MEASUREMENT OF STREAMFLOW GAINS AND LOSSES ON MISSION CREEK AT SANTA BARBARA, CALIFORNIA, JULY AND SEPTEMBER 1987

By Michael C. McFadden, Keith G. Polinoski, *and* Peter Martin

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CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
acre	0.004047	square kilometer
acre-foot (acre-ft)	1,233	cubic meter
acre-foot per day (acre-ft/d)	1,233	cubic meter per day
acre-foot per day per mile [(acre-ft/d)/mi]	766	cubic meter per day per kilometer
foot (ft)	0.3048	meter
foot per day (ft/d)	0.3048	meter per day
foot per mile (ft/mi)	0.1894	meter per kilometer
cubic foot per second (ft^3/s)	0.3048	cubic meter per second
inch (in.)	25.4	millimeter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

Vertical Datum

In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

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ABSTRACT

Streamflow was measured between successive measuring stations on Mission Creek at Santa Barbara, California, to determine streamflow gains and losses along the stream channel. Water was released from Gibraltar Reservoir into Mission Creek channel at a nearly constant rate during two separate periods when otherwise there would have been virtually no flow in the channel: July 25-31, 1987, and September 18-25, 1987. After streamflow had stabilized, streamflow measurements were made at as many as 10 stations downstream of the release point. All losses in streamflow between successive measurement stations were considered to be the result of seepage.

Results of the study indicate that measurable losses in streamflow were not substantial until the streamflow had crossed the Mission Ridge fault, upstream of Rocky Nook Park (site 4), about 2.2 miles downstream of the release point (site 1). The total seepage loss between the station at Rocky Nook Park (site 4) and the station near Mission Street (site 7) averaged 3.52 acre-feet per day for both releases. The greatest seepage losses during both releases (3.61 and 4.15 acre-feet per day) were measured in the 0.99-mile section of the channel between the measurement station at Alamar Avenue (site 6) and the station near Mission Street (site 7).

No substantial seepage losses occurred downstream of the station near Mission Street (site 7) except along a short unlined section of the channel between Mission Street and Arrellaga Street (site 8). The total losses in streamflow measured between the station near Mission Street (site 7) and the station at Gutierrez Street (site 10) during both releases (0.88 and 0.46 acre-feet per day) were substantially less than that measured by the U.S. Geological Survey in 1979 (1.93 acre-feet per day). A probable explanation for the difference is that in 1987 the water table in the shallow zone was close to or above the bottom of the channel in its lower reach; whereas, in 1979 the water table in the shallow zone was considerably below the bottom of the channel in response to 14 months of continuous municipal pumping in the basin. Results of the 1979 study indicate that streamflow losses are substantial in the unlined section of the channel between Canon Perdido Street (site 9) and Gutierrez Street (site 10) when the water table in the shallow zone is considerably below the channel bottom. However, historical water-level data indicate that the water table usually is close to or above the channel bottom, which would preclude substantial streamflow losses downstream of Canon Perdido Street (site 9) during years of normal or above normal precipitation. In addition, it usually is during the summer--when there is no natural streamflow in this reach of the channel--that the water table in the shallow zone occasionally drops below the bottom of the channel.

INTRODUCTION

The U.S. Army Corps of Engineers has proposed a project in the city of Santa Barbara, California, to extend the concrete lining of the lower part of Mission Creek to reduce the potential for property damage due to floods along the channel. There is concern by local residents, however, that the lining could reduce the amount of streamflow that seeps to and recharges the underlying ground-water basin. Ground water is an important supplemental source of water to the city of Santa Barbara because of increased water demands caused by population growth coupled with decreased capacity of surface reservoir supplies due to siltation.

Purpose and Scope

This report describes the results of a study to determine the quantity of streamflow gains and losses between measuring stations on Mission Creek. The purpose of the study was to improve the understanding of streamflow gains and losses along the stream channel and, thus, to help determine which sections of the channel provide the greatest potential for recharging the ground-water basin.

To determine streamflow gains and losses accurately along the Mission Creek channel, water was released from Gibraltar Reservoir into the Mission Creek channel at a nearly constant rate during two separate periods when otherwise there would have been virtually no flow in the channel: July 25-31, 1987, and September 18-25, 1987. Streamflow was monitored continuously during both releases at two U.S. Geological Survey gaging stations (sites 4 and 7) downstream of the release point (site 1) (fig. 1). After streamflow had stabilized at sites 4 and 7, streamflow measurements were made at 10 stations downstream of site 1 (fig. 1). All losses in streamflow between successive measurement stations were assumed to be the result of seepage because potential evapotranspiration in the Santa Barbara area is small (less than 0.01 ft/d (Todd, 1978, p. 37)) in comparison with the measured streamflow losses. The distances along the channel between the streamflow-measurement stations were determined so that the rate of streamflow loss could be calculated for particular reaches of the channel. Water-level measurements from wells along the stream channel were used to help determine ground-water/surface-water interaction.

Location and General Features of Mission Creek

Mission Creek flows from its headwaters in the Santa Ynez Mountains through the city of Santa Barbara in a roughly crescent-shaped course before discharging into the Pacific Ocean (fig. 1). The stream channel is about 8 mi long and crosses both the Foothill and Santa Barbara ground-water basins. Hydrologically, the two ground-water basins are divided into three storage units by the Mesa and Mission Ridge faults (Martin, 1984, p. 2). Natural flow in the channel is intermittent; during much of the year, there is little or no flow, especially in the lower reaches between sites 3 and 9. During periods when there is little or no pumping of ground water from Storage Unit I of the Santa Barbara ground-water basin, ground water discharges from the ground-water basin into Mission Creek downstream of site 9. Between site 2 and site 9, the water table historically has been significantly beneath the channel bottom.

The upper half of the Mission Creek channel has a steep gradient (more than 850 ft/mi) and the streambed consists of boulders. In the lower half of the creek, the gradient decreases to less than 75 ft/mi, and the streambed consists of small cobbles, gravel, sand, and silt.

As of 1988, the stream channel is lined with concrete in two sections: along a 0.25-mile reach downstream from site 7 and the 0.75-mile reach between site 8 and site 9 (fig. 1). The U.S. Army Corps of Engineers has proposed that the concrete lining be extended from site 9 downstream to site 10 (fig. 1), a distance of 0.56 mile.

