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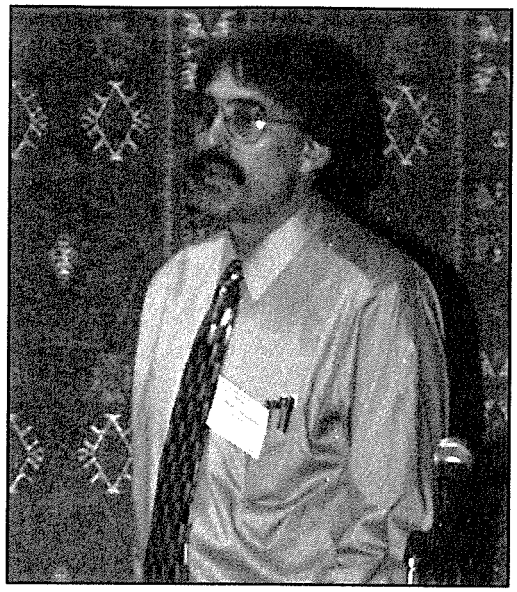

U.S. Geological Survey Seepage Investigations of the Lower Rio Grande in the Mesilla Valley

Introduction

Good afternoon. My presentation today is a summary of results from U.S. Geological Survey (USGS) seepage investigations of the Lower Rio Grande in the Mesilla Valley (Figure 1). The Mesilla Valley is located in Doña Ana County, New Mexico, and El Paso County, Texas. The Mesilla Basin monitoring program, established in 1987, is conducted by the USGS in cooperation with local, state, and federal agencies including the Elephant Butte Irrigation District, El Paso County Water Improvement District No. 1, Las Cruces Utilities, El Paso Water Utilities, New Mexico State University, New Mexico Office of the State Engineer, International Boundary and Water Commission-U.S. Section, and Bureau of Reclamation. The objective of the Mesilla Basin monitoring program is to document hydrologic conditions within the Mesilla groundwater basin and establish a long-term data base to permit future quantitative evaluation of the groundwater flow system and stream-aquifer relations. One of the work elements of the Mesilla Basin monitoring program is the Rio Grande seepage investigations. The purpose of the seepage investigations is to identify stream-aquifer relations and document associated water quality at low flow.

The City of El Paso, Texas, currently obtains approximately 43 percent of its municipal water supply from the Rio Grande. However, El Paso surface-water treatment plants do not process river water during the nonirrigation season (winter months) at low flows, when relatively high concentrations of salinity occur. Recent water management strategies have focused on possible year-round surface-water deliveries from the Rio Grande for municipal water use. River seepage and associated water quality during low-flow periods are important factors when considering winter surface-water deliveries.

Seepage Investigations

The USGS conducted seepage investigations of the Lower Rio Grande in the Mesilla Valley during water years 1988 through 1998. The 62.4-mile reach of investigation (Figure 1) starts at the Rio Grande below Leasburg Dam near Radium Springs, New Mexico (site 1), and ends at the Rio Grande at El Paso, Texas (site 34). Seepage investigation results for water years 1988 through 1992 are presented in Nickerson (1995). Results of individual seepage investigations and associated water-quality analyses were published by water year in USGS Water-Data Reports for New Mexico.

The seepage investigations were conducted under steady streamflow conditions at low flows during the nonirrigation season (winter); typically in January. Starting in 1993, small winter releases from Caballo Reservoir (44 miles upstream) provided an opportunity to conduct the investigations at low flows during scheduled winter releases. No diver-

