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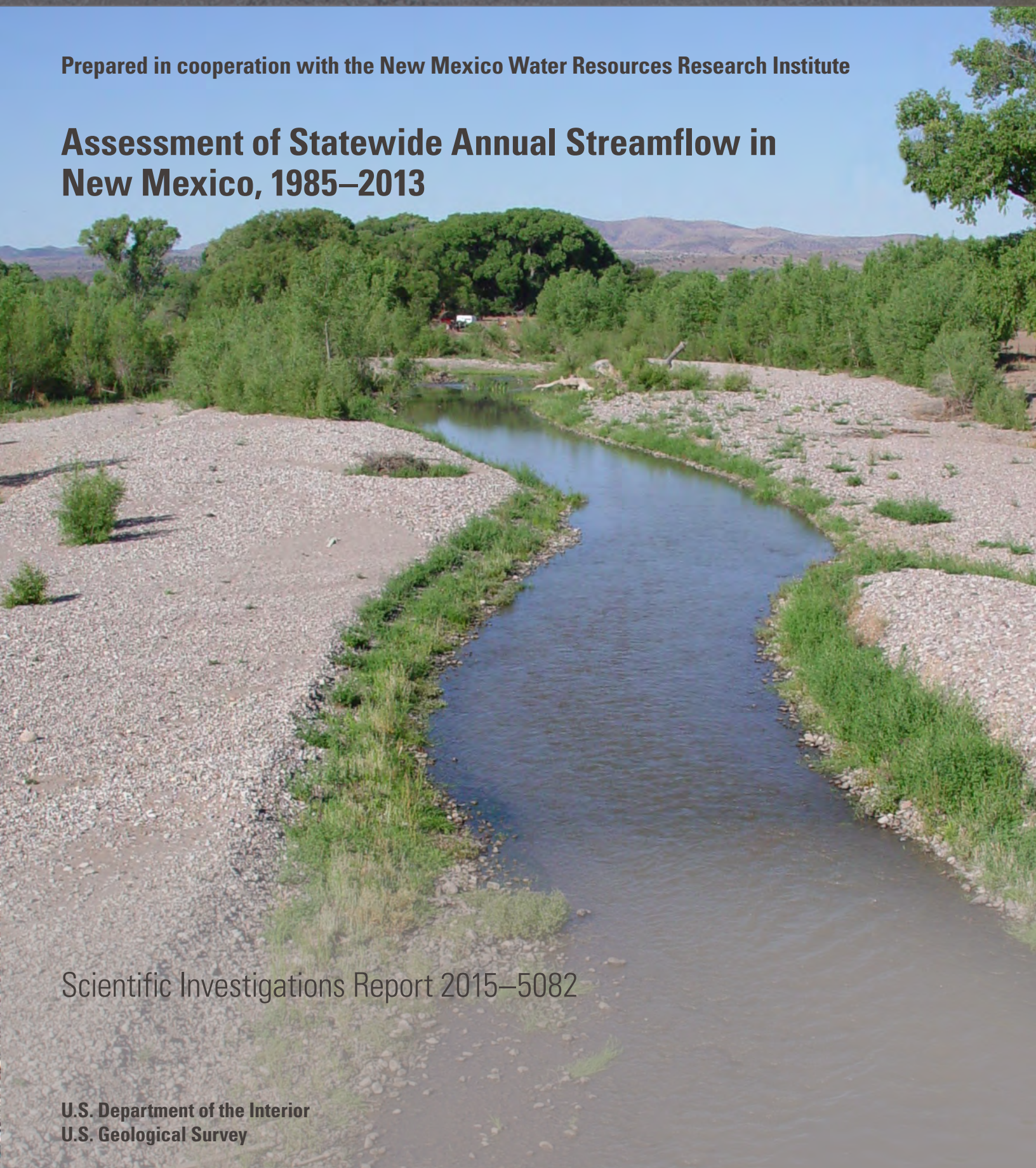
Assessment of Statewide Annual Streamflow in New Mexico, 1985–2013



Scientific Investigations Report 2015–5082

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

Cover.
Photograph showing the Gila River from Old Iron Bridge, located about 1.6 miles south of Cliff, New Mexico. The Big Burro Mountains can be seen in the background.

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By Joseph A. Affinati and Nathan C. Myers

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U.S. Department of the Interior
SALLY JEWELL, Secretary

U.S. Geological Survey
Suzette M. Kimball, Acting Director

U.S. Geological Survey, Reston, Virginia: 2015

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Conversion Factors

Inch/Pound to International System of Units

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
acre-foot (acre-ft)	1,233	cubic meter (m^3)
	Flow rate	
acre-foot per day (acre-ft/d)	0.01427	cubic meter per second (m^3/s)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Datums

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Assessment of Statewide Annual Streamflow in New Mexico, 1985–2013

By Joseph A. Affinati and Nathan C. Myers

Abstract

In 2014, the New Mexico Water Resources Research Institute began a statewide assessment of the water resources of New Mexico. The U.S. Geological Survey, in cooperation with the New Mexico Water Resources Research Institute, addressed the streamflow component of the assessment by examining streamgage data for major river basins and streams in New Mexico for the study period over water years 1985–2013 (all references to years in this report are to water years).

Overall, the total annual inflow to and outflow from New Mexico generally decreased over the study period. The highest annual flows for the Rio Grande occurred in 1985–87, and except at the Rio Grande below Elephant Butte Dam, N. Mex. (08361000), and Rio Grande at El Paso, Texas (08364000), streamgages, the lowest flows occurred in 2002–03. Reaches from the Colorado-New Mexico State line southward to Los Alamos, N. Mex. (reaches RG–1 through RG–4), were all gaining reaches. Based on mean annual streamflow during the study period, reaches from Los Alamos (reach RG–5) southward to El Paso (reach RG–9) were all losing reaches except for the Socorro, N. Mex., reach (reach RG–7). From 1985 to 1995, annual flows in the Red River generally were above the mean annual streamflow, but after 1995, annual flows were more frequently below the mean annual streamflow. The Rio Hondo, Rio Pueblo de Taos, and Jemez River followed similar annual trends as the Red River, but to a lesser extent, over the study period.

Over the study period, annual flows in the Rio Chama generally increased downstream, and after 1995, the frequency of above average annual flows decreased, and below average flows became more frequent. The Rio Chama reaches were gaining in most of the years from 1985 to 2013. The Rio Puerco annual flows, at both of the streamgages on this stream, generally decreased after 2000. Reach RP–1 was a gaining reach for 24 years of the study period.

In general, Pecos River annual flows decreased substantially from the mean annual streamflow after 2000. The greatest gain on the Pecos River was estimated for the reach below Lake Sumner (reach PEC–5), which had gains in all 29 years of the study, whereas the reach from Lake Avalon southward to Red Bluff Reservoir (reach PEC–9) had losses in all 29 years. The highest flows at all streamgages on the Rio Hondo occurred in 1987; high flows there have generally decreased since 1992. Reaches from Ruidoso to below Two Rivers Reservoir, reaches RH–1 and RH–2, were losing reaches for 16 years and 28 years, respectively, over the study period.

The San Juan River for the study period had some of the highest flows of any river in New Mexico, and flow on the river generally increased in the downstream direction. Annual flows at the Animas River streamgages were highly variable but after 1993, generally, tended to decrease. The extended periods of high flows on the Animas River seemed to end in 2000. Over the study period, the reach from the New Mexico border southward to Farmington, N. Mex. (reach ANI–1), generally was a losing reach except for 1987 and 1997. Annual flows at the La Plata River near Farmington, N. Mex. (09367500), streamgage generally were less than the annual inflow to the State at the La Plata River at Colorado-New Mexico State line (09366500) streamgage. Over the study period, the reach from the New Mexico border southward to Farmington (reach PLA–1) generally was a losing reach except for 1986, 1987, and 1993.

Prior to 1999, annual flows at Canadian River streamgages varied above and below average, but after 1999, annual flows generally were below average. The Canadian River reaches, below the confluence of the Cimarron River (reach CAN–1) and the Canadian River to Ute Reservoir (reach CAN–2), display that the upstream reach (reach CAN–1) was a gaining reach for all 29 water years but that the downstream reach (reach CAN–2) was a losing reach for all years except 2003. Annual flows for the Cimarron River varied above and below average until 1999 and then generally were below average through 2013. The Cimarron River reach, below Eagle Nest Lake to about halfway to the confluence with the Canadian River (reach CIM–1), generally was a gaining reach except for 1996, 2002, 2011, and 2013.

Gila River annual flows varied above and below average until 2005 and thereafter generally were below average. Over the study period, the reach from the Gila River near Gila, N. Mex. (09430500), streamgage to the Gila River below Blue Creek, near Virden, N. Mex. (09432000), streamgage (reach GIL–1) was a gaining reach for all years except 1990 and 2013, while the reach from the Gila River below Blue

Creek, near Virden, N. Mex. (09432000), streamgage to the Gila River near Clifton, Ariz. (09442000), streamgage (reach GIL–2) was a losing reach for all years with data except 1999.

The San Francisco River annual flows were relatively high compared to other years in the study in 1985, 1991–93, 1995, and 2005 but were near or below average for the rest of the years of the study. Both reaches on the San Francisco River were gaining reaches for all 29 years of the study.

Introduction

In 2014, the New Mexico Water Resources Research Institute began a statewide assessment of the water resources of New Mexico (New Mexico Water Resources Research Institute, 2014). The assessment includes estimates of precipitation, groundwater recharge, evapotranspiration, changes in groundwater storage, and streamflow. The components of the statewide water resources assessment are being addressed by various groups of researchers; the U.S. Geological Survey (USGS), in cooperation with the New Mexico Water Resources Research Institute, addressed the streamflow component by examining streamgage data for major river basins and streams in New Mexico for the study period over water years 1985–2013 (all references to years in this report are to water years; a water year is the 12-month period October 1 through September 30 designated by the calendar year in which it ends).

Most of New Mexico is located within an arid to semiarid climate zone (Levick and others, 2008). Surface water currently provides about 50 percent of the annual water supply (Longworth and others, 2008). Under interstate compact regulations and international treaties, water in streams crossing New Mexico's borders must be shared with the bordering States and Mexico (New Mexico Interstate Stream Commission, 2015), but the amount of water available from year to year can vary widely. Within the State, the quantity and timing of streamflow in many river reaches are controlled by a system of dams and reservoirs (Kelly, 2011). In addition, recent studies have shown that the timing and availability of spring runoff are changing (Stewart and others, 2004; Dettinger, 2005; Hidalgo and others, 2009; Clow, 2010; Llewellyn and Vaddey, 2013). Lins (2005) has shown that trends in the departure from long-term average streamflow parameters (maximum, minimum, and median) can change abruptly and are not always predictable. Because changes in streamflow could substantially affect the way surface water must be managed in New Mexico, it is important that water managers have a readily available and up-to-date assessment of surface-water resources.

Major river basins and streams in New Mexico included in this study are the Rio Grande and the Pecos, San Juan, Canadian, Gila, and San Francisco Rivers (fig. 1). With its headwaters in Colorado, the Rio Grande is the longest river in New Mexico. The Rio Grande drains most of the central part of the State and exits the southern border of the State near El Paso, Texas. The Pecos River originates in New Mexico, drains the east-central and southeastern parts of the State, and exits the State on its southern border. The San Juan River originates in Colorado, flows southwest into New Mexico, and exits the State near the Four Corners area, the conjunction of Utah, Colorado, New Mexico, and Arizona. The Canadian River originates in New Mexico and Colorado, drains the northeastern part of New Mexico, and exits the State on its eastern border. The Gila and San Francisco Rivers originate in New Mexico and flow west into Arizona.

Purpose and Scope of Report

This report presents the results of a statewide assessment of annual streamflow for the study period from 1985 to 2013 at selected streamgages in New Mexico and bordering States and only quantifies the volume of streamflow entering and exiting New Mexico. Annual differences in streamflow along river reaches were also used to identify areas where streamflow gains and losses occur along selected streams within New Mexico; however, in this study there was no attempt to determine the causes of gains and losses.

Previous Studies

Many studies have analyzed streamflow characteristics over parts of New Mexico, but few studies have encompassed the entirety of the State. Two studies covered the geographic area of New Mexico: (1) the New Mexico Interstate Stream Commission and New Mexico Office of the State Engineer (2002) published a water resource atlas for the State, which contains graphical streamflow information for selected streamgages, and (2) Waltemeyer (1989) conducted a statewide assessment of streamflow conditions and presented statistical summaries of streamflow (mean monthly and mean annual streamflow, low- and high-flow frequencies, and flow duration) collected at 169 streamgages in the State. In two studies that extended beyond the boundaries of New Mexico, Waltemeyer (1996, 2008) presented analyses of the frequency and recurrence of peak streamflow at selected streamgages in New Mexico.

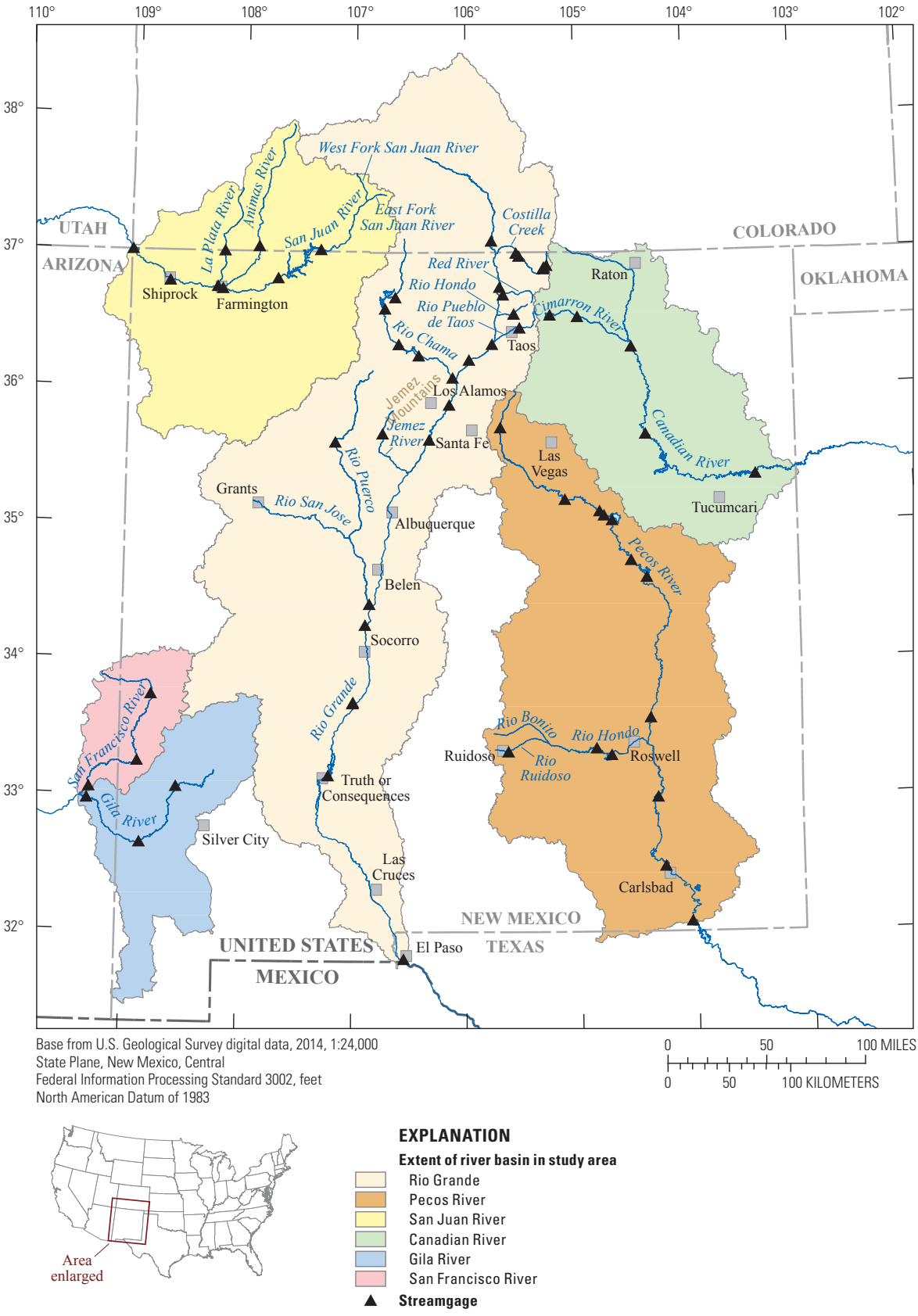

Figure 1. River basins, rivers, and streamgages selected for study of annual streamflow in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.

Approach

Criteria for Selecting Streams and Streamgages

Criteria for selecting major streams for this study included the following:

- The major stream must be perennial over most of its course in New Mexico.
- The major stream originates in New Mexico or an adjacent State and flows through New Mexico and then exits at the New Mexico border.
- Tributaries to the major streams must have one or more streamgages and must contribute a substantial amount of water to the major stream.

Criteria for selecting streamgages for this study included the following:

- The streamgage is a continuous record streamgage with streamflow data for the entire study period (1985–2013).
- The streamgage is on a major stream or a tributary to a major stream.
- The streamgage is located in New Mexico or in an adjoining State if there is no streamgage near the border in New Mexico.
- If possible, the streamgage was upstream or downstream from reservoirs.
- The streamgage accounts for all of the water in the stream (none of the water bypasses the streamgage in irrigation conveyances or is otherwise diverted immediately upstream from the streamgage).

The USGS network of streamgages was not established for the purpose of conducting a statewide water assessment; however, a sufficient number of streamgages in appropriate locations were identified for an analysis of surface-water resources. New Mexico streamgages were examined to find those closest to State borders, and preference was given to streamgages closest to the New Mexico border if located in another State. Most streamgages where the flow was not confined to one channel were eliminated, but in one case, the streamflow at two streamgages was combined (Rio Grande Conveyance Channel at San Marcial, N. Mex. [08358300], and Rio Grande Floodway at San Marcial, N. Mex. [08358400]) (table 1).

Data Sources and Uncertainty

Annual and monthly streamflow data for the network of USGS streamgages in New Mexico and adjacent States were obtained from the USGS National Water Information System (NWIS) database and NWISWeb site (http://waterdata.usgs.gov/nwis/sw). Instrumentation at each streamgage records the height of water above a datum in the stream at 15-minute intervals. Streamflow is computed on the basis of a stage-streamflow relation that is established on the basis of manual streamflow measurements at each streamgage site. Multiple streamflow measurements are made every year at each streamgage by following standard USGS protocols (Rantz and others, 1982; Kilpatrick and Schneider, 1983; Nolan and Shields, 2000; Oberg and others, 2005; Turnipseed and Sauer, 2010). Each streamflow record is assigned a qualitative accuracy rating by the hydrographer on the basis of an assessment of many factors that affect the accuracy of the record. The qualitative accuracy ratings (“excellent,” “good,” “fair,” and “poor”) provide a measure of uncertainty for each streamflow record. “Excellent” means that about 95 percent of the daily discharges are within 5 percent of the true value, “good” within 10 percent, and “fair” within 15 percent. Records that do not meet the criteria mentioned are rated “poor” (Borland and Beal, 1988). The majority of accuracy ratings for streamflow measurements for this study ranged from “good” to “fair,” with 17 percent being “poor,” one rating being “excellent,” and 2.3 percent having no accuracy ratings available (app. 1).

The standard value of streamflow reported by the USGS is daily mean streamflow in cubic feet per second. Values of total monthly and annual streamflow are computed by the USGS Automated Data Processing System (ADAPS) by summing the daily mean streamflow values for each month or year (Bartholoma and others, 2003). Total annual and monthly streamflow data for streamgages in New Mexico and Arizona were retrieved from ADAPS for 1985–2013. Data for Colorado streamgages for 1985–2005 were obtained from USGS annual data reports (Denis and others, 1986; Beal and Gold, 1987a; Beal and Gold, 1987b; Borland and Beal, 1988; Borland and others, 1990, 1991, 1992; Cruz and others, 1993, 1994; Borland and Ong, 1995; Ortiz and Lange, 1996, 1997; Ortiz and others, 1998, 1999, 2000, 2001; Byrd and others, 2002, 2003; Byrd and others, 2004, 2005). Data for 2006–13 for Colorado streamgages were obtained from the USGS water resources data for the United States (http://wdr.water.usgs.gov/allsearch.php). Data for the Rio Grande at El Paso, Tex. (08364000), streamgage were obtained from the United States Section of the International Boundary and Water Commission (Cliff Regensberg, written commun., 2014).

Table 1. Attributes of selected streamgages by river basin, listed in downstream order, in the six-basin study area, New Mexico and parts of bordering States and Mexico.

[NAD 83, North American Datum of 1983; ft, feet; NGVD 29, National Geodetic Vertical Datum of 1929; mi^2, square miles; N. Mex., New Mexico; Colo., Colorado; *, streamgage data added together; N/A, data not available; Tex., Texas; Ariz., Arizona]

River basin	Station identification number	Streamgage name	Latitude (NAD 83)	Longitude (NAD 83)	Elevation (ft) (NGVD 29)	Contributing drainage area (mi^2)
Rio Grande Basin			Costilla Creek			
	08252500	Costilla Creek above Costilla Dam, N. Mex.	36°53′54.1″	105°15′17″	9,450	25.1
	08253500	Santistevan Creek near Costilla, N. Mex.	36°53′03″	105°16′52″	9,520	2.15
	08254000	Costilla Creek below Costilla Dam, N. Mex.	36°52′22.1″	105°17′01″	9,300	54.6
	08255500	Costilla Creek near Costilla, N. Mex.	36°58′00.7″	105°30′26″	7,940	195
	08261000	Costilla Creek near Garcia, Colo.	36°59′20.5″	105°31′57″	7,820	200
			Rio Grande			
	08251500	Rio Grande near Lobatos, Colo.	37°04′42″	105°45′24″	7,430	4,760
	08263500	Rio Grande near Cerro, N. Mex.	36°44′24.1″	105°41′00″	7,110	5,500
	08276500	Rio Grande below Taos Junction Bridge near Taos, N. Mex.	36°19′12.1″	105°45′16″	6,050	6,790
	08279500	Rio Grande at Embudo, N. Mex.	36°12′20″	105°57′50″	5,790	7,460
	08313000	Rio Grande at Otowi Bridge, N. Mex.	35°52′28.2″	106°08′33″	5,490	11,360
	08317400	Rio Grande below Cochiti Dam, N. Mex.	35°37′04.8″	106°19′26″	5,230	14,900
	08354900	Rio Grande Floodway at San Acacia, N. Mex.	34°15′23″	106°53′27″	4,560	23,830
	08358300*	Rio Grande Conveyance Channel at San Marcial, N. Mex.	33°41′15.6″	106°59′33″	4,450	N/A
	08358400*	Rio Grande Floodway at San Marcial, N. Mex.	33°40′44.7″	106°59′49″	4,460	24,760
	08361000	Rio Grande below Elephant Butte Dam, N. Mex.	33°08′54.6″	107°12′24″	4,240	26,510
	08364000	Rio Grande at El Paso, Tex.	31°48′10″	106°32′27″	3,720	29,270
			Rio Grande tributaries			
	08266820	Red River below Fish Hatchery, near Questa, N. Mex.	36°40′58.2″	105°39′15″	7,110	185
	08267500	Rio Hondo near Valdez, N. Mex.	36°32′30.5″	105°33′23″	7,650	36.2
	08269000	Rio Pueblo de Taos near Taos, N. Mex.	36°26′22″	105°30′13″	7,380	66.6
	08284100	Rio Chama near La Puente, N. Mex.	36°39′45.6″	106°38′00″	7,080	480
	08285500	Rio Chama below El Vado Dam, N. Mex.	36°34′49.4″	106°43′29″	6,700	777
	08286500	Rio Chama above Abiquiu Reservoir, N. Mex.	36°19′07.8″	106°35′58″	6,280	1,500
	08287000	Rio Chama below Abiquiu Dam, N. Mex.	36°14′14″	106°25′03″	6,040	2,047

Table 1. Attributes of selected streamgages by river basin, listed in downstream order, in the six-basin study area, New Mexico and parts of bordering States and Mexico.—Continued

[NAD 83, North American Datum of 1983; ft, feet; NGVD 29, National Geodetic Vertical Datum of 1929; mi^2, square miles; N. Mex., New Mexico; Colo., Colorado; *, streamgage data added together; N/A, data not available; Tex., Texas; Ariz., Arizona]

River basin	Station identification number	Streamgage name	Latitude (NAD 83)	Longitude (NAD 83)	Elevation (ft) (NGVD 29)	Contributing drainage area (mi^2)
Rio Grande Basin—Continued		Rio Grande tributaries—Continued				
	08290000	Rio Chama near Chamita, N. Mex.	36°04′24.8″	106°06′42″	5,650	3,044
	08324000	Jemez River near Jemez, N. Mex.	35°39′43.1″	106°44′36″	5,620	470
	08334000	Rio Puerco above Arroyo Chico near Guadalupe, N. Mex.	35°36′03.2″	107°09′60″	5,950	420
	08353000	Rio Puerco near Bernardo, N. Mex.	34°24′37″	106°51′16″	4,720	6,220
Pecos River Basin		Pecos River				
	08378500	Pecos River near Pecos, N. Mex.	35°42′30.1″	105°40′58″	7,500	189
	08379500	Pecos River near Anton Chico, N. Mex.	35°10′43.2″	105°06′32″	5,130	1,050
	08382600	Pecos River above Canon del Uta near Colonias, N. Mex.	35°05′29″	104°48′02″	4,800	2,330
	08382650	Pecos River above Santa Rosa Lake, N. Mex.	35°03′34″	104°45′40″	4,760	2,340
	08382830	Pecos River below Santa Rosa Dam, N. Mex.	35°01′27″	104°41′20″	4,640	2,430
	08383500	Pecos River near Puerto de Luna, N. Mex.	34°43′48.3″	104°31′20″	4,310	3,970
	08384500	Pecos River below Sumner Dam, N. Mex.	34°36′14.6″	104°23′17″	4,140	4,390
	08386000	Pecos River near Acme, N. Mex.	33°34′18.68″	104°22′24.97″	3,510	11,380
	08395500	Pecos River near Lake Arthur, N. Mex.	32°59′21.5″	104°19′16″	3,330	14,760
	08404000	Pecos River below Avalon Dam, N. Mex.	32°28′51.08″	104°15′46.73″	3,130	18,080
	08407500	Pecos River at Red Bluff, N. Mex.	32°04′30.7″	104°02′22″	2,850	19,540
		Pecos River tributaries				
	08387000	Rio Ruidoso at Hollywood, N. Mex.	33°19′36.1″	105°37′31″	6,420	120
	08390500	Rio Hondo at Diamond A Ranch near Roswell, N. Mex.	33°20′57″	104°51′06″	4,190	947
	08390800	Rio Hondo below Diamond A Dam near Roswell, N. Mex.	33°17′59.5″	104°43′18″	3,950	963
San Juan River Basin		San Juan River				
	09346400	San Juan River near Carracas, Colo.	37°00′49.02″	107°18′44.16″	6,090	1,230
	09355500	San Juan River near Archuleta, N. Mex.	36°48′06.8″	107°41′55″	5,650	3,260
	09368000	San Juan River at Shiprock, N. Mex.	36°46′36″	108°40′59″	4,890	12,900
	09371010	San Juan River at Four Corners, Colo.	37°00′04.1″	109°01′47″	4,600	14,600

Table 1. Attributes of selected streamgages by river basin, listed in downstream order, in the six-basin study area, New Mexico and parts of bordering States and Mexico.—Continued

[NAD 83, North American Datum of 1983; ft, feet; NGVD 29, National Geodetic Vertical Datum of 1929; mi^2, square miles; N. Mex., New Mexico; Colo., Colorado; *, streamgage data added together; N/A, data not available; Tex., Texas; Ariz., Arizona]

River basin	Station identification number	Streamgage name	Latitude (NAD 83)	Longitude (NAD 83)	Elevation (ft) (NGVD 29)	Contributing drainage area (mi^2)
San Juan River Basin—Continued			San Juan River tributaries			
	09363500	Animas River near Cedar Hill, N. Mex.	37°02′11.7″	107°52′31″	5,960	1,090
	09364500	Animas River at Farmington, N. Mex.	36°43′21″	108°12′06″	5,280	1,360
	09366500	La Plata River at Colorado-New Mexico State line	36°59′59″	108°11′19″	5,970	331
	09367500	La Plata River near Farmington, N. Mex.	36°44′15.3″	108°15′01″	5,220	583
Canadian River Basin			Canadian River			
	07211500	Canadian River near Taylor Springs, N. Mex.	36°17′51.3″	104°29′44″	5,640	2,850
	07221500	Canadian River near Sanchez, N. Mex.	35°39′17.4″	104°22′43″	4,500	5,712
	07227000	Canadian River at Logan, N. Mex.	35°21′00″	103°23′59″	3,670	10,031
			Canadian River tributaries			
	07206000	Cimarron River below Eagle Nest Dam, N. Mex.	36°31′55.7″	105°13′41″	8,080	167
	07207000	Cimarron River near Cimarron, N. Mex.	36°31′11.4″	104°58′43″	6,600	294
Gila River Basin			Gila River			
	09430500	Gila River near Gila, N. Mex.	33°03′41.4″	108°32′15″	4,650	1,864
	09432000	Gila River below Blue Creek, near Virden, N. Mex.	32°38′53″	108°50′43″	3,880	3,203
	09442000	Gila River near Clifton, Ariz.	32°57′57.23″	109°18′37.25″	3,340	4,010
San Francisco River Basin			San Francisco River			
	09442680	San Francisco River near Reserve, N. Mex.	33°44′12.2″	108°46′16″	5,820	350
	09444000	San Francisco River near Glenwood, N. Mex.	33°14′49.8″	108°52′48″	4,560	1,653
	09444500	San Francisco River at Clifton, Ariz.	33°02′58″	109°17′45″	3,440	2,763

For this report, total streamflow is the sum of all annual data for a streamgage over the study period, whereas mean annual streamflow is the annual average for the streamgage over the study period. Because the timing and magnitude of streamflow in New Mexico are heavily influenced by reservoir operations (Kelly, 2011), monthly streamflow values are not discussed in this report, but the monthly values used in the annual discussion are included as appendixes to this report (apps. 2–9).

Statewide Inflow and Outflow and Reach-Specific Gain/Loss Computations

In this report, the terms "gain" and "loss" refer to many collective hydrologic processes that may contribute water to or remove water from a stream. A gain in flow between two streamgages may occur because of inflow from perennial tributary streams, inflow from intermittent and ephemeral streams, seepage of groundwater into the stream, inflow from irrigation tail water conveyances, inflow from land-drainage systems, sewage-treatment-plant discharge, urban runoff, and direct precipitation. A loss in flow between two streamgages may occur because of evaporation from streams and reservoirs, diversion of water for various uses (irrigation, public supply, maintenance of wildlife habitat, and others), and seepage of surface water into the subsurface.

The statewide tabulation of inflow to and outflow from New Mexico was computed differently for through-flowing streams (streams that originate in another State and flow through New Mexico) than for streams originating within New Mexico. For through-flowing streams (Rio Grande, San Juan River, and Costilla Creek), inflows to New Mexico were tabulated for the most upstream streamgage within New Mexico or a streamgage in an adjoining State if that streamgage was closer to the State border. Outflows from New Mexico were tabulated for the most downstream streamgage within New Mexico or a streamgage in an adjoining State if that streamgage was closer to the State border. Costilla Creek has only one streamgage that is operated year round (Costilla Creek near Costilla, N. Mex. [08255500]), and that streamgage is located near the point where Costilla Creek exits New Mexico. Consequently, only outflows were tabulated for Costilla Creek. For streams originating within New Mexico (Pecos, Canadian, Gila, and San Francisco Rivers), inflows were zero, and outflows from the State were tabulated for the most downstream streamgage within New Mexico or a streamgage in an adjoining State if that streamgage was closer to the State border. Although some of the headwater reaches of the Canadian River originate in Colorado, there are no streamgages to quantify inflow from Colorado.

For all streams, the difference between the total annual streamflow at the most downstream streamgage in New Mexico and the total annual streamflow at the most upstream streamgage on the stream (zero for streams originating within New Mexico) was computed to provide a measure of the balance of water entering and exiting the State. This balance does not account for water originating and being consumed within the State. Tributary inflows to the major streams were not included in the statewide tabulation of inflow and outflow. The intent of this study was to show generalized gains or losses in streamflow down the length of major rivers and, as such, does not differentiate sources of or sinks in streamflow within a reach.

Annual streamflow data were used to determine the gains and losses for reaches of selected streams. Streamflow at the downstream streamgage was subtracted from the streamflow at the nearest upstream streamgage for each specific stream reach to obtain annual differences. This procedure was repeated for all stream reaches defined by streamgage pairs in the study area (fig. 1).

Limitations and Appropriate Use of Data

This report does not capture all of the streamflow that occurs in New Mexico. This report accounts for major inflows to the State (where rivers originate in another State) and major outflows from the State but does not account for water that originates within New Mexico that is not measured by a streamgage. This report does not account for water in ungaged streams that cross State borders, nor does it account for runoff from precipitation or snowmelt that infiltrates the subsurface before it passes a streamgage.

