UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

WATER-BUDGET STUDIES OF LOWER MESILLA VALLEY AND EL PASO VALLEY, EL PASO COUNTY, TEXAS

By

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in cooperation with the
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ABSTRACT

The total inflow of water to the lower Mesilla Valley in 1970 was 390,510 acre-feet. Of this amount, 41,300 acre-feet was consumptively used by crops and phreatophytes and 4,700 acre-feet was lost by evaporation. Ground-water storage increased by 320 acre-feet, and 360,060 acre-feet left the valley as surface- and ground-water outflow.

Ground-water recharge was approximately 26,170 acre-feet.

The total inflow to the lower Mesilla Valley in 1971 was 282,880 acre-feet, of which 41,800 acre-feet was consumptively used by crops and phreatophytes and 4,500 acre-feet was lost by evaporation. Ground-water storage decreased by 3,970 acre-feet and 244,320 acre-feet left the valley as surface- and ground-water outflow. Ground-water recharge was approximately 33,500 acre-feet.

The average yearly inflow to the El Paso Valley in 1968-71 was 301,770 acre-feet. The average consumptive use by irrigated crops and phreatophytes was 138,870 acre-feet; the average evaporation loss was 27,000 acre-feet; the average change in ground-water storage was a decrease of 3,225 acre-feet; and the average outflow from the valley was 96,640 acre-feet. Ground-water recharge averaged about 80,710 acre-feet.

INTRODUCTION

The U.S. Geological Survey, in cooperation with the city of El Paso and the Texas Water Development Board, began water-budget studies of the lower Mesilla Valley and El Paso Valley, El Paso County, Texas, in 1968 to determine the amount of water that could be pumped for municipal supply from the shallow alluvial aquifer without depleting the supply for irrigation. Preliminary findings were presented in an open-file report (Meyer and Gordon, 1970). This report presents the data for 1970 and 1971 and summarizes the 4-year study.

The lower Mesilla Valley in Texas extends from Anthony, Texas, to the gorge of the Rio Grande at El Paso (fig. 1). The valley is about 4.2 miles wide in the vicinity of Anthony, but is less than 1,000 feet wide at the gorge. About half of the area of the lower Mesilla Valley is in Texas, and about half is in New Mexico. The amount of land irrigated by surface and ground water ranges from about 14,000 to 15,000 acres, and about 1,000 acres are irrigated by ground water only.

The El Paso Valley extends from the gorge of the Rio Grande at El Paso southeast to the Hudspeth-El Paso County line, and from the rim-rock on the north and northeast to the Rio Grande on the south and southeast. The Mexican side of the El Paso Valley is not included in the study.

The El Paso Valley encompasses about 50,000 acres, of which more than 45,000 acres are irrigated with surface water. When surface-water supplies are inadequate, water from the shallow alluvial aquifer is used as a supplementary supply.

The water-budget study in the lower Mesilla Valley was made only for 1970 and 1971 because the gaging station on the Rio Grande at Vinton Bridge near Anthony was installed in January 1970. Data for 4 years were available for the El Paso Valley because gages were in operation during the entire study.

WATER BUDGET

In an inventory of the total water resources of an area, the accretions must balance the depletions. The water budget may be stated as:

$$Q_i = Q_o + L + \Delta S$$

where

Q_i = inflow, which consists of surface water (river, canals, drains, and sewage discharged to the river), precipitation, and ground water;

Q_o = outflow, which consists of surface water (river, canals, and drains) and ground water;

L = water losses, which consist of evaporation and consumptive use by crops and phreatophytes; and

ΔS = change in ground-water storage.

Lower Mesilla Valley

Inflow

The inflow to the lower Mesilla Valley consists of surface water, ground water, and precipitation. Surface water inflow includes the flow in the Rio Grande; the flow in La Union East and West Canals; and the flow in Vinton Drain, Nemexas Drain, and West Drain (table 1). In addition, several arroyos occasionally discharge water into the Rio Grande between the gaging stations at Vinton Bridge and El Paso (fig. 1). Hydrographs for the flow of the Rio Grande near Anthony and near El Paso are shown in figures 2 and 3.