USGS Seepage Investigations of the Lower Rio Grande in the Mesilla Valley

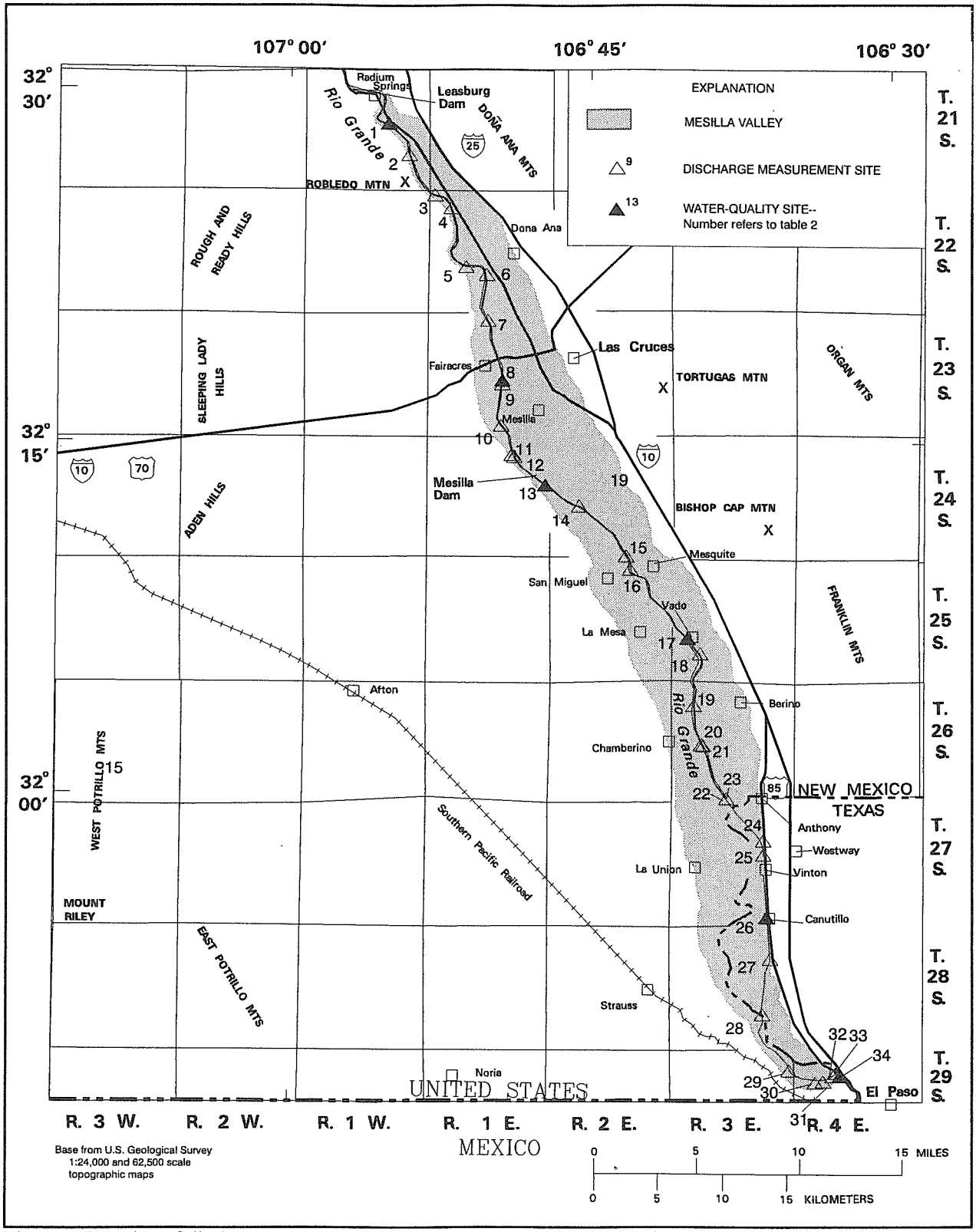

Figure 1. Location of discharge measurement sites and water-quality sites during seepage investigations of the Rio Grande from Radium Springs, New Mexico, to El Paso, Texas, water years 1988 through 1998 (modified from Nickerson, 1995, Fig. 8)

sions (side-channel outflow) occurred during the seepage investigations, and evaporation from the water surface of the river in January is considered negligible.

Discharge was measured at 34 surface-water sites (Figure 1): Rio Grande main-stem discharge was measured at 22 sites, and tributary discharge (side-channel inflow) was measured at 12 sites. Water-quality samples were collected at six main-stem sites (Figure 1) for chemical analyses to determine dissolved-solids concentrations (salinity) and concentrations of major ions, nutrients, and selected trace elements.