The Foothill and Santa Barbara ground-water basins consist of unconsolidated deposits of sand, silt, and clay with occasional gravel layers. Consolidated sedimentary rocks of Tertiary age underlie the ground-water basin and compose the surrounding hills. In Storage Unit I, the unconsolidated deposits range in thickness from less than 200 feet just south of the Mission fault (near site 3) to more than 1,000 feet at the Pacific Ocean (near site 11) (fig. 2). In the Foothill ground-water basin (Storage Unit II) the unconsolidated deposits are as much as 700 feet thick on the north side of the Mission Ridge fault, becoming progressively thinner northward.

On the basis of data from electric and geologic logs of selected wells, Martin (1984, p. 5) subdivided the unconsolidated deposits into five main zones: (1) the shallow zone; (2) the upper producing zone, (3) the middle zone, (4) the lower producing zone, and (5) the deep zone (fig. 2). The shallow zone underlies the Mission Creek channel in its lower reaches. Water-bearing deposits are present in the shallow zone; however, this zone consists primarily of fine-grained deposits of low permeability (Martin, 1984, p. 5). The upper and lower producing zones are the two main water-bearing zones tapped by wells in the Santa Barbara area.

Previous Seepage Studies on Mission Creek

The results of two seepage studies on Mission Creek completed in the late 1970's have been published. The first study was completed on June 9, 1978, on natural streamflow in Mission Creek. The results of that study were presented in a consulting engineer report by Todd (1978). During the June 1978 study, streamflow at the Mission Street gaging station (site 7) averaged 1.31 acre-ft/d, about two-thirds the average streamflow measured at the station during the current study. The second study was done during an 8-day controlled release of reservoir water to Mission Creek in September 1979 (Martin, 1984). During the release, streamflow at the Mission Street station (site 7) averaged 4.17 acre-ft/d, almost double the average streamflow measured at site 7 during the current study. In both previous studies, all losses in streamflow were considered to be the result of seepage.

During the June 1978 and September 1979 studies no seepage losses were reported until the streamflow had crossed over Mission Ridge fault near Rocky Nook Park (site 4) (fig. 1). The greatest rates of seepage loss (see Todd, 1978, p. 38; Martin, 1984, p. 6) were measured in the 0.85-mile reach between Rocky Nook Park and Alamar Avenue (about 200 ft downstream of site 6) (1.05 acre-ft/d during June 1978 and 1.75 acre-ft/d during September 1979) and in the 0.95-mile reach between Alamar Avenue and the station near Mission Street (site 7) (1.51 acre-ft/d during June 1978 and 1.46 acre-ft/d during September 1979).

No streamflow measurements were made downstream of the station near Mission Street (site 7) during the June 1978 study, and measurements were made during the September 1979 study at only one station, near Gutierrez Street (site 10). During the September 1979 study, seepage-loss rates averaged 1.93 acre-ft/d in the 1.87-mile reach between site 7 and site 10 (Martin 1984, p. 6). The reduction in seepage-loss rates downstream of site 7 in comparison with the rate for the reach of the stream channel between site 3 and site 7 was attributed to the concrete lining in

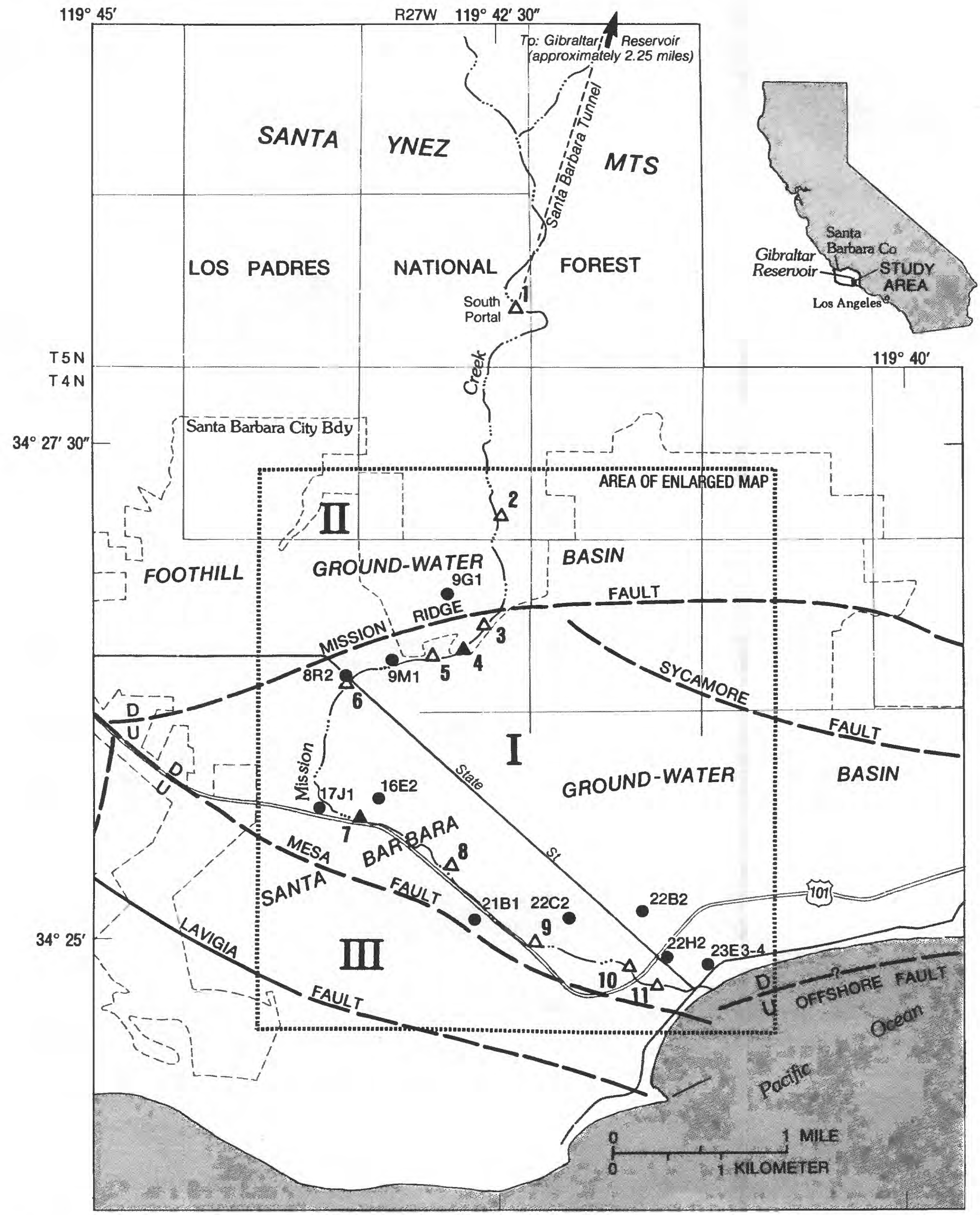


Figure 1. Location of Mission Creek streamflow-measuring stations, wells, and general features of the Santa Barbara ground-water basin.

