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STATE BOARD OF CONSERVATION

DIVISION OF GEOLOGY
Robert O. Vernon, Director

REPORT OF INVESTIGATIONS NO. 53

LOW STREAMFLOW IN THE MYAKKA RIVER BASIN AREA IN FLORIDA

By
H. N. Flippo, Jr. and B. F. Joyner
U. S. Geological Survey

Prepared by the
UNITED STATES GEOLOGICAL SURVEY
In cooperation with the
DIVISION OF GEOLOGY, FLORIDA BOARD OF CONSERVATION,
SARASOTA COUNTY
and the
CITY OF SARASOTA, FLORIDA

Tallahassee
1968

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STATE BOARD OF CONSERVATION

Division of Geology

Tallahassee

June 25, 1968

Honorable Claude R. Kirk, Jr., *Chairman*
State Board of Conservation
Tallahassee, Florida

Dear Governor Kirk:

The Division of Geology, Florida Board of Conservation, is publishing as Report of Investigations No. 53, a study of the "Low Streamflow in the Myakka River Basin Area in Florida." This report was prepared as a part of the cooperative program between the Division of Geology and the U. S. Geological Survey, by H. N. Flippo, Jr., and B. F. Joyner.

The Sarasota-Manatee area is a water-short area and the study was undertaken in 1963 in order to determine the storage capability and discharge rates of the Myakka water shed. It was found that many of the streams of the water shed were virtually dry during part of every year. However, the basins of the Myakka lakes, through which the river flows offer some storage potential, that if properly developed would provide a continuance drift of about seven million gallons of water per day of good quality water that would be high in color and temperature upon occasion. With reasonable treatment some of this water could be used to meet the present needs of the rapidly expanding coastal areas.

Respectfully yours,

Robert O. Vernon
Director and State Geologist

ROV:jkm

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CONTENTS

ILLUSTRATIONS

TABLES

LOW STREAMFLOW IN THE MYAKKA RIVER BASIN AREA IN FLORIDA

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ABSTRACT

Streamflow data, collected in the Myakka River basin area since 1936 and supplemented by means of a more complete network of stream-gaging stations since 1963, indicate that all non-tidal reaches of streams in the area ceased natural flows during at least five droughts since 1938. Many of these non-tidal reaches go virtually dry during the late spring of most years. Effective utilization of streamflow is restricted by these frequent droughts and a limited choice of practicable storage sites. Upper and Lower Myakka Lakes, through which the Myakka River flows, occupy two of the largest natural depressions in the area and have a total storage capacity of approximately 8,100 acre-feet. Average discharge at a stream-gaging station located between these lakes is 266 cfs (cubic feet per second), or about 192,000 acre-feet per year. Draft-storage studies indicate that these lakes will provide a continuous draft of at least 6.5 mgd (million gallons per day), provided their storage potential is adequately developed.

Surface waters that are derived from natural drainage are of good quality, except for occasional high color and temperatures of about 90°F. during the summer months. In many channels in low lying areas, low flows are often supplemented by waters of relatively high dissolved solids content derived from irrigation wells and domestic waste.

INTRODUCTION

A thorough knowledge of the occurrence, availability, and quality of the water resources of any area is prerequisite to the orderly development and utilization of that resource. This report is one of several resulting from an investigation to appraise the water resources of the Myakka River basin area and to define specific problems associated with obtaining adequate supplies of fresh water in the area. The investigation was conducted by the U.S. Geological Survey, in cooperation with Sarasota County, the City of Sarasota, and the Division of Geology, Florida Board of Conservation.

PURPOSE AND SCOPE

The purposes of this report are to describe briefly the climate, topography, drainage, and geology of the area, and to explain their influences on the low-flow characteristics of the streams; to point out and illustrate the similarities and differences among the major streams during periods of low flow; to present the hydrologic data and to interpret these data for use in considering the major streams in the area as future sources of fresh water. Data obtained at several stream-gaging stations located outside the area of investigation have been included and used for comparative purposes.

DESCRIPTION OF THE AREA

The area investigated includes all of Sarasota County, that part of Charlotte County located west of Charlotte Harbor, and that part of the Myakka River basin lying within Manatee and Hardee counties—an area of about 1,000 square miles, figure 1.

CLIMATE

The climate of the area is humid-subtropical; annual rainfall averages 54 inches, about the same as for the State. The driest part of the year is usually November through May. Heavy rains, generally associated with convective thunderstorms, occur during the summer months.

Mean annual lake evaporation is approximately 52 inches, with about 60 percent occurring from May to October (Kohler and others, 1959, pl. 2, 4). Evaporation and transpiration from shallow vegetation-filled lakes probably exceeds 60 inches per year. Overall evapotranspiration, excluding bays and estuaries, is estimated at 35 to 40 inches per year. Runoff, based on records for the three long-term stations, averages about 14 inches per year; however, average annual runoff from upland areas exceeds 18 inches based on records collected in the Manatee River basin.

TOPOGRAPHY AND DRAINAGE

Land surface altitudes in the area range from sea level to about 115 feet above sea level at the headwaters of the Myakka River. The topography is generally flat away from the streams, with a fairly sharp break from these flats into the stream channels. Except where deepened by man, the sloughs which serve as tributaries to the larger streams are seldom more than a few feet deep, but they

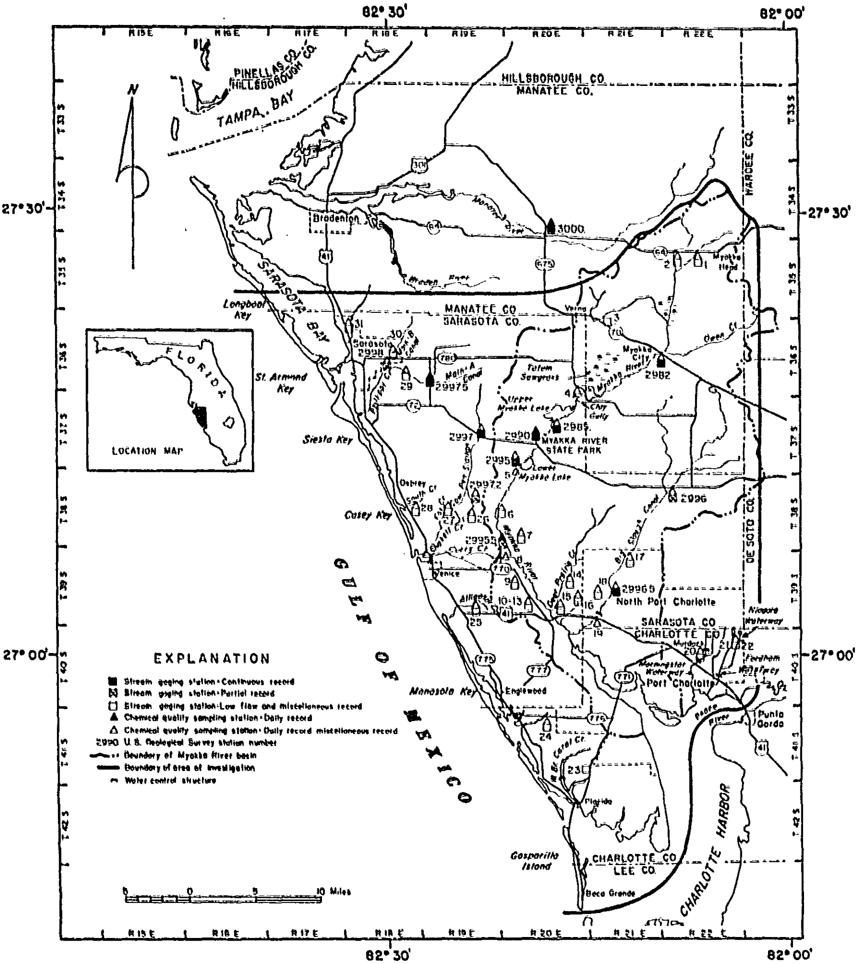

Figure 1. Myakka River basin area showing location of data-collection stations.

may range in width from several feet to more than a mile. Numerous wet-weather ponds dot the broad, flat landscape in the central part of the area, where the water table is usually within a few feet of the ground surface. Marsh and swamps each occupy about 5 percent of the upland lying above 40 feet in altitude. This upland is composed of the remnants of several Pleistocene marine terraces.

In a topographically low area, near the center of its basin, the Myakka River flows through Upper and Lower Myakka Lakes. Both lakes are entirely within the Myakka River State Park. The combined lake area is about 1,380 acres and depths are usually between 5 and 6 feet over most of this area; however, the levels of these lakes fluctuate widely with seasonal climatic changes. Both lakes are considerably larger than any of the other perennial lakes in the area.

In 1941, a low concrete dam was constructed at the outlet to the upper lake; an earthen dam had been installed several years earlier at the outlet to the lower lake. The purpose of these controls was to provide enough storage so that the lakes would not go completely dry during seasonal droughts. The concrete control maintained a minimum of 3 feet of water in the upper lake during the severe drought of 1943-45; the lower control was in a washed-out condition (as it is at the present time) and the lower lake dried up completely in 1945.

The Myakka River and a tributary, Big Slough Canal, are the two major streams whose basins lie entirely within the area of investigation. Phillippi Creek and Cow Pen Slough (Shakett Creek) are the largest coastal streams; both have been dredged for drainage purposes. About 20 other small coastal streams, such as Alligator, Fox, and South Creeks, arise within several miles of the coast and flow into bays and estuaries; each of these streams is tidal throughout much of its reach. The long, low keys which parallel the coast have no defined drainage channels.

GEOLOGY

The Hawthorn Formation of late Miocene age, consisting primarily of phosphatic sandstones, clays, and sandy limestones, underlies the entire area. Recent dredging in the lower reaches of Cow Pen Slough has exposed beds of stratified shell and clay that are similar to Hawthorn deposits which have been penetrated by wells in the general locality. These relatively impervious beds, which are now under study by interested parties, may represent the shallowest occurrences of the Hawthorn Formation in the area.

In the upper Myakka River valley, generally northeast of the 60-foot altitude contour, the clayey quartz and phosphatic sand of the Bone Valley Formation, of Pliocene age, overlie the Hawthorn Formation and are unconformably overlain by Pleistocene terrace deposits.

Exposures of the Caloosahatchee Marl composed of beds of sandy marl and dolomite of early Pleistocene age (Dubar, 1962, p. 8) occur in several creeks near Punta Gorda, in some canals in Port Charlotte, and in the Myakka River channel east of Venice. The Caloosahatchee Marl underlies thin surficial sands on the east side of the Myakka River, in the southeastern part of the area.