Estimates of gains and losses between selected streamgages give a general indication of annual streamflow conditions, but care should be exercised when assessing the causes of changes in flow at a single streamgage or gains and losses of flow between two streamgages. Many hydrologic processes can contribute to the gain or loss of flow in a stream, as enumerated in section "Statewide Inflow and Outflow and Reach-Specific Gain/Loss Computations." The purpose of this report is to identify inflow to and outflow from the State and determine net gains and losses for streams within the State, not to identify the hydrologic processes that cause a gain or loss. Each of these hydrologic processes can be more or less active over the course of a year, and some processes may be more active in certain river reaches than in others. It is likely that combinations of gaining and losing hydrologic processes will be active in any given reach at a given time. While streamgages cannot measure or quantify the effects of each of these ongoing hydrologic processes, the difference in flow between two streamgages is a measure of the net effect of the active gaining and losing hydrologic processes.

The data in this report provide a general assessment of the flow conditions and changes in flow conditions from 1985 to 2013. Patterns of streamflow gain and loss may show river reaches where more or less attention by water managers is needed to alleviate water stresses in New Mexico.

The data in this report should not be used to supplant streamflow estimates made by interstate compact commissions. Compact commissions utilize specific streamgages and water accounting formulae to determine adherence to compact rules and regulations. Data in this report should also not be used to supplant the New Mexico Office of the State Engineer estimates of water availability. The difference between inflow to and outflow from the State along a major stream presented in this report should not be used as a measure of how much water was consumed within the State; the actual amount could be more or less than the inflow-outflow difference because of the many hydrologic processes and human uses of water that occur within the State.

A full assessment of streamflow would require a more extensive study than afforded by the tabulation of streamflow in this report. A full assessment would require the addition of streamgages to selected streams, refinement of regression equations used to estimate flow in ungaged areas of New Mexico (Waltemeyer, 1996, 2008), and the development of watershed models encompassing the entire State.

Statewide Annual Streamflow, Gains, and Losses

Annual inflow to and outflow from New Mexico generally decreased over the study period from 1985 to 2013 (table 2). More specifically, inflows to the State decreased for 1985–90, then increased for 1991–95, were variable from 1995 to 2008, and thereafter decreased. Outflows from the State decreased sharply from 1987 to 1990 but showed an increase through 1993 despite missing data for the Gila River near Clifton, Ariz. (09442000), streamgage. Outflows varied for 1993–2008 but thereafter decreased except for a slight increase in 2013. The inflows to the State ranged from a high of 1,709,300 acre-feet (acre-ft) in 1985 to a low of 165,590 acre-ft in 2002 (table 2). The mean annual inflow over the study period was 746,718 acre-ft, and the mean annual outflow was 2,179,249 acre-ft. Caution should be used when using and interpreting the inflow and outflow values presented herein because they represent hydrologic conditions only occurring at the State border. In addition, the inflow values do not include inflow for Costilla Creek, the Canadian River, and smaller streams that flow across the New Mexico border. Outflow values do not include Gila River (Gila River near Clifton, Ariz. [09442000], streamgage) outflow for 1990–95 and do not include outflow across the New Mexico border in smaller streams.

Rio Grande Basin Streamflow

Costilla Creek

Costilla Creek, located in the northern part of the Rio Grande Basin, has four streamgages and one tributary streamgage on Santistevan Creek (fig. 2). Of the five streamgages, only one (Costilla Creek near Costilla, N. Mex. [08255500]) recorded year-round data for the entire study period. The other four streamgages were operated only during summer months. Monthly data for the five streamgages are presented in appendix 2. Because of the limited data, annual data were tabulated only for the Costilla Creek near Costilla, N. Mex. (08255500), streamgage (table 2), so gains and losses were not computed for Costilla Creek. The increases in flow between the Costilla Creek below Costilla Dam, N. Mex. (08254000), streamgage and the Costilla Creek near Costilla, N. Mex. (08255500), streamgage indicated that there were substantial gains in flow between the two streamgages. Streamgages operated year round upstream and downstream from Costilla Reservoir would provide a fuller assessment of Costilla Creek streamflow.

Rio Grande

The Rio Grande originates in southern Colorado, flows through central New Mexico, exits the State near El Paso, Tex., and forms the border between Texas and Mexico (fig. 2). Tributaries to the Rio Grande included in this study are the Red River, Rio Hondo, Rio Pueblo de Taos, Rio Chama, Jemez River, and Rio Puerco. There are Cochiti Lake, Elephant Butte Reservoir, and Caballo Reservoir on the Rio Grande and three reservoirs, Abiquiu, Heron, and El Vado, on the Rio Chama (fig. 2). Reservoir operations and diversions of water for public supply and irrigation, especially in central and southern New Mexico, alter the natural flow of the river and the streamflows measured at downstream streamgages (Kelly, 2011).

For this report, data were compiled for 10 streamgages on the Rio Grande (fig. 2; table 3) and for 11 streamgages on tributaries (fig. 2; table 4). Monthly data for these streamgages on the Rio Grande and on its tributaries are presented in appendixes 3 and 4, respectively. The data indicate an overall pattern of decreasing annual streamflow since 1985 (figs. 3*A* and 3*B*; table 3). Except at the Rio Grande below Elephant Butte Dam, N. Mex. (08361000), streamgage and the Rio Grande at El Paso, Tex. (08364000), streamgage, the lowest flows occurred in 2002–03 (fig. 3*B*; table 3). Data were not available for the Rio Grande near Cerro, N. Mex. (08263500), streamgage for 1995 (fig. 3*A*; table 3).

Table 2. Summary of annual inflow, outflow, outflow minus inflow, annual mean, and total streamflow for selected streamgages on major streams in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.

[acre-ft, acre-feet; Colo., Colorado; Tex., Texas; N. Mex., New Mexico; Ariz., Arizona; --, no data]

Water year	Through-flowing stream					Stream originating in New Mexico				All streams		
	Rio Grande		San Juan River		Costilla Creek	Pecos River	Canadian River	Gila River	San Francisco River			
	Inflow (acre-ft)	Outflow (acre-ft)	Inflow (acre-ft)	Outflow (acre-ft)	Outflow (acre-ft)	Outflow (acre-ft)	Outflow (acre-ft)	Outflow (acre-ft)	Outflow (acre-ft)			
	08251500 Rio Grande near Lobatos, Colo.	08364000 Rio Grande at El Paso, Tex.	09346400 San Juan River near Carracas, Colo.	09371010 San Juan River at Four Corners, Colo.	08255500 Costilla Creek near Costilla, N. Mex.	08407500 Pecos River at Red Bluff, N. Mex.	07227000 Canadian River at Logan, N. Mex.	09442000 Gila River near Clifton, Ariz.[1]	09444500 San Francisco River at Clifton, Ariz.	Inflow (acre-ft)[2]	Outflow (acre-ft)[1]	Outflow minus inflow (acre-ft)[1,2]
1985	840,000	348,700	869,300	2,695,000	57,070	50,760	2,090	374,000	372,600	1,709,300	3,900,220	2,190,920
1986	766,800	705,600	761,300	2,475,000	39,900	215,300	1,670	193,800	139,900	1,528,100	3,771,170	2,243,070
1987	915,400	1,414,000	640,200	3,026,000	59,860	215,000	99,900	142,300	198,400	1,555,600	5,155,460	3,599,860
1988	191,800	580,700	318,800	1,044,000	24,260	60,480	3,370	200,300	193,700	510,600	2,106,810	1,596,210
1989	241,400	442,500	358,200	811,700	28,320	41,180	13,000	78,180	70,630	599,600	1,485,510	885,910
1990	144,000	384,100	282,900	717,500	27,950	28,970	14,080	--	51,510	426,900	1,224,110	797,210
1991	324,500	370,000	464,100	1,087,000	37,790	57,710	17,670	--	274,400	788,600	1,844,570	1,055,970
1992	246,200	456,700	473,100	1,513,000	48,170	160,900	16,770	--	345,900	719,300	2,541,440	1,822,140
1993	387,300	516,800	657,900	2,217,000	41,250	66,780	26,350	--	601,400	1,045,200	3,469,580	2,424,380
1994	288,900	485,400	490,100	1,411,000	59,200	60,480	93,360	--	65,960	779,000	2,175,400	1,396,400
1995	537,100	705,000	732,600	2,102,000	57,820	74,640	72,640	--	301,300	1,269,700	3,313,400	2,043,700
1996	143,700	474,860	205,200	815,800	25,220	74,610	31,150	93,800	65,700	348,900	1,581,140	1,232,240
1997	433,400	472,400	495,300	1,884,000	30,530	62,430	52,460	193,000	112,200	928,700	2,807,020	1,878,320
1998	352,000	462,400	406,900	1,402,000	31,220	96,000	2,210	201,800	154,200	758,900	2,349,830	1,590,930
1999	425,700	459,800	488,100	1,902,000	39,550	82,240	104,800	95,340	106,600	913,800	2,790,330	1,876,530
2000	166,800	433,800	188,400	928,800	29,780	55,160	42,860	42,990	40,560	355,200	1,573,950	1,218,750
2001	284,600	459,600	413,300	1,288,000	29,350	51,630	3,130	138,200	237,800	697,900	2,207,710	1,509,810
2002	84,490	471,900	81,100	534,700	11,210	37,720	2,510	45,210	52,010	165,590	1,155,260	989,670
2003	68,710	211,000	200,600	635,600	20,760	32,110	2,810	47,610	57,940	269,310	1,007,830	738,520

Table 2. Summary of annual inflow, outflow, outflow minus inflow, annual mean, and total streamflow for selected streamgages on major streams in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued

[acre-ft, acre-feet; Colo., Colorado; Tex., Texas; N. Mex., New Mexico; Ariz., Arizona; --, no data]

Water year	Through-flowing stream					Stream originating in New Mexico				All streams		
	Rio Grande		San Juan River		Costilla Creek	Pecos River	Canadian River	Gila River	San Francisco River			
	Inflow (acre-ft)	Outflow (acre-ft)	Inflow (acre-ft)	Outflow (acre-ft)	Outflow (acre-ft)	Outflow (acre-ft)	Outflow (acre-ft)	Outflow (acre-ft)	Outflow (acre-ft)			
	08251500 Rio Grande near Lobatos, Colo.	08364000 Rio Grande at El Paso, Tex.	09346400 San Juan River near Carracas, Colo.	09371010 San Juan River at Four Corners, Colo.	08255500 Costilla Creek near Costilla, N. Mex.	08407500 Pecos River at Red Bluff, N. Mex.	07227000 Canadian River at Logan, N. Mex.	09442000 Gila River near Clifton, Ariz.[1]	09444500 San Francisco River at Clifton, Ariz.	Inflow (acre-ft)[2]	Outflow (acre-ft)[1]	Outflow minus inflow (acre-ft)[1,2]
2004	192,100	182,500	329,600	740,000	27,060	87,610	2,710	98,030	69,610	521,700	1,207,520	685,820
2005	443,900	307,500	624,800	1,576,000	47,760	98,590	2,790	301,900	296,100	1,068,700	2,630,640	1,561,940
2006	178,600	286,500	277,200	838,100	23,100	96,430	21,580	197,100	120,500	455,800	1,583,310	1,127,510
2007	325,500	329,400	454,600	1,329,000	36,790	62,660	2,500	130,700	97,830	780,100	1,988,880	1,208,780
2008	430,400	370,100	561,700	1,992,000	40,560	58,120	2,540	152,700	180,800	992,100	2,796,820	1,804,720
2009	284,200	399,100	361,000	950,400	37,080	62,890	2,600	60,490	50,200	645,200	1,562,760	917,560
2010	219,000	369,100	376,200	804,700	37,980	42,570	2,360	210,500	193,800	595,200	1,661,010	1,065,810
2011	182,400	242,400	337,900	893,500	18,900	48,200	2,120	39,580	43,760	520,300	1,288,460	768,160
2012	160,300	133,500	230,400	716,800	15,040	17,240	2,060	55,320	49,450	390,700	989,410	598,710
2013	96,210	56,760	218,600	618,200	13,610	42,330	2,070	134,100	161,600	314,810	1,028,670	713,860
Annual mean, 1985–2013 (acre-feet per year)	**322,600**	**432,142**	**424,117**	**1,343,062**	**34,382**	**73,819**	**22,281**	**140,302**	**162,288**	**746,718**	**2,179,249**	**1,432,531**
Total, 1985–2013 (acre-feet per year)	**9,355,410**	**12,532,120**	**12,299,400**	**38,948,800**	**997,090**	**2,140,740**	**646,160**	**3,226,950**	**4,706,360**	**21,654,810**	**63,198,220**	**41,543,410**

[1]Gila River near Clifton, Ariz. Outflow values missing from water years 1990 to 1995.

[2]Total inflow values do not include inflow from the Canadian River and Costilla Creek.

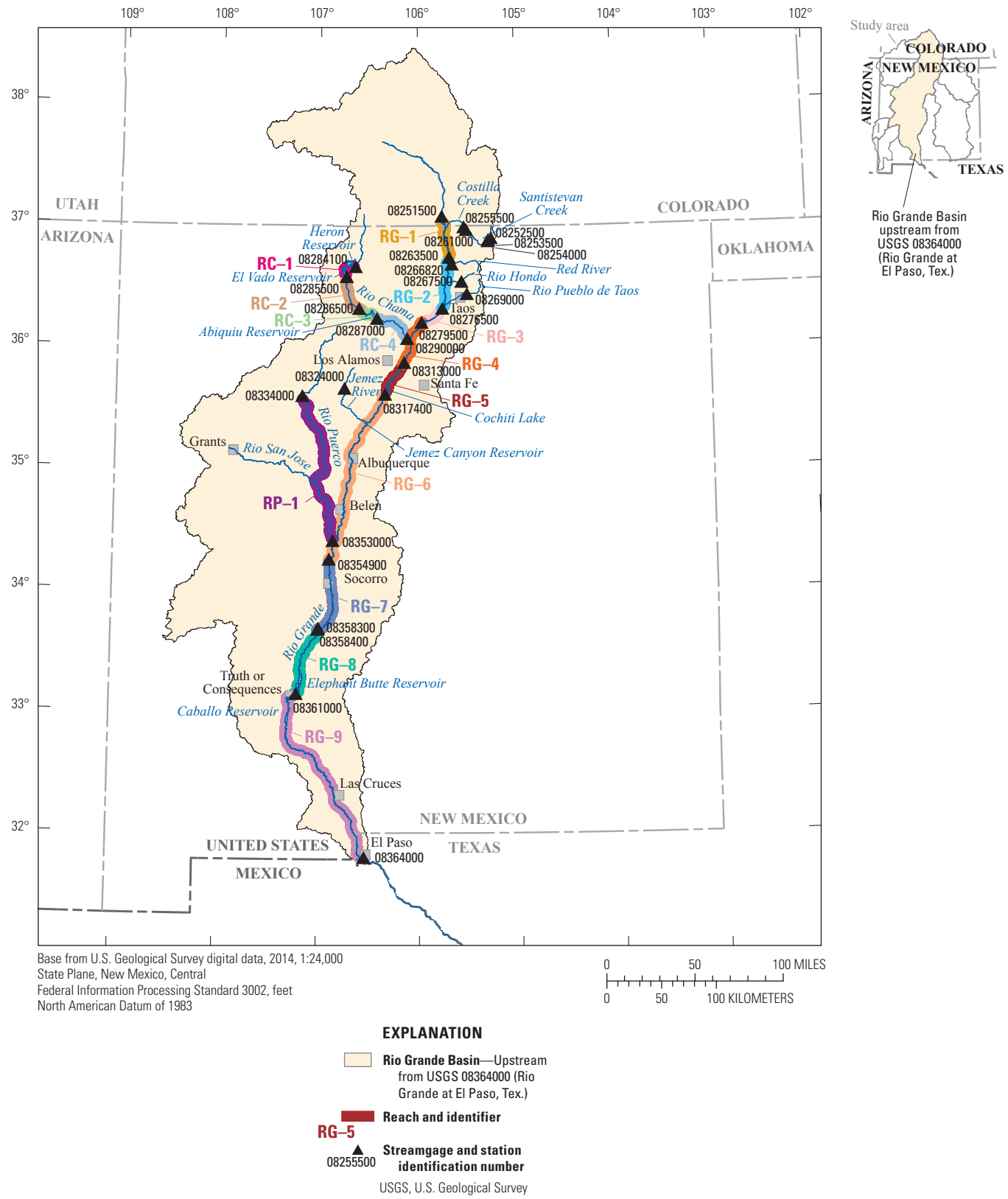

Figure 2. Rio Grande Basin, streams, stream reaches, and streamgages upstream from the Rio Grande at El Paso, Texas (08364000), streamgage in the six-basin study area, New Mexico and parts of bordering States and Mexico.

Table 3. Annual streamflow and annual difference in streamflow by reach for selected streamgages on the Rio Grande in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.

[Colo., Colorado; acre-ft, acre-feet; N. Mex., New Mexico; Tex., Texas; --, no data; RG, Rio Grande reach, numbered in downstream order]

	Annual streamflow									
Water year	08251500 Rio Grande near Lobatos, Colo. (acre-ft)	08263500 Rio Grande near Cerro, N. Mex. (acre-ft)	08276500 Rio Grande below Taos Junction Bridge near Taos, N. Mex. (acre-ft)	08279500 Rio Grande at Embudo, N. Mex. (acre-ft)	08313000 Rio Grande at Otowi Bridge, N. Mex. (acre-ft)	08317400 Rio Grande below Cochiti Dam, N. Mex. (acre-ft)	08354900 Rio Grande Floodway at San Acacia, N. Mex. (acre-ft)	08358400 Rio Grande Floodway at San Marcial, N. Mex., and 08358300 Rio Grande Conveyance Channel at San Marcial, N. Mex. (acre-ft)	08361000 Rio Grande below Elephant Butte Dam, N. Mex. (acre-ft)	08364000 Rio Grande at El Paso, Tex. (acre-ft)
1985	840,000	859,400	1,158,000	1,297,000	1,935,000	1,691,000	1,318,000	1,542,000	901,000	348,700
1986	766,800	766,300	1,010,000	1,085,000	1,754,000	1,705,000	1,827,000	1,576,000	1,101,000	705,600
1987	915,400	923,200	1,201,000	1,293,000	2,001,000	1,695,000	1,770,000	1,732,000	1,630,000	1,414,000
1988	191,800	227,300	345,500	392,100	835,700	880,800	933,700	930,300	685,300	580,700
1989	241,400	291,900	440,000	469,900	842,400	794,400	518,800	668,400	730,800	442,500
1990	144,000	179,900	317,700	371,400	637,400	519,000	365,700	347,100	666,100	384,100
1991	324,500	383,200	608,500	675,400	1,284,000	1,133,000	1,115,000	1,043,000	573,100	370,000
1992	246,200	303,900	498,800	609,100	1,256,000	1,161,000	1,113,000	1,167,000	705,800	456,700
1993	387,300	440,100	687,600	755,800	1,412,000	1,360,000	1,266,000	1,254,000	1,061,000	516,800
1994	288,900	339,000	642,100	730,700	1,377,000	1,297,000	1,181,000	1,176,000	711,100	485,400
1995	537,100	--	858,500	926,200	1,618,000	1,556,000	1,394,000	1,385,000	1,184,000	705,000
1996	143,700	183,700	306,100	331,000	772,400	694,300	442,200	525,700	698,200	474,860
1997	433,400	475,100	660,600	754,100	1,150,000	1,077,000	879,800	943,200	741,300	472,400
1998	352,000	399,700	566,200	635,400	1,139,000	1,041,000	784,400	919,200	825,900	462,400
1999	425,700	455,100	643,400	708,500	1,073,000	993,900	818,700	870,500	726,000	459,800
2000	166,800	199,900	317,900	341,500	801,200	717,500	451,500	462,000	788,600	433,800
2001	284,600	304,900	469,100	491,200	764,200	668,200	434,600	482,100	785,100	459,600
2002	84,490	108,100	216,700	217,800	572,200	477,500	265,200	260,500	828,200	471,900
2003	68,710	95,940	220,300	250,000	491,800	398,700	231,900	206,090	388,200	211,000
2004	192,100	210,400	333,700	369,400	648,000	572,000	396,500	377,500	423,000	182,500
2005	443,900	458,000	696,800	769,300	1,276,000	1227000	998,200	958,700	699,300	307,500
2006	178,600	189,300	309,800	340,100	603,100	511,500	454,200	484,700	508,400	286,500
2007	325,500	337,400	511,700	551,900	888,300	777,200	655,400	647,800	607,200	329,400
2008	430,400	445,100	692,500	714,700	1,280,000	1,257,000	968,400	914,100	688,000	370,100
2009	284,200	318,900	504,400	553,600	998,900	935,500	605,900	700,700	789,800	399,100
2010	219,000	235,200	438,400	492,400	980,600	852,300	548,800	549,900	724,200	369,100
2011	182,400	201,200	321,500	338,400	641,100	557,500	259,200	302,200	409,900	242,400
2012	160,300	178,800	310,300	352,400	674,200	588,000	320,700	317,100	366,000	133,500
2013	96,210	117,300	229,600	248,200	513,100	400,800	275,000	252,900	168,900	56,760
Mean annual streamflow	**322,600**	**343,866**	**535,059**	**588,466**	**1,042,055**	**949,624**	**779,062**	**792,955**	**728,117**	**432,142**

Table 3. Annual streamflow and annual difference in streamflow by reach for selected streamgages on the Rio Grande in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued

[Colo., Colorado; acre-ft, acre-feet; N. Mex., New Mexico; Tex., Texas; --, no data; RG, Rio Grande reach, numbered in downstream order]

	Annual difference in streamflow by reach								
	RG–1	RG–2	RG–3	RG–4	RG–5	RG–6	RG–7	RG–8	RG–9
Water year	08251500 Rio Grande near Lobatos, Colo., to 08263500 Rio Grande near Cerro, N. Mex. (acre-ft)	08263500 Rio Grande near Cerro, N. Mex., to 08276500 Rio Grande below Taos Junction Bridge near Taos, N. Mex. (acre-ft)	08276500 Rio Grande below Taos Junction Bridge near Taos, N. Mex., to 08279500 Rio Grande at Embudo, N. Mex. (acre-ft)	08279500 Rio Grande at Embudo, N. Mex., to 08313000 Rio Grande at Otowi Bridge, N. Mex. (acre-ft)	08313000 Rio Grande at Otowi Bridge, N. Mex., to 08317400 Rio Grande below Cochiti Dam, N. Mex. (acre-ft)	08317400 Rio Grande below Cochiti Dam, N. Mex., to 08354900 Rio Grande Floodway at San Acacia, N. Mex. (acre-ft)	08354900 Rio Grande Floodway at San Acacia, N. Mex., to 08358400 Rio Grande Floodway at San Marcial, N. Mex., and 08358300 Rio Grande Conveyance Channel at San Marcial, N. Mex. (acre-ft)	08358400 Rio Grande Floodway at San Marcial, N. Mex., and 08358300 Rio Grande Conveyance Channel at San Marcial, N. Mex., to 08361000 Rio Grande below Elephant Butte Dam, N. Mex. (acre-ft)	08361000 Rio Grande below Elephant Butte Dam, N. Mex., to 08364000 Rio Grande at El Paso, Tex. (acre-ft)
1985	19,400	298,600	139,000	638,000	-244,000	-373,000	224,000	-641,000	-552,300
1986	-500	243,700	75,000	669,000	-49,000	122,000	-251,000	-475,000	-395,400
1987	7,800	277,800	92,000	708,000	-306,000	75,000	-38,000	-102,000	-216,000
1988	35,500	118,200	46,600	443,600	45,100	52,900	-3,400	-245,000	-104,600
1989	50,500	148,100	29,900	372,500	-48,000	-275,600	149,600	62,400	-288,300
1990	35,900	137,800	53,700	266,000	-118,400	-153,300	-18,600	319,000	-282,000
1991	58,700	225,300	66,900	608,600	-151,000	-18,000	-72,000	-469,900	-203,100
1992	57,700	194,900	110,300	646,900	-95,000	-48,000	54,000	-461,200	-249,100
1993	52,800	247,500	68,200	656,200	-52,000	-94,000	-12,000	-193,000	-544,200
1994	50,100	303,100	88,600	646,300	-80,000	-116,000	-5,000	-464,900	-225,700
1995	--	--	67,700	691,800	-62,000	-162,000	-9,000	-201,000	-479,000
1996	40,000	122,400	24,900	441,400	-78,100	-252,100	83,500	172,500	-223,340
1997	41,700	185,500	93,500	395,900	-73,000	-197,200	63,400	-201,900	-268,900
1998	47,700	166,500	69,200	503,600	-98,000	-256,600	134,800	-93,300	-363,500
1999	29,400	188,300	65,100	364,500	-79,100	-175,200	51,800	-144,500	-266,200
2000	33,100	118,000	23,600	459,700	-83,700	-266,000	10,500	326,600	-354,800
2001	20,300	164,200	22,100	273,000	-96,000	-233,600	47,500	303,000	-325,500
2002	23,610	108,600	1,100	354,400	-94,700	-212,300	-4,700	567,700	-356,300
2003	27,230	124,360	29,700	241,800	-93,100	-166,800	-25,810	182,110	-177,200
2004	18,300	123,300	35,700	278,600	-76,000	-175,500	-19,000	45,500	-240,500
2005	14,100	238,800	72,500	506,700	-49,000	-228,800	-39,500	-259,400	-391,800
2006	10,700	120,500	30,300	263,000	-91,600	-57,300	30,500	23,700	-221,900
2007	11,900	174,300	40,200	336,400	-111,100	-121,800	-7,600	-40,600	-277,800
2008	14,700	247,400	22,200	565,300	-23,000	-288,600	-54,300	-226,100	-317,900
2009	34,700	185,500	49,200	445,300	-63,400	-329,600	94,800	89,100	-390,700
2010	16,200	203,200	54,000	488,200	-128,300	-303,500	1,100	174,300	-355,100
2011	18,800	120,300	16,900	302,700	-83,600	-298,300	43,000	107,700	-167,500
2012	18,500	131,500	42,100	321,800	-86,200	-267,300	-3,600	48,900	-232,500
2013	21,090	112,300	18,600	264,900	-112,300	-125,800	-22,100	-84,000	-112,140
Mean annual streamflow	**28,926**	**179,641**	**53,407**	**453,590**	**-92,431**	**-170,562**	**13,893**	**-64,838**	**-295,975**

Table 4. Annual streamflow and annual difference in streamflow by reach for selected streamgages on Rio Grande tributaries in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.

[N. Mex., New Mexico; acre-ft, acre-feet; N. Mex., New Mexico; RC, Rio Chama reach, numbered in downstream order; RP, Rio Puerco reach, numbered in downstream order]

Water year	Annual streamflow										
	08266820 Red River below Fish Hatchery, near Questa, N. Mex. (acre-ft)	08267500 Rio Hondo near Valdez, N. Mex. (acre-ft)	08269000 Rio Pueblo de Taos near Taos, N. Mex. (acre-ft)	08284100 Rio Chama near La Puente, N. Mex. (acre-ft)	08285500 Rio Chama below El Vado Dam, N. Mex. (acre-ft)	08286500 Rio Chama above Abiquiu Reservoir, N. Mex. (acre-ft)	08287000 Rio Chama below Abiquiu Dam, N. Mex. (acre-ft)	08290000 Rio Chama near Chamita, N. Mex. (acre-ft)	08324000 Jemez River near Jemez, N. Mex. (acre-ft)	08334000 Rio Puerco above Arroyo Chico near Guadalupe, N. Mex. (acre-ft)	08353000 Rio Puerco near Bernardo, N. Mex. (acre-ft)
1985	84,420	38,730	38,440	523,600	546,200	561,900	443,500	536,200	126,700	20,110	34,990
1986	67,740	29,890	26,060	393,400	482,300	480,700	533,700	573,200	64,510	9,860	16,880
1987	69,840	29,050	26,010	350,200	507,500	528,400	631,700	668,000	106,400	14,240	33,820
1988	42,990	18,520	11,520	205,100	238,200	254,300	351,700	383,600	57,180	9,500	45,770
1989	51,170	22,860	17,000	183,100	275,300	282,900	313,600	353,700	42,750	3,580	8,640
1990	44,390	22,830	15,030	133,900	178,000	176,200	191,800	195,500	38,960	3,460	20,160
1991	59,770	30,620	24,920	326,200	382,000	395,200	401,700	457,400	67,740	16,980	44,870
1992	61,010	30,020	26,260	301,000	407,400	423,800	537,100	558,700	96,810	22,550	23,820
1993	72,830	40,000	29,020	414,200	507,300	542,800	482,200	592,900	86,690	22,130	25,880
1994	81,970	39,060	38,420	334,400	438,300	481,400	547,800	624,100	37,650	6,870	17,090
1995	85,850	45,880	41,340	495,000	523,500	591,500	505,200	637,600	95,700	19,840	14,990
1996	37,600	13,180	8,970	115,800	306,800	309,000	443,100	461,100	16,650	9,370	26,780
1997	54,540	28,030	23,220	318,000	320,200	349,200	345,500	416,900	70,440	8,030	19,850
1998	47,510	21,530	15,580	259,500	401,400	421,800	437,500	478,100	58,020	12,080	10,360
1999	58,110	22,280	17,740	252,600	240,300	257,400	251,900	316,400	48,510	16,040	35,890
2000	31,720	10,050	6,320	88,840	332,300	331,300	448,900	455,100	27,130	2,890	3,490
2001	45,470	25,610	16,720	225,200	205,800	211,500	184,500	214,000	54,850	6,230	4,300
2002	24,530	7,240	3,850	33,440	285,700	281,800	346,700	350,800	16,010	2,810	5,610
2003	34,810	16,100	11,500	166,200	211,500	213,600	216,400	219,600	31,050	8,080	14,030
2004	35,040	14,370	9,670	170,200	260,300	261,200	216,600	251,200	42,600	8,570	18,430
2005	65,200	35,030	29,520	367,500	335,300	340,300	370,800	442,800	69,780	5,180	8,450
2006	33,660	12,890	6,810	114,700	256,900	259,500	213,400	228,200	18,740	4,620	77,300
2007	51,570	21,190	15,920	242,800	242,600	261,800	263,300	271,500	53,100	34,000	10,910
2008	76,340	37,770	29,070	347,700	394,900	433,000	461,000	524,000	48,350	14,120	9,470
2009	65,980	27,830	20,420	265,100	399,500	415,000	418,700	439,500	31,810	1,880	5,280
2010	57,500	25,920	25,720	231,100	335,800	351,400	370,100	383,000	41,660	6,760	12,070
2011	33,190	13,430	9,770	190,900	295,300	291,300	299,800	295,200	19,330	300	6,410
2012	39,220	17,730	11,250	145,400	303,800	304,900	326,700	337,400	28,080	5,260	5,800
2013	30,740	12,540	7,180	90,540	239,800	249,400	258,800	260,600	19,800	9,240	48,810
Mean annual streamflow	**53,266**	**24,489**	**19,422**	**251,228**	**339,800**	**353,879**	**372,886**	**411,252**	**52,310**	**10,503**	**21,040**

Table 4. Annual streamflow and annual difference in streamflow by reach for selected streamgages on Rio Grande tributaries in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued

[N. Mex., New Mexico; acre-ft, acre-feet; N. Mex., New Mexico; RC, Rio Chama reach, numbered in downstream order; RP, Rio Puerco reach, numbered in downstream order]

Water year	Annual difference in streamflow by reach				
	RC–1	RC–2	RC–3	RC–4	RP–1
	08284100 Rio Chama near La Puente, N. Mex., to 08285500 Rio Chama below El Vado Dam, N. Mex. (acre-ft)	08285500 Rio Chama below El Vado Dam, N. Mex., to 08286500 Rio Chama above Abiquiu Reservoir, N. Mex. (acre-ft)	08286500 Rio Chama above Abiquiu Reservoir, N. Mex., to 08287000 Rio Chama below Abiquiu Dam, N. Mex. (acre-ft)	08287000 Rio Chama below Abiquiu Dam, N. Mex., to 08290000 Rio Chama near Chamita, N. Mex. (acre-ft)	08334000 Rio Puerco above Arroyo Chico near Guadalupe, N. Mex., to 08353000 Rio Puerco near Bernardo, N. Mex. (acre-ft)
1985	22,600	15,700	-118,400	92,700	14,880
1986	88,900	-1,600	53,000	39,500	7,020
1987	157,300	20,900	103,300	36,300	19,580
1988	33,100	16,100	97,400	31,900	36,270
1989	92,200	7,600	30,700	40,100	5,060
1990	44,100	-1,800	15,600	3,700	16,700
1991	55,800	13,200	6,500	55,700	27,890
1992	106,400	16,400	113,300	21,600	1,270
1993	93,100	35,500	-60,600	110,700	3,750
1994	103,900	43,100	66,400	76,300	10,220
1995	28,500	68,000	-86,300	132,400	-4,850
1996	191,000	2,200	134,100	18,000	17,410
1997	2,200	29,000	-3,700	71,400	11,820
1998	141,900	20,400	15,700	40,600	-1,720
1999	-12,300	17,100	-5,500	64,500	19,850
2000	243,460	-1,000	117,600	6,200	600
2001	-19,400	5,700	-27,000	29,500	-1,930
2002	252,260	-3,900	64,900	4,100	2,800
2003	45,300	2,100	2,800	3,200	5,950
2004	90,100	900	-44,600	34,600	9,860
2005	-32,200	5,000	30,500	72,000	3,270
2006	142,200	2,600	-46,100	14,800	72,680
2007	-200	19,200	1,500	8,200	-23,090
2008	47,200	38,100	28,000	63,000	-4,650
2009	134,400	15,500	3,700	20,800	3,400
2010	104,700	15,600	18,700	12,900	5,310
2011	104,400	-4,000	8,500	-4,600	6,110
2012	158,400	1,100	21,800	10,700	540
2013	149,260	9,600	9,400	1,800	39,570
Mean annual streamflow	**88,572**	**14,079**	**19,007**	**38,366**	**10,537**

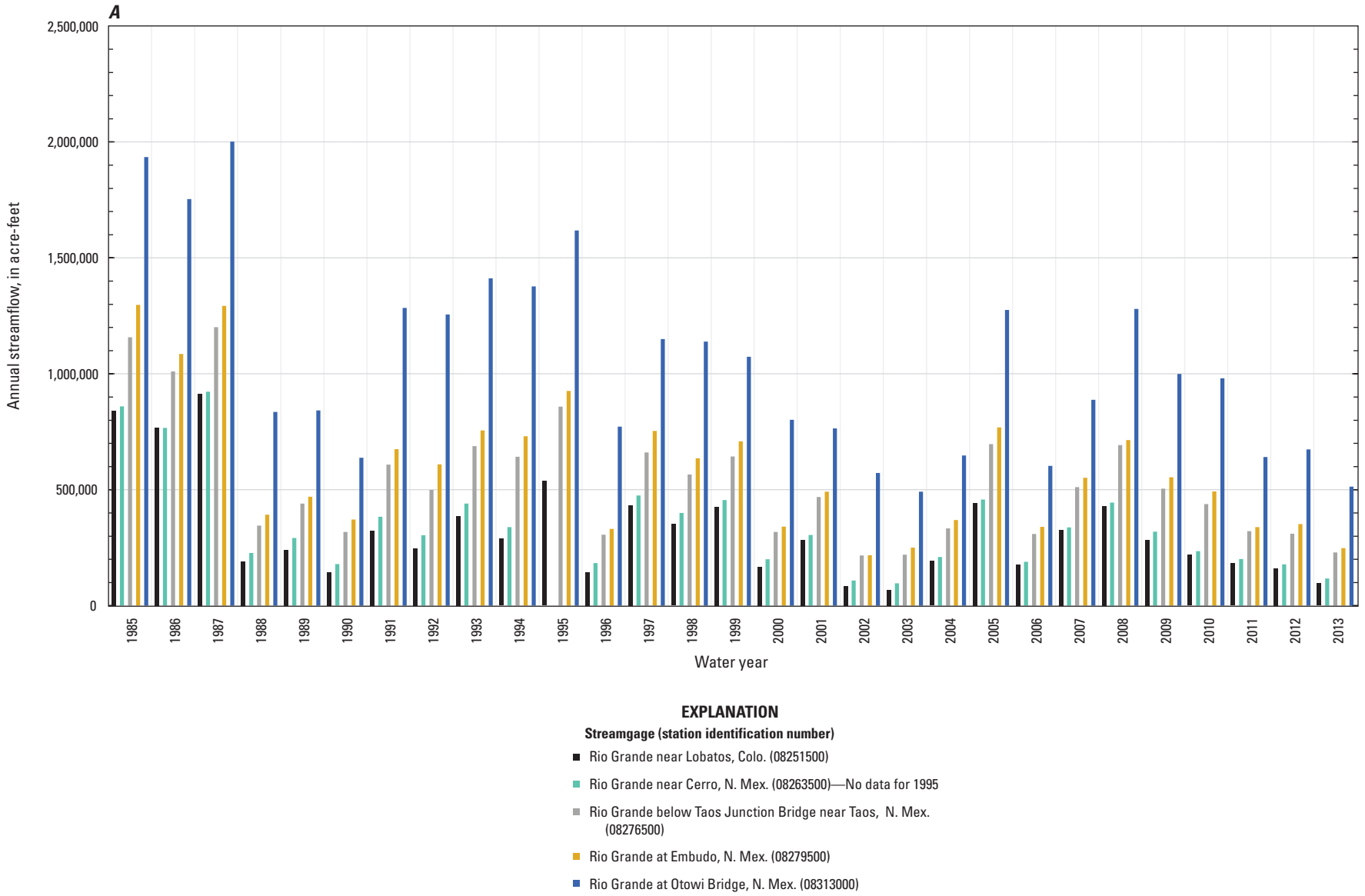

Figure 3. Annual streamflow, departure of annual streamflow from mean annual streamflow, and annual difference in streamflow for streams in the Rio Grande Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.
A, Rio Grande annual streamflow by streamgage, in downstream order, upstream from the Rio Grande at Otowi Bridge, N. Mex. (08313000), streamgage.

