Drainage-Return, Surface-Water Withdrawal, and Land-Use Data for the Sacramento-San Joaquin Delta, with Emphasis on Twitchell Island, California

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U.S. GEOLOGICAL SURVEY

Open-File Report 97-350

Prepared in cooperation with the
CALIFORNIA DEPARTMENT OF WATER RESOURCES

6217-34

Sacramento, California
1997

U.S. DEPARTMENT OF THE INTERIOR
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CONVERSION FACTORS, VERTICAL DATUM, DEFINITION, AND SELECTED WATER-UNIT RELATIONS

Conversion Factors

Multiply	By	To obtain
acre	0.4047	hectare
acre-foot (acre-ft)	1,234	cubic meter
acre-foot per year (acre-ft/yr)	1,234	cubic meter per year
mile (mi)	1.609	kilometer
square mile (mi^2)	259.0	hectare
	2.590	square kilometer

Vertical Datum

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

Definition

An acre-foot is the quantity of water required to cover 1 acre to a depth of 1 foot.

Selected Water-Unit Relations

1 gallon = 8.3453 pounds
1 million gallons = 3.07 acre-feet
1 thousand acre-feet per year = 1.121 million gallons per day
1 cubic foot = 62.4 pounds
1 cubic foot = 7.48 gallons
1 acre-foot = 325,851 gallons
1 acre-foot = 43,560 cubic feet
1 kilowatt = 0.7457 horsepower
1 kilowatt hour = 0.000293 British Thermal Units

Drainage-Return, Surface-Water Withdrawal, and Land-Use Data for the Sacramento-San Joaquin Delta, with Emphasis on Twitchell Island, California

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ABSTRACT

Partial data on drainage returns and surface-water withdrawals are presented for areas of the Sacramento-San Joaquin Delta, California, for March 1994 through February 1996. These areas cover most of the delta. Data are also presented for all drainage returns and some surface-water withdrawals for Twitchell Island, which is in the western part of the delta. Changes in land use between 1968 and 1991 are also presented for the delta.

Measurements of monthly drainage returns and surface-water withdrawals were made using flowmeters installed in siphons and drain pipes on Twitchell Island. Estimates of monthly returns throughout the delta were made using electric power-consumption data with pump-efficiency-test data. For Twitchell Island, monthly measured drainage returns for the 1995 calendar year totaled about 11,200 acre-feet, whereas drainage returns estimated from power-consumption data totaled 5 percent less at about 10,600 acre-feet. Monthly surface-water withdrawals onto Twitchell Island through 12 of the 21 siphons totaled about 2,400 acre-feet for 1995. For most of the delta, the monthly estimated drainage returns for 1995 totaled about 430,000 acre-feet. The area consisting of Bouldin, Brannan, Staten, Tyler, and Venice Islands had the largest estimated drainage returns for calendar year 1995.

Between 1968 and 1991, native vegetation in the delta decreased by 25 percent (about 40,000 acres), and grain and hay crops increased by 340 percent (about 71,000 acres). For Twitchell Island, native vegetation decreased about 77 percent (about 850 acres), while field crop acreage increased by about 44 percent (about 780 acres).

INTRODUCTION

The Sacramento-San Joaquin Delta of California is an area consisting of about 738,000 acres of islands and channels (fig. 1) that receive runoff from about 40 percent of the State's land area (California Department of Water Resources, 1993). About 500,000 acres of the delta is agricultural land, much of which is below sea level and is dependent on levees for protection from flooding. The delta is part of California's water-delivery system, which stores water in reservoirs north and south of the delta and delivers irrigation water to millions of acres of farm land south of the delta and drinking water to two-thirds of the State's population. Many of California's water issues involve delta water use issues.

In 1993, a cooperative study of the Sacramento-San Joaquin River Delta was started by the U.S. Geological Survey (USGS) and the California Department of Water Resources (DWR), Division of Local Assistance, Municipal Water Quality Investigations Section, and Division of Planning, Delta Modeling Section. The purpose of the study was to update drainage-return data for delta islands, to quantify surface-water withdrawls, and to compile digitized land-use data needed to improve DWR's model of consumptive use on the delta islands.

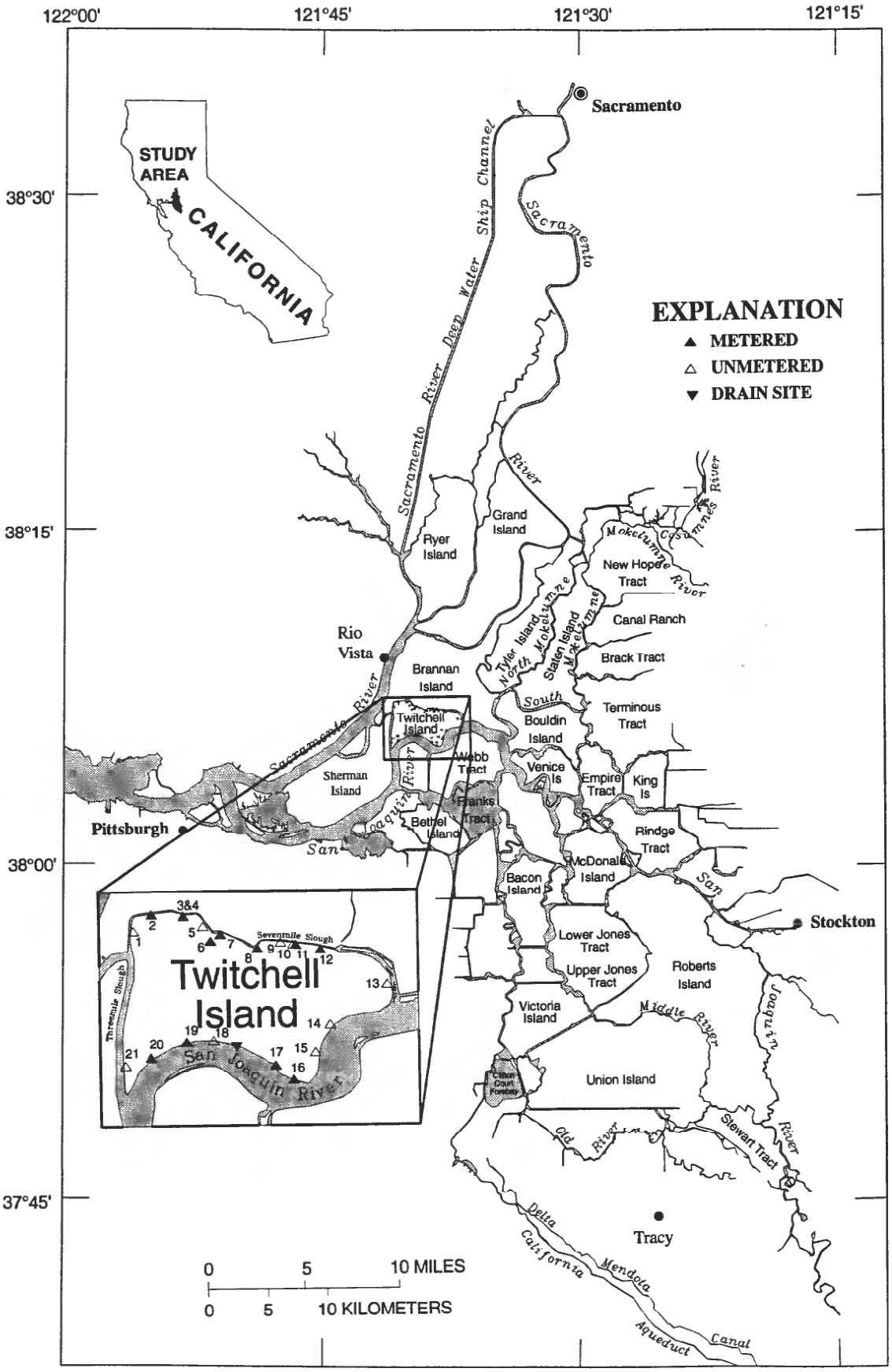

Figure 1. Locations of the Sacramento-San Joaquin Delta and of the withdrawal siphons and the drain site on Twitchell Island.

The methods used for the drainage study are similar to the methods used during a study by the California Department of Water Resources (1956). Since 1956, the need for more current water-use information has increased with increased concerns about water and land use in the delta and the effects of these uses on the quality and quantity of water available from the delta. Knowledge of water consumption in the delta is needed to estimate freshwater discharge to San Francisco Bay. Agricultural drainage pumped off the islands into delta channels contains natural organic chemicals that form carcinogens (such as trihalomethanes) when the water is chlorinated for municipal use. Island drainage also introduces pesticide residues into the habitat of threatened fish species.

The objectives of this study were to estimate drainage returns using electrical power-consumption data, to measure selected surface-water withdrawals, to digitize land-use maps for 1968, and to compare the 1968 maps with the digital land-use maps available for 1991. The study involved estimating drainage returns for 236 drains with electrically powered pumps, quantifying surface-water withdrawals at 12 of the 1,800 surface-water withdrawal sites, and digitizing the 1968 land-use maps. Twitchell Island was selected for intensive monitoring of drainage returns and surface-water withdrawals because it is owned by DWR and because one of the withdrawal siphons on the island was already being measured.

The purpose of this report is to present data on delta drainage returns and surface-water withdrawals collected between March 1994 and February 1996, a tabulation of changes in delta land use between 1968 and 1991 for the areas of DWR's consumptive-use model, and methods used to obtain these data.

The authors gratefully acknowledge the assistance of personnel from other agencies and companies who have contributed to this study. In particular, we would like to recognize Rick Carter, Linda Carter, and Joe DaCruz, Reclamation District 1601; Todd Bruce and Michael Menard, Pacific Gas and Electric Company; Kim Robinson, Electronic Engineering; Leonard Kirkpatrick, Kirkpatrick & Associates; and Ted Mayer, Sharman Incorporated.

DRAINAGE RETURNS

To prevent flooding of the delta islands, drainage returns—which are a combination of precipitation, seepage, unconsumed irrigation water, and surface-water withdrawals for other uses—are pumped into adjacent channels (fig. 2). To obtain a record of Twitchell Island's drainage returns, DWR collected weekly drainage-return and electric power-consumption data at its one drain site (fig. 1). Independently, USGS collected monthly drainage-return and electric power-consumption data at the Twitchell Island drain site and obtained monthly power-consumption records from Pacific Gas and Electric Company (PG&E). USGS used this power-consumption data with pump-efficiency-test data provided by PG&E, Twitchell Island Reclamation District, and DWR to make additional drainage-return estimates.

Measurement Using Flowmeters

The drain on Twitchell Island was equipped with a flowmeter during this study; it is the only drain site of the 236 drains (fig. 3) in the PG&E data base known to be equipped with a flowmeter. Thus, drainage returns were measured at this drain site. McCrometer invasive flowmeters with straightening vanes were used to measure flows discharged by the main pump and the auxiliary pump at the drain site. These flowmeters are reported to have an absolute relative error of less than 2 percent (Schwankl and Hanson, 1993, p. 6). The data were obtained by manually recording dial readings and calculating cumulative flows. Electric power-consumption readings were also manually recorded during each visit.

DWR recorded weekly drainage returns for Twitchell Island between August 1994 and January 1996 (table 1). USGS recorded monthly drainage returns within 1 day of the first day of each month (table 2). Drainage returns pumped from Twitchell Island during 1995 totaled 11,232 acre-ft (table 2). The largest monthly drainage returns during 1995 were pumped during January and March (2,499 and 1,926 acre-ft, respectively), and the smallest monthly total returns were pumped during September, October, and November (323, 298, and 340 acre-ft, respectively) (table 2).