Table 1.--Surface-water inflow to the lower Mesilla Valley

	Flow (acre-feet)	
	1970	1971
Rio Grande	260,300	177,500
La Union East Canal	39,500	32,160
La Union West Canal	39,000	29,090
Vinton Drain	970	480
Nemexas Drain	7,870	4,490
West Drain	14,520	8,960
Arroyo runoff	2,800	4,000
Totals	364,960	256,680

Two important hydrologic events are suggested by the hydrographs. First, the river changes from a losing stream to a gaining stream shortly after irrigation water is applied, and secondly, when the difference in discharge is greater than the increase in flow due to the drain effects of the river, the increase correlates with precipitation and is a rough measure of the arroyo flow--as shown by the flows of June 6, July 6, 21, and 25, 1970, and July 2, 23, and August 18, 1971.

On the basis of an average transmissivity of 18,000 feet squared per day, a hydraulic gradient of 4.5 feet per mile, and a width of 4.2 miles, the amount of ground water discharged from the shallow alluvial aquifer is about 2,800 acre-feet per year.

Precipitation as measured by the National Weather Service at La Tuna was 6.01 inches in 1970 and 6.52 inches in 1971. The total precipitation over the irrigated part of the valley was about 7,750 acre-feet in 1970 and about 8,400 acre-feet in 1971.

Outflow

Surface-water outflow from the lower Mesilla Valley is measured by the International Boundary and Water Commission gaging station Rio Grande near El Paso. The discharge at this station, which includes all the drain flow, is the sum of the discharge measured in the American Canal and the discharge measured below the American Diversion Dam. The outflow of surface water was 360,700 acre-feet in 1970 (table 3) and 244,160 acre-feet in 1971 (table 4). Ground-water outflow averages only about 160 acre-feet per year.

Losses

The consumptive use of water by crops was estimated by the Blaney-Criddle method (Blaney and Criddle, 1950), which is based on average temperatures, percent of daylight hours, length of growing season, and an empirical coefficient K for each crop. The acreage of each crop grown and the water used is given in table 2.

Table 2.--Total consumptive use of water by crops in the lower Mesilla Valley

Crop	Acres		Consumptive use (acre-feet per acre) 1/	Water use (acre-feet)	
	1970	1971		1970	1971
Barley	120	60	1.62	194	97
Milo	478	580	1.62	774	940
Alfalfa	2,782	2,900	3.81	10,599	11,049
Pasture	410	410	3.38	1,386	1,386
Silage	184	200	1.40	258	280
Cotton	10,362	10,206	2.45	25,387	25,005
Vegetables	892	1,092	1.97	1,757	2,151
Totals	15,228	15,448	Totals	40,355	40,908

1/ Precipitation is considered insignificant.

Saltcedar and cattails, the two most prevalent phreatophytes in the valley, grow along the drains and in parts of the lower end of the valley where the water table is high. Assuming a 50 percent density on 200 acres, approximately 900 acre-feet per year is used by phreatophytes.

Most of the precipitation occurs during the growing season, when the average evaporation rate from a standard National Weather Service pan is about 0.4 inch per day, which is equivalent to 0.28 inch per day from a free-water surface. The total evaporation was estimated at 4,700 acre-feet in 1970, and 4,500 acre-feet in 1971. This estimate includes evapotranspiration from the soil and evaporation from the free-water surfaces of the river, canals, and drains.

Changes in Ground-Water Storage

The change in ground-water storage was determined from maps showing the change in water levels between 1969-70 and 1970-71. The area between each contour was measured with a planimeter; this area, multiplied by the average change between each contour, gives a measure of the volume of aquifer that was dewatered. The volumes were added algebraically and multiplied by a storage coefficient of 0.20 to give the increase or decrease in storage. There was a slight increase in storage in 1970 of about 320 acre-feet and a decrease in 1971 of 3,970 acre-feet.

Summary of the Water Budget

Because most factors in the water budget have been measured or estimated, the water budget for 1970 and 1971 can be summarized as shown in tables 3 and 4.