In general, the Pleistocene and Holocene deposits exert the greatest geologic influence on the low-flow characteristics of the streams. Driller's logs indicate that the higher marine terraces, such as in the vicinity of Myakka Head, are underlain by deposits of fine to coarse quartz sands, some pea gravel, and minor amounts of shell and clay. These deposits are believed to be relatively thin beneath the channels of deeply incised streams, but they may exceed 100 feet in thickness beneath the ridges. The soils on the ridges have been classified by the U.S. Department of Agriculture (Caldwell, 1958, p. 3) as "excessively to moderately well drained deep sandy soils." The predominant soil types in this upland area are somewhat poorly drained, because they are usually underlain by thin, but poorly permeable, dark-colored organic hardpans. Alluvial and organic materials (peat) that have been deposited within the Myakka River valley and its associated marshes have a texture and composition which produce poor drainage characteristics.

Late Pleistocene and Holocene deposits, which cover most of the Sarasota and Charlotte County parts of the area of investigation, are composed chiefly of quartz sand, shell, and marl. Soils which have developed on these materials are poorly to very poorly drained. Several Holocene deposits of peat or "muck", covering several square miles in the Cow Pen Slough and Phillippi Creek basins, are also very poorly drained (Wildermuth, 1959, p. 28, 36).

The relatively impermeable beds of clay and marl of Miocene, Pliocene and early Pleistocene ages that lie relatively near the ground surface influence the low-flow characteristics of streams because some are perching or confining layers (aquicludes). The influences of these aquicludes upon low flows are discussed in the section on factors affecting low flows.

STREAMFLOW DATA

Although long-term records of daily stage and discharge are available for sites on the three larger streams in, and adjacent to, the area of investigation, there is a dearth of record for the numerous small streams and canals in the area. Prior to 1962, practically no quality of surface-water information was collected in this region by the U.S. Geological Survey; however, in the past 50 years, several analyses of water from the Myakka River and from privately owned springs were made by both State agencies and private analysts. Records of surface water that are available for gaging stations in the area are shown in figure 2. The locations of surface-water data-collection stations are shown in figure 1. Miscellaneous stations are numbered consecutively in downstream order, excluding Nos. 20, 21, and 22 which are in the Peace River basin. Continuous and partial-record stations are numbered, in downstream order, with the essential digits of the seven digit U.S. Geological Survey numbering system. Table 1 summarizes the results of low-flow measurements made at these data-collection stations during the period of this investigation.

Streamflow records used in this report have been collected since 1936 by the U.S. Geological Survey in cooperation with the Division of Geology, Florida Board of Conservation, the Florida State Road Department, Sarasota County, and the city of Sarasota.

DRY SEASON STREAMFLOW

FACTORS AFFECTING LOW FLOWS

The base flow of streams in the study area is principally influenced by (1) the permeability and porosity of the surficial Pleistocene and Holocene deposits; (2) the interrelations among these deposits and older, underlying beds; (3) the relative altitudes of the water table and the surface in the streams; (4) soil moisture conditions and evapotranspiration rates; (5) manmade changes to the regimens of streams, such as the dredging of sloughs, inflow of ground water discharged from wells, and inflow of water from sewage disposal facilities, and (6) time distribution of precipitation.

The Pleistocene age sand and gravel deposits, which cover most of the study area and which are the principal contributors to base flow, are porous and permeable on the upland ridges and knolls but less permeable over broad, flat areas. Natural streamflow in upland areas, such as at Myakka River at Myakka City (station No. 2982), diminishes rapidly at the end of the summer rainy season and approaches zero if there is a month or more of little or no rainfall. Somewhat poorly drained sandy soils occupy about 100 of the 125 square miles that the Myakka River drains above this station. Although the relief between the drainage divides and the river bottom exceeds 50 feet along more than half the length of the main channel, low permeability beds that underlie these soils restrict the downward movement of water and thus help maintain relatively high water table. Many shallow depressions scattered among low knolls are the sites of wet-weather ponds. The low permeabilities of the hardpan and clay strata greatly restrict the downward per-

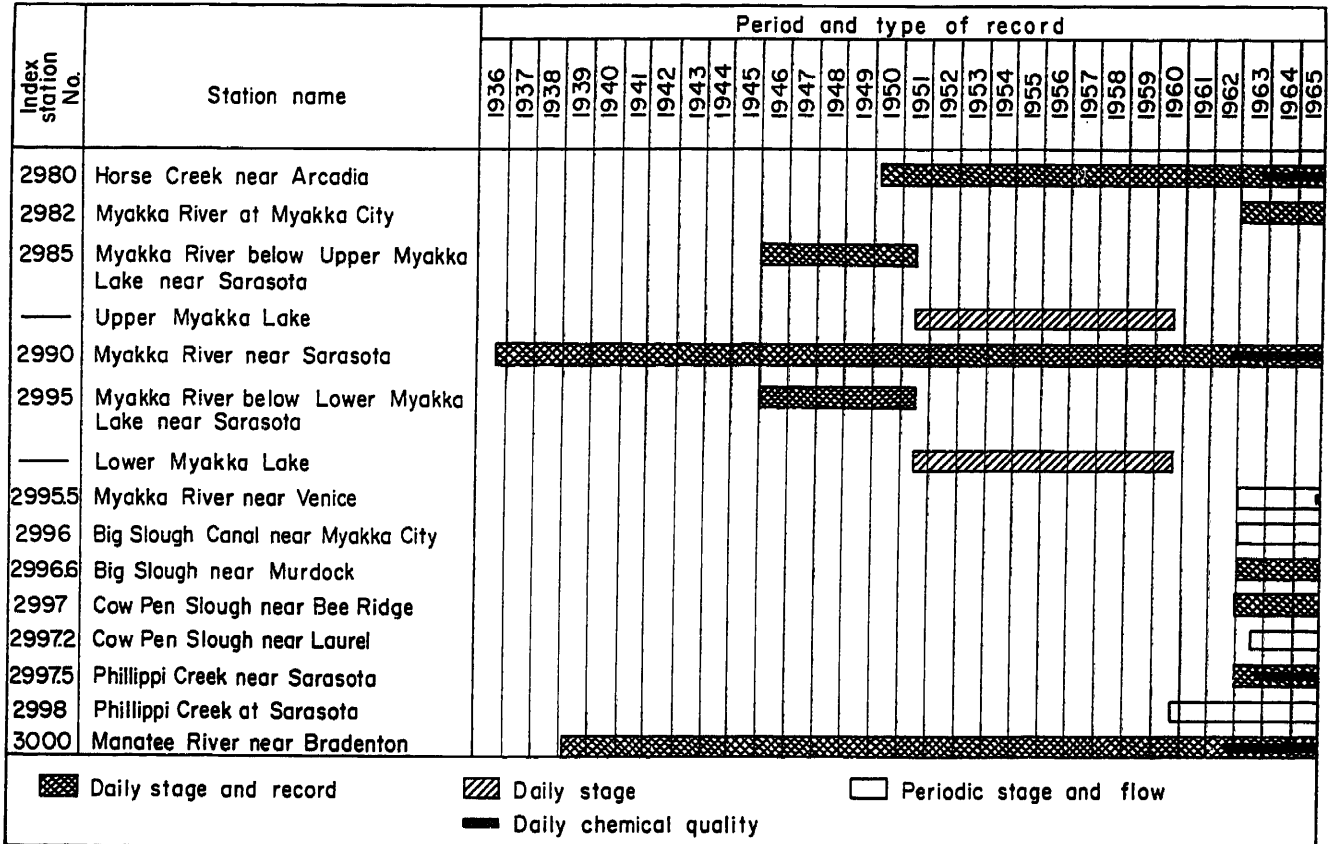

Figure 2. Period and type of hydrologic record for surface waters in Myakka River basin and vicinity.

TABLE 1. SELECTED LOW-FLOW DISCHARGE MEASUREMENTS MADE AT VARIOUS GAGING STATIONS

Map No. (fig. 1)	Station name	Location and drainage area	Measurements: Date	Gage height (msl)	Discharge (cfs)
		Peace River Basin			
20	Morningstar Waterway (at Port Charlotte)	NE¼ sec. 16, T. 40 S., R. 22 E., below mouth of Dorchester Waterway and about 500 ft. below bridge on Midway Boulevard in Port Charlotte, and 2.6 miles southeast of Murdock, Charlotte County.	5-13-63	-	0.79
			5-21-64	-	.32
			4- 5-65	-	0
			5- 3-65	-	** .05
			6- 4-65	-	** .14
21	Fordham Waterway (at Port Charlotte)	NW¼ sec. 12, T. 40 S., R. 22 E., at culvert on Quesada Boulevard in Port Charlotte and 4¾ miles east of Murdock, Charlotte County.	5-13-63	-	.22
			5-21-64	-	.20
			4- 5-64	-	0
			5- 3-65	-	** .10
			6- 4-65	-	1.25
22	Niagara Waterway (at Port Charlotte)	NW¼ sec. 12 T. 40 S., R. 22 E., at culvert on Quesada Boulevard in Port Charlotte and 5 miles east of Murdock, Charlotte County.	5-13-63	-	.13
			5-21-64	-	.05
			4- 5-65	-	1.40
			5- 3-65	-	.41
			6- 4-65	-	.34
		Myakka River basin			
1	Myakka River (near Myakka City)	SE¼ sec. 4, T. 35 S., R. 22 E., at bridge on State Highway 64, 8¼ miles northeast of Myakka City, Manatee County. Drainage area: 11 sq mi., approximately.	4-16-63	-	0
			5-19-64	-	0
			4- 5-65	-	* .03
			5- 3-65	-	* .002
			6- 1-65	-	0
2	Wingate Creek (near Myakka City)	NE¼ sec. 7, T. 35 S., R. 22 E., ½ mile below State Highway 64, and 7¼ miles north of Myakka City, Manatee County.	4-24-56	-	** .05
			4-16-63	-	* .78
			5-19-64	-	* .89
			4- 5-65	-	* .97
			5- 3-65	-	* .82
			6- 1-65	-	1.39
3	Ogleby Creek (near Myakka City)	NW¼ sec. 5, T. 36 S., R. 21 E., at culvert on State Highway 70, 5.0 miles northwest of Myakka City, Manatee County.	5- 3-65	-	0
2982.	Myakka River at Myakka City	Lat. 27°20′47″, long. 82°09′17″, in E½ sec. 13, T. 36 S., R. 21 E., on downstream side of bridge on State Highway 70, 0.2 mile downstream from Owen Creek and 0.6 mile southeast of Myakka City post office, Manatee County. Drainage area: 125 sq mi.	5-15-63	28.04	* .01
			4- 6-65	28.61	2.74
			5- 3-65	28.42	* .73
			6- 1-65	28.33	** .02