Estimates Using Electric Power-Consumption Data

Drainage returns can be estimated using electric power-consumption data with pump-efficiency-test data. PG&E maintains a pump-efficiency-test data base that includes 58 of 236 drains in the delta for which they have electric power-consumption records. Additional drains may operate in the delta, but a complete inventory of the drains in the delta was beyond the scope of this study. At the time of this study, the data

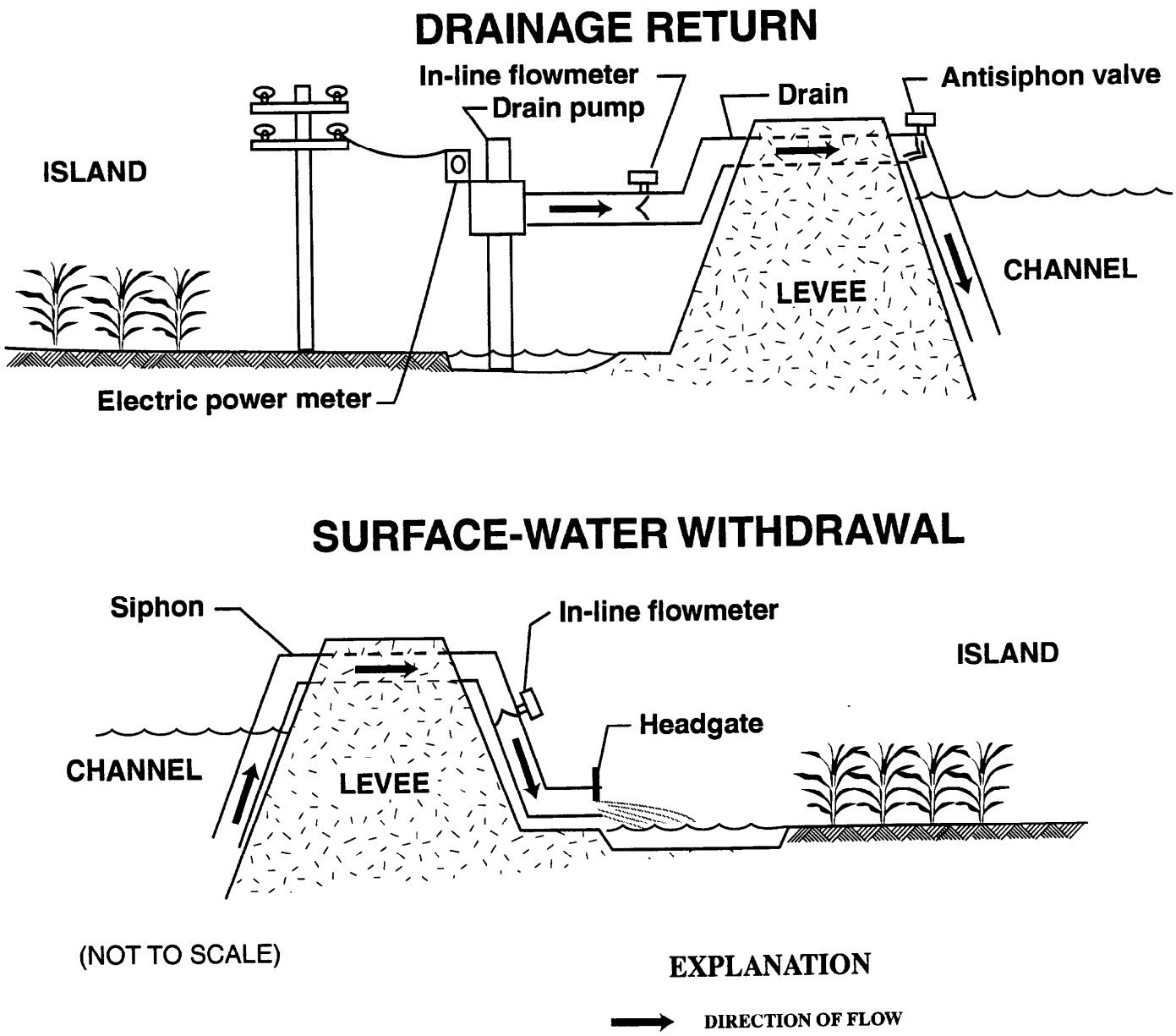

Figure 2. A schematic of a drainage-return site and a surface-water withdrawal siphon similar to those on Twitchell Island in the Sacramento-San Joaquin Delta, California.

base contained data on 220 pump-efficiency tests done at the 58 drains. USGS acquired the power records from PG&E with an agreement that the records would be released only after being aggregated into areas more than 36 mi^2. For Twitchell Island, USGS computed monthly drainage-return estimates using power-consumption data collected during site visits with PG&E pump-efficiency data.

Methods

An empirical equation called the unit power-consumption method (Diamond and Williamson, 1983, p. 7) or the coefficient of power method (Ogilbee and Mitten, 1970, p. 7) was used to estimate drainage returns from the power-consumption data. The equation has the form

pumpage (acre-feet) = power (kilowatt hours)/unit-use coefficient (kilowatt hours per acre-foot).

The unit-use coefficient is determined by conducting pump-efficiency tests during which pumpage and power consumption are measured. The unit power-consumption method is the most convenient method of estimating pumpage because the needed data are

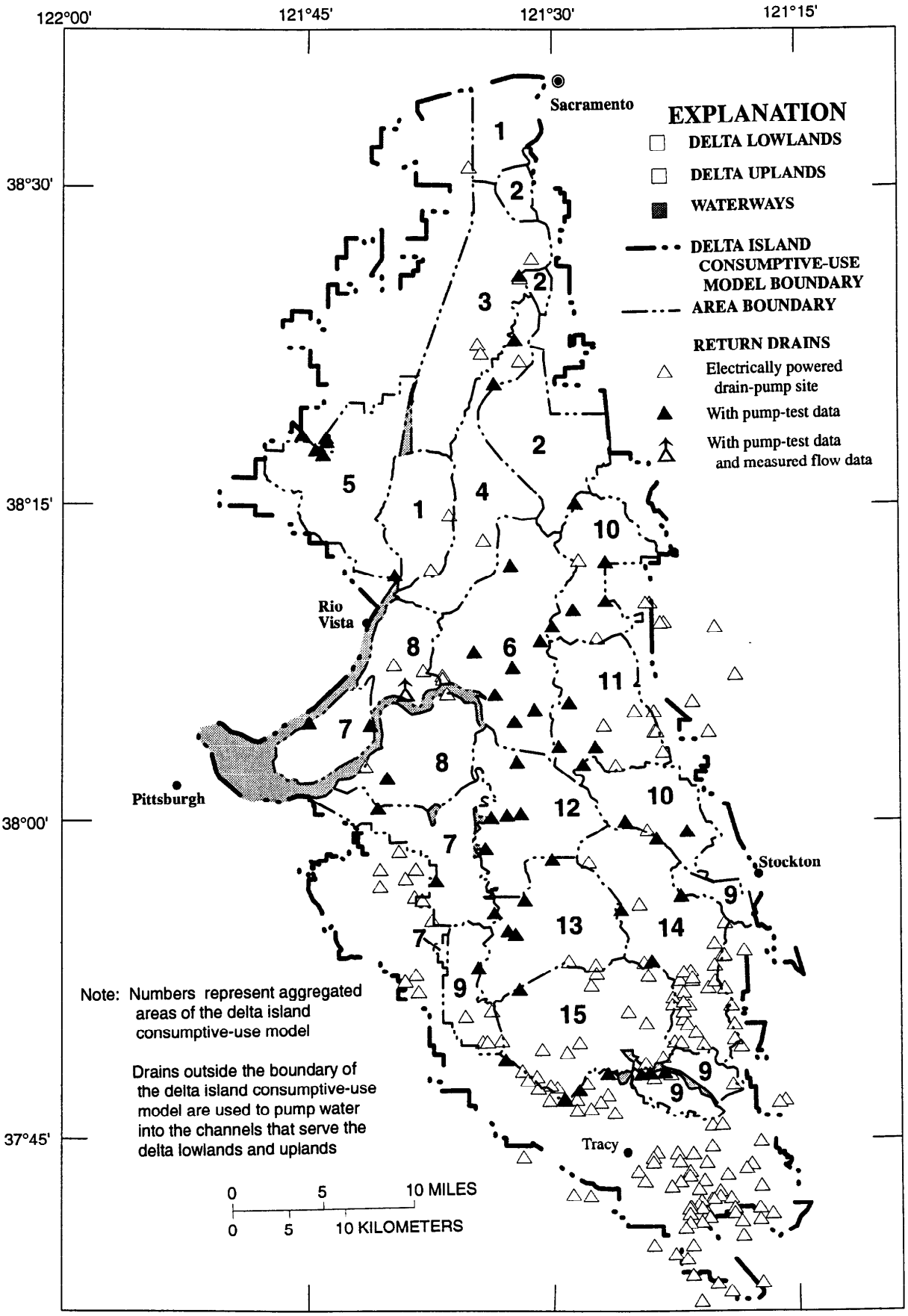

Figure 3. Locations of the return drains in the Sacramento-San Joaquin Delta, California, and of the aggregated areas of the California Department of Water Resources' delta island consumptive-use model. Boundaries of areas generally are the channels.

Table 1. Drainage returns from Twitchell Island in the Sacramento-San Joaquin Delta measured weekly by the California Department of Water Resources, August 9, 1994, to January 8, 1996[1]

[Values, in acre-feet, are the differences between successive readings of cumulative flows. NR, not read]

Date meter was read	East pump	West pump	Total	Date meter was read	East pump	West pump	Total
08/09/94	67.32	282.75	350.07	05/01/95	0	112.50	112.50
08/16/94	NR	NR	NR	05/08/95	67.48	96.55	164.03
08/23/94	65.95	329.59	395.54	05/15/95	50.14	104.18	154.32
08/30/94	19.04	117.75	136.79	05/22/95	2.67	143.28	145.95
				05/29/95	0	157.26	157.26
09/06/94	17.37	95.59	112.96				
09/13/94	15.98	128.59	144.57	06/05/95	3.46	115.04	118.50
09/20/94	20.80	156.33	177.13	06/12/95	10.80	110.59	121.39
09/27/94	20.24	153.54	173.78	06/19/95	16.92	110.55	127.47
				06/26/95	4.67	134.16	138.83
10/05/94	28.34	182.99	211.33				
10/11/94	20.11	127.87	147.98	07/03/95	.27	143.92	144.19
10/17/94	14.06	103.58	117.64	07/10/95	0	114.22	114.22
10/26/94	33.51	69.50	103.01	07/17/95	0	145.04	145.04
				07/24/95	0	157.27	157.27
11/02/94	3.80	73.66	77.46	07/31/95	0	225.91	225.91
11/09/94	0	101.64	101.64				
11/16/94	0	111.43	111.43	08/07/95	0	206.58	206.58
11/23/94	0	106.94	106.94	08/14/95	0	210.03	210.03
11/30/94	0	122.12	122.12	08/21/95	0	205.90	205.90
				08/28/95	0	173.57	173.57
12/07/94	.10	141.97	142.07				
12/14/94	.00	156.98	156.98	09/05/95	0	135.69	135.69
12/21/94	.13	199.69	199.82	09/11/95	0	69.04	69.04
12/28/94	NR	NR	NR	09/18/95	0	72.04	72.04
				09/25/95	21.59	46.98	68.57
01/04/95	115.06	538.40	653.46				
01/11/95	213.27	287.17	500.44	10/02/95	43.06	29.53	72.59
01/18/95	267.25	297.04	564.29	10/10/95	25.57	47.03	72.60
01/25/95	261.30	298.15	559.45	10/16/95	27.39	38.49	65.88
				10/23/95	4.16	56.00	60.16
02/01/95	252.60	300.25	552.85	10/30/95	NR	NR	NR
02/08/95	68.74	303.86	372.60				
02/15/95	12.71	282.78	295.49	11/06/95	32.36	116.49	148.85
02/22/95	14.07	274.10	288.17	11/14/95	NR	NR	NR
				11/20/95	63.53	89.45	152.98
03/01/95	.39	213.76	214.15	11/27/95	0	74.73	74.73
03/08/95	61.26	279.53	340.79				
03/15/95	213.30	321.45	534.75	12/04/95	55.60	24.96	80.56
03/22/95	125.35	299.82	425.17	12/11/95	NR	NR	NR
03/29/95	226.37	330.73	557.10	12/18/95	119.65	191.67	311.32
04/05/95	.11	207.22	207.33	01/08/95	66.57	711.60	778.17
04/12/95	.25	177.72	177.97				
04/19/95	6.91	161.85	168.76				
04/26/95	.20	163.79	163.99	Total	2,781.78	11,870.38	14,652.16

[1]Because of differences in periods of record, monthly totals for these meter readings may not agree with totals in table 2. However, the total for August 1994 through December 1995 agree (14,652 acre-feet).

usually available (Ogilbee and Mitten, 1970, p. 7; Diamond and Williamson, 1983, p. 7).

