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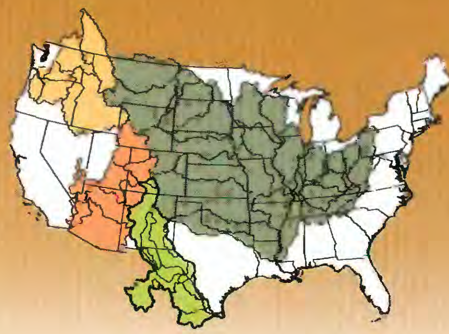

Monitoring the Water Quality of the Nation's Large Rivers

Rio Grande NASQAN Program

The U.S. Geological Survey (USGS) has monitored the water quality in the Rio Grande Basin as part of the redesigned National Stream Quality Accounting Network (NASQAN) since 1995 (Hooper and others, 1997). The NASQAN program was designed to characterize the concentrations and transport of sediment and selected chemical constituents found in the Nation's large rivers—including the Mississippi, Colorado, and Columbia in addition to the Rio Grande. In these four basins, the USGS currently (1998) operates a network of 40 NASQAN sites, with an emphasis on quantifying the mass flux for each constituent (the amount of material moving past the site, expressed in tons per day).

By applying a consistent flux-based approach in the Rio Grande Basin, the NASQAN program is generating the information needed to identify regional sources for a variety of constituents, including agricultural chemicals and trace elements, in the basin. The effect of the large reservoirs on the Rio Grande can be observed as constituent fluxes are routed downstream. The analysis of constituent fluxes on a basin-wide scale will provide the means to assess the influence of human activity on water-quality conditions in the Rio Grande.

Environmental Setting

The Rio Grande originates in the San Juan Mountains of southern Colorado and follows a 1,885-mile course before it flows into the Gulf of Mexico (fig. 1). Along the way, the river and its tributaries drain a land area of 182,200 square miles. This drainage encompasses a widely varied landscape in the United States and Mexico, including mountains, forests, and deserts. The basin is home to diverse native plants and wildlife as well as some 10 million people—8 million in Mexico alone. For approximately two-thirds of its course, the river also serves as the boundary between the United States and Mexico.

In this mostly arid to semiarid region, the absence of flow in the river as well as the presence of flow determines the basin's character. Many of the river tributaries are intermittent streams. Much of the flow is controlled by numerous reservoirs in the basin. Throughout the basin, an extensive system of water structures captures and controls the flow of water in the subbasins to meet regional needs for flood control, power generation, and storage for domestic, agricultural, and industrial purposes. Irrigation withdrawals from the Rio Grande (in the lower Rio Grande Valley, which comprises Cameron, Hildalgo, Starr, and Willacy Counties) accounted for about 44 percent of the surface-water irrigation withdrawals in Texas during 1994 (Texas Water Development Board, 1996).

Site Selection

Eight NASQAN sampling sites (fig. 1, table 1) were selected in the Rio Grande Basin to monitor the fluxes from subbasins. Sites were located specifically to measure inflow and outflow of material from the two main-stem reservoirs (Amistad International and Falcon International) that strongly affect the flux of chemical constituents and sediment in the Rio Grande. Land use in the subbasins is dominated by rangeland, with forest, agricultural, and urban areas constituting the remainder (Texas Natural Resource Conservation Commission, 1994, fig. 1.2). In descriptions of each site below, the numbers in parentheses correspond to site numbers in figure 1 and table 1.

Rio Grande at El Paso (1) reflects drainage of the entire Rio Grande main stem in Colorado and New Mexico. The site at El Paso is 125 river miles downstream of Elephant Butte Reservoir in New Mexico and 1.7 miles upstream of the American Dam at El Paso. Streamflow in the Rio Grande at El Paso is controlled largely by releases from Elephant Butte Reservoir. At American Dam, much of the flow in the Rio Grande is diverted for irrigation and municipal uses to the American Canal in Texas and the Acequia Madre Canal in Mexico. Downstream of El Paso/Ciudad Juárez, the Rio Grande has little or no flow until the waters of the Río Conchos, which originates in the Sierra Madre Occidental in Mexico, join the river near Presidio/Ojinaga.

Rio Grande at Foster Ranch near Langtry (2) is approximately 600 miles downstream of El Paso and 300 miles downstream of the confluence of the Rio Grande and Río Conchos. Because much of the water reaching El Paso is diverted, streamflow at Foster Ranch is largely from the Río Conchos. This site, in conjunction with the Pecos River site, provides data to describe the flux of constituents and sediment into Amistad International Reservoir.