Figure 2 shows indicated gain or loss of streamflow during seepage investigations of the Rio Grande from Radium Springs, New Mexico to El Paso, Texas water years 1988 through 1998. The seepage results represent gain or loss of streamflow through the riverbed. Cumulative gain or loss, in cubic feet per second (ft^3/s), is shown by river mile and site number. Individual seepage investigations are identified by various symbols with corresponding dates in the explanation. Seepage gains generally occurred in the upper reach (13.5 miles) from site 1 Rio Grande below Leasburg Dam, New Mexico to site 7 Rio Grande near Picacho, New Mexico. The Rio Grande is predominantly a losing stream along the remaining reach in the Mesilla Valley. Relatively large seepage losses occurred in the upper-middle reach (9.3 miles) from site 7 to site 13 Rio Grande below Mesilla Dam, New Mexico. Slight gains and losses occurred along the middle reach (24.8 miles) from site 13 to site 25 Rio Grande at Vinton Bridge near Vinton, Texas. Relatively mod-erate losses occurred in the lower reach (14.8 miles) from site 25 to site 34 Rio Grande at El Paso, Texas.

Table 1 is a summary of all Rio Grande seepage investigation results from Radium Springs, New Mexico to El Paso, Texas water years 1988 through 1998. Net seepage losses occurred during all seepage investigations. Recorded seepage losses ranged from 7.2 ft^3/s on January 10-11, 1989 to 78 ft^3/s on January 28-29, 1997.

Five of the seepage investigations shown in Table 1 were conducted at low flow with no winter releases. These investigations occurred in 1989 through 1991 and in 1995. Seepage investigation results on December 17, 1991 were reported for the upstream reach only, from Radium Springs to Vado, New Mexico. Net seepage losses from Radium Springs, New Mexico to El Paso, Texas at low flow with no winter releases ranged from 7.2 ft^3/s on January 10-11, 1989 to 42.3 ft^3/s on January 8-9, 1991. The average net seepage loss was 25.0 ft^3/s with an average initial streamflow of 40.4 ft^3/s at site 1.

Six of the seepage investigations shown in Table 1 were conducted at low flow during various winter releases in 1988, 1993, 1994, 1996, 1997, and 1998. Net seepage losses during winter releases ranged from 26.1 ft^3/s on January 5-6, 1988 to 78 ft^3/s on January 28-29, 1997; initial streamflow ranged from 95.1 to 331 ft^3/s at site 1. Net seepage losses generally were greater during winter releases at higher flows.

Tributary flow was greater than net seepage losses during the seepage investigations. Tributary flow is predominantly from irrigation drains in the downstream reach from Vado, New Mexico to El Paso, Texas.

Water Quality

Water-quality samples were collected from the Rio Grande at six sites (Figure 1) in conjunction with the seepage investigations. Field determinations included specific conductance, pH, temperature, dissolved oxygen, and alkalinity. River samples were collected and processed for chemical analyses to determine dissolved-solids concentrations (salinity) and concentrations of major ions, nutrients, and selected trace elements. Water-quality analyses are stored in the USGS National Water Information System (NWIS) data base. Table 2 provides a list of the selected water-quality sites sampled during the seepage investigations including the USGS water-quality station number and location information.

Table 3 provides a summary of water-quality analyses of samples collected from the Rio Grande during seepage investigations, water years 1988 through 1998. The summary table represents 2,786 analyses of selected field properties and analytes. The summary table lists the property or analyte, the unit of measurement, the number of samples, the minimum value and site(s), and the maximum value and site(s). Also included are the U.S. Environmental Protection Agency (EPA) drinking-water standards: maximum contaminant levels (MCLs); secondary maximum contaminant levels (SMCLs); and lifetime health advisories (HAs). The EPA drinking-water standards are listed for comparison only. Drinking-water standards apply to finished (treated) drinking water delivered to a public water system, and do not apply to raw river water.