For Twitchell Island, the mean unit-use coefficient for all PG&E pump-efficiency tests provided by the Twitchell Island Reclamation District, 50 kilowatt hours per acre-ft, was used with USGS records of electrical power consumption for the Twitchell Island drain to calculate drainage returns. For the 58 drains in the

Table 2. Drainage returns from Twitchell Island in the Sacramento-San Joaquin Delta, California, measured monthly by the U.S. Geological Survey, August 1994 through January 1996

[Values are in acre-feet]

Month	West pump	East pump	Total
1994			
August	743	155	898
September	590	82	672
October	477	89	566
November	469	0	469
December	815	0	815
Total	3,094	326	3,420
1995			
January	1,390	1,109	2,499
February	1,074	96	1,170
March	1,300	626	1,926
April	756	7	763
May	535	121	656
June	521	36	557
July	736	0	736
August	846	0	846
September	265	58	323
October	227	71	298
November	224	116	340
December	903	214	1,118
Total	8,777	2,454	11,232
Total for 1994-95	11,871	2,780	14,652
1996			
January	1,007	326	1,333
Total for period of record	12,878	3,106	15,985

delta with pump-efficiency-test data, the mean unit-use coefficient for each drain was used with PG&E power-consumption records to calculate drainage returns. These coefficients ranged from a high of 83 kilowatt hours per acre-ft to a low of 18 kilowatt hours per acre-ft. For the remaining 178 drains in the delta for which no pump-efficiency-test data were available, using pump horsepower to infer a unit-use coefficient was considered. However, coefficient-horsepower plots of the 220 pump-efficiency-test results indicated that the correlation of the data in the present pump-efficiency-test data base is poor (fig. 4). Therefore, the mean unit-use coefficient of all pump tests in the pump-efficiency-test data base, 40.6 kilowatt hours per acre-ft, was used with the power-consumption data to calculate drainage returns for the remaining 178 drains. Drainage-return estimates were aggregated into larger areas using the geographic information system, ARC/INFO.

Results

Drainage returns from Twitchell Island were estimated using both USGS and PG&E power-consumption records for the drain (table 3, fig. 5). Both USGS and PG&E power-consumption records indicate that the total drainage-return estimates for 1995 was about 10,600 acre-ft. The total for estimated returns was about 5 percent less than the total for the measured returns (about 11,200 acre-ft). Monthly drainage returns for 1995, estimated from USGS power-consumption records, ranged from 14 percent less than the measured returns in April to almost 4 percent more than the measured returns in December (table 3). Differences between the estimated monthly drainage returns generated from USGS and DWR power-consumption records probably result primarily because of different intervals between the meter readings. The most notable difference was in March 1995 (fig. 5); this large difference occurred because the meter had not been read by PG&E since December 1994.

Monthly drainage returns were estimated for the 236 drains in the delta using PG&E power-consumption data for January 1995 through February 1996. The estimates for the 236 drains were aggregated into 62 of the 142 subareas in DWR's delta island consumptive-use model; these 62 subareas cover most of the delta (the shaded areas on fig. 6). To meet a confidentiality agreement with PG&E, which restricts the releasing of pumping data for individual accounts or for areas of less than 36 mi^2, the estimates for the drainage returns were then aggregated into 17 areas for reporting (table 4): the 15 areas within the delta island consumptive-use model area, which represent the delta lowlands; the delta upland area; and the area just outside the boundary of the delta island consumptive-use model (fig. 3). (The drains outside the delta island consumptive-use model boundary are used to pump water into the channels that serve the delta lowlands and uplands and thus were used for this study.) The data were aggregated using ARC/INFO (fig. 6). Of the 236 drains with power-consumption data, 215 of the drains are in the 62 subareas, with 91 of the drains in the delta uplands; the remaining 21 drains are outside the model boundary. Area 2 is the only aggregated area for which there were no power-consumption data available to make drainage estimates.

Area 6 (fig. 3), which consists of Bouldin, Brannan, Staten, Tyler, and Venice Islands, had the largest estimated drainage returns (about 73,000 and 96,400 acre-ft for calendar year 1995 and for the period

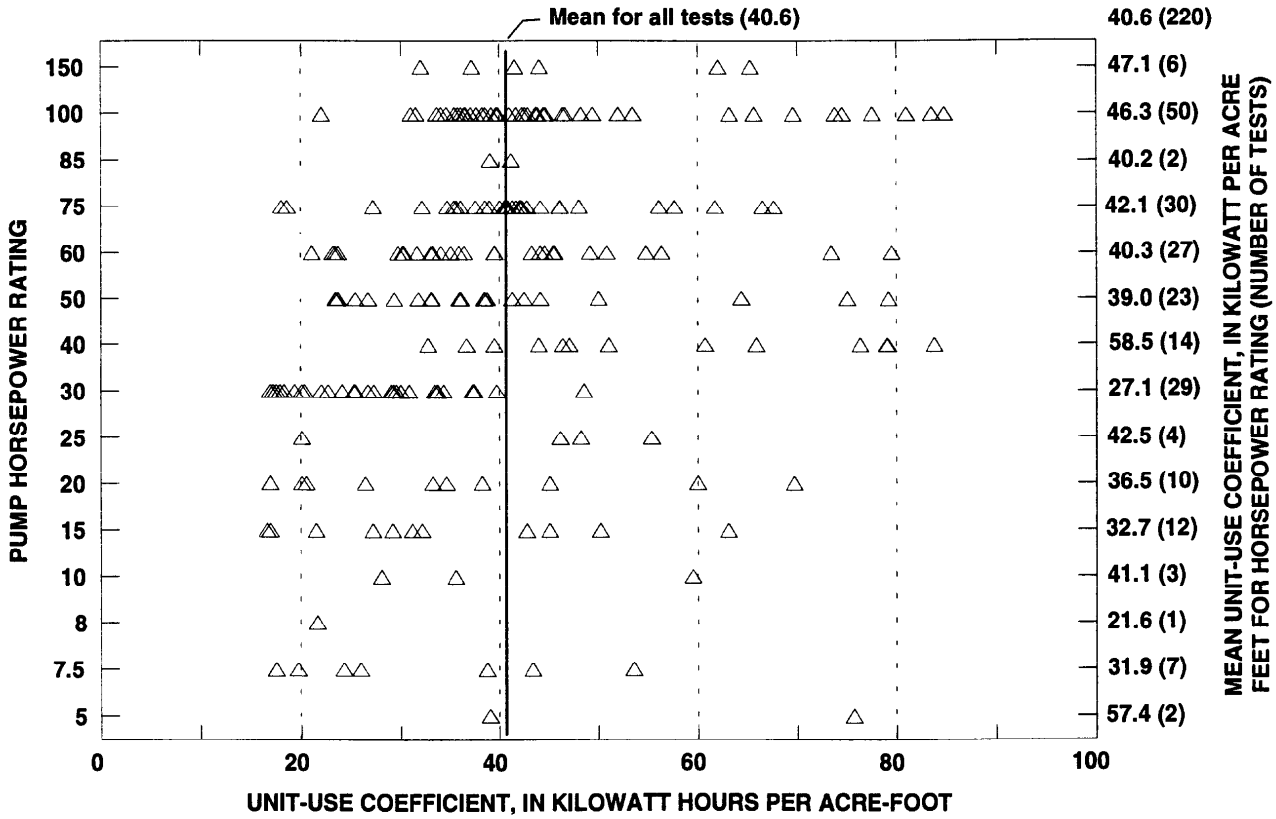

Figure 4. Horsepower ratings of pumps as related to unit-use coefficients derived from pump-efficiency tests for drains in the Sacramento-San Joaquin Delta, California.

January 1995 through February 1996, respectively, table 4). The 1995 estimate for area 6 was about 17 percent of the total estimated drainage returns (430,000 acre-ft) for the delta and about 18 percent of the total estimated drainage returns (about 537,000 acre-ft) for the period January 1995 through February 1996. Monthly drainage-return estimates were largest in March 1995 (about 61,900 acre-ft) and smallest in November 1995 (about 11,200 acre-ft). Drainage-return estimates were also large in August 1995 and January and February 1996 (about 53,100; 50,600; and 55,100 acre-ft, respectively) (table 4).

SURFACE-WATER WITHDRAWALS ONTO TWITCHELL ISLAND

Water is siphoned from the channels of the delta over the levees onto the islands (fig. 2). The hydraulic properties of each siphon and the opening of the delivery end of the pipe control the flow rate through each siphon. Although the hydraulic properties of a siphon can be readily estimated, doing so for a large number of siphons is a laborious task that had not been done at the time of this study. Even if hydraulic information were available, data on the time histories of pipe openings and tides would also be needed to estimate the quantities of water withdrawn by a siphon. Instead of recording pipe openings and tides, USGS and DWR used flowmeters to measure withdrawals onto Twitchell Island for 12 of the 21 siphons.

Methods

At the time of this study, DWR (Environmental Services Office) and the California Department of Fish and Game were using McCrometer flowmeters in a study of the effectiveness of fish screens on siphons in the delta, including siphon 16 on Twitchell Island (fig. 1). Eleven additional McCrometer flowmeters were installed on the siphons on Twitchell Island for this study. The flowmeters were operated by DWR and USGS. The data were obtained by manually recording dial readings and calculating cumulative flows.