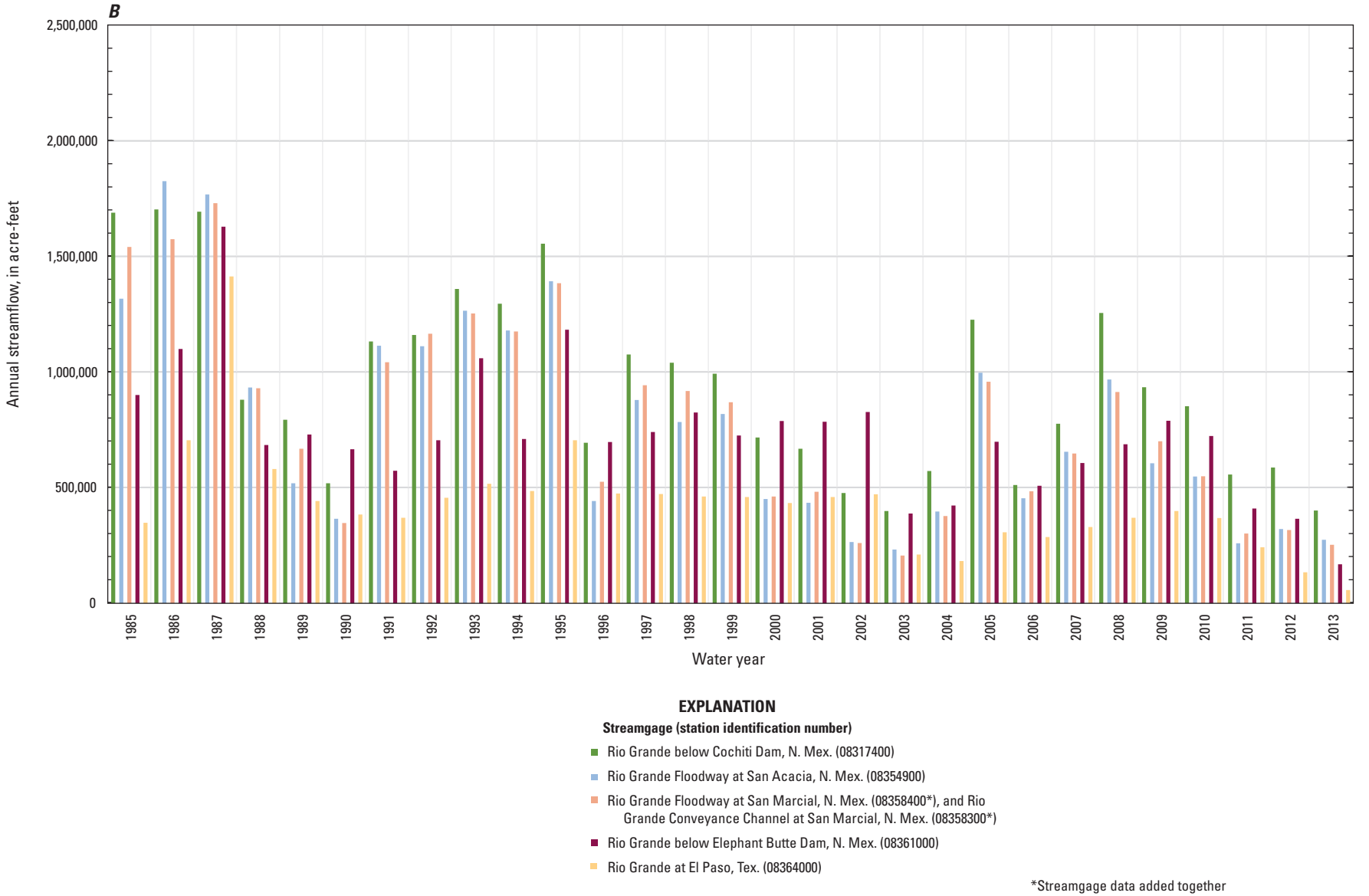

Figure 3. Annual streamflow, departure of annual streamflow from mean annual streamflow, and annual difference in streamflow for streams in the Rio Grande Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued

B, Rio Grande annual streamflow by streamgage, in downstream order, from the Rio Grande below Cochiti Dam, N. Mex. (08317400), streamgage to the Rio Grande at El Paso, Tex. (08364000), streamgage.

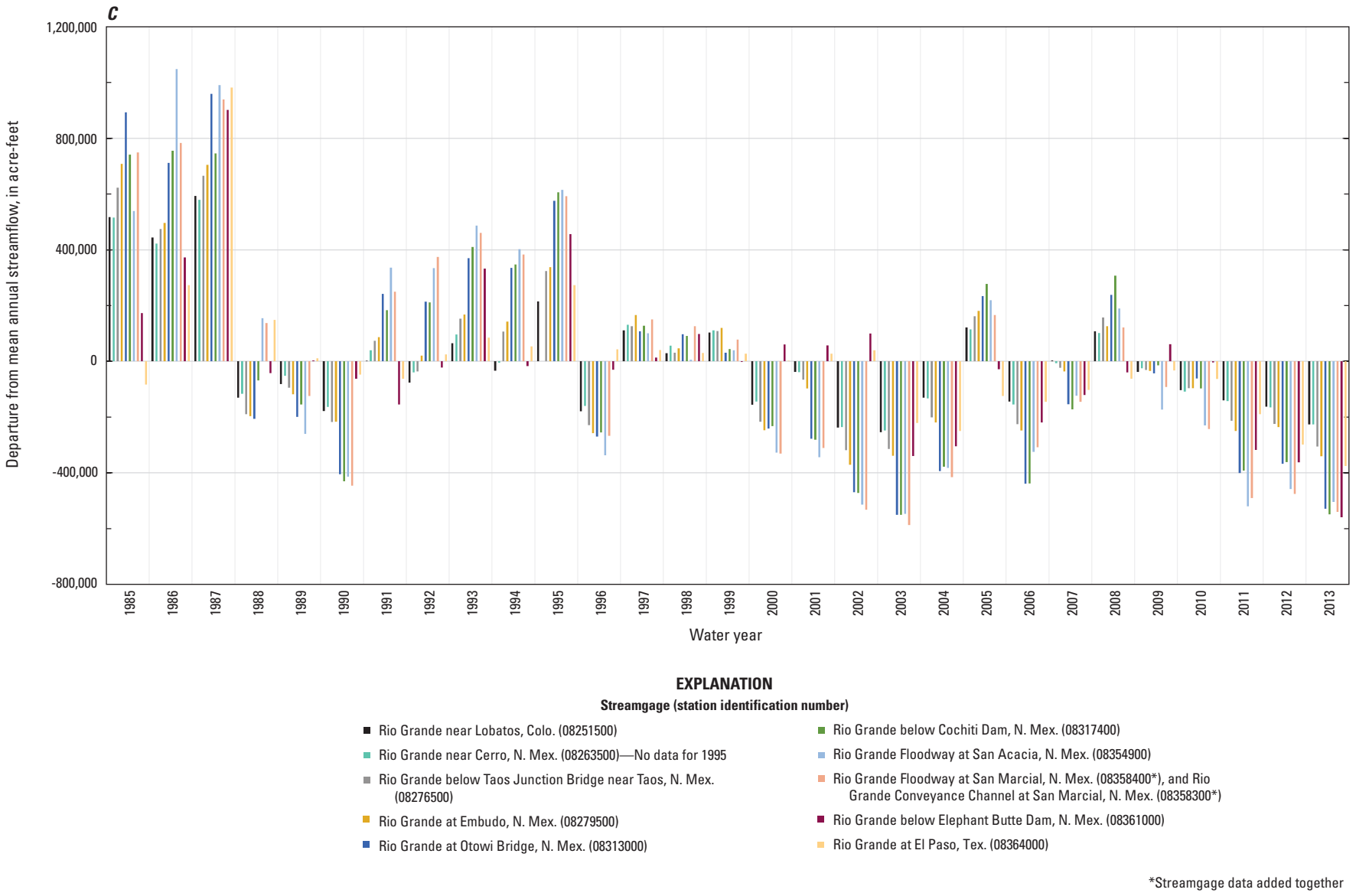

Figure 3. Annual streamflow, departure of annual streamflow from mean annual streamflow, and annual difference in streamflow for streams in the Rio Grande Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued
C, Departure of annual streamflow from mean annual streamflow at Rio Grande streamgages.

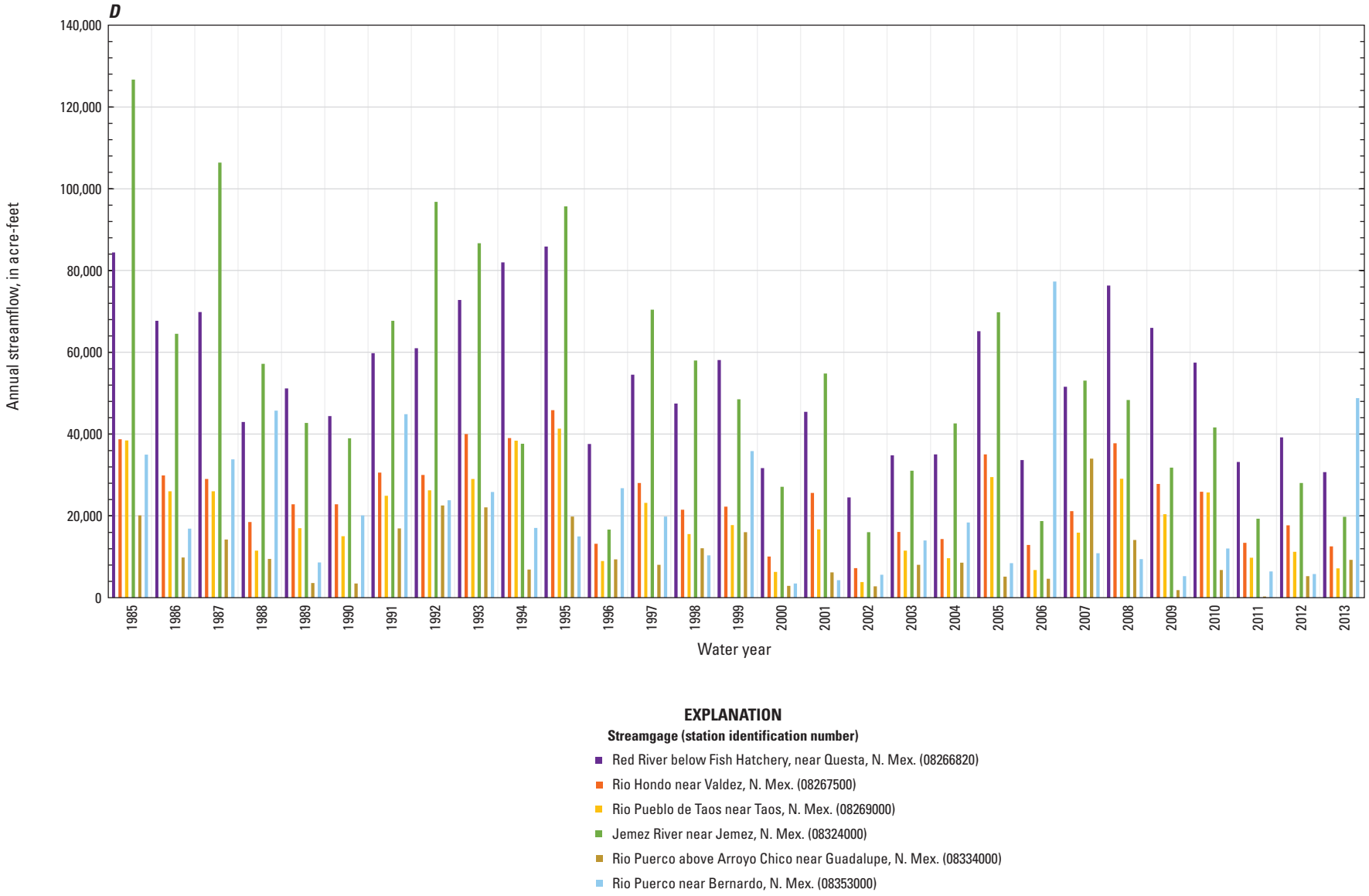

Figure 3. Annual streamflow, departure of annual streamflow from mean annual streamflow, and annual difference in streamflow for streams in the Rio Grande Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued
D, Rio Grande Basin tributary annual streamflow by streamgage, in downstream order. Rio Chama streamgages are omitted.

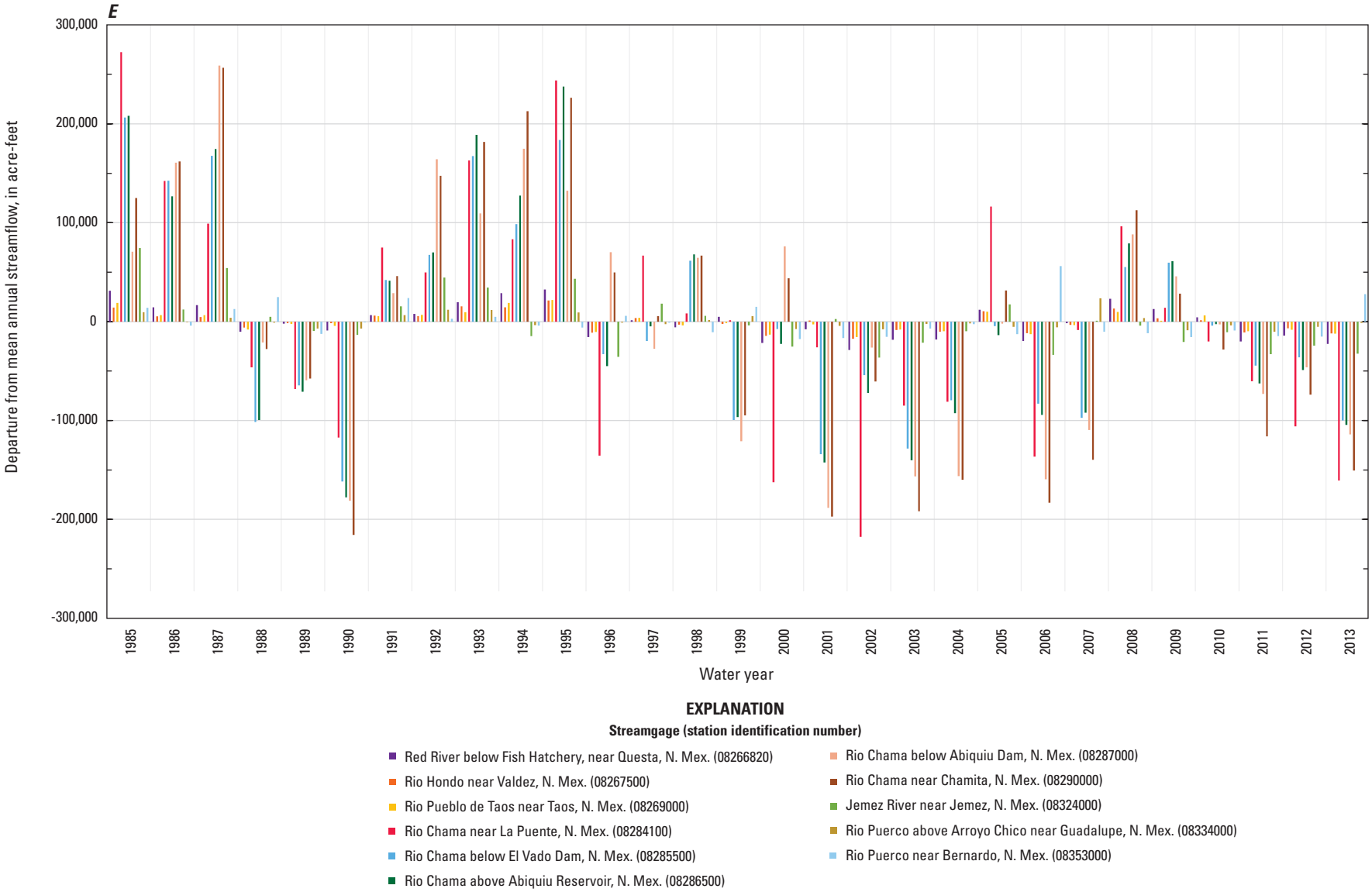

Figure 3. Annual streamflow, departure of annual streamflow from mean annual streamflow, and annual difference in streamflow for streams in the Rio Grande Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued
E, Departure of annual streamflow from mean annual streamflow at Rio Grande Basin tributary streamgages.

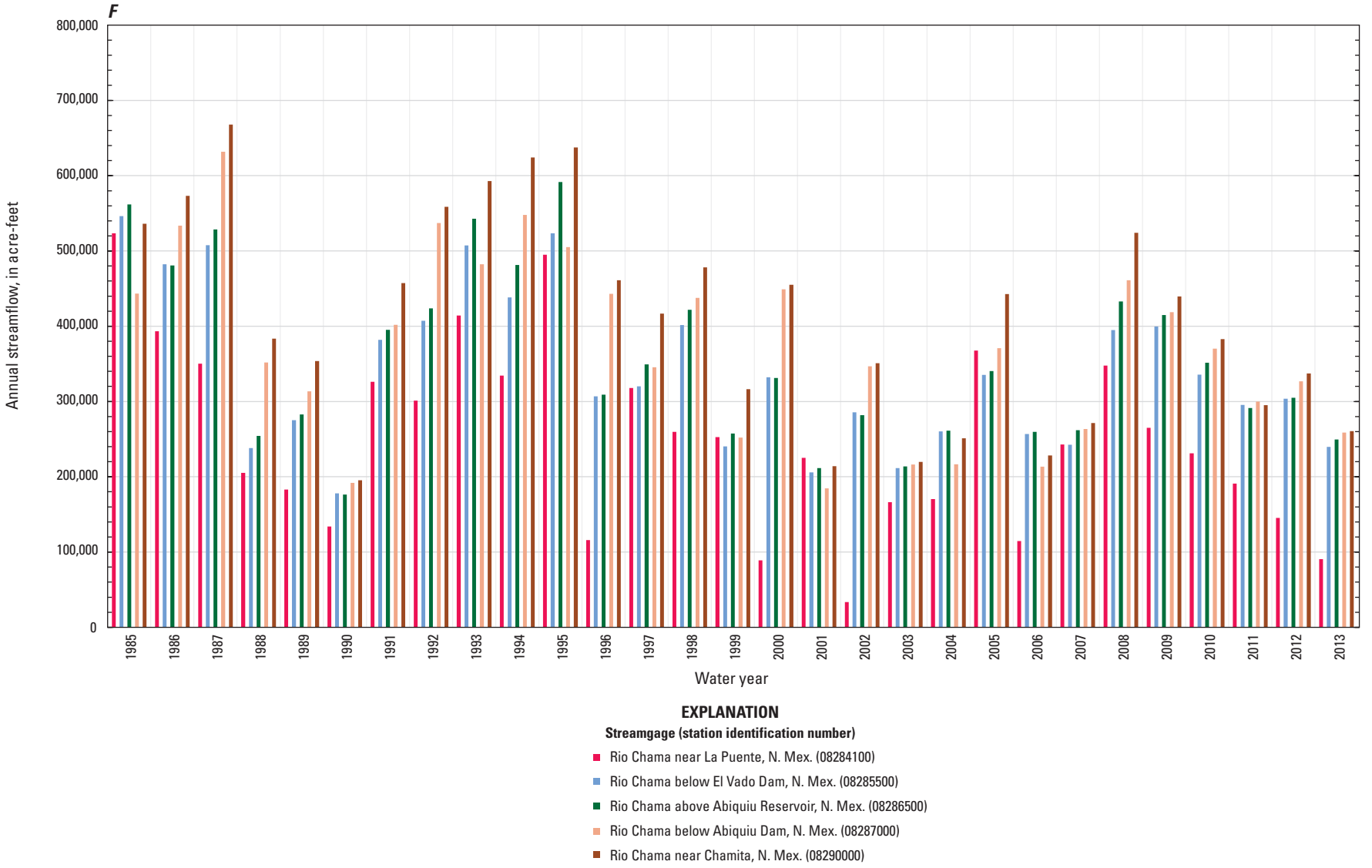

Figure 3. Annual streamflow, departure of annual streamflow from mean annual streamflow, and annual difference in streamflow for streams in the Rio Grande Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued
F, Rio Chama annual streamflow by streamgage, in downstream order.

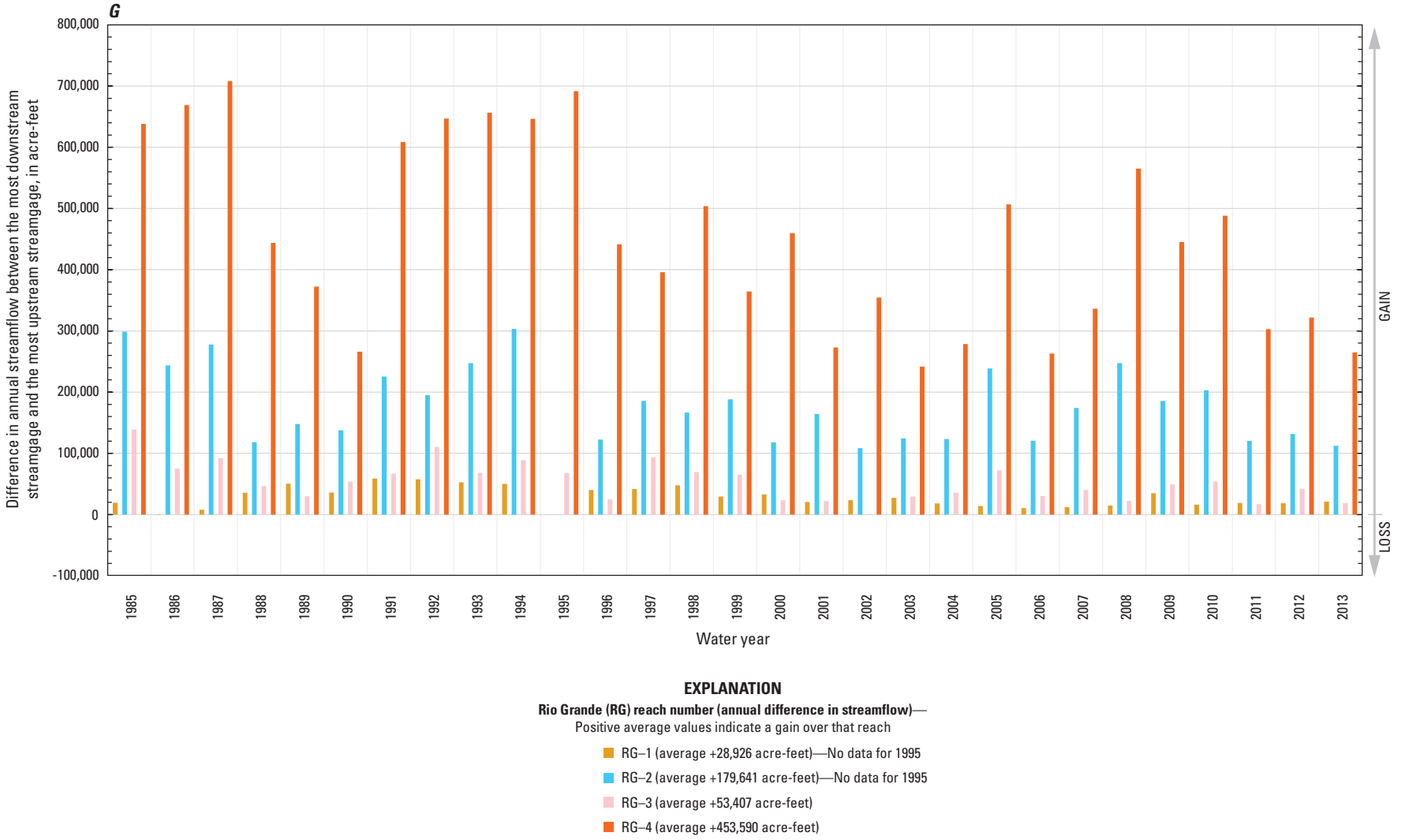

Figure 3. Annual streamflow, departure of annual streamflow from mean annual streamflow, and annual difference in streamflow for streams in the Rio Grande Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued
G, Rio Grande annual difference in streamflow by reach, RG–1 to RG–4.

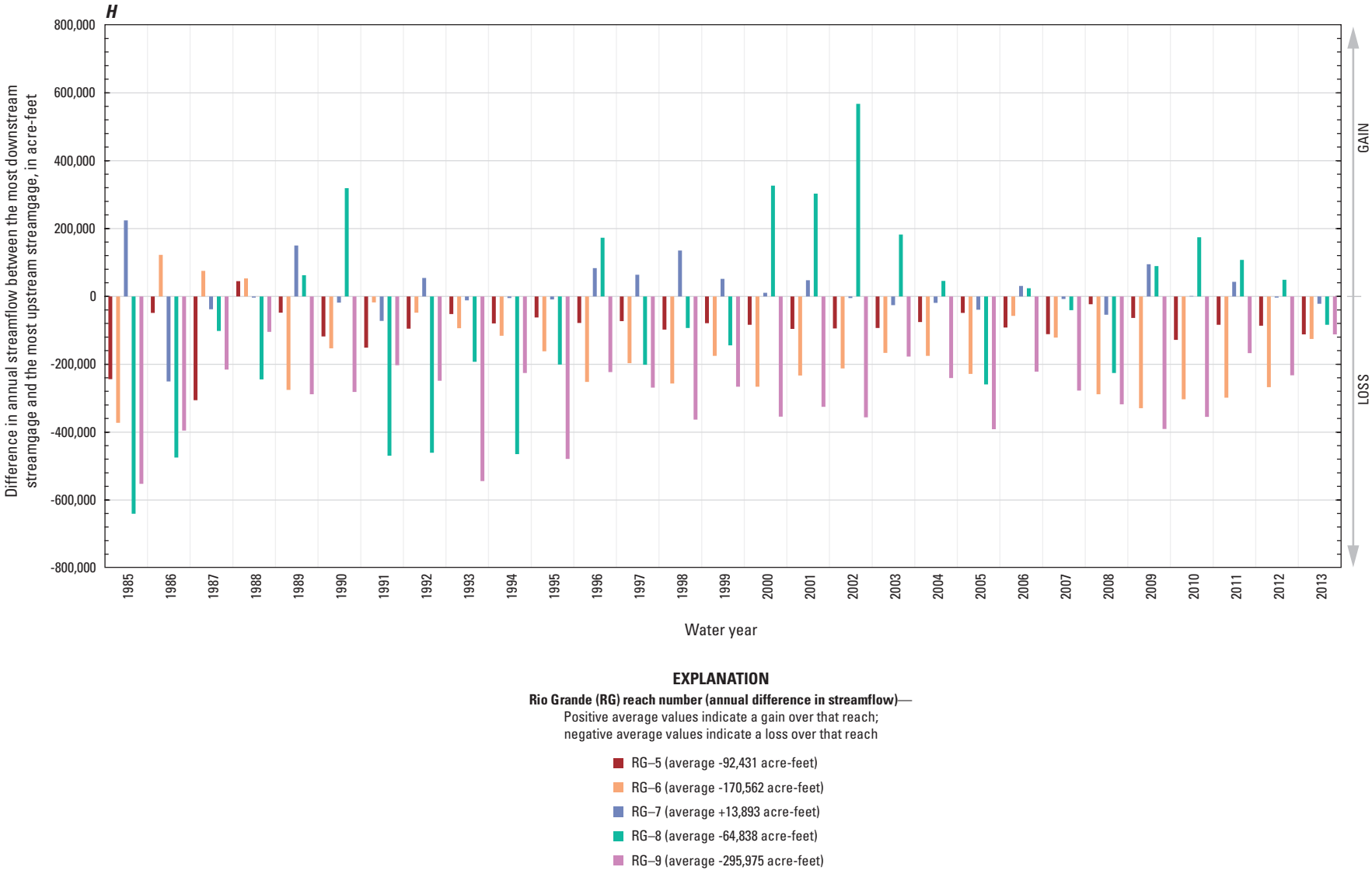

Figure 3. Annual streamflow, departure of annual streamflow from mean annual streamflow, and annual difference in streamflow for streams in the Rio Grande Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued
H, Rio Grande annual difference in streamflow by reach, RG–5 to RG–9.