2990.	Myakka River near Sarasota	Lat. 27°14′25″, long. 82°18′50″, in sec. 21, T. 37 S., R. 20 E., on right bank, half a mile upstream from bridge on State Highway 72, 2 miles upstream from Lower Myakka Lake, and 14 miles southeast of Sarasota, Sarasota County. Drainage area: 235 sq mi., approximately.	5-15-63 4- 5-65 5- 5-65 6- 2-65	9.47 10.27 9.52 8.66	0 8.09 0 0
6	Myakka River (at Rocky Ford near Venice)	NE¼ sec. 24, T. 38 S., R. 19 E., at Rocky Ford, 6½ miles northeast of Venice, Sarasota County.	3- 1-62 5-14-63 4- 7-65 5- 5-65	- - - -	* .85 .99 9.55 * .97
2995.5	Myakka River near Venice	SW¼ sec. 31, T. 38 S., R. 20 E., at bridge on county road, ¾ mile upstream from Blackburn Canal and 6 miles northeast of post office in Venice, Sarasota County. Drainage area: 270 sq mi., approximately.	5- 4-65	-0.51	a
9	Myakka River Tributary (near Venice)	NE¼ sec. 18, T. 39 S., R. 20 E., at culvert on county road, 6½ miles east of Venice, Sarasota County.	4- 6-65 5- 5-65 6- 3-65	- - -	.63 .40 .21
10	Myakka River Tributary No. 2 (near Venice)	NW¼ sec. 28, T. 39 S., R. 20 E., at culvert on county road, 8.2 miles southeast of Venice, Sarasota County.	4- 6-65 5- 5-65 6- 3-65	- - -	.62 .79 .79
11	Myakka River Tributary No. 3 (near Venice)	S½ sec. 28, T. 39 S., R. 20 E., at culvert on county road, 8.7 miles southeast of Venice, Sarasota County.	4- 6-65 5- 5-65 6- 3-65	- - -	.01 ** .15 0
12	Myakka River Tribuary No. 4 (near Venice)	SE¼ sec. 28, T. 39 S., R. 20 E., at culvert on county road, 9.1 miles southeast of Venice, Sarasota County.	4- 6-65 5- 5-65 6- 3-65	- - -	.03 ** .05 a-.18
13	Myakka River Tributary No. 5 (near Venice)	NE¼ sec. 33, T. 39 S., R. 20 E., at culvert on county road, 9.3 miles southeast of Venice, Sarasota County.	4- 6-65 5- 5-65 6- 3-65	- - -	.02 ** .01 a-.69
14	Deer Prairie Creek (near Venice)	NE¼ sec. 14, T. 39 S., R. 20 E., at ford, 10¼ miles east of Venice, Sarasota, County.	3- 1-62 5-13-63 5-21-64 4- 7-65 5- 3-65 6- 3-65	- - - - - -	* .14 * .29 .60 .60 .56 * .34
15	Deer Prairie Creek at dam (near Venice)	SE¼ sec. 22, T. 39 S., R. 20 E., at concrete dam, 10 miles southeast of Venice, Sarasota County.	5-21-64 4- 8-65 5- 3-65	- - -	.90 .55 .55
16	Warm Mineral (Salt) Spring (near Murdock)	N½ sec. 25, T. 39 S., R. 20 E., at head of Salt Creek, 8 miles northwest of Murdock, Charlotte County.	4-24-56 6- 7-62	- -	9.53 9.25

TABLE 1. (Continued)

Map No. (fig. 1)	Station name	Location and drainage area	Measurements		
			Date	Gage height (msl)	Discharge (cfs)
2996.	Big Slough near Myakka City	On line between secs. 6 and 7, T. 38 S., R. 22 E., Sarasota County, at bridges on State Highway 72, 11 miles south of Myakka City, Manatee County. Drainage area: 36.5 sq mi.	6- 4-62 5-15-63 4- 5-65 5- 5-65 6- 2-65	27.31 27.26 27.40 27.26 27.09	* .24 * .07 .43 * .07 0
17	Big Slough (near Murdock)	SE¼ sec. 4, T. 39 S., R. 21 E., Sarasota County, 5 miles north of U. S. Highway 41 and 7½ miles northwest of Murdock, Charlotte County.	6- 5-62 5-13-63 4- 6-65 5- 3-65 6- 4-65	- - - - -	* .15 * .12 1.16 * .39 * .09
2996.5	Big Slough near Murdock	Lat. 27°04′15″, long. 82°13′05″, in NW¼ sec. 21, T. 39 S., R. 21 E., Sarasota County, near left bank, 3 miles upstream from bridge on U. S. Highway 41 and 5¾ miles northwest of Murdock, Charlotte County. Drainage area: 87.5 sq mi.	6- 5-62 5-13-63 4- 6-65 5- 3-65 6- 4-65	5.37 6.48 6.59 6.54 6.45	.48 * .32 1.53 1.11 * .20
18	Little Salt Spring (near Murdock)	NW¼ sec. 20, T. 39 S., R. 21 E., at head of unnamed ditch, 7 miles northwest of Murdock, Charlotte County.	4-24-56 6- 5-62	- -	1.22 .89
		Coastal area between Myakka and Alafia Rivers			
23	East Branch Coral Creek (near Placida)	NW¼ sec. 32, T. 41 S., R. 21 E., at culvert on State Highway 771, 3 miles north of Placida, Charlotte County.	4-11-62 5-13-63 5- 3-65	- - -	0 0 0
24	Oyster Creek (near Englewood)	SW¼ sec. 3, T. 41 S., R. 20 E., Charlotte County, at culvert on State Highway 776, 3.5 miles southeast of Englewood, Sarasota County.	4-11-62 5-13-63 5- 3-65	- - -	** .17 * .02 ** .04
25	Alligator Creek (near Venice)	NW¼ sec. 27, T. 39 S., R. 19 E., at lateral canal 1.0 mile upstream from bridge on U. S. Highway 41, 4 miles southeast of Venice, Sarasota County.	5-14-63 6-11-64	- -	.48 .41
2997.	Cow Pen Slough near Bee Ridge	Lat. 27°14′56″, long. 82°23′10″, in E½ sec. 22, T. 37 S., R. 19 E., near right bank on downstream side of bridge on State Highway 72, 6¼ miles southeast of Bee Ridge, Sarasota County, and 13 miles upstream from U. S. Highway 41. Drainage area: 38 sq mi. approximately.	5-16-63 4- 5-65 5- 5-65 6- 2-65	16.64 17.41 16.99 17.53	* .02 .61 0 .81

2997.2	Cow Pen Slough near Laurel	Sec. 15, T. 38 S., R. 19 E., at bridge on private road, 4½ miles northwest of Laurel, Sarasota County. Drainage area: 56 sq mi., approximately.	5-14-63 4- 8-65 5- 4-65 6- 3-65	6.80 6.79 7.03 7.11	* .11 .99 * .15 * .02
26	Cow Pen Slough (near Laurel)	Sec. 22, T. 38 S., R. 19 E., 800 feet above bridge on private road, 4 miles northeast of Laurel, Sarasota County.	5-14-63 6-11-64 5- 4-65 6- 3-65	- - - -	* .94 1.15 * .76 * .39
27	Fox Creek (near Laurel)	Sec. 20, T. 38 S., R. 19 E., 0.6 mile above bridge on private road, 2½ miles northeast of Laurel, Sarasota County.	5-14-63 6-11-64 5- 4-65 6- 3-65	- - - -	* .04 * .02 ** .01 0
28	South Creek (near Osprey)	NW¼ sec. 13, T. 38 S., R. 18 E., at Seaboard Airline R. R. bridge, 2½ miles southeast of Osprey, Sarasota County.	5-14-63 5-20-64 5- 4-65 6- 3-65	- - - -	* .27 * .29 ** .30 ** .22
2997.5	Phillippi Creek near Sarasota	Lat. 27°18'30", long 82°27'06" in E½ sec. 36, T. 36 S., R. 18 E., near center of span on downstream side of bridge on State Highway 785, 0.2 mile downstream from Main-C Canal and 2½ miles southeast of Sarasota city limits, Sarasota County. Drainage area: 24 sq. mi., approximately.	5-15-63 4- 9-65 5- 5-65 6- 2-65	7.06 7.82 7.70 7.78	3.30 3.74 1.90 2.25
29	Phillippi Creek (near Sarasota)	SW¼ sec. 26, T. 36 S., R. 18 E., at bridge on Bahia Vista Street, 0.7 mile southeast of Sarasota city limits, Sarasota County.	4- 9-65 5- 5-65 6- 2-65	- - -	4.30 *2.68 *2.83
30	Main-B Canal (at Sarasota)	Sec. 22, T. 36 S., R. 18 E., at bridge on State Highway 780 (Fruitville Road), in Sarasota, Sarasota County.	5-15-63 5-19-64 5- 4-65 6- 2-65	- - - -	*1.28 2.85 *1.44 *1.23
2998.	Phillippi Creek (at Sarasota)	SE¼ sec. 28, T. 36 S., R. 18 E., at bridge on Bahia Vista Street, Sarasota, Sarasota County, 1.5 miles east of U. S. Highway 41, and about 5 miles above mouth. Drainage area: 45 sq mi., approximately.	2-19-62 7-22-64	0.63 2.31	8.52 a10.6
31	Walker Creek (at Sarasota)	Sec. 6, T. 36 S., R. 18 E., at bridge on 38th Street in Sarasota, Sarasota County.	1-29-63 6-12-64 4- 8-65 5- 4-65 6- 2-65	- - - - -	1.44 * .43 * .57 * .50 * .24

* Base runoff
** Field estimate
a Flow reversed by tide

colation and recharge to the Bone Valley and Hawthorn Formations throughout much of this upland area, despite a generally favorable hydraulic gradient.

Some of the direct runoff from showers in the headwaters of the Myakka River is temporarily stored in a swamp just north of Myakka City. Most of this stored water is believed to be lost by evapotranspiration, because the piezometric head in the Hawthorn Formation is too high to permit recharge and because little runoff from sporadic showers is measured at the gaging station at Myakka City. As a drought progresses and the water table falls, the upper Myakka River will cease flowing, drying up altogether in its shallower reaches.

Southwest of Myakka City, the Myakka River flows through the southern part of the 4,300-acre Tatum Sawgrass before it enters upper Myakka Lake. Much of the streamflow that results from showers occurring during seasonal droughts is lost to evapotranspiration in this marsh, in Upper and Lower Myakka Lakes, and in the marsh and swamp that separate the lakes. Thus, flow from the lakes ceases nearly every year.

The fair to poor permeabilities of surficial materials in the flat areas between the larger streams coupled with the lack of a well developed drainage system retards the movement of water out of the area. Thus the water table remains within a few feet of ground surface unless artificial drainage is imposed.

Low water stages of the Myakka River in the reach between Lower Myakka Lake and Rocky Ford (station No. 6, fig. 1) are less than 8 feet above msl (mean sea level), and the flatlands bordering the well-incised channel are about 15 feet above msl. Land immediately adjacent to the channel may be fairly well drained, while land only a few hundred yards away may have a water table within 3 feet of ground surface. Downstream from Rocky Ford, the Myakka River channel is deeply incised and the flow is reversed by the tide during periods of very low flows. In general, the water table in the flatlands slopes at low gradients toward the natural streams and sloughs except when the water table is lower than these channels, and the channels are completely dry.