Results

DWR recorded flowmeter readings weekly between August 9, 1994, and January 8, 1996 (table 5)

Table 3. Drainage returns from Twitchell Island in the Sacramento-San Joaquin Delta, California, estimated and measured monthly by the U.S. Geological Survey, August 1994 through January 1996

[Values are in acre-feet. USGS, U.S. Geological Survey; PG&E, Pacific Gas and Electric Company]

Month	Estimated drainage returns using data collected by USGS (A)	Estimated drainage returns using data from PG&E (B)	Metered drainage returns (C)	Difference between estimated returns (USGS data) and metered returns (A - C)	Percent difference $\frac{A-C}{C}x100$	Difference between estimated returns (PG&E data) and metered returns (B - C)	Percent difference $\frac{B-C}{C}x100$
1994							
August	743	0	898	-155	-17.3	-898	-100.0
September	599	855	672	-73	-10.9	183	27.2
October	512	1,289	566	-54	-9.5	723	127.7
November	391	1,319	469	-78	-16.6	850	181.2
December	698	741	815	-117	-14.4	-74	-9.1
Total (excludes percentages)	2,943	4,204	3,420	-477	-13.9	784	22.9
1995							
January	2,489	0	2,499	-10	-0.4	-2,499	-100.0
February	1,077	0	1,170	-93	-7.9	-1,170	-100.0
March	1,809	6,239	1,926	-117	-6.1	4,313	223.9
April	653	0	763	-110	-14.4	-763	-100.0
May	586	1,205	656	-70	-10.7	549	83.7
June	483	0	557	-74	-13.3	-557	-100.0
July	647	1,039	736	-89	-12.1	303	41.2
August	751	796	846	-95	-11.2	-50	-5.9
September	317	0	323	-6	-1.9	-323	-100.0
October	296	288	298	-2	-0.7	-10	-3.4
November	349	354	340	9	2.6	14	4.1
December	1,160	663	1,118	42	3.8	-455	-40.7
Total (excludes percentages)	10,617	10,584	11,232	-615	-5.5	-648	-5.8
1996							
January	1,457	1,812	1,333	124	9.2	479	35.9
TOTAL (excludes percentages)	15,017	16,600	15,985	-968	-6.1	615	3.8

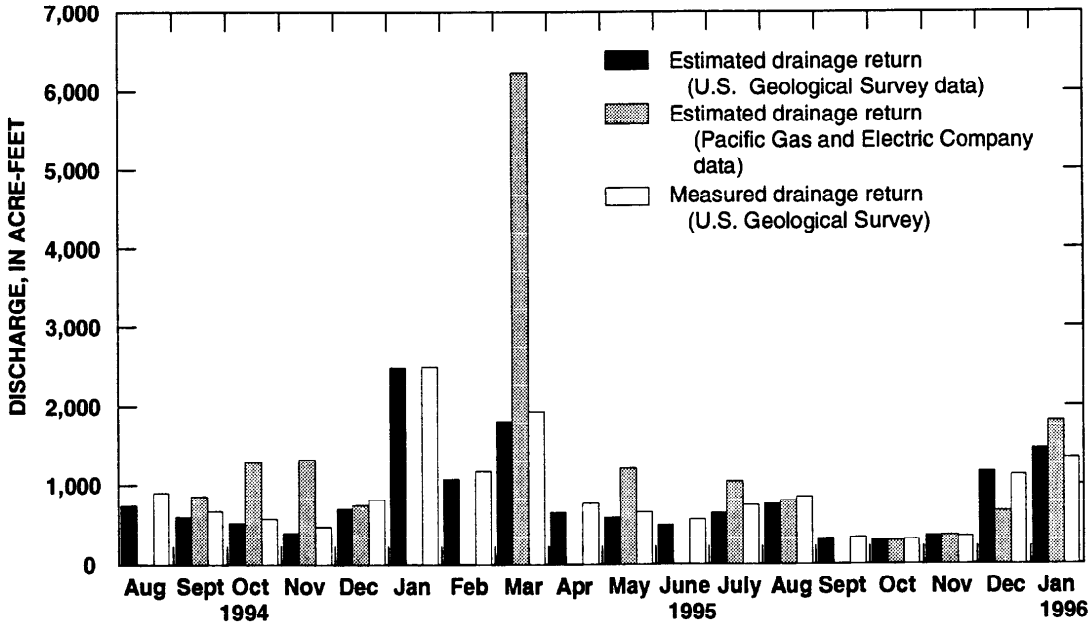

Figure 5. Estimated and measured monthly totals for drainage returns from Twitchell Island in the Sacramento-San Joaquin Delta, California, August 1994 through January 1996. Estimates were made by the U.S. Geological Survey using U.S. Geological Survey and Pacific Gas and Electric Company data.

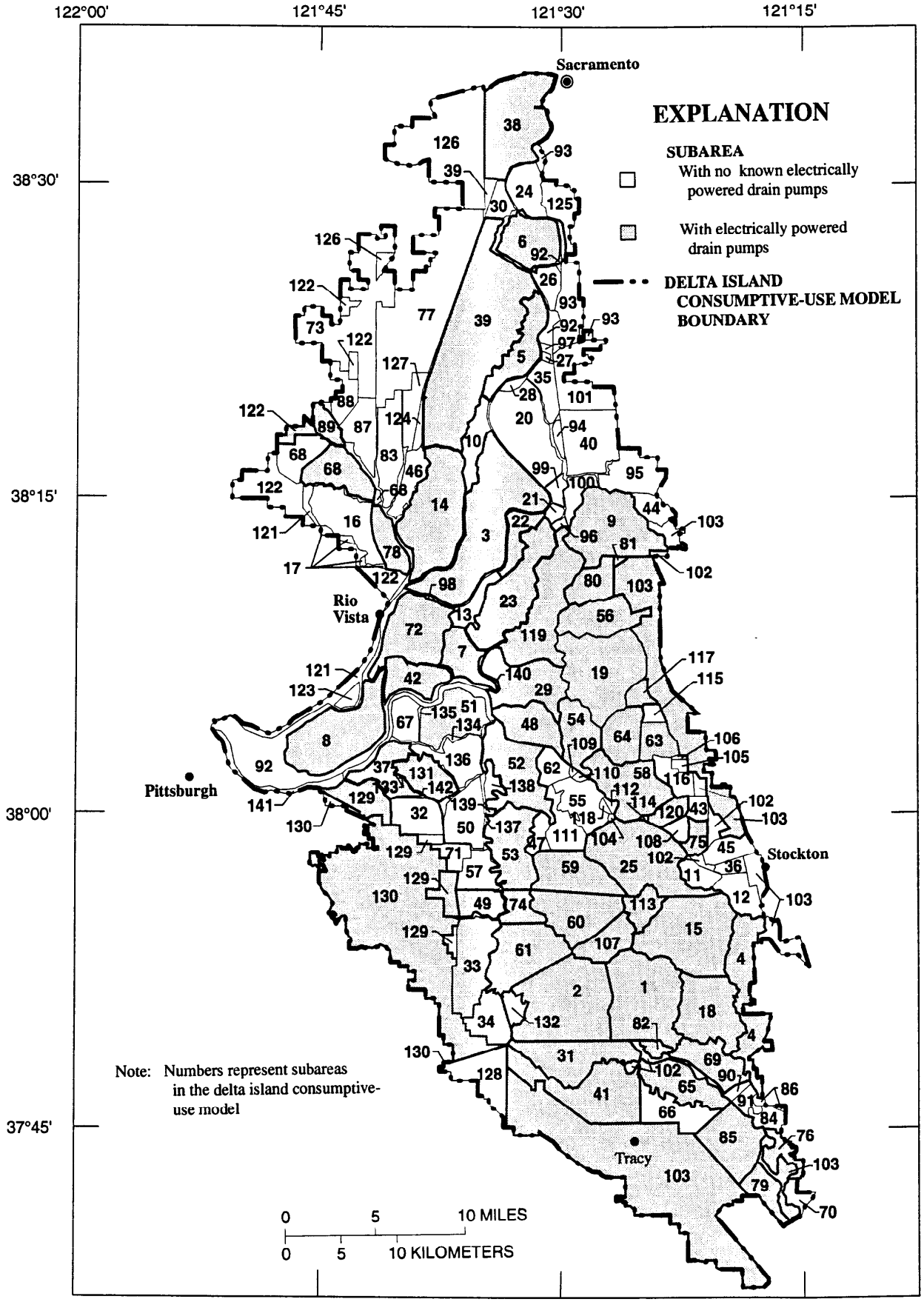

Figure 6. Subareas of the California Department of Water Resources' delta island consumptive-use model for the Sacramento-San Joaquin Delta, California.

Table 4. Drainage returns estimated monthly for aggregated areas of the California Department of Water Resources' delta island consumptive-use model for the Sacramento-San Joaquin Delta, California, January 1995 through February 1996

[Area 2 is omitted because no power-consumption data were available. Values are in acre-feet. Area boundaries are shown on figure 3]

	Aggregated area								
	([1])	1	3	4	5	6	7	8	9
Number of pumps	**21**	**2**	**5**	**4**	**2**	**9**	**6**	**6**	**13**
1995									
January	5	0	1,037	0	0	3,086	37	95	184
February	59	0	953	1,638	1,205	6,233	2,523	173	1,047
March	4	0	838	591	2,472	19,409	2,310	6,374	225
April	90	384	1,413	1,756	288	3,254	2,251	163	2,098
May	301	0	329	726	472	9,545	834	13,463	2,246
June	538	0	294	4,487	671	5,046	885	525	2,095
July	323	0	164	406	1,156	4,573	1,345	2,425	3,436
August	538	0	182	490	1,261	8,957	26	2,865	3,614
September	555	0	109	8	0	1,634	0	0	62
October	233	0	9	216	157	1,910	41	391	1,438
November	115	0	13	0	145	2,217	45	662	188
December	8	0	50	152	264	7,313	187	2,175	372
Total	2,769	384	5,391	10,470	8,091	73,177	10,484	29,311	17,005
1996									
January	25	0	276	404	437	13,432	208	3,451	210
February	41	0	688	1,146	1,295	9,838	538	3,828	487
Total	66	0	964	1,550	1,732	23,270	746	7,279	697
TOTAL	2,835	384	6,355	12,020	9,823	96,447	11,230	36,590	17,702

	Aggregated area							
	10	11	12	13	14	15	([2])	Total
Number of pumps	**12**	**8**	**5**	**7**	**29**	**16**	**91**	**236**
1995								
January	8,383	4,907	7,115	7,832	3,627	611	744	37,663
February	6,941	2,681	5,262	11,689	3,626	116	1,385	45,531
March	10,683	6,227	4,865	3,851	1,297	1,429	1,280	61,855
April	5,367	2,441	5,620	10,253	3,586	316	2,859	42,139
May	3,953	1,010	1,409	2,998	3,277	1,433	3,198	45,194
June	3,542	2,196	2,063	2,570	2,596	729	5,066	33,303
July	7,133	4,278	2,082	1,754	4,015	1,123	4,781	38,994
August	7,529	3,844	6,062	6,612	4,368	922	5,816	53,086
September	5,197	1,784	2,809	2,882	3,879	446	4,595	23,960
October	2,594	582	1,623	1,905	1,875	402	2,824	16,200
November	1,971	592	1,896	1,927	705	114	614	11,204
December	4,286	3,000	1,547	1,788	303	287	318	22,050
Total	67,579	33,542	42,353	56,061	33,154	7,928	33,480	431,179
1996								
January	4,361	4,635	8,024	10,876	3,266	473	486	50,564
February	12,391	6,252	4,963	7,701	3,841	865	1,199	55,073
Total	16,752	10,887	12,987	18,577	7,107	1,338	1,685	105,637
TOTAL	84,331	44,429	55,340	74,638	40,261	9,266	35,165	536,816

[1]Area outside the delta uplands and lowlands.

[2]Delta uplands.