Table 3.--Summary of the water budget for the lower Mesilla Valley in 1970

Water-budget item	Q_i (acre-feet)	$Q_o + L + \Delta S$ (acre-feet)
Surface-water inflow	364,960	
Ground-water inflow	17,800	
Precipitation	7,750	
Total	390,510	
Surface-water outflow		360,700
Ground-water outflow		160
Consumptive use by irrigated crops		40,400
Consumptive use by phreatophytes		900
Evaporation		4,700
Change in ground-water storage		320
Total		407,180
Water budget imbalance		- 17,670

Table 4.--Summary of the water budget for the lower Mesilla Valley in 1971

Water-budget item	Q_i (acre-feet)	$Q_o + L + \Delta S$ (acre-feet)
Surface-water inflow	256,680	
Ground-water inflow	17,800	
Precipitation	8,400	
Total	282,880	
Surface-water outflow		244,160
Ground-water outflow		160
Consumptive use by irrigated crops		40,900
Consumptive use by phreatophytes		900
Evaporation		4,500
Change in ground-water storage		-3,970
Total		286,650
Water-budget imbalance		- 3,770

Computations in this report for inflow into the valley include only the inflow from the alluvial aquifer. However, the Santa Fe aquifer is recharged from both sides of the valley. As this aquifer has no apparent outlet, water is probably moving upward into the shallow aquifer and then discharging into drains and the river at the lower end of the valley. Leggat and others (1962), estimated this recharge to be at least 15,000 acre-feet. More recent information indicates that the recharge may be even greater.

Ground-Water Recharge

The total recharge to the shallow alluvial aquifer in the lower Mesilla Valley was estimated by determining the factors in the relation

$$R \doteq D + \Delta S$$

where

R = recharge;

D = discharge; and

ΔS = change in storage.

For conditions that existed in 1970, the potential ground-water recharge is represented by: (1) Increase in drainflow within the valley (19,830 acre-feet); (2) loss to phreatophytes (900 acre-feet); (3) pumpage from the alluvium (9,430 acre-feet) and the Santa Fe aquifer (13,330 acre-feet); (4) increase in ground-water storage (320 acre-feet); and (5) the difference between ground-water outflow and inflow (-17,640 acre-feet).

These estimates indicate that potential recharge in 1970 was 27,840 acre-feet, which is the equivalent to 1.83 acre-feet per acre irrigated, or about 40 percent of the water diverted for irrigation.

For conditions that existed in 1971, ground-water recharge is represented by the sum of: (1) Increase of drainflow within the valley (15,800 acre-feet); (2) loss to phreatophytes (900 acre-feet); (3) pumpage from the alluvium (23,850 acre-feet) and from the Santa Fe aquifer (14,560 acre-feet); (4) decrease in ground-water storage (-3,970 acre-feet); and (5) the difference between ground-water outflow and inflow (-17,640 acre-feet). Ground-water recharge was approximately 33,500 acre-feet, or 2.2 acre-feet per acre irrigated. The increase is derived from seepage from the river.

El Paso Valley

Inflow

The surface-water inflow to the El Paso Valley is the discharge of the American Canal minus the diversions to the water-treatment plant of the city of El Paso, plus the treated sewage effluent returned to the river by the city. Precipitation, which is an item of inflow, was determined from records of the National Weather Service at El Paso, Ysleta, and Fabens. The inflow and precipitation in the El Paso Valley for the period of study is given in table 5.

Table 5.--Surface-water inflow and precipitation in the El Paso Valley

Year	Surface-water inflow (acre-feet)	Precipitation (acre-feet)
1968	240,800	50,000
1969	308,900	24,000
1970	304,500	28,200
1971	211,800	27,500

The El Paso Valley is entrenched in the Hueco Bolson; consequently ground water moves into the valley from both sides. However, because no data are available on the transmissivity and hydraulic gradient in the southern part of the valley in Mexico, it is assumed that ground water moving into the valley is derived only from the bolson north of the valley.