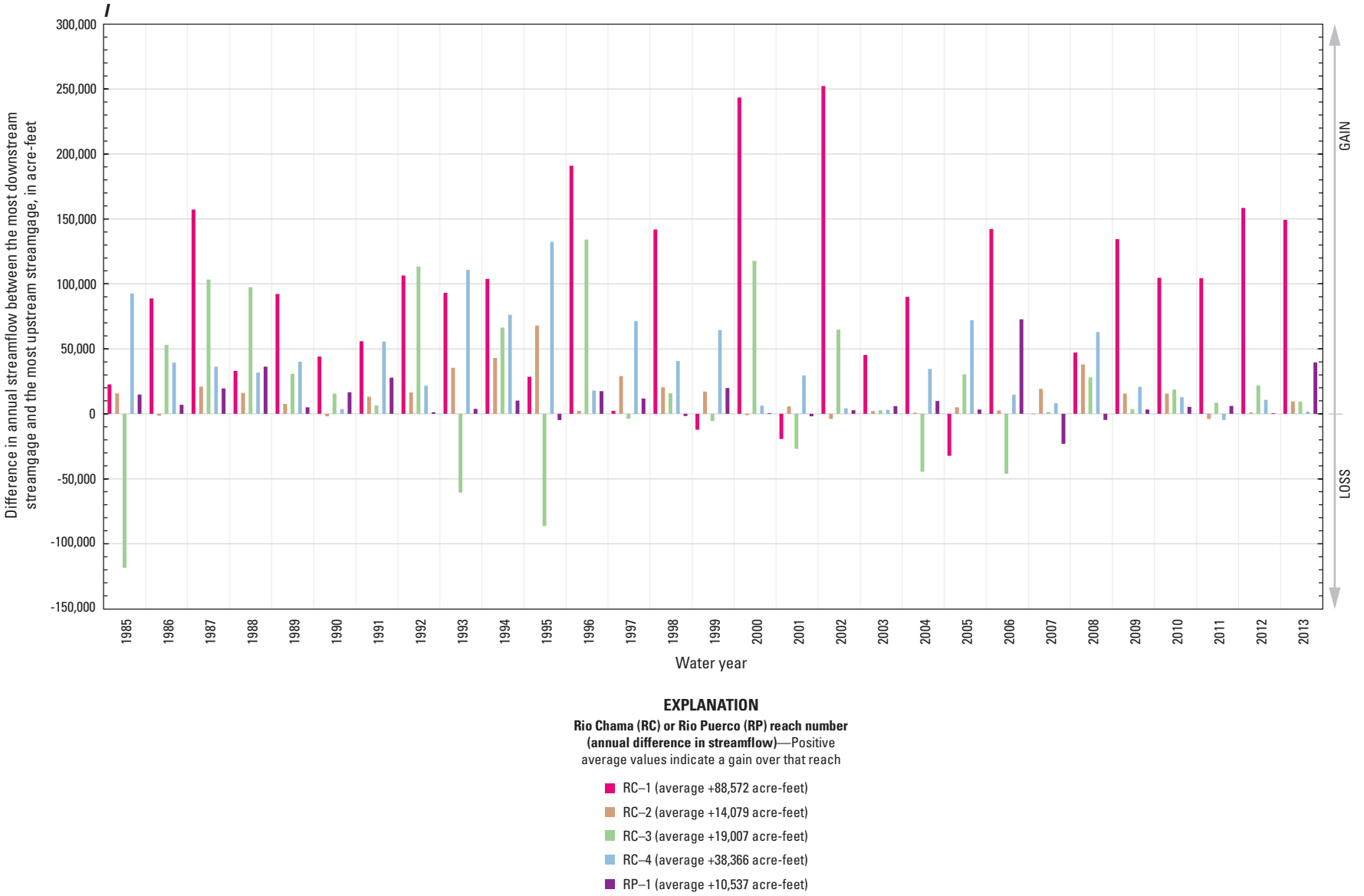

Figure 3. Annual streamflow, departure of annual streamflow from mean annual streamflow, and annual difference in streamflow for streams in the Rio Grande Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued
I, Rio Grande Basin tributary annual difference in streamflow by reach.

The greatest positive departure from mean annual streamflow occurred during 1985–87; the departure became negative for 1988–90 (fig. 3*C*). In 1991, the departures from mean annual streamflow became positive and increased in magnitude until 1995. In 1996, departures from mean annual streamflow were negative, but from 1997 to 1999 the departures were just above the mean. For 2000–13, departures from mean annual streamflow were, for the most part, negative except for 2005 and 2008 (fig. 3*C*).

Mean annual streamflows in the Rio Grande for the study period increased in magnitude downstream to a high of 1,042,055 acre-ft at the Rio Grande at Otowi Bridge, N. Mex. (08313000), streamgage but, in general, decreased downstream from this location, reaching a low of 432,142 acre-ft at the Rio Grande at El Paso, Tex. (08364000), streamgage (table 3). The Rio Grande at Otowi Bridge, N. Mex. (08313000), streamgage consistently recorded the highest flow on the river, due in part to the large flow contributed by the Rio Chama upstream from that streamgage (fig. 3*A*; table 3).

Red River

The Red River is one of the shorter tributaries to the Rio Grande and is the northernmost tributary that is entirely within New Mexico (fig. 2). Only one streamgage on the Red River, the Red River below Fish Hatchery, near Questa, N. Mex. (08266820), streamgage (fig. 2), had data for the entire study period, so gains and losses were not computed for this stream. The Red River mean annual streamflow at the Red River below Fish Hatchery, near Questa, N. Mex. (08266820), streamgage for the study period was 53,266 acre-ft, indicating that this stream was the second largest tributary to the Rio Grande (table 4). During the study period, the highest annual flow, 85,850 acre-ft, occurred in 1995, and the lowest annual flow, 24,530 acre-ft, occurred in 2002 (fig. 3*D*; table 4). Departures from mean annual streamflow generally were positive for 1985–87, 1991–95, and 2008–09 and generally were negative during the rest of the study period (fig. 3*E*).

Rio Hondo

The Rio Hondo is located directly south of the Red River (fig. 2). Only one streamgage on the Rio Hondo, the Rio Hondo near Valdez, N. Mex. (08267500), streamgage (fig. 2), had data for the entire study period, so gains and losses were not computed for this stream. Annual flows at the Rio Hondo near Valdez, N. Mex. (08267500), streamgage were of lesser magnitude than the Red River but had a similar pattern of departure from the mean annual streamflow as the Red River (figs. 3*D* and 3*E*; table 4). Mean annual streamflow at the Rio Hondo near Valdez, N. Mex. (08267500), streamgage for the study period was 24,489 acre-ft, indicating that this stream was the fourth largest tributary to the Rio Grande (fig. 3*D*; table 4). Similar to the Red River, the Rio Hondo had its highest annual flow, 45,880 acre-ft, in 1995 and its lowest annual flow, 7,240 acre-ft, in 2002 (fig. 3*D*; table 4).

Rio Pueblo de Taos

The Rio Pueblo de Taos is located directly south of the Rio Hondo (fig. 2). Only one streamgage on the Rio Pueblo de Taos, the Rio Pueblo de Taos near Taos, N. Mex. (08269000), streamgage (fig. 2), had data for the entire study period, so gains and losses were not computed for this stream. The mean annual streamflow at the Rio Pueblo de Taos near Taos, N. Mex. (08269000), streamgage was 19,422 acre-ft, indicating that this stream was the sixth largest (and therefore the smallest) tributary to the Rio Grande (table 4). Similar to flows in the Red River and Rio Hondo, departure from mean annual streamflow generally was positive for 1985–87, 1991–95, and 2008–09 and generally was negative during the rest of the study period (fig. 3*E*). Like the Red River and Rio Hondo, the highest annual streamflow at the Rio Pueblo de Taos near Taos, N. Mex. (08269000), streamgage was in 1995 at 41,340 acre-ft, and its lowest annual streamflow was in 2002 at 3,850 acre-ft (fig. 3*D*; table 4).

Rio Chama

The Rio Chama originates in Colorado and joins the Rio Grande in northern New Mexico (fig. 2). In addition to water from its natural headwater area, the Rio Chama receives water that is diverted from streams in the San Juan River Basin and transferred to the Rio Chama by way of man-made conveyances. There are two reservoirs, El Vado and Abiquiu, on the Rio Chama and a third, Heron (which stores and releases the water transferred from the San Juan River Basin), on a small tributary to the Rio Chama (fig. 2).

Five streamgages on the Rio Chama included in this study are the Rio Chama near La Puente, N. Mex. (08284100), the Rio Chama below El Vado Dam, N. Mex. (08285500), the Rio Chama above Abiquiu Reservoir, N. Mex. (08286500), the Rio Chama below Abiquiu Dam, N. Mex. (08287000), and the Rio Chama near Chamita, N. Mex. (08290000), streamgages (fig. 2). The Rio Chama is the largest tributary to the Rio Grande (table 4). Monthly data for these streamgages on the Rio Chama are presented in appendix 4. The data indicate an overall pattern of decreasing annual streamflow since 1985 (fig. 3*F;* table 4). Except at the Rio Chama near La Puente, N. Mex. (08284100), streamgage and the Rio Chama below Abiquiu Dam, N. Mex. (08287000), streamgage, the lowest flows occurred in 1990 (fig. 3*F;* table 4).

Mean annual streamflow in the Rio Chama generally increased downstream over the study period (table 4). For 1985–95, only 1988–90 had negative departures from mean annual streamflow (fig. 3*E*). After 1995, negative departures from the mean became more frequent.

Jemez River

The Jemez River originates in the Jemez Mountains, N. Mex. (fig. 1), and flows southeast to the Rio Grande (fig. 2). Jemez Canyon Reservoir is located downstream from the study

streamgage. Only one streamgage on the Jemez River, the Jemez River near Jemez, N. Mex. (08324000), streamgage (fig. 2), had data for the entire study period, so gains and losses were not computed for this stream. Annual flows at the Jemez River near Jemez, N. Mex. (08324000), streamgage generally decreased after 1995 (fig. 3*D*; table 4). The highest annual flow, 126,700 acre-ft, occurred in 1985, and the lowest flow, 16,010 acre-ft, occurred in 2002 (fig. 3*D*); the mean annual streamflow at the Jemez River near Jemez, N. Mex. (08324000), streamgage was 52,310 acre-ft, indicating that this stream was the third largest tributary to the Rio Grande (table 4).

Rio Puerco

The Rio Puerco originates east of the Jemez Mountains (fig. 1) and flows southeast to the Rio Grande between Belen, N. Mex., and Socorro (fig. 2). Two streamgages on the Rio Puerco, the Rio Puerco above Arroyo Chico near Guadalupe, N. Mex. (08334000), streamgage and the Rio Puerco near Bernardo, N. Mex. (08353000), streamgage (fig. 2), were identified for inclusion in this study. Annual flows in the Rio Puerco at both streamgages generally decreased after 2000 (fig. 3*D*; table 4). Annual flows at the Rio Puerco above Arroyo Chico near Guadalupe, N. Mex. (08334000), streamgage decreased gradually over the study period but had high annual flows in 2007–08. Annual flows at the Rio Puerco above Arroyo Chico near Guadalupe, N. Mex. (08334000), streamgage ranged from a high of 34,000 acre-ft in 2007 to a low of 300 acre-ft in 2011, and the mean annual streamflow was 10,503 acre-ft (fig. 3*D*; table 4). Annual flows at the Rio Puerco near Bernardo, N. Mex. (08353000), streamgage showed a greater decrease over the years than at the Rio Puerco above Arroyo Chico near Guadalupe, N. Mex. (08334000), streamgage but exhibited high annual flows in 2006 and 2013. Annual flows at the Rio Puerco near Bernardo, N. Mex. (08353000), streamgage ranged from a high of 77,300 acre-ft in 2006 to a low of 3,490 acre-ft in 2000 and had a mean annual streamflow of 21,040 acre-ft, indicating that this stream was the fifth largest tributary to the Rio Grande (fig. 3*D*; table 4).

Rio Grande Basin Gains and Losses

Rio Grande

Reaches RG–1 through RG–4 (fig. 2) were all gaining reaches except for reach RG–1 in 1986, with no data for RG–1 and RG–2 in 1995 (fig. 3*G*; table 3). For the study period, mean annual streamflow gains were 28,926 acre-ft for reach RG–1; 179,641 acre-ft for reach RG–2; 53,407 acre-ft for reach RG–3; and 453,590 acre-ft for reach RG–4 (table 3). For the reaches farther downstream (fig. 2), at reach RG–5, the river became a losing stream through reach RG–9, except for reach RG–7, which was a gaining reach (fig. 3*H*; table 3).

Reach RG–5 includes Cochiti Lake (fig. 2). Gains and losses for reach RG–5 ranged from a gain of 45,100 acre-ft in 1988 to a loss of 306,000 acre-ft in 1987, with a mean annual loss of 92,431 acre-ft over the study period (fig. 3*H*; table 3). Gains and losses for reach RG–6 ranged from a gain of 122,000 acre-ft in 1986 to a loss of 373,000 acre-ft in 1985, with a mean annual loss of 170,562 acre-ft over the study period (fig. 3*H*; table 3). Reach RG–7 had 13 gaining years interspersed with losing years (fig. 3*H*; table 3). Gains and losses ranged from a gain of 224,000 acre-ft in 1985 to a loss of 251,000 acre-ft in 1986, with a mean annual gain of 13,893 acre-ft over the study period (fig. 3*H*; table 3). Reach RG–8, which includes Elephant Butte Reservoir (fig. 2), had 13 gaining years interspersed with losing years (fig. 3*H*; table 3). Gains and losses ranged from a gain of 567,700 acre-ft in 2002 to a loss of 641,000 acre-ft in 1985, with a mean annual loss of 64,838 acre-ft over the study period (fig. 3*H*; table 3). For the study period, reach RG–9, which includes Caballo Reservoir (fig. 2) and much of the irrigated land in New Mexico, was a losing reach for all years (fig. 3*H*; table 3). Annual losses ranged from 104,600 acre-ft in 1988 to 552,300 acre-ft in 1985 and had a mean annual loss of 295,975 acre-ft over the study period (fig. 3*H*; table 3).

Rio Chama

The Rio Chama reaches (fig. 2) were gaining in most of the 29 years of the study period: reach RC–1 was gaining for 25 years, reach RC–2 was gaining for 24 years, reach RC–3 was gaining for 21 years, and reach RC–4 was gaining for 28 years (fig. 3*I*; table 4). Reach RC–1, which includes El Vado Reservoir and has San Juan-Chama Project water inflows from Heron Reservoir (fig. 2), had the greatest gains of all reaches in the basin, which ranged from a gain of 252,260 acre-ft in 2002 to a loss of 32,200 acre-ft in 2005 and had a mean annual gain of 88,572 acre-ft (fig. 3*I*; table 4).

Rio Puerco

Reach RP–1 (fig. 2) was a gaining reach for 24 years of the study period (fig. 3*I*; table 4). Annual gains and losses for reach RP–1 ranged from a gain of 72,680 acre-ft in 2006 to a loss of 23,090 acre-ft in 2007, with a mean annual gain of 10,537 acre-ft (fig. 3*I*; table 4).

Pecos River Basin Streamflow

Pecos River

The Pecos River originates in northern New Mexico in the central part of the State, flows down the eastern half of New Mexico, and enters Texas in southeastern New Mexico

(fig. 4). One tributary to the Pecos River, the Rio Hondo (fig. 4), is included in this report. The Rio Hondo begins at the confluence of the Rio Bonito and the Rio Ruidoso and joins the Pecos River near Roswell, N. Mex. Data for 11 streamgages on the Pecos River, 2 on the Rio Hondo, and 1 on the Rio Ruidoso (fig. 4; table 5) were compiled for this report. Monthly data for these streamgages are presented in appendix 5.

The Pecos River Basin has many reservoirs and lakes, including Santa Rosa Lake, Lake Sumner, Brantley Lake, Lake Avalon, and Red Bluff Reservoir on the Pecos River, and the Two Rivers Reservoir on the Rio Hondo (fig. 4). The Pecos River below Avalon Dam, N. Mex. (08404000), streamgage had 4 years of little to no flow (1988, 1990, 2010, and 2012), although flow occurred at the other streamgages (figs. 5*A* and 5*B*; table 5). The Pecos River above Canon del Uta near Colonias, N. Mex. (08382600), streamgage lacked data for 2008. There are also substantial irrigation diversions along the Pecos River in New Mexico.

In general, annual streamflow on the Pecos River increased from 1985 to 1995 but decreased from 1995 to 2013 (figs. 5*A* and 5*B*; table 5). Departures from the mean annual streamflow generally were positive for 1985–2000 and negative for 2001–13 (fig. 5*C*). The Pecos River near Puerto de Luna, N. Mex. (08383500), streamgage had the highest mean annual streamflow for the Pecos River for the study period with 133,589 acre-ft, with annual streamflow that ranged from 71,610 acre-ft in 2012 to 230,000 acre-ft in 1995. The Pecos River below Avalon Dam, N. Mex. (08404000), streamgage had the lowest mean annual streamflow with 27,362 acre-ft, with annual streamflow that ranged from 0.00 acre-ft in 1988, 2010, and 2012 to 130,800 acre-ft in 1987 (table 5). Highest annual flows at the streamgages upstream from the Pecos River below Sumner Dam, N. Mex. (08384500), streamgage occurred in the 1990s (fig. 5*A*; table 5), whereas highest annual flows at the streamgages from the Pecos River near Acme, N. Mex. (08386000), streamgage to the Pecos River at Red Bluff, N. Mex. (08407500), streamgage occurred in 1987, except at the Pecos River at Red Bluff, N. Mex. (08407500), streamgage, which had highest annual flow in 1986 (fig. 5*B*; table 5). Periods of the lowest flow on the Pecos River occurred between 2009 and 2013, with some exceptions; the Pecos River near Pecos, N. Mex. (08378500), streamgage and the Pecos River near Anton Chico, N. Mex. (08379500), streamgage had the lowest annual flows in 2002, whereas the Pecos River below Avalon Dam, N. Mex. (08404000), streamgage had 4 years with 0–3.5 acre-ft and an annual flow of 68 acre-ft in 1989 (figs. 5*A* and 5*B*; table 5). Mean annual streamflows ranged from 133,589 acre-ft at the Pecos River near Puerto de Luna, N. Mex. (08383500), streamgage to 27,362 acre-ft at the Pecos River below Avalon Dam, N. Mex. (08404000), streamgage (table 5).

Rio Hondo

The Rio Hondo forms at the confluence of the Rio Ruidoso and Rio Bonito (fig. 4). Although the USGS has operated streamgages on the Rio Bonito in the past, there are no streamgages with a continuous record for the study period. One streamgage on the Rio Ruidoso (Rio Ruidoso at Hollywood, N. Mex. [08387000]) has continuous data for the entire study period. This streamgage on the Rio Ruidoso was used with the Rio Hondo at Diamond A Ranch near Roswell, N. Mex. (08390500), streamgage to create a reach that encompassed the upper Rio Hondo, and flow difference was calculated for this reach. The Rio Hondo has one reservoir, Two Rivers Reservoir (fig. 4). Low annual streamflows generally occurred in 1999–2004, 2009, and 2011–12 (fig. 5*D*; table 5). The highest annual streamflow at all streamgages occurred in 1987. Annual streamflows generally have decreased in magnitude from 1992 to 2013, but there were moderate flows at some locations during 2006–13. Annual flows at the Rio Ruidoso at Hollywood, N. Mex. (08387000), streamgage ranged from a low of 4,370 acre-ft in 2002 to a high of 35,950 acre-ft in 1987 and had a mean annual streamflow of 15,275 acre-ft (fig. 5*D*; table 5). Annual flows at the Rio Hondo at Diamond A Ranch near Roswell, N. Mex. (08390500), streamgage ranged from a low of 13 acre-ft in 2003 to a high of 78,570 acre-ft in 1987 and had a mean annual streamflow of 17,390 acre-ft. Annual flows at the Rio Hondo below Diamond A Dam near Roswell, N. Mex. (08390800), streamgage ranged from a low of 0.9 acre-ft in 2000 to a high of 62,000 acre-ft in 1987 and had a mean annual streamflow of 10,427 acre-ft. Both the Rio Hondo at Diamond A Ranch near Roswell, N. Mex. (08390800), streamgage and the Rio Hondo below Diamond A Dam near Roswell, N. Mex. (08390800), streamgage showed notably low flows from 1999 to 2003 (fig. 5*D*; table 5). Departures from the mean annual streamflow generally were negative after 2000 (fig. 5*C*).

Pecos River Basin Gains and Losses

Pecos River

The Pecos River was divided into 10 reaches (fig. 4), which varied greatly in terms of annual gains and losses (figs. 5*E* and 5*F*; table 5). The first reach, PEC–1, had gains in 18 of 29 years. Gains and losses ranged from a gain of 57,400 acre-ft in 1991 to a loss of 21,650 acre-ft in 2012 (fig. 5*E*; table 5). Reach PEC–2 had losses in 25 of 28 years. Annual gains and losses ranged from a gain of 34,380 acre-ft in 2013 to a loss of 43,700 acre-ft in 1997. Reach PEC–3 had gains in 26 of 28 years. Annual gains and losses ranged from a gain of 36,460 acre-ft in 1999 to a loss of 15,040 acre-ft in 2004. Reach PEC–4 had losses in 17 of 29 years. Annual gains and losses ranged from a gain of 79,200 acre-ft in 2000 to a loss of 95,640 acre-ft in 2013.

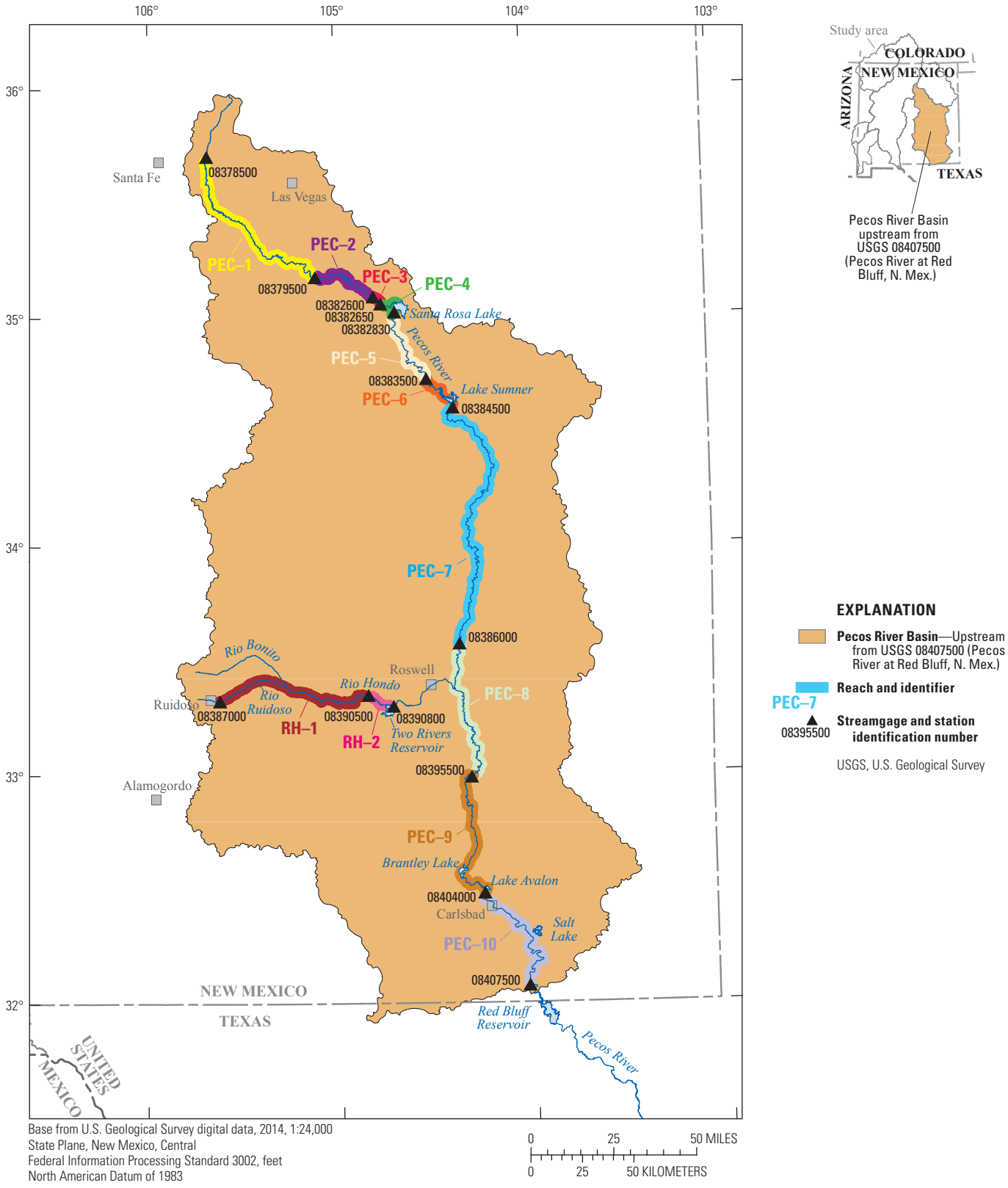

Figure 4. Pecos River Basin, streams, stream reaches, and streamgages upstream from the Pecos River at Red Bluff, New Mexico (08407500), streamgage in the six-basin study area, New Mexico and parts of bordering States and Mexico.

Table 5. Annual streamflow and annual difference in streamflow by reach for selected Pecos River Basin streamgages in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.

[N. Mex., New Mexico; acre-ft, acre-feet; --, no data; PEC, Pecos River reach, numbered in downstream order; RH, Rio Hondo reach, numbered in downstream order]

Annual streamflow														
	Pecos River											Tributaries		
Water year	08378500 Pecos River near Pecos, N. Mex. (acre-ft)	08379500 Pecos River near Anton Chico, N. Mex. (acre-ft)	08382600 Pecos River above Canon del Uta near Colonias, N. Mex. (acre-ft)	08382650 Pecos River above Santa Rosa Lake, N. Mex. (acre-ft)	08382830 Pecos River below Santa Rosa Dam, N. Mex. (acre-ft)	08383500 Pecos River near Puerto de Luna, N. Mex. (acre-ft)	08384500 Pecos River below Sumner Dam, N. Mex. (acre-ft)	08386000 Pecos River near Acme, N. Mex. (acre-ft)	08395500 Pecos River near Lake Arthur, N. Mex. (acre-ft)	08404000 Pecos River below Avalon Dam, N. Mex. (acre-ft)	08407500 Pecos River at Red Bluff, N. Mex. (acre-ft)	08387000 Rio Ruidoso at Hollywood, N. Mex. (acre-ft)	08390500 Rio Hondo at Diamond A Ranch near Roswell, N. Mex. (acre-ft)	08390800 Rio Hondo below Diamond A Dam near Roswell, N. Mex. (acre-ft)
1985	120,800	159,200	118,900	132,400	43,570	101,800	105,700	86,530	115,300	4,950	50,760	35,570	47,160	36,250
1986	84,680	100,900	65,690	84,900	56,980	136,300	92,820	89,330	176,100	127,400	215,300	24,950	58,350	28,980
1987	98,590	146,700	133,200	161,800	134,200	192,100	199,300	182,900	250,100	130,800	215,000	35,950	78,570	62,000
1988	74,940	74,310	59,520	83,190	93,620	172,200	170,300	135,100	150,300	0.00	60,480	19,610	29,640	21,790
1989	50,180	41,240	21,470	39,130	84,390	144,800	137,700	112,100	119,700	68	41,180	13,370	15,410	10,870
1990	56,020	49,620	45,920	56,480	49,390	110,100	102,500	75,660	76,980	3.5	28,970	15,130	11,060	7,230
1991	120,000	177,400	177,300	192,100	98,320	157,100	121,000	151,200	191,100	19,020	57,710	27,170	40,920	25,830
1992	100,700	110,300	80,480	93,330	76,780	137,200	134,000	137,800	163,200	85,230	160,900	29,400	41,000	31,640
1993	103,000	118,600	99,970	127,800	112,200	173,600	150,100	146,300	153,500	17,020	66,780	19,720	21,030	13,000
1994	90,350	113,800	101,700	122,800	119,100	178,500	180,100	140,400	166,200	14,060	60,480	8,600	10,670	6,450
1995	127,100	148,000	144,200	145,300	155,500	230,000	206,000	171,000	180,900	23,220	74,640	13,720	9,660	6,300
1996	33,580	44,060	30,350	59,950	81,810	137,400	138,300	107,500	143,200	23,380	74,610	9,860	14,970	3,540
1997	136,900	175,500	131,800	151,600	77,840	166,900	138,800	137,000	148,100	14,280	62,430	16,390	7,670	6,950
1998	98,070	90,850	62,300	89,500	129,800	199,000	210,000	176,400	190,800	43,880	96,000	18,640	3,400	957
1999	87,980	115,100	88,240	124,700	37,930	113,600	78,960	115,400	163,100	24,720	82,240	10,230	250	47
2000	34,030	19,450	8,850	23,900	103,100	163,900	186,400	135,200	160,700	18,020	55,160	6,800	48	0.9
2001	70,380	74,930	51,230	71,710	47,630	117,700	111,000	75,840	103,600	12,370	51,630	7,660	363	553
2002	18,230	6,180	3,090	13,800	16,880	74,400	70,470	49,290	77,780	11,920	37,720	4,370	484	163
2003	46,710	27,290	12,350	19,290	18,980	76,990	69,550	34,390	60,950	10,890	32,110	6,790	13	1.5
2004	53,610	79,190	83,920	68,880	40,200	103,100	96,710	78,660	104,500	37,190	87,610	6,100	2,400	1,500
2005	109,700	159,400	131,600	135,000	48,160	118,000	71,290	91,830	151,300	37,530	98,590	16,040	3,530	1,550
2006	41,990	58,800	64,040	62,330	71,060	136,700	141,700	132,000	161,400	49,540	96,430	19,780	33,590	10,010
2007	71,510	70,760	35,240	49,720	62,000	121,300	115,200	94,470	112,700	11,120	62,660	23,130	16,000	7,910
2008	73,480	75,330	--	65,550	71,430	134,700	128,800	101,300	133,400	17,500	58,120	11,250	18,300	8,320
2009	75,140	57,310	39,750	48,160	47,270	108,400	98,800	76,300	99,270	17,110	62,890	5,170	231	67
2010	81,140	98,220	80,290	90,490	60,150	120,000	113,200	78,930	95,800	0.00	42,570	22,580	14,030	6,990
2011	30,210	11,090	932	8,890	31,870	87,550	88,970	53,580	72,850	17,680	48,200	5,070	586	45
2012	54,180	32,530	17,740	17,790	19,250	71,610	64,820	20,150	32,620	0.00	17,240	4,520	397	19
2013	36,550	56,150	90,530	100,500	4,860	89,120	62,010	54,180	99,940	24,590	42,330	5,410	24,570	3,430
Mean annual streamflow	**75,164**	**85,938**	**70,736**	**84,172**	**68,768**	**133,589**	**123,603**	**104,853**	**132,944**	**27,362**	**73,819**	**15,275**	**17,390**	**10,427**

Table 5. Annual streamflow and annual difference in streamflow by reach for selected Pecos River Basin streamgages in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued

[N. Mex., New Mexico; acre-ft, acre-feet; --, no data; PEC, Pecos River reach, numbered in downstream order; RH, Rio Hondo reach, numbered in downstream order]

