate, were detected in ground-water samples from shallow wells (within the top 10-15 feet of the water table). Samples from deeper ground water underlying the Rio Grande flood plain, which is more typically used as a drinking-water source, contained one pesticide, no VOCs, and nitrates (pages 10, 13, and 14).

- Nitrate concentrations exceeded the U.S. Environmental Protection Agency (EPA) drinking-water standard in 31 percent of shallow wells in the San Luis Valley and 17 percent of shallow wells in the Rincon Valley. Both of these areas are predominantly agricultural land use.
- Pesticides were detected in both agricultural and urban land-use areas, with 29 percent of shallow wells containing at least one pesticide. Prometon and metolachlor were the most frequently detected, yet neither compound exceeded EPA drinking-water standards, although standards do not exist for all pesticides detected Only one pesticide was detected in the deeper ground water.
- Six VOCs were detected in shallow ground water from 11 percent of the wells sampled, most commonly in an urban land-use area. No VOCs were found in deeper ground water. No concentrations exceeded EPA drinking-water standards; however, standards exist for only three of the six compounds detected.
- Radon, a naturally occurring radionuclide in the Rio Grande Valley, was detected in all ground-water samples in concentrations that ranged from 190 to 2,300 picocuries per liter. The highest median concentrations occurred in shallow wells in the San Luis Valley and in the deeper ground water. About 57 percent of the samples exceeded 300 picocuries per liter, the proposed EPA drinking-water standard that has recently been withdrawn for further evaluation.

Issue: Pesticides are present in surface water, bed sediment, and whole-body fish at sites sampled in the Rio Grande and its tributaries and drains.

No pesticide concentration detected in surface water exceeded EPA drinking-water standards or applicable Federal or State ambient criterion or guideline. One or more pesticides were detected at 94 percent of the sites sampled in the Rio Grande, its tributaries, or drains; most concentrations, however, were at or only slightly above the laboratory level of detection (pages 10, 11, and 12).

- In the Mesilla Valley, there were more detections of more different pesticides during the nonirrigation season than during the irrigation season; as many as 27 percent of the pesticide detections attributed to pesticide use in the Mesilla Valley may be from urban sources.
- In the Rincon Valley, more pesticide compounds were detected more frequently in agricultural drains in April than in October or January; some individual pesticides detected in agricultural drains were not detected in shallow ground water.
- Concentrations of DDE were detected in composited samples of fish collected at 10 of 11 sites; these concentrations, however, are below the national median reported by the U.S. Fish and Wildlife Service (FWS) National Contaminant Biomonitoring Program.
- The presence of DDT and its metabolites, DDE and DDD, in bed sediment and whole-body fish confirms the persistence of this pesticide in the environment.
- *Cis*-chlordane, *trans*-chlordane, and *trans*-nonachlor were detected in whole-body fish samples; concentrations, however, were below the national median reported by the FWS National Contaminant Biomonitoring Program.

Issue: Have elevated trace-element concentrations impaired reaches of the Rio Grande and its tributaries and, if so, can the sources be identified?

The water quality in reaches of the Rio Grande and some of its tributaries has been impaired by elevated concentrations of trace elements; however, data indicate that the concentrations tend to decrease downstream from the source. A combination of natural conditions and human activities appears to be associated with elevated trace-element concentrations (page 19).

- Highly elevated concentrations of antimony, arsenic, cadmium, copper, lead, mercury, silver, and zinc were detected in bed sediment from Willow Creek and the Rio Grande, downstream from the Creede, Colorado, Mining District.
- Elevated concentrations of arsenic, cadmium, copper, lead, and zinc were detected in fish tissue (liver) in the Rio Grande downstream from the Creede, Colorado, Mining District.
- Analysis of data collected using transplanted bryophytes (moss) indicates that concentrations of cadmium, copper, lead, and zinc in bryophytes increased at sites on the Rio Grande immediately downstream from tributaries that drain mining districts but decreased with distance from the tributaries. Concentrations of most trace elements in bryophytes were lower in a tributary stream downstream from urban land use than at sites near mining or agricultural land use.
- Dissolved concentrations of beryllium, cadmium, cobalt, lithium, manganese, molybdenum, nickel, and zinc were moderately higher at a site on the lower Red River than in the Rio Grande downstream of its confluence with the Red River.
- Highly elevated concentrations of dissolved cadmium, cobalt, copper, iron, manganese, nickel, strontium, uranium, and vanadium were detected in the Alamosa River where it enters the San Luis Valley.
- Maximum total recoverable concentrations of most trace elements in bed sediment were detected near the mouth of the Rio Puerco, an indication of the importance of sediment in trace-element transport.

Issue: Is the fish community structure in the Rio Grande Valley an indication that sites are environmentally stressed?

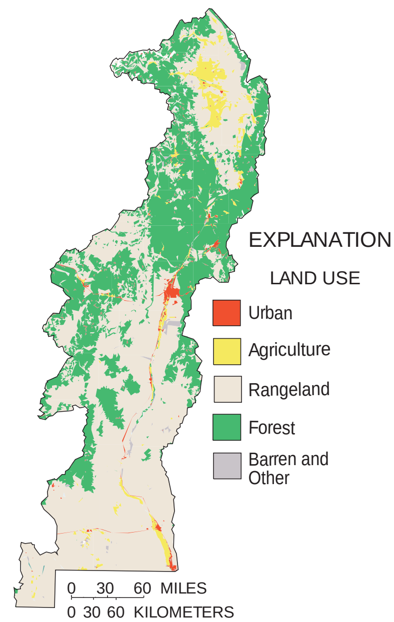
Based on the number of introduced, omnivorous, pollution-tolerant fish and the number of fish with external anomalies, six of the ten sites sampled appear to show some indications of environmental perturbation (page 20).

- Fish community-structure data indicate that introduced species predominate at four of the six sites sampled during 1994. Stocking introduced species has probably resulted in the displacement of native species through competition or predation.
- The number of introduced, omnivorous, pollution-tolerant, and anomalous fish at sites sampled in the Rio Grande indicate that sites are environmentally stressed.

Issue: Is significant habitat degradation occurring in the Rio Grande Valley?

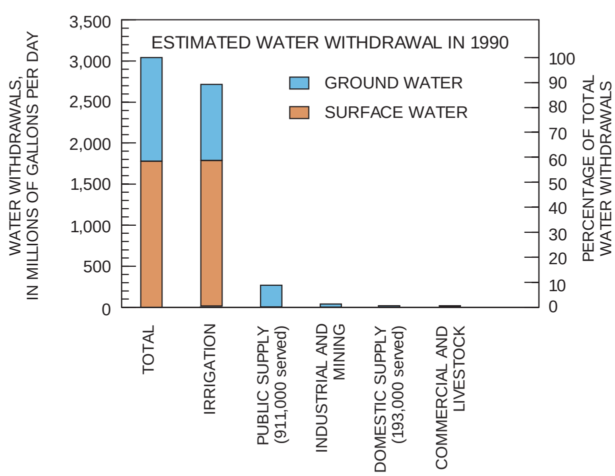
Six of the 10 sites sampled appear to have significant habitat degradation based on stream modification, bank erosion, bank vegetation stability, and riparian vegetation density (page 21).

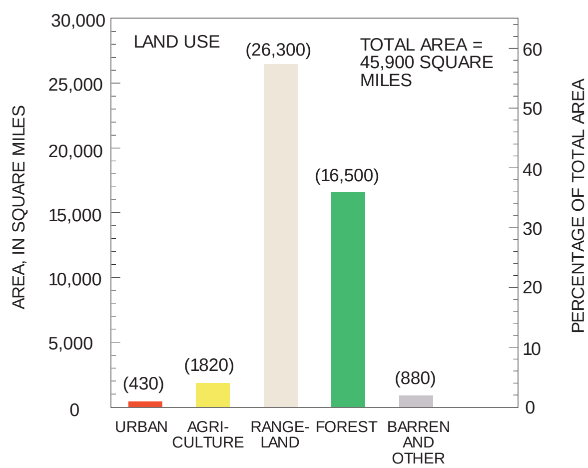
- Rio Grande near Del Norte, Colorado; Conejos River near Lasauses, Colorado; Rio Chama near Chamita, New Mexico; Santa Fe River above Cochiti Lake, New Mexico; Rio Grande at Isleta, New Mexico; and Rio Grande at El Paso, Texas, appear to have significant habitat degradation.



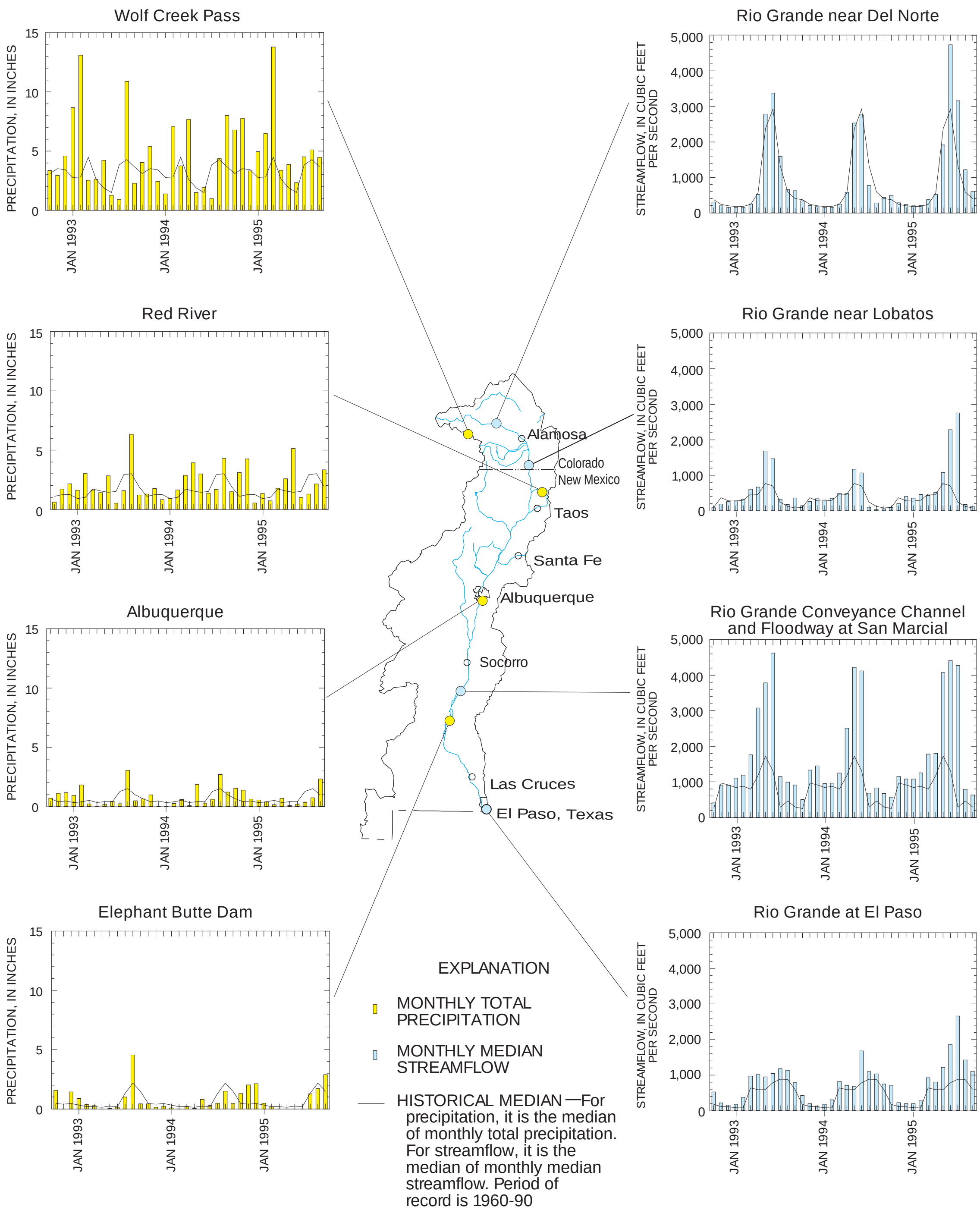
The Rio Grande Valley Study Unit is located in three physiographic provinces. Extreme contrasts in precipitation, runoff, and temperature characteristics exist between the Southern Rocky Mountains and the Basin and Range Provinces. These characteristics strongly affect land and water use in the Study Unit.

Rangeland is dominant in the Basin and Range Province, and forest is dominant in the Southern Rocky Mountains and Colorado Plateaus Provinces. Agricultural land use is limited primarily to areas where surface water or shallow ground water is available for irrigation.





Approximately 5 percent of the land use is agricultural and urban; however, agricultural and urban land uses account for 89 percent and 8 percent, respectively, of the water used in the study area. Almost all public and domestic supplies rely on ground water, primarily from deeper aquifers. Surface-water availability typically is necessary for agriculture with the exception of a few areas where ground water is available in sufficient quantities.



A comparison of precipitation and streamflow at selected sites for the study period 1992-95 with the historical period 1960-90 is shown above. Monthly total precipitation during the study period was generally higher than the monthly median at the two northern sites, whereas precipitation at the two southern sites was near the median. The monthly median streamflow at the two northern sites was generally about the same as the historical median monthly streamflow except during spring runoff when the monthly median during the study period exceeded the historical median streamflow. The streamflow at the two southern sites is controlled primarily by reservoir releases, but did exceed the historical median during the irrigation season. The impact of the above average precipitation and streamflow on the water quality of the Study Unit cannot be generalized, it must be evaluated on a site by site basis. This detailed evaluation is necessary because of the complexity of the interaction of surface water and ground water, irrigation withdrawal and return, and reservoir storage and release.

A discussion of water-quality issues, results, or findings in the Rio Grande Valley Study Unit (fig. 1) necessarily emphasizes the historical importance of surface water in this arid to semiarid environment. Surface water has been the “lifeblood of the Rio Grande Valley.” Records from the sixteenth-century Spanish expeditions into the area report that irrigated agriculture was in use by some of the indigenous peoples. Where surface water and springs existed, people could exist. As European colonization of the area occurred, the introduction of new crops, such as wheat, barley, and oats, required the expansion of irrigation systems. As a result, settlements were established on the flood plains of the streams where agricultural land could be irrigated. Only when technological developments facilitated access to water in deep aquifers did settlements begin to appear throughout the Study Unit.

> The Rio Grande is the only river I ever saw that needed irrigation.
>
> —Will Rogers

For the people living in the Rio Grande Valley, the importance of water—both quantity and quality—is an ongoing issue. Water-resource issues of a local or regional nature appear in the news virtually everyday. As competition for the limited water resource intensifies, major economic decisions, both locally and regionally, will be controlled by the availability of usable quantities of ground and surface water.

The objective of the NAWQA Program is to assess the status of and trends in the Nation’s water quality. In the Rio Grande Valley Study Unit, a series of interrelated but separate study components were conducted during 1992-95 to assess the quality of ground and surface water (fig. 2). The primary focus was along the Rio Grande flood plain. Limited work also was conducted on tributary and nontributary streams in the northern part of the Study Unit. The only exception was an agricultural land-use study component assessing shallow ground water in basin-fill deposits in the San Luis Valley located primarily outside the flood plain. For a discussion of the objectives, a brief description, and the water-quality measures of these study components, see the Study Design and Data Collection section (page 26). Selected results and interpretations based on these study components are discussed in the following sections. Detailed data interpretation for selected study components is reported in individual reports (see References section, page 34).

The following discussion includes interpretation of data collected for analysis of pesticides, nutrients, radon, volatile organic compounds, dissolved solids, and trace elements and results of ecological studies of biological communities and stream habitat. Where applicable, these constituents are compared to EPA maximum contaminant levels (MCLs), secondary maximum contaminant levels (SMCLs), or health advisories (HAs) for public water systems (U.S. Environmental Protection Agency, 1996a). For ambient water, the EPA, National Academy of Sciences, and Environment Canada have established water-quality criteria or guidelines for aquatic organisms. These criteria may be used by State agencies to establish local ambient criteria. The FWS has reported median values for organochlorine compounds and polychlorinated biphenyls as part of their National Biomonitoring Program (Schmitt and others, 1985, 1990; Schmitt and Brumbaugh, 1990).

Not all data collected as part of the NAWQA Program have been compiled in reports. These data have been collected at specific sites throughout the Study Unit and are available in project files. For example, ground-water data were collected at two sites in Albuquerque and at one site in the Mesilla Valley to determine the age of ground water with depth. Biological community surveys conducted at selected surface-water sites include quantitative and qualitative sampling methods for algae and benthic invertebrates; habitat characterization including stream-reach characterization, instream and

Figure 1.—Rio Grande Valley Study Unit.

bank vegetation species, density, and species dominance along transects perpendicular to the stream; and stream meandering, gradient, elevation, and water-management features (dams, bridges, canals, or diversions).