Assuming that the transmissivity is 3,340 feet squared per day, the length of the bolson is 40 miles, and the hydraulic gradient is 2.5 feet per mile, the ground-water inflow is 2,800 acre-feet per year.

Outflow

Surface-water outflow from the El Paso Valley consists of the sum of flows in Tornillo Canal, Tornillo Drain, Hudspeth Feeder Canal, and the Rio Grande at the county line. The outflow is summarized in table 6.

Table 6.--Surface-water outflow from the El Paso Valley

Unit	Flow (acre-feet)			
	1968	1969	1970	1971
Tornillo Canal	10,720	24,200	32,920	12,000
Tornillo Drain	16,530	27,500	35,530	27,340
Hudspeth Feeder Canal	17,830	47,500	51,900	22,050
Rio Grande at county line	8,900	17,700	24,200	1,360
Totals	53,980	116,900	144,550	62,750

On the basis of an average transmissivity of 10,700 feet squared per day, a width of 4.65 miles, and a hydraulic gradient of 5 feet per mile, the ground-water outflow averaged 2,100 acre-feet per year.

Losses

The consumptive use of water by crops was estimated by the Blaney-Criddle method. The acreage of various crops grown each year and the water used by these crops is given in table 7.

Approximately 4 to 5 percent of the valley is covered by phreatophytes, mostly saltcedar and willows, primarily along drains and at the lower end of the valley. Assuming that about 5 acre-feet per acre per year is consumed by these plants, the total use per year is about 12,000 acre-feet.

Most of the precipitation occurs during the growing season when the evaporation rates from a standard National Weather Service pan is about 0.4 inch per day, which is equivalent to 0.28 inch per day from a free-water surface. The estimated total evaporation is given in table 8, which includes evapotranspiration and evaporation from the free-water surfaces of the river, canals, and drains.

Table 7.--Consumptive use of water by crops in the El Paso Valley for the years 1968-71

Crop	Acres				Consumptive use acre-feet per acre	Water used (acre-feet)			
	1968	1969	1970	1971		1968	1969	1970	1971
Cotton	32,021	36,962	28,248	26,956	2.45	78,451	90,557	69,208	66,042
Barley	2,024	2,687	5,473	4,168	1.62	3,279	4,353	8,866	6,752
Alfalfa	6,363	7,831	8,120	8,940	3.81	24,243	29,836	30,937	34,061
Milo	4,057	6,666	6,280	3,743	1.62	6,572	10,799	10,074	6,064
Silage	492	227	738	545	1.40	689	318	1,033	763
Pasture	775	539	626	998	3.38	2,620	1,823	2,116	3,373
Vegetables	416	762	435	453	1.97	820	1,501	857	892
Pecans	315	592	712	747	3.61	1,137	2,137	2,570	2,697
Corns			384	735	1.80			691	1,323
Totals	46,463	56,266	51,016	47,285		117,811	141,324	126,352	121,967

Table 8.--Evaporation losses for the years 1968-71

Year	Evaporation loss (acre-feet)
1968	46,400
1969	19,100
1970	21,200
1971	21,300

Changes in Ground-Water Storage

The change in ground-water storage was determined from maps showing the change in water levels between 1969-70 and 1970-71. The area between each contour was measured with a planimeter; this area multiplied by the average change between each contour gives a measure of the volume of aquifer that was dewatered. The volumes were added algebraically and multiplied by a storage coefficient of 0.20 to give the increase or decrease of storage. In 1968, the amount of water in storage increased by 3,400 acre-feet. However, in 1969 the amount of water in storage decreased by 3,200 acre-feet; in 1970 the decrease was 2,100 acre-feet, and in 1971 the decrease was 11,000 acre-feet.

Summary of the Water Budget

Because most factors in the water budget have been measured or estimated, the water budgets for 1968-71 can be summarized as shown in tables 9-12.