EXPLANATION

D / U ——? FAULT -- Dashed where approximately located, queried where doubtful. U upthrown side; D downthrown side

□□□□□□□ CONCRETE-LINED SECTION OF MISSION CREEK

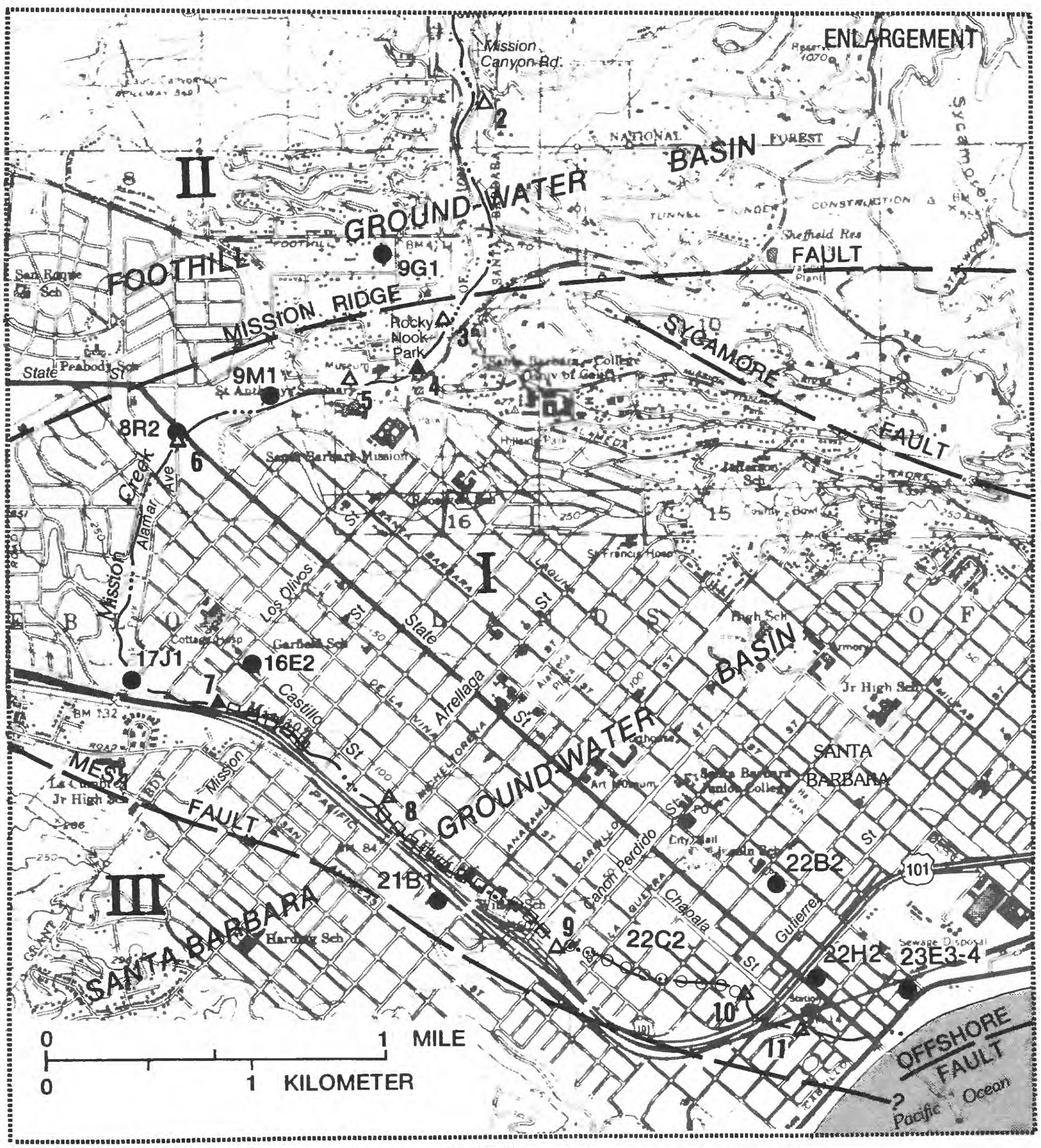
○○○○○○○ SECTION OF MISSION CREEK PROPOSED TO BE CONCRETE LINED

II GROUND-WATER STORAGE UNIT -- Faults control storage-unit boundaries

▲4 GAGING STATION -- Number assigned for this study

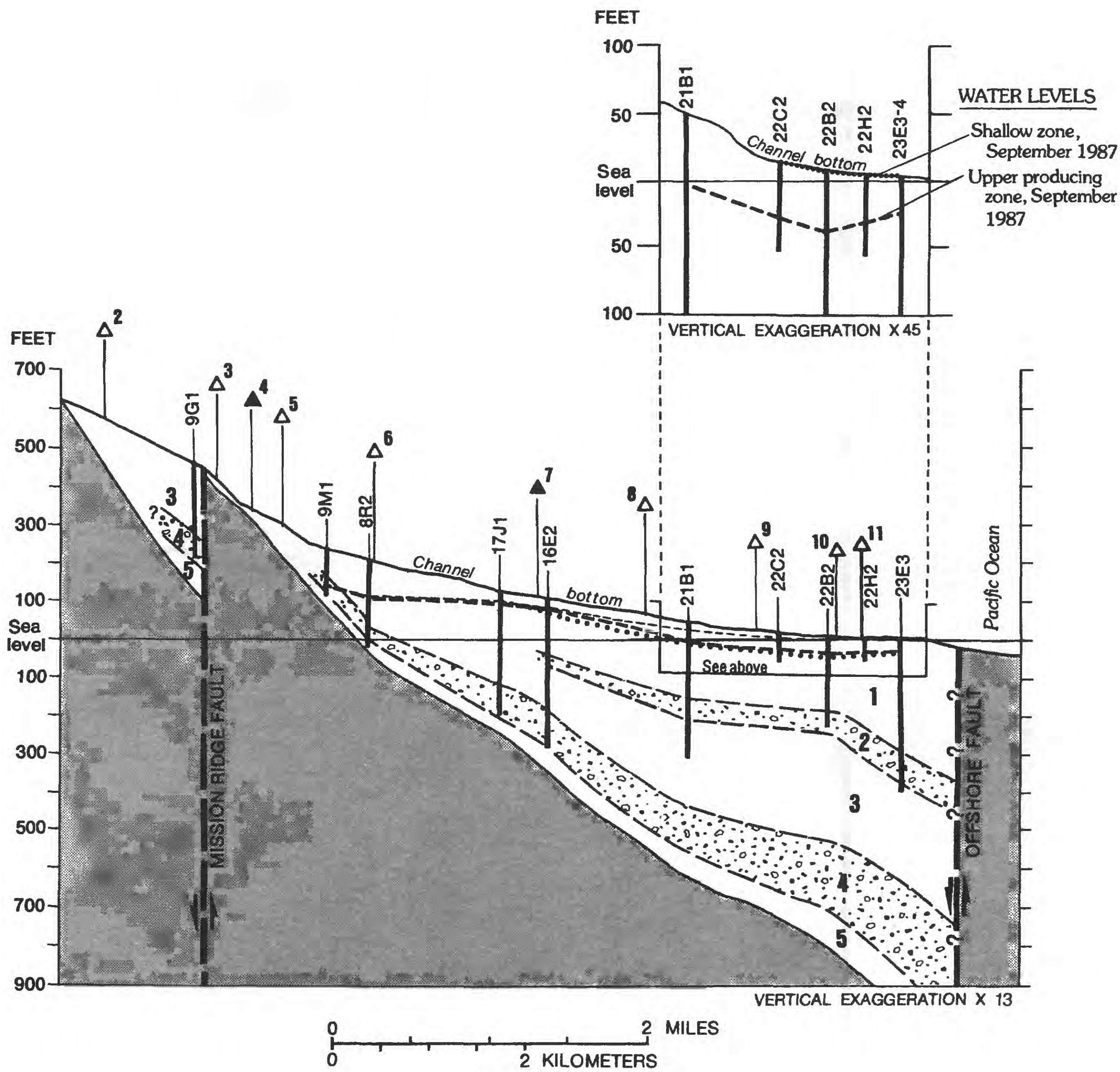
△3 TEMPORARY STREAMFLOW-MEASUREMENT STATION AND NUMBER

●22B2 WELL AND NUMBER -- Abbreviated number does not include township and range designations (see "Well-Numbering System")



Base from U.S. Geological Survey
Santa Barbara 1:24,000, 1967

R 27 W



EXPLANATION

Figure 2. Generalized geohydrologic section along Mission Creek showing ground-water levels in September 1979 and July and September 1987.

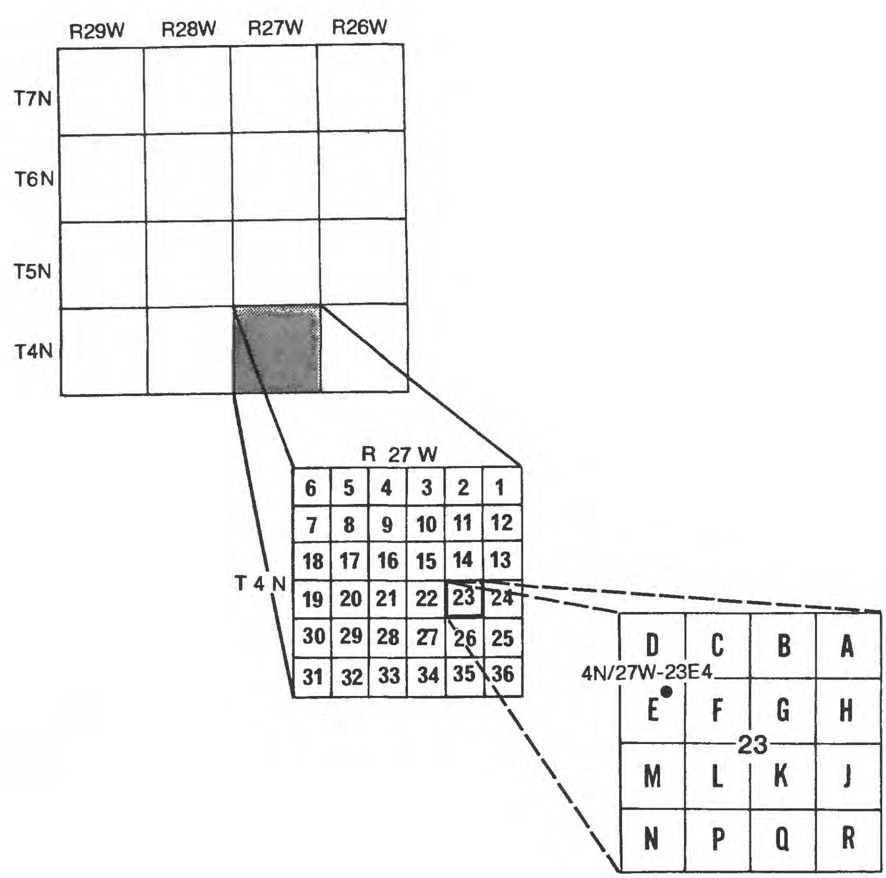
much of this reach (downstream of site 7) of the stream channel (Martin, 1984, p. 7). No attempt was made in either study to determine the seepage-loss rates in the unlined section of the channel between Canon Perdido Street (site 9) and Gutierrez Street (site 10) that the U.S. Army Corps of Engineers has proposed to line with concrete.

Acknowledgments

The cooperation and assistance of the city of Santa Barbara Public Works Department, Division of Water Resources, in regulating the controlled releases to Mission Creek are gratefully acknowledged.

Well-Numbering System