The selected analytes did not exceed the MCLs or the HAs in samples collected during the seepage investigations. Only four selected analytes exceeded the SMCLs. The SMCLs are nonenforceable federal guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. Field determinations of pH exceeded the SMCL upper limit of 8.5 in 6 of 54 samples.

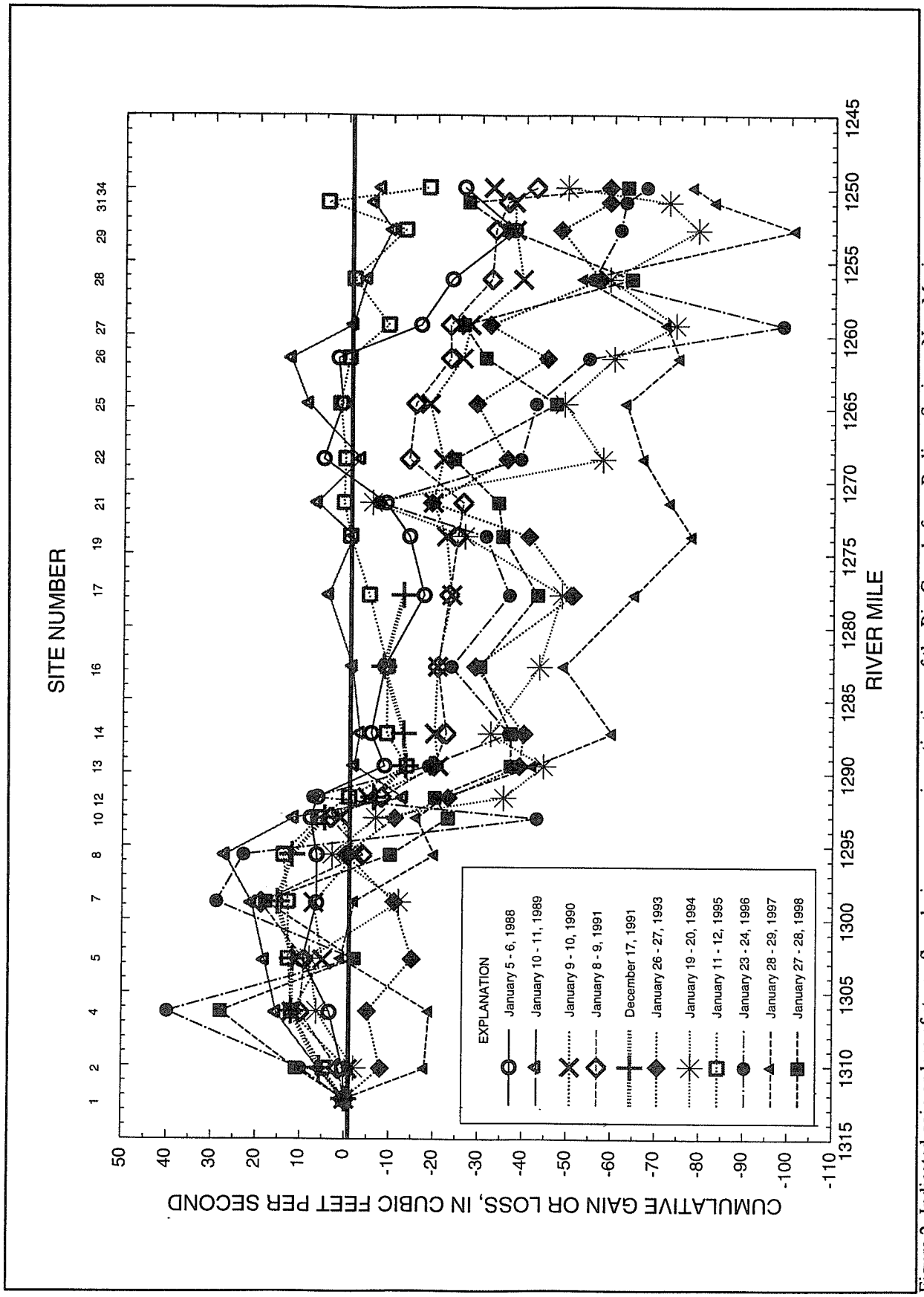

Figure 2. Indicated gain or loss of streamflow during seepage investigations of the Rio Grande from Radium Springs, New Mexico to El Paso, Texas water years 1988 through 1998 (modified from Nickerson, 1995, Fig. 9).