The Study Unit, approximately 45,900 square miles, contains diverse hydrologic and climatological regimes. Altitudes range from peaks exceeding 14,000 feet in the northern part of the Study Unit to approximately 3,700 feet at the lower basin boundary. The climate in the high mountain headwater areas of the Rio Grande and its northern tributaries is alpine tundra where average annual precipitation may exceed 50 inches; most of this precipitation is in the form of snow. Annual runoff in mountainous areas may exceed 30 inches. In contrast, 750 miles downstream near the lower basin boundary of the Study Unit, the Rio Grande flows through a portion of the Chihuahuan Desert where average annual precipitation is less than 8 inches; most of this precipitation is in the form of summer thunderstorms. Annual runoff is less than 0.01 inch. In the mountainous headwater areas, annual potential evaporation is less than 70 percent of annual precipitation, whereas in the southern part of the Study Unit, annual potential evaporation may exceed 1,000 percent of annual precipitation.

The existence of a reliable source of surface water in the southern part of the Study Unit is the result of human alteration of the river system by the construction of reservoirs to control runoff. The storage of runoff in the springtime allows for a dependable source of water to support irrigation needs throughout the long growing season. This alteration of the river system has affected the water quality of the Rio Grande.

Within the Study Unit, two groundwater land-use studies and one aquifer subunit survey focused on the flood plain of the Rio Grande from Cochiti Lake in New Mexico, to El Paso,

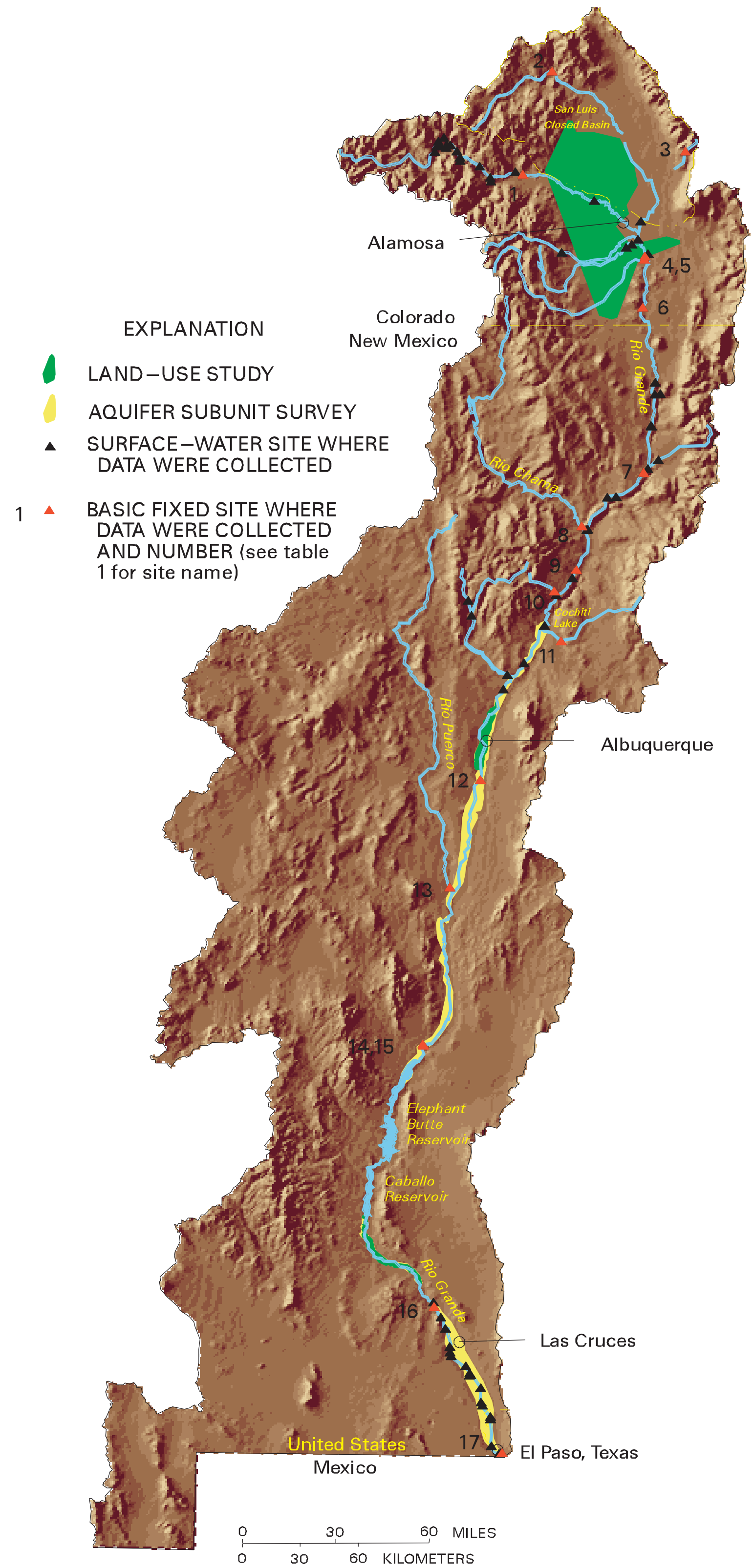


Figure 2.—Land-use studies, aquifer subunit survey, and surface-water sites.

Table 1.—Rio Grande Valley Study Unit Basic Fixed Sites

[Main-stem sites shown in blue]

Site number	Station name
1	Rio Grande near Del Norte, Colo.
2	Saguache Creek near Saguache, Colo.
3	Medano Creek near Mosca, Colo.
4	Rio Grande above mouth of Trinchera Creek, near Lasauses, Colo.
5	Conejos River near Lasauses, Colo.
6	Rio Grande near Lobatos, Colo.
7	Rio Grande below Taos Junction Bridge, near Taos, N. Mex.
8	Rio Chama near Chamita, N. Mex.
9	Rio Grande at Otowi Bridge near San Ildefonso, N. Mex.
10	Rito de los Frijoles in Bandelier National Monument, N. Mex.
11	Santa Fe River above Cochiti Lake, N. Mex.
12	Rio Grande at Isleta, N. Mex.
13	Rio Puerco near Bernardo, N. Mex.
14	Rio Grande Conveyance Channel at San Marcial, N. Mex.
15	Rio Grande Floodway at San Marcial, N. Mex.
16	Rio Grande below Leasburg Dam near Leasburg, N. Mex.
17	Rio Grande at El Paso, Tex.

Texas. One land-use study was conducted in the basin-fill deposits in the San Luis Valley in Colorado. Only when the hydrologic system along the Rio Grande is understood can the complexity of the many influences that affect water quality throughout the Study Unit be appreciated. A detailed discussion of the ground-water system in the Study Unit is presented in Ellis and others (1993). The following is a brief description of the ground-water system to aid in understanding the following water-quality discussions.

Complex interactions occur between ground water and surface water in the Rio Grande flood plain. A system of canals distributes surface water for agricultural irrigation and a system of drains intercepts shallow ground water and returns it to the Rio Grande. Surface water leaks from the Rio Grande and canals to recharge the shallow ground-water system. In places, deeper ground water flows upward to recharge the shallow ground-water system and/or to contribute flow to the Rio Grande. In addition, excess applied irrigation water infiltrates and recharges the shallow ground-water system. Evapotranspiration losses from vegetation, land, and water surfaces, can have a major effect on the quality of ground water.

Rio Grande Reservoir, in the headwaters of the Rio Grande, is used to store runoff for irrigation at surface-water diversions in the San Luis Valley (photograph by Sherman R. Ellis, U.S. Geological Survey).

Two land-use studies, in the Albuquerque area and in the Rincon Valley, focused on the upper 10-15 feet of ground water in the flood-plain alluvium (referred to as shallow ground water in this report). This water generally is not used for domestic supply. However, because of the interaction with surface water and, in isolated areas, because declines in the water level in the deeper aquifer have caused the shallow aquifer to be a recharge source in some areas, knowing the quality of the shallow ground water is important in making management decisions.

The aquifer subunit survey, from Cochiti Lake to El Paso, focused on deeper water underlying the flood-plain (referred to as deeper ground water in this report). This water is used for domestic supply in some areas.

The land-use study in the San Luis Valley was not entirely in the Rio Grande flood plain. Most of the area is in the San Luis Closed Basin, which is both a ground-water and surface-water closed basin. Neither ground water nor surface water flows out of the Closed Basin. The shallow ground water is in unconsolidated basin-fill deposits. The water in these basin-fill deposits is used extensively for irrigation and, on a limited basis, for domestic supply. However, these wells generally tap several tens of feet of the aquifer. The study wells were completed in the upper 10-15 feet of the saturated basin-fill deposits.

Historically, streamflow in the Rio Grande was caused by spring snowmelt (April through June) and summer monsoon thunderstorms (July and August). This natural streamflow pattern has been altered and regulated by the construction of reservoirs on the main stem and tributaries that impound and store water for later use, primarily irrigation.

All surface water in the Rio Grande is appropriated by various compacts, treaties, and individual water rights. Appropriated surface-water rights on the Rio Grande in Colorado and New Mexico usually exceed the annual mean flow of the river (Ellis and others, 1993).

As the discussion of the water-quality data is presented, it is important to realize that 89 percent of water use in the Study Unit in 1990 was for irrigation, 8 percent for public supply, and 3 percent for all other uses. The effect that irrigation and urban use has on the quality of surface water is related to the processes to which the water is subjected as it moves downstream. It is repeatedly diverted, applied to fields, returned to the Rio Grande directly or through drains, impounded in reservoirs, lost to evapotranspiration, or consumptively used. Urban areas contribute wastewater and anthropogenic organic chemicals such as volatile organic compounds and pesticides; agricultural areas contribute chemicals from fertilizers and pesticides; mining areas contribute trace elements; atmospheric deposition contributes chemicals such as nitrate and phosphorus; and the use and reuse of water increases dissolved-solids concentrations because of evapotranspiration. All of these processes can contribute to deterioration in surface-water quality of the Rio Grande as it moves through the basin.

Typical ephemeral tributary channel to the Rio Grande in the lower part of the Study Unit. Runoff occurs in response to precipitation (photograph by Sherman R. Ellis, U.S. Geological Survey).

San Acacia Diversion Dam on the Rio Grande about 55 miles downstream from Albuquerque is one of several diversion dams established on the Rio Grande for surface-water irrigation (photograph by Sherman R. Ellis, U.S. Geological Survey).

Synthetic organic compounds have been detected in ground and surface water, sediment, and biota of the aquifers, rivers, and lakes throughout the United States. These organic compounds enter the hydrologic system in point-source discharges, nonpoint-source runoff, atmospheric deposition, and ground-water discharges.

Why are Pesticides of Interest?

Pesticides are used to control many different types of weeds, insects, and other pests in a wide variety of agricultural and urban settings. Concerns have grown steadily about the potential adverse effects of pesticides on the environment and human health through contamination of the hydrologic system. Water is one of the primary means by which pesticides are transported from their application areas to other parts of the environment. Through physical processes such as erosion, surface runoff, and ground-water recharge, trace amounts of pesticides used on lawns, gardens, road rights-of-way, and crops can eventually end up in the ground-water system and in streams. Although many modern pesticides are designed to degrade rapidly, the short distance between the land surface and shallow water table makes shallow wells more susceptible to contamination than deeper wells.

Organochlorine pesticides are synthetic hydrophobic organic chemicals that pose a threat to the environment because of their persistence (their use has been banned in the U.S. since the early 1970's) and toxicity to most organisms. They tend to adsorb to organic carbon in suspended or bed sediments rather than dissolve in the water column. Because of this characteristic, these compounds can be present in sediments in concentrations that are much larger than those in the water column. Sediments can provide a mechanism by which organochlorine pesticides remain in a surface-water system many years after their initial introduction and are available for downstream transport and bioaccumulation in aquatic organisms.

Pesticides in Ground Water

During 1993-95, 65 wells that tap shallow ground water were sampled in two agricultural land-use studies (table 2). Eighteen wells had detectable pesticides, with 6 different pesticides detected a total of 23 times. Of the 24 wells that represent urban land use overlying shallow ground water, 8 wells had detectable pesticides, with 5 different pesticides detected a total of nine times. The aquifer subunit survey, which sampled water from existing wells that are completed in the deeper aquifer, yielded only 1 pesticide detection for 30 wells. The pesticides detected most often were prometon (12) and metolachlor (10) (table 2). No concentrations of pesticides exceeded any EPA MCL or HA.

The small number of different pesticides detected and the small concentrations of those pesticides indicate little leaching of pesticides from land surface to shallow ground water in these land-use areas. The detection of only one pesticide in the samples from the aquifer subunit survey suggests that shallow ground water containing pesticides has not moved into deeper parts of the aquifer.

Pesticides in Surface Water

During 1994-95, 156 water samples were collected at 40 stream and drain sites to study the occurrence and seasonal variability of pesticides. The samples were collected as part of four separate study components (table 3). Collectively, 322 detections of 23 pesticides occurred in 125 of the 156 samples. The most commonly detected pesticides were DCPA (65 samples), metolachlor (53), prometon (37), and simazine (36). The pesticides detected

Table 2.—Pesticide detections in ground water

[µg/L, micrograms per liter; MCL, U.S. Environmental Protection Agency maximum contaminant level; HA, U.S. Environmental Protection Agency lifetime health advisory; E, estimated;[1] --, no MCL or HA established]

Pesticide	Number of detections	Detection concentration (µg/L)	MCL (µg/L)	HA (µg/L)
San Luis Valley agricultural land-use study (35 samples)				
Metribuzin	3	E0.005 - 0.017	--	100
Metolachlor	1	0.072	--	70
p,p'-DDE	1	E0.002	--	--
Prometon	1	0.01	--	100
Albuquerque urban land-use study (24 samples)				
Prometon	5	E0.005 - 0.27	--	100
Atrazine	1	0.016	3	3
Bromacil	1	0.52	--	90
Carbaryl	1	E0.021	--	700
Carbofuran	1	E0.010	40	40
Rincon Valley agricultural land-use study (30 samples)				
Metolachlor	9	E0.005 - 5.4	--	70
Prometon	5	E0.005 - 0.32	--	100
Diazinon	1	0.077	--	--
Napropamide	1	0.014	--	--
p,p'-DDE	1	E0.002	--	--
Aquifer subunit survey (30 samples)				
Prometon	1	0.038	--	100

[1]Pesticide identified but concentration was not determined at a 99-percent confidence level.

Ground-water sampling at one of the monitoring wells in the San Luis Valley (photograph by Sherman R. Ellis, U.S. Geological Survey).

at the largest number of sites were DCPA (25 sites), metolachlor (23), prometon (14), and carbofuran (14). The maximum pesticide concentration detected was an estimated 0.75 microgram per liter carbofuran. The presence of pesticides in surface water is erratic and probably highly dependent on the amount applied and the timing, location, and method of application.

On the basis of data collected, pesticide concentrations are usually small and do not presently appear to be a major concern in the surface waters of the Rio Grande Valley. Table 4 lists the eight pesticides with the largest concentrations; all but one site is located in the Rincon or Mesilla Valley. Of these pesticides, only carbofuran has an established EPA MCL and it was not exceeded. No pesticide concentration exceeded EPA MCLs, HAs, or any applicable Federal or State ambient criteria or exposure guidelines. The relatively frequent detection of pesticides at low levels, however, indicates ongoing exposure that merits careful monitoring. Water-quality standards have not been set for many pesticides and existing standards do not consider cumulative effects of several pesticides in the water at the same time.

The pesticide synoptic study conducted in the Mesilla Valley enabled pesticide concentrations during the irrigation and the nonirrigation seasons to be compared. There were more detections of different pesticides during the nonirrigation season than during the irrigation season. The synoptic study also allowed comparison between urban contributions (samples from wastewater-treatment plant effluent) and agricultural contributions (drains). About one- fourth of the pesticide detections in the Mesilla Valley may be from urban sources.

During the temporal study of drains in the Rincon Valley, pesticides were detected more frequently in drains in April than in October or January. Also, some pesticides were detected in drains but not in shallow ground water. This may mean that pesticides are entering drains as a result of surface runoff from fields or that the timing of ground-water sampling in the area (April-May) was not representative of ground-water quality throughout the year.

Pesticides in Bed Sediment and Whole-Body Fish Tissue

As part of the pesticide sampling in the Mesilla and Rincon Valleys, bed sediment also was sampled near the mouths of nine drains. Samples of bed sediment from all nine drains contained detectable concentrations of DDT, DDD, and DDE.