Table 1. Description of NASQAN sampling sites in the Rio Grande Basin

[--, not applicable]

Site no. (fig. 1)	Name	Drainage area (square miles)	Incremental increase in drainage area (square miles)	Mean streamflow (cubic feet per second)	Incremental increase/ decrease in streamflow (cubic feet per second)
1	Rio Grande at El Paso, Tex.	29,267	0	640	640
2	Rio Grande at Foster Ranch near Langtry, Tex.	80,742	51,475	1,946	1,306
3	Pecos River near Langtry, Tex.	35,179	0	262	262
4	Rio Grande below Amistad Dam near Del Rio, Tex.	123,143	42,401	2,510	302
5	Rio Grande below Laredo, Tex.	132,578	9,435	3,433	923
6	Rio Grande below Falcon Dam, Tex.	159,270	26,692	3,223	-210
7	Arroyo Colorado at Harlingen, Tex.	182	--	247	--
8	Rio Grande near Brownsville, Tex.	176,333	17,063	2,226	-997

Pecos River near Langtry (3) is on the Pecos River approximately 15 miles upstream of its confluence with the Rio Grande. The Pecos River is the major tributary to the Rio Grande within the United States. The Pecos River originates in the mountains of northern New Mexico, flows southward through eastern New Mexico, and empties into Red Bluff Reservoir at the Texas-New Mexico border. The flow of the Pecos River at Langtry has been regulated by this reservoir since 1937. The Pecos River joins the Rio Grande at the upstream end of Amistad International Reservoir.

Rio Grande below Amistad Dam near Del Rio (4). Water in Amistad International Reservoir has a mean residence time of about 1.6 years, which allows for numerous chemical, physical, and biological processes to alter the quality of the inflowing water. These processes include deposition of sediment, evaporative concentration of solutes, and biological removal of nutrients. This site provides data on the outflow from the reservoir, which can be compared to data on the inflow to assess the effect of retention and transformation of material within the reservoir.