Table 1.--Summary of Rio Grande seepage investigation results from Radium Springs, New Mexico, to El Paso, Texas, water years 1988 through 1998

[--, not applicable]

Date	Discharge, in cubic feet per second		
	Initial streamflow[1]	Tributary flow[2]	Seepage gain (+) or loss (-)[3]
1/5-6/88	95.1	125	-26.1
1/10-11/89	33.1	104	-7.2
1/9-10/90	37.8	92.3	-32.5
1/8-9/91	38.4	93.1	-42.3
12/17/91	43.2	--	--
1/26-27/93	189	106	-59
1/19-20/94	187	97.5	-49.4
1/11-12/95	52.2	112	-18.1
1/23-24/96	313	99.4	-67.3
1/28-29/97	331	82.1	-78
1/27-28/98	326	93.1	-63

[1]Instantaneous streamflow at discharge measurement site 1 Rio Grande below Leasburg Dam approximately 1.5 miles southeast of Radium Springs, New Mexico.

[2]Tributary flow recorded as side-channel inflow from irrigation drains and wastewater-treatment plants is considered a contribution, not a gain. No side-channel outflow (diversions) occurred during the seepage investigation.

[3]Net seepage gain or loss through the riverbed. Evaporation from the river in January is considered negligible.

Table 2.--Selected water-quality sites sampled during seepage investigations of the Rio Grande from Radium Springs, New Mexico, to El Paso, Texas, water years 1988 through 1998

Site number (fig. 1)	River mile	U.S. Geological Survey water-quality station		Sample location	
		Number	Name	Latitude	Longitude
1	1,312.3	322841106551010	Rio Grande below Leasburg Dam, N. Mex.	32°28'41"	106°55'10"
8	1,295.6	321745106492510	Rio Grande below Picacho Bridge near Las Cruces, N. Mex.	32°17'45"	106°49'25"
13	1,289.5	321317106471510	Rio Grande below Mesilla Dam near Santo Tomas, N. Mex.	32°13'17"	106°47'15"
17	1,277.8	320648106400510	Rio Grande at NM-227 Bridge near Vado, N. Mex.	32°06'48"	106°40'05"
26	1,261.6	315454106360610	Rio Grande at TX-259 Bridge, Cañutillo, Tex.	31°54'54"	106°36'06"
34	1,249.9	08364000	Rio Grande at El Paso, Tex.	31°48'10"	106°32'25"

Dissolved-solids concentrations exceeded the SMCL of 500 milligrams per liter (mg/L) in all 65 samples; the minimum concentration was 509 mg/L at site 8 on January 23, 1996 (winter release), the maximum concentration was 1,400 mg/L at site 34 on January 10, 1990 (no release). Dissolved-solids concentrations exceeded 1,000 mg/L in 23 of 65 samples, and generally increased downstream. Samples at the Rio Grande at El Paso, Texas (site 34) exceeded 1,000 mg/L at a discharge of 230 ft^3/s or less.

Sulfate concentrations exceeded the SMCL of 250 mg/L in 38 of 65 samples; the minimum concentration was 140 mg/L at site 1 on January 23, 1996 (winter release), and the maximum concentration was 470 mg/L at site 34 on January 11, 1989 (no release). Sulfate concentrations exceeded 250 mg/L in samples collected at low flow with no winter release. Sulfate concentrations usually were less than 250 mg/L in samples collected at low flow during winter releases, with the exception of January 5-6, 1988 (small winter release).