The major sloughs in the study area have been deepened in the past 40 years, mainly to drain agricultural lands. The deepened drainage channels include Deer Prairie Creek, Big Slough, Alligator Creek, Curry Creek (Blackburn Canal), Cow Pen Slough, and Phillippi Creek. Channel deepening has probably increased low flows; however no measurements were made under natural conditions, prior to excavation. In Alligator Creek, as in other creeks draining small coastal basins, the deepened channels permit inland intrusion of sea water in the stream.

Streamflow and quality characteristics indicate that the artesian ground-water contributions to the Myakka River, in the reach of possible artesian flow between Myakka City and the outlet to Lower Myakka Lake, is negligible. It is possible that the underlying artesian aquifers contribute, by means of natural hydraulic connections with the stream channels, a small and relatively insignificant amount of moderately mineralized ground waters to the low flows of some streams—for example, the Myakka River and Big Slough. Upper and Lower Myakka Lakes appear to be solution features and thereby offer the possibility that ground water from artesian zones may contribute to these lakes through debris-filled fractures or sinks. However, the lakes and the Myakka River channel are shallowly underlain by rather impermeable clays. A sinkhole, more than 125 feet deep near the river channel at the outlet of Lower Myakka Lake, was estimated to be discharging 0.1 cfs on June 5, 1946; there was no flow from the lake at that time. This flow of artesian water, which is chemically similar to that obtained from wells which penetrate the deeper artesian zones of the Floridan aquifer that underlie the Hawthorn Formation, probably ceases when the Myakka River is high enough to flood out the hole.

Drainage from agricultural lands irrigated with ground water pumped from the deeper aquifers is at times an appreciable part of the low flow in sloughs. From quality and discharge data collected on Big Slough (station No. 2996.5), it was estimated that for discharges of about 0.1 cfs, pumped ground water contributes from less than 10 to more than 60 percent of the discharge, depending on the pumpage rate and climatic conditions.

Warm Mineral and Little Salt Springs (station Nos. 16 and 18, fig 1.), which are sources of highly saline ground water, are located a few miles downstream from the Big Slough station. Smaller springs of this type, which are debris filled and, therefore, not noticeable at the ground surface, may occur in the lower Big Slough basin and contribute slightly to the somewhat saline character of low flows in the channel.

It is believed that the hardpans and clays which overlie the Hawthorn Formation in the Cow Pen Slough, Phillippi Creek, and other coastal basins prohibit significant amounts of artesian water from seeping upward to the stream channels. Rainfall-runoff relationships are too indeterminate, and the contributions made by wells too inadequately known, to accurately determine the relationships between ground water and streamflow in these coastal basins. However, the concentrations of dissolved solids—about 400 to 500 ppm (parts per million)—at low flows in coastal streams whose watersheds are relatively unpopulated, such as Fox and South Creeks, are usually 4 to 10 times the concentrations of dissolved solids (about 50 to 100 ppm) in those streams that drain upland areas. Thus, the low flows of most coastal streams are not derived solely from the drainage of surficial deposits. In the non-tidal streams the water is of the bicarbonate type and is otherwise similar to water from the upper part of the Floridan aquifer. Furthermore, the concentration of fluoride in the non-tidal streams is less than half the concentration of fluoride in water from the Hawthorn Formation and is only slightly greater than the concentration in most upland streams.

On the basis of the chemical analyses of low flows and knowledge of the ground-water hydrology, it is concluded that much of the low flows in these coastal streams is ultimately derived from the large number of wells that tap the Floridan aquifer. Whatever the sources of water in the non-tidal streams may be, the combined runoff is usually insufficient to sustain streamflow during severe droughts, excluding Phillippi Creek as previously mentioned.

LOW-FLOW CHARACTERISTICS

The flow characteristics and the physical and chemical traits of a stream vary with time, location along the stream, and manmade changes within the watershed. The low-flow characteristics of a stream are often the factors which control its value and utilization for water power, water supplies, recreation, navigation, and fish production. Low-flow characteristics of particular significance in the Myakka River basin are: the length of periods of low streamflow, the median minimum annual discharges for selected periods of time, and the frequency at which a given discharge will recur as the average minimum flow for a selected period of time.

For the purposes of this report, "low flow" refers to the average minimum discharges for periods of selected lengths, in days, within the climatic year, and "frequency" refers to the average recurrence interval (R.I.), in years, of a low-flow discharge. "Base flow" refers to sustained or fair weather streamflow.

FREQUENCY

The occurrences of annual periods of relatively small streamflows are primarily determined by climatic conditions. Base flow conditions, when streamflow is composed chiefly of ground water, usually occur twice yearly in southern Florida—in May and June and in November or December. Rainfall and streamflow records indicate that there have been five droughts since 1938 during which the non-tidal reaches of practically all streams in the area either dried up or ceased flowing. These occurrences of extremely low flows were in 1939, 1944, 1945, 1950, and 1956. Each of the corresponding meteorological droughts was moderate to severe; and in each instance, rainfall for the prior year was below normal.

Because of the effects of the time distribution of rainfall upon the net volume of drought discharges in the Myakka River area, the relative severity of droughts is probably best determined by comparing rainfall deficiencies. For the period December through May in both 1944-45 and 1949-50, rainfall at Myakka River State Park was 60 to 65 percent below normal. Rainfall records for the Park and other sites indicate that these were the two most severe droughts since 1939. For comparison, an areal rainfall deficiency of 29 percent, in the period December 1964 to May 1965, produced a relatively mild drought. Minimum discharges for the Myakka and Manatee Rivers, such as the averages for this period, may be expected to recur about every 2.4 years, on the average.

Discharge records for Myakka River near Sarasota (station No. 2990) are the only available records, for a stream within the study area, that are of sufficient length to adequately define magnitude and frequency relationships for low-flow periods. These relationships for this locality on the Myakka River are summarized for periods of 90, 120, 150, 183, and 274 days in table 2.

Records of daily streamflow, collected from 1946 to 1951 at two

TABLE 2. MAGNITUDE AND FREQUENCY OF ANNUAL LOW FLOW OF MYAKKA RIVER NEAR SARASOTA.

Period (Consecutive days)	Lowest average flow, in cfs, for indicated recurrence interval, in years							
	2	3	5	7	10	15	20	30
90	7.3	0.7	<0.1	0	0	0	0	0
120	12	3.2	.3	<.1	0	0	0	0
150	27	6.3	1.7	.9	.5	.25	.15	<.1
183	43	10	3.5	2.1	1.4	.9	.7	.5
274		88	36	25	19	16	14	12

other stations on the Myakka River at the State Park (station Nos. 2985 and 2995), indicate that the low-flow characteristics for the outlets of Upper and Lower Myakka Lakes are approximately equivalent to those, as given above, for the long-term station.

The droughts which occur nearly every year during the spring months produce conditions of low streamflow on all non-tidal streams in the area. The average rainfall for each of the months of February, March, April, and May is 2.9 to 3.2 inches, but monthly rainfalls vary considerably from year to year. Table 3 gives the mean, median, and minimum discharges for the months of March, April, and May, for the respective periods of record, at continuous record gaging stations (figs. 1 and 2). The median monthly discharge is more reliable than the mean for estimation of the normal, or expected, monthly discharge. Records for the short-term stations are not of sufficient length to give reliable estimates of the expected monthly discharges.

The decline in mean discharges for the period March through May, as shown by the long-term stations in table 3, results from drainage of the water-table aquifer and increasing evapotranspiration rates. Because of the combined effects of storage and evapotranspiration in both the Myakka Lakes and surrounding marshlands, no-flow conditions occur with slightly greater frequency at the Park stations on the Myakka River than they do on most of the other streams. The Myakka River temporarily ceases flowing at station 2990 every 1.3 years, on the average. However, the longest period of no flow that has been recorded at this station was 133 days in 1950.

Although extended periods of no flow are common in the upper Myakka River, the median of the annual minimum 7-day flow (the average discharge for the 7-day period of lowest flow that may be expected to recur every 2 years) for most other streams in the study area may be used as an index of low-flow characteristics. Furthermore, for the few streams where discharges are partially sustained by flowing wells, springs, and domestic sources of water, the 7-day 10-year annual low flow may be used as an index of low flow. These low-flow characteristics were estimated for all stations, lying within the study area (fig. 1), for which low flows are relatively unaffected by tidal influences. These estimates are based upon regression curves that relate measured and rated discharges at some of these stations with contemporaneous flows at Manatee River near Bradenton (station No. 3000), the 7-day frequency curve of minimum flows at Manatee River near Bradenton, correlations of base-flow meas-

TABLE 3. MONTHLY MEAN, MEDIAN, AND MINIMUM DISCHARGES FOR MARCH, APRIL, AND MAY AT CONTINUOUS-RECORD STATIONS

Map No. (fig. 1)	Station name	Number of water years of record	Drainage area (sq mi.)	March Discharge (cfs)			April Discharge (cfs)			May Discharge (cfs)		
				Mean[1]	Median[2]	Minimum[3]	Mean	Median	Minimum	Mean	Median	Minimum
*2980.	Horse Creek near Arcadia	15	218	118	94.6	3.20	85.8	72.7	0.63	49.3	4.65	0.63
2982.	Myakka River at Myakka City	2	125	85.9	....	49.8	30.9	....	2.43	4.88	....	.16
2985.	Myakka River below Upper Myakka Lake near Sarasota	5	a 220	45.7	9.95	0	26.3	.13	0	4.08	0	0
2990.	Myakka River near Sarasota	29	a 235	135	36.9	0	74.9	36.0	0	26.1	3.77	0
2995.	Myakka River below Lower Myakka Lake near Sarasota	5	a 240	41.8	7.82	0	24.5	.83	0	4.86	0	0
2996.5	Big Slough near Murdock	2	87.5	31.8	....	11.4	6.38	....	1.66	1.52	....	.87
2997.	Cow Pen Slough near Bee Ridge	2	a 38	13.5	....	3.10	6.42	....	.54	.62	....	.04
2997.5	Phillippi Creek near Sarasota	2	a 24	15.7	....	5.79	7.98	....	3.05	5.53	....	1.68
3000.	Manatee River near Bradenton	26	a 80	75.3	33.9	4.19	31.1	16.9	2.81	16.4	7.56	1.87

* Not shown in figure 1.
a Approximately.
[1] Mean monthly discharge—for a specified month, the total of the monthly average discharges divided by the number of years of record.
[2] Median discharge—the average monthly discharge that is the mid-most value when all monthly averages are scaled from highest to lowest.
[3] Minimum discharge—for a specified month, the lowest average monthly discharge for the period of record.

urements (especially those made in 1965), and comparisons of base-flow yields per square mile with the yields at the continuous-record stations. The calculated low-flow characteristics for the stations whose records were amendable to these analyses are presented in table 4.