Bed sediment was sampled at 18 sites between September 1992 and March 1993 to characterize the geographic distribution of organochlorine pesticides and polychlorinated biphenyls (PCBs). Six of the bed-sediment samples had detectable concentrations of at least one DDT-related compound. No other organochlorine pesticides were reported in bed sediment.

As part of the whole-body fish-tissue contaminant study, fish were collected at 11 of the 18 bed-sediment sites and analyzed for organochlorine pesticides and PCBs. Concentrations of DDE were detected in composited samples of fish collected at 10 of the 11 sites; these concentrations, however, were below the median reported

Table 3.—Surface-water pesticide study components

Study-Unit component	Number of sites	Number of samples	Number of detections
Mesilla Valley pesticide synoptic study	19	51	100
Rincon Valley temporal drain study	11	37	93
Basic Fixed Site study	9	45	120
Intensive Fixed Site study	1	23	9

Table 4.—Eight largest pesticide concentrations detected in surface water

[µg/L, micrograms per liter; MCL, U.S. Environmental Protection Agency maximum contaminant level; E, estimated;[1] --, no MCL; WWTP, wastewater-treatment plant]

Pesticide	Concentration (µg/L)	Date	Location	MCL (µg/L)
Carbofuran	E0.75	04/27/94	East Side Drain at levee road near Anthony, Tex.	40
Metolachlor	0.41	01/04/95	Hatch Drain at Rio Grande, near Hatch, N. Mex.	--
DCPA	0.21	10/26/94	Rincon Drain at Rio Grande, near Rincon, N. Mex.	--
Diazinon	0.21	09/06/95	Santa Fe River above Cochiti Lake, N. Mex.	--
Chlorpyrifos	0.19	04/26/94	Las Cruces WWTP outflow at levee road, Las Cruces, N. Mex.	--
DCPA	0.17	04/22/94	Rincon Drain at Rio Grande, near Rincon, N. Mex.	--
Diazinon	0.16	04/28/94	Sunland Park WWTP at Sunland Park, N. Mex.	--
Carbofuran	E0.15	04/20/94	Garfield Drain at Road 391, near Salem, N. Mex.	40

[1]Pesticide identified, but concentration was not determined at a 99-percent confidence level.

by the FWS National Contaminant Biomonitoring Program. C*is*-chlordane, *trans*-chlordane, and *trans*-nonachlor were other compounds detected in whole-body samples of fish from at least one site; these concentrations also were below the median reported by the FWS National Contaminant Biomonitoring Program.

Comparison of pesticide data for bed sediment and whole-body fish tissue indicates (1) organochlorine pesticides were reported more frequently in fish samples and (2) more types of pesticides were detected in fish samples. The presence of DDT and its metabolites, DDD and DDE, in bed sediment and whole-body fish confirms the persistence of this pesticide in the environment.

Pesticides in Elephant Butte Reservoir Sediment Core

In July 1995, a site in Elephant Butte Reservoir was cored and analyzed for DDT metabolites (Van Metre and others, 1997). The core was age-dated by correlating sample depth with the radioactive isotope cesium-137. Total DDT concentrations in the core reached a maximum of about 10.5 µg/kg in sediments deposited in the late 1960s, then decreased exponentially, indicating the gradual removal of residual total DDT from the watershed. The largest concentration detected in the core does not exceed sediment-quality guidelines published for aquatic life (Environment Canada, 1995, and Environmental Protection Agency, 1996b).

A site in Elephant Butte Reservoir, one of four major reservoirs on the main stem of the Rio Grande, was cored for analysis of selected pesticides (photograph by Sherman R. Ellis, U.S. Geological Survey).

Volatile Organic Compounds in Ground Water

Volatile organic compounds (VOCs) are carbon-containing chemicals that readily evaporate at normal air temperature and pressure. They are contained in many commercial products such as gasoline, paints, adhesives, solvents, wood preservatives, dry-cleaning agents, pesticides, fertilizers, cosmetics, and refrigerants. Some VOCs are suspected carcinogens and are toxic to humans or wildlife.

Improper disposal of VOCs can result in the leaching or infiltration of these compounds to the shallow ground-water system. VOCs can also be removed from ground water by adsorption onto clays or organic materials, or they can be broken down by bacteria and other microbes in soils. The detection of VOCs in ground water indicates compounds generally associated with human activities leaching into ground water.

Table 5.—Volatile organic compounds detected in shallow ground water

[µg/L, micrograms per liter; MCL, U.S. Environmental Protection Agency maximum contaminant level; HA, U.S. Environmental Protection Agency lifetime health advisory; --, no MCL or HA]

Volatile organic compound	Number of detections	Detection concentration (µg/L)	MCL (µg/L)	HA (µg/L)
San Luis Valley agricultural land-use study (35 samples)				
Methyl *tert*-butyl ether	1	0.6	--	20 - 200
Albuquerque urban land-use study (24 samples)				
Methyl *tert*-butyl ether	1	7.9	--	20 - 200
Trichloroethene	1	1.1	5.0	--
1,1-Dichloroethane	2	0.2 - 0.5	--	--
p-Isopropyltoluene	1	0.4	--	--
cis-1,2-Dichloroethene	2	0.3	70	--
Rincon Valley agricultural land-use study (20 samples)				
Xylene	3	0.3 - 2.8	10,000	10,000

Samples were collected from 79 shallow wells and 30 deeper wells for analysis of 60 VOCs. No concentrations exceeded an EPA MCL or HA (table 5).

Water from 9 of the 79 wells sampled had detectable concentrations of one or more VOCs. In the Albuquerque urban land-use study, five different VOCs, two of which were found in more than one sample, were detected in water from 5 of the 24 shallow wells (table 5). Four of the VOCs detected are solvents or metal degreasers. The other is methyl *tert*-butyl ether (MTBE), a gasoline additive that was detected at a concentration of 7.9 µg/L, which was the largest VOC concentration measured in the Study Unit. In the Rincon Valley agricultural land-use study, only one VOC, xylene, was detected in 3 of 20 samples. In the San Luis Valley agricultural land-use study, MTBE was detected in one well.

Although few VOCs were detected and the concentrations were relatively small, their presence in shallow ground water means that shallow ground-water quality has been adversely affected by human activities. VOCs were detected more frequently in the Albuquerque urban land-use study than in the agricultural land-use studies, perhaps because urban areas have more sources of VOCs.

The wells sampled in the aquifer subunit survey had no VOC detections. This may mean that VOCs have not moved into deeper parts of the aquifer.

Semivolatile Organic Compounds in Bed Sediment

Semivolatile organic compounds are a large group of environmentally important organic compounds. Three groups of compounds, polycyclic aromatic hydrocarbons (PAHs), phenols, and phthalate esters, were included in the analysis of bed sediment collected at 17 sites in the Study Unit. These compounds are abundant in the environment, are toxic and often carcinogenic to organisms, and could represent a long-term source of contamination.

The analysis of the PAH data show one or more PAH compounds were detected at 14 sites. Four of these sites had about 60 percent of the detections; three sites had no detections. Two of the four sites are downstream from urban land-use areas, one is downstream from a mining area, and one is in a forested area.

Phenol compounds were detected at 13 sites with 50 percent of the detections at 5 sites. Two sites had no detections. No relation to land use was apparent for the phenol compound detections.

Four phthalate ester compounds were detected at 10 sites. Only one site, downstream from an urban land-use area, had detections of more than one phthalate ester.

Nutrients include nitrogen and phosphorus compounds that are necessary components for the growth of plants and animals. However, in excessive concentrations, nutrients are a water-quality concern in drinking water and are a major contributor to eutrophication in rivers, lakes, and reservoirs. Large nutrient concentrations can contribute to excessive growth of algae and other aquatic plants that can cause destruction of habitat and depletion of dissolved oxygen, which usually results in the disappearance of intolerant aquatic insect species and fish. Major sources of nutrients are fertilizers, sewage effluent, precipitation, and dissolution of naturally occurring minerals (Mueller and Helsel, 1996, p. 10). Fertilizers, which include commercial fertilizers and animal manure, are applied in urban and agricultural areas. Sewage effluent includes municipal WWTP discharge to streams and wastewater from septic tanks or cesspools. An estimate of nutrient loads to the entire Study Unit indicated that loading from fertilizers and WWTP effluent is considerably larger than loading from precipitation (Anderholm and others, 1995, p. 127). As a result of human activities in the Rio Grande Valley Study Unit, nutrient concentrations in both ground water and surface water have exceeded established Federal and State standards.

The EPA has established an MCL for nitrate in drinking water of 10 milligrams per liter (mg/L) as nitrogen. The EPA recommends that total (not dissolved) phosphorus concentrations should be less than 0.1 mg/L in rivers and less than 0.05 mg/L where rivers enter lakes and reservoirs because concentrations greater than this could contribute to eutrophication. The States of Colorado, New Mexico, and Texas have also established individual aquatic-life criteria for selected nutrients that apply to specific river reaches within the Study Unit.

Nutrients in Ground Water

In the San Luis Valley agricultural land-use study, water from 11 of the 35 wells sampled contained nitrate concentrations greater than the EPA MCL; the largest concentration was 58 mg/L (table 6). In the Rincon Valley agricultural land-use study, water from 5 of the 30 wells sampled exceeded the EPA MCL; the largest concentration was 33 mg/L. These elevated nitrate concentrations are indicative of leaching of fertilizers into shallow ground water. However, the spatial variation in nitrate concentrations indicates that leaching of fertilizer is not uniform throughout these areas. The spatial variation may be the result of variable fertilizer application rates, timing of fertilizer application, timing of application of irrigation water, and recharge rates controlled by soil type, texture, permeability, precipitation, and biological/geochemical processes in the unsaturated zone.

In the Albuquerque urban land-use study, the largest nitrate concentration was 2.8 mg/L, which is considerably below the EPA MCL. Although infiltration of septic tank effluent results in considerable loading of nutrients to the shallow aquifer in this area, the small nitrate concentrations suggest that nitrogen compounds in the effluent are not being converted to nitrate. This is probably due to the lack of dissolved oxygen and the relatively large dissolved organic carbon concentrations in shallow ground water in the area. Large ammonia concentrations, which would be expected, are not present in shallow ground water because ammonia is adsorbed on clays in the aquifer or soil zone.

Nitrate concentrations in water from deep wells sampled during the aquifer subunit survey ranged from less than 0.05 to 1.9 mg/L. Throughout most of the area of the aquifer subunit survey, the small nitrate concentrations in water from deeper parts of the basin-fill aquifers probably indicate that shallow ground-water recharge into the deeper parts of the aquifer is limited.

Nutrients in Surface Water

Dissolved Nutrients

Dissolved nutrient concentrations are shown in Table 7. The largest concentrations of dissolved nutrients in surface water were detected at sites downstream from urban land use. Generally, a WWTP was associated with the urban area and was located upstream from the sampling site. In general, dissolved nutrient concentrations were larger at Basic Fixed Sites downstream from Cochiti Lake. This is probably the result of the increase in urban land use along the Rio Grande and the associated WWTPs.

Dissolved nutrient concentrations in agricultural drains in the Mesilla and Rincon Valleys were small. These concentrations could be small because of

Table 6.—Nitrate detected in ground water

[mg/L, milligrams per liter; <, less than]

Ground-water study component	Number of samples	Range in concentration (mg/L)	Median (mg/L)
San Luis Valley agricultural land-use study	35	<0.05 - 58	2.7
Albuquerque urban land-use study	24	<0.05 - 2.8	<0.05
Rincon Valley agricultural land-use study	30	<0.05 - 33	0.48
Aquifer subunit survey	30	<0.05 - 1.9	<0.05

Table 7—Nutrients detected in surface water

[mg/L, milligrams per lite; <, less than]

Nutrient	Number of analyses	Range in concentration, (mg/L)	Median (mg/L)
Nitrite, dissolved	584	<0.01 - 1.2	<0.01
Nitrite plus nitrate, dissolved	582	<0.05 - 15	0.11
Ammonia, dissolved	584	<0.015 - 27	0.02
Ammonia plus organic nitrogen, dissolved	566	<0.2 - 29	0.2
Ammonia plus organic nitrogen, total	556	<0.2 - 57	0.3
Phosphorus, dissolved	579	<0.01 - 3.9	0.03
Phosphorus, total	555	<0.01 - 45	0.08
Orthophosphate, dissolved	577	<0.01 - 3.4	0.03

biological uptake of nutrients and no widespread excessive nitrate concentrations in ground water that is discharging to drains. Comparison of data for the Mesilla Valley synoptic study shows that the inflow of nutrient loads to the Rio Grande from urban sources (WWTPs) may equal or exceed the inflow from agricultural sources (drains).

Of 455 samples at sites where aquatic-life criteria apply, un-ionized ammonia concentrations exceeded the applicable criterion only twice. No other dissolved nutrient concentration in surface water exceeded any applicable Federal or State criterion or standard.

The EPA has recommended total phosphorus concentrations for streams not discharging to a lake and for streams near where they discharge to a lake. These recommendations are not criteria or standards. Out of 526 samples from these sites, 250 equaled or exceeded the recommended concentrations.

Total Nutrients

Total nutrient concentration in surface water is affected significantly by suspended-sediment concentration because nutrients adsorb to suspended sediment and are transported by water. The largest concentrations of total nutrients were detected at the Basic Fixed Site on the Rio Puerco (fig. 2) and were associated with runoff from summer thunderstorms, which historically have transported large loads of suspended sediment.

Approximately 35 percent of the samples from the Basic Fixed Sites have total phosphorus and total nitrogen concentrations in the eutrophic or highly eutrophic range of most trophic classification systems. Among the environmental effects of eutrophication are large diurnal dissolved-oxygen (DO) fluctuations. In addition, the decay of large amounts of dead vegetation puts a demand upon available DO concentrations. During this study, DO concentrations less than the EPA recommended minimum ambient criterion of 5 mg/L for the health of an aquatic ecosystem were detected less than 7 percent of the time at sites in Colorado.

Nutrients in Reservoirs

The effect that reservoirs can have on water quality is evident when dissolved and total nutrient concentrations are compared at sites upstream and downstream from reservoirs. Although not directly addressed during this study, historical data for sites on the Rio Grande show nutrient concentrations in water decreasing significantly while stored in reservoirs (Anderholm and others, 1995). The decrease downstream from reservoirs is attributed to biological uptake of nutrients and suspended sediment settling out of the water column.

Wastewater-treatment plants affect nutrient concentrations in the Rio Grande (photograph by Sherman R. Ellis, U.S. Geological Survey).

Radon in Ground Water

Radon, which can cause lung cancer, is a radioactive, odorless, and chemically inert gas that occurs naturally in the air, soil, and ground water. Radon is a decay product of radium, which in turn is a decay product of uranium. Rocks break down mechanically and chemically to form sediments that contain differing amounts of uranium, depending on the source rocks. The higher the uranium concentration is in the source rocks, the greater the chances are for radon in the air, soil, or ground water. Other potential sources of uranium in the environment are improper disposal of uranium mining waste and nuclear fuel processing, combustion of wood and fossil fuels, or roasting of rocks in metal extraction or cement industries.

Radon in ground water affects radon concentrations in indoor air in homes because it escapes to the indoor air as people use water. Open water-distribution systems allow ground water to aerate and radon to escape. In small, closed water-distribution systems with short transit times, radon cannot escape from the system; therefore, it escapes into the indoor air. Research suggests that ingestion of water with high radon concentrations also may pose risks, although these risks are believed to be much lower than those from inhalation of radon.

Until late 1996, the EPA had proposed an MCL of 300 pCi/L for radon in drinking water. However, this proposed MCL was withdrawn by EPA for further evaluation; thus, no proposed MCL currently exists. Radon concentrations measured during this study were larger than the previously proposed MCL in 57 percent of the wells.

Radon concentrations were equal to or greater than 512 pCi/L in water from all shallow wells sampled in the San Luis Valley land-use study (table 8). Although the range in concentration is not as large in the Albuquerque land-use study, values for seven samples were greater than 300 pCi/L. In the Rincon Valley land-use study, only three samples exceeded 300 pCi/L. The largest range in concentration was from the aquifer subunit survey (table 8), which also had the largest radon concentration measured, 2,300 pCi/L. More than one-half the wells sampled from the deeper aquifer have water with a radon concentration greater than 300 pCi/L.

On the basis of these reported concentrations, it is apparent that radon in both shallow and deeper ground water is a potential human health concern. The likely source for the elevated concentrations of dissolved radon in ground water is from naturally occurring minerals that contain uranium in the sediments that compose the aquifer. There is no direct evidence that land use has affected radon concentrations in shallow ground water in the Study Unit.