Table 9.--Summary of the water budget for the El Paso Valley in 1968

Water-budget item	Q_i (acre-feet)	$Q_o + L + \Delta S$ (acre-feet)
Surface-water inflow	240,800	
Ground-water inflow	2,800	
Precipitation	50,000	
Total	293,600	
Surface-water outflow		54,000
Ground-water outflow		2,100
Consumptive use by irrigated crops		117,800
Consumptive use by phreatophytes		12,000
Evaporation		46,400
Change in ground-water storage		3,400
Total		235,700
Water-budget imbalance		57,900

Table 10.--Summary of the water budget for the El Paso Valley in 1969

Water-budget item	Q_i (acre-feet)	$Q_o + L + \Delta S$ (acre-feet)
Surface-water inflow	308,900	
Ground-water inflow	2,800	
Precipitation	24,000	
Total	335,700	
Surface-water outflow		116,900
Ground-water outflow		2,100
Consumptive use by irrigated crops		141,300
Consumptive use by phreatophytes		12,000
Evaporation		19,100
Change in ground-water storage		- 3,200
Total		288,200
Water-budget imbalance		47,500

Table 11.--Summary of the water budget for the El Paso Valley in 1970

Water-budget item	Q_i (acre-feet)	$Q_o + L + \Delta S$ (acre-feet)
Surface-water inflow	304,500	
Ground-water inflow	2,800	
Precipitation	28,200	
Total	335,500	
Surface-water outflow		144,500
Ground-water outflow		2,100
Consumptive use by irrigated crops		126,400
Consumptive use by phreatophytes		12,000
Evaporation		21,200
Change in ground-water storage		- 2,100
Total		304,100
Water-budget imbalance		31,400

Table 12.--Summary of the water budget for the El Paso Valley in 1971

Water-budget item	Q_i (acre-feet)	$Q_o + L + \Delta S$ (acre-feet)
Surface-water inflow	211,800	
Ground-water inflow	2,800	
Precipitation	27,500	
Total	242,100	
Surface-water outflow		62,750
Ground-water outflow		2,100
Consumptive use by irrigated crops		122,000
Consumptive use by phreatophytes		12,000
Evaporation		21,300
Change in ground-water storage		-11,000
Total		209,150
Water-budget imbalance		32,950

The average yearly inflow to the El Paso Valley in 1968-71 was 301,770 acre-feet. The average consumptive use by irrigated crops and phreatophytes was 138,870 acre-feet; the average evaporation loss was 27,000 acre-feet; the average change in ground-water storage was a decrease of 3,225 acre-feet; and the average outflow from the valley was 96,640 acre-feet. Ground-water recharge averaged about 80,710 acre-feet.

The imbalance in the water budget for the El Paso Valley indicates that some losses have not been accounted for. In 1971, at least 20,000 acre-feet per year was lost by leakage from the alluvium to the underlying bolson deposits. This loss is not included in the water-budget summary because the amount will decline as natural recharge decreases. This leakage is caused by the difference in the head between the two aquifers. This computation was made by determining a coefficient of leakage of 0.23 gallon per day over the area where the 40-foot head differential occurred.

The difference between the static or nonpumping heads in the aquifers is about 50 to 90 feet in the center of the industrial area, about 25 feet near the southeast corner of Ascarate Park, and about 43 feet near the Evergreen Cemetery and Cotton Street overpass. When the wells in the vicinity of the Stanton Street bridge are pumping, the differential head during the pumping season is about 60 feet; during the nonpumping season, the heads are about equal.

In 1968, a part of the channel of the Rio Grande and the upper end of the Franklin Canal were lined with concrete. The result was a sharp decrease in recharge, and the water levels in the alluvial aquifer began to decline, the largest declines occurring near the lined reaches. During the past 4 years, the water table near the Stanton Street bridge declined about 45 feet; at the Cotton Street overpass, the decline was 15 feet; and near the Evergreen Cemetery and at the south end of Concepcion Street, the decline was 11.4 and 11.9 feet, respectively. In contrast, the water table in the alluvial aquifer near the industrial area declined only 3 feet.

Ground-Water Recharge

The water that percolates downward to the water table is recharge to the ground-water system. Whether this water remains in storage in the aquifer or moves out of the valley as drain or river flow depends upon the altitude of the water table in relation to the altitude of the river bed. If the water table is below the river bed, the water will remain in storage and be available for use.