Table 5. Surface-water withdrawals from the 12 metered siphons on Twitchell Island in the Sacramento-San Joaquin Delta, California, measured weekly by the California Department of Water Resources, August 9, 1994, through January 8, 1996

[Values are in acre-feet. NR, not read; --, no data. Because of different periods of record, these totals will not agree with totals for period in table 6]

Date meter was read	Siphon number and flowmeter number												Total
	No. 2, 95-981-12	No. 3, 95-983-8	No. 4, 94-4586-12	No. 6, 94-5142-08	No. 7, 95-985-16	No. 8, 95-980-10	No. 11, 95-987-18	No. 12, 95-982-12	No. 16, 92-1612-7	No. 17, 94-4559-24	No. 19, 95-986-16	No. 20, 95-984-16	
08/09/94	--	--	--	NR	--	--	--	--	25.06	26.71	--	--	51.77
08/16/94	--	--	--	NR	--	--	--	--	11.23	NR	--	--	11.23
08/23/94	--	--	--	NR	--	--	--	--	18.58	26.02	--	--	44.60
08/30/94	--	--	--	NR	--	--	--	--	6.26	0	--	--	6.26
09/06/94	--	--	--	NR	--	--	--	--	NR	0	--	--	0
09/13/94	--	--	--	NR	--	--	--	--	6.34	0	--	--	6.34
09/20/94	--	--	--	NR	--	--	--	--	NR	0	--	--	0
09/27/94	--	--	--	0.02	--	--	--	--	0	0	--	--	.02
10/11/94	--	--	--	0	--	--	--	--	14.25	0	--	--	14.25
10/19/94	--	--	--	0	--	--	--	--	6.77	0	--	--	6.77
10/26/94	--	--	--	0	--	--	--	--	0	0	--	--	0
11/02/94	--	--	--	0	--	--	--	--	0	0	--	--	0
11/09/94	--	--	--	0	--	--	--	--	0	0	--	--	0
11/16/94	--	--	--	0	--	--	--	--	.08	0	--	--	.08
11/25/94	--	--	--	0	--	--	--	--	0	0	--	--	0
11/30/94	--	--	--	0	--	--	--	--	0	0	--	--	0
12/07/94	--	--	--	0	--	--	--	--	0	0	--	--	0
12/14/94	--	--	--	0	--	--	--	--	0	0	--	--	0
12/21/94	--	--	--	0	--	--	--	--	1.64	0	--	--	1.64
01/04/95	--	--	--	0	--	--	--	--	0	0	--	--	0
01/11/95	--	--	--	NR	--	--	--	--	0	0	--	--	0
01/18/95	--	--	--	0	--	--	--	--	0	0	--	--	0
01/25/95	--	--	--	0	--	--	--	--	0	0	--	--	0
02/01/95	--	--	--	0	--	--	--	--	0	0	--	--	0
02/08/95	--	--	--	0	--	--	--	--	0	0	--	--	0
02/15/95	--	--	--	0	--	--	--	--	0	0	--	--	0
02/22/95	--	--	--	0	--	--	--	--	0	0	--	--	0

Table 5. Surface-water withdrawals from the 12 metered siphons on Twitchell Island in the Sacramento-San Joaquin Delta, California, measured weekly by the California Department of Water Resources, August 9, 1994, through January 8, 1996—Continued

Date meter was read	Siphon number and flowmeter number												Total
	No. 2, 95-981-12	No. 3, 95-983-8	No. 4, 94-4586-12	No. 6, 94-5142-08	No. 7 95-985-16	No. 8, 95-980-10	No. 11, 95-987-18	No. 12, 95-982-12	No. 16, 92-1612-7	No. 17, 94-4559-24	No. 19, 95-986-16	No. 20, 95-984-16	
03/01/95	--	--	--	0	--	--	--	--	0.54	0	--	--	0.54
03/08/95	--	--	--	0	--	--	--	--	0	0	--	--	0
03/15/95	--	--	--	0	--	--	--	--	NR	0	--	--	0
03/22/95	--	--	--	0	--	--	--	--	NR	0	--	--	0
03/29/95	--	--	--	0	--	--	--	--	0	0	--	--	0
04/05/95	--	--	--	NR	--	--	--	--	0	0	--	--	0
04/12/95	--	--	--	0	--	--	--	--	0	0	--	--	0
04/19/95	--	--	--	NR	--	--	--	--	0	0	--	--	0
04/26/95	--	--	--	NR	--	--	--	--	0	0	--	--	0
05/01/95	--	--	--	NR	--	--	--	--	0	0	--	--	0
05/08/95	--	--	--	NR	--	--	--	--	0	0	--	--	0
05/15/95	--	--	--	NR	--	--	--	--	NR	NR	--	--	0
05/22/95	--	--	--	0	--	--	--	--	0	0	--	--	0
05/30/95	--	--	--	0	--	--	--	--	0	0	--	--	0
06/05/95	--	--	--	NR	--	--	--	--	5.96	0	--	--	5.96
06/12/95	--	--	--	NR	--	--	--	--	4.99	0	--	--	4.99
06/19/95	NR	0	0	0	0	0	36.42	0	5.10	0	0	0	41.52
06/26/95	0	NR	NR	0	NR	0	77.49	NR	4.52	0	0	NR	82.01
07/03/95	0	0	0	0	0	0	74.57	NR	11.39	0	0	.02	85.98
07/10/95	0	0	0	0	0	4.30	55.06	NR	0	0	0	.01	59.37
07/17/95	0	.40	0	0	0	18.67	77.85	0	12.16	0	0	0	109.08
07/24/95	0	0	0	0	0	22.84	122.07	0	11.49	0	46.05	0	202.45
07/31/95	0	.07	.01	0	0	30.41	145.29	0	34.07	0	36.76	0	246.61
08/07/95	0	NR	NR	NR	NR	NR	NR	NR	.13	0	12.34	3.30	15.77
08/14/95	0	40.44	42.53	0	0	32.73	207.42	.04	35.53	1.74	0	1.93	362.36
08/21/95	0	15.49	22.79	0	0	27.20	50.53	0	22.85	53.06	102.07	.03	294.02
08/28/95	0	30.42	0	0	NR	22.99	96.03	0	27.02	50.46	24.70	3.27	254.89

Table 5. Surface-water withdrawals from the 12 metered siphons on Twitchell Island in the Sacramento-San Joaquin Delta, California, measured weekly by the California Department of Water Resources, August 9, 1994, through January 8, 1996—Continued

Date meter was read	Siphon number and flowmeter number												Total
	No. 2, 95-981-12	No. 3, 95-983-8	No. 4, 94-4586-12	No. 6, 94-5142-08	No. 7 95-985-16	No. 8, 95-980-10	No. 11, 95-987-18	No. 12, 95-982-12	No. 16, 92-1612-7	No. 17, 94-4559-24	No. 19, 95-986-16	No. 20, 95-984-16	
09/05/95	0	16.45	0	0	0	16.73	58.25	0	25.38	0.99	0	0	117.80
09/11/95	0	0	0	0	0	0	22.61	0	.11	0	0	0	22.72
09/18/95	0	0	0	0	0	0	0	0	0	0	0	0	0
09/25/95	0	0	0	0	0	0	0	0	0	0	0	NR	0
10/02/95	0	0	0	0	0	0	0	0	0	0	0	.11	.11
10/10/95	0	0	0	0	0	0	0	0	0	0	0	0	0
10/16/95	0	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0
10/23/95	0	0	0	0	0	0	0	0	0	0	0	0	0
10/30/95	0	0	0	0	0	0	0	0	0	0	0	0	0
11/06/95	0	NR	NR	NR	NR	NR	NR	NR	0	0	0	NR	0
11/14/95	0	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0
11/20/95	0	NR	NR	NR	NR	NR	NR	NR	0	0	0	NR	0
11/27/95	0	0	0	NR	0	NR	0	NR	0	0	0	NR	0
12/04/95	0	0	0	NR	NR	0	0	0	0	0	0	NR	0
12/11/95	0	0	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0
12/18/95	0	0	0	0	0	NR	0	0	0	0	0	NR	0
01/08/96	0	0	0	0	0	0	0	0	0	0	399.45	NR	399.45
Total	0	103.27	65.33	0.02	0	175.87	1,023.59	0.04	291.45	158.98	621.37	8.67	2,448.59

for the 12 metered siphons on Twitchell Island, and USGS recorded readings monthly between March 1994 and January 1996 (table 6). Measured surface-water withdrawals were largest during July and August 1995. Because 9 of the 21 siphons on the island were not measured, it is not known if total monthly withdrawals for Twitchell Island were also largest during July and August.

Withdrawals at siphon 16 totaled more than 400 acre-ft during a 23-month period of record and more than 200 acre-ft for calendar year 1995 (table 6). At siphons 6 and 17, measured withdrawals were 0 and 170 acre-ft, respectively, for an 18-month period of record. At siphon 17, more than 100 acre-ft was siphoned during calendar year 1995; siphon 6 was not used during the 18-month period of record.

The remaining nine metered siphons had 8-month periods of record (table 6). Siphons 11 and 19 had the largest recorded withdrawals. Withdrawals at siphon 11 totaled more than 1,000 acre-ft between June and September 1995, with recorded monthly values of about 440 and 370 acre-ft for July and August 1995, respectively. Siphon 19 had the largest recorded monthly value, about 450 acre-ft, during December 1995; however, this monthly value includes the reading for the first 10 days of January 1996. The December reading was not made until January 9 or 10, 1996. Withdrawals at the nine remaining metered siphons ranged from 0 acre-ft at siphons 2 and 7 to about 180 acre-ft at siphon 8.

LAND USE

Land-use maps for 1968 were digitized and compared with digital land-use maps available for 1991. Changes in crop acreages between 1968 and 1991 were identified, and the crop types were aggregated into the subareas of DWR's delta island consumptive-use model.

Methods

DWR used USGS 7.5-minute topographic quadrangle maps to map land use in the delta in 1968 using their standard mapping methods (California Department of Water Resources, 1971). DWR provided USGS with full-size paper copies of these maps from which land-use coverages were created. USGS digitized the land-use maps, quality assured the data, and aggregated the data into subareas (fig. 6) of DWR's delta island consumptive-use model using ARC/INFO.

Land use during 1991 was mapped and digitized by DWR, and an ARC/INFO coverage was created by the California Department of Pesticide Regulation. These 1991 data were compared with the 1968 data. Delineations of subareas of DWR's delta island consumptive-use model (California Department of Water Resources, 1995) were used to create the coverage of the subareas (fig. 6) used in this study to aggregate land use and drainage returns.

Quality-assurance checks included automated analyses done within ARC/INFO at the time the maps were digitized and visual comparisons between the original copies and the digitized maps. In addition, differences were calculated between the digitized and the actual locations of the corners of the 7.5 minute topographic quadrangle maps to estimate the error introduced in digitizing the paper maps.

The 34 individual land-use coverages for 1968 were combined into a single coverage for the entire study area. The coverages for 1968 and 1991 were combined with the coverage of DWR's delta island consumptive-use model, and land-use acreages were then tabulated by subarea. The land-use attributes used for the 1991 coverage were also used with the 1968 data. The aggregated data are limited because the mapping of the 1968 data was less detailed and less complete than the 1991 data.

Results

The differences among the 34 quadrangles digitized for 1968 land use were, for the most part, within the standard of 0.005, with differences ranging from 0.001 to 0.018. This variability is attributed primarily to the use of paper copies of the maps, which are not scale stable. This degree of variability, however, was acceptable for the purposes of this report

Annual land-use data for 1968 and 1991 were aggregated by subareas of DWR's delta island consumptive-use model for comparison (table 7). The changes in acreage totals for land uses throughout the delta between 1968 and 1991 indicate that native vegetation decreased by 25 percent (39,945 acres), from 159,259 acres to 119,314 acres, and grain and hay crops increased by 340 percent (71,452 acres), from 21,034 acres in 1968 to 92,486 acres in 1991 (table 7). Field-crop acreage on Twitchell Island (subarea 42, fig. 6) increased by 44 percent (782 acres), from 1,787 acres in 1968 to 2,569 acres in 1991, and native vegetation decreased 77 percent (855 acres), from 1,115 to 260 acres between 1968 and 1991 (table 7).