Table 8.—Radon detected in ground water

[pCi/L, picocuries per liter]

Ground-water study component	Number of detections	Range in concentration (pCi/L)	Median (pCi/L)
San Luis Valley agricultural land-use study (29 samples)	29	512 - 1,798	1,190
Albuquerque urban land-use study (22 samples)	22	198 - 397	280
Rincon Valley agricultural land-use study (18 samples)	18	210 - 440	260
Aquifer subunit survey (29 samples)	29	190 - 2,300	380

Dissolved Solids in Surface Water

A knowledge of the dissolved-solids concentration in irrigation water can be useful to water users in determining application rates for different soil and crop types and drainage requirements. Dissolved-solids concentration is a measure of the dissolved constituents in water and is commonly used as a general indicator of salinity or water quality. Although dissolved-solids concentration has an important effect on the use of irrigation water, there is no Federal or State standard.

Evaporation, transpiration, and dissolution of minerals are the three major processes that result in an increase of dissolved-solids concentration. All of these processes are major contributors to the increases in dissolved solids measured in the Study Unit.

In general, the dissolved-solids concentration in surface water increases with the length of time that the water has been in the hydrologic system. This is illustrated by data from the Basic-Fixed-Site network. The smaller dissolved-solids concentrations are in the northern part of the study area and generally represent runoff derived from snowmelt or water that has been subjected to limited irrigation use (fig. 3 and table 9). The median dissolved-solids concentration for main-stem sites increases downstream from site 1 to site 17, with the exception of site 4 (sites are highlighted in blue in table 9). The cause of the anomalously high median concentration at site 4 is unknown. Possible causes are ground-water recharge to the Rio Grande, introduction of ground water pumped from the sump area of the Closed Basin, or discharge from the Alamosa WWTP. The downstream increase in

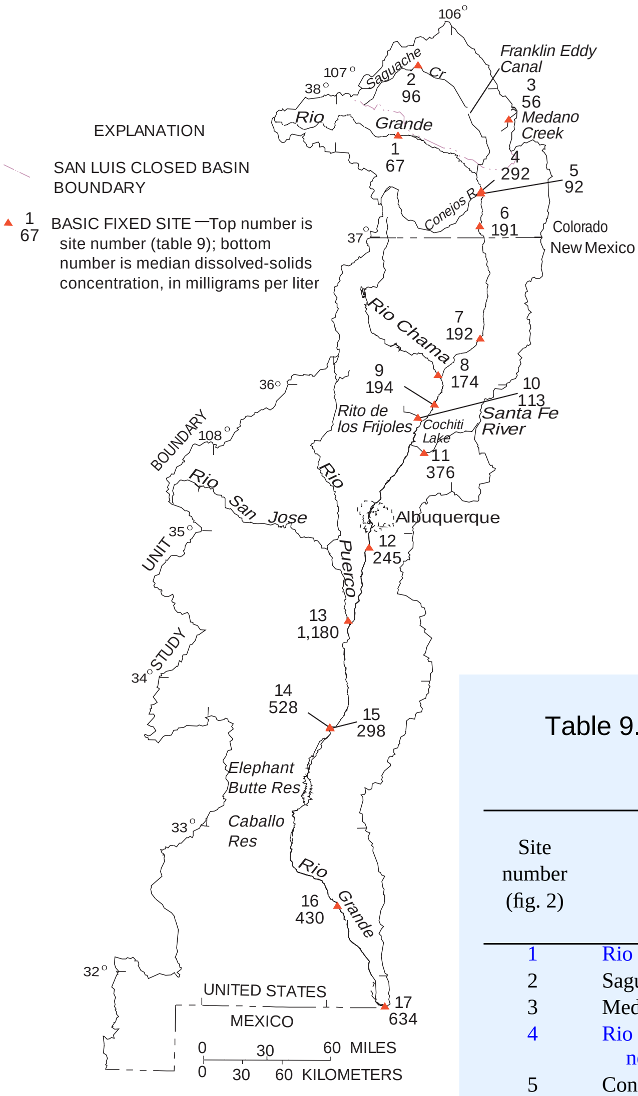


Figure 3.—Median dissolved-solids concentrations at Basic Fixed Sites.

dissolved-solids concentration at the Basic Fixed Sites illustrates the effect that evaporation, transpiration, and dissolution of minerals can have on water as it moves through the system. All three of these processes occur extensively along the Rio Grande as a result of the most significant water use, irrigation.

The largest median dissolved-solids concentration for the Basic Fixed Sites was at site 13 on the Rio Puerco. The Rio Puerco, a typical tributary to the Rio Grande in the southern part of the basin, was the only ephemeral stream sampled in this area. It illustrates the importance that ephemeral streams in semiarid environments have on dissolved-solids concentrations, particularly in load calculations. In one or two storm-runoff events from these tributaries, most of the calculated dissolved-solids load for the year can occur.

Table 9.—Dissolved-solids concentration at Basic Fixed Sites

[Main-stem sites shown in blue; mg/L,milligrams per liter]

Site number (fig. 2)	Station name	Median dissolved-solids concentration (mg/L)	Range of dissolved-solids concentration (mg/L)
1	Rio Grande near Del Norte, Colo.	67	39 - 92
2	Saguache Creek near Saguache, Colo.	96	72 - 112
3	Medano Creek near Mosca, Colo.	56	31 - 66
4	Rio Grande above mouth of Trinchera Creek, near Lasauses, Colo.	292	161 - 428
5	Conejos River near Lasauses, Colo.	92	62 - 158
6	Rio Grande near Lobatos, Colo.	191	118 - 413
7	Rio Grande below Taos Junction Bridge, near Taos, N. Mex.	192	113 - 242
8	Rio Chama near Chamita, N. Mex.	174	138 - 242
9	Rio Grande at Otowi Bridge near San Ildefonso, N. Mex.	194	124 - 221
10	Rito de los Frijoles in Bandelier National Monument, N. Mex.	113	96 - 126
11	Santa Fe River above Cochiti Lake, N. Mex.	376	117 - 459
12	Rio Grande at Isleta, N. Mex.	245	142 - 297
13	Rio Puerco near Bernardo, N. Mex.	1,180	274 - 2,110
14	Rio Grande Conveyance Channel at San Marcial, N. Mex.	528	452 - 634
15	Rio Grande Floodway at San Marcial, N. Mex.	298	169 - 751
16	Rio Grande below Leasburg Dam near Leasburg, N. Mex.	430	353 - 929
17	Rio Grande at El Paso, Tex.	634	472 - 1,350

Many trace elements are essential nutrients; however, certain trace elements such as arsenic, cadmium, and mercury are known to be persistent environmental contaminants and toxic to most forms of life (Schmitt and Brumbaugh, 1990). Trace elements are generally present in small concentrations in natural water systems. Their occurrence in ground and surface water can be due to natural sources such as dissolution of naturally occurring minerals containing trace elements in the soil zone or the aquifer material or to human activities such as mining, application of pesticides, burning of fossil fuels, smelting of ores, and improper disposal of industrial wastes.

The EPA has established primary and secondary MCLs, HAs, and issued guidelines for the establishment of aquatic-life criteria as they apply to trace elements. The States of Colorado, New Mexico, and Texas have also established individual aquatic-life criteria for selected trace elements that apply to specific river reaches within the Study Unit. Acute exposure (short term, high concentration) to certain metals can kill organisms directly, whereas chronic exposure (long term, low concentration) can result in either mortality or nonlethal effects such as stunted growth, reduced reproductive success, deformities, or lesions.

Trace Elements in Ground Water

During 1992-95, ground-water samples were collected for analysis of trace elements during three land-use studies and the aquifer subunit survey. Most trace-element concentrations in ground water ranged from less than 1 to 10 micrograms per liter (µg/L). Only four trace elements exceeded EPA MCLs, SMCLs, or HAs (table 10). Uranium concentrations in water from 15 of 119 wells exceeded the EPA-proposed MCL of 20 µg/L (U.S. Environmental Protection Agency, 1996a). Water from two wells exceeded the EPA HA of 40 µg/L for molybdenum. The relatively low number of detections and small concentrations of most trace elements indicate that they are influenced more by natural processes and less by land use.

Two trace elements that consistently exceeded SMCLs were manganese and iron, which can stain plumbing fixtures or impart a metallic taste to the water. Manganese concentrations in water from 62 wells and iron concentrations in water from 14 wells exceeded EPA SMCLs. Large manganese and iron concentrations are often associated with small dissolved-oxygen concentrations. Where oxygen has been consumed, microorganisms will reduce manganese and iron, resulting in large concentrations. This commonly occurs in areas of septic-system effluent discharge.

On the basis of analysis of the spatial distribution and range of trace-element concentrations (table 10), human activities have not caused widespread trace-element contamination in ground water. The majority of trace elements detected are likely the result of dissolution of naturally occurring minerals in the aquifer.

Trace Elements in the Surface-Water Environment

Since the late 1800's, mining activities have been prevalent in the northern part of the Study Unit in Colorado and New Mexico. Most mining activities have ceased, and several areas are in various stages of remediation. To document the surface-water quality in and immediately adjacent to the Rio Grande, a synoptic study focusing on trace elements in the water column, suspended sediment, and bed material was conducted in June and September 1994. In January 1995, selected trace elements were analyzed in samples collected in the Mesilla and Rincon Valleys as part of a pesticide and nutrient synoptic study.

Water column

Analysis of trace-element data collected in the northern part of the study area confirmed previous study results. Moderately to highly elevated trace-

Table 10.—Trace elements in ground water that exceed U.S. Environmental Protection Agency standards or guidelines

[µg/L, micrograms per liter; MCL, U.S. Environmental Protection Agency (EPA) maximum contaminant level; SMCL, EPA secondary maximum contaminant level; HA, EPA lifetime health advisory; --, no data]

Trace element	Number of wells sampled	Number of detections	Detection concentration (µg/L)	Proposed MCL (µg/L)	SMCL (µg/L)	HA (µg/L)
San Luis Valley agricultural land-use study						
Uranium	35	5	23 - 84	20	--	--
Manganese	35	6	69 - 682	--	50	--
Molybdenum	35	1	52	--	--	40
Albuquerque urban land-use study						
Uranium	24	5	21 - 89	20	--	--
Iron	24	7	340 - 3,800	--	300	--
Manganese	24	21	130 - 3,600	--	50	--
Rincon Valley agricultural land-use study						
Uranium	30	4	26 - 62	20	--	--
Iron	30	5	980 - 1,900	--	300	--
Manganese	30	25	77 - 2,130	--	50	--
Aquifer subunit survey						
Uranium	30	1	102	20	--	--
Iron	30	2	360 - 550	--	300	--
Manganese	30	10	58 - 654	--	50	--
Molybdenum	30	1	59	--	--	40

element concentrations were detected in the Creede, Colorado, and Red River, New Mexico, mining areas and in the Alamosa River, which drains a mining area and also contains several areas of naturally occurring minerals that contribute trace elements to the water column.

For the entire reach of the Rio Grande sampled in 1994, the largest concentrations of dissolved antimony, beryllium, cadmium, cobalt, copper, iron, lead, mercury, nickel, silver, and zinc were detected at sites downstream from areas of known mineral extraction. Dissolved concentrations of beryllium, cadmium, cobalt, lithium, manganese, molybdenum, nickel, and zinc were moderately higher at a site on the lower Red River than in the Rio Grande downstream of its confluence. At the site on the Alamosa River where it enters the San Luis Valley, highly elevated concentrations of dissolved cadmium, cobalt, copper, iron, manganese, nickel, strontium, uranium, and vanadium were detected.

The largest concentrations of dissolved arsenic, barium, boron, chromium, lithium, molybdenum, and uranium were detected at sites in the Mesilla and Rincon Valleys. The elevated concentrations of these trace elements may be related to discharges from geothermal springs, the return flow of irrigation water, or urban land-use discharges.

Concentrations of dissolved cadmium, copper, manganese, iron, silver, and zinc in the water column exceeded the following applicable standards at one or more sites. Dissolved concentrations of cadmium, copper, iron, and zinc exceeded the Colorado chronic aquatic-life standard (Colorado Water Quality Control Commission, 1989) at the site on the Alamosa River and dissolved silver concentrations exceeded the Colorado chronic aquatic-life standard for trout at four sites in Colorado . The copper concentration at one site on the Red River exceeded the New Mexico cold-water fishery chronic standard (New Mexico Water Quality Control Commission, 1991).

Bed sediment

Bed-sediment samples were collected to characterize the occurrence and distribution of trace elements in the Study Unit. Because of the large areal extent of naturally occurring mineralized areas in the Study Unit, particularly in the northern one-third, the source of trace-element concentrations detected in bed-sediment samples may be natural rather than anthropogenic.

Trace-element concentrations in bed sediment closely reflect the same pattern as water-column concentrations. Highly elevated concentrations of antimony, arsenic, cadmium, copper, lead, mercury, silver, and zinc were detected in bed-sediment material from Willow Creek and the Rio Grande downstream from the Creede mining area compared to the rest of the study area. Concentrations of these elements in samples from the Alamosa River and Red River areas were elevated compared with the rest of the study area. At present, no Federal or State guidelines have been established for trace-element concentrations in bed sediment.

Fish tissue (liver)

As part of the fish-tissue contaminant study, fish were collected at 12 sites and their livers analyzed for trace-elements. The bioavailability of trace elements is an important factor in assessing threats to aquatic organisms, ecosystems, and public health. As with water-column and bed-sediment samples, the sample from the Rio Grande near Creede contained elevated concentrations of arsenic, cadmium, copper, lead, and zinc. Some trace elements were detected at higher concentrations in liver samples than in bed-sediment samples from the same site.

Accumulation of trace elements by fish appears to be species dependent. Zinc concentrations in liver samples of common carp liver at certain sites were three to four times those in samples of white sucker at other sites. A brown trout sample contained significantly higher concentrations of arsenic, copper, mercury, and selenium than all other fish samples. To differentiate between environmental and species-dependent factors, however, the collection of multiple species at a number of individual sites would be necessary.

Bryophytes (moss)

Transplanted bryophytes (moss) were used to determine the spatial distribution of trace elements in relation to land-use practices, compare accumulation rates of trace elements in bryophytes at sites known to be contaminated by trace elements, and evaluate transplanted bryophytes as a tool for examining the bioavailability of trace elements in relation to concentrations in water and bed sediment.

Thirteen sites on the Rio Grande and tributary streams in southern Colorado and northern New Mexico were sampled for determination of 12 trace elements in transplanted bryophytes. Analysis of the data indicates that (1) concentrations of cadmium, copper, lead, and zinc in bryophytes increased at sites on the Rio Grande immediately downstream from tributaries that drain the mining districts, (2) concentrations of these metals in bryophytes decreased with distance from the tributaries, and (3) concentrations of most trace elements in bryophytes were lower in a tributary stream downstream from an urban area than at sites near mining or agricultural land use.

Fish communities and stream habitat (instream and riparian) were assessed at selected sites in three major physiographic provinces and three of four ecoregions of the Rio Grande Valley Study Unit. The structure of a community can be influenced by natural and human changes to physical and chemical characteristics of the stream. A stream reach, or section of stream, was selected to assess fish communities and stream habitat that best represented the condition of a longer river segment. This allows for an integrated approach to characterizing surface-water quality. A combination of qualitative and quantitative sampling methods was used to determine the species present in a reach and to provide a measure of structure, which can be expressed in a variety of ways including species richness, relative abundance, trophic complexity, native/nonnative composition, and tolerance to human disturbance. Samples of fish were collected primarily during the summer low-flow period in 1993-95. These samples, in addition to more than 30 instream and riparian characteristics of stream habitat (including stream modification, bank erosion, bank vegetation stability, and riparian vegetation density) were used to describe water-quality conditions.

Fish Communities

Fish communities were assessed at 10 sites in the Study Unit. In 25 samples, 29 species representing 10 families were identified. Species richness ranged from 1 to 13. Species richness was lowest at Medano Creek near Mosca, Colorado, where the Colorado Division of Wildlife removed all other species from the stream in an effort to reintroduce the Rio Grande cutthroat trout. Species richness increased downstream with increasing contributing drainage area; the Rio Grande at El Paso site had the most species. Warm-water fisheries generally support more species than cold-water fisheries; however, the site at El Paso may have the most species because it is downstream from a very large warm-water reservoir which could provide seed populations that are present downstream.

Fish, which are relatively long lived and can travel long distances, integrate water-quality conditions over a longer period of time and at a relatively larger spatial scale than algae and benthic invertebrates. Four indicators of biotic integrity (percentages of introduced species, omnivores, tolerant species, and anomalies) were used to provide a broad overview of the fish community structure.

At sites sampled during this study, 13 native and 16 introduced species of fish were identified. Introduced fish species predominate at four of six sites sampled in 1994, probably because of stocking of some of these fish species. The dominance of omnivores in samples from the Rio Grande below Taos Junction Bridge, Rio Chama near Chamita, Rio Grande at Isleta, and Rio Grande at El Paso (fig. 2) can be an indication of environmental stress at these sites. However, omnivores can also be an indication of increasing stream size. In 1994, tolerant species accounted for the entire fish community at Rio Grande at Isleta.