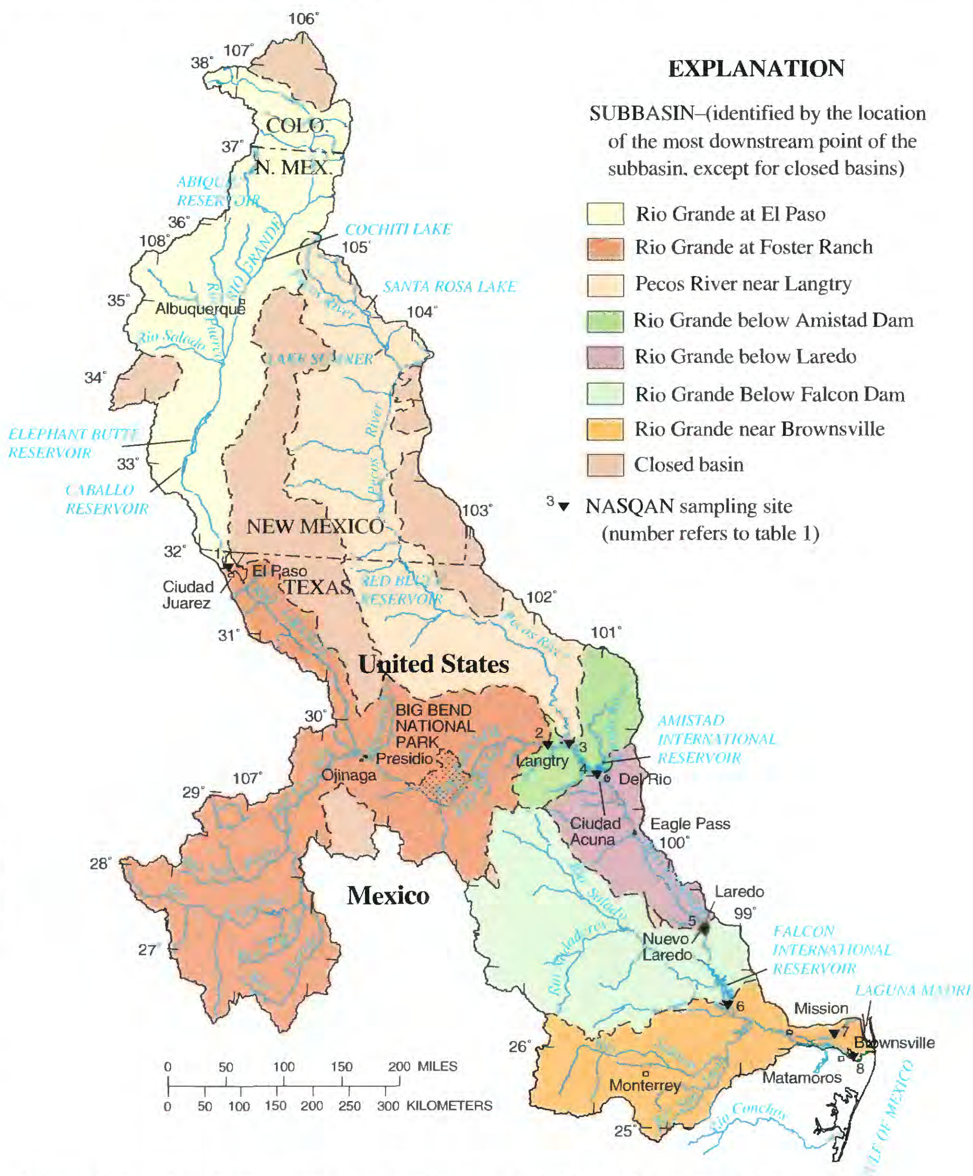

Figure 1. Rio Grande Basin showing subbasins and NASQAN sampling sites.

Rio Grande below Laredo (5). About 37 percent of the water that discharges from the Rio Grande Basin enters the river between the Amistad International Reservoir and Laredo. This reach also has large centers of population and industry that could affect water quality. This site provides data to account for the inflow of chemical constituents and sediment from this major subbasin to the Rio Grande and to describe the quality of inflow to Falcon International Reservoir.

Rio Grande below Falcon Dam (6) is 2.5 miles downstream of Falcon Dam. The Río Salado in Mexico, which joins the Rio Grande at the upstream end of Falcon International Reservoir, is the major tributary to this reach. This site provides data on the retention and transformation of materials transported into Falcon International Reservoir.

Arroyo Colorado at Harlingen (7) and **Rio Grande near Brownsville** (8) reflect the total outflow of the Rio Grande to the Laguna Madre and the Gulf of Mexico. These sites reflect runoff from the principal agricultural area in the Rio Grande Basin. At Anzalduas Dam near Mission, Tex., much of the flow in the Rio Grande is diverted into the Anzalduas Canal for irrigation. On the U.S. side of the basin downstream of Anzalduas Dam, almost all the water withdrawn from the Arroyo Colorado or the Rio Grande for irrigation and municipal purposes is returned to the Arroyo Colorado. The Arroyo Colorado drains into the Laguna Madre, which effectively becomes an estuary for the Rio Grande during spring and summer irrigation seasons.

Sampling Strategy

Constituents measured as a part of the NASQAN program include major nutrients and carbon, suspended and dissolved trace elements such as copper, lead, and zinc, many common water-soluble pesticides such as atrazine and metalochlor, and suspended sediment. Frequency of sampling ranges from 6 to 10 times per year depending on local site characteristics. In the upper Rio Grande Basin, flow generally peaks in the early summer. In the middle and lower regions of the basin, flow is controlled primarily by releases from Amistad International and Falcon International Reservoirs. Because these reservoir releases are dictated largely by irrigation needs, streamflow in the middle and lower basin tends to be more evenly distributed than that in the upper basin and peak flows typically occur in the late summer and early fall. The sampling strategy is to assess water-quality conditions throughout the range of flows, with an emphasis on high flows. The strategy will be adjusted as the program progresses in an iterative process as more is learned about patterns of concentrations and fluxes throughout the basin.

Water-Quality Issues

Until recently, few studies had examined the water quality of the entire Rio Grande Basin in detail. In general, the water is of good quality in the upper parts of the basin, but the quality decreases as the water moves downstream.The decrease in downstream quality of water generally is associated with large quantities of agricultural return flow, a lack of effective wastewater treatment, and extensive year-round agriculture in the lower basin.

Salinity has long been recognized as a major water-quality problem throughout the Rio Grande Basin. In some places, the water is not suitable for drinking or for irrigation. A common measure of salinity is the concentration of dissolved solids, which is large (generally greater than 1,000 milligrams per liter) below El Paso. These large concentrations can be attributed to natural saline springs, irrigation return flows, and evaporation during the summer months.