The ground-water recharge is obtained by taking the sum of: (1) Drain flow; (2) pumpage from the alluvial aquifer; (3) ground-water used by phreatophytes; (4) the difference between ground-water outflow and ground-water inflow; and (5) the change in ground-water storage.

Ground-water recharge for the years 1968 through 1971 is given in table 13.

Table 13.--Ground-water recharge in the El Paso Valley, 1968-71

Source	Quantity of water (acre-feet)			
	1968	1969	1970	1971
Drain flow	49,400	65,500	77,130	56,900
Pumpage	10,000	5,000	3,000	24,000
Evapotranspiration by phreatophytes	12,000	12,000	12,000	12,000
Ground-water outflow less ground-water inflow	-700	-700	-700	-700
Change in ground-water storage	3,400	-3,200	-2,100	-11,000
Total	74,100	78,600	89,330	80,800
	or	or	or	or
	1.59	1.40	1.75	1.72
	acre-feet/acre	acre-feet/acre	acre-feet/acre	acre-feet/acre

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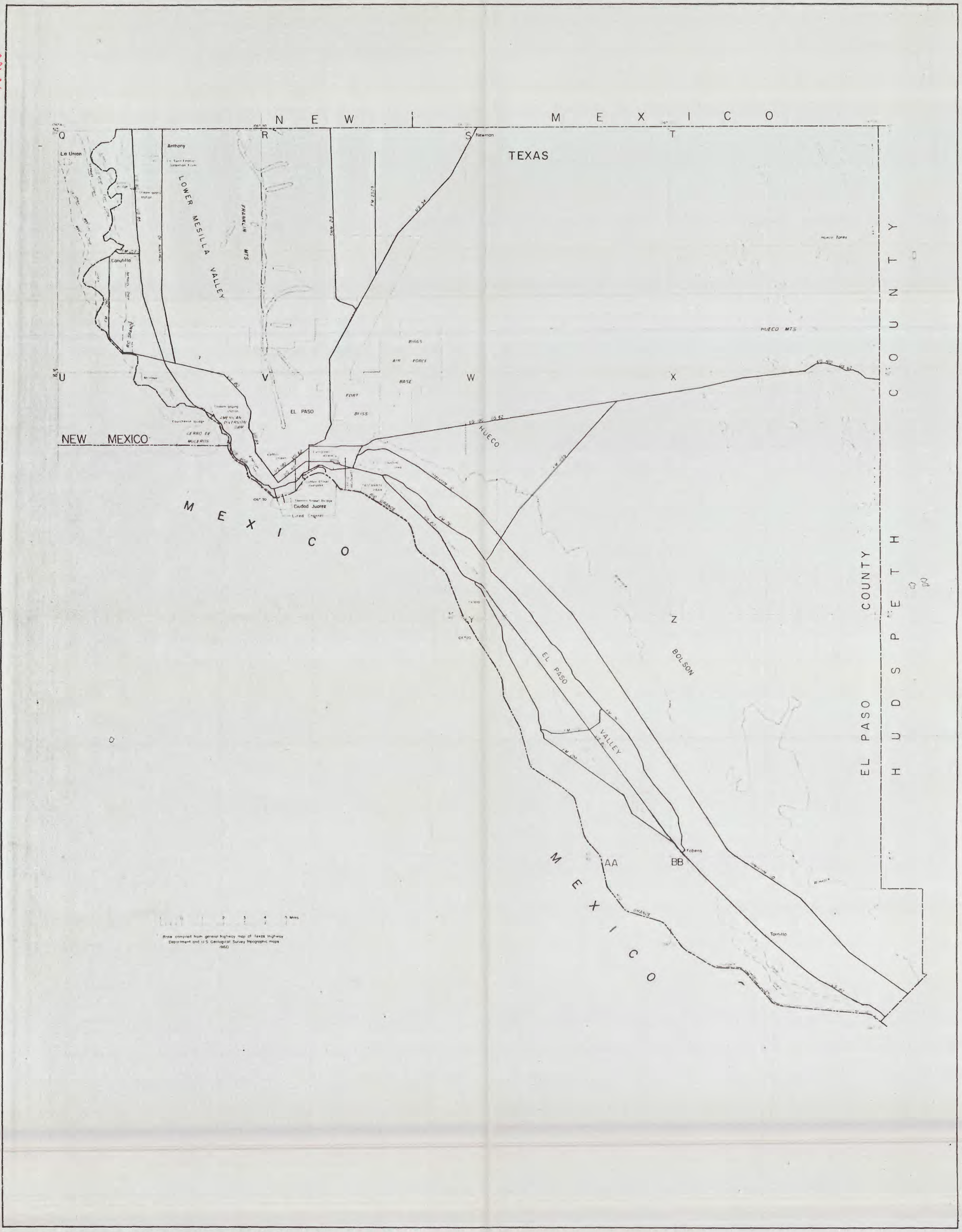