Manganese concentrations exceeded the SMCL of 50 micrograms per liter (µg/L) in 5 of 65 samples; the minimum concentration was 2 µg/L at sites 1, 8, and 17; and the maximum concentration was 100 µg/L at site 34 on January 11, 1989. Manganese concentrations exceeded 50 µg/L at site 34 in four samples collected in 1988 through 1991. EPA drinking-water standards include many more analytes that were not sampled for during the seepage investigations.

Summary

Rio Grande seepage investigations were conducted during water years 1988 through 1998 along a 62.4-mile reach in the Mesilla Valley from Radium Springs, New Mexico to El Paso, Texas. Stream-aquifer relations were identified and associated water quality documented during the annual low-flow seepage investigations. The investigations were conducted at low flow and during scheduled winter releases. The Rio Grande seepage investigations represent low-flow periods in the Mesilla Valley.

The Rio Grande is predominantly a losing stream in the Mesilla Valley. Seepage gains generally occurred in the upper reach. Relatively large seepage losses occurred in the upper-middle reach; slight gains and losses occurred along the middle reach; and relatively moderate losses occurred in the lower reach. Net seepage losses occurred during all seepage investigations, ranging from 7.2 ft^3/s on January 10-11, 1989 to 78 ft^3/s on January 28-29,

1997. Tributary flow was greater than net seepage losses during the seepage investigations.

Water-quality samples were collected at six sites in conjunction with the Rio Grande seepage investigations. River samples were collected and processed for chemical analyses to determine dissolved-solids concentrations (salinity) and concentrations of major ions, nutrients, and selected trace elements. The EPA drinking-water standards are listed for comparison only and do not apply to raw river water. The selected analytes did not exceed the EPA MCLs or HAs in samples collected during the seepage investigations. Four selected analytes exceeded the SMCLs. Field determinations of pH exceeded the SMCL upper limit of 8.5 in 6 of 54 samples. Dissolved-solids concentrations exceeded the SMCL of 500 mg/L in all 65 samples, and exceeded 1,000 mg/L in 23 of 65 samples. Sulfate concentrations exceeded the SMCL of 250 mg/L in 38 of 65 samples, and manganese concentrations exceeded the SMCL of 50 µg/L in 5 of 65 samples.

References

Borland, J.P. and Beal, L.V., 1989, Water resources data, New Mexico, water year 1988: U.S. Geological Survey Water-Data Report NM-88-1, 490 p.

Borland, J.P., DeWees, R.K., McCracken, R.L., Lepp, R.L., Ortiz, D., and Shaull, D.A., 1990, Water resources data, New Mexico, water year 1989: U.S. Geological Survey Water-Data Report NM-89-1, 426 p.

Borland, J.P., Cruz, R.R., McCracken, R.L., Lepp, R.L., Ortiz, D., and Shaull, D.A., 1991, Water resources data, New Mexico, water year 1990: U.S. Geological Survey Water-Data Report NM-90-1, 466 p.

Borland, J.P., DeWees, R.K., McCracken, R.L., Lepp, R.L., Ortiz, D., and Shaull, D.A., 1992, Water resources data, New Mexico, water year 1991: U.S. Geological Survey Water-Data Report NM-91-1, 557 p.

Borland, J.P. and Ong, K., 1995, Water resources data, New Mexico, water year 1994: U.S. Geological Survey Water-Data Report NM-94-1, 581 p.

Cruz, R.R., DeWees, R.K., Funderburg, D.E., Lepp, R.L., Ortiz, D., and Shaull, D.A., 1993, Water resources data, New Mexico, water year 1992: U.S. Geological Survey Water-Data Report NM-92-1, 526 p.

Cruz, R.R., DeWees, R.K., Funderburg, D.E., Lepp, R.L., Ortiz, D., and Shaull, D.A., 1994, Water resources data, New Mexico, water year 1993: U.S. Geological Survey Water-Data Report NM-93-1, 590 p.

Nickerson, E.L., 1995, Selected hydrologic data for the Mesilla ground-water basin, 1987 through 1992 water years, Doña Ana County, New Mexico, and El Paso County, Texas: U.S. Geological Survey Open-File Report 95-111, 123 p.