The low-flow estimates shown for the short-term continuous-record stations should be more reliable than the short-term records for estimating future low flows on these respective streams. However, watershed development projects currently in progress, changes in man-made accretions to low flows, and additional streamflow regulation may be expected to somewhat alter the low-flow characteristics of nearly all of these streams within the next decade.

DURATION AND MAGNITUDE

The duration of a low-flow period is directly related to both antecedent and prevailing climatic conditions. The magnitude of base-flow discharges during these periods is primarily dependent on the permeability and porosity of the surficial geologic units and the level of the water table within these units.

Flow-duration data for the nine daily-record stations in the Myakka River basin area are given in table 5. Two stations, Horse Creek near Arcadia and Manatee River near Bradenton, are not within the area of investigation, but data from these stations were useful in adjusting the records for short-term stations to a standard base period, 1940-64, for comparative purposes. The headwaters of both Horse Creek and the Manatee River adjoin those of the Myakka River. Adjustments of short-term records to the longer period were made for those streams where channel conditions have remained essentially unchanged throughout the base period, and where the contribution of ground-water flow from wells is usually an insignificant part of the total flow.

The flow-duration data given in table 5, when plotted on logarithmic probability paper, provide a convenient method for comparison of flow characteristics. Duration curves for low flows at four selected stations, for the 25-year base period, are shown in figure 3 to illustrate the variability of low flows in adjacent basins which lie in a homogeneous climatic region.

Duration curves for the streams in the study area commonly have a steep slope, which indicates a high variability of low flows. The low discharge ends of the duration curves for the three Myakka stations shown in figure 3 have very similar steep slopes. The steepness of these curves, which is slightly greater than that for most

TABLE 4. LOW-FLOW CHARACTERISTICS AT SHORT-TERM-CONTINUOUS, PARTIAL AND MISCELLANEOUS RECORD STATIONS

Map No. (fig. 1)	Station name	Drainage area (sq. mi.)	Estimated 7-day annual low flow, cubic feet per second	
			2-year	10-year
1	Myakka River (near Myakka City)		0	0
2	Wingate Creek (near Myakka City)		.5	.1
3	Ogleby Creek (near Myakka City)		0	0
2982.	Myakka River at Myakka City	125	0	0
2985.	Myakka River, below Upper Myakka Lake, near Sarasota	a 220	0	0
2995.	Myakka River, below Lower Myakka Lake, near Sarasota	240	0	0
6	Myakka River (at Rocky Ford near Venice)		.8	.2
14	Deer Prairie Creek (near Venice)		.3	<.1
15	Deer Prairie Creek at dam (near Venice)		.3	<.1
2996.	Big Slough near Myakka City	36.5	<.1	0
17	Big Slough (near Murdock)		.1	0
2996.5	Big Slough near Murdock	87.5	.35	b .15
20	Morningstar Waterway (at Port Charlotte)		b <.1	b 0
25 & 22	Niagara and Fordham Waterways (at Port Charlotte)	a 3.5	b .3	b <.1
23	East Branch Coral Creek (near Placida)		0	0
24	Oyster Creek (near Englewood)		<.1	0
2997.	Cow Pen Slough near Bee Ridge	a 38	b 0	b 0
2997.2	Cow Pen Slough near Laurel	a 56	b <.1	b 0
26	Cow Pen Slough (near Laurel)		b .2	b <.1
27	Fox Creek (near Laurel)		0	0
28	South Creek (near Osprey)		<.2	0
2997.5	Phillippi Creek near Sarasota	a 24	b 1.1	b .6
30	Main-B Canal (at Sarasota)		b .4	b .2
31	Walker Creek (at Sarasota)		b .2	b <.1

a Approximate.
b Subject to diversion and/or regulation.

TABLE 5. DURATION OF DAILY FLOW AT CONTINUOUS-RECORD STATIONS IN MYAKKA RIVER BASIN AREA

Station No. (fig. 1)	Station name	Drainage area (sq mi.)	Period	Average flow[1] (cfs)	Flow, in cubic feet per second, which was equaled or exceeded for indicated percent of time																
					99.5	99	98	95	90	80	70	60	50	40	30	20	10	5	2	1	0.5
	Peace River basin																				
2980.	Horse Creek near Arcadia	218	1951-64	232	0.1	0.2	0.4	1.5	3.0	7.1	17	35	62	105	176	308	597	975	1,710	2,420	3,310
			‡1940-64	244	0	.1	.2	.6	1.8	5.0	11	22	45	85	155	295	600	1,000	1,750	2,400	3,300
	Myakka River basin																				
2982.	Myakka River at Myakka City	125	*	150	0	0	0	.1	.4	3.7	7.5	17	35	62	105	210	432	680	1,160	1,540	1,810
			‡1940-64	162	0	0	0	0	.1	1.4	4.7	11	24	46	86	170	403	740	1,290	1,790	2,380
2985.	Myakka River below Upper Myakka Lake, near Sarasota	a 220	1946-50	289	0	0	0	0	0	0	.1	11	32	76	170	390	870	1,530	2,450	3,100	3,750
			‡1940-64	268	0	0	0	0	0	0	12	26	49	94	185	360	690	1,100	1,780	2,380	3,080
2990.	Myakka River near Sarasota	a 235	1937-64	266	0	0	0	0	.1	1.6	8.2	28	59	109	193	355	760	1,280	2,060	2,740	3,550
			1940-64	259	0	0	0	0	.1	1.7	8.6	30	62	111	192	347	715	1,190	1,950	2,680	3,510
			1946-50	305	0	0	0	0	0	.2	1.9	10	41	93	170	370	1,020	1,600	2,580	3,400	4,380
2995.	Myakka River below Lower Myakka Lake, near Sarasota	a 240	1946-50	314	0	0	0	0	0	.1	1.2	10	31	75	183	453	1,020	1,700	2,600	3,300	4,060
			‡1940-64	300	0	0	0	0	0	1.1	9.5	24	46	94	205	430	830	1,260	1,950	2,550	3,280
2996.5	Big Slough near Murdock	87.5	*	85	.3	.3	.4	.6	.9	1.5	2.7	5.9	13	26	50	95	221	508	700	1,030	1,300
			‡1940-64	80	.1	.2	.2	.4	.7	1.2	2.0	4.3	11	21	40	86	220	445	850	1,270	1,840
	Coastal basins																				
2997.	Cow Pen Slough near Bee Ridge	a 38	**	24	.1	.1	.1	.2	.3	.6	1.0	1.8	3.5	7.4	15	32	73	123	196	248	302
2997.5	Phillippi Creek near Sarasota	a 24	**	24	1.2	1.9	2.4	2.9	3.5	4.8	6.3	8.2	11	14	19	27	48	81	166	270	413
3000.	Manatee River near Bradenton	a 80	1940-64	109	2.0	2.5	3.2	4.6	6.2	8.9	12	17	24	37	61	114	264	485	905	1,330	1,890

a Approximate
‡ Data are adjusted on basis of relation to data at nearby gaging station.
* April 1963 to September 1965.
** April 1963 to March 1965.
[1] Average flow—the total cfs-days for the period of record shown divided by the number of days. For adjusted record, duration curves were correlated to obtain the average flow.

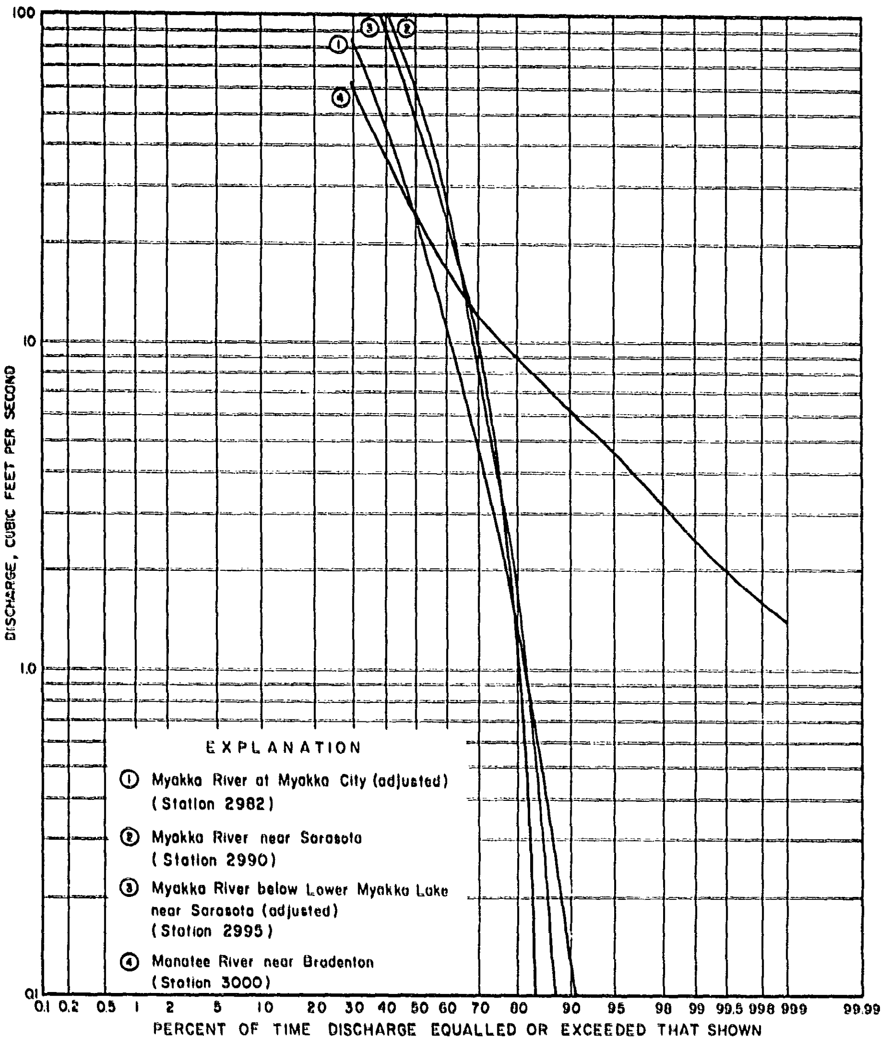

Figure 8. Duration curves of daily low flow for selected streams, standard period—1940-64.

other streams in the study area, results from the climatic conditions, the hydraulic characteristics of the surficial deposits, and the topography of the upper Myakka River basin. The hydrologic significance of these factors was previously discussed under the section "Factors Affecting Low Flows."