Table 6. Surface-water withdrawals from the 12 metered siphons on Twitchell Island in the Sacramento-San Joaquin Delta, California, measured monthly by the U.S. Geological Survey, March 1994 through January 1996

[Values are in acre-feet. NR, not read; --, no data]

Month	Siphon number and flowmeter number												Partial total for months and years
	No. 2, 95-981-12	No. 3, 95-983-8	No. 4, 94-4586-12	No. 6, 94-5142-08	No. 7, 95-985-16	No. 8 95-980-10	No. 11, 95-987-18	No. 12, 95-982-12	No. 16, 92-1612-7	No. 17, 94-4559-24	No. 19 95-986-16	No. 20, 95-984-16	
1994													
March	--	--	--	--	--	--	--	--	0.01	--	--	--	0.01
April	--	--	--	--	--	--	--	--	3.95	--	--	--	3.95
May	--	--	--	--	--	--	--	--	38.07	--	--	--	38.07
June	--	--	--	--	--	--	--	--	21.82	--	--	--	21.82
July	--	--	--	--	--	--	--	--	88.73	--	--	--	88.73
August	--	--	--	0	--	--	--	--	61.14	52.73	--	--	113.87
September	--	--	--	0	--	--	--	--	14.17	0	--	--	14.17
October	--	--	--	0	--	--	--	--	13.19	0	--	--	13.19
November	--	--	--	0	--	--	--	--	.08	0	--	--	.08
December	--	--	--	0	--	--	--	--	1.64	0	--	--	1.64
Total				0					242.80	52.73			295.53
1995													
January	--	--	--	0	--	--	--	--	0	0	--	--	0
February	--	--	--	0	--	--	--	--	.54	0	--	--	.54
March	--	--	--	0	--	--	--	--	0	0	--	--	0
April	--	--	--	0	--	--	--	--	0	0	--	--	0
May	--	--	--	0	--	--	--	--	0	0	--	--	0
June	[1]0	[1]0	[1]0	0	[1]0	[1]0	[1]163.86	[1]0	31.96	0	[1]0	[1]0.02	195.84
July	0	1.11	.04	0	0	80.77	440.87	.04	57.83	0	95.15	.01	675.82
August	0	102.17	65.29	0	0	79.00	370.81	0	110.80	106.25	126.77	8.53	969.62
September	0	0	0	0	0	16.10	48.05	0	.11	0	0	.11	64.37
October	0	0	0	0	0	0	0	0	0	0	0	0	0
November	0	0	0	0	0	0	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0	0	0	0	[2]450.07	0	450.07
Total	0	103.28	65.33	0	0	175.87	1,023.59	0.04	201.24	106.25	671.99	8.67	2,356.26
1996													
January	0	0	0	0	0	0	0	0	0	11.89	0	0	11.89
TOTAL	0	103.28	65.33	0	0	175.87	1,023.59	0.04	444.04	170.87	671.99	8.67	2,663.68

[1]Indicates incomplete readings for month meter was installed.

[2]December reading includes the first 10 days of January 1996. The total for December 1996 is 50.62 acre-feet larger than total for January 8, 1996, in table 5 because of the 2 added days to the December reading (meter was read by the U.S. Geological Survey January 10, 1996)

Table 7. Land use in 1968 and 1991 for subareas of the California Department of Water Resources' delta island consumptive-use model of the Sacramento-San Joaquin Delta, California

[Values are in acres. <, actual value is less than shown]

Land use	Subarea 1		Subarea 2		Subarea 3		Subarea 4		Subarea 5	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	208	513	0	0	1,691	1,904	240	176	238	381
Grain and hay crops	980	675	918	425	0	4,579	<1	546	0	890
Field crops	2,476	3,367	1,953	5,739	7,288	6,471	1,501	890	2,478	846
Truck and berry crops	5,125	2,740	7,353	2,291	2,969	1,849	774	1,716	1,075	777
Pasture	2,450	3,974	2,519	4,403	1,749	1,048	3,076	2,134	242	548
Vineyards	0	0	0	0	0	0	76	0	0	1,093
Rice	0	0	0	0	0	0	0	0	0	0
Idle	0	38	0	8	0	0	0	382	0	25
Semiagricultural	28	75	50	77	0	174	<1	108	0	69
Native	502	390	960	809	3,146	778	1,766	819	879	308
Urban	0	10	0	0	85	153	86	1,053	0	23
Undesignated	13	1	2	0	0	0	145	<1	0	3
Total acres	11,782	11,783	13,755	13,752	16,928	16,956	7,664	7,824	4,912	4,963
Double-crop acres	0	0	0	0	0	27	0	159	0	51

Land use	Subarea 6		Subarea 7		Subarea 8		Subarea 9		Subarea 10	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	19	0	0	0	0	0	0	0	13
Deciduous fruits and nuts	46	21	2	0	56	0	153	281	1,055	1,080
Grain and hay crops	0	882	0	441	0	1,732	1,874	1,668	0	181
Field crops	2,665	2,316	2,092	2,605	3,172	6,589	2,116	3,336	892	454
Truck and berry crops	380	1,094	137	0	946	463	3,193	2,061	147	285
Pasture	1,195	1,045	62	0	521	380	1,851	556	270	167
Vineyards	0	202	0	0	0	0	23	1,174	0	153
Rice	0	0	0	0	0	0	26	0	0	0
Idle	0	23	0	38	0	646	34	1	0	1
Semiagricultural	0	34	0	2	0	47	40	128	0	32
Native	1,544	111	1,094	135	2,750	528	332	507	250	245
Urban	0	111	46	213	5	51	279	428	0	5
Undesignated	29	0	0	0	2,986	0	53	0	0	0
Total acres	5,859	5,858	3,433	3,434	10,436	10,436	9,974	10,140	2,614	2,616
Double-crop acres	0	0	0	0	0	0	0	165	0	0

Table 7. Land use in 1968 and 1991 for subareas of the California Department of Water Resources' delta island consumptive-use model of the Sacramento-San Joaquin Delta, California—Continued

Land use	Subarea									
	11		12		13		14		15	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	20	0	0
Deciduous fruits and nuts	0	0	0	0	203	115	172	420	166	49
Grain and hay crops	0	358	<1	0	0	357	0	3,263	1,381	1,306
Field crops	0	0	0	0	655	889	6,832	3,879	1,670	3,424
Truck and berry crops	0	0	84	0	53	0	2,173	2,126	2,499	3,049
Pasture	0	0	22	78	151	0	551	1,170	5,049	3,134
Vineyards	0	0	0	0	0	0	0	537	0	0
Rice	0	0	0	0	0	0	0	0	0	0
Idle	0	0	0	0	0	3	0	23	0	33
Semiagricultural	0	0	0	174	0	12	0	80	63	148
Native	31	444	650	350	492	165	2,250	440	293	251
Urban	1,529	836	1,925	2,079	174	188	<1	9	381	585
Undesignated	78	0	<1	0	0	0	0	13	477	0
Total acres	1,638	1,638	2,681	2,681	1,728	1,729	11,978	11,980	11,979	11,979
Double-crop acres	0	0	0	0	0	0	0	0	0	0

Land use	Subarea									
	16		17		18		19		20	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	0	0	0	0	41	211	0	0	1,541	1,509
Grain and hay crops	0	347	0	127	12	1,473	1,573	3,299	424	871
Field crops	1,389	1,551	3	39	0	1,944	4,870	5,211	3,529	2,537
Truck and berry crops	647	0	0	0	143	1,054	3,574	357	1,270	1,952
Pasture	317	1,100	<1	22	167	2,790	<1	1,039	1,793	332
Vineyards	0	0	0	0	0	122	0	191	81	1,003
Rice	0	0	0	0	0	0	0	0	0	0
Idle	0	1,373	0	67	0	20	95	134	0	267
Semiagricultural	0	14	0	0	<1	80	7	52	80	139
Native	3,198	1,149	569	243	128	266	779	954	103	126
Urban	0	16	0	72	0	0	68	39	0	84
Undesignated	0	0	0	0	7,224	0	75	0	0	0
Total acres	5,551	5,550	572	570	7,715	7,960	11,041	11,276	8,821	8,820
Double-crop acres	0	0	0	0	0	245	0	235	0	0

Table 7. Land use in 1968 and 1991 for subareas of the California Department of Water Resources' delta island consumptive-use model of the Sacramento-San Joaquin Delta, California—Continued

Land use	Subarea									
	21		22		23		24		25	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	28	<1	423	435	250	275	8	0	28	14
Grain and hay crops	0	147	0	586	0	2,665	0	0	2,027	2,830
Field crops	166	0	988	705	5,422	4,922	625	0	3,939	2,688
Truck and berry crops	97	0	412	234	509	199	525	7	3,839	3,136
Pasture	0	179	143	218	91	351	470	0	508	1,534
Vineyards	0	0	0	21	0	0	0	0	0	0
Rice	0	0	0	0	0	0	0	0	0	0
Idle	0	9	0	0	0	0	0	0	0	214
Semiagricultural	0	4	0	28	0	40	0	124	60	114
Native	123	42	445	190	2,642	446	293	366	859	779
Urban	88	122	21	17	23	39	37	2,759	219	272
Undesignated	0	0	0	0	0	0	1,299	0	101	0
Total acres	502	503	2,432	2,434	8,937	8,937	3,257	3,256	11,580	11,581
Double-crop acres	0	0	0	0	0	0	0	0	0	0

Land use	Subarea									
	26		27		28		29		30	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	106	118	118	0	357	338	0	0	0	0
Grain and hay crops	0	290	0	0	0	0	0	1,993	0	228
Field crops	655	628	<1	0	0	0	4,299	3,396	621	201
Truck and berry crops	412	233	4	0	49	0	856	0	0	366
Pasture	96	162	0	0	<1	0	76	0	299	413
Vineyards	0	0	0	112	0	0	0	0	0	0
Rice	0	0	0	0	0	0	0	0	0	0
Idle	0	0	0	0	0	45	0	4	0	0
Semiagricultural	0	39	0	8	0	6	0	18	0	6
Native	322	122	8	10	16	36	1,673	1,340	386	130
Urban	0	0	0	0	3	0	11	165	0	29
Undesignated	0	0	0	0	0	0	0	0	65	0
Total acres	1,591	1,592	130	130	425	425	6,915	6,916	1,371	1,373
Double-crop acres	0	0	0	0	0	0	0	0	0	0

Table 7. Land use in 1968 and 1991 for subareas of the California Department of Water Resources' delta island consumptive-use model of the Sacramento-San Joaquin Delta, California—Continued

Land use	Subarea									
	31		32		33		34		35	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	62	53	23	0	0	0	0	0	139	162
Grain and hay crops	0	261	0	157	513	804	0	0	147	115
Field crops	1,066	743	0	0	2,391	732	297	540	938	675
Truck and berry crops	2,400	2,976	0	0	1,710	1,205	195	0	239	240
Pasture	2,491	2,242	1,864	1,652	1,206	1,091	37	0	610	101
Vineyards	0	0	0	0	0	0	0	0	0	782
Rice	0	0	0	0	0	0	0	0	0	0
Idle	0	37	0	433	0	69	2,533	13	0	25
Semiagricultural	0	24	47	52	0	12	8	6	0	15
Native	838	475	1,206	769	344	1,231	322	2,869	88	49
Urban	0	25	256	332	192	1,227	0	0	0	0
Undesignated	0	22	0	0	15	0	35	0	0	0
Total acres	6,857	6,858	3,396	3,395	6,371	6,371	3,427	3,428	2,161	2,164
Double-crop acres	0	0	0	0	0	0	0	0	0	0

Land use	Subarea									
	36		37		38		39		40	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	0	0	0	0	0	94	13	75	180	132
Grain and hay crops	0	0	0	0	0	1,190	0	6,089	686	932
Field crops	0	0	571	0	0	2,815	11,658	8,281	2,331	2,195
Truck and berry crops	0	0	0	0	0	249	4,771	4,217	250	475
Pasture	0	0	2,355	2,805	0	600	5,287	4,444	2,558	2,033
Vineyards	0	0	0	0	0	53	0	716	0	310
Rice	0	0	0	0	0	0	0	0	325	0
Idle	0	0	0	16	0	422	0	381	51	0
Semiagricultural	0	0	0	9	0	192	10	377	36	63
Native	0	87	626	729	0	1,002	3,780	1,319	141	348
Urban	772	685	8	0	0	4,360	153	245	0	71
Undesignated	0	0	0	0	10,976	1	159	3	0	0
Total acres	772	772	3,560	3,559	10,976	10,978	25,831	26,147	6,558	6,559
Double-crop acres	0	0	0	0	0	0	0	316	0	0

Table 7. Land use in 1968 and 1991 for subareas of the California Department of Water Resources' delta island consumptive-use model of the Sacramento-San Joaquin Delta, California—Continued