Ortiz, D. and Lange, K.M., 1996, Water resources data, New Mexico, water year 1995: U.S. Geological Survey Water-Data Report NM-95-1, 628 p.

Ortiz, D. and Lange, K.M., 1997, Water resources data, New Mexico, water year 1996: U.S. Geological Survey Water-Data Report NM-96-1, 446 p.

Ortiz, D., Lange, K., and Beal, L., 1998, Water resources data, New Mexico, water year 1997: U.S. Geological Survey Water-Data Report NM-97-1, 574 p.

U.S. Environmental Protection Agency, October 1996, Drinking water regulations and health advisories: Office of Water EPA-822-B-96-002, revised June 10, 1998, accessed October 7, 1998, at URL http://www.epa.gov/OST/Tools/dwstds.html.

U.S. Environmental Protection Agency, Current drinking water standards: Office of Ground Water and Drinking Water, revised September 21, 1998, accessed January 14, 1999, at URL http://www.epa.gov/OGWDW/wot/appa.html.

Table 3.--Summary of water-quality analyses of samples collected from the Rio Grande during seepage investigations, water years 1988 through 1998

[Property or analyte: dissolved, analyte in a representative water sample passed through a 0.45-micron filter membrane. Unit: ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter. Value: <, less than analytical detection limit; --, no data. Site: water-quality site location shown in figure 1. EPA: U.S. Environmental Protection Agency drinking-water standards; MCL, maximum contaminant level; SMCL, secondary maximum contaminant level; HA, lifetime health advisory. Source: U.S. Geological Survey National Water Information System (NWIS) data base. Water-quality data were published in U.S. Geological Survey Water-Data Reports NM-88-1 through NM-97-1]

Property or analyte	Unit	Number of samples	Minimum		Maximum		EPA		
			Value	Site	Value	Site	MCL[1]	SMCL[2]	HA[3]
Field properties									
Streamflow, instantaneous	ft^3/s	65	26.2	17	354	34	--	--	--
Specific conductance	µS/cm	65	810	1	2,100	34	--	--	--
pH (hydrogen ion activity)	pH units	54	8.0	8	9.0	17	--	6.5-8.5	--
Temperature, air	degrees Celsius	59	-3.0	17	25.0	34	--	--	--
Temperature, water	degrees Celsius	65	1.5	17	14.0	17,34	--	--	--
Oxygen, dissolved	mg/L	24	9.5	13	12.5	17	--	--	--
Alkalinity, field, dissolved	mg/L as $CaCO_3$	55	152	1	270	34	--	--	--
Dissolved solids and major ions									
Dissolved solids, residue at 180 °C	mg/L	65	509	8	1,400	34	--	500	--
Calcium	mg/L as Ca	64	57	1	140	1,8	--	--	--
Magnesium	mg/L as Mg	65	14	1,8,13,17	29	34	--	--	--
Sodium	mg/L as Na	65	85	1	300	34	--	--	--
Potassium	mg/L as K	65	5.7	1	13	13,26	--	--	--
Bicarbonate, field, dissolved	mg/L as $CaCO_3$	55	185	1	295	34	--	--	--
Carbonate, field, dissolved	mg/L as $CaCO_3$	55	0.0	1,8,13,17,26,34	22	17,26	--	--	--
Sulfate	mg/L as SO_4	65	140	1	470	34	--	250	--
Chloride	mg/L as Cl	65	67	1	250	34	--	250	--
Fluoride	mg/L as F	65	.20	1	.80	1-34	4	2	--
Silica	mg/L as SiO_2	65	4.5	1	25	34	--	--	--

Table 3.--Summary of water-quality analyses of samples collected from the Rio Grande during seepage investigations, water years 1988 through 1998--Continued