FIGURE 1. - Location map of the El Paso area

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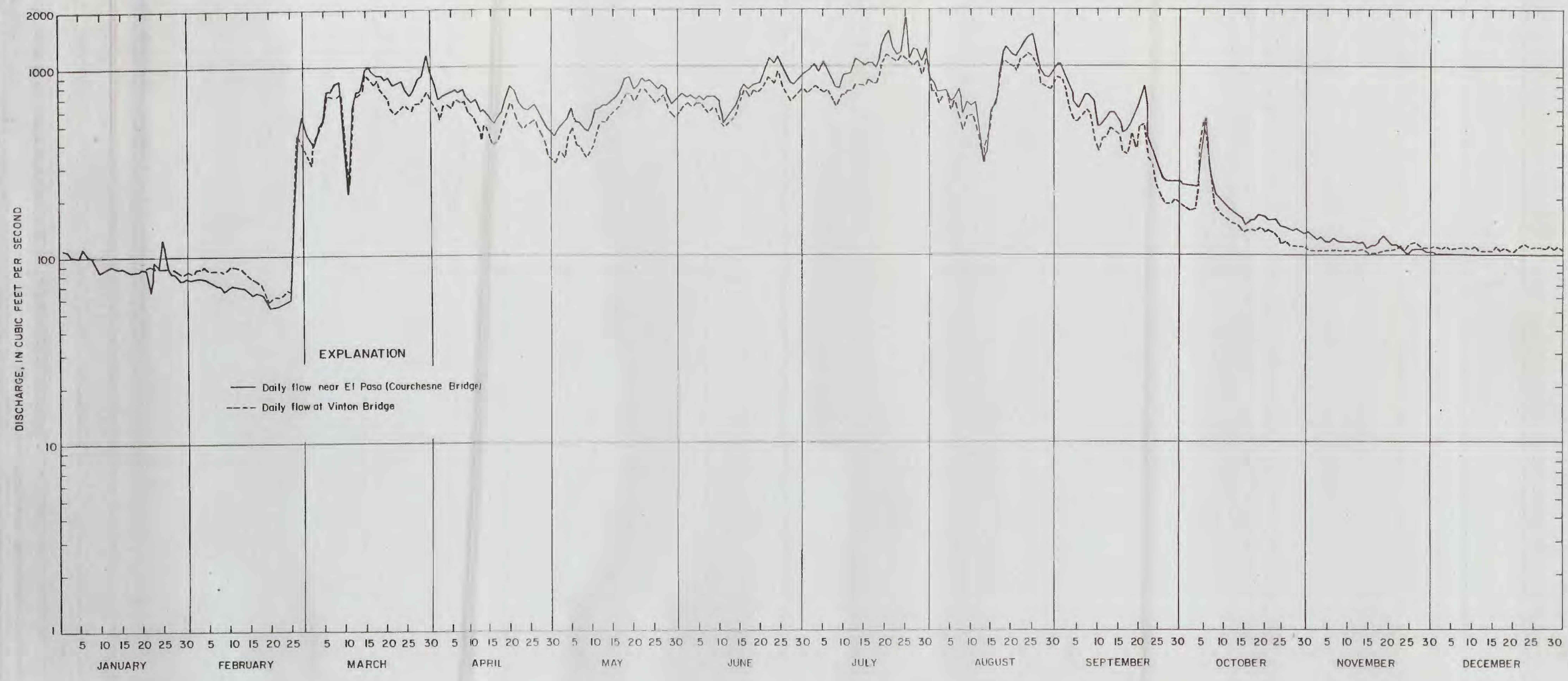