Wells are numbered according to their location in the rectangular system for subdivision of public land. For example, in the well number 4N/27W-23E4, the part of the number preceding the slash indicates the township (T. 4 N); the number following the slash indicates the range (R. 27 W.); the number following the hyphen indicates the section (sec. 23); and the letter following the section number indicates the 40-acre subdivision according to the lettered diagram below. The final digit is a serial number for wells in each 40-acre subdivision.



STREAMFLOW MEASUREMENTS DURING TWO CONTROLLED RELEASES TO MISSION CREEK

The city of Santa Barbara obtains water for municipal supply from Gibraltar Reservoir on the Santa Ynez River (fig. 1). The reservoir water is diverted to Santa Barbara through a tunnel in the Santa Ynez Mountains. For this study, reservoir water was released at the south portal of the tunnel (site 1) into Mission Creek during two separate periods: July 25-31, 1987, and September 18-25, 1987. Both releases started when the creek was dry along most of its length. The first release was made after an 8-month period of reduced pumping from Storage Unit I of the Santa Barbara ground-water basin. At that time, the storage unit was full, as indicated by flowing wells near the coast (for example, well 4N/27W-23E4, fig. 2). The second release was made after about 2 months of municipal pumping from Storage Unit I when water levels in the storage unit had declined in response to the pumping (fig. 2).