	Annual difference in streamflow by reach											
	Pecos River										Tributaries	
	PEC–1	PEC–2	PEC–3	PEC–4	PEC–5	PEC–6	PEC–7	PEC–8	PEC–9	PEC–10	RH–1	RH–2
Water year	08378500 Pecos River near Pecos, N. Mex., to 08379500 Pecos River near Anton Chico, N. Mex. (acre-ft)	08379500 Pecos River near Anton Chico, N. Mex., to 08382600 Pecos River above Canon del Uta near Colonias, N. Mex. (acre-ft)	08382600 Pecos River above Canon del Uta near Colonias, N. Mex., to 08382650 Pecos River above Santa Rosa Lake, N. Mex. (acre-ft)	08382650 Pecos River above Santa Rosa Lake, N. Mex., to 08382830 Pecos River below Santa Rosa Dam, N. Mex. (acre-ft)	08382830 Pecos River below Santa Rosa Dam, N. Mex., to 08383500 Pecos River near Puerto de Luna, N. Mex. (acre-ft)	08383500 Pecos River near Puerto de Luna, N. Mex., to 08384500 Pecos River below Sumner Dam, N. Mex. (acre-ft)	08384500 Pecos River below Sumner Dam, N. Mex., to 08386000 Pecos River near Acme, N. Mex. (acre-ft)	08386000 Pecos River near Acme, N. Mex., to 08395500 Pecos River near Lake Arthur, N. Mex. (acre-ft)	08395500 Pecos River near Lake Arthur, N. Mex., to 08404000 Pecos River below Avalon Dam, N. Mex. (acre-ft)	08404000 Pecos River below Avalon Dam, N. Mex., to 08407500 Pecos River at Red Bluff, N. Mex. (acre-ft)	08387000 Rio Ruidoso at Hollywood, N. Mex., to 08390500 Rio Hondo at Diamond A Ranch near Roswell, N. Mex. (acre-ft)	08390500 Rio Hondo at Diamond A Ranch near Roswell, N. Mex., to 08390800 Rio Hondo below Diamond A Dam near Roswell, N. Mex. (acre-ft)
1985	38,400	-40,300	13,500	-88,830	58,230	3,900	-19,170	28,770	-110,350	45,810	11,590	-10,910
1986	16,220	-35,210	19,210	-27,920	79,320	-43,480	-3,490	86,770	-48,700	87,900	33,400	-29,370
1987	48,110	-13,500	28,600	-27,600	57,900	7,200	-16,400	67,200	-119,300	84,200	42,620	-16,570
1988	-630	-14,790	23,670	10,430	78,580	-1,900	-35,200	15,200	-150,300	60,480	10,030	-7,850
1989	-8,940	-19,770	17,660	45,260	60,410	-7,100	-25,600	7,600	-119,632	41,112	2,040	-4,540
1990	-6,400	-3,700	10,560	-7,090	60,710	-7,600	-26,840	1,320	-76,977	28,967	-4,070	-3,830
1991	57,400	-100	14,800	-93,780	58,780	-36,100	30,200	39,900	-172,080	38,690	13,750	-15,090
1992	9,600	-29,820	12,850	-16,550	60,420	-3,200	3,800	25,400	-77,970	75,670	11,600	-9,360
1993	15,600	-18,630	27,830	-15,600	61,400	-23,500	-3,800	7,200	-136,480	49,760	1,310	-8,030
1994	23,450	-12,100	21,100	-3,700	59,400	1,600	-39,700	25,800	-152,140	46,420	2,070	-4,220
1995	20,900	-3,800	1,100	10,200	74,500	-24,000	-35,000	9,900	-157,680	51,420	-4,060	-3,360
1996	10,480	-13,710	29,600	21,860	55,590	900	-30,800	35,700	-119,820	51,230	5,110	-11,430
1997	38,600	-43,700	19,800	-73,760	89,060	-28,100	-1,800	11,100	-133,820	48,150	-8,720	-720
1998	-7,220	-28,550	27,200	40,300	69,200	11,000	-33,600	14,400	-146,920	52,120	-15,240	-2,443
1999	27,120	-26,860	36,460	-86,770	75,670	-34,640	36,440	47,700	-138,380	57,520	-9,980	-203
2000	-14,580	-10,600	15,050	79,200	60,800	22,500	-51,200	25,500	-142,680	37,140	-6,752	-47
2001	4,550	-23,700	20,480	-24,080	70,070	-6,700	-35,160	27,760	-91,230	39,260	-7,297	190
2002	-12,050	-3,090	10,710	3,080	57,520	-3,930	-21,180	28,490	-65,860	25,800	-3,886	-321
2003	-19,420	-14,940	6,940	-310	58,010	-7,440	-35,160	26,560	-50,060	21,220	-6,777	-12
2004	25,580	4,730	-15,040	-28,680	62,900	-6,390	-18,050	25,840	-67,310	50,420	-3,700	-900
2005	49,700	-27,800	3,400	-86,840	69,840	-46,710	20,540	59,470	-113,770	61,060	-12,510	-1,980
2006	16,810	5,240	-1,710	8,730	65,640	5,000	-9,700	29,400	-111,860	46,890	13,810	-23,580
2007	-750	-35,520	14,480	12,280	59,300	-6,100	-20,730	18,230	-101,580	51,540	-7,130	-8,090
2008	1,850	--	--	5,880	63,270	-5,900	-27,500	32,100	-115,900	40,620	7,050	-9,980
2009	-17,830	-17,560	8,410	-890	61,130	-9,600	-22,500	22,970	-82,160	45,780	-4,939	-164
2010	17,080	-17,930	10,200	-30,340	59,850	-6,800	-34,270	16,870	-95,800	42,570	-8,550	-7,040
2011	-19,120	-10,158	7,958	22,980	55,680	1,420	-35,390	19,270	-55,170	30,520	-4,484	-541
2012	-21,650	-14,790	50	1,460	52,360	-6,790	-44,670	12,470	-32,620	17,240	-4,123	-378
2013	19,600	34,380	9,970	-95,640	84,260	-27,110	-7,830	45,760	-75,350	17,740	19,160	-21,140
Mean annual streamflow	**10,774**	**-15,581**	**14,101**	**-15,404**	**64,821**	**-9,985**	**-18,750**	**28,091**	**-105,583**	**46,457**	**2,115**	**-6,962**

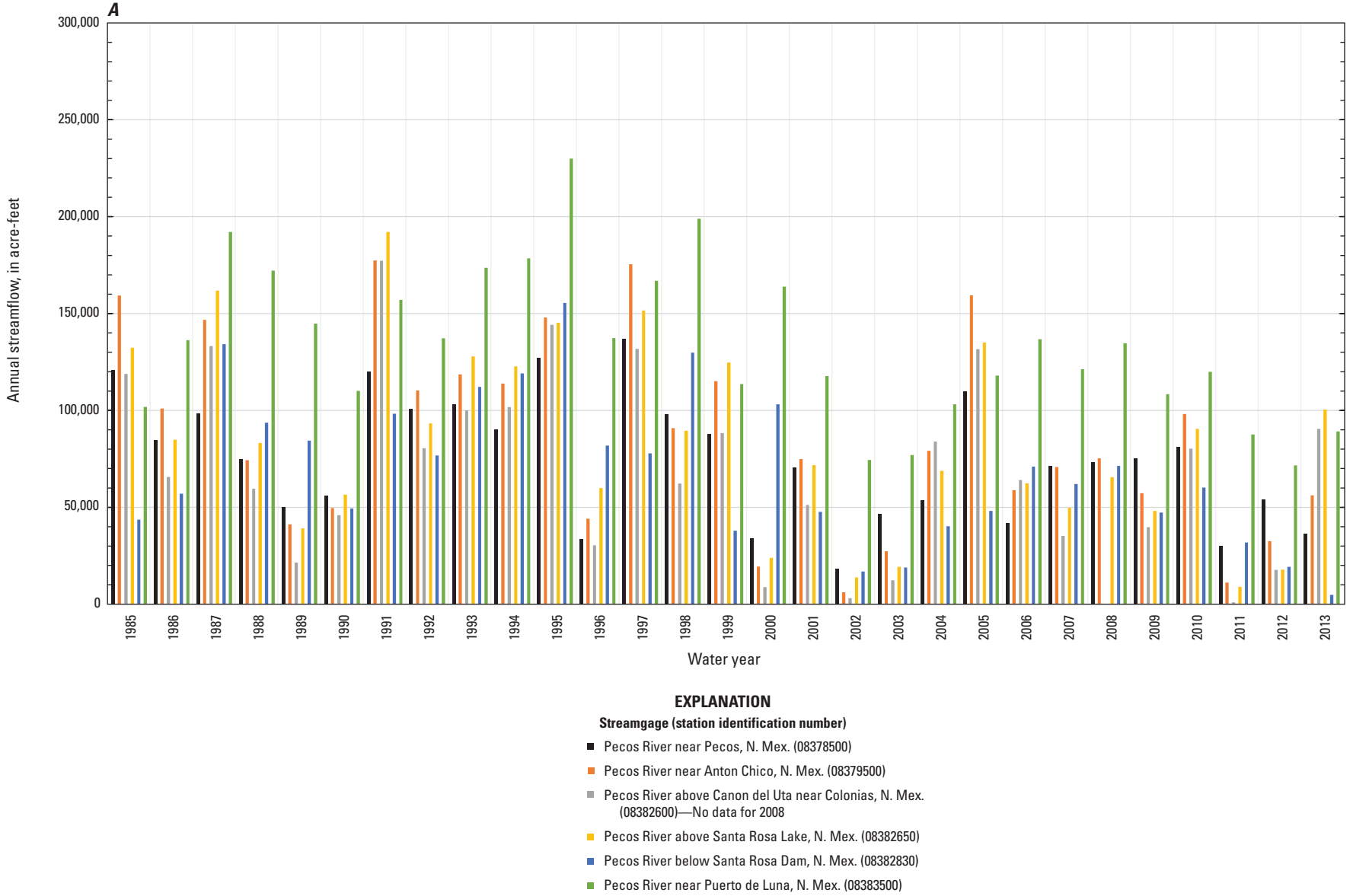

Figure 5. Annual streamflow, departure of annual streamflow from mean annual streamflow, and annual difference in streamflow for streams in the Pecos River Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.
A, Pecos River annual streamflow by streamgage, in downstream order, upstream from the Pecos River near Puerto de Luna, N. Mex. (08383500), streamgage.

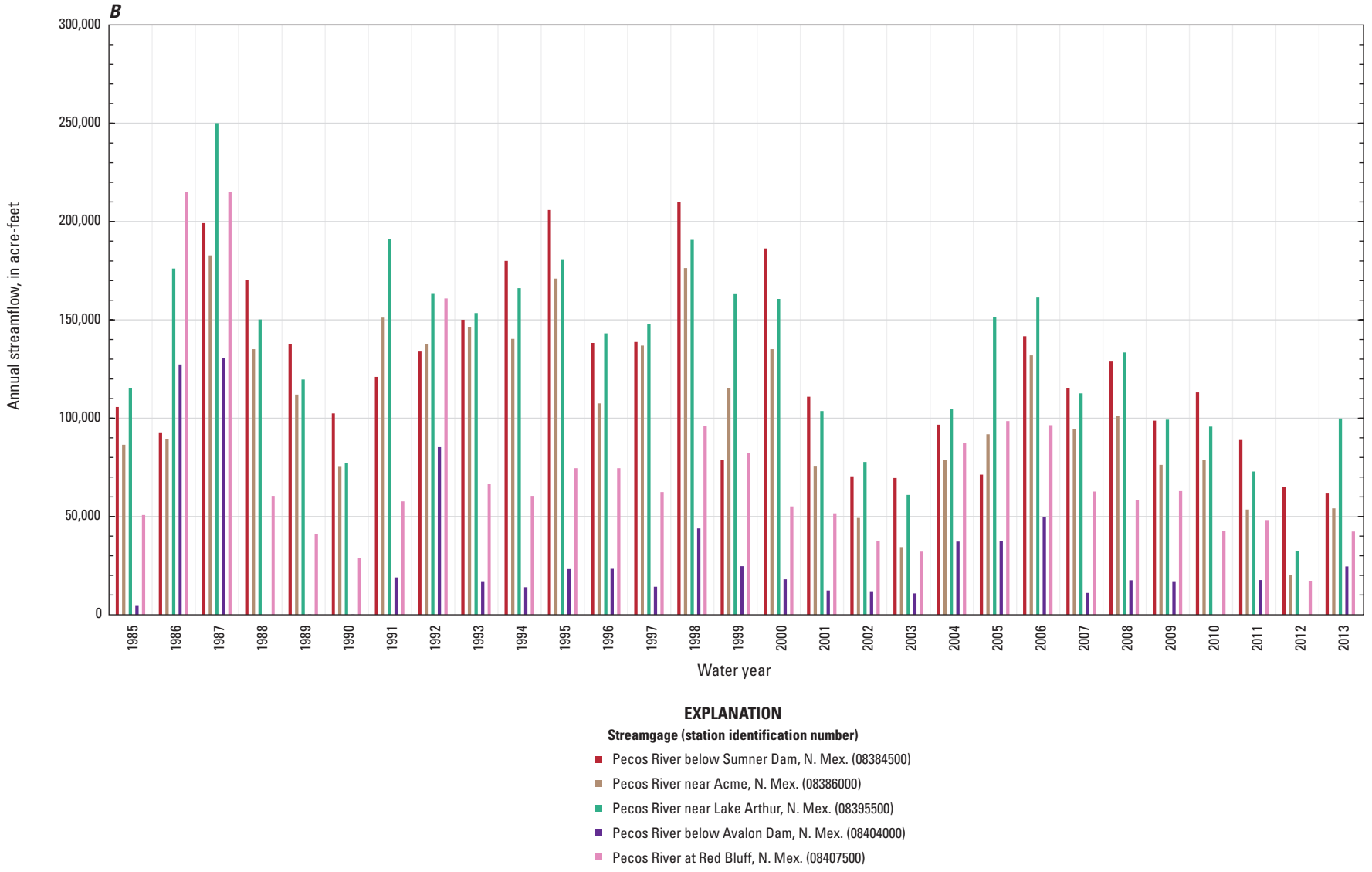

Figure 5. Annual streamflow, departure of annual streamflow from mean annual streamflow, and annual difference in streamflow for streams in the Pecos River Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued
B, Pecos River annual streamflow by streamgage, in downstream order, from the Pecos River below Sumner Dam, N. Mex. (08384500), streamgage to the Pecos River at Red Bluff, N. Mex. (08407500), streamgage.

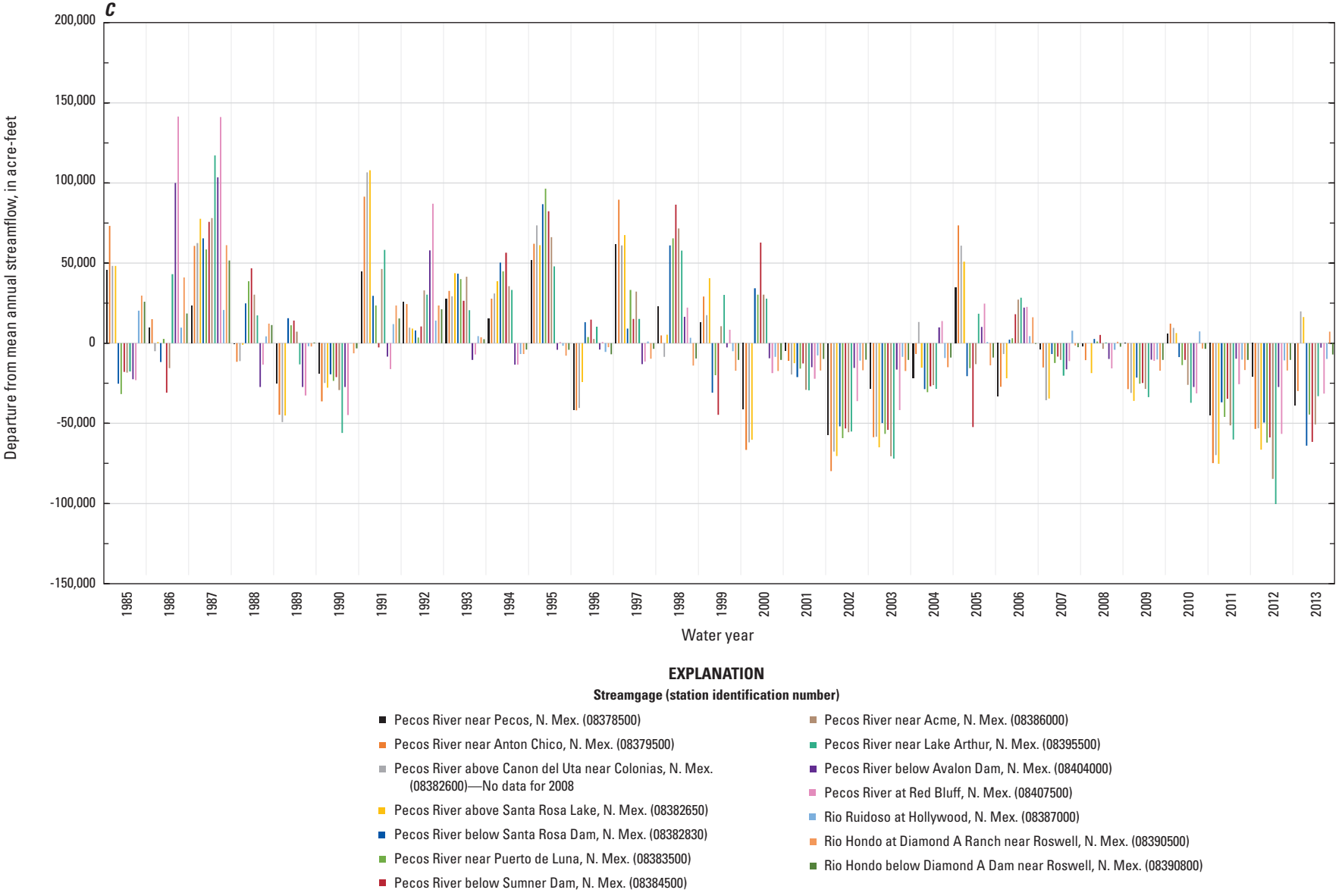

Figure 5. Annual streamflow, departure of annual streamflow from mean annual streamflow, and annual difference in streamflow for streams in the Pecos River Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued
C, Departure of annual streamflow from mean annual streamflow at Pecos River and tributary streamgages.

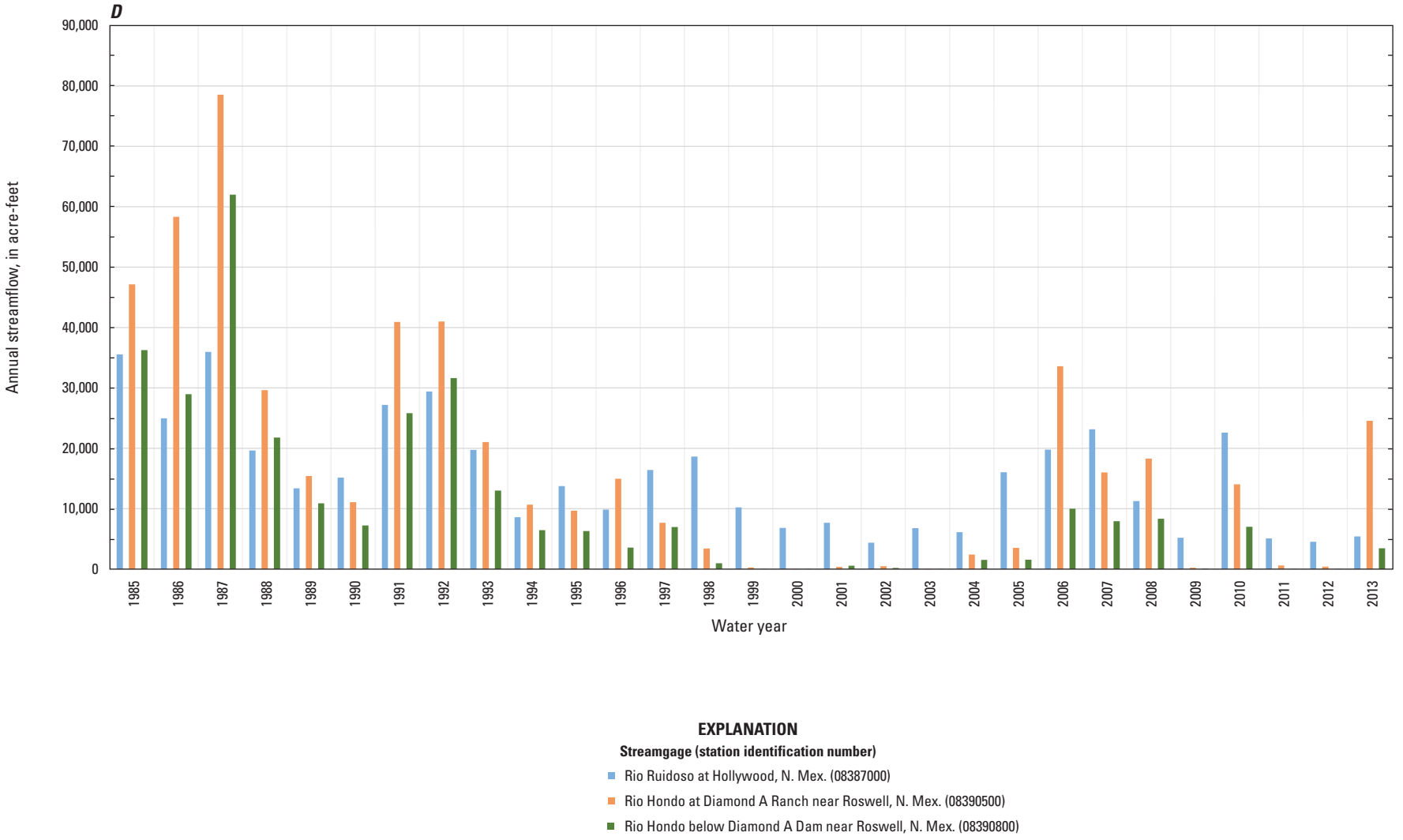

Figure 5. Annual streamflow, departure of annual streamflow from mean annual streamflow, and annual difference in streamflow for streams in the Pecos River Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued
D, Pecos River Basin tributary annual streamflow, in downstream order.

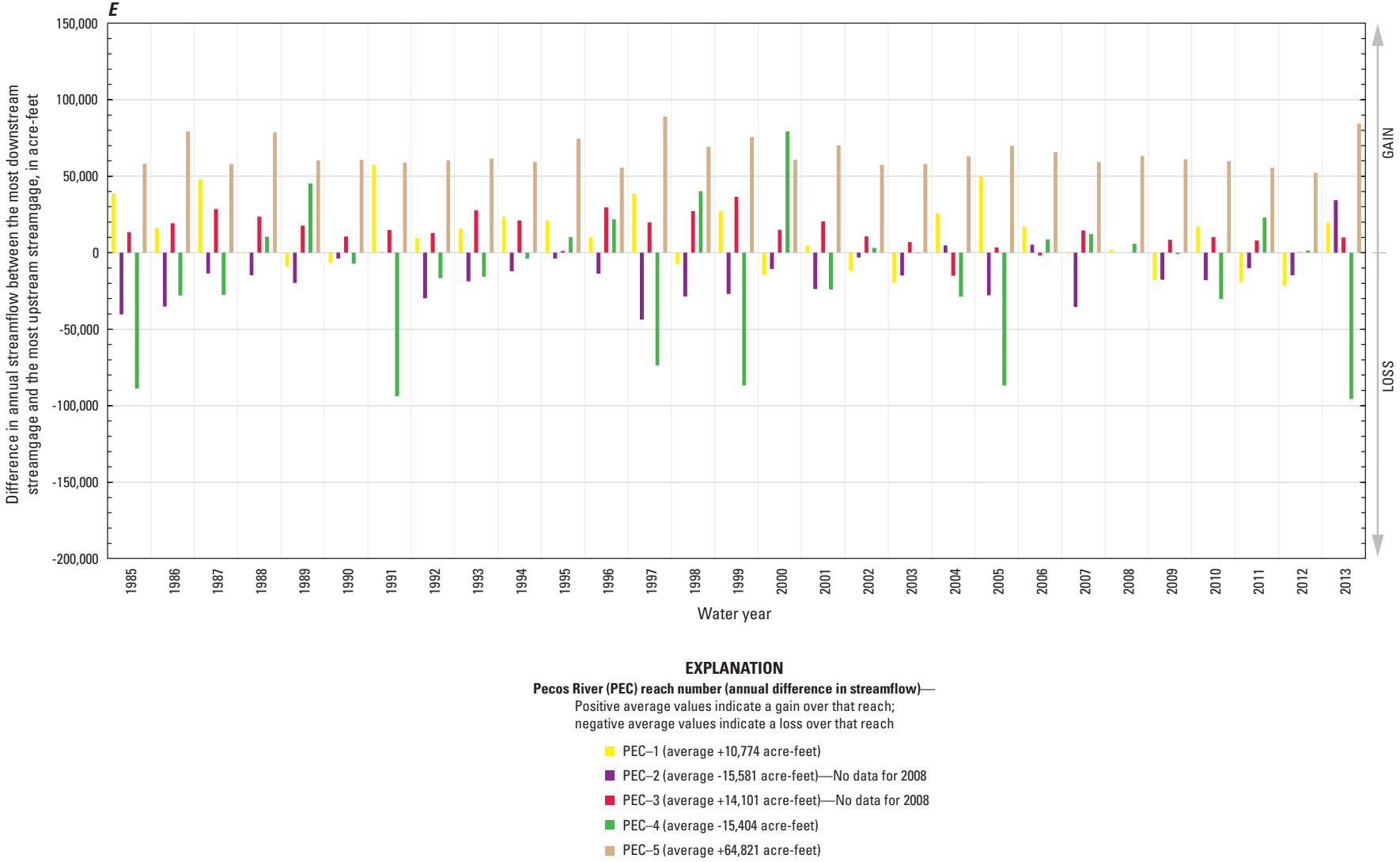

Figure 5. Annual streamflow, departure of annual streamflow from mean annual streamflow, and annual difference in streamflow for streams in the Pecos River Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued
E, Pecos River Basin annual difference in streamflow by reach, PEC–1 to PEC–5.

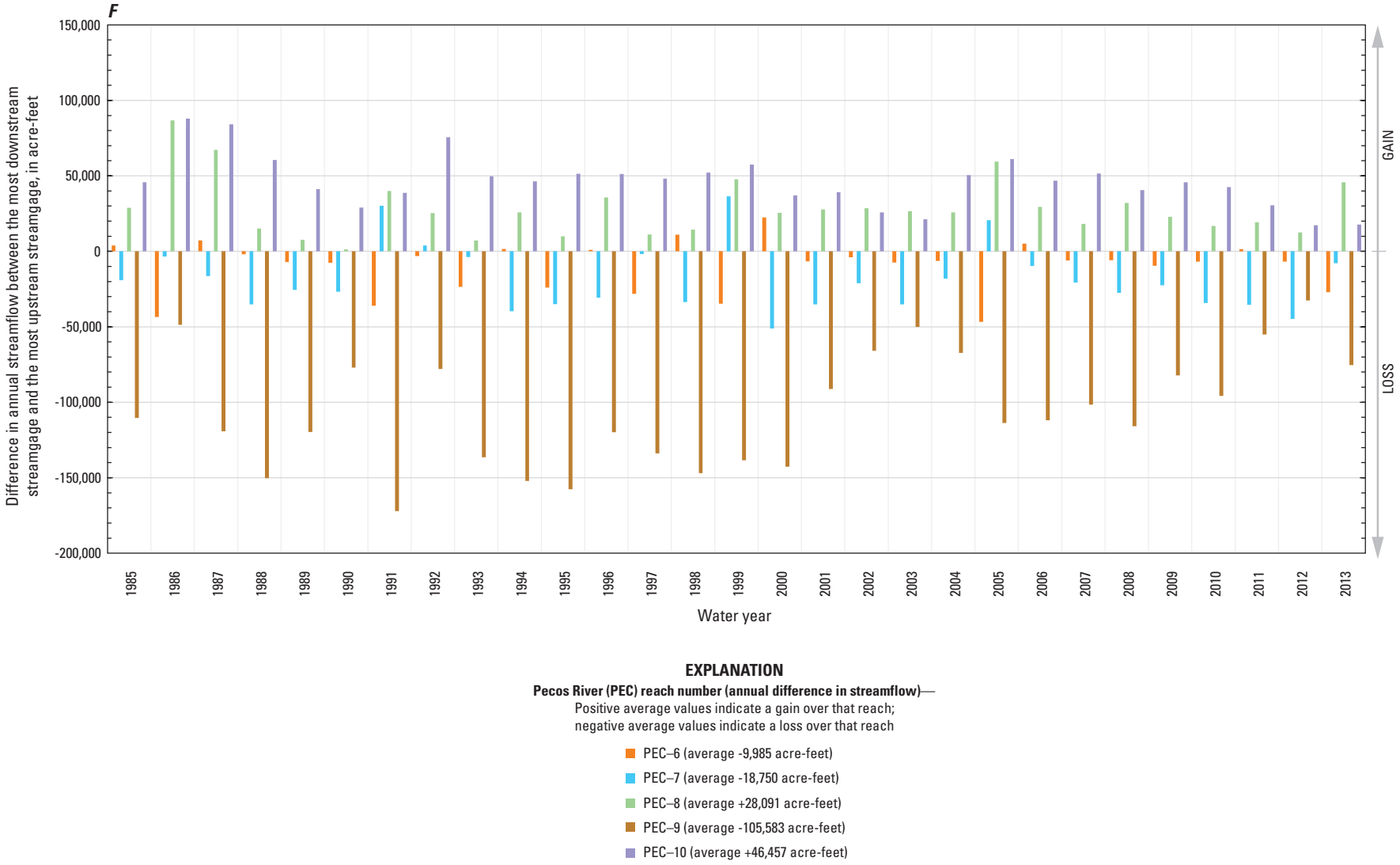

Figure 5. Annual streamflow, departure of annual streamflow from mean annual streamflow, and annual difference in streamflow for streams in the Pecos River Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued
F, Pecos River Basin annual difference in streamflow by reach, PEC–6 to PEC–10.

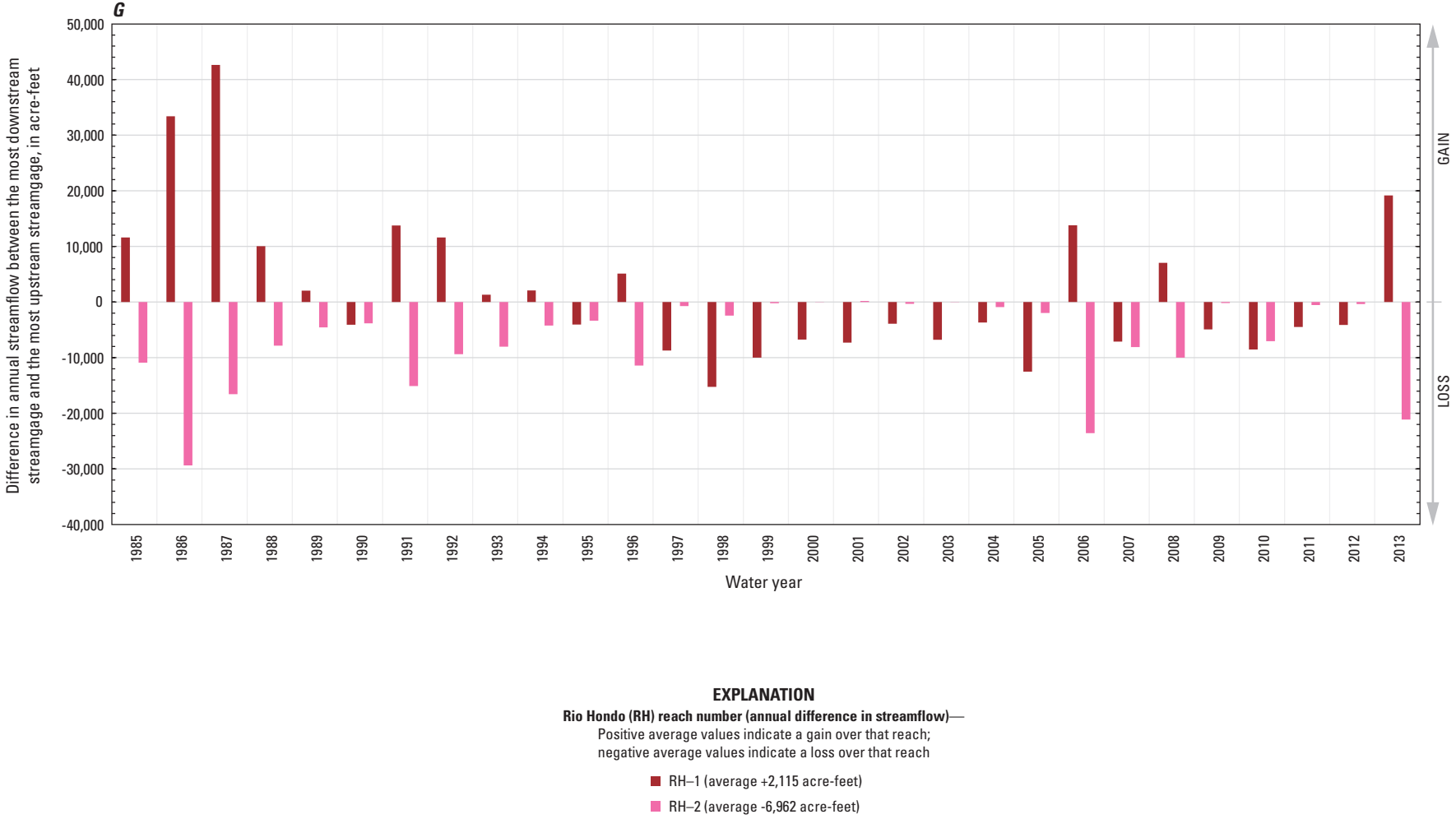

Figure 5. Annual streamflow, departure of annual streamflow from mean annual streamflow, and annual difference in streamflow for streams in the Pecos River Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued
G, Pecos River Basin tributary annual difference in streamflow by reach.

Reach PEC–5 had gains in all 29 years, which ranged from 52,360 acre-ft in 2012 to 89,060 acre-ft in 1997, and had the highest mean annual gain for the study period, 64,821 acre-ft (fig. 5*E*; table 5). Reach PEC–6 had losses in 21 of 29 years. Annual gains and losses ranged from a gain of 22,500 acre-ft in 2000 to a loss of 46,710 acre-ft in 2005 (fig. 5*F*; table 5). Reach PEC–7 had losses in 25 of 29 years. Annual gains and losses ranged from a gain of 36,440 acre-ft in 1999 to a loss of 51,200 acre-ft in 2000. Reach PEC–8 had gains in all 29 years, which ranged from 1,320 acre-ft in 1990 to 86,770 acre-ft in 1986 (fig. 5*F*; table 5). The Rio Hondo joins the Pecos River in reach PEC–8 and contributes to the streamflow gains in the Pecos River. Reach PEC–9 had losses in all 29 years, which ranged from 32,620 acre-ft in 2012 to 172,080 acre-ft in 1991, and had the greatest mean annual loss for the study period, 105,583 acre-ft. Reach PEC–10 had gains in 29 years, which ranged from a low of 17,240 acre-ft in 2012 to a high 87,900 acre-ft in 1986 (fig. 5*F*; table 5).

The Pecos River does not have inflow to the State since it originates in New Mexico (fig. 4). A gain/loss computation was not done for the entirety of the stream, but the Pecos River contributed a mean annual outflow of 73,819 acre-ft and a total outflow of 2,140,740 acre-ft from 1985 to 2013 (table 2).