The relatively flat curve for Manatee River near Bradenton indicates that this stream has a higher sustained low flow than do the other streams. The low flow of the Manatee River near Bradenton is sustained by the slow drainage of ground water from the moderately to poorly permeable beds of fine sand and clay into which the river is fairly deeply entrenched. The deep entrenchment of the river channel permits drainage to the stream of a greater thickness of the surficial materials than would occur if the channel were shallower.

Phillippi Creek near Sarasota (station No. 2997.5) is the only nontidal reach of stream channel in the outlined area of investigation that may be expected to maintain a flow in excess of 0.2 cfs throughout critical droughts, such as those of 1939, 1944, 1945, and 1950. However, low flows at this station are augmented by effluent from sewerage plants and ground water from irrigation and domestic wells. Most of the wells tap moderately mineralized waters in artesian zones.

Some of the deeper drainage canals and waterways have somewhat greater low-flow yields per unit of drainage area than do many natural, or slightly improved, channels. As an example, for the lowest of 10 low-flow measurements made since April 1962 on the Niagara and the Fordham Waterways in North Port Charlotte, the combined discharge was 0.25 cfs (table 1). This discharge corresponds to a yield of 0.057 cfs per sq. mi. (cubic feet per second per square mile) for the 3.5 square-mile drainage area, after subtracting 0.05 cfs as the estimated contribution of a flowing well. This yield is significantly greater than the minimum yields that have been recorded since 1963 for some of the larger basins. The 125 square miles of the upper Myakka River basin has yielded no flow for 14 to 27 days during each spring, for a total of 57 days of zero flow in 3 years. The minimum yield at Big Slough near Murdock (station No. 2996.5; drainage area, 87.5 sq mi.) has been 0.0023 cfs per sq mi., without adjustment for the contributions from wells.

LOW-FLOW QUALITY

In general, streams which derive their low flows from drainage of surficial deposits, provided that these deposits are relatively unaffected by natural artesian flow or waters from irrigation wells, have low concentrations of total dissolved solids, sulfate, chloride, and fluoride, as well as low concentrations for other dissolved materials. The Myakka River near Sarasota (station No. 2990) was sampled daily from 1962 to 1966 for standard chemical analysis. Although evaporation tends to concentrate the dissolved materials in this water, the maximum concentrations determined for the following constituents were: total dissolved solids, 98 ppm (parts per million); sulfate, 25 ppm; chloride, 30 ppm; and fluoride, 0.7 ppm. The U.S. Public Health Service (PHS, 1962, p. 7, 8) recommends that concentrations of these constituents in drinking water do not exceed the following limits: total dissolved solids, 500 ppm, sulfate, 250 ppm; chloride, 250 ppm; and fluoride, 1.2 ppm in warm climates.

Above the outlet to Lower Myakka Lake, the water in the Myakka River probably always has a carbonate hardness of less than 60 ppm, which is moderately soft. Thus, the water in the Myakka Lakes is of generally good quality. However, water temperatures sometimes exceed 90°F., and color (platinum-cobalt index) may exceed 220. Objectionable quality characteristics that occasionally occur during periods of high runoff are dissolved iron concentrations of about 0.3 ppm and suspended organic matter, including some algae.

The dissolved solids content may be moderately high in streams that contain water derived from irrigation, stock, and other wells that yield moderately to highly mineralized water from the deep aquifers. Furthermore, streams and canals which are affected by sea and salty spring waters are usually very saline. Table 6 gives selected chemical analyses of surface waters in the study area. Note the high concentrations of chloride and dissolved solids for stations 2995.5, 8, 9, 16, 18, and 24. Salinity barriers in tidal reaches of streams generally provide good protection from sea water intrusions. Occasionally, there is some leakage of sea water through these barriers, as evidenced by the sample taken on the immediate upstream side of the lower barrier on Morningstar Waterway (station No. 20) on April 4, 1965.

The ranges in concentrations of some noteworthy constituents in Phillippi Creek near Sarasota (station No. 2997.5) measured for the water year October 1964 to September 1965, were: total dissolved solids, 160 to 1,030 ppm; sulfate, 52 to 430 ppm; chloride, 11 to 60 ppm; and fluoride, 0.3 to 1.3 ppm. The higher concentrations occurred during periods of low flow, when most of the discharge was derived from irrigation wells and domestic waste water. The quality characteristics of Cow Pen Slough and Big Slough are similarly, but to a lesser extent, influenced by inflow of ground water from wells.

CURRENT USAGE OF SURFACE WATER

Big Slough is the only major stream in the study area currently being directly utilized as a municipal water supply. In 1965, the

TABLE 6. CHEMICAL ANALYSIS OF SURFACE WATERS DURING LOW-FLOW PERIODS

Map number (fig. 1)	Station	Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)[a]	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids[b]	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)	pH	Color	Field Temperature (°F)
				Parts per million																	
1	Myakka River (near Myakka City)	1-18-63	1.76	4.6	0.16	6.4	2.2	6.8	0.8	14	1.8	16	0.3	0.4	47	25	14	86	6.4	140	-
		5- 3-65	.002	1.7	.17	8.8	2.9	8.6	.3	21	5.3	14	.3	.0	53	34	17	120	6.7	100	78
2	Wingate Creek (near Myakka City)	5- 3-65	.82	4.7	.02	8.8	2.4	4.2	.3	25	4.8	8	.1	.1	46	32	12	100	6.8	20	66
2982.	Myakka River at Myakka City	1-18-63	16.4	2.1	.09	7.6	2.7	7.1	1.3	19	3.6	16	.2	.4	51	30	14	95	6.6	100	-
		5- 3-65	.73	3.2	.10	12	1.0	6.0	.4	31	3.2	12	.1	.0	54	34	8	95	7.0	60	72
4	Myakka River (above Upper Myakka Lake near Sarasota)	5-16-63	<.2	2.4	.07	19	7.9	10	1.3	43	33	17	.6	2.5	115	80	45	260	6.8	70	80
2985.	Myakka River below Upper Myakka Lake near Sarasota — at gage site	5-16-63	0	.6	.11	10	1.7	8.2	1.1	21	8.4	16	.4	.7	58	32	15	110	6.2	100	83
2990.	Myakka River near Sarasota	2-20-62	.4	8.3	.05	12	4.9	13	1.0	16	25	25	.3	.7	98	58	37	168	7.0	80	75
		c7-10-63	d280[1]	3.7	.15	6.8	2.7	5.6	.6	15	10	9	.3	.1	47	28	16	76	6.6	220	d91
		e6- 5-65	0	1.2	.10	12	5.1	10	1.2	28	19	29	.4	.0	92	51	28	170	7.1	80	-
2995.	Myakka River below Lower Myakka Lake near Sarasota	7-15-65	>1,000[1]	5.1	.27	8.0	2.8	5.6	.6	23	8.4	10	.4	.1	53	32	12	85	6.7	200	82
5	Deep Hole (at Lower Myakka Lake Outlet)	5-16-63	-	2.1	.04	98	34	16	2.5	66	308	26	.9	.7	521	384	330	760	6.6	50	-
		7-15-65	-	13	.14	115	41	15	1.8	71	384	30	.9	4.5	641	456	398	922	6.9	100	77
6	Myakka River (at Rocky Ford near Venice)	3- 1-62	.85	3.8	.02	128	29	24	2.0	188	260	37	.7	.2	578	439	285	860	7.6	35	80
		4- 7-65	9.55	1.8	.06	19	3.5	11	1.1	39	20	21	.5	.4	98	62	30	180	7.0	100	78
		5- 5-65	.97	3.9	.05	51	9.0	14	1.4	121	50	28	.4	.0	219	164	65	370	7.4	50	78
2995.5	Myakka River near Venice	5-15-63	f	2.5	.04	152	161	1,370	58	171	450	2,320	.7	.3	4,600	1,040	900	5,200	7.5	60	83
		4- 7-65	-	2.1	.06	26	6.6	15	1.3	58	30	27	.5	.0	138	92	44	252	7.0	100	78
		5- 4-65	f	4.5	.05	238	11	113	3.7	164	413	235	.6	1.1	1,100	639	504	1,620	7.6	50	77
7	Blackburn Dolomite Pit (near Venice)	2-22-62	-	8.1	.02	134	58	148	4.0	312	214	290	.6	.8	1,010	573	318	1,650	8.0	8	71