The quantity of flow released to Mission Creek at the south portal release (site 1) was computed by the city of Santa Barbara Public Works Department, Water Resources Division, using the following equation:

$$B_1 - B_2 = Q,$$

where

B_1 is the metered flow to municipal supply prior to the release to Mission Creek,

B_2 is the metered flow to municipal supply during the release to Mission Creek, and

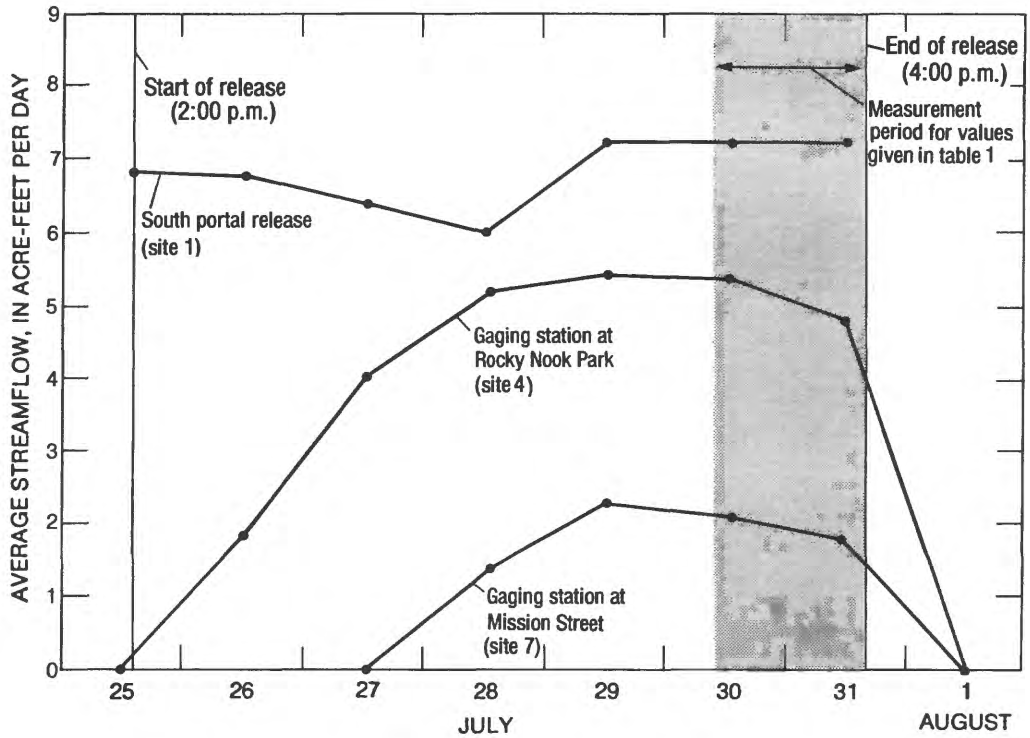
Q is the flow released to Mission Creek.

The above equation is valid if the flow released from Gibraltar Reservoir was constant prior to and during the release to Mission Creek. Data from a U.S. Geological Survey gaging station about 5 mi upstream from site 1 (Gibraltar Dam Division Weir, number 11121900--not shown in figures) indicate that the release from Gibraltar Reservoir was constant during both release periods. The daily average flow determined by the city of Santa Barbara during both release periods is shown in figure 3.

Downstream of the south portal release (site 1), two existing gaging stations [11119745 and 11119750] (sites 4 and 7, respectively) and as many as eight temporary streamflow-measurement stations (sites 2, 3, 5, 6, 8, 9, 10, and 11) were used to measure streamflow during the study (fig. 1). Streamflow was monitored continuously at the gaging stations to determine when streamflow had stabilized. After the initial release, it took about 3 days for flow to stabilize at the station at Rocky Nook Park (site 4) and about 4 days at the station near Mission Street (site 7). (See fig. 3.)

Once streamflow had stabilized, streamflow measurements were made at the gaging stations and at the temporary streamflow-measurement stations to determine streamflow gains and losses along the stream channel. During the first release (July 25-31, 1987), streamflow measurements were made at seven sites downstream of the south portal release on July 30 and 31 (table 1). No measurements were made between the south portal release (site 1) and the station at Rocky Nook Park (site 4) during the first release. During the second release (September 18-25, 1987), streamflow measurements were made at 10 sites downstream of the south portal release on September 24 and 25 (table 2). Two of the additional sites (sites 2 and 3) were between the south portal release (site 1) and the station at Rocky Nook Park (site 4), and the third additional site (site 5) was one-quarter mile south of the station at Rocky Nook Park (table 2, fig. 1).

Streamflow measurements were made at all sites with a standard pygmy meter mounted to