Rio Hondo

Reach RH–1 (fig. 4) was a losing reach for 16 years of the study, with annual gains early in the study period. The magnitude of the gains decreased over time, and reach RH–1 ultimately became a losing reach with periodic gaining years. Annual gains and losses in reach RH–1 ranged from a 42,620 acre-ft gain in 1987 to a 15,240 acre-ft loss in 1998. Reach RH–2 (fig. 4) was a losing reach for 28 years over the study period. Annual gains and losses for reach RH–2 ranged from a gain of 190 acre-ft in 2001 to a loss of 29,370 acre-ft in 1986 (fig. 5*G*; table 5).

San Juan River Basin Streamflow

San Juan River

The San Juan River originates in southern Colorado, flows through the northwestern corner of New Mexico, and exits the State near the Four Corners area (fig. 6). Navajo Reservoir, located between the San Juan River near Carracas, Colo. (09346400), and San Juan River near Archuleta, N. Mex. (09355500), streamgages, is a major hydrologic feature on the San Juan River (fig. 6). In addition to four streamgages on the San Juan River, data were compiled for four streamgages on two tributaries to the San Juan River: two on the Animas River and two on the La Plata River (fig. 6). The Animas and La Plata Rivers both join the San Juan River between the San Juan River near Archuleta, N. Mex. (09355500), and the San Juan River at Shiprock, N. Mex. (09368000), streamgages near Farmington (fig. 6). Monthly values for these streamgages for the period of record are presented in appendix 6.

Over the study period, the San Juan River had some of the highest flows of any river in New Mexico, and flow on the river generally increased in the downstream direction (fig. 7*A*; tables 2 and 6). The mean annual streamflow at the San Juan River near Carracas, Colo. (09346400), streamgage was 424,117 acre-ft, and annual flow ranged from 81,100 acre-ft in 2002 to 869,300 acre-ft in 1985 (fig. 7*A*; table 6). The mean annual streamflow at the San Juan River near Archuleta, N. Mex. (09355500), streamgage was 746,800 acre-ft, and annual flow ranged from 282,400 acre-ft in 2004 to 1,945,000 acre-ft in 1987. The mean annual streamflow at the San Juan River at Shiprock, N. Mex. (09368000), streamgage was 1,270,448 acre-ft, and annual flow ranged from 475,400 acre-ft in 2002 to 2,915,000 acre-ft in 1987. The mean annual streamflow at the San Juan River at Four Corners, Colo. (09371010), streamgage was 1,343,062 acre-ft, and annual flow ranged from 534,700 acre-ft in 2002 to 3,026,000 acre-ft in 1987 (fig. 7*A*; table 6).

Departures from mean annual streamflow were positive from 1985 to 1987 and peaked in 1987 (fig. 7*B*). Departures generally were negative for 1988–91 and were variable for 1992–99. From 2000 to 2013, departures from the mean annual streamflow were predominantly negative; positive departures occurred for some or all streamgages in 2001, 2005, 2007, and 2008.

Animas River

The Animas River originates in Colorado, flows south into New Mexico, and joins the San Juan River at Farmington (fig. 6). The streamgages selected for this study were the Animas River near Cedar Hill, N. Mex. (09363500), streamgage and the Animas River at Farmington, N. Mex. (09364500), streamgage. Annual flow at the Animas River at Farmington, N. Mex. (09364500), streamgage, representing flow into the San Juan River, generally was less than the annual inflow to the State, measured at the Animas River at Cedar Hill, N. Mex. (09363500), streamgage, except for 1987 and 1997 (fig. 7*A*; table 6). Streamflow on the Animas River was highly variable year to year but, after 1999, generally tended to decrease (fig. 7*A*; table 6). Over the study period, annual flows at the Animas River near Cedar Hill, N. Mex. (09363500), streamgage ranged from 193,700 acre-ft in 2002 to 1,048,000 acre-ft in 1997, with a mean annual streamflow of 643,359 acre-ft. Annual flows at the Animas River at Farmington, N. Mex. (09364500), streamgage ranged from 128,300 acre-ft in 2002 to 1,059,000 acre-ft in 1997, with a mean annual streamflow of 587,372 acre-ft (fig. 7*A*; table 6).

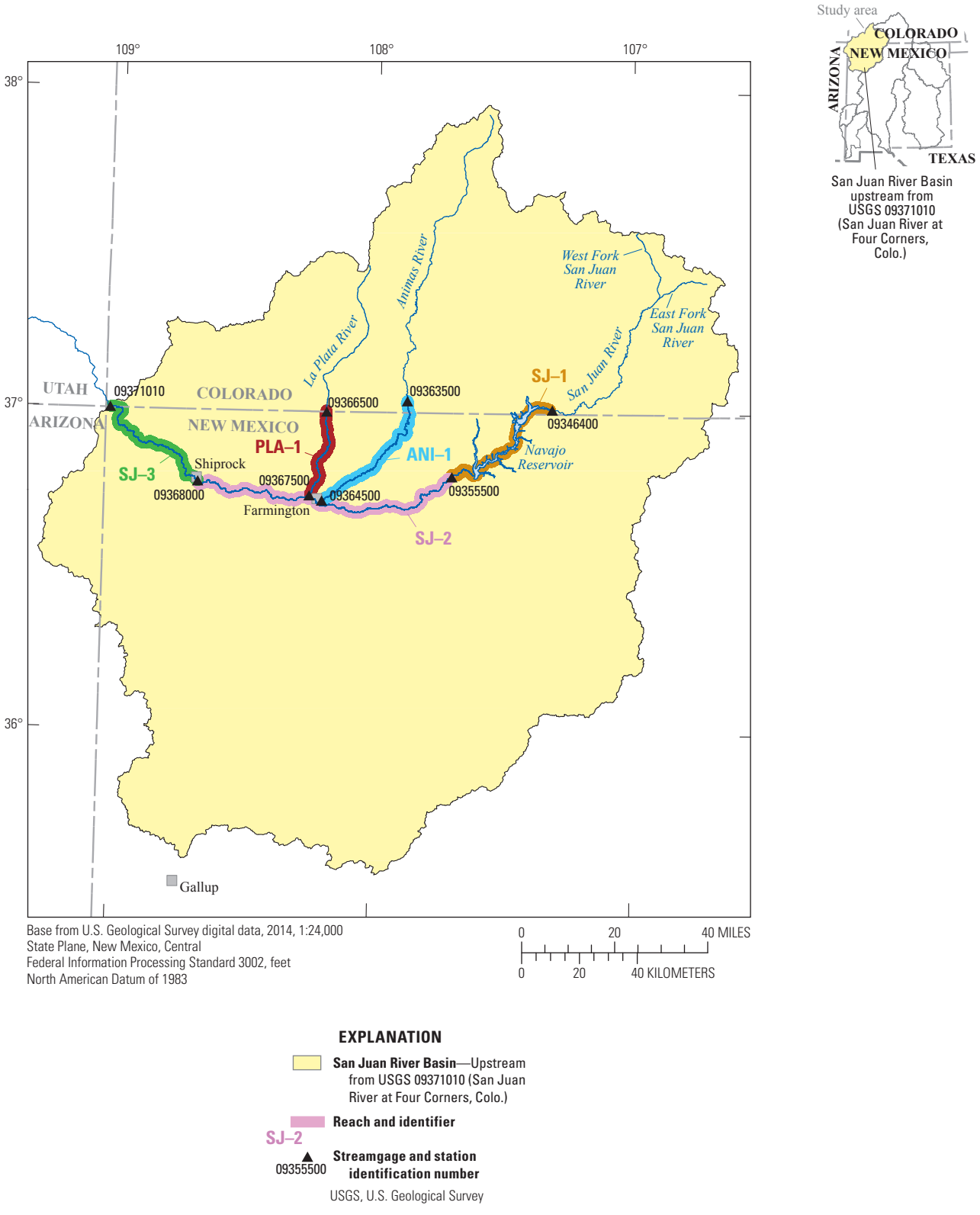

Figure 6. San Juan River Basin, streams, stream reaches, and streamgages upstream from the San Juan River at Four Corners, Colorado (09371010), streamgage in the six-basin study area, New Mexico and parts of bordering States and Mexico.

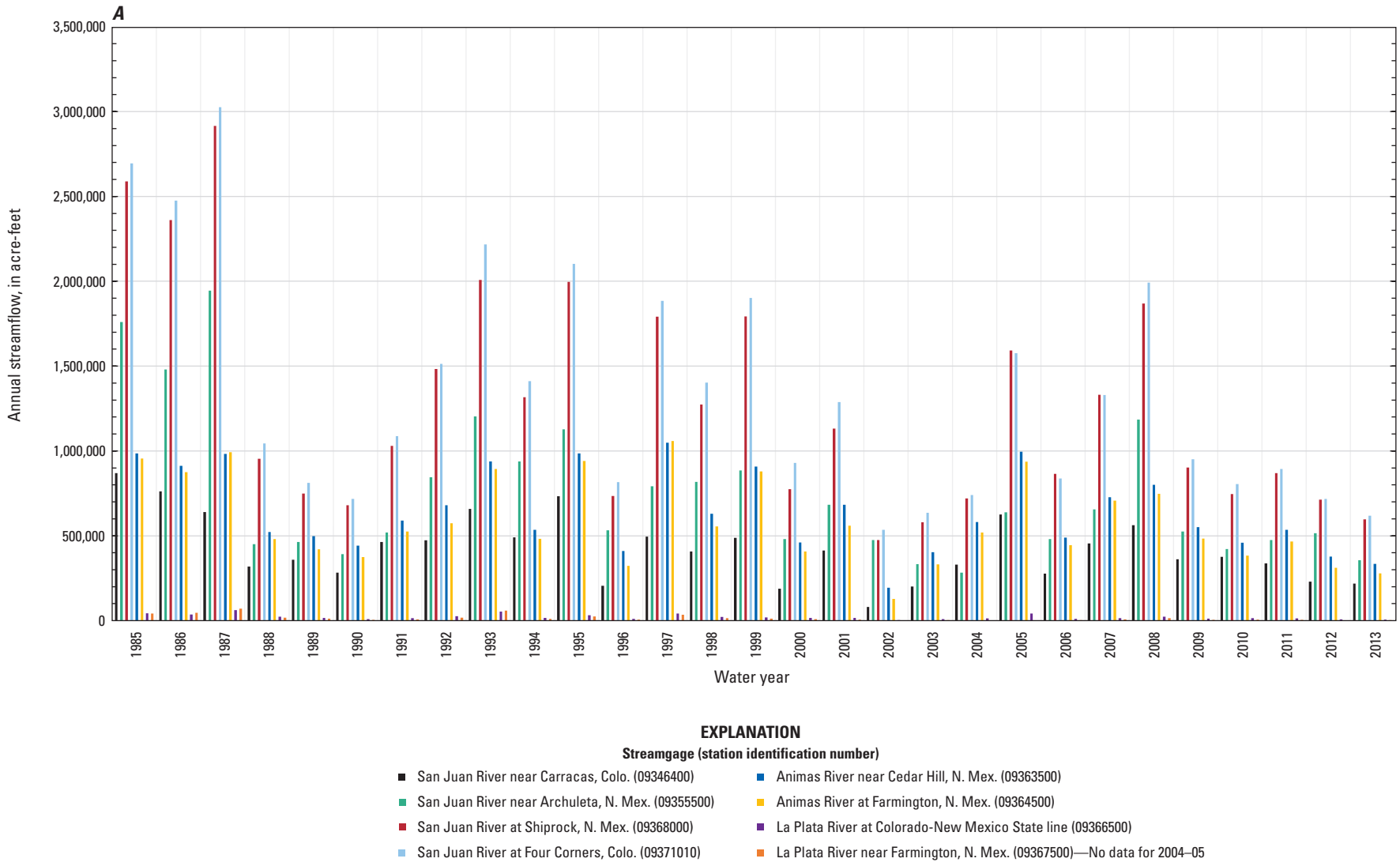

Figure 7. Annual streamflow, departure from mean annual streamflow, and annual difference in streamflow for streams in the San Juan River Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.
A, San Juan River Basin annual streamflow by streamgage, in downstream order.

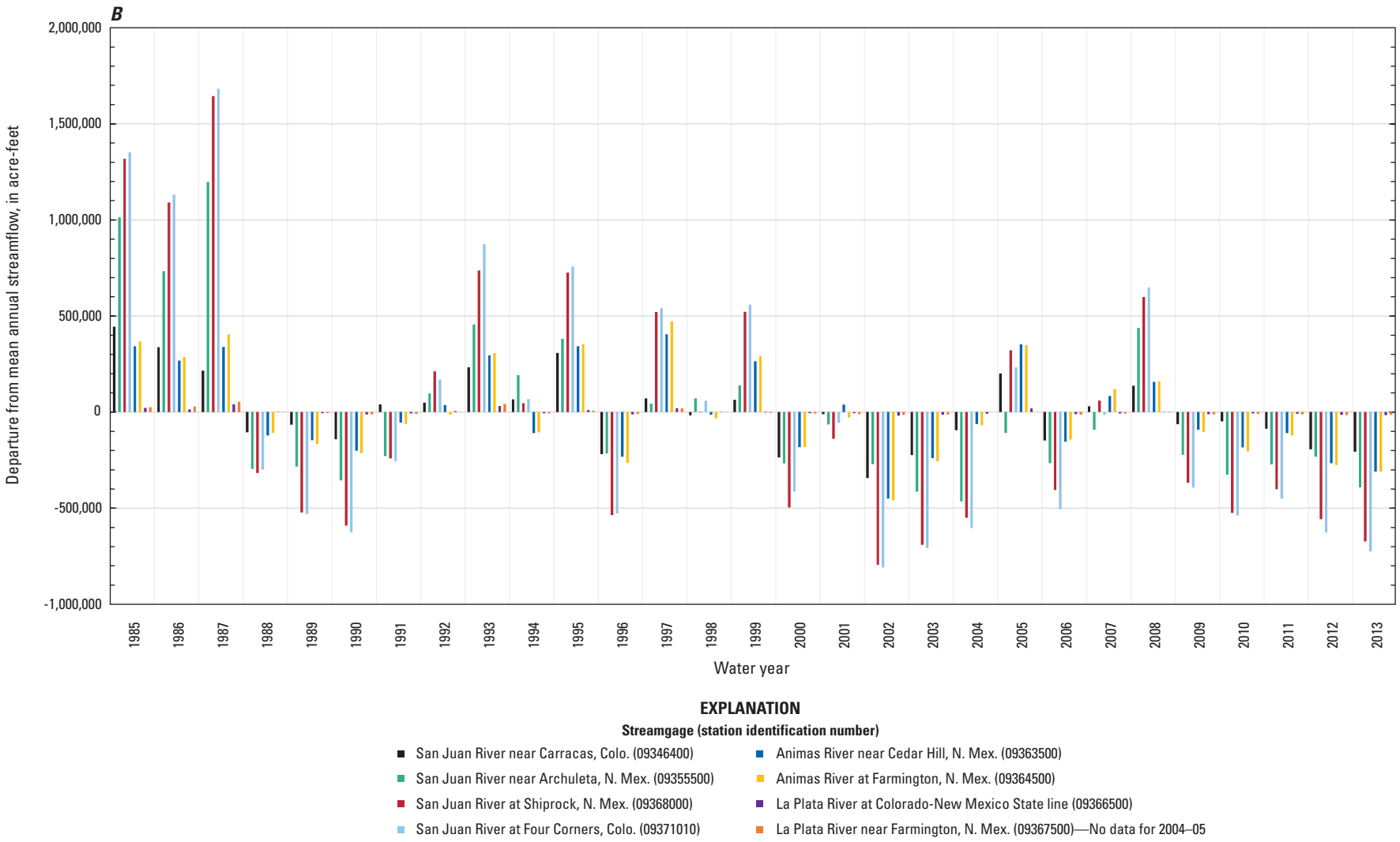

Figure 7. Annual streamflow, departure from mean annual streamflow, and annual difference in streamflow for streams in the San Juan River Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued
B, Departure of annual streamflow from mean annual streamflow at San Juan River and tributary streamgages.

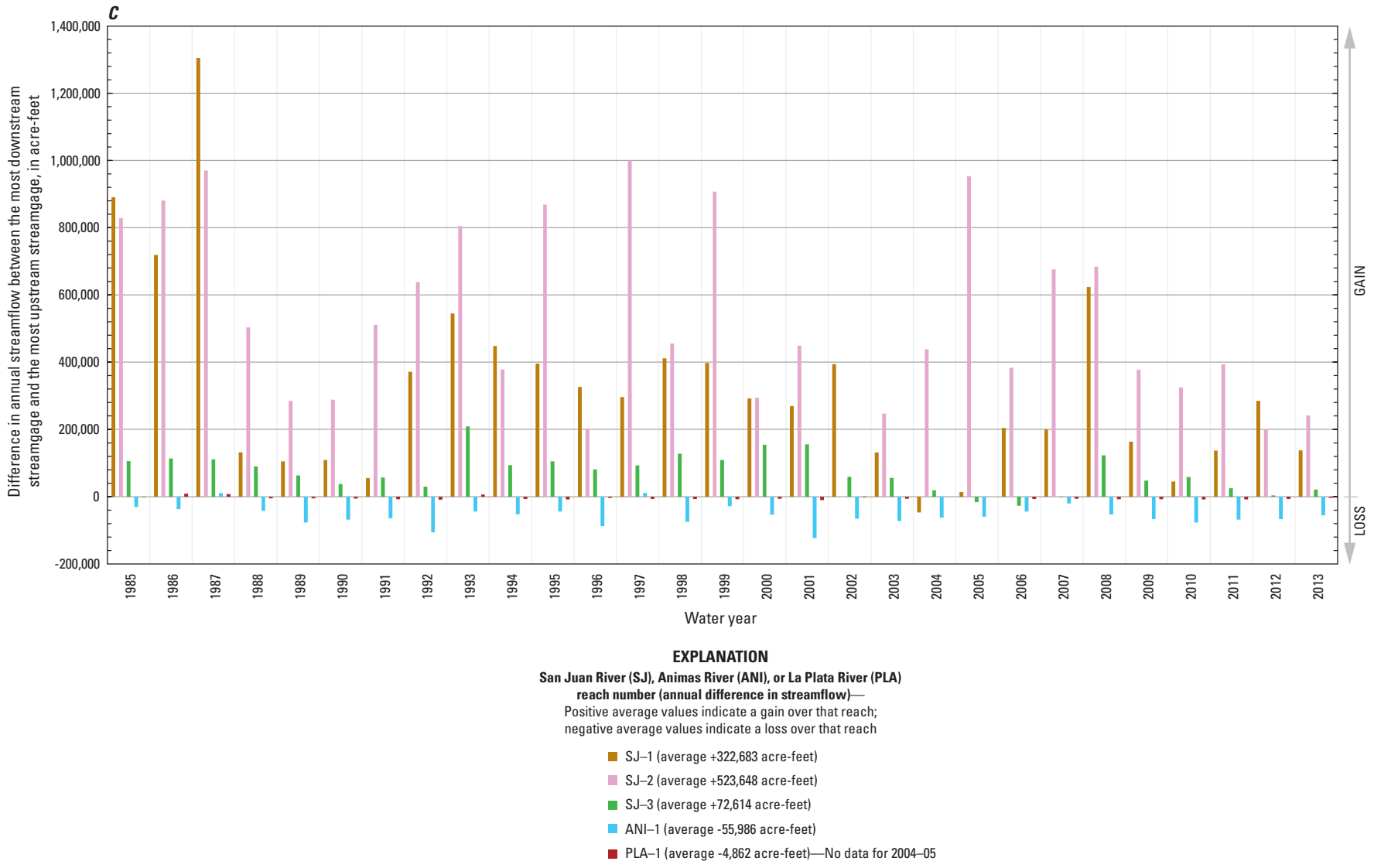

Figure 7. Annual streamflow, departure from mean annual streamflow, and annual difference in streamflow for streams in the San Juan River Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued
C, San Juan River Basin annual difference in streamflow by reach.

Table 6. Annual streamflow and annual difference in streamflow by reach for selected San Juan River Basin streamgages in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.

[Colo., Colorado; acre-ft, acre-feet; N. Mex., New Mexico; --, no data; SJ, San Juan River reach, numbered in downstream order; ANI, Animas River reach, numbered in downstream order; PLA, La Plata River reach, numbered in downstream order]

	Annual streamflow							
	San Juan River				Tributaries			
Water year	09346400 San Juan River near Carracas, Colo. (acre-ft)	09355500 San Juan River near Archuleta, N. Mex. (acre-ft)	09368000 San Juan River at Shiprock, N. Mex. (acre-ft)	09371010 San Juan River at Four Corners, Colo. (acre-ft)	09363500 Animas River near Cedar Hill, N. Mex. (acre-ft)	09364500 Animas River at Farmington, N. Mex. (acre-ft)	09366500 La Plata River at Colorado-New Mexico State line (acre-ft)	09367500 La Plata River near Farmington, N. Mex. (acre-ft)
1985	869,300	1,760,000	2,589,000	2,695,000	985,600	955,000	42,840	41,460
1986	761,300	1,480,000	2,361,000	2,475,000	911,900	874,700	36,350	45,500
1987	640,200	1,945,000	2,915,000	3,026,000	981,900	992,300	62,150	69,840
1988	318,800	450,800	954,100	1,044,000	522,000	480,100	22,510	17,280
1989	358,200	463,400	748,500	811,700	497,600	420,800	16,410	11,220
1990	282,900	391,700	679,700	717,500	442,200	374,100	9,390	3,960
1991	464,100	518,900	1,030,000	1,087,000	589,300	525,300	15,210	7,330
1992	473,100	845,000	1,483,000	1,513,000	679,800	573,800	26,750	17,740
1993	657,900	1,203,000	2,008,000	2,217,000	938,400	893,900	52,860	59,190
1994	490,100	938,600	1,317,000	1,411,000	534,700	482,700	16,520	9,680
1995	732,600	1,128,000	1,997,000	2,102,000	985,700	941,400	32,090	24,160
1996	205,200	531,700	734,900	815,800	410,700	322,900	10,260	6,640
1997	495,300	791,300	1,791,000	1,884,000	1,048,000	1,059,000	42,180	35,350
1998	406,900	818,200	1,274,000	1,402,000	630,200	555,400	22,120	15,170
1999	488,100	885,500	1,793,000	1,902,000	907,800	879,300	19,600	12,060
2000	188,400	480,400	774,600	928,800	460,600	406,900	15,910	9,360
2001	413,300	682,800	1,132,000	1,288,000	682,400	559,500	15,860	5,300
2002	81,100	475,500	475,400	534,700	193,700	128,300	3,650	1,370
2003	200,600	332,600	579,900	635,600	403,400	331,100	9,110	2,820
2004	329,600	282,400	720,800	740,000	581,400	519,000	13,680	--
2005	624,800	638,800	1,592,000	1,576,000	995,600	936,200	41,160	--
2006	277,200	481,200	865,000	838,100	489,500	445,200	10,380	3,460
2007	454,600	655,200	1,331,000	1,329,000	727,700	707,400	14,520	8,060
2008	561,700	1,185,000	1,869,000	1,992,000	800,300	747,100	22,580	14,830
2009	361,000	524,800	902,600	950,400	551,300	484,200	11,430	3,880
2010	376,200	421,200	746,200	804,700	459,300	382,600	14,370	6,410
2011	337,900	475,000	868,600	893,500	534,700	466,300	12,940	4,880
2012	230,400	515,200	713,300	716,800	377,900	311,100	7,440	782
2013	218,600	356,000	597,400	618,200	333,800	278,200	6,040	2,470
Mean annual streamflow	**424,117**	**746,800**	**1,270,448**	**1,343,062**	**643,359**	**587,372**	**21,597**	**16,304**

Table 6. Annual streamflow and annual difference in streamflow by reach for selected San Juan River Basin streamgages in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued

[Colo., Colorado; acre-ft, acre-feet; N. Mex., New Mexico; --, no data; SJ, San Juan River reach, numbered in downstream order; ANI, Animas River reach, numbered in downstream order; PLA, La Plata River reach, numbered in downstream order]

	Annual difference in streamflow by reach				
	San Juan River			Tributaries	
	SJ–1	SJ–2	SJ–3	ANI–1	PLA–1
Water year	09346400 San Juan River near Carracas, Colo., to 09355500 San Juan River near Archuleta, N. Mex. (acre-ft)	09355500 San Juan River near Archuleta, N. Mex., to 09368000 San Juan River at Shiprock, N. Mex. (acre-ft)	09368000 San Juan River at Shiprock, N. Mex., to 09371010 San Juan River at Four Corners, Colo. (acre-ft)	09363500 Animas River near Cedar Hill, N. Mex., to 09364500 Animas River at Farmington, N. Mex. (acre-ft)	09366500 La Plata River at Colorado-New Mexico State line to 09367500 La Plata River near Farmington, N. Mex. (acre-ft)
1985	890,700	829,000	106,000	-30,600	-1,380
1986	718,700	881,000	114,000	-37,200	9,150
1987	1,304,800	970,000	111,000	10,400	7,690
1988	132,000	503,300	89,900	-41,900	-5,230
1989	105,200	285,100	63,200	-76,800	-5,190
1990	108,800	288,000	37,800	-68,100	-5,430
1991	54,800	511,100	57,000	-64,000	-7,880
1992	371,900	638,000	30,000	-106,000	-9,010
1993	545,100	805,000	209,000	-44,500	6,330
1994	448,500	378,400	94,000	-52,000	-6,840
1995	395,400	869,000	105,000	-44,300	-7,930
1996	326,500	203,200	80,900	-87,800	-3,620
1997	296,000	999,700	93,000	11,000	-6,830
1998	411,300	455,800	128,000	-74,800	-6,950
1999	397,400	907,500	109,000	-28,500	-7,540
2000	292,000	294,200	154,200	-53,700	-6,550
2001	269,500	449,200	156,000	-122,900	-10,560
2002	394,400	-100	59,300	-65,400	-2,280
2003	132,000	247,300	55,700	-72,300	-6,290
2004	-47,200	438,400	19,200	-62,400	--
2005	14,000	953,200	-16,000	-59,400	--
2006	204,000	383,800	-26,900	-44,300	-6,920
2007	200,600	675,800	-2,000	-20,300	-6,460
2008	623,300	684,000	123,000	-53,200	-7,750
2009	163,800	377,800	47,800	-67,100	-7,550
2010	45,000	325,000	58,500	-76,700	-7,960
2011	137,100	393,600	24,900	-68,400	-8,060
2012	284,800	198,100	3,500	-66,800	-6,658
2013	137,400	241,400	20,800	-55,600	-3,570
Mean annual streamflow	**322,683**	**523,648**	**72,614**	**-55,986**	**-4,862**

Departure from mean annual streamflow on the Animas River was positive from 1985 to 1987 but was negative from 1988 to 1991, except for one positive year at the Animas River near Cedar Hill, N. Mex. (09363500), streamgage in 1991 (fig. 7*B*). From 1993 to 2001, departures were variable. In 2002, the most negative departure for the study period occurred, but the magnitude of the departures decreased from 2002 to 2005. From 2006 to 2013, departures generally remained negative, with positive departures in 2007 and 2008 (fig. 7*B*).

La Plata River

The La Plata River, located west of the Animas River, originates in Colorado and flows south to join the San Juan River near Farmington (fig. 6). The streamgages selected for this study were the La Plata River at Colorado-New Mexico State line (09366500) streamgage and the La Plata River near Farmington, N. Mex. (09367500), streamgage. The La Plata River near Farmington, N. Mex. (09367500), streamgage record is missing data for 2004 and for 9 months of 2005 (fig. 7*A*; table 6). The La Plata River is a smaller tributary in volume of flow than the Animas River. Annual flows at the La Plata River near Farmington, N. Mex. (09367500), streamgage, representing flow into the San Juan River, generally were less than the annual inflow to the State at the La Plata River at Colorado-New Mexico State line (09366500) streamgage. Annual flows at the La Plata River at Colorado-New Mexico State line (09366500) streamgage ranged from 3,650 acre-ft in 2002 to 62,150 acre-ft in 1987, with a mean annual streamflow of 21,597 acre-ft. Annual flows at the La Plata River near Farmington, N. Mex. (09367500), streamgage, disregarding the years of missing data, ranged from 782 acre-ft in 2012 to 69,840 acre-ft in 1987, with a mean annual streamflow of 16,304 acre-ft (fig. 7*A*; table 6).

Departures from mean annual streamflow in the La Plata River were positive from 1985 to 1987 but decreased to near average flows in 1998 (fig. 7*B*). After 1987, departures from mean annual streamflow were close to zero, except for 1993 and 1997 (fig. 7*B*).

San Juan River Basin Gains and Losses

San Juan River

Gains and losses were estimated for three San Juan River reaches (fig. 6), with reach SJ–1 including Navajo Reservoir. Gains and losses for reach SJ–1 ranged from a gain of 1,304,800 acre-ft in 1987 to the only loss, 47,200 acre-ft, in 2004 and had a mean annual gain of 322,683 acre-ft (fig. 7*C*; table 6). Gains and losses for reach SJ–2 ranged from a gain of 999,700 acre-ft in 1997 to the only loss, 100 acre-ft, in 2002 and had a mean annual gain of 523,648 acre-ft. Gains and losses for reach SJ–3 ranged from a gain of 209,000 acre-ft in 1993 to a loss of 26,900 acre-ft in 2006 and had a mean annual gain of 72,614 acre-ft. Of the three San Juan River reaches, the second, reach SJ–2, consistently had the greatest gains, except for 1985, 1987, 1994, 1996, 2002, and 2012, when the first, reach SJ–1, had the greatest gains.

Annual gains for reaches SJ–1 (average gain of 322,683 acre-ft) and SJ–2 (average gain of 523,648 acre-ft) from 1985 to 1987 were above average but after 1987 dropped below average until 1992 (fig. 7*C*; table 6). From 1992 to 1996, reach SJ–1 had above average gains, fell below average in 1997, and then rose to above average from 1998 to 1999. From 2000 to 2013, reach SJ–1 recorded only two above average gains, in 2002 and 2008. Reach SJ–2 had above average gains in 1992 and 1993. From 1994 to 1999, above average gains were recorded in 1995, 1997, and 1999. From 2000 to 2013, reach SJ–2 had above average gains in 2005, 2007, and 2008 (fig. 7*C*; table 6).

Reach SJ–3 (average gain of 72,614 acre-ft) had above average gains from 1985 to 1988, but gains fell below average from 1989 to 1992. From 1993 to 2001, reach SJ–3 recorded above average gains, but from 2002 to 2013, this reach had three losses (2005–07) and one above average gain (2008) (fig. 7*C*; table 6).

Animas River

Over the study period, the Animas River reach, ANI–1 (fig. 6), generally was a losing reach except for 1987 and 1997, with a mean annual loss of 55,986 acre-ft (fig. 7*C*; table 6). From 1985 to 2000, above average losses were less frequent, and losses were lower than those from 2000 to 2013. The 2001 annual loss of 122,900 acre-ft was the largest loss for the study period, and above average losses occurred for the remaining years except for 2006–08 and 2013, where losses were just below the average losses (fig. 7*C*; table 6).

La Plata River

Over the study period, the La Plata River reach, PLA–1 (fig. 6), generally was a losing reach except for 1986, 1987, and 1993 (fig. 7*C*; table 6). Reach PLA–1 had its greatest annual gain, 9,150 acre-ft, in 1986. Annual losses for reach PLA–1 are fairly consistent over the study period, and most are above the mean annual loss of 4,862 acre-ft. Reach PLA–1 had below average losses in 1985, 1996, 2002, and 2013. The greatest annual loss, 10,560 acre-ft, occurred in 2001 (fig. 7*C*; table 6).

Canadian River Basin Streamflow

Canadian River

The Canadian River Basin is in the northeastern corner of New Mexico (fig. 8). The Canadian River originates in southern

Colorado, flows through the northeastern corner of New Mexico, and exits the State along its eastern border. There are Eagle Nest Lake on the Cimarron River and Conchas Lake and Ute Reservoir on the Canadian River. Three Canadian River streamgages and two Cimarron River streamgages were selected for this study (fig. 8). Monthly values for these streamgages are presented in appendix 7.

Annual flows at the Canadian River near Sanchez, N. Mex. (07221500), streamgage were higher than at other streamgages, with a mean annual streamflow of 92,103 acre-ft for the study period, and ranged from a high of 335,800 acre-ft in 1987 to a low of 2,580 acre-ft in 2012 (fig. 9*A*; table 7). The most upstream streamgage, the Canadian River near Taylor Springs, N. Mex. (07211500), had a mean annual streamflow of 42,550 acre-ft and ranged from a high of 182,900 acre-ft in 1987 to a low of 1,570 acre-ft in 2012. The most downstream streamgage, Canadian River at Logan, N. Mex. (07227000), had the lowest mean annual streamflow at 22,281 acre-ft and ranged from a high of 104,800 acre-ft in 1999 to a low of 1,670 acre-ft in 1986. The low mean annual streamflow at the Canadian River at Logan, N. Mex. (07227000), streamgage may be, in part, attributable to the reservoirs storing water upstream from this streamgage (fig. 9*A*; table 7). Prior to 1999, departures from mean annual streamflow at the Canadian River streamgages were variable, but after 1999, departures generally were negative (fig. 9*B*).

The lowest annual flows occurred in 2003, 2011, and 2012. The Canadian River at Logan, N. Mex. (07227000), streamgage had low flows from 2001 to 2013, with a small peak in 2006 (fig. 9*A*; table 7). Inflow from the Canadian River in Colorado is unknown (ungaged) but for the purposes of this report is assumed to be zero. The annual outflow from New Mexico at the Canadian River at Logan, N. Mex. (07227000), streamgage ranged from a low of 1,670 acre-ft in 1986 to a high of 104,800 acre-ft in 1999 (table 2).