Property or analyte	Unit	Number of samples	Minimum Value	Minimum Site	Maximum Value	Maximum Site	MCL[1]	EPA SMCL[2]	HA[3]
			Nutrients						
Nitrogen, nitrite, dissolved	mg/L as N	65	<0.01	1,8,13	0.28	17	1	--	--
Nitrogen, nitrite + nitrate, dissolved	mg/L as N	65	<.05	1,8	2.60	17	10	--	--
Nitrogen, ammonia, dissolved	mg/L as N	65	<.015	1,8,13	1.90	13	--	--	--
Nitrogen, ammonia + organic, total	mg/L as N	65	<.20	1,8	3.0	13	--	--	--
Phosphorus, total	mg/L as P	65	<.01	1,8	1.40	17	--	--	--
Phosphorus, dissolved	mg/L as P	65	<.01	1,8,17	1.50	17	--	--	--
Phosphorus, orthophosphate, dissolved	mg/L as P	65	<.01	1,8,13,17	1.10	17	--	--	--
			Selected trace elements						
Aluminum, dissolved	µg/L as Al	65	<5	1,8,13,17,26,34	20	8,13,26,34	--	50-200	--
Arsenic, dissolved	µg/L as As	62	<1	8	4	34	50	--	--
Barium, dissolved	µg/L as Ba	65	56	8	110	8,13,17	2,000	--	2,000
Beryllium, dissolved	µg/L as Be	24	<.5	1,8,13,17,26,34	<10	34	4	--	--
Boron, dissolved	µg/L as B	6	210	1	330	34	--	--	600
Bromide, dissolved	µg/L as Br	6	.21	17	.28	34	--	--	--
Cadmium, dissolved	µg/L as Cd	62	<1	1,8,13,17,26,34	2	1,13	5	--	5
Chromium, dissolved	µg/L as Cr	62	<1	1,8,13,17,26,34	2	26,34	[4]100	--	[4]100
Cobalt, dissolved	µg/L as Co	65	<1	13	<12	1,8,13,17,26,34	--	--	--
Copper, dissolved	µg/L as Cu	62	<1	1,8,13,17,26,34	7	17	[5]1,300	1,000	--
Iron, dissolved	µg/L as Fe	65	<3	1,8,13,17,26,34	31	13	--	300	--
Lead, dissolved	µg/L as Pb	62	<1	1,8,13,17,26,34	10	13,17	[5]15	--	--
Lithium, dissolved	µg/L as Li	65	76	1	200	34	--	--	--
Manganese, dissolved	µg/L as Mn	65	2	1,8,17	100	34	--	50	--
Mercury, dissolved	µg/L as Hg	62	<.1	1,8,13,17,26,34	.5	8	2	--	2
Molybdenum, dissolved	µg/L as Mo	65	8	34	20	1,17,34	--	--	40
Nickel, dissolved	µg/L as Ni	65	<1	1,8,13,17,26,34	6	8	--	--	100
Selenium, dissolved	µg/L as Se	65	<1	1,8,13,17,26,34	<2	1	50	--	--
Silver, dissolved	µg/L as Ag	65	<1	1,8,13,17,26,34	3	26	--	100	100
Strontium, dissolved	µg/L as Sr	65	720	1	1,800	34	--	--	17,000
Vanadium, dissolved	µg/L as V	65	2	34	7	34	--	--	--
Zinc, dissolved	µg/L as Zn	62	<3	1,8,17,26	110	26	--	5,000	2,000

Table 3.--Summary of water-quality analyses of samples collected from the Rio Grande during seepage investigations, water years 1988 through 1998--Concluded

[1] Maximum permissible level of a contaminant in water which is delivered to any user of a public water system (U.S. Environmental Protection Agency Current Drinking Water Standards, revised September 21, 1998).

[2] Secondary drinking water standards are nonenforceable Federal guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water (U.S. Environmental Protection Agency Current Drinking Water Standards, revised September 21, 1998).

[3] Concentration of a chemical in drinking water that is not expected to cause any adverse noncarcinogenic effects for an adult over a lifetime of exposure, with a margin of safety (U.S. Environmental Protection Agency Drinking Water Regulations and Health Advisory, October 1996 (revised June 10, 1998)).

[4]Total, includes analysis of all chromium species.

[5] Action level.