Land use	Subarea									
	41		42		43		44		45	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	23	28	0	0	0	0	0	0	0	0
Grain and hay crops	0	665	0	189	151	0	102	167	1	0
Field crops	1,495	1,511	1,787	2,569	105	0	201	768	<1	0
Truck and berry crops	1,906	1,027	597	242	222	0	385	307	0	0
Pasture	3,538	3,911	133	320	0	0	259	185	0	0
Vineyards	0	0	0	0	0	0	0	213	0	0
Rice	0	0	0	0	0	0	600	0	0	0
Idle	0	235	0	25	0	0	0	0	0	0
Semiagricultural	0	272	0	15	0	14	10	9	0	0
Native	2,069	501	1,115	260	183	129	203	99	33	149
Urban	578	1,569	0	10	301	828	0	0	2,025	1,911
Undesignated	0	25	0	0	9	<1	9	23	0	0
Total acres	9,609	9,744	3,632	3,630	971	971	1,769	1,771	2,059	2,060
Double-crop acres	0	134	0	0	0	0	0	0	0	0

Land use	Subarea									
	46		47		48		49		50	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	0	0	0	0	0	0	0	0	0	0
Grain and hay crops	0	390	0	0	0	1,146	0	172	0	2,926
Field crops	716	613	759	0	2,232	1,575	929	438	1,730	63
Truck and berry crops	471	254	0	0	306	0	837	1,147	434	0
Pasture	0	0	0	0	0	0	180	381	689	304
Vineyards	0	0	0	0	0	0	0	0	0	0
Rice	0	0	0	0	0	0	0	0	0	0
Idle	0	0	0	0	0	0	0	32	0	481
Semiagricultural	0	<1	0	0	0	4	0	32	63	14
Native	1,165	1,089	545	1,304	2,039	1,851	479	214	1,315	442
Urban	0	0	0	0	0	<1	0	9	0	0
Undesignated	0	7	0	0	0	0	0	0	0	0
Total acres	2,352	2,353	1,304	1,304	4,577	4,576	2,425	2,425	4,231	4,230
Double-crop acres	0	0	0	0	0	0	0	0	0	0

Table 7. Land use in 1968 and 1991 for subareas of the California Department of Water Resources' delta island consumptive-use model of the Sacramento-San Joaquin Delta, California—Continued

Land use	Subarea									
	51		52		53		54		55	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	32	0	0	0	0	0	0
Deciduous fruits and nuts	0	0	3	1	0	0	0	0	0	0
Grain and hay crops	0	1,334	0	401	0	0	0	1,344	0	643
Field crops	4,074	3,464	1,216	2,916	402	2,215	2,638	1,982	1,083	1,001
Truck and berry crops	26	0	2,932	1,017	4,422	2,908	605	123	1,896	863
Pasture	0	0	0	6	0	0	0	0	0	389
Vineyards	0	0	238	475	0	57	0	0	12	0
Rice	0	0	0	0	0	0	0	0	0	0
Idle	0	46	0	50	0	29	0	0	0	139
Semiagricultural	0	25	0	32	0	36	0	11	0	17
Native	1,347	581	3,385	2,843	1,780	1,407	1,190	967	730	604
Urban	0	0	0	1	0	25	0	7	0	66
Undesignated	3	0	0	0	73	0	0	0	2	0
Total acres	5,450	5,450	7,774	7,774	6,677	6,677	4,433	4,434	3,723	3,722
Double-crop acres	0	0	0	0	0	0	0	0	0	0

Land use	Subarea									
	56		57		58		59		60	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	0	3	0	0	0	0	0	0	0	0
Grain and hay crops	767	596	0	1,309	71	712	922	1,756	765	1,073
Field crops	1,600	2,217	1,752	574	3,678	4,535	2,611	930	4,205	2,169
Truck and berry crops	623	405	0	15	2,549	1,025	798	2,582	1,068	1,952
Pasture	1,729	691	22	292	105	19	1,229	0	0	685
Vineyards	0	511	0	0	0	0	0	0	0	0
Rice	0	0	0	0	0	0	0	0	0	0
Idle	0	146	0	81	0	133	0	267	0	0
Semiagricultural	0	25	0	3	0	32	0	32	0	13
Native	323	488	791	289	644	670	391	311	800	834
Urban	0	0	0	0	0	0	0	82	0	112
Undesignated	37	0	0	0	80	0	0	0	0	0
Total acres	5,079	5,082	2,565	2,563	7,127	7,126	5,951	5,960	6,838	6,838
Double-crop acres	0	0	0	0	0	0	0	8	0	0

Table 7. Land use in 1968 and 1991 for subareas of the California Department of Water Resources' delta island consumptive-use model of the Sacramento-San Joaquin Delta, California—Continued

Land use	Subarea									
	61		62		63		64		65	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	0	0	0	0	0	0	0	0	36	7
Grain and hay crops	0	1,318	0	134	755	446	0	1,890	0	85
Field crops	6,760	934	521	952	623	152	1,493	931	582	1,067
Truck and berry crops	118	3,238	0	0	591	192	1,245	512	1,636	1,346
Pasture	0	1,481	0	0	0	1,276	0	0	2,013	1,977
Vineyards	0	0	0	0	0	0	0	0	0	0
Rice	0	0	0	0	0	0	0	0	0	0
Idle	0	0	0	0	67	0	0	0	0	68
Semiagricultural	0	11	0	0	0	4	0	4	0	99
Native	901	798	1,280	702	236	184	1,111	735	607	191
Urban	0	79	0	22	0	18	11	29	0	78
Undesignated	0	0	9	0	0	0	0	0	43	0
Total acres	7,779	7,859	1,810	1,810	2,272	2,272	3,860	4,101	4,917	4,918
Double-crop acres	0	79	0	0	0	0	0	241	0	0

Land use	Subarea									
	66		67		68		69		70	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	7	0	0	0	0	0	170	123	0	0
Grain and hay crops	0	84	0	0	0	292	0	693	0	0
Field crops	622	809	1,097	0	2,431	1,586	1,234	356	110	242
Truck and berry crops	680	518	0	0	1,491	517	618	1,215	351	260
Pasture	2,004	1,576	99	637	2,317	2,257	1,450	1,454	304	328
Vineyards	0	0	0	0	0	29	0	0	0	0
Rice	0	0	0	0	0	0	0	0	0	0
Idle	0	32	0	1,287	0	1,664	0	0	0	50
Semiagricultural	19	116	0	9	0	37	0	7	13	24
Native	582	342	964	206	1,236	1,094	692	360	291	167
Urban	186	624	15	35	0	0	0	28	21	20
Undesignated	0	0	0	0	0	0	73	0	0	0
Total acres	4,100	4,101	2,175	2,174	7,475	7,476	4,237	4,236	1,090	1,091
Double-crop acres	0	0	0	0	0	0	0	0	0	0

Table 7. Land use in 1968 and 1991 for subareas of the California Department of Water Resources' delta island consumptive-use model of the Sacramento-San Joaquin Delta, California—Continued

Land use	Subarea									
	71		72		73		74		75	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	0	0	192	165	0	0	0	0	0	0
Grain and hay crops	0	882	0	1,530	0	3,297	0	899	429	210
Field crops	752	0	3,393	5,084	1,438	2,672	429	0	356	30
Truck and berry crops	153	0	360	25	488	62	612	749	361	0
Pasture	169	74	573	63	8,493	3,910	0	0	0	188
Vineyards	0	0	0	103	0	0	0	0	0	0
Rice	0	0	0	0	0	0	0	0	0	0
Idle	0	257	0	45	0	2,255	0	40	0	80
Semiagricultural	0	0	0	33	0	56	0	5	0	6
Native	286	148	3,211	546	2,848	993	1,117	453	190	149
Urban	0	0	15	151	43	143	0	13	<1	674
Undesignated	0	0	0	0	0	<1	0	0	0	0
Total acres	1,360	1,361	7,744	7,745	13,310	13,388	2,158	2,159	1,336	1,337
Double-crop acres	0	0	0	0	0	79	0	0	0	0

Land use	Subarea									
	76		77		78		79		80	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	0	0	0	0	0	0	1	0	0	0
Grain and hay crops	0	120	0	1,548	0	<1	0	79	1,374	456
Field crops	311	458	3,419	3,365	1,148	1,657	470	292	893	1,835
Truck and berry crops	399	321	470	192	455	283	540	203	181	412
Pasture	887	895	4,507	1,455	495	560	324	1,418	285	114
Vineyards	0	0	0	0	0	0	0	0	0	0
Rice	0	0	458	0	0	0	0	0	0	0
Idle	0	23	0	6,195	0	98	0	97	119	0
Semiagricultural	0	13	0	20	0	0	0	26	10	11
Native	263	47	10,998	7,058	710	208	887	103	252	300
Urban	0	<1	0	0	0	0	249	252	0	0
Undesignated	17	0	0	1	0	0	0	<1	15	0
Total acres	1,877	1,877	19,852	19,834	2,808	2,806	2,471	2,470	3,129	3,128
Double-crop acres	0	0	18	0	0	0	0	0	0	0

Table 7. Land use in 1968 and 1991 for subareas of the California Department of Water Resources' delta island consumptive-use model of the Sacramento-San Joaquin Delta, California—Continued

Land use	Subarea									
	81		82		83		84		85	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	0	0	0	0	0	0	2	5	31	40
Grain and hay crops	0	0	88	130	0	2,537	0	72	0	233
Field crops	0	56	139	212	2,357	1,231	432	438	703	1,604
Truck and berry crops	64	0	223	0	1,152	265	337	346	2,805	1,459
Pasture	95	61	236	308	0	0	15	192	1,049	1,943
Vineyards	0	50	0	0	0	0	0	0	0	0
Rice	0	0	0	0	0	0	0	0	0	0
Idle	0	0	0	0	0	26	0	13	0	39
Semiagricultural	0	0	0	3	0	221	0	8	10	70
Native	0	0	58	90	1,089	319	533	247	1,394	360
Urban	0	0	0	0	0	0	0	0	156	412
Undesignated	7	0	0	0	0	0	0	0	12	0
Total acres	166	167	744	743	4,598	4,599	1,319	1,321	6,160	6,160
Double-crop acres	0	0	0	0	0	0	0	0	0	0

Land use	Subarea									
	86		87		88		89		90	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	0	0	0	0	0	0	0	0	17	6
Grain and hay crops	0	0	0	0	0	795	0	0	0	68
Field crops	0	0	1,113	225	0	220	355	73	76	0
Truck and berry crops	47	51	112	582	0	0	0	0	5	98
Pasture	7	0	211	1,616	790	0	987	955	238	258
Vineyards	0	0	0	0	0	0	0	0	0	0
Rice	0	0	0	0	0	0	0	0	0	0
Idle	0	8	0	659	0	0	0	328	0	0
Semiagricultural	0	0	0	54	0	0	0	0	0	0
Native	107	87	2,039	350	1,320	1,096	173	159	127	14
Urban	54	69	11	0	0	0	0	0	5	92
Undesignated	0	0	0	0	0	0	0	0	0	0
Total acres	215	215	3,486	3,486	2,110	2,111	1,515	1,515	468	536
Double-crop acres	0	0	0	0	0	0	0	0	0	68

Table 7. Land use in 1968 and 1991 for subareas of the California Department of Water Resources' delta island consumptive-use model of the Sacramento-San Joaquin Delta, California—Continued