Cimarron River

The Cimarron River joins the Canadian River upstream from the Canadian River near Taylor Springs, N. Mex. (07211500), streamgage. Eagle Nest Lake (fig. 8) is upstream from both streamgages selected for this study, the Cimarron River below Eagle Nest Dam, N. Mex. (07206000), streamgage and the Cimarron River near Cimarron, N. Mex. (07207000), streamgage. Over the study period, Cimarron River mean annual streamflows were 14,010 acre-ft at the Cimarron River below Eagle Nest Dam, N. Mex. (07206000), streamgage and were 19,091 acre-ft at the Cimarron River near Cimarron, N. Mex. (07207000), streamgage (table 7). Annual flows at the Cimarron River below Eagle Nest Dam, N. Mex. (07206000), streamgage ranged from 6,200 acre-ft in 2004 to 40,890 acre-ft in 1994 and at the Cimarron River near Cimarron, N. Mex. (07207000), streamgage ranged from 9,050 acre-ft in 2002 to 58,410 in 1994 (fig. 9*A*; table 7). Departures from mean annual streamflow for the Cimarron River were variable through 1999 but generally were negative through 2013 (fig. 9*B*).

Canadian River Basin Gains and Losses

Canadian River

Over the study period, reach CAN–1 (fig. 8) was a gaining reach for all 29 years, with the greatest annual gain, 168,400 acre-ft, in 1999, the smallest annual gain, 490 acre-ft, in 2003, and a mean annual gain of 49,553 acre-ft (fig. 9*C*; table 7). Gains generally were above average from 1985 to 1999 but fell below average in 2000 and generally remained below average through 2013. For 1985–2013, reach CAN–2 (fig. 8) was a losing reach for all years except 2003 (fig. 9*C*; table 7). Reach CAN–2 gains and losses ranged from a gain of 110 acre-ft in 2003 to a loss of 235,900 acre-ft in 1987 and a mean annual loss over the study period of 69,822 acre-ft. Losses generally were below the mean before 1999, but thereafter losses tended to be above the mean.

No inflow to the State is reported for the Canadian River because the first streamgage of the study is in New Mexico (fig. 8). Gain/loss was not computed for the entirety of the stream, but the Canadian River contributed a mean annual outflow of 22,281 acre-ft and a total outflow of 646,160 from 1985 to 2013 (table 2).

Cimarron River

Over the study period, reach CIM–1 (fig. 8) generally was gaining except for 1996, 2002, 2011, and 2013 (fig. 9*C*; table 7). The mean annual gain for reach CIM–1 was 5,082 acre-ft. There were 13 above average annual gains over the 29-year study period. The annual gains and losses ranged from a gain of 17,520 acre-ft in 1994 to a loss of 2,330 acre-ft in 2002.

Gila River Basin Streamflow

The Gila River originates in southwestern New Mexico, flows across the western State border, and joins the San Francisco River near Clifton, Ariz. (fig. 10). No tributaries to the Gila River were included in this study, and there are no major reservoirs on this river. The three streamgages selected for this study were the Gila River near Gila, N. Mex. (09430500), streamgage; the Gila River below Blue Creek, near Virden, N. Mex. (09432000), streamgage; and the Gila River near Clifton, Ariz. (09442000), streamgage (fig. 10). The Gila River near Clifton, Ariz. (09442000), streamgage record is missing data from 1990 to 1995 (table 8). Monthly streamflow values for these streamgages are presented in appendix 8.

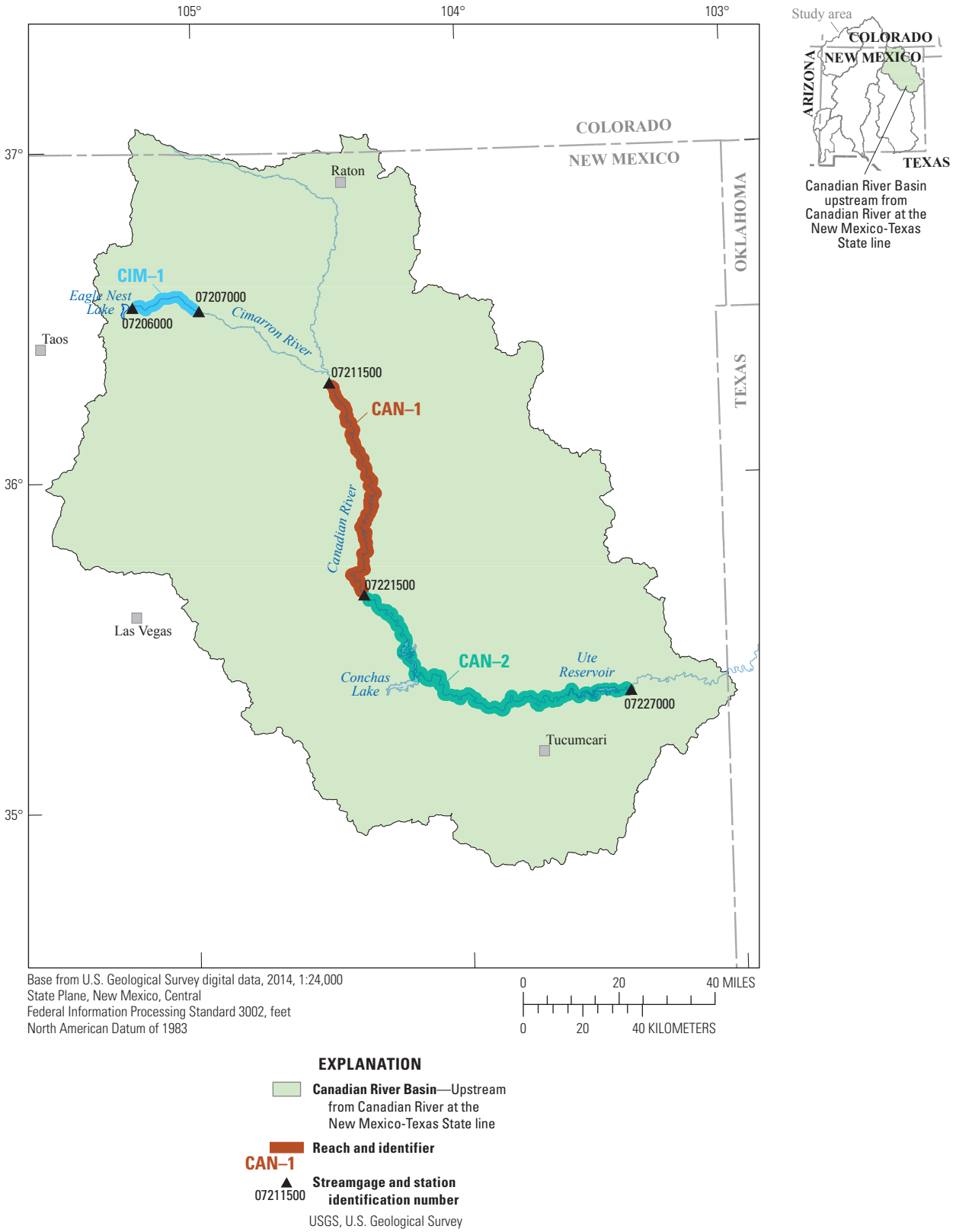

Figure 8. Canadian River Basin, streams, stream reaches, and streamgages upstream from the Canadian River at the New Mexico-Texas State line in the six-basin study area, New Mexico and parts of bordering States and Mexico.

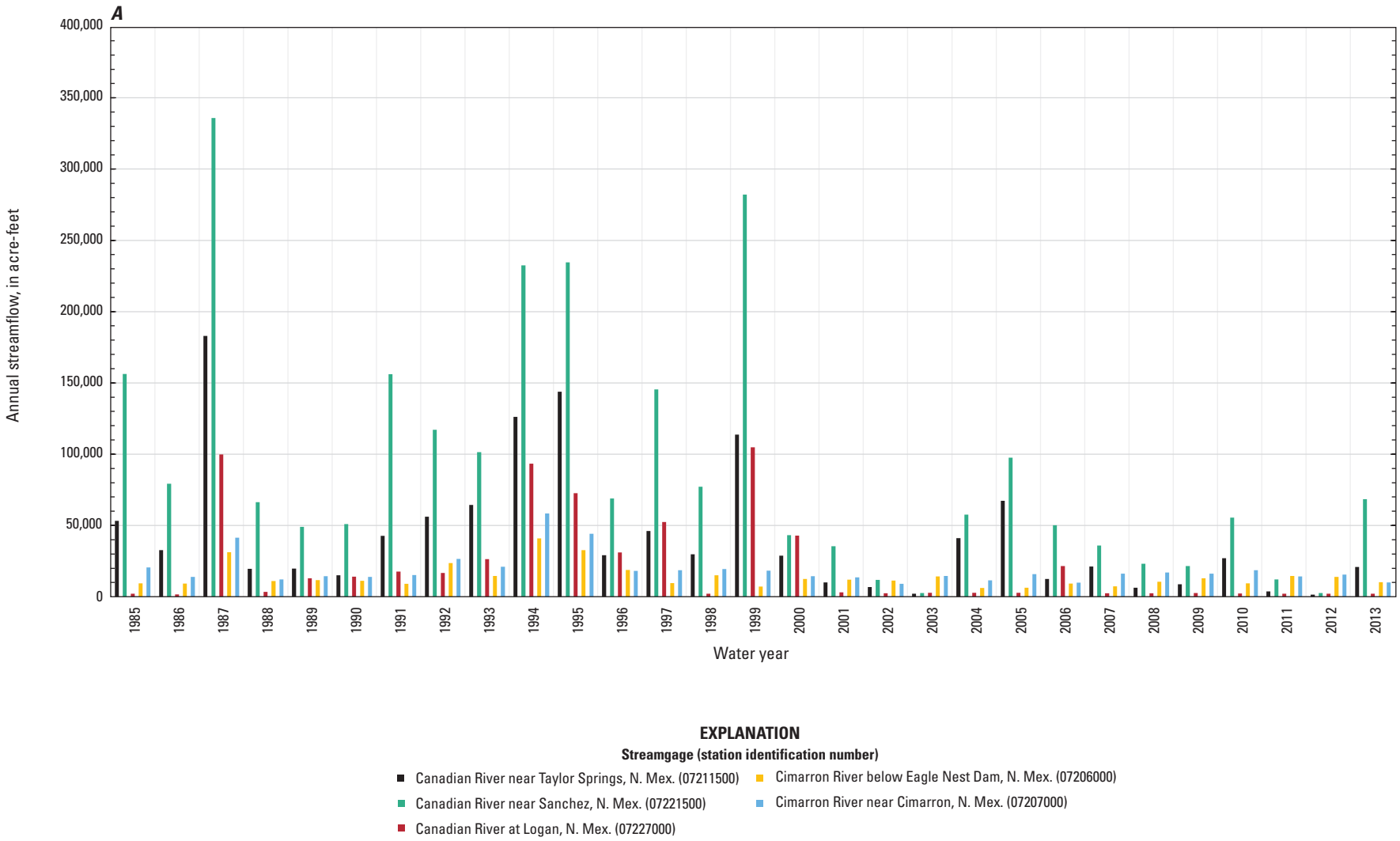

Figure 9. Annual streamflow, departure from mean annual streamflow, and annual difference in streamflow for streams in the Canadian River Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.
A, Canadian River Basin annual streamflow by streamgage, in downstream order.

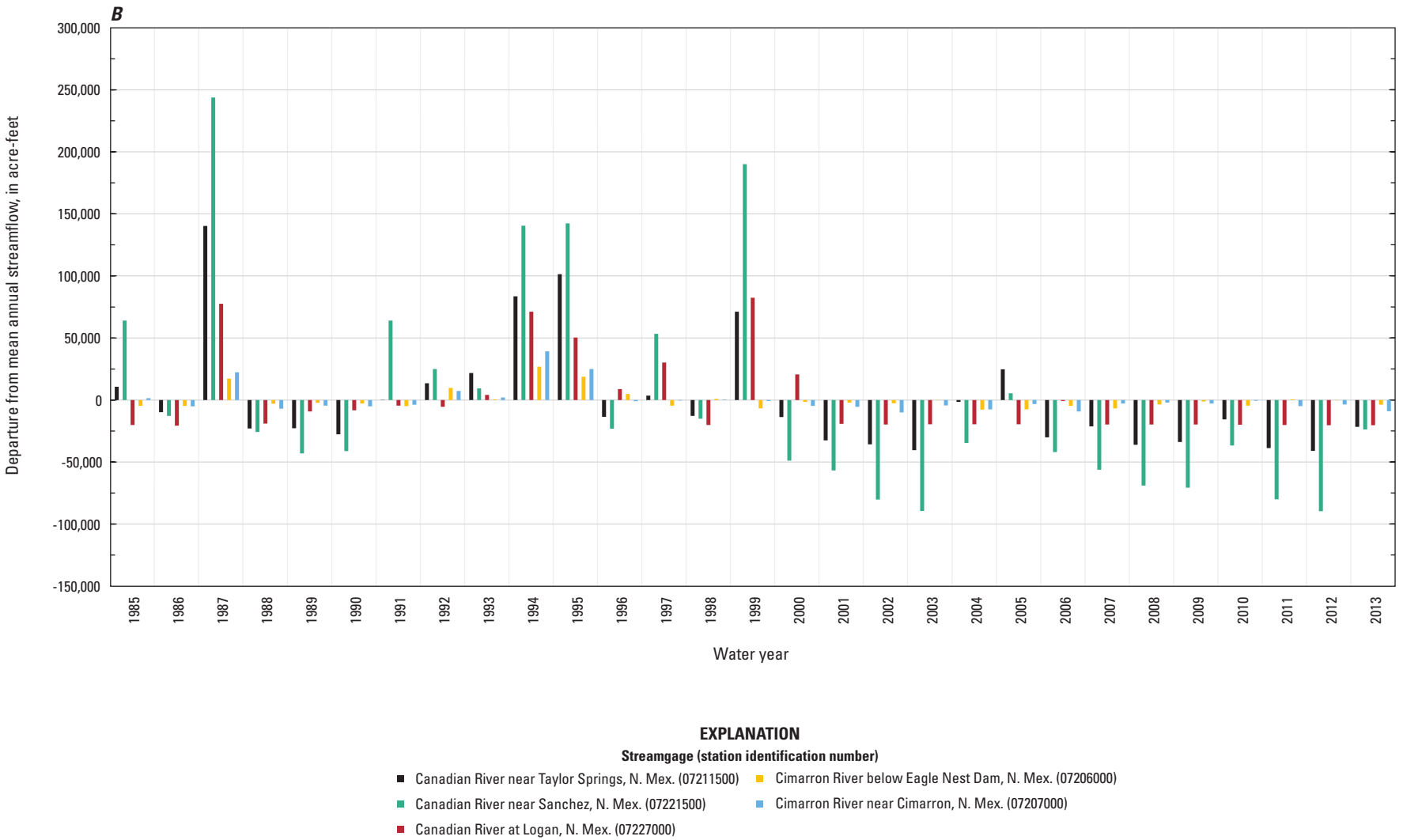

Figure 9. Annual streamflow, departure from mean annual streamflow, and annual difference in streamflow for streams in the Canadian River Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued
B, Departure of annual streamflow from mean annual streamflow at Canadian River and tributary streamgages.

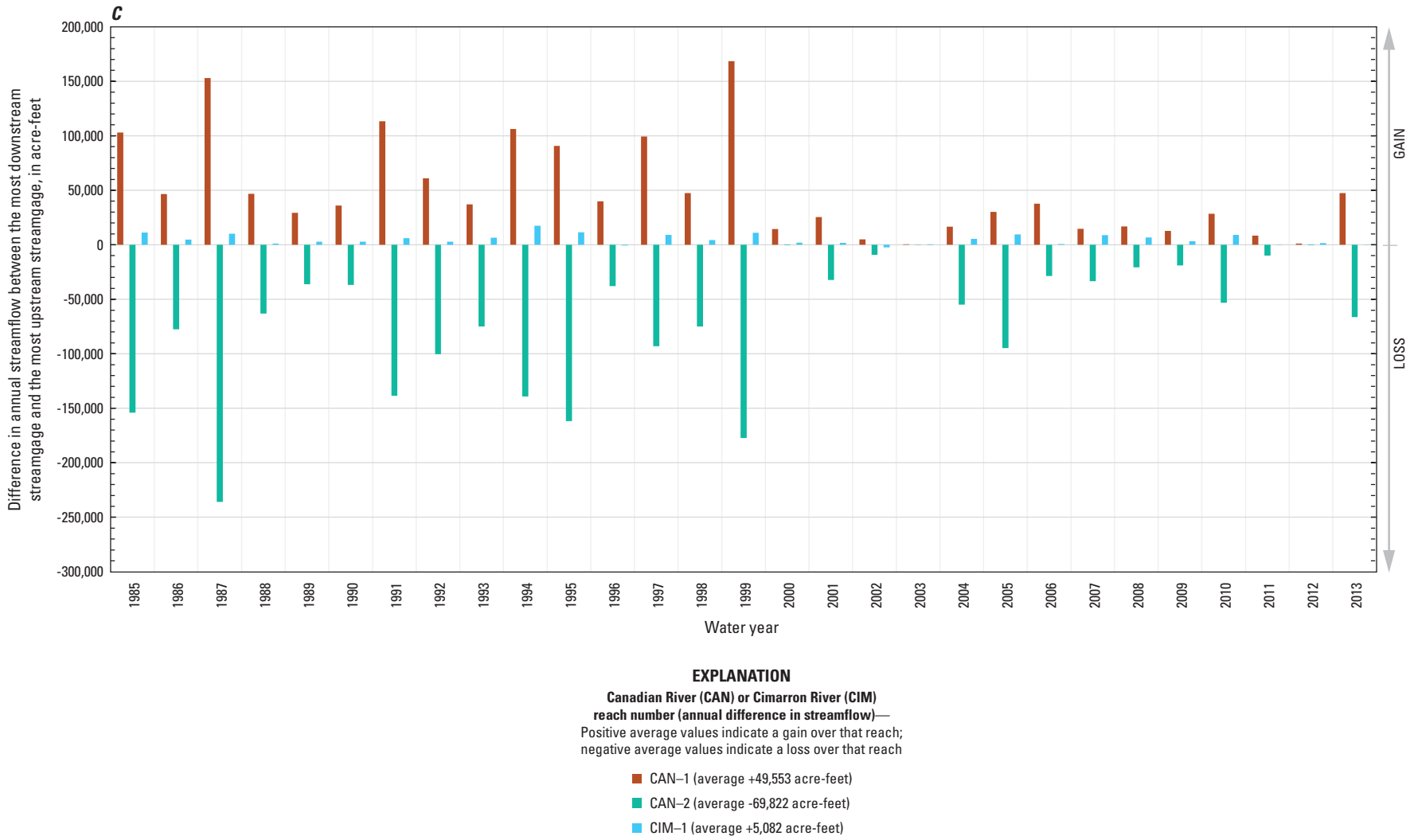

Figure 9. Annual streamflow, departure from mean annual streamflow, and annual difference in streamflow for streams in the Canadian River Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued
C, Canadian River Basin annual difference in streamflow by reach.

Table 7. Annual streamflow and annual difference in streamflow by reach for selected Canadian River Basin streamgages in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.

[N. Mex., New Mexico; acre-ft, acre-feet; CAN, Canadian River reach, numbered in downstream order; CIM, Cimarron River reach, numbered in downstream order]

	Annual streamflow					Annual difference in streamflow by reach		
	Canadian River			Tributary		Canadian River		Tributary
						CAN–1	CAN–2	CIM–1
Water year	07211500 Canadian River near Taylor Springs, N. Mex. (acre-ft)	07221500 Canadian River near Sanchez, N. Mex. (acre-ft)	07227000 Canadian River at Logan, N. Mex. (acre-ft)	07206000 Cimarron River below Eagle Nest Dam, N. Mex. (acre-ft)	07207000 Cimarron River near Cimarron, N. Mex. (acre-ft)	07211500 Canadian River near Taylor Springs, N. Mex., to 07221500 Canadian River near Sanchez, N. Mex. (acre-ft)	07221500 Canadian River near Sanchez, N. Mex., to 07227000 Canadian River at Logan, N. Mex. (acre-ft)	07206000 Cimarron River below Eagle Nest Dam, N. Mex., to 07207000 Cimarron River near Cimarron, N. Mex. (acre-ft)
1985	53,200	156,200	2,090	9,370	20,560	103,000	-154,110	11,190
1986	32,740	79,310	1,670	9,270	13,990	46,570	-77,640	4,720
1987	182,900	335,800	99,900	31,250	41,460	152,900	-235,900	10,210
1988	19,670	66,420	3,370	11,020	12,120	46,750	-63,050	1,100
1989	19,800	49,110	13,000	11,650	14,510	29,310	-36,110	2,860
1990	15,020	50,990	14,080	11,160	14,020	35,970	-36,910	2,860
1991	42,740	156,100	17,670	9,150	15,250	113,360	-138,430	6,100
1992	56,130	117,100	16,770	23,670	26,490	60,970	-100,330	2,820
1993	64,390	101,400	26,350	14,610	21,080	37,010	-75,050	6,470
1994	126,200	232,500	93,360	40,890	58,410	106,300	-139,140	17,520
1995	143,900	234,500	72,640	32,740	44,140	90,600	-161,860	11,400
1996	29,070	68,980	31,150	18,850	18,180	39,910	-37,830	-670
1997	46,150	145,500	52,460	9,530	18,670	99,350	-93,040	9,140
1998	29,810	77,130	2,210	15,010	19,400	47,320	-74,920	4,390
1999	113,700	282,100	104,800	7,170	18,250	168,400	-177,300	11,080
2000	28,830	43,290	42,860	12,520	14,410	14,460	-430	1,890
2001	10,070	35,420	3,130	12,000	13,630	25,350	-32,290	1,630
2002	6,870	11,860	2,510	11,380	9,050	4,990	-9,350	-2,330
2003	2,210	2,700	2,810	14,230	14,670	490	110	440
2004	41,100	57,600	2,710	6,200	11,600	16,500	-54,890	5,400
2005	67,300	97,540	2,790	6,410	15,940	30,240	-94,750	9,530
2006	12,440	50,240	21,580	9,290	9,880	37,800	-28,660	590
2007	21,260	35,870	2,500	7,270	16,190	14,610	-33,370	8,920
2008	6,420	23,200	2,540	10,490	17,090	16,780	-20,660	6,600
2009	8,750	21,520	2,600	12,960	16,180	12,770	-18,920	3,220
2010	27,040	55,530	2,360	9,480	18,570	28,490	-53,170	9,090
2011	3,760	12,100	2,120	14,550	14,260	8,340	-9,980	-290
2012	1,570	2,580	2,060	13,920	15,510	1,010	-520	1,590
2013	20,920	68,410	2,070	10,240	10,140	47,490	-66,340	-100
Mean annual streamflow	**42,550**	**92,103**	**22,281**	**14,010**	**19,091**	**49,553**	**-69,822**	**5,082**

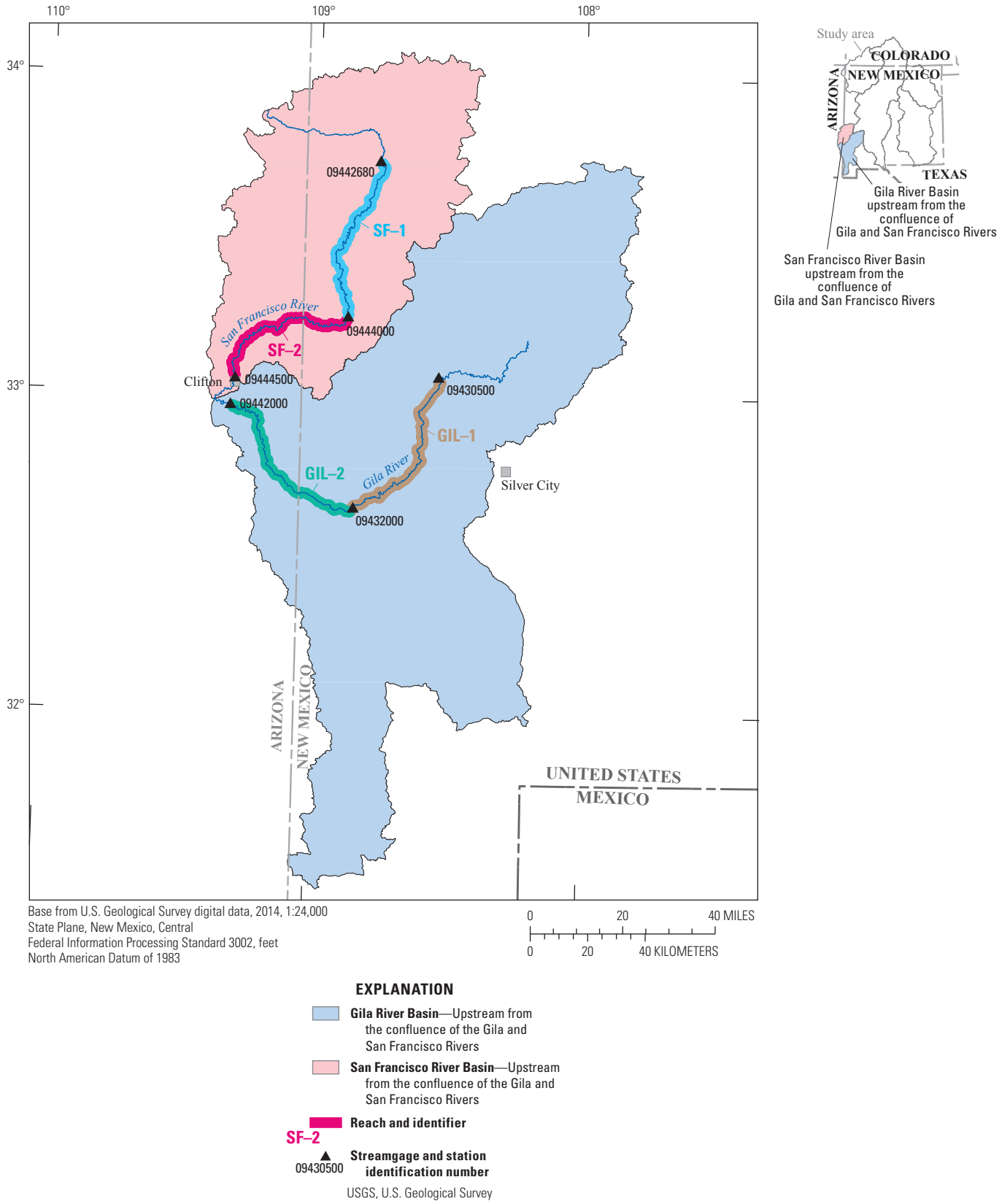

Figure 10. Gila and San Francisco River Basins, streams, stream reaches, and streamgages upstream from the confluence of the Gila and San Francisco Rivers in the six-basin study area, New Mexico and parts of bordering States and Mexico.

Table 8. Annual streamflow and annual difference in streamflow by reach for selected Gila River Basin streamgages in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.

[N. Mex., New Mexico; acre-ft, acre-feet; Ariz., Arizona; GIL, Gila River reach, numbered in downstream order; --, no data]

	Annual streamflow			Annual difference in streamflow by reach	
				GIL–1	GIL–2
Water year	09430500 Gila River near Gila, N. Mex. (acre-ft)	09432000 Gila River below Blue Creek, near Virden, N. Mex. (acre-ft)	09442000 Gila River near Clifton, Ariz. (acre-ft)	09430500 Gila River near Gila, N. Mex., to 09432000 Gila River below Blue Creek, near Virden, N. Mex. (acre-ft)	09432000 Gila River below Blue Creek, near Virden, N. Mex., to 09442000 Gila River near Clifton, Ariz. (acre-ft)
1985	305,900	405,100	374,000	99,200	-31,100
1986	153,300	237,500	193,800	84,200	-43,700
1987	127,900	156,100	142,300	28,200	-13,800
1988	191,900	232,800	200,300	40,900	-32,500
1989	64,800	80,500	78,180	15,700	-2,320
1990	58,300	54,830	--	-3,470	--
1991	223,400	295,600	--	72,200	--
1992	240,600	377,700	--	137,100	--
1993	310,100	539,900	--	229,800	--
1994	54,820	72,520	--	17,700	--
1995	227,300	408,300	--	181,000	--
1996	63,280	94,260	93,800	30,980	-460
1997	152,800	213,400	193,000	60,600	-20,400
1998	147,800	215,000	201,800	67,200	-13,200
1999	74,660	93,640	95,340	18,980	1,700
2000	36,740	45,540	42,990	8,800	-2,550
2001	113,100	164,100	138,200	51,000	-25,900
2002	42,920	56,690	45,210	13,770	-11,480
2003	48,160	56,870	47,610	8,710	-9,260
2004	77,730	115,900	98,030	38,170	-17,870
2005	250,600	367,600	301,900	117,000	-65,700
2006	135,000	202,400	197,100	67,400	-5,300
2007	109,400	142,600	130,700	33,200	-11,900
2008	141,700	177,100	152,700	35,400	-24,400
2009	56,620	60,720	60,490	4,100	-230
2010	155,800	237,600	210,500	81,800	-27,100
2011	47,100	48,740	39,580	1,640	-9,160
2012	59,760	65,810	55,320	6,050	-10,490
2013	204,600	155,900	134,100	-48,700	-21,800
Mean annual streamflow	**133,658**	**185,335**	**140,302**	**51,677**	**-17,344**

Over the study period, mean annual streamflow was 133,658 acre-ft at the Gila River near Gila, N. Mex. (09430500), streamgage; 185,335 acre-ft at the Gila River below Blue Creek, near Virden, N. Mex. (09432000), streamgage; and 140,302 acre-ft at the Gila River near Clifton, Ariz. (09442000), streamgage (table 8). Over the study period, annual flows at the Gila River near Gila, N. Mex. (09430500), streamgage ranged from 36,740 acre-ft in 2000 to 310,100 acre-ft in 1993, at the Gila River below Blue Creek, near Virden, N. Mex. (09432000), streamgage ranged from 45,540 in 2000 to 539,900 acre-ft in 1993, and at the Gila River near Clifton, Ariz. (09442000), streamgage ranged from 39,580 acre-ft in 2011 to 374,000 acre-ft in 1985 (fig. 11*A*; table 8). Annual flows at the Gila River below Blue Creek, near Virden, N. Mex. (09432000), streamgage generally were higher than at the other two streamgages, except for 1990, 1999, and 2013 (fig. 11*A*; table 8). Departures from mean annual streamflow on the Gila River were variable from 1985 to 1998 and generally were negative thereafter, except for 2005–06 and 2010 (fig. 11*B*).

Gila River Basin Gains and Losses

Over the study period, reach GIL–1 (fig. 10) was a gaining reach for all years except 1990 and 2013 (fig. 11*C*; table 8). Gains and losses for reach GIL–1 ranged from a gain of 229,800 acre-ft in 1993 to a loss of 48,700 acre-ft in 2013, with a mean annual gain of 51,677 acre-ft over the study period. In general, gains in reach GIL–1 decreased over the study period. Reach GIL–2 (fig. 10) was a losing reach for all years with data except 1999. Annual gains and losses ranged from a gain of 1,700 acre-ft in 1999 to a loss of 65,700 acre-ft in 2005, with a mean annual loss of 17,344 acre-ft over the study period. Losses were relatively low (fig. 11*C*; table 8) as compared to other streams included in this study.

The Gila River does not have inflow to the State since it originates in New Mexico (fig. 10). A gain/loss computation was not done for the entirety of the stream, but the Gila River contributed a mean annual outflow of 140,302 acre-ft and a total outflow of 3,226,950 acre-ft from 1985 to 2013 (table 2).

San Francisco River Basin Streamflow

The San Francisco River originates in New Mexico, flows into Arizona, and joins the Gila River near Clifton, Ariz. (fig. 10). No tributaries were included for this basin, and there are no major reservoirs on the reaches of the San Francisco River included in this study. Three San Francisco River streamgages were selected for this study: the San Francisco River near Reserve, N. Mex. (09442680), streamgage; the San Francisco River near Glenwood, N. Mex. (09444000), streamgage; and the San Francisco River near Clifton, Ariz. (09444500), streamgage (fig. 10). Monthly streamflow values for these streamgages are presented in appendix 9. Mean annual streamflow was 15,815 acre-ft at the San Francisco River near Reserve, N. Mex. (09442680), streamgage; 73,010 acre-ft at the San Francisco River near Glenwood, N. Mex. (09444000), streamgage; and 162,288 acre-ft at the San Francisco at Clifton, Ariz. (09444500), streamgage (table 9). Annual flows at the San Francisco River near Reserve, N. Mex. (09442680), streamgage ranged from 3,290 acre-ft in 2004 to 56,240 acre-ft in 1993, at the San Francisco River near Glenwood, N. Mex. (09444000), streamgage ranged from 19,880 acre-ft in 2000 to 252,800 acre-ft in 1993, and at the San Francisco River near Clifton, Ariz. (09444500), streamgage ranged from 40,560 acre-ft in 2000 to 601,400 acre-ft in 1993 (fig. 12*A*; table 9). Departures from mean annual streamflow were strongly positive for 1985, 1991–93, 1995, and 2005 but were near zero or negative for the remainder of the study period (fig. 12*B*).