The occurrence of external anomalies on all fish samples was less than 2 percent except for the sample from Rio Grande at Isleta, which was 14 percent. Based on the relative percentages of introduced, omnivorous, tolerant fish and the number of fish with external anomalies, six of the sampled sites appear to show some indications of environmental perturbation. The biotic integrity at the Rio Grande at Isleta site appears to be the most impaired of all sites.

In 1995, fish communities were sampled in three separate reaches in both the Santa Fe River above Cochiti Lake and the Rio Grande near Isleta sites to assess small-scale spatial patterns in the structure of fish communities among the reaches at each site and to determine the influence of physical and chemical characteristics of each reach on the fish communities of each stream. The fish communities showed some variability among reaches at both of these sites. The variability in the spatial pattern at both sites might be because of natural variability; however, at the Santa Fe River site, the variability also could be related to the presence or absence of such important habitat features as shallow pools. The stream physical or chemical characteristics among each reach at each site did not seem to influence the spatial pattern of fish communities. No significant correlation existed between fish communities at each reach and either the physical variables (such as channel width, depth, and substrate composition) or the chemical variables (such as water temperature, DO, and specific conductance).

The relative abundance of fish species and the total number of individuals varied in samples collected at sites sampled annually. All sites, except for Rio Grande near Del Norte, had a decline in the total number of individuals in a sample from 1993 to 1995. This temporal decline also could be caused by natural variability within the fish community or some artifact of sampling.

Stream Habitat

Stream habitat characteristics are used to describe the environmental setting at sites selected for ecological surveys. At the spatial scales of basin, stream segment, stream reach, and microhabitat, physical characteristics of streams strongly influence water quality and the capacity of a stream to support healthy biological communities. Basin factors, such as physiographic province, ecoregion, and climate, can be used to evaluate natural influence on biological communities. Stream segments are a more discrete unit that should have relatively homogeneous physical, chemical, and biological characteristics. Within a stream segment, a stream reach was selected for an intensive site evaluation. Microhabitat features, such as macrophyte beds, woody debris, and bed substrate, also were evaluated within each stream reach. The presence or absence of different biological communities at Study-Unit sites is influenced to varying degrees by the environmental setting at a particular site. For instance, fish communities are more influenced by climate, which is considered a basin factor, than by specific microhabitat conditions.

Principal component analysis was used to determine the overall variance in the combination of various stream habitat characteristics. Physiographic province and ecoregion were the physical variables that explained most variance among sites. Physiographic provinces are distinct areas that have common topography, rock types and structure, and geologic and geomorphic history. Ecoregions are relatively homogeneous ecological regions and are classified by spatially variable combinations of geomorphology, soils, physiography, land use and land cover, and potential natural vegetation. Because a combination of physical variables define both physiographic province and ecoregion, most variance among sites is explained by these two habitat characteristics.

A habitat degradation index also was used to describe the physical condition of the sites selected for ecological surveys. The index included four habitat characteristics: stream modification, bank erosion, bank vegetation stability, and riparian vegetation density. Use of these four habitat characteristics revealed that 6 of 10 sites sampled appear to have significant habitat degradation. These sites are Rio Grande near Del Norte, Colorado; Conejos River near Lasauses, Colorado; Rio Chama near Chamita, New Mexico; Santa Fe River above Cochiti Lake, New Mexico; Rio Grande at Isleta, New Mexico; and Rio Grande at El Paso, Texas. Saguache Creek near Saguache, Colorado; Medano Creek near Mosca, Colorado; and Rio Grande below Taos Junction Bridge near Taos, New Mexico, were sites that have moderate to minimal habitat degradation. Rito de los Frijoles in Bandelier National Monument, New Mexico, was the only site that had minimal habitat degradation. The habitat at Rito de los Frijoles was characterized by no stream modification, very little bank erosion, highly stable banks, and dense riparian vegetation.

Stream habitat changes significantly from the upper to the lower part of the basin. Top photograph is Rio Grande near Del Norte, Colorado; lower photograph is Rio Grande at El Paso, Texas (photographs by Lisa F. Carter, U.S. Geological Survey).

Comparison of Stream Quality in the Rio Grande Valley with Nationwide NAWQA Findings

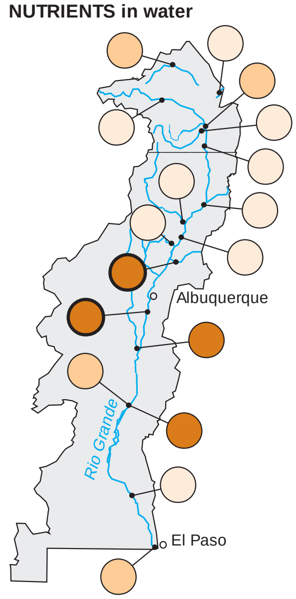
Seven major water-quality characteristics were evaluated for stream sites in each NAWQA Study Unit. Summary scores for each characteristic were computed for all sites that had adequate data. Scores for each site in the Rio Grande Valley were compared with scores for all sites sampled in the 20 NAWQA Study Units during 1992–95. Results are summarized by percentiles; higher percentile values generally indicate poorer quality compared with other NAWQA sites. Water-quality conditions at each site also are compared to established criteria for protection of aquatic life. Applicable criteria are limited to nutrients and pesticides in water, and semivolatile organic compounds, organochlorine pesticides and PCBs in sediment. (Methods used to compute rankings and evaluate aquatic-life criteria are described by Gilliom and others, in press.)

EXPLANATION

Ranking of stream quality relative to all NAWQA stream sites — Darker colored circles generally indicate poorer quality. Bold outline of circle indicates one or more aquatic-life criteria were exceeded.

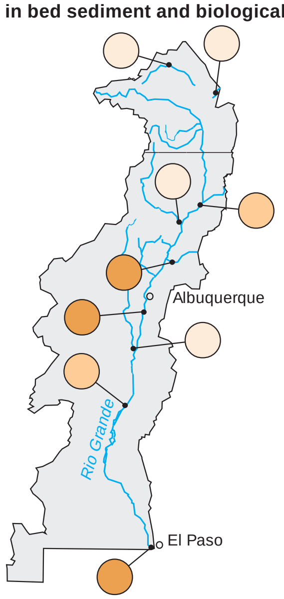
- **Greater than the 75th percentile** (among the highest 25 percent of NAWQA stream sites)
- **Between the median and the 75th percentile**
- **Between the 25th percentile and the median**
- **Less than the 25th percentile** (among the lowest 25 percent of NAWQA stream sites)

NUTRIENTS in water



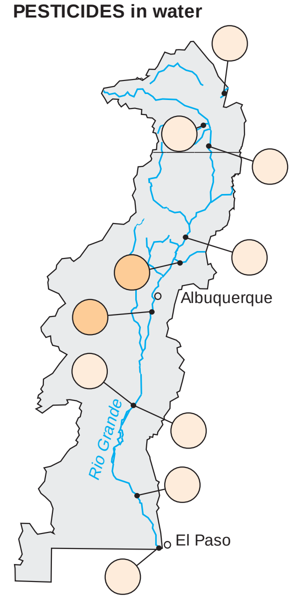
Nutrient concentrations downstream from urban areas and in a sediment-laden tributary were among the highest in the Nation. The impact of reservoirs on reducing nutrient concentrations is shown by the reduced concentrations at the two lower sites.

ORGANOCHLORINE PESTICIDES and PCBs in bed sediment and biological tissue



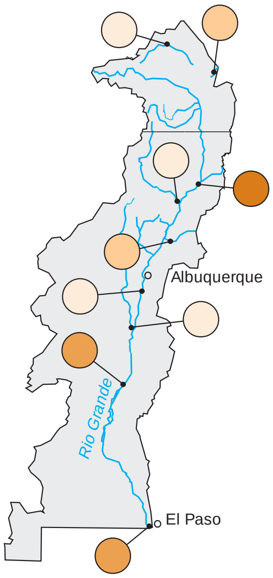
The largest concentrations of organochlorines and PCBs were at sites downstream from urban areas. Three sites had levels above the national NAWQA median.

PESTICIDES in water



Pesticide concentrations in surface water ranked among the lowest of all NAWQA sites nationwide. Within the Study Unit, the two sites with the highest concentrations were below urban land-use areas.

TRACE ELEMENTS in bed sediment



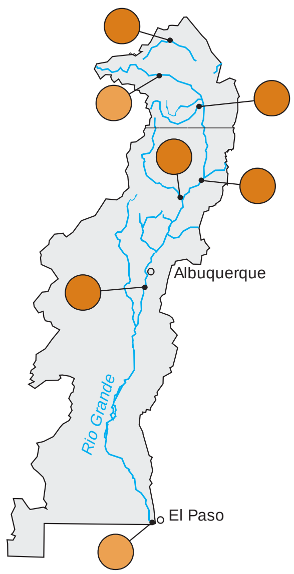
For the trace elements measured for this comparison, one site was in the highest 25 percent nationwide. Two sites in the lower part of the Study Unit have levels greater than the median for all NAWQA sites.

CONCLUSIONS

Compared to other NAWQA Study Units, in the Rio Grande Valley

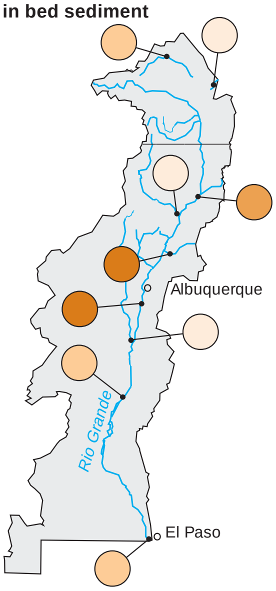
- Based on the water-quality data collected and presented here, land use in the middle part of the Study Unit has a major impact on nutrient concentrations.
- Pesticide concentrations have not affected the quality of surface water at the sampled sites.
- Fish community rankings were strongly influenced by the predominance of introduced and omnivorous species.

FISH COMMUNITY DEGRADATION



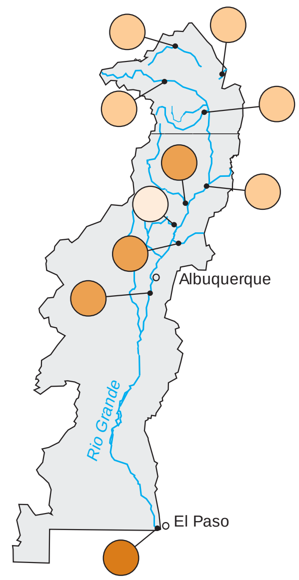
On the basis of attributes used to provide a broad overview of the fish community structure—introduced species, omnivorous species, percent tolerant species, and external anomalies—all of the sites were above the national median. The ranking was strongly influenced by the predominance of introduced and omnivorous species at many of the sites.

SEMIVOLATILE ORGANIC COMPOUNDS in bed sediment



Six of the nine sites have concentrations lower than the national median. Two sites located downstream from urban areas ranked among the highest in the Nation for semivolatile organic compounds in sediment.

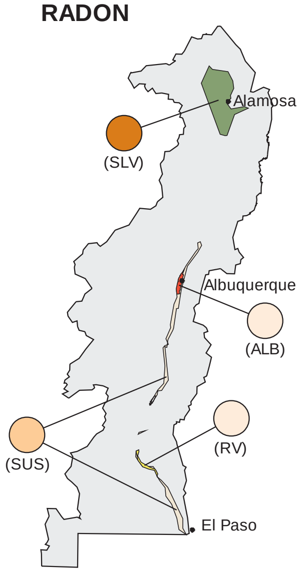
STREAM HABITAT DEGRADATION



Four of 10 sites in the Study Unit were above the national median; however, all sites showed some signs of degradation. Two sites ranked as highly degraded compared with other sites. The rankings were influenced most by the lack of dense riparian vegetation.

Five major water-quality characteristics were evaluated for ground-water studies in each NAWQA Study Unit. Ground-water resources were divided into two categories: (1) drinking-water aquifers, and (2) shallow ground water underlying agricultural or urban areas. Summary scores were computed for each characteristic for all aquifers and shallow ground-water areas that had adequate data. Scores for each aquifer and shallow ground-water area in the Rio Grande Valley were compared with scores for all aquifers and shallow ground-water areas sampled in the 20 NAWQA Study Units during 1992–95. Results are summarized by percentiles; higher percentile values generally indicate poorer quality compared with other NAWQA ground-water studies. Water-quality conditions for each drinking-water aquifer also are compared to established drinking-water standards and criteria for protection of human health. (Methods used to compute rankings and evaluate standards and criteria are described by Gilliom and others, in press.)

RADON



Radon concentrations in the San Luis Valley were among the highest measured nationwide. However, radon concentrations in the rest of the Study Unit were smaller than the national median value.

EXPLANATION

Drinking-water aquifers

Aquifer subunit survey (SUS)

Shallow ground-water areas

Agricultural area; Rincon Valley (RV)

Cropland area; San Luis Valley (SLV)

Urban area; Albuquerque area (ALB)

Ranking of ground-water quality relative to all NAWQA ground-water studies—Darker colored circles generally indicate poorer quality. Bold outline of circle indicates one or more standards or criteria were exceeded

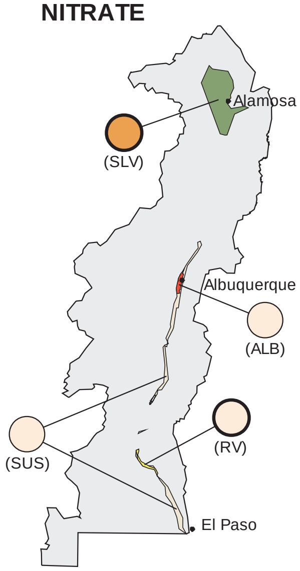
Greater than the 75th percentile (Among the highest 25 percent of NAWQA ground-water studies)

Between the median and the 75th percentile

Between the 25th percentile and the median

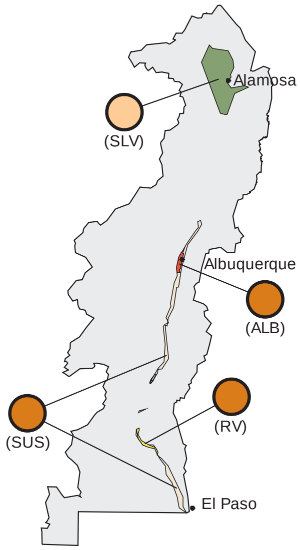
Less than the 25th percentile (Among the lowest 25 percent of NAWQA ground-water studies)

NITRATE



Nitrate concentrations throughout most of the Study Unit were among the lowest in the Nation. However, in the San Luis Valley, nitrate concentrations were higher than the national median and, along with the Rincon Valley area, exceeded drinking-water standards in some wells.

DISSOLVED SOLIDS



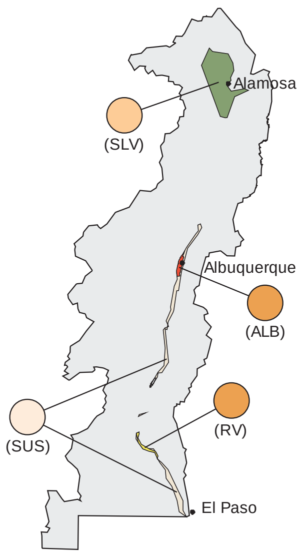
The median dissolved-solids concentration in water from the Albuquerque and Rincon land-use studies and aquifer subunit survey ranked in the top 25 percent nationwide. Drinking-water standards were exceeded in some wells in all areas.

CONCLUSIONS

Compared to other NAWQA Study Units, in the Rio Grande Valley

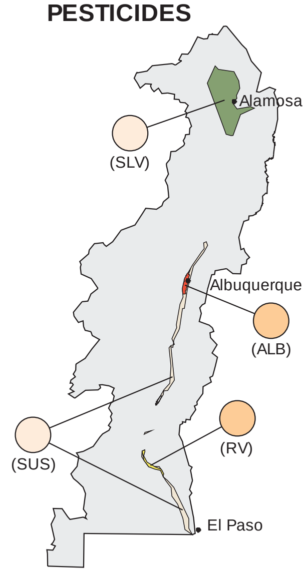
- Pesticide concentrations detected in shallow ground water in the agricultural and urban land-use areas have not exceeded any drinking-water standards.
- Radon concentrations in the San Luis Valley and in parts of the aquifer subunit survey area may be high enough to be of potential health concern.
- Dissolved-solids concentrations are higher in the middle to lower parts of the study area. This may indicate interaction of ground water and surface water along the Rio Grande and deeper water has been recharged at basin boundaries and traveled large distances.