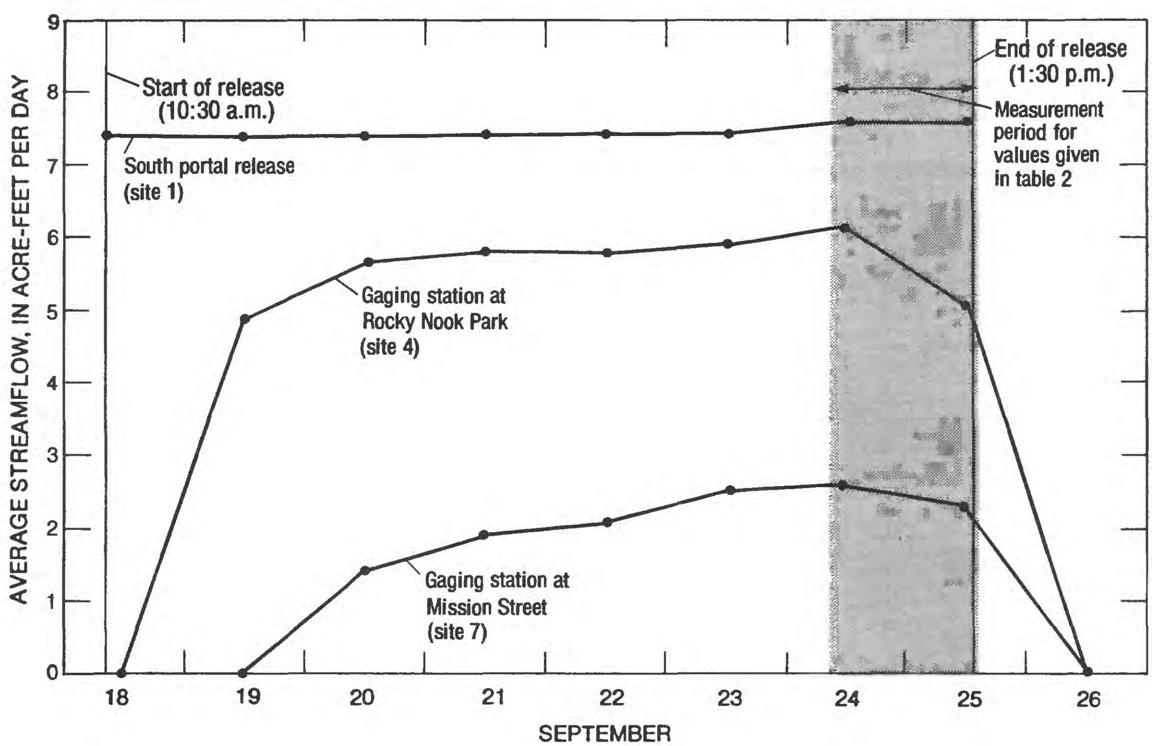


Figure 3. Streamflow hydrographs showing daily average streamflow during two controlled releases to Mission Creek, July and September 1987.

Table 1. *Streamflow measurements during controlled release to Mission Creek, July 25-31, 1987*

[Station locations are shown in figure 1. Streamflow: values are instantaneous measurements and will not necessarily match values given in figure 3, which are daily average values. Measurement rating: excellent (less than 5 percent error); good (5 percent); fair (8 percent); and poor (more than 8 percent). Average streamflow: cubic feet per second (ft^3/s) times 1.9835 equals acre-feet per day (acre-ft/d). Flow distance between stations from U.S. Army Corps of Engineers, 1975, and Martin, 1984. ft^3/s, cubic feet per second; acre-ft/d, acre-feet per day; (acre-ft/d)/mi, acre-feet per day per mile; --, no data]

Station		Date	Time	Stream-flow (ft^3/s)	Measure-ment rating	Average streamflow		Gain (+) or loss (-) of streamflow between stations (acre-ft/d)	Flow distance between stations (mi)	Rate of gain (+) or loss (-) of streamflow between stations ((acre-ft/d)/mi)
Site No.	Location					(ft^3/s)	(acre-ft/d)			
1	South portal release (to Mission Creek)	7/30-31/87	--	[1]3.65	--	3.65	7.24	--	--	--
4	Gaging station at Rocky Nook Park	7/30/87	1625	2.57	Good	2.62	5.20	-2.04	2.46	-0.83
			1805	2.53	do.					
		7/31/87	1410	2.62	do.					
			1445	2.77	do.					
6	Alamar Avenue	7/30/87	1455	2.86	Fair	2.84	5.63	+0.43	0.81	+0.53
			1530	2.58	Good					
		7/31/87	1205	3.07	do.					
			1240	2.85	do.					
7	Gaging station near Mission Street	7/30/87	1400	1.17	Fair	1.02	2.02	-3.61	0.99	-3.65
			1425	.91	do.					
		7/31/87	1015	1.05	do.					
			1100	.95	do.					
8	Arrellaga Street	7/30/87	1130	0.64	Fair	0.68	1.34	-0.68	0.61	-1.11
			1300	.89	do.					
		7/31/87	1015	.56	do.					
			1115	.62	do.					
9	Canon Perdido Street	7/30/87	1105	0.71	Fair	0.62	1.23	-0.11	0.70	-0.16
			1250	.77	do.					
		7/31/87	0825	.52	--					
			0905	.49	do.					
10	Gutierrez Street	7/30/87	0925	0.56	Fair	0.58	1.14	-0.09	0.56	-0.16
			0940	.60	do.					
		7/31/87	0825	.62	do.					
			0910	.52	do.					
11	Chapala Street	7/31/87	1315	0.51	Poor	0.55	1.09	-0.05	0.25	-0.20
			1355	.59	Fair					

[1]Average during measuring period--determined by city of Santa Barbara Public Works Department, Water Resources Division.

Table 2. *Streamflow measurements during controlled release to Mission Creek, September 18-25, 1987*

[Station locations are shown in figure 1. Streamflow: values are instantaneous measurements and will not necessarily match values given in figure 3, which are daily average values. Measurement rating: excellent (less than 5 percent error); good (5 percent); fair (8 percent); and poor (more than 8 percent). Average streamflow: cubic feet per second (ft^3/s) times 1.9835 equals acre-feet per day (acre-ft/d). Flow distance between stations from U.S. Army Corps of Engineers, 1975, and Martin, 1984. ft^3/s, cubic feet per second; acre-ft/d, acre-feet per day; (acre-ft/d)/mi, acre-feet per day per mile; --, no data]

Station		Date	Time	Stream-flow (ft^3/s)	Measure-ment rating	Average streamflow		Gain (+) or loss (-) of streamflow between stations (acre-ft/d)	Flow distance between stations (mi)	Rate of gain (+) or loss (-) of streamflow between stations ((acre-ft/d)/mi)
Site No.	Location					(ft^3/s)	(acre-ft/d)			
1	South portal release (to Mission Creek)	9/24-25/87	--	[1]3.84	--	3.84	7.62	--	--	--
2	Mission Canyon Road	9/24/87	0850	3.41	Fair	3.41	6.76	-0.86	1.61	-0.53
3	One-eighth mi downstream from Mission Ridge fault	9/25/87	1350 1410	3.77 4.19	Poor Fair	3.98	7.89	+1.13	0.66	+1.71
4	Gaging station at Rocky Nook Park	9/24/87 9/25/87	0950 1245	3.14 3.31	Good do.	3.24	6.43	-1.46	0.25	-5.96
5	One-fourth mi downstream from Rocky Nook Park	9/24/87 9/25/87	1230 1350	2.87 2.91	Fair do.	2.89	5.73	-0.70	0.25	-3.28
6	Alamar Avenue	9/24/87 9/25/87	1105 1155	3.32 3.47	do. do.	3.40	6.73	+1.00	0.56	+1.78
7	Gaging station near Mission Street	9/24/87 9/25/87	1255 1400 1030	1.25 1.31 1.34	do Good Fair	1.30	2.58	-4.15	0.99	-4.19
8	Arrellaga Street	9/24/87 9/25/87	1450 0950 1110	0.85 .88 1.07	do. Good Fair	0.93	1.84	-0.74	0.61	-1.21
9	Canon Perdido Street	9/24/87 9/25/87	1500 1540 0835 0905	1.01 .87 1.23 1.08	do. do. do. do.	1.05	2.08	+0.24	0.70	+0.34
10	Gutierrez Street	9/24/87 9/25/87	1405 1555 0820 0920	1.07 1.00 1.13 1.08	Good do. do. do.	1.07	2.12	+0.04	0.56	+0.07
11	Chapala Street	9/25/87	1005	1.08	Poor	1.08	2.14	+0.02	0.25	+0.08

[1]Average during measuring period--determined by city of Santa Barbara Public Works Department, Water Resources Division.

a top-setting wading rod according to standard methods described by Rantz and others (1982, p. 143-146). Despite efforts to modify the channel to improve measurement conditions, at some stations the flow depth was less than the recommended limit of 0.3 ft for a standard pygmy meter. For those stations, the flood-drift method (Rantz and others, 1982, p. 261-262) or the weir-stick method (U.S. Bureau of Reclamation, 1967, p. 177) was used to verify the measurements obtained using the standard pygmy meter. The various measurement techniques gave comparable results.