8	Blackburn Canal (near Venice)	4- 7-65	f	8.9	.02	284	73	206	5.8	248	704	400	.8	1.6	1,810	1,010	807	2,520	7.6	45	79
9	Myakka River Tributary (near Venice)	4- 6-65	.63	1.3	.03	232	37	140	1.5	300	426	280	.3	1.2	1,270	730	484	1,900	7.8	60	79
		5- 5-65	.40	1.1	.04	254	67	161	1.6	256	524	335	.3	.0	1,470	910	700	2,250	7.6	50	76
10	Myakka River Tributary No. 2 (near Venice)	4- 6-65	.62	9.9	.08	131	10	48	.2	396	38	70	.4	.1	498	370	46	800	8.0	70	78
		5- 5-65	.79	10	.03	137	7.8	24	.3	410	42	34	.3	.1	458	374	38	900	7.9	60	79
11	Myakka River Tributary No. 3 (near Venice)	4- 6-65	.01	3.8	.01	78	12	32	.3	240	50	44	.3	.0	338	244	48	560	7.8	30	82
12	Myakka River Tributary No. 4 (near Venice)	4- 6-65	.03	8.4	.00	96	3.0	20	.1	302	60	30	.3	.4	313	252	4	522	7.8	20	81
		6- 3-65	f-.18															1,910			82
13	Myakka River Tributary No. 5 (near Venice)	4- 6-65	.02	7.3	.00	90	3.3	20	.2	280	72	34	.3	.0	300	238	8	508	7.9	1	81
		6- 3-65	f-.69															16,000			89
14	Deer Prairie Creek (near Venice)	3- 1-62	.14	5.2	.02	59	3.2	12	.3	184	6.8	18	.3	.3	196	160	9	358	7.7	15	75
		4- 7-65	.60	6.1	.01	59	4.1	12	.4	187	6.4	19	.3	.1	200	164	11	340	7.8	20	78
		5- 3-65	.56	7.0	.02	67	2.9	12	.4	199	7.2	20	.3	.1	215	179	16	370	7.7	10	75
15	Deer Prairie Creek at dam (near Venice)	5- 3-65	.55															378			78
16	Warm Mineral (Salt) Spring (near Murdock)	6-15-62	-	17	.00	508	571	5,380	176	158	1,600	9,100	1.8	15	17,400	3,604	3,470	26,600	7.3	5	86
2996	Big Slough Canal near Myakka City	5-17-63	<.07	5.0	.02	69	41	41	.7	161	172	54	1.3	.6	484	340	208	720	7.5	40	77
		4- 5-65	.43	.9	.03	54	21	22	.4	223	28	36	.9	.0	274	222	40	478	7.7	50	86
		5- 5-65	.07	.8	.01	51	31	28	.3	164	94	44	1.0	.0	331	255	120	570	7.7	40	82
17	Big Slough (near Murdock)	2-23-62	.70	1.8	.02	86	31	36	1.2	161	160	68	1.2	.0	465	342	210	810	7.3	30	80
		5- 3-65	.39	3.6	.01	68	24	50	.7	157	112	94	1.1	.0	431	270	142	720	7.6	40	84
2996.5	Big Slough near Murdock, Fla.	2-23-62	.96	1.8	.05	91	40	42	1.1	149	228	73	1.4	.0	552	392	270	975	7.5	30	83
		4- 6-65	1.53	2.4	.02	78	20	37	.6	207	84	65	.8	.0	391	276	106	648	7.8	50	70
		5- 3-65	1.11	2.7	.05	80	12	34	.5	203	62	66	.8	.2	359	250	84	630	7.7	20	72
18	Little Salt Spring (near Murdock)	2-22-62	1.25	19	.01	206	118	700	24	168	467	1,325	2.0	3.0	2,947	1,000	862	5,000	7.6	10	81
19	Big Slough Canal at dam (at North Port Charlotte)	1- 7-65	-	2.4	.02	80	16	36	1.5	215	66	70	.6	.0	379	264	88	618	7.5	40	65
20	Morningstar Waterway (at Port Charlotte)	5-15-63	.1	12	.01	78	7.2	22	.4	252	16	34	.5	.5	295	224	18	510	7.9	30	77
		4- 5-65	0	6.4	.00	136	88	680	26	308	232	1,220	.6	5.5	2,550	700	448	4,240	7.6	20	88
21	Fordham Waterway (at Port Charlotte)	4-11-62	.54	4.4	.03	71	14	75	1.0	170	37	133	.6	.2	420	234	95	766	7.8	60	86
		5-15-63	.2	10	.05	51	1.7	28	.4	186	9.6	46	.6	.6	215	134	22	380	7.2	80	-
		4- 5-65	0	9.4	.02	91	5.1	58	.0	226	33	112	.7	.0	420	248	63	726	7.7	45	81
22	Niagara Waterway (at Port Charlotte)	6-11-62	.19	6.3	.27	18	1.5	20	.0	37	4.4	36	.1	.0	105	51	20	242	6.8	100	85
		5-15-63	.1	4.8	.09	19	.4	22	.4	37	4.4	38	.4	.6	107	49	18	140	6.5	100	77
		4- 5-65	1.40	5.6	.18	53	4.9	24	.2	148	7.2	54	.2	.0	222	152	30	389	7.6	75	87
24	Oyster Creek (near Englewood)	4-11-62	f0.17	5.6	.04	410	282	1,880	49	156	603	3,800	1.2	.4	7,059	1,980	1,850	12,000	7.4	50	76
		5- 3-65	f .04	11	.02	470	335	2,480	54	168	483	5,080	1.4	.8	8,950	2,550	2,410	15,000	7.3	50	75

TABLE 6. (Continued)

Map number (fig. 1)	Station	Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe) [a]	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids [b]	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)	pH	Color	Field Temperature (°F)
				Parts per million																	
25	Alligator Creek (near Venice)	1-17-63	3.24	2.4	.12	125	20	64	2.4	260	130	122	.5	.0	595	396	183	830	8.0	85	-
		4- 8-65	f	8.1	.04	214	8.3	86	.8	313	225	185	.2	.0	881	568	312	1,400	7.9	50	88
2997.	Cow Pen Slough near Bee Ridge	2-20-62	.05	4.9	.02	54	14	24	.2	140	56	44	.7	.6	268	192	78	452	7.4	15	72
		5-16-63	.02	6.7	.02	119	41	22	.9	86	371	33	1.2	.5	638	466	376	-	7.0	20	85
		4- 5-65	.61	4.1	.00	59	11	39	.2	131	71	70	.7	.7	321	192	84	534	7.6	20	81
2997.2	Cow Pen Slough near Laurel	1-15-63	3.87	9.8	.15	109	17	24	3.9	215	134	45	.6	.0	448	336	160	610	8.0	50	-
		4- 8-65	.99	6.0	.02	115	9.5	32	.2	264	100	60	.6	.0	453	326	110	728	7.8	45	78
26	Cow Pen Slough (near Laurel)	2-21-62	.7	7.3	.03	148	15	20	.3	280	192	30	.5	.1	551	431	202	854	7.9	55	81
		1-15-63	5.30	10	.02	119	15	22	3.2	252	128	39	.6	.1	461	360	154	630	7.9	50	65
		4- 8-65	2.22	7.0	.01	144	12	41	.3	291	152	42	.6	.0	542	408	170	790	7.9	50	77
27	Fox Creek (near Laurel)	2-21-62	.05	9.9	.03	140	4.0	13	.1	438	6.0	22	.4	.0	412	366	7	715	7.8	25	70
		1-15-63	.62	8.2	.04	111	5.6	37	3.7	324	22	59	.5	.3	407	300	34	605	8.0	80	63
		5- 4-65	.01	10	.05	123	2.2	26	.3	392	8.0	34	.5	.0	397	316	0	650	8.0	50	83
28	South Creek (near Osprey)	1-17-63	2.17	5.1	.05	97	12	35	7.7	283	32	67	.5	.0	396	292	60	600	8.0	70	66
		5- 4-65	.30	10	.00	180	29	45	1.0	327	283	81	.5	.2	791	570	302	1,200	7.6	20	74
2997.5	Phillippi Creek near Sarasota	2-20-62	3.16	10	.02	138	53	29	3.7	203	348	46	1.2	.1	730	562	396	1,080	7.7	45	71
		5-20-64	8.6	9.5	.08	122	48	27	2.7	179	346	35	1.1	.0	680	502	355	960	7.7	45	79
		4- 9-65	3.74	6.0	.01	130	47	29	2.1	191	352	41	1.0	.1	703	516	360	980	7.8	45	71
		5- 5-65	1.90	9.9	.03	184	15	39	3.1	171	360	60	1.0	.0	757	520	380	1,200	7.4	30	84
29	Phillippi Creek (near Sarasota)	6- 2-65	2.83															961			83
30	Main-B Canal (at Sarasota)	2-19-62	1.50	11	.03	42	12	87	6.8	145	118	60	1.1	6.0	418	154	36	655	7.5	35	73
		4- 9-65	2.20	9.4	.03	40	8.0	20	2.6	97	45	28	.9	8.4	217	133	54	350	7.2	20	75
		5- 4-65	1.44	10	.03	39	11	44	3.5	95	67	63	1.0	.7	292	142	64	530	7.1	30	85

2998.	Phillippi Creek at Sarasota	2-19-62	8.52	7.0	.02	79	30	43	4.8	187	168	55	1.1	1.2	484	320	168	760	7.5	45	76
		4- 9-65	f	5.3	.01	91	28	30	2.4	185	190	44	.9	.1	486	344	192	740	7.5	30	80
		5- 5-65	0	6.7	.01	92	32	42	4.1	181	213	56	1.3	.2	539	360	212	840	7.4	30	80
81	Walker Creek (at Sarasota)	1-29-63	1.44	8.0	.01	152	36	60	3.5	204	312	104	1.1	.0	779	528	359	1,000	7.8	50	72
		4- 8-65	.57	8.5	.02	88	27	62	2.5	215	161	86	1.2	.3	544	330	154	880	7.7	50	80
3000.	Manatee River near Bradenton	c5-10-65	d6.0	5.0	.02	13	4.3	5.5	1.0	50	7.6	9	.4	.0	72	50	9	119	7.2	20	-

a In solution when analyzed.
b Calculated from determined constituents.
c Ten-day composite sample.
d Ten-day mean.
e Five-day composite sample.
f Flow reversed by tide.
< Less than.
> Greater than.
[1] Relatively high flow. Chemical data shown for comparison of high and low flow quality of water.

City of North Port Charlotte withdrew about 200,000 gallons daily from waters impounded behind a low-head dam. Fordham Waterway at Port Charlotte is used as a surface-water collection pond for municipal supply. This source is supplemented with water from shallow wells. On the West Branch Coral Creek near Placida, a low concrete dam maintains a high ground-water level in the well field which supplies Cape Haze, a nearby housing development, with up to 3 million gallons of water per month.

On the north side of the study area, the Braden River has served as the major water supply for the city of Bradenton since October 1939. The reservoir, impounded by a dam, was pumped at the average rate of 2.64 mgd in 1965. A well is maintained as a reserve for severe droughts. Damming of the Manatee River for the Manatee County public supply system was completed in 1967.

The amount of irrigation water withdrawn annually from streams and canals is relatively insignificant.

The flow characteristics of major streams in the study area are indicated by tables 1-5 and the duration curves in figure 3. These streams practically cease flowing for periods of 3 months or more during critical springtime droughts, and storage must be provided if a continuous draft is to be maintained.

DRAFT-STORAGE RELATIONS

Only for the upper Myakka River is the period of discharge record long enough to permit derivation of reliable draft-storage relationships. Upper and Lower Myakka Lakes are the largest and probably the most practicable storage sites in the study area. Their utilization as storage reservoirs is possible because of the considerable volume of water which they can store, their central location with respect to the populated coastal area (fig. 1), and the relatively large amount of water delivered to them annually by the Myakka River (table 5).