VOLATILE ORGANIC COMPOUNDS

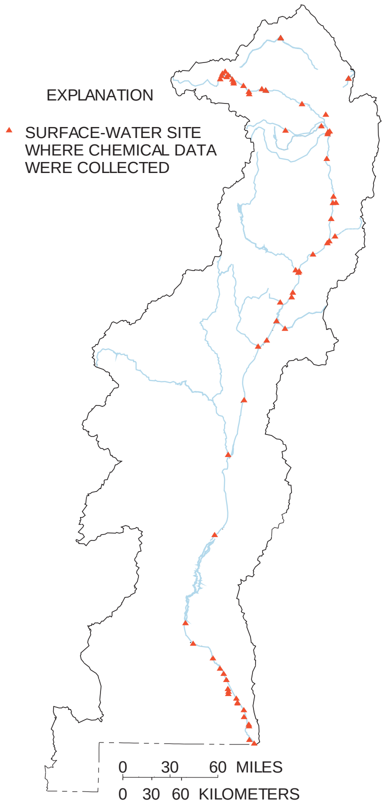


The percentage of wells with VOC detections in urban and agricultural areas ranked in the middle categories nationwide. No VOCs were detected in aquifer subunit survey samples.

PESTICIDES



Pesticide detections for the San Luis Valley and aquifer subunit survey were among the lowest of all NAWQA ground-water studies and were only slightly higher in the Albuquerque area and Rincon Valley. No standards were exceeded in any samples from the four areas.

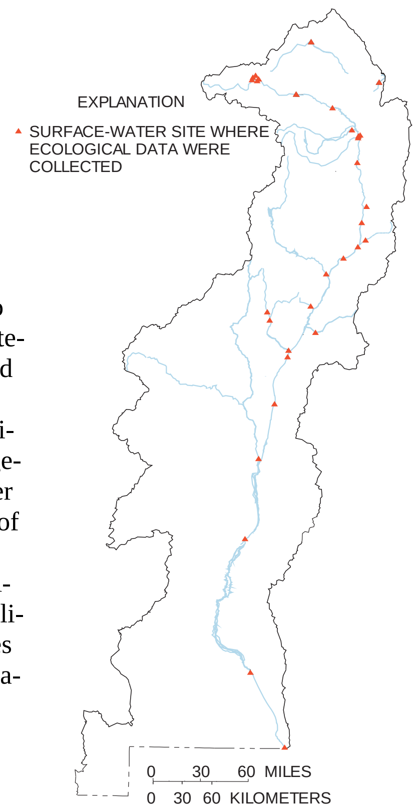


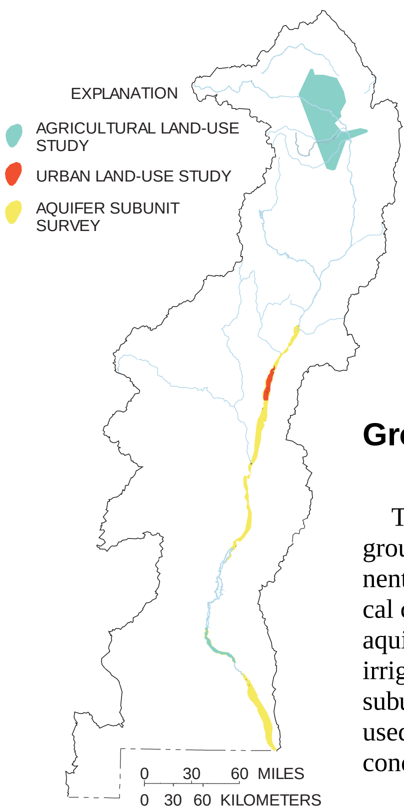
Stream Chemistry

The primary objective of the stream chemistry component was to assess the relationship between land use and chemical constituents of surface water. Surface-water sites were distributed among land uses; site types include basic, intensive, and synoptic sites for pesticides, nutrients, and trace elements.

Stream Ecology

The primary objective of the stream ecology component was to assess surface-water quality by integrating the physical, chemical, and biological factors. Ecology sites were distributed among forest, irrigated agriculture, urban, and rangeland. Sites were classified as either intensive or synoptic on the basis of the level of the sampling effort or the number of years data were collected. A special study on the applicability of transplanted bryophytes (moss) for trace-element accumulation was also conducted.





Ground-Water Chemistry

The primary objective of the ground-water chemistry component was to determine if the chemical constituents in the shallow aquifer were related to urban and irrigated agricultural land use. A subunit survey of a deeper aquifer used for domestic supply was also conducted.

SUMMARY OF DATA COLLECTION IN THE RIO GRANDE VALLEY STUDY UNIT, 1992-95

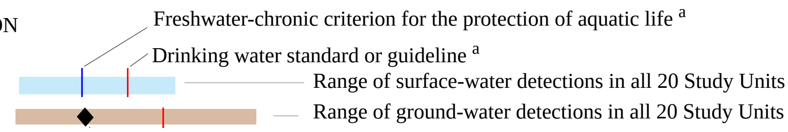
Study component	What data were collected and Why	Types of sites sampled	Number of sites	Sampling frequency and period
Stream Chemistry				
Bed-sediment study	Determine presence of potentially toxic compounds attached to sediments in major streams.	Sample depositional zones of the Rio Grande and selected tributaries and non-tributaries for trace elements and hydrophobic organic compounds.	18	1 1992-93
Water chemistry — Basic Fixed Site study	Describe concentrations and loads of chemicals, suspended sediment, and nutrients at selected sites throughout the Study Unit.	Sample at or near sites where streamflow is measured continuously for major constituents, nutrients, and suspended sediment.	17	Monthly, April 1993-Sept. 1995
Water chemistry — Intensive Fixed Site study	Determine concentration and timing of pesticides transported by runoff to streams.	Select an agricultural basin where pesticides, dissolved solids, major constituents, and nutrients were sampled weekly and during selected runoff events.	1	Weekly, April-Sept. 1994
Water chemistry — Trace-element synoptic study	Describe presence and distribution of trace elements in the water column, suspended sediment, and bed material in the Rio Grande and tributaries in the northern part of the Study Unit.	Sample water column and suspended sediment during high flow (June) and water column and bed material during low flow (September) for trace elements and major constituents.	34	1 1994
Water chemistry—Mesilla Valley pesticide and nutrient synoptic study	Describe presence and distribution of pesticides and nutrients in the water column in the Rio Grande and drains in the Mesilla Valley.	Sample water column during high flow (irrigation season) for pesticides, nutrients, dissolved solids, and major constituents and during low flow (nonirrigation season) for pesticides, nutrients, dissolved solids, major constituents, and trace elements. Sample bed material in drains during low flow for pesticides.	19	1 1994-95
Water chemistry—Rincon Valley temporal drain study	Describe temporal water-quality variation in surface drains and Rio Grande in an agricultural area flood irrigated with surface water.	Sample selected sites twice during nonirrigation season (low flow) and at the beginning and end of the irrigation season (high flow). Water analyzed for dissolved solids, major constituents, nutrients, organic carbon, trace elements, and pesticides.	11	4 1994-95
Stream Ecology				
Fish-tissue contaminant study	Determine the presence of contaminants in fish tissue from species that can be found in most streams of the Study Unit.	Sample composites of whole-body fish for: hydrophobic organic contaminants fish livers for trace elements.	 11 12	1 1992-93
Intensive ecological assessments	Assess fish, macroinvertebrates, and algae communities and habitat in streams representing three ecological regions.	Sample aquatic communities at a subset of water-chemistry basic sites; quantitatively describe stream habitat for these organisms. Sample aquatic communities at a subset of water-chemistry basic sites; quantitatively describe stream habitat for these organisms.	2 8	3 reaches/ site in 1995; 1 reach/year, 1993-95
Ecological synoptic studies	Assess aquatic and terrestrial communities and habitat in representative streams throughout the Study Unit.	Sample macroinvertebrates and algae at or near water-chemistry sites and describe habitat. Sample adult insects using ultraviolet light traps at or near water-chemistry sites.	16 14	1 1994-95
Transplanted aquatic bryophyte study	Determine spatial distribution of trace elements in the upper Rio Grande Valley Study Unit using transplanted aquatic bryophytes.	Transplant bryophyte samples (*Hygrohypnum ochraceum)* for variable lengths of time and analyze samples for trace-element concentration.	13	1 1994
Ground-water Chemistry				
Land-use studies	Examine natural and human factors that affect the quality of shallow ground water that underlies areas of urban land, overhead, center-pivot sprinkler-irrigated agriculture land, or flood-irrigated agricultural land.	Install shallow wells and sample water from wells for analysis of dissolved solids, major constituents, nutrients, dissolved organic carbon, trace elements, pesticides, volatile organic compounds, and radionuclides. (1) San Luis Valley agricultural land-use study of an area irrigated with ground water by overhead, center-pivot sprinklers. (2) Albuquerque urban land-use study. (3) Rincon Valley agricultural land-use study of an area flood irrigated with surface water.	 35 24 30	 1993 1993 1994
Aquifer subunit survey	Describe the overall water quality in the part of the basin-fill aquifer used for domestic supply, public supply, or irrigation.	Randomly select and sample existing wells located in the Rio Grande flood plain from Cochiti Lake, New Mexico, to El Paso, Texas, for analysis of major constituents, nutrients, dissolved organic carbon, trace elements, pesticides, volatile organic compounds, and radionuclides.	30	1 1995

SUMMARY OF COMPOUND DETECTIONS AND CONCENTRATIONS

The following tables summarize data collected for NAWQA studies from 1992-95 by showing results for the Rio Grande Valley Study Unit compared to the NAWQA national range for each compound detected. The data were collected at a wide variety of locations and times. In order to represent the wide concentration ranges observed among Study Units, logarithmic scales are used to emphasize the general magnitude of concentrations (such as 10, 100, or 1000), rather than the precise number. The complete dataset used to construct these tables is available upon request.

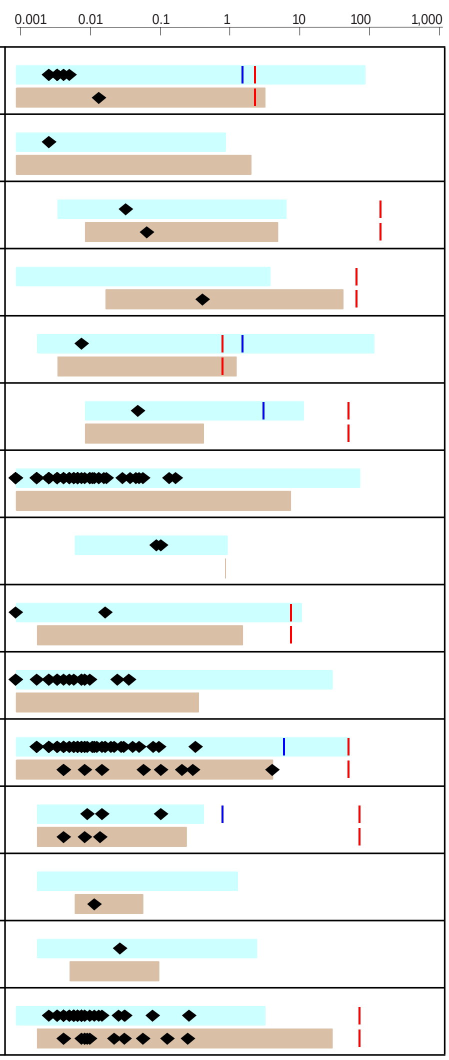
Concentrations of pesticides, volatile organic compounds, and nutrients detected in ground and surface waters of the Rio Grande Valley Study Unit. [mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; %, percent; <, less than; - -, not measured; trade names may vary]

EXPLANATION



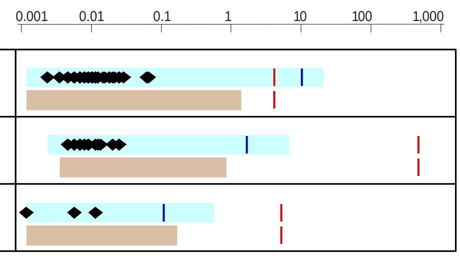
Herbicide (Trade or common name)	Rate of detection [b]
Atrazine (AAtrex, Gesaprim)	<1% 1%
Deethylatrazine[c] (Atrazine metabolite)	<1% 0%
Bentazon (Basagran, bentazone)	1% 1%
Bromacil (Hyvar X, Urox B, Bromax)	0% 1%
Cyanazine (Bladex, Fortrol)	<1% 0%
2,4-D (2,4-PA)	1% 0%
DCPA (Dacthal, chlo-rthal-dimethyl)	10% 0%
Dacthal, mono-acid (Dacthal metabolite)	2% 0%
Diuron (Karmex, Direx, DCMU)	1% 0%
EPTC (Eptam)	3% 0%
Metolachlor (Dual, Pennant)	11% 6%
Metribuzin (Lexone, Sencor)	2% 2%
Napropamide (Devrinol)	0% 1%
Pendimethalin (Prowl, Stomp, Herb-	1% 0%
Prometon (Gesa-gram, prometone)	7% 8%

Concentration, in µg/L



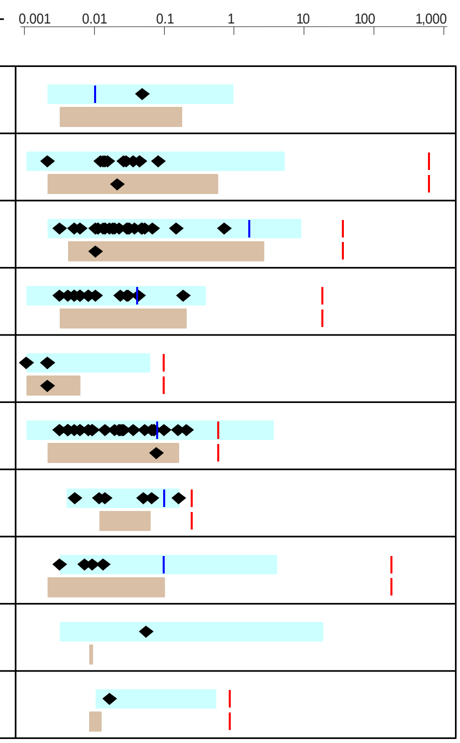
Herbicide (Trade or common name)	Rate of detection [b]
Simazine (Aquazine, Princep, GEsatop,	12% 0%
Tebuthiuron (Spike, Perflan)	3% 0%
Trifluralin (Treflan, Trinin, Elancolan)	1% 0%

Concentration, in µg/L



Insecticide (Trade or common name)	Rate of detection [b]
Azinphos-methyl[c] (Guthion, Gusathion	1% 0%
Carbaryl[c] (Sevin, Savit)	6% 1%
Carbofuran[c] (Furadan, Curaterr,	11% 1%
Chlorpyrifos (Durs-ban, Lorsban, Dowco	3% 0%
p,p'-DDE (*p,p'*-DDT metabolite)	<1% <1%
Diazinon	10% 1%
gamma-HCH	2% 0%
Malathion (maldison, malathon, Cythion)	1% 0%
Propargite (Comite, Omite, BPPS)	1% 0%
Terbufos (Counter)	1% 0%

Concentration, in µg/L



Volatile organic compound (Trade or common name)	Rate of detection [b]	Concentration, in µg/L (0.01, 0.1, 1, 10, 100, 1,000)
Trichloroethene (TCE)	-- 1%	
cis-1,2-Dichloroethene ((Z)-1,2-Dichlo-	-- 2%	
p-Isopropyltoluene (*p*-Cymene)	-- 1%	
1,1-Dichloroethane (Ethylidene dichloride)	-- 2%	
Dimethylbenzenes (Xylenes, total)	-- 3%	

Volatile organic compound (Trade or common name)	Rate of detection [b]	Concentration, in µg/L (0.01, 0.1, 1, 10, 100, 1,000, 10,000, 100,000)
Methyl *tert*-butyl[d] ether (MTBE)	-- 2%	

Nutrient (Trade or common name)	Rate of detection [b]	Concentration, in mg/L (0.01, 0.1, 1, 10, 100, 1,000, 10,000, 100,000)
Dissolved ammonia	75% 78%	
Dissolved ammonia plus organic nitrogen as nitrogen	53% 39%	
Dissolved phosphorus as phosphorus	82% 72%	
Dissolved nitrite plus nitrate	66% 65%	

Other	Rate of detection [b]	Concentration, in pCi/L (1, 10, 100, 1,000, 10,000, 100,000)
Radon 222	-- 100%	

Herbicides, insecticides, volatile organic compounds, and nutrients not detected in ground and surface waters of the Rio Grande Valley Study Unit.