Metals also could be present in the Rio Grande because of extensive mining in New Mexico and in the Río Conchos Basin in Mexico. The rapid development of *maquiladoras* (assembly plants in Mexico) also could contribute to trace element concentrations in the lower Rio Grande Basin (Texas Natural Resource Conservation Commission, 1994). Historical data for riverbed sediments in the Rio Grande indicate increasing temporal trends in more trace elements in the reaches of the river near El Paso and Laredo than in other reaches, which could be related to human activities within the subbasins upstream of El Paso and Laredo (Lee and Wilson, 1997).

Numerous pesticides could be present in the waters of the lower Rio Grande Basin. The presence of pesticides would be a likely consequence of the large variety of crops grown year-round in the basin and the fact that irrigation water commonly returns to the streams.

Questions NASQAN Data Might Answer

Specific questions regarding the Rio Grande Basin that NASQAN data might answer include:

- What are the sources for the high salinity in the Rio Grande Basin? Are the salinity-control programs developed by the Texas Natural Resource Conservation Commission (TNRCC) and Pecos River Commission (Texas Natural Resource Conservation Commission, 1994) helping to decrease the dissolved solids concentrations in the Pecos River?

Irrigation in the Lower Rio Grande Valley (TNRCC photo)

Elephant Butte Reservoir on the Rio Grande, New Mexico

- What pesticides are present in the waters of the Rio Grande Basin? What are the major source areas for the pesticides? Do observed concentrations exceed or approach health advisories or maximum contaminant levels established by the U.S. Environmental Protection Agency?
- What associations can be observed between mining and industrial activities in the Rio Grande Basin and concentrations of trace elements within the river system?

Relation to other USGS Water-Quality Programs

The NASQAN program and the USGS NAWQA (National Water-Quality Assessment) program, which involves intensive water-quality studies in smaller areas called study units, are complementary (Hooper and others, 1997). Comparable data are collected in both programs. A central feature of the NAWQA program is an examination of the effect of land use on water quality. The USGS recently has completed a high-intensity sampling phase for the NAWQA in the upper Rio Grande Basin (upstream of El Paso) (Levings and others, 1998). The Upper Rio Grande NAWQA, with its study of cause-and-effect relations between land use and water quality within a part of the larger regional NASQAN setting, exemplifies the complementary nature of the NASQAN and NAWQA programs. Findings from NAWQA studies might be used to develop regional models that address the influence of land use on water quality in NASQAN basins.

Work is being done by the USGS in cooperation with the TNRCC Clean Rivers Program to study the occurrence and distribution of dissolved hydrophobic organic compounds such as organochlorine pesticides and polychlorinated biphenyls (PCBs) within the Rio Grande Basin (J.B. Moring, U.S. Geological Survey, written commun., 1998). A new method, the semi-permeable membrane device (SPMD), is being used to assess the occurrence of selected organic compounds in streams. SPMDs simulate the exposure to and passive uptake of highly lipid-soluble organic compounds by biological membranes and concentrate such compounds above ambient concentrations in water. The small concentrations of the compounds in streams might not be detected by traditional sampling methods.

The USGS has included the Rio Grande Basin as one of the study areas for the Biomonitoring of Environmental Status and Trends (BEST) program (Tim Bartish, U.S. Geological Survey, written commun., 1997). Fish tissues and fluid were collected during fall 1997 at all eight Rio Grande NASQAN sites for biomarker assessment. Biomarkers are physiological changes in an organism that indicate exposure to a chemical. The information from the BEST program will indicate how fish are affected by water quality in various reaches of the basin (Tim Bartish, U.S. Geological Survey, written commun., 1997).

In 1995, the USGS, in cooperation with various State and local agencies, collected bottom-sediment cores from Elephant Butte, Amistad International, and Falcon International Reservoirs as part of a study to assess historical changes in surface-water quality in the Rio Grande Basin (Van Metre and others, 1997). Concentrations of trace elements and some persistent pesticides and organic compounds in bottom sediments, in many cases, can provide a partial historical record of water quality.

Products of the NASQAN Program

Data from the Rio Grande NASQAN are published annually in the USGS water resources data for Texas reports (for example, Gandara and others, 1997). Additionally, NASQAN data from the Rio Grande Basin (and the Mississippi, Colorado, and Columbia Basins) are being released electronically on the World Wide Web at http://water.usgs.gov/public/nasqan.

After the initial 3 to 5 years of data collection have been completed and baseline concentrations have been established for the measured constituents in the basin, the Rio Grande NASQAN program might be altered to more closely examine specific water-quality issues.

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