FIGURE 2. - Hydrographs for the Rio Grande near El Paso and at Vinton Bridge near Anthony, 1970

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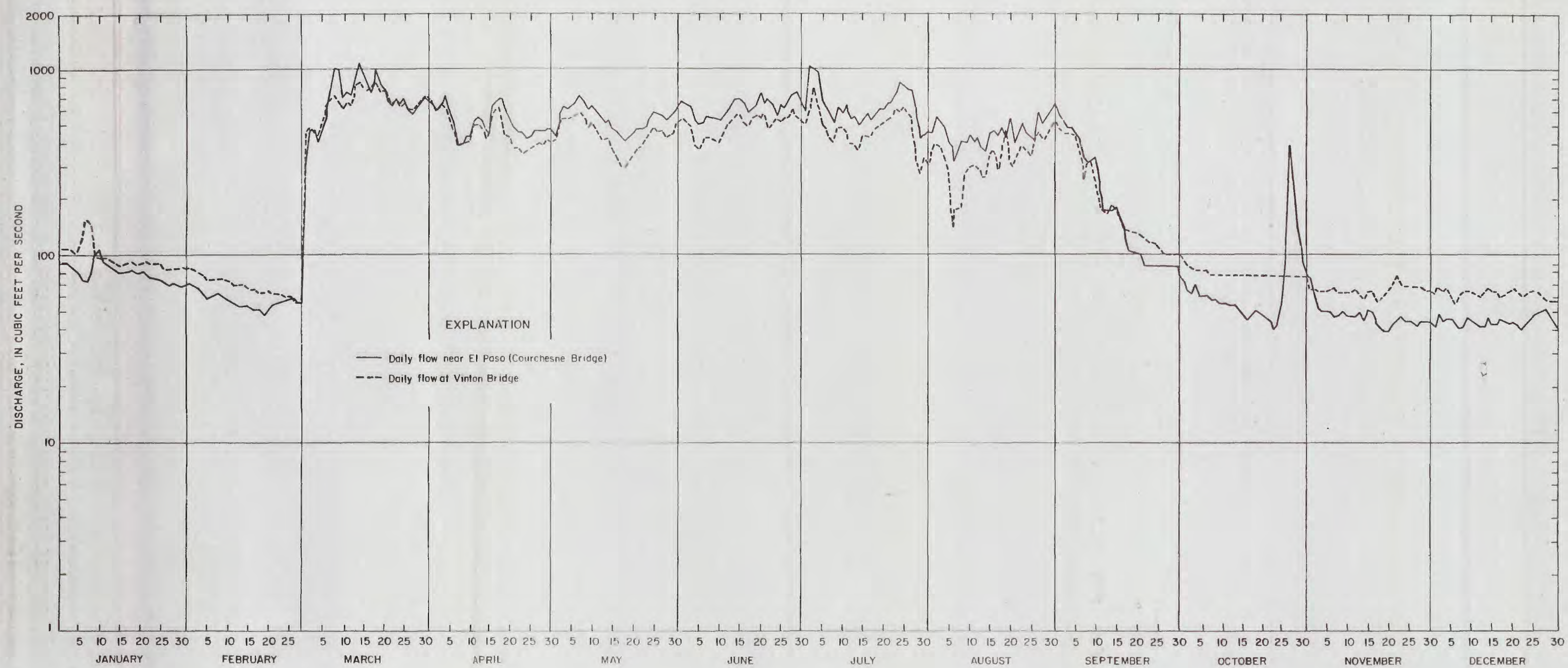

FIGURE 3. - Hydrographs for the Rio Grande near El Paso and at Vinton Bridge near Anthony, 1971