Herbicides

2,4,5-T

2,4,5-TP (Silvex, Fenoprop)

2,4-DB (Butyrac, Butoxone, Embutox Plus, Embutone)

2,6-Diethylaniline (Metabolite of Alachlor)

Acetochlor (Harness Plus, Surpass)

Acifluorfen (Blazer, Tackle 2S)

Alachlor (Lasso, Bronco, Lariat, Bullet)

Benfluralin (Balan, Benefin, Bonalan, Benefex)

Bromoxynil (Buctril, Brominal)

Butylate (Sutan +, Genate Plus, Butilate)

Chloramben (Amiben, Amilon-WP, Vegiben)

Clopyralid (Stinger, Lontrel, Reclaim, Transline)

Dicamba (Banvel, Dianat, Scotts Proturf)

Dichlorprop (2,4-DP, Seritox 50, Kildip, Lentemul)

Dinoseb (Dinosebe)

Ethalfluralin (Sonalan, Curbit)

Fenuron (Fenulon, Fenidim)

Fluometuron (Flo-Met, Cotoran, Cottonex, Meturon)

Linuron (Lorox, Linex, Sarclex, Linurex, Afalon)

MCPA (Rhomene, Rhonox, Chiptox)

MCPB (Thistrol)

Molinate (Ordram)

Neburon (Neburea, Neburyl, Noruben)

Norflurazon (Evital, Predict, Solicam, Zorial)

Oryzalin (Surflan, Dirimal)

Pebulate (Tillam, PEBC)

Picloram (Grazon, Tordon)

Pronamide (Kerb, Propyzamid)

Propachlor (Ramrod, Satecid)

Propanil (Stam, Stampede, Wham, Surcopur, Prop-Job)

Propham (Tuberite)

Terbacil (Sinbar)

Thiobencarb (Bolero, Saturn, Benthiocarb, Abolish)

Triallate (Far-Go, Avadex BW, Tri-allate)

Triclopyr (Garlon, Grandstand, Redeem, Remedy)

Insecticides

3-Hydroxycarbofuran (Carbofuran metabolite)

Aldicarb sulfone (Standak, aldoxycarb, aldicarb metabolite)

Aldicarb sulfoxide (Aldicarb metabolite)

Aldicarb (Temik, Ambush, Pounce)

Dieldrin (Panoram D-31, Octalox, Compound 497, Aldrin epoxide)

Disulfoton (Disyston, Di-Syston, Frumin AL, Solvirex, Ethylthiodemeton)

Ethoprop (Mocap, Ethoprophos)

Fonofos (Dyfonate, Capfos, Cudgel, Tycap)

Methiocarb (Slug-Geta, Grandslam, Mesurol)

Methomyl (Lanox, Lannate, Acinate)

Methyl parathion (Penncap-M, Folidol-M, Metacide, Bladan M)

Oxamyl (Vydate L, Pratt)

Parathion (Roethyl-P, Alkron, Panthion, Phoskil)

Phorate (Thimet, Granutox, Geomet, Rampart)

Propoxur (Baygon, Blattanex, Unden, Proprotox)

alpha-HCH (*alpha*-BHC, *alpha*-lindane, *alpha*-hexachlorocyclohexane, *alpha*-benzene hexachloride)

cis-Permethrin (Ambush, Astro, Pounce, Pramex, Pertox, Ambushfog, Kafil, Perthrine, Picket, Picket G, Dragnet, Talcord, Outflank, Stockade, Eksmin, Coopex, Peregin, Stomoxin, Stomoxin P, Qamlin, Corsair, Tornade)

Volatile organic compounds

1,1,1,2-Tetrachloroethane (1,1,1,2-TeCA)

1,1,1-Trichloroethane (Methylchloroform)

1,1,2,2-Tetrachloroethane

1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113, CFC 113)

1,1,2-Trichloroethane (Vinyl trichloride)

1,1-Dichloroethene (Vinylidene chloride)

1,1-Dichloropropene

1,2,3-Trichlorobenzene (1,2,3-TCB)

1,2,3-Trichloropropane (Allyl trichloride)

1,2,4-Trichlorobenzene

1,2,4-Trimethylbenzene (Pseudocumene)

1,2-Dibromo-3-chloropropane (DBCP, Nemagon)

1,2-Dibromoethane (EDB, Ethylene dibromide)

1,2-Dichlorobenzene (*o*-Dichlorobenzene, 1,2-DCB)

1,2-Dichloroethane (Ethylene dichloride)

1,2-Dichloropropane (Propylene dichloride)

1,3,5-Trimethylbenzene (Mesitylene)

1,3-Dichlorobenzene (*m*-Dichlorobenzene)

1,3-Dichloropropane (Trimethylene dichloride)

1,4-Dichlorobenzene (*p*-Dichlorobenzene, 1,4-DCB)

1-Chloro-2-methylbenzene (*o*-Chlorotoluene)

1-Chloro-4-methylbenzene (*p*-Chlorotoluene)

2,2-Dichloropropane

Benzene

Bromobenzene (Phenyl bromide)

Bromochloromethane (Methylene chlorobromide)

Bromomethane (Methyl bromide)

Chlorobenzene (Monochlorobenzene)

Chloroethane (Ethyl chloride)

Chloroethene (Vinyl Chloride)

Chloromethane (Methyl chloride)

Dibromomethane (Methylene dibromide)

Dichlorodifluoromethane (CFC 12, Freon 12)

Dichloromethane (Methylene chloride)

Ethenylbenzene (Styrene)

Ethylbenzene (Phenylethane)

Hexachlorobutadiene

Isopropylbenzene (Cumene)

Methylbenzene (Toluene)

Naphthalene

Tetrachloroethene (Perchloroethene)

Tetrachloromethane (Carbon tetrachloride)

Total Trihalomethanes (Trichloromethane (Chloroform), Dibromochloromethane, Bromodichloromethane, Tribromomethane (Bromoform))

Trichlorofluoromethane (CFC 11, Freon 11)

cis-1,3-Dichloropropene ((Z)-1,3-Dichloropropene)

n-Butylbenzene (1-Phenylbutane)

n-Propylbenzene (Isocumene)

sec-Butylbenzene

tert-Butylbenzene

trans-1,2-Dichloroethene ((E)-1,2-Dichlorothene)

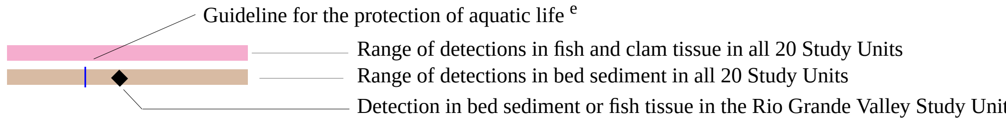
trans-1,3-Dichloropropene ((E)-1,3-Dichloropropene)

Nutrients

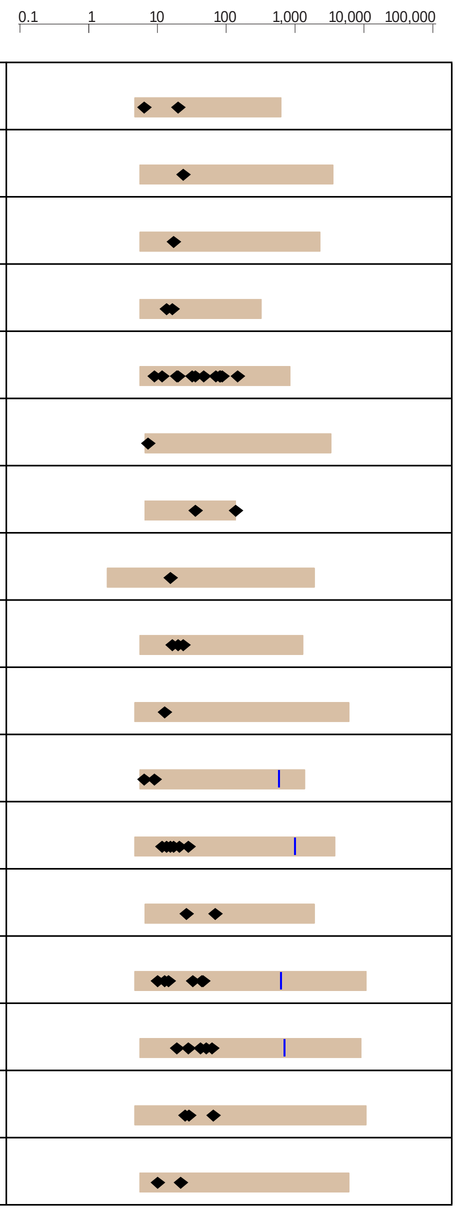
No non-detects

Concentrations of semivolatile organic compounds, organochlorine compounds, and trace elements detected in fish tissue and bed sediment of the Rio Grande Valley Study Unit. [µg/g, micrograms per gram; µg/kg, micrograms per kilogram; %, percent; <, less than; - - , not measured; trade names may vary]

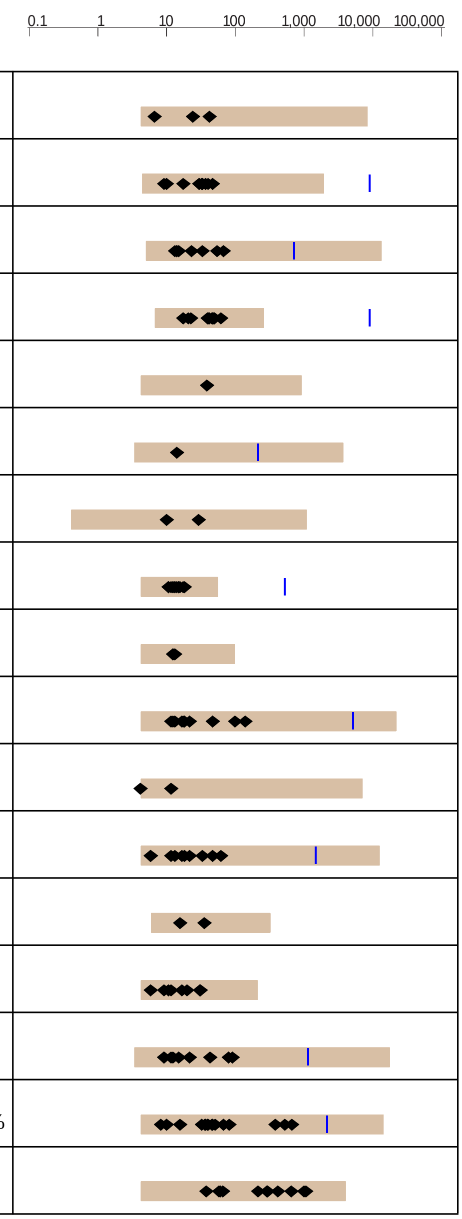
EXPLANATION



Semivolatile organic compound	Rate of detection [b]	Concentration, in µg/kg
1,6-Dimethylnaphthalene	-- 13%	
1-Methylphenanthrene	-- 6%	
1-Methylpyrene	-- 6%	
2,3,6-Trimethylnaphthalene	-- 13%	
2,6-Dimethylnaphthalene	-- 81%	
2-Methylanthracene	-- 6%	
3,5-Dimethylphenol	-- 13%	
4,5-Methylenephenanthrene	-- 6%	
9H-Carbazole	-- 19%	
9H-Fluorene	-- 6%	
Acenaphthylene	-- 13%	
Anthracene	-- 38%	
Anthraquinone	-- 13%	
Benz[*a*]anthracene	-- 38%	
Benzo[*a*]pyrene	-- 31%	
Benzo[*b*]fluoranthene	-- 19%	
Benzo[*ghi*]perylene	-- 13%	



Semivolatile organic compound	Rate of detection [b]	Concentration, in µg/kg
Benzo[*k*]fluoranthene	-- 19%	
Butylbenzylphthalate	-- 69%	
Chrysene	-- 50%	
Di- *n* -butylphthalate	-- 88%	
Di- *n* -octylphthalate	-- 6%	
Dibenz[*a,h*] anthracene	-- 6%	
Dibenzothiophene	-- 13%	
Diethylphthalate	-- 81%	
Dimethylphthalate	-- 19%	
Fluoranthene	-- 62%	
Indeno[1,2,3- *cd*] pyrene	-- 13%	
Phenanthrene	-- 62%	
Phenanthridine	-- 13%	
Phenol	-- 50%	
Pyrene	-- 56%	
bis(2-Ethylhexyl)phthalate	-- 100%	
p-Cresol	-- 69%	



Organochlorine compound (Trade name)	Rate of detection [b]	Concentration, in µg/kg (0.01, 0.1, 1, 10, 100, 1,000, 10,000, 100,000)
total-Chlordane	9% 0%	
PCB, total	45% 0%	
p,p'-DDE	91% 31%	
total-DDT	91% 31%	
gamma-HCH (lin-dane, *gamma*-BHC,	9% --	
Hexachlorobenzene	9% --	

Trace element	Rate of detection [b]	Concentration, in µg/g (0.01, 0.1, 1, 10, 100, 1,000, 10,000)
Arsenic	92% 100%	
Cadmium	83% 100%	
Chromium	75% 100%	
Copper	100% 100%	
Lead	17% 100%	
Mercury	75% 73%	
Nickel	50% 100%	
Selenium	100% 100%	
Zinc	100% 100%	

Semivolatile organic compounds, organochlorine compounds, and trace elements not detected in fish tissue and bed sediment of the Rio Grande Valley Study Unit.

Semivolatile organic compounds

1,2,4-Trichlorobenzene

1,2-Dichlorobenzene (*o*-Dichlorobenzene, 1,2-DCB)

1,2-Dimethylnaphthalene

1,3-Dichlorobenzene (*m*-Dichlorobenzene)

1,4-Dichlorobenzene (*p*-Dichlorobenzene, 1,4-DCB)

1-Methyl-9H-fluorene

2,2-Biquinoline

2,4-Dinitrotoluene

2,6-Dinitrotoluene

2-Chloronaphthalene

2-Chlorophenol

2-Ethylnaphthalene

4-Bromophenyl-phenylether

4-Chloro-3-methylphenol

4-Chlorophenyl-phenylether

Acenaphthene

Acridine

Azobenzene

Benzo [*c*] cinnoline

C8-Alkylphenol

Isophorone

Isoquinoline

N-Nitrosodi-n-propylamine

N-Nitrosodiphenylamine

Naphthalene

Nitrobenzene

Pentachloronitrobenzene

Quinoline

bis (2-Chloroethoxy)methane

Organochlorine compounds

Aldrin (HHDN, Octalene)

Chloroneb (chloronebe, Demosan, Soil Fungicide 1823)

DCPA (Dacthal, chlorthal-dimethyl)

Dieldrin (Panoram D-31, Octalox, Compound 497, Aldrin epoxide)

Endosulfan I (*alpha*-Endosulfan, Thiodan, Cyclodan, Beosit, Malix, Thimul, Thifor)

Endrin (Endrine)

Heptachlor epoxide (Heptachlor metabolite)

Heptachlor (Heptachlore, Velsicol 104)

Isodrin (Isodrine, Compound 711)

Mirex (Dechlorane)

Oxychlordane (Chlordane metabolite)

Pentachloroanisole (PCA, pentachlorophenol metabolite)

Total Trihalomethanes (Trichloromethane (Chloroform), Dibromochloromethane, Bromodichloromethane, Tribromomethane (Bromoform))

Toxaphene (Camphechlor, Hercules 3956)

alpha-HCH (*alpha*-BHC, *alpha*-lindane, *alpha*-hexachlorocyclohexane, *alpha*-benzene hexachloride)

beta-HCH (*beta*-BHC, *beta*-hexachlorocyclohexane, *alpha*-benzene hexachloride)

cis-Permethrin (Ambush, Astro, Pounce, Pramex, Pertox, Ambushfog, Kafil, Perthrine, Picket, Picket G, Dragnet, Talcord, Outflank, Stockade, Eksmin, Coopex, Peregin, Stomoxin, Stomoxin P, Qamlin, Corsair, Tornade)

delta-HCH (*delta*-BHC, *delta*-hexachlorocyclohexane, *delta*-benzene hexachloride)

o,p'-Methoxychlor

p,p'-Methoxychlor (Marlate, methoxychlore)

trans-Permethrin (Ambush, Astro, Pounce, Pramex, Pertox, Ambushfog, Kafil, Perthrine, Picket, Picket G, Dragnet, Talcord, Outflank, Stockade, Eksmin, Coopex, Peregin, Stomoxin, Stomoxin P, Qamlin, Corsair, Tornade)

Trace elements

No non-detects

[a] Selected water quality standards and guidelines (Gilliom and others, in press).