Figure 4 shows the stage-volume relationships for Upper and Lower Myakka Lakes below altitudes of 16.0 feet and 14.0 feet above msl, respectively. The total storage, at these two altitudes, is approximately 8,100 acre-feet, including about 40 acre-feet of channel storage at 14.0 feet above msl. The lakes begin to overflow onto much of the surrounding terrain when their altitudes exceed the maximum altitudes shown in figure 4, precluding the practicability of obtaining more storage by maintaining higher lake altitudes. It is noteworthy that, with the present natural and manmade features

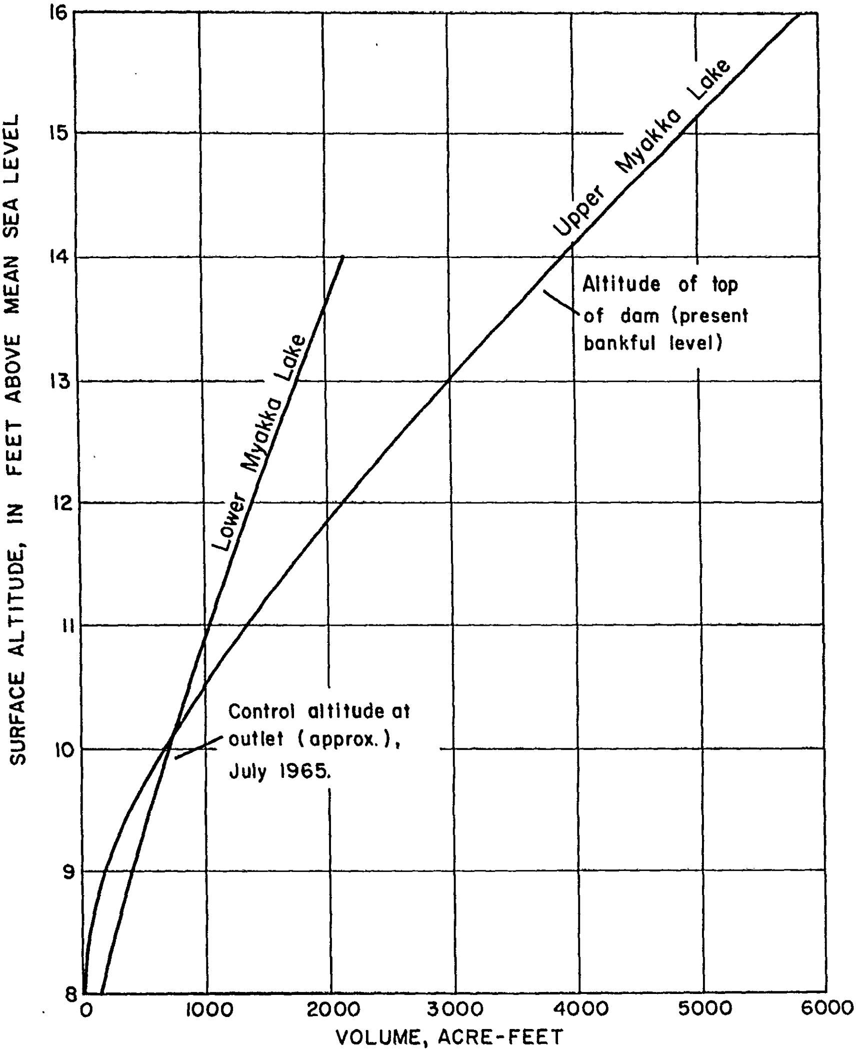

Figure 4. Stage versus volume, Upper and Lower Myakka Lakes.

which control the flow of flood waters through the State Park, these altitudes will be exceeded about once a year on the average.

A draft-storage analysis was made using the discharge records for Myakka River near Sarasota (station No. 2990). Flow at this station, which is downstream from Upper Myakka Lake, is influenced by both the evaporation from Upper Myakka Lake and the upper channel, and seepage inflow in the 2.5 miles of channel between Upper Myakka Lake outlet and the gage. Correlation of monthly mean discharges for the three Myakka River stations near the Park (Nos. 2985, 2990, 2995), for the period January 1946 to June 1951, showed their flows to be nearly equivalent within reasonable limits of error.

A mass curve of daily volumes of flow is shown in figure 5. On the assumption of a full reservoir and beginning with October 1, 1943, volumes in cfs-days were accumulated, chronologically, to prepare this curve. This analysis shows, for example, the storage required to sustain a constant draft rate of 10 cfs (6.46 mgd) from the Myakka River at the Park, during the period of most deficient streamflow since 1936. A line of constant slope equal to a draft rate of 10 cfs was drawn from the point where the slope of the mass curve became less than that of the draft rate to the point of intersection with the mass curve at a later time. The greatest vertical distance between the draft rate line and the mass curve indicates the minimum storage required to supply the hypothetical draft rate which was applied. This study showed that 1,930 cfs-days (3,830 acre-feet) would have been required for a draft of 10 cfs during the period November 1943 through June 1944. This period represented a drought that may be expected to recur, on the average, once every 30 years. Other draft rates may be substituted in figure 5, as shown, to determine the storage required.

A frequency-mass curve for a 30-year recurrence interval of minimum flows, prepared from cumulative volumes, in cfs-days, that were computed from the data in table 2, indicated that only 1,780 cfs-days would have been required to supply the indicated draft rate throughout a drought with a 30-year recurrence interval.

It is noteworthy that a draft of 10 cfs (6.46 mgd) is 1.4 times the average output of the city of Sarasota water system in May 1965, the month of peak pumpage that year. The average aggregate output for 1965 of all public water utilities in Sarasota County was about 6.9 mgd.

In the spring of 1941, the present concrete control at the main outlet of Upper Myakka Lake was constructed to replace, at the same site, a control at a lower altitude which had partially washed out. The crest of the present dam is 13.65 feet above msl. The median level of Upper Myakka Lake, as determined from the flow-duration curve (adjusted to 1940-65) and the stage-discharge relations for station No. 2985, is about 14.0 feet, under present conditions. During the period January 1, 1946 to October 2, 1960, the level fluctuated between about 12.0 and 20.3 feet. Lower Myakka Lake ex-

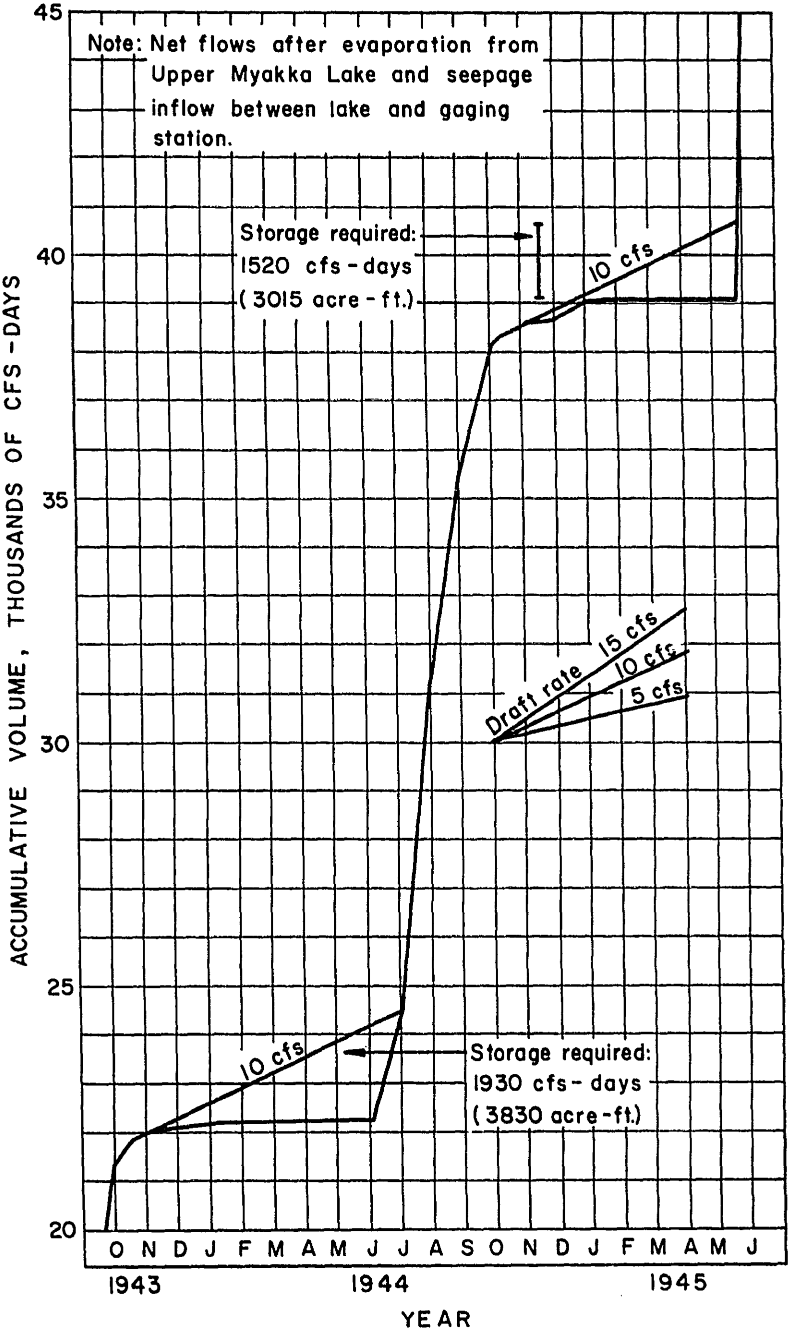

Figure 5. Mass curve of daily volumes, Myakka River near Sarasota, Florida.

perienced similar fluctuations in stage during this period and was completely dry in the spring of 1945 and nearly dry in 1950, after the earthen dam at its outlet had washed out.

If controls had been in place during the drought of 1943-44 to provide 8,100 acre-feet of usable storage in the two lakes, a draft rate of 6.46 mgd could have been obtained and the lake levels would have been no lower than the minimum levels that were actually recorded for that drought. Under such conditions the lower lake would have been nearly dry while the upper lake would have had a minimum altitude of 11.5 feet, with a considerably reduced area.

With the present control altitudes shown in figure 4, total dead storage is about 4,300 acre-feet. However, if these controls were removed during fair weather, the configuration of the lake bottoms are such that, after drainage, Lower Myakka Lake would contain about 100 acre-feet of water and Upper Myakka Lake would contain about 650 acre-feet. The volume of stored water that could be drained from the lakes (8,100 acre-feet full capacity) if the existing controls were removed is estimated to be 7,350 acre-feet.

Streamflow records collected since 1936 indicate that the period June through October 1944 was the summer of most deficient streamflow in the past 30 years. However, the total discharge of the Myakka River near Sarasota during the drought period was in excess of 31,000 acre-feet. This volume is nearly four times that required to fill the two lakes to the suggested practical storage of 8,100 acre-feet. Thus, the assumption of a full reservoir at the beginning of a 30-year drought is reasonably safe.

CONCLUSIONS

Flow-duration data at sites on streams with daily discharge records, and other low-flow measurements, indicate that all natural, or uncontrolled, flow nearly ceases in the non-tidal reaches of those streams included within the area of investigation during severe droughts. The condition of no flow in all streams may be expected to occur once about every 5 years on the average; however, most small streams practically go dry during the period March through May of most years.

The smaller streams, canals, and sloughs are not reliable sources of water due to their intermittency and low annual yields. Fordham Waterway in Port Charlotte; West Branch of Coral Creek near Placida; and the Braden River are currently being utilized, directly or indirectly, as municipal water supplies. The quality of the water in the streams and canals is generally good except where affected by tidal waters, salty springs, or ground-water flow from wells. Upper and Lower Myakka Lakes, through which the Myakka River flows, have a total practicable storage capacity of about 8,100 acre-feet. Usable storage, without dredging of the lake bottoms, is about 7,350 acre-feet. Since 1936, river discharge during the summer months has been more than three times the practicable storage capacity. This supply of water, if adequately controlled by dams, would amply provide for a draft rate of 6.5 mgd of water of good chemical quality during a 30-year drought. This water would be subject to the quality limitations that are characteristic of water in shallow reservoirs located in sub-tropical regions: high temperatures, high color, a dissolved iron content of about 0.3 ppm, and occasionally suspended organic matter.

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