Land use	Subarea									
	91		92		93		94		95	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	0	0	273	222	0	0	0	0	0	79
Grain and hay crops	0	24	16	91	0	268	29	0	259	571
Field crops	176	0	349	192	561	784	250	168	545	1,193
Truck and berry crops	219	44	15	8	304	16	190	159	267	190
Pasture	132	514	151	59	601	217	0	171	2,264	685
Vineyards	0	0	<1	64	0	0	0	0	0	0
Rice	0	0	0	0	0	0	0	0	31	0
Idle	0	0	0	<1	0	107	0	0	18	71
Semiagricultural	0	16	2	13	<1	75	0	1	0	22
Native	395	275	7,684	15,036	3,918	3,255	64	34	860	1,428
Urban	9	58	19	152	1,656	2,839	0	0	0	25
Undesignated	0	0	7,328	0	519	<1	0	0	21	<1
Total acres	931	931	15,837	15,837	7,559	7,561	533	533	4,265	4,264
Double-crop acres	0	0	0	0	0	0	0	0	0	0

Land use	Subarea									
	96		97		98		99		100	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	0	0	5	0	0	0	76	89	0	0
Grain and hay crops	0	0	73	0	0	0	0	0	383	181
Field crops	189	0	87	0	35	30	52	0	611	1,067
Truck and berry crops	0	190	1	0	0	0	0	0	369	276
Pasture	0	0	2	79	0	0	0	92	129	0
Vineyards	0	0	0	10	0	0	0	0	0	0
Rice	0	0	0	0	0	0	0	0	0	0
Idle	0	0	0	14	0	0	0	54	0	0
Semiagricultural	0	0	9	2	0	0	0	3	0	3
Native	38	36	32	90	11	3	600	490	90	60
Urban	0	0	45	55	13	27	24	24	0	3
Undesignated	0	0	0	0	0	0	0	0	7	0
Total acres	227	226	254	250	59	60	752	752	1,589	1,590
Double-crop acres	0	0	0	0	0	0	0	0	0	0

Table 7. Land use in 1968 and 1991 for subareas of the California Department of Water Resources' delta island consumptive-use model of the Sacramento-San Joaquin Delta, California—Continued

Land use	Subarea									
	101		102		103		104		105	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	0	0	187	269	5,309	5,505	0	0	0	0
Grain and hay crops	452	269	352	20	645	2,429	0	0	224	0
Field crops	1,060	1,924	551	0	6,008	12,112	0	0	5	0
Truck and berry crops	22	130	479	251	14,308	4,654	0	0	90	0
Pasture	2,676	1,293	421	14	16,390	11,368	0	0	<1	0
Vineyards	0	303	0	167	0	470	0	0	0	0
Rice	69	0	0	0	98	0	0	0	0	0
Idle	0	57	0	190	0	1,751	0	0	0	296
Semiagricultural	0	59	17	147	406	939	0	0	0	0
Native	747	938	781	847	5,326	2,802	89	89	59	82
Urban	1	96	452	1,340	6,154	13,078	0	0	0	0
Undesignated	42	0	3	0	184	69	0	0	0	0
Total acres	5,069	5,069	3,243	3,245	54,828	55,177	89	89	378	378
Double-crop acres	0	0	0	0	0	348	0	0	0	0

Land use	Subarea									
	106		107		108		109		110	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	0	0	0	0	0	0	0	0	0	0
Grain and hay crops	1	0	734	0	0	711	0	0	0	0
Field crops	15	0	813	739	402	0	0	0	0	0
Truck and berry crops	<1	0	1,536	1,711	397	60	0	0	0	0
Pasture	0	0	2	563	0	0	0	0	0	0
Vineyards	0	0	0	0	0	0	0	0	0	0
Rice	0	0	0	0	0	0	0	0	0	0
Idle	0	19	0	0	0	0	0	0	0	0
Semiagricultural	0	0	0	12	0	0	0	0	0	0
Native	90	84	153	267	85	112	130	130	195	195
Urban	0	0	0	0	0	0	0	0	0	0
Undesignated	0	4	55	0	0	0	0	0	0	0
Total acres	106	107	3,293	3,292	884	883	130	130	195	195
Double-crop acres	0	0	0	0	0	0	0	0	0	0

Table 7. Land use in 1968 and 1991 for subareas of the California Department of Water Resources' delta island consumptive-use model of the Sacramento-San Joaquin Delta, California—Continued

Land use	Subarea									
	111		112		113		114		115	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	0	0	0	0	0	0	0	0	0	0
Grain and hay crops	0	273	0	0	69	126	0	0	254	351
Field crops	477	0	0	0	586	682	0	0	169	55
Truck and berry crops	1,329	1,533	0	0	926	85	0	0	214	0
Pasture	0	171	0	0	544	1,182	0	0	0	222
Vineyards	138	0	0	0	0	0	0	0	0	0
Rice	0	0	0	0	0	0	0	0	0	0
Idle	0	397	0	0	0	45	0	0	0	0
Semiagricultural	0	57	0	0	18	43	0	0	0	7
Native	926	436	248	250	111	58	87	87	92	93
Urban	19	22	0	0	0	39	0	0	0	0
Undesignated	0	0	2	0	6	0	0	0	0	0
Total acres	2,889	2,889	250	250	2,260	2,260	87	87	729	728
Double-crop acres	0	0	0	0	0	0	0	0	0	0

Land use	Subarea									
	116		117		118		119		120	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	0	209	0	0	0	0	0	0	0	0
Grain and hay crops	718	264	370	320	0	0	0	3,208	118	529
Field crops	366	178	118	342	0	0	6,407	5,204	249	731
Truck and berry crops	561	266	523	148	0	0	0	337	746	83
Pasture	65	785	0	194	0	0	165	0	0	0
Vineyards	0	0	0	0	0	0	0	0	0	0
Rice	0	0	0	0	0	0	0	18	0	0
Idle	0	8	0	0	0	0	0	0	0	0
Semiagricultural	0	6	0	<1	0	0	0	17	0	20
Native	230	209	85	92	182	182	3,276	1,055	260	254
Urban	0	17	0	0	0	0	0	9	106	0
Undesignated	<1	0	0	0	0	0	0	0	6	<1
Total acres	1,940	1,942	1,096	1,096	182	182	9,848	9,848	1,485	1,617
Double-crop acres	0	0	0	0	0	0	0	0	0	133

Table 7. Land use in 1968 and 1991 for subareas of the California Department of Water Resources' delta island consumptive-use model of the Sacramento-San Joaquin Delta, California—Continued

Land use	Subarea									
	121		122		123		124		125	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	<1	0	0	0	0	0	0	0	<1	0
Grain and hay crops	0	67	0	651	0	0	0	177	0	0
Field crops	29	59	613	323	0	0	244	108	<1	0
Truck and berry crops	2	<1	411	0	0	0	127	177	1	0
Pasture	256	252	1,139	952	0	0	0	0	<1	0
Vineyards	0	0	0	0	0	0	0	0	0	0
Rice	0	0	0	0	0	0	0	0	0	0
Idle	0	7	0	893	0	0	0	0	0	0
Semiagricultural	0	11	0	28	0	0	0	0	0	0
Native	5,313	6,112	6,690	5,185	636	636	181	90	803	1,123
Urban	21	19	103	402	0	0	0	0	<1	1
Undesignated	924	19	0	522	0	0	0	0	321	<1
Total acres	6,545	6,546	8,956	8,956	636	636	552	552	1,125	1,124
Double-crop acres	0	0	0	0	0	0	0	0	0	0

Land use	Subarea									
	126		127		128		129		130	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	0	7	0	0	0	0	68	23	13,611	6,045
Grain and hay crops	0	2,811	0	0	0	219	0	531	8	3,415
Field crops	581	6,597	1,357	0	787	0	549	552	1,681	2,244
Truck and berry crops	2,780	2,217	0	0	0	0	591	182	6,409	6,176
Pasture	1,215	1,039	0	0	1,450	2,330	1,157	924	3,176	3,018
Vineyards	0	0	0	0	0	0	59	46	145	255
Rice	696	0	0	0	0	0	0	0	0	0
Idle	0	387	0	0	0	558	0	438	208	3,338
Semiagricultural	0	32	0	0	0	26	83	64	6	571
Native	1,612	1,567	890	2,247	2,303	1,390	3,402	2,605	6,641	3,650
Urban	3	189	0	0	41	155	114	599	891	4,152
Undesignated	7,768	13	0	0	111	15	4	0	3	7
Total acres	14,655	14,859	2,247	2,247	4,692	4,693	6,027	5,964	32,779	32,871
Double-crop acres	0	204	0	0	0	0	64	<1	8	99

Table 7. Land use in 1968 and 1991 for subareas of the California Department of Water Resources' delta island consumptive-use model of the Sacramento-San Joaquin Delta, California—Continued

Land use	Subarea 131		132		133		134		135		136		137	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deciduous fruits and nuts	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grain and hay crops	0	0	369	348	0	0	0	0	0	0	0	0	0	0
Field crops	0	0	0	526	0	0	0	0	1	0	0	0	27	0
Truck and berry crops	0	0	545	31	0	0	0	0	0	0	0	0	0	0
Pasture	1,066	8	0	0	1	0	<1	0	0	0	0	0	0	0
Vineyards	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rice	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Idle	0	2,488	0	0	0	0	0	0	0	0	0	0	0	0
Semiagricultural	70	137	0	3	0	0	0	0	0	0	0	0	0	0
Native	1,908	346	302	304	333	359	1,354	1,365	122	123	3,602	3,602	1,505	1,533
Urban	458	524	0	8	26	<1	12	<1	0	0	0	0	0	0
Undesignated	0	0	4	0	0	0	0	0	0	0	0	0	0	0
Total acres	3,502	3,503	1,220	1,220	360	359	1,366	1,365	123	123	3,602	3,602	1,532	1,533
Double-crop acres	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Land use	Subarea 138		139		140		141		142		Total	
	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991	1968	1991
Subtropical fruits	0	0	0	0	0	0	0	0	0	0	0	84
Deciduous fruits and nuts	0	0	0	0	0	0	0	0	0	0	27,558	21,184
Grain and hay crops	0	304	0	0	0	0	0	0	0	0	21,034	92,486
Field crops	632	0	0	0	21	0	0	0	0	0	174,621	172,439
Truck and berry crops	0	0	0	0	0	0	0	0	0	0	117,743	80,988
Pasture	0	0	0	0	0	0	0	0	<1	0	108,510	100,056
Vineyards	0	0	0	0	0	0	0	0	0	0	772	9,222
Rice	0	0	0	0	0	0	0	0	0	0	2,303	18
Idle	0	298	0	0	0	0	0	0	0	<1	3,125	31,094
Semiagricultural	0	0	0	0	0	0	0	0	0	0	1,165	6,319
Native	174	204	86	86	2,124	2,145	403	1,604	174	174	159,259	119,314
Urban	0	0	0	0	<1	<1	0	<1	0	<1	20,198	47,495
Undesignated	<1	0	0	0	0	0	1,201	0	0	0	42,630	748
Total acres	806	806	86	86	2,145	2,145	1,664	1,604	174	174	678,918	681,447
Double-crop acres	0	0	0	0	0	0	0	0	0	0	90	2,591

SUMMARY

Partial data on drainage returns and surface-water withdrawals from March 1994 through January 8, 1996, are presented for areas of the Sacramento-San Joaquin Delta.These areas cover most of the delta. Measurements were made using flowmeters installed in drain pipes and siphons, and estimates were made using electric power-consumption data with pump-efficiency-test data. In 1995, measured drainage returns for Twitchell Island totaled about 11,200 acre-feet, whereas estimated drainage returns calculated from power-consumption data totaled about 10,600 acre-feet. Drainage-return estimates for most of the delta totaled about 430,000 acre-feet for 1995. Surface-water withdrawals onto Twitchell Island measured for 12 of 21 siphons totaled about 2,400 acre-feet for 1995.

Data on changes in delta land use between 1968 and 1991 are also presented. Maps of land use in 1968 were digitized and stored in a geographic information system (ARC/INFO) and compared with digital land-use information for 1991. Between 1968 and 1991, native vegetation in the delta decreased by 25 percent (about 40,000 acres), and grain and hay crops increased by 340 percent (about 71,000 acres). For Twitchell Island, native vegetation decreased about 