[b] Rates of detection are based on the number of analyses and detections in the Study Unit, not on national data. Rates of detection for herbicides and insecticides were computed by only counting detections equal to or greater than 0.01 µg/L to facilitate equal comparisons among compounds that had varying detection limits; a value of <1% signifies that there were only detections below, or <1% above, the 0.01 µg/L level. Some herbicides and insecticides were not reliably detected as low as the 0.01 µg/L level, so frequencies may be underestimated for some compounds. For other compound groups, all detections were counted and detection limits for most compounds were similar to the lower end of the national ranges shown. Method detection limits for all compounds in all groups are summarized in Gilliom and others, in press.

[c] Detections of these compounds are reliable, but concentrations are determined with greater uncertainty than for the other compounds and are reported as estimated values (Zaugg and others, 1995).

[d] The guideline for methyl *tert*-butyl ether is between 20 and 40 µg/L; if the tentative cancer classification C is accepted, the lifetime health advisory will be 20 µg/L (Gilliom and others, in press).

[e] Selected sediment quality guidelines (Gilliom and others, in press).

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The terms in this glossary were compiled from numerous sources. Some definitions have been modified and may not be the only valid ones for these terms.

Alluvial aquifer - A water-bearing deposit of unconsolidated material (sand and gravel) left behind by a river or other flowing water.

Anomalies - As related to fish, externally visible skin or subcutaneous disorders, including deformities, eroded fins, lesions, and tumors.

Anthropogenic - Occurring because of, or influenced by, human activity.

Aquatic-life criteria - Water-quality guidelines for protection of aquatic life. Often refers to U.S. Environmental Protection Agency water-quality criteria for protection of aquatic organisms. *See also* Water-quality guidelines and Water-quality criteria.

Aquifer - A water-bearing layer of soil, sand, gravel, or rock that will yield usable quantities of water to a well.

Basic Fixed Sites - Sites on streams at which streamflow is measured and samples are collected for temperature, salinity, suspended sediment, major ions and metals, nutrients, and organic carbon to assess the broad-scale spatial and temporal character and transport of inorganic constituents of streamwater in relation to hydrologic conditions and environmental settings.

Bed sediment and tissue studies - Assessment of concentrations and distributions of trace elements and hydrophobic organic contaminants in streambed sediment and tissues of aquatic organisms to identify potential sources and to assess spatial distribution.

Benthic - Refers to plants or animals that live on the bottom of lakes, streams, or oceans.

Bioaccumulation - The biological sequestering of a substance at a higher concentration than that at which it occurs in the surrounding environment or medium. Also, the process whereby a substance enters organisms through the gills, epithelial tissues, dietary, or other sources.

Bioavailability - The capacity of a chemical constituent to be taken up by living organisms either through physical contact or by ingestion.

Biodegradation - Transformation of a substance into new compounds through biochemical reactions or the actions of microorganisms such as bacteria.

Community - In ecology, the species that interact in a common area.

Concentration - The amount or mass of a substance present in a given volume or mass of sample. Usually expressed as microgram per liter (water sample) or micrograms per kilogram (sediment or tissue sample).

Confluence - The flowing together of two or more streams; the place where a tributary joins the main stream.

Constituent - A chemical or biological substance in water, sediment, or biota that can be measured by an analytical method.

Contamination - Degradation of water quality compared to original or natural conditions due to human activity.

Criterion - A standard rule or test on which a judgment or decision can be based.

Degradation products - Compounds resulting from transformation of an organic substance through chemical, photochemical, and/or biochemical reactions.

Detection limit - The concentration below which a particular analytical method cannot determine, with a high degree of certainty, a concentration.

DDT - Dichloro-diphenyl-trichloroethane. An organochlorine insecticide no longer registered for use in the United States.

Dissolved solids - Amount of minerals, such as salt, that are dissolved in water; amount of dissolved solids is an indicator of salinity or hardness.

Diversion - A turning aside or alteration of the natural course of a flow of water, normally considered physically to leave the natural channel. In some States, this can be a consumptive use direct from another stream, such as by livestock watering. In other States, a diversion must consist of such actions as taking water through a canal, pipe, or conduit.

Drainage basin - The portion of the surface of the Earth that contributes water to a stream through overland run-off, including tributaries and impoundments.

Drinking-water standard or guideline - A threshold concentration in a public drinking-water supply, designed to protect human health. As defined here, standards are U.S. Environmental Protection Agency regulations that specify the maximum contamination levels for public water systems required to protect the public welfare; guidelines have no regulatory status and are issued in an advisory capacity.

Ecological studies - Studies of biological communities and habitat characteristics to evaluate the effects of physical and chemical characteristics of water and hydrologic conditions on aquatic biota and to determine how biological and habitat characteristics differ among environmental settings in NAWQA Study Units.

Ecoregion - An area of similar climate, landform, soil, potential natural vegetation, hydrology, or other ecologically relevant variables.

Ecosystem - The interacting populations of plants, animals, and microorganisms occupying an area, plus their physical environment.

Effluent - Outflow from a particular source, such as a stream that flows from a lake or liquid waste that flows from a factory or sewage-treatment plant.

Environmental setting - Land area characterized by a unique combination of natural and human-related factors, such as row-crop cultivation or glacial-till soils.

Ephemeral stream - A stream or part of a stream that flows only in direct response to precipitation or snowmelt. Its channel is above the water table at all times.

Eutrophication - The process by which water becomes enriched with plant nutrients, most commonly phosphorus and nitrogen.

Evapotranspiration - A collective term that includes water lost through evaporation from the soil and surface-water bodies and by plant transpiration.

FDA action level - A regulatory level recommended by the U.S. Environmental Protection Agency for enforcement by the FDA when pesticide residues occur in food commodities for reasons other than the direct application of the pesticide. Action levels are set for inadvertent pesticide residues resulting from previous legal use or accidental contamination. Applies to edible portions of fish and shellfish in interstate commerce.

Fixed Sites - NAWQA's most comprehensive monitoring sites. *See also* Basic Fixed Sites and Intensive Fixed Sites.

Flood irrigation - The application of irrigation water where the entire surface of the soil is covered by ponded water.

Flood plain - The relatively level area of land bordering a stream channel and inundated during moderate to severe floods.

Ground water - In general, any water that exists beneath the land surface, but more commonly applied to water in fully saturated soils and geologic formations.

Habitat - The part of the physical environment where plants and animals live.

Health advisory - Nonregulatory levels of contaminants in drinking water that may be used as guidance in the absence of regulatory limits. Advisories consist of estimates of concentrations that would result in no known or anticipated health effects (for carcinogens, a specified cancer risk) determined for a child or for an adult for various exposure periods.

Herbicide - A chemical or other agent applied for the purpose of killing undesirable plants. *See also* Pesticide.

Human health advisory - Guidance provided by U.S. Environmental Protection Agency, State agencies or scientific organizations, in the absence of regulatory limits, to describe acceptable contaminant levels in drinking water or edible fish.

Index of Biotic Integrity (IBI) - An aggregated number, or index, based on several attributes or metrics of a fish community that provides an assessment of biological conditions.

Indicator sites - Stream sampling sites located at outlets of drainage basins with relatively homogeneous land use and physiographic conditions; most indicator-site basins have drainage areas ranging from 20 to 200 square miles.

Infiltration - Movement of water, typically downward, into soil or porous rock.

Insecticide - A substance or mixture of substances intended to destroy or repel insects.

Integrator or Mixed-use site - Stream sampling site located at an outlet of a drainage basin that contains multiple environmental settings. Most integrator sites are on major streams with relatively large drainage areas.

Intensive Fixed Sites - Basic Fixed Sites with increased sampling frequency during selected seasonal periods and analysis of dissolved pesticides for 1 year. Most NAWQA Study Units have one to two integrator Intensive Fixed Sites and one to four indicator Intensive Fixed Sites.

Intermittent stream - A stream that flows only when it receives water from rainfall runoff or springs, or from some surface source such as melting snow.

Intolerant organisms - Organisms that are not adaptable to human alterations to the environment and thus decline in numbers where human alterations occur. *See also* Tolerant species.

Irrigation return flow - The part of irrigation applied to the surface that is not consumed by evapotranspiration or uptake by plants and that migrates to an aquifer or surface-water body.

Land-use study - A network of existing shallow wells in an area having a relatively uniform land use. These studies are a subset of the Study-Unit Survey and have the goal of relating the quality of shallow ground water to land use. *See also* Study-Unit Survey.

Main stem - The principal course of a river or a stream.

Major ions - Constituents commonly present in concentrations exceeding 1.0 milligram per liter. Dissolved cations generally are calcium, magnesium, sodium, and potassium; the major anions are sulfate, chloride, fluoride, nitrate, and those contributing to alkalinity, most generally assumed to be bicarbonate and carbonate.

Maximum contaminant level (MCL) - Maximum permissible level of a contaminant in water that is delivered to any user of a public water system. MCL's are enforceable standards established by the U.S. Environmental Protection Agency.

Mean discharge (MEAN) - The arithmetic mean of individual daily mean discharges during a specific period, usually daily, monthly, or annually.

Median - The middle or central value in a distribution of data ranked in order of magnitude. The median is also known as the 50th percentile.

Method detection limit - The minimum concentration of a substance that can be accurately identified and measured with present laboratory technologies.

Micrograms per liter (μg/L) - A unit expressing the concentration of constituents in solution as weight (micrograms) of solute per unit volume (liter) of water; equivalent to one part per billion in most streamwater and ground water. One thousand micrograms per liter equals 1 mg/L.

Milligrams per liter (mg/L) - A unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water; equivalent to one part per million in most streamwater and ground water. One thousand micrograms per liter equals 1 mg/L.

Minimum reporting level (MRL) - The smallest measured concentration of a constituent that may be reliably reported using a given analytical method. In many cases, the MRL is used when documentation for the method detection limit is not available.

Monitoring well - A well designed for measuring water levels and testing ground-water quality.

Nonpoint source - A pollution source that cannot be defined as originating from discrete points such as pipe discharge. Areas of fertilizer and pesticide applications, atmospheric deposition, manure, and natural inputs from plants and trees are types of nonpoint source pollution.

Nutrient - Element or compound essential for animal and plant growth. Common nutrients in fertilizer include nitrogen, phosphorus, and potassium.

Occurrence and distribution assessment - Characterization of the broad-scale spatial and temporal distributions of water-quality conditions in relation to major contaminant sources and background conditions for surface water and ground water.

Organochlorine compound - Synthetic organic compounds containing chlorine. As generally used, term refers to compounds containing mostly or exclusively carbon, hydrogen, and chlorine. Examples include organochlorine insecticides, polychlorinated biphenyls, and some solvents containing chlorine.

Pesticide - A chemical applied to crops, rights of way, lawns, or residences to control weeds, insects, fungi, nematodes, rodents or other "pests".

Point-source contaminant - Any substance that degrades water quality and originates from discrete locations such as discharge pipes, drainage ditches, wells, concentrated livestock operations, or floating craft.

Pollutant - Any substance that, when present in a hydrologic system at sufficient concentration, degrades water quality in ways that are or could become harmful to human and/or ecological health or that impair the use of water for recreation, agriculture, industry, commerce, or domestic purposes.

Polychlorinated biphenyls (PCBs) - A mixture of chlorinated derivatives of biphenyl, marketed under the trade name Aroclor with a number designating the chlorine content (such as Aroclor 1260). PCBs were used in transformers and capacitors for insulating purposes and in gas pipeline systems as a lubricant. Further sale for new use was banned by law in 1979.

Polycyclic aromatic hydrocarbon (PAH) - A class of organic compounds with a fused-ring aromatic structure. PAHs result from incomplete combustion of organic carbon (including wood), municipal solid waste, and fossil fuels, as well as from natural or anthropogenic introduction of uncombusted coal and oil. PAHs include benzo(a)pyrene, fluoranthene, and pyrene.

Radon - A naturally occurring, colorless, odorless, radioactive gas formed by the disintegration of the element radium; damaging to human lungs when inhaled.

Riparian - Areas adjacent to rivers and streams with a high density, diversity, and productivity of plant and animal species relative to nearby uplands.

Secondary maximum contaminant level (SMCL) - The maximum contamination level in public water systems that, in the judgment of the U.S. Environmental Protection Agency, are required to protect the public welfare. SMCLs are secondary (nonenforceable) drinking water regulations established by the USEPA for contaminants that may adversely affect the odor or appearance of such water.

Sediment quality guideline - Threshold concentration above which there is a high probability of adverse effects on aquatic life from sediment contamination, determined using modified EPA (1996c) procedures.

Semivolatile organic compound (SVOC) - Operationally defined as a group of synthetic organic compounds that are solvent-extractable and can be determined by gas chromatography/mass spectrometry. SVOCs include phenols, phthalates, and polycyclic aromatic hydrocarbons (PAHs).

Species diversity - An ecological concept that incorporates both the number of species in a particular sampling area and the evenness with which individuals are distributed among the various species.

Specific conductance - A measure of the ability of a liquid to conduct an electrical current.

Stream-aquifer interactions - Relations of water flow and chemistry between streams and aquifers that are hydraulically connected.

Stream reach - A continuous part of a stream between two specified points.

Study Unit - A major hydrologic system of the United States in which NAWQA studies are focused. Study Units are geographically defined by a combination of ground- and surface-water features and generally encompass more than 4,000 square miles of land area.

Study-Unit Survey - Broad assessment of the water-quality conditions of the major aquifer systems of each Study Unit. The Study-Unit Survey relies primarily on sampling existing wells and, wherever possible, on existing data collected by other agencies and programs. Typically, 20 to 30 wells are sampled in each of three to five aquifer subunits.

Subsurface drain - A shallow drain installed in an irrigated field to intercept the rising ground-water level and maintain the water table at an acceptable depth below the land surface.

Suspended (as used in tables of chemical analyses) - The amount (concentration) of undissolved material in a water- sediment mixture. It is associated with the material retained on a 0.45- micrometer filter.

Synoptic sites - Sites sampled during a short-term investigation of specific water-quality conditions during selected seasonal or hydrologic conditions to provide improved spatial resolution for critical water-quality conditions.

Tissue study - The assessment of concentrations and distributions of trace elements and certain organic contaminants in tissues of aquatic organisms.

Trace element - An element found in only minor amounts (concentrations less than 1.0 milligram per liter) in water or sediment; includes arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc.

Urban Site - A site that has greater than 50 percent urbanized and less than 25 percent agricultural area.

Volatile organic compounds (VOCs) - Organic chemicals that have a high vapor pressure relative to their water solubility. VOCs include components of gasoline, fuel oils, and lubricants, as well as organic solvents, fumigants, some inert ingredients in pesticides, and some by-products of chlorine disinfection.

Wasteway - A waterway used to drain excess irrigation water dumped from the irrigation delivery system.

Water-quality criteria - Specific levels of water quality which, if reached, are expected to render a body of water unsuitable for its designated use. Commonly refers to water-quality criteria established by the U.S. Environmental Protection Agency. Water-quality criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.

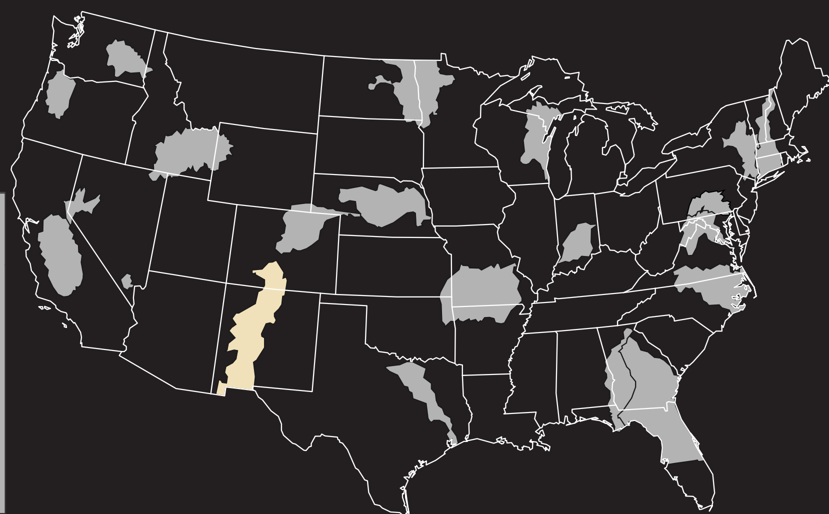
Water-quality guidelines - Specific levels of water quality which, if reached, may adversely affect human health or aquatic life. These are nonenforceable guidelines issued by a governmental agency or other institution.

Water-quality standards - State-adopted and U.S. Environmental Protection Agency-approved ambient standards for water bodies. Standards include the use of the water body and the water-quality criteria that must be met to protect the designated use or uses.

Water table - The point below the land surface where ground water is first encountered and below which the earth is saturated. Depth to the water table varies widely across the country.

NAWQA

National Water-Quality Assessment (NAWQA) Program
Rio Grande Valley



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