SEEPAGE CHARACTERISTICS OF THE MISSION CREEK CHANNEL

Streamflow measurements, average gain or loss between streamflow stations, flow distance between stations, and rate of gain or loss of streamflow between stations are given in tables 1 and 2 for both controlled-release periods.

During the first release (July 25-31, 1987), a seepage loss of 2.04 acre-ft/d occurred between the south portal release (site 1) and the gaging station at Rocky Nook Park (site 4) (table 1). Previous seepage studies on Mission Creek (Todd, 1978, p. 37, and Martin, 1984, p. 6) showed small gains in streamflow in this reach of the channel. During the second release (September 18-25, 1987), additional streamflow measurements were made upstream of the station at Rocky Nook Park (site 4). These measurements indicate that there was a slight loss in streamflow between the south portal release (site 1) and Mission Canyon Road (site 2), a gain in streamflow between Mission Canyon Road and the station near Mission Ridge fault (site 3), and then a loss in streamflow between Mission Ridge fault and the station at Rocky Nook Park (site 4) (table 2). Therefore, measurements made during the second release indicate that losses in streamflow were not substantial until the streamflow had crossed the Mission Ridge fault--as reported in previous seepage studies (Todd, 1978, p. 37; Martin, 1984, p. 6).

As shown in figure 2, the ground-water table in the shallow zone is significantly below the channel bottom between Mission Canyon Road (site 2) and Mission Ridge fault (site 3). The gain in streamflow between site 2 and site 3 probably is the result of surface runoff from lawn watering. Upstream of the Mission Ridge fault, consolidated rock and relatively impermeable clay layers beneath the stream channel preclude significant seepage losses (Martin, 1984, p. 7). The higher seepage-loss rate downstream of site 3 may be the result of significantly less clay in the shallow unconsolidated deposits downstream of the Mission Ridge fault in comparison with the shallow deposits on the north side of the fault. The clay layers that are present on the north side of the fault may have been removed by erosion south of the fault because of the upward displacement of the deposits (fig. 2) on the south side of the fault (Martin, 1984, p. 7).

During both releases, measurements indicated gains in streamflow between the gaging station at Rocky Nook Park (site 4) and the station at Alamar Avenue (site 6) (tables 1 and 2). This gain in streamflow is contrary to the results reported by Todd (1978, p. 38) and Martin (1984, p. 6), which indicated substantial seepage loss (1.05 and 1.75 acre-ft/d, respectively) in this reach of the stream. (In the previous studies measurements were made about 200 feet downstream of site 6.) During the second release, streamflow measurements were made at site 5, one-quarter mile downstream of the station at Rocky Nook Park. These measurements indicated a 0.70 acre-ft/d loss in streamflow between the station at site 4 and the station one-quarter mile downstream at site 5 and a 1.00 acre-ft/d gain in streamflow between site 5 and the station at Alamar Avenue (site 6). The gain in streamflow is surprising because no sources of surface inflow were noted and the ground-water table in the shallow zone is considerably below the channel bottom in this reach of the stream (fig. 2). Additional data need to be collected in this reach of the stream to understand fully the seepage characteristics of the channel.

The greatest loss in streamflow during both releases was measured between the station at Alamar Avenue (site 6) and the station near Mission Street (site 7) (tables 1 and 2). The measured loss in streamflow was 3.61 acre-ft/d for the first release and 4.15 acre-ft/d for the second release. These losses are more than double the losses reported by Todd (1978, p. 38) and Martin (1984, p. 6) for approximately the same reach of the stream. Although the streamflow losses measured in 1987 between the station at Rocky Nook Park (site 4) and the station at Alamar Avenue (site 6) and between the station at Alamar Avenue and the station near Mission Street (site 7) are different from those of previous studies, the total losses measured between the stations at Rocky Nook Park (site 4) and Mission Street (site 7) are about the same. The average total loss during both releases in 1987 was 3.52 acre-ft/d (tables 1 and 2), in comparison with losses of 2.56 acre-ft/d in the June 1978 study (Todd, 1978, p. 37) and 3.21 acre-ft/d in the September 1979 study (Martin, 1984, p. 6).

Downstream of the station near Mission Street (site 7), the only reach of the stream that had substantial seepage loss was the 0.42-mile unlined section of the channel between Mission Street (0.19 mi downstream of site 7) and the station at Arrellaga Street (site 8) (fig. 1). Streamflow losses in this reach of the stream were 0.68 acre-ft/d during the first release and 0.74 acre-ft/d during the second release. The average rate of streamflow loss over this 0.42-mile unlined section of the channel during both releases was 1.69 (acre-ft/d)/mi. Downstream of Arrellaga Street (site 8) there was little if any seepage loss during either release. During the first release a slight loss of 0.25 acre-ft/d was measured between Arrellaga Street (site 8) and the station at Chapala Street (site 11); however, during the second release a gain in streamflow of 0.30 acre-ft/d was measured in this same reach. Because ground-water levels were lower during the second release than the first, the apparent gain in streamflow during the second release could be the result of runoff from lawn watering or measurement error.

The net streamflow loss between the station near Mission Street (site 7) and the station at Gutierrez Street (site 10) was 0.88 acre-ft/d during the first release and 0.46 acre-ft/d during the second release. These losses are substantially less than the loss of 1.93 acre-ft/d reported by Martin (1984, p. 6) for the same reach of the stream channel. The measurements reported by Martin (1984, p. 6) were made in September 1979 after almost 14 months of continuous municipal pumping in Storage Unit I. The greater seepage loss downstream of the station near Mission Street in 1979 may be the result of this extended pumping, which lowered the water table in the shallow zone beneath the channel (fig. 4). During the 1987 releases the water table in the shallow zone was close to the bottom of the channel downstream of site 9, even after 2 months of municipal pumping (figs. 2 and 4).