San Francisco River Basin Gains and Losses

Reach SF–1 (fig. 10) was a gaining reach for the study period (fig. 12*C*; table 9). Over the study period, gains for reach SF–1 ranged from 14,450 acre-ft in 2011 to 196,560 acre-ft in 1993. Reach SF–2 (fig. 10) was also a gaining reach, with gains ranging from 20,680 acre-ft in 2000 to 348,600 acre-ft in 1993. The San Francisco River does not have inflow to the State since it originates in New Mexico (fig. 10). Gain/loss was not computed for the entirety of the stream, but the San Francisco River contributed a mean annual outflow of 162,288 acre-ft and a total outflow of 4,706,360 acre-ft over the study period (table 2). Annual outflows to Arizona ranged from 40,560 acre-ft in 2000 to 601,400 acre-ft in 1993.

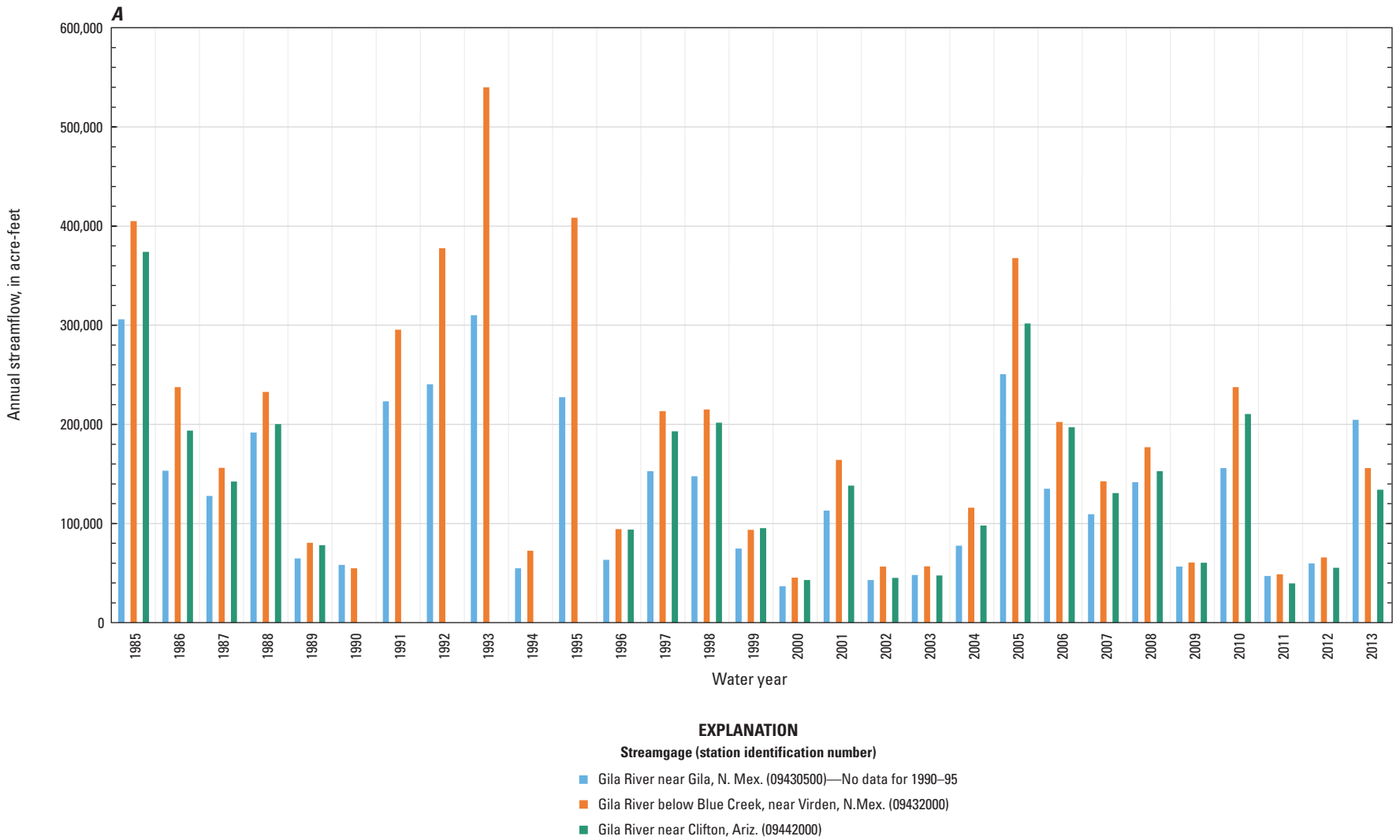

Figure 11. Annual streamflow, departure from mean annual streamflow, and annual difference in streamflow for streams in the Gila River Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.
A, Gila River Basin annual streamflow by streamgage, in downstream order.

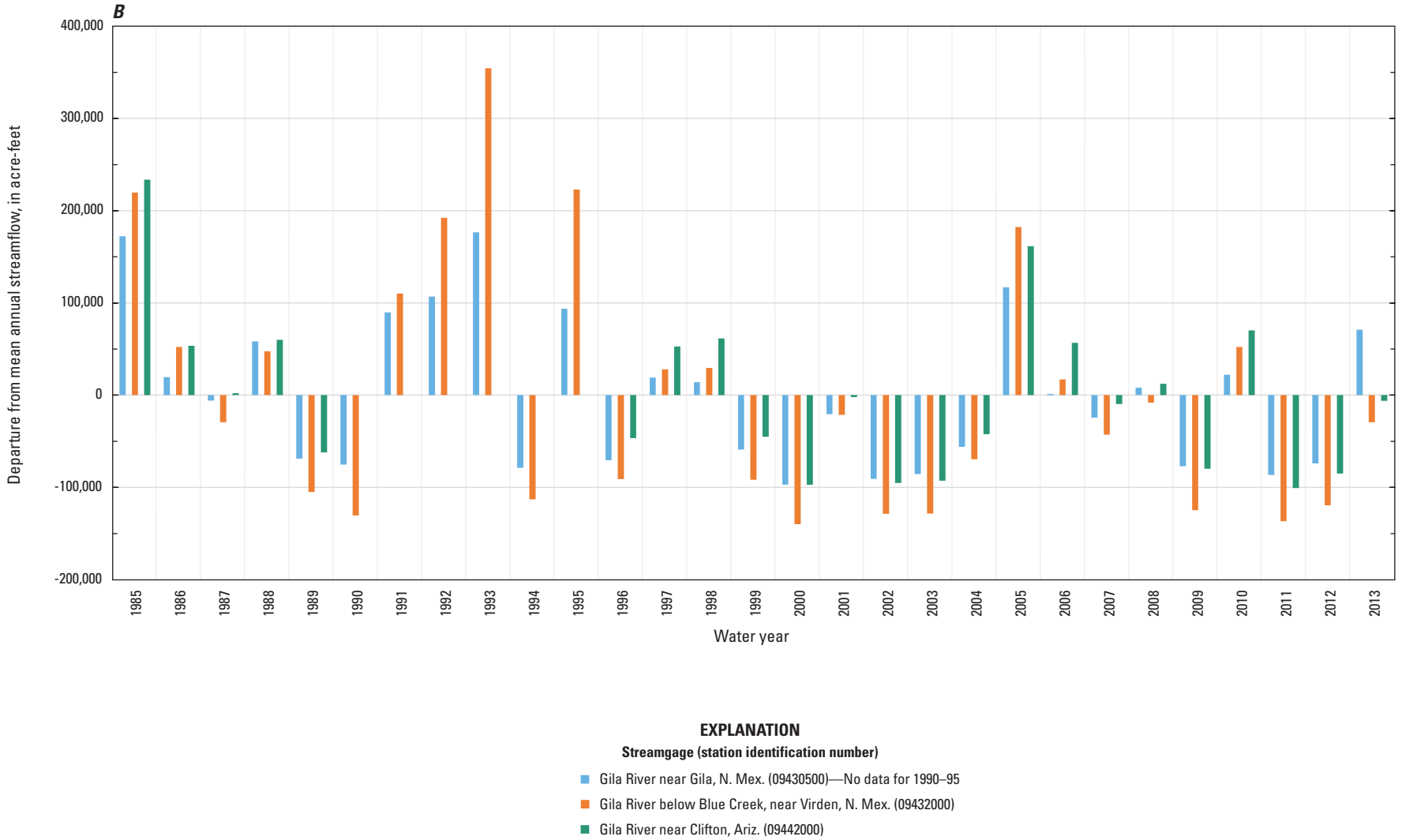

Figure 11. Annual streamflow, departure from mean annual streamflow, and annual difference in streamflow for streams in the Gila River Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued
B, Departure of annual streamflow from mean annual streamflow at Gila River streamgages.

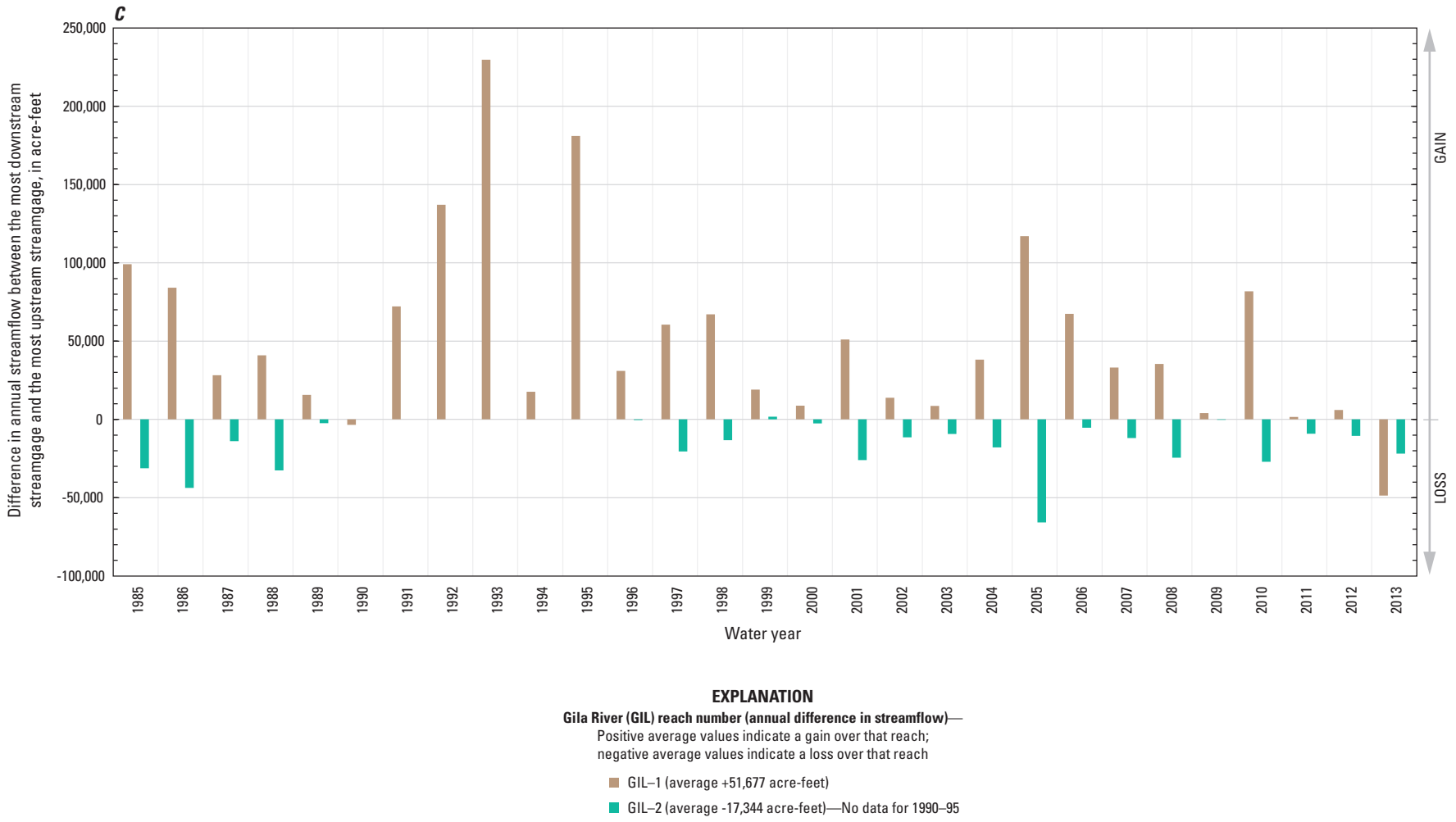

Figure 11. Annual streamflow, departure from mean annual streamflow, and annual difference in streamflow for streams in the Gila River Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued
C, Gila River Basin annual difference in streamflow by reach.

Table 9. Annual streamflow and annual difference in streamflow by reach for selected San Francisco River Basin streamgages in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.

[N. Mex., New Mexico; acre-ft, acre-feet; Ariz., Arizona; SF, San Francisco River reach, numbered in downstream order]

	Annual streamflow			Annual difference in streamflow by reach	
				SF–1	SF–2
Water year	09442680 San Francisco River near Reserve, N. Mex. (acre-ft)	09444000 San Francisco River near Glenwood, N. Mex. (acre-ft)	09444500 San Francisco River at Clifton, Ariz. (acre-ft)	09442680 San Francisco River near Reserve, N. Mex., to 09444000 San Francisco River near Glenwood, N. Mex. (acre-ft)	09444000 San Francisco River near Glenwood, N. Mex., to 09444500 San Francisco River at Clifton, Ariz. (acre-ft)
1985	51,790	209,700	372,600	157,910	162,900
1986	11,740	60,660	139,900	48,920	79,240
1987	40,270	109,500	198,400	69,230	88,900
1988	25,640	95,670	193,700	70,030	98,030
1989	9,200	33,580	70,630	24,380	37,050
1990	4,940	21,120	51,510	16,180	30,390
1991	19,740	129,400	274,400	109,660	145,000
1992	31,420	139,500	345,900	108,080	206,400
1993	56,240	252,800	601,400	196,560	348,600
1994	7,160	32,680	65,960	25,520	33,280
1995	24,160	123,500	301,300	99,340	177,800
1996	4,310	22,530	65,700	18,220	43,170
1997	13,860	37,330	112,200	23,470	74,870
1998	12,290	67,060	154,200	54,770	87,140
1999	14,720	44,200	106,600	29,480	62,400
2000	4,200	19,880	40,560	15,680	20,680
2001	19,130	109,600	237,800	90,470	128,200
2002	4,020	27,360	52,010	23,340	24,650
2003	3,640	23,200	57,940	19,560	34,740
2004	3,290	25,620	69,610	22,330	43,990
2005	22,790	112,500	296,100	89,710	183,600
2006	8,090	60,020	120,500	51,930	60,480
2007	8,520	42,410	97,830	33,890	55,420
2008	14,340	75,070	180,800	60,730	105,730
2009	4,780	22,010	50,200	17,230	28,190
2010	16,000	78,990	193,800	62,990	114,810
2011	5,610	20,060	43,760	14,450	23,700
2012	5,550	23,610	49,450	18,060	25,840
2013	11,200	97,730	161,600	86,530	63,870
Mean annual streamflow	**15,815**	**73,010**	**162,288**	**57,195**	**89,278**

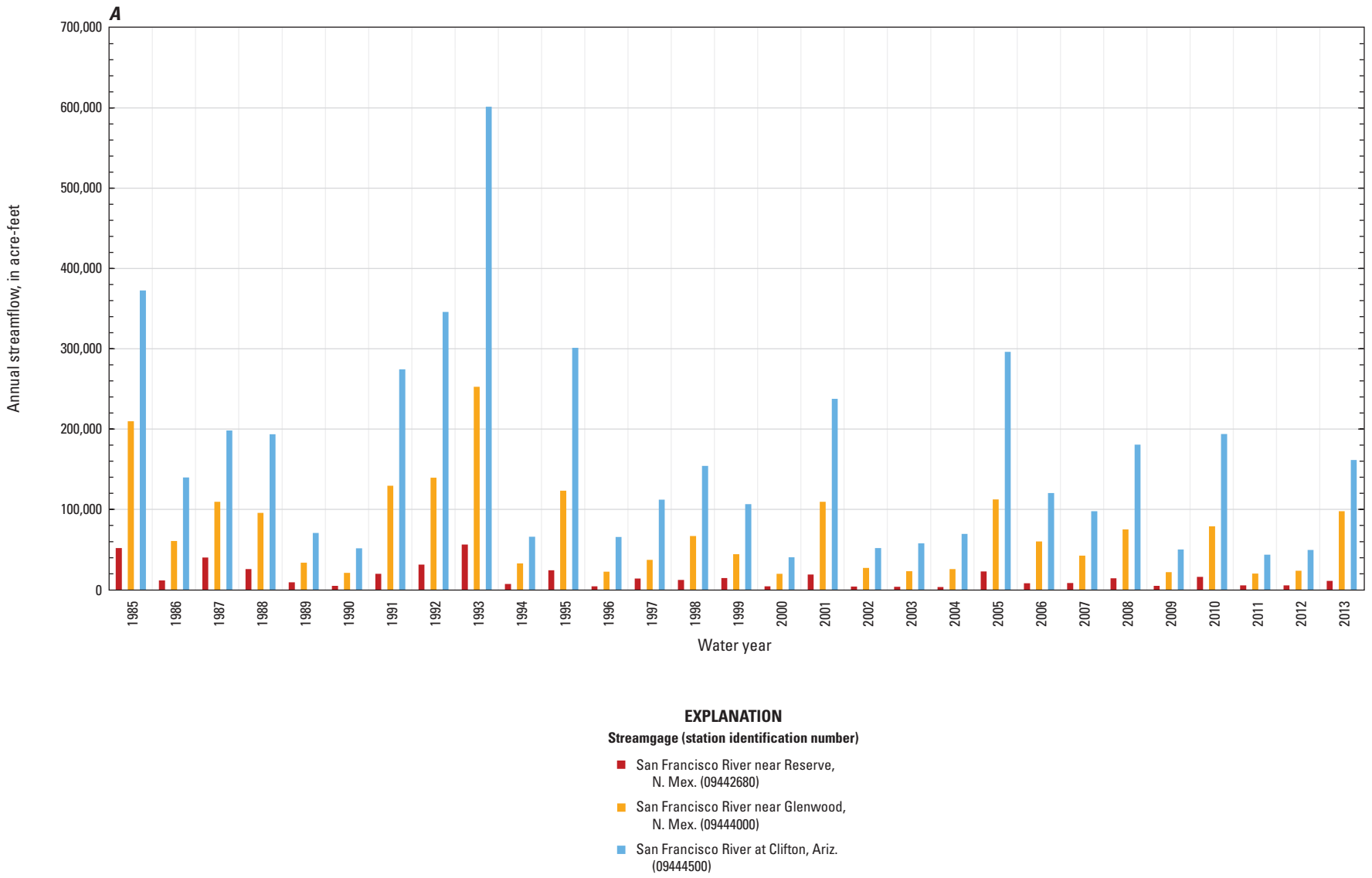

Figure 12. Annual streamflow, departure from mean annual streamflow, and annual difference in streamflow for streams in the San Francisco River Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.
A, San Francisco River Basin annual streamflow by streamgage, in downstream order.

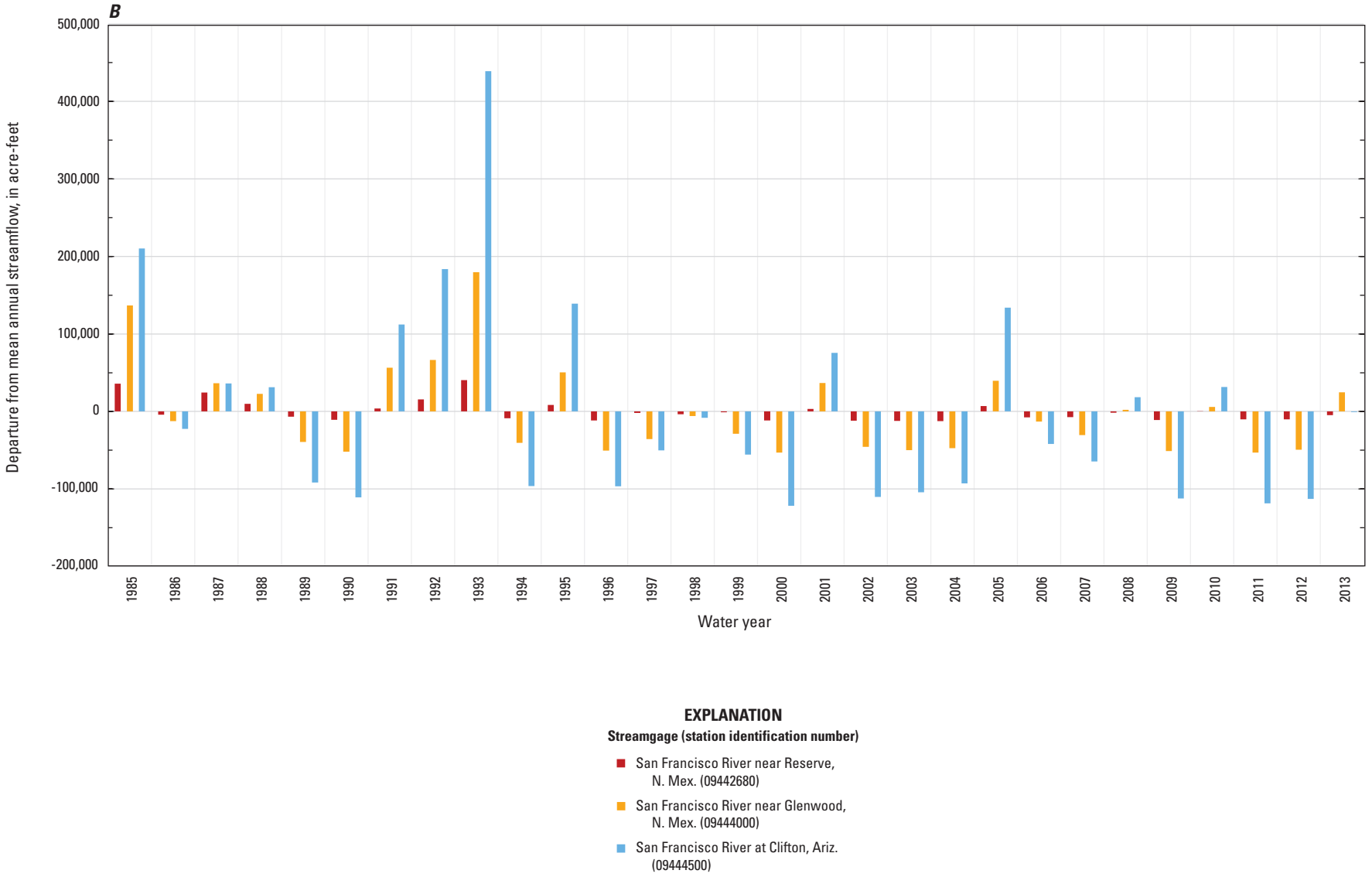

Figure 12. Annual streamflow, departure from mean annual streamflow, and annual difference in streamflow for streams in the San Francisco River Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued
B, Departure of annual streamflow from mean annual streamflow at San Francisco River streamgages.

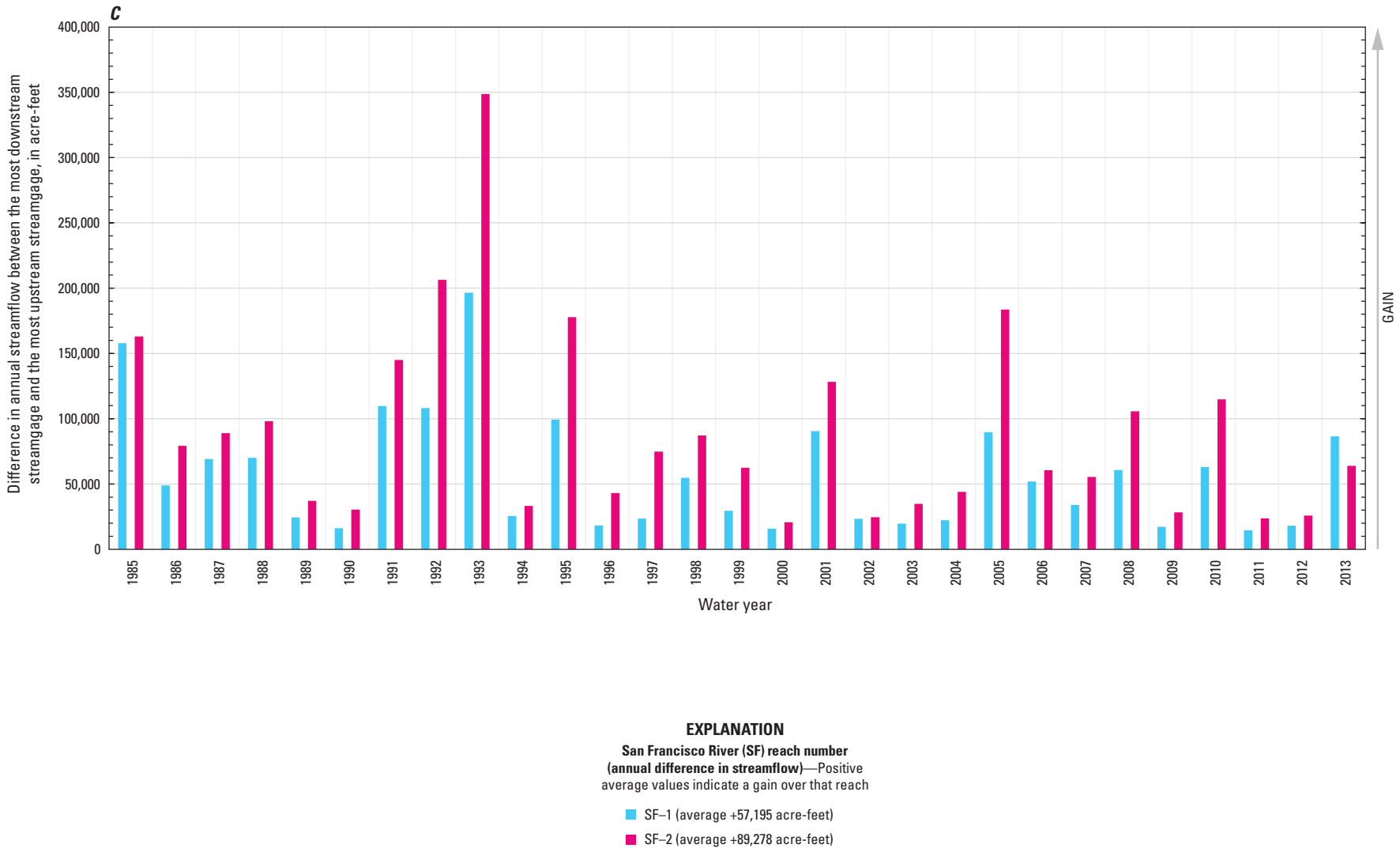

Figure 12. Annual streamflow, departure from mean annual streamflow, and annual difference in streamflow for streams in the San Francisco River Basin in the six-basin study area, New Mexico and parts of bordering States and Mexico, water years 1985–2013.—Continued
C, San Francisco River Basin annual difference in streamflow by reach.

Summary

In 2014, the New Mexico Water Resources Research Institute began a statewide assessment of the water resources of New Mexico. The U.S. Geological Survey, in cooperation with the New Mexico Water Resources Research Institute, addressed the streamflow component of the assessment by examining streamgage data for major river basins and streams in New Mexico for the study period over water years 1985–2013 (all references to years in this report are to water years).

The annual inflow to and outflow from New Mexico generally decreased over the study period. The mean annual inflow over the study period was 746,718 acre-feet (acre-ft), and the mean annual outflow was 2,179,249 acre-ft.

In the Rio Grande Basin, increases in flow between the Costilla Creek below Costilla Dam, N. Mex. (08254000), streamgage and the Costilla Creek near Costilla, N. Mex. (08255500), streamgage indicate that there were substantial gains in flow between the two streamgages. The highest annual flows for the Rio Grande occurred in 1985–87, and except at the Rio Grande below Elephant Butte Dam, N. Mex. (08361000), streamgage and the Rio Grande at El Paso, Texas (08364000), streamgage the lowest flows occurred in 2002–03. Mean annual streamflows in the Rio Grande from 1985 to 2013 increased in magnitude in the downstream direction to a high of 1,042,055 acre-ft at the Rio Grande at Otowi Bridge, N. Mex. (08313000), streamgage but in general decreased downstream from this streamgage, reaching a low mean annual streamflow of 432,142 acre-ft at the Rio Grande at El Paso, Tex. (08364000), streamgage. For the Red River, Rio Hondo, and Rio Pueblo, departures from mean annual streamflow generally were positive for 1985–87, 1991–95, and 2008–09 and generally were negative during the rest of the study period.

Over the study period, annual flows in the Rio Chama generally increased downstream. For 1985–95, only 1988–90 had negative departures from mean annual streamflow. After 1995, negative departures from the mean annual streamflow became more frequent. The Rio Chama reaches were gaining in most years over the study period.

The Rio Puerco annual flows, at both streamgages, generally decreased after 2000. Annual flows at the Rio Puerco near Bernardo, N. Mex. (08353000), streamgage showed a greater decrease over the years than at the Rio Puerco above Arroyo Chico near Guadalupe, N. Mex. (08334000), streamgage but exhibited high annual flows in 2006 and 2013. Reach RP–1 was a gaining reach for 24 years of the study period.

In general, total annual streamflow on the Pecos River increased from 1985 to 1995 but decreased from 1995 to 2013. Departures from mean annual streamflow generally were positive for 1985–2000 and negative for 2001–13. The greatest gain on the Pecos River was estimated at reach PEC–5, which had gains in all 29 years and had the greatest mean annual gain, 64,821 acre-ft. Reach PEC–9 had losses in all 29 years and had the greatest mean annual loss for the study period, 105,583 acre-ft. The Pecos River contributed a mean annual outflow of 73,819 acre-ft and a total outflow of 2,140,740 acre-ft from 1985 to 2013.

For the Rio Hondo, low annual streamflows generally occurred in 1999–2004, 2009, and 2011–12. The highest annual streamflow at all streamgages occurred in 1987. Annual streamflows have generally decreased in magnitude since 1992, but there were moderate flows at some locations during 2006–13. Reach RH–1 was a losing reach for 16 years of the study, with annual gains early in the study period. The magnitude of the gains decreased over time, and reach RH–1 ultimately became a losing reach with periodic gaining years. Reach RH–2 was a losing reach for 28 years over the study period.

Over the study period, the San Juan River had some of the highest flows of any river in New Mexico, and flow on the river generally increased in the downstream direction. Departures from mean annual streamflow were positive from 1985 to 1987 and peaked in 1987. From 2000 to 2013, departures from the mean annual streamflow were predominantly negative; positive departures occurred for some or all of the San Juan River streamgages in 2001, 2005, 2007, and 2008.

Streamflow at the Animas River streamgages was highly variable from year to year but after 1999, generally, tended to decrease. Over the study period, reach ANI–1 generally was a losing reach except for 1987 and 1997. Annual flows at the La Plata River near Farmington, N. Mex. (09367500), streamgage generally were less than the annual inflow to the State at the La Plata River at Colorado-New Mexico State line (09366500) streamgage. Departures from mean annual streamflow in the La Plata River were positive from 1985 to 1987 but decreased to just above average flows in 1998. After 1987, departures from mean annual streamflow were close to zero, except for 1993. Over the study period, reach PLA–1 generally was a losing reach except for 1986, 1987, and 1993.

Prior to 1999, departures from mean annual streamflow at Canadian River streamgages were variable, but after 1999, departures generally were negative. The lowest annual flows occurred in 2003, 2011, and 2012. Inflow from the Canadian River in Colorado for this report is assumed to be zero since the first Canadian River streamgage of the study is in New Mexico. Canadian River annual outflow from New Mexico ranged from a high of 104,800 acre-ft in 1999 to a low of 1,670 acre-ft in 1986. Over the study period, reach CAN–1 was a gaining reach for all 29 years, with gains above average from 1985 to 1999, but, in general, remained below average through 2013. Reach CAN–2 was a losing reach for all years except 2003. Losses were below the mean before 1999, but thereafter losses tended to be above the mean. The Canadian River contributed a mean annual outflow of 22,281 acre-ft and a total outflow of 646,160 acre-ft from 1985 to 2013.

Departures from mean annual streamflow for the Cimarron River were variable through 1999 but generally were negative through 2013. Over the study period, reach CIM–1 generally was a gaining reach except for 1996, 2002,

2011, and 2013. There were 13 above average annual gains over the 29-year study period.

Departures from mean annual streamflow on the Gila River were variable from 1985 to 1998 and generally were negative thereafter, except for 2005–06 and 2010. Annual flows at the Gila River below Blue Creek, near Virden, N. Mex. (09432000), streamgage generally were higher than at the other two Gila River streamgages, except for 1990, 1999, and 2013. Over the study period, reach GIL–1 was a gaining reach for all years except 1990 and 2013, while reach GIL–2 was a losing reach for all years with data except 1999. The Gila River contributed a mean annual outflow of 140,302 acre-ft and a total outflow of 3,226,950 acre-ft over the study period.

Departures from mean annual streamflow on the San Francisco River were strongly positive for 1985, 1991–93, 1995, and 2005 but were near zero or negative for the remainder of the study period. Both reaches on the San Francisco River were gaining reaches. The San Francisco River contributed a mean annual outflow of 162,288 acre-ft and a total outflow of 4,706,360 acre-ft over the study period.

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