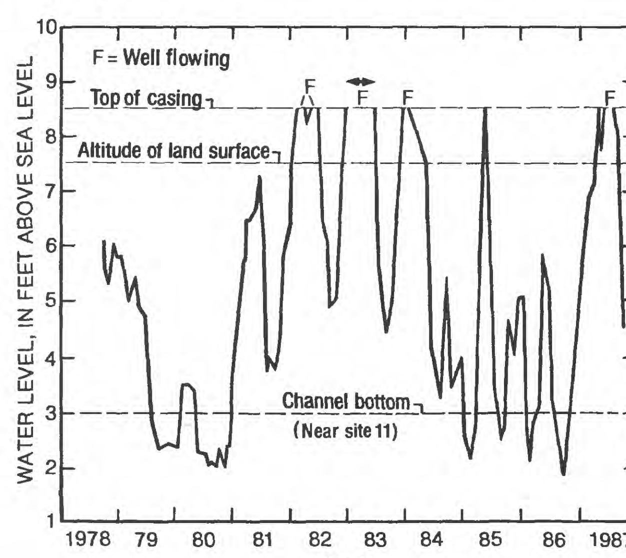


Figure 4. Water-level hydrograph of shallow-zone well 4N/27W-23E4, October 1978 to September 1987.

Streamflow data from the 1979 study (Martin, 1984, p. 6) and from the current study can be combined to estimate the potential streamflow loss in the unlined section of the channel between Canon Perdido Street (site 9) and Gutierrez Street (site 10) when the water table in the shallow zone is significantly below the channel bottom, as it was in 1979 (fig. 4).

In 1979 and during both releases in 1987 the water table was considerably below the channel bottom in the reach between the station near Mission Street (site 7) and Arrellaga Street (site 8) (fig. 2). Consequently, the streamflow losses in this reach during 1979 probably were similar to the average streamflow loss measured in 1987 (0.70 acre-ft/d). Subtracting this quantity from the 1.93 acre-ft/d loss measured in 1979 for the entire reach between the station near Mission Street (site 7) and Gutierrez Street (site 10) gives 1.23 acre-ft/d. If streamflow losses in the 0.70-mile concrete-lined reach between Arrellaga Street (site 8) and Canon Perdido Street (site 9) are considered negligible, then the potential streamflow loss in the 0.56-mile unlined reach between Canon Perdido Street (site 9) and Gutierrez Street (site 10) is 1.23 acre-ft/d. This estimate of potential streamflow loss probably is high because losses in the lined section are ignored. In any case, the potential streamflow losses between Canon Perdido Street (site 9) and Gutierrez Street (site 10) are substantial. However, the water table in the shallow zone downstream of Canon Perdido Street historically has been close to or above the bottom of the channel (fig. 4), which would preclude substantial streamflow loss in this reach of the channel. In addition, it usually is during the summer--when there is no natural streamflow in this reach of the channel--that the water table occasionally drops below the bottom of the channel (fig. 4).

SUMMARY AND CONCLUSIONS

Streamflow was measured between successive measurement stations on Mission Creek during two controlled releases (July 25-31, 1987, and September 18-25, 1987) of water from Gibraltar Reservoir to Mission Creek to determine streamflow gains and losses along the stream channel. At the south portal release (site 1) streamflow averaged 7.24 acre-ft/d during the first release and 7.62 acre-ft/d during the second release. The measurements indicate that there were no substantial seepage losses until the streamflow had crossed the Mission Ridge fault (site 3) about one-quarter mile upstream from Rocky Nook Park. An unexplained gain in streamflow was measured between the station at Rocky Nook Park (site 4) and the station at Alamar Avenue (site 6). The greatest seepage losses (3.61 and 4.15 acre-ft/d) during both releases were measured between the station at Alamar Avenue (site 6) and the station near Mission Street (site 7). The average net loss in streamflow between the station at Rocky Nook Park and the station near Mission Street for the two release periods was 3.52 acre-ft/d, about the same as the losses reported in earlier investigations.

No substantial streamflow losses occurred downstream of the station near Mission Street (site 7), except for an average 0.70 acre-ft/d loss in the 0.42-mile unlined section of the channel between Mission Street (0.19 mi downstream of site 7) and Arrellaga Street (site 8). Downstream of Arrellaga Street to Canon Perdido Street (site 9), the channel is lined with concrete. As expected, streamflow losses were negligible in this reach of the channel. During both releases, streamflow losses also were negligible in the unlined section between Canon Perdido and Gutierrez Street (site 10) that the

U.S. Army Corps of Engineers has proposed to line with concrete.

The net loss in streamflow measured between the station near Mission Street (site 7) and the station at Gutierrez Street (site 10) during this study was 0.88 acre-ft/d during the first release and 0.46 acre-ft/d during the second release. These losses are substantially less than the loss of 1.93 acre-ft/d measured over this 1.87-mile reach by the U.S. Geological Survey in 1979. In 1979, and during both releases in 1987, the water table in the shallow zone was considerably below the channel bottom upstream of Canon Perdido Street (site 9). Streamflow loss between the station near Mission Street (site 7) and the station at Arrellaga Street (site 8) in 1979 probably was similar to the average loss of 0.70 acre-ft/d measured during 1987 because the water table in the shallow zone also was low in this reach in 1987.

If streamflow losses are considered negligible in the concrete-lined section between Arrellaga Street (site 8) and Canon Perdido (site 9), then the streamflow loss in the unlined section between Canon Perdido and Gutierrez Street (site 10) could have been as high as 1.23 acre-ft/d in 1979, in comparison with an average of 0.02 acre-ft/d during both releases in 1987. A probable explanation for the difference is that downstream of Canon Perdido Street the ground-water table in the shallow zone was close to or above the channel bottom during both releases in 1987; whereas, in 1979 the water table in the shallow zone was considerably below the channel bottom in response to almost 14 months of continuous municipal pumping in the basin. On the basis of the 1979 study, streamflow losses in the unlined section of the channel between Canon Perdido Street and Gutierrez Street are substantial when the water table in the shallow zone is considerably below the channel bottom. However, historical water-level data for this part of the basin indicate that the water table in the shallow zone usually is close to or above the channel bottom, which would preclude substantial streamflow losses during years of normal or above normal precipitation. In addition, it usually is during the summer--when there is no natural streamflow in this reach of the channel--that the water table in the shallow zone occasionally drops below the bottom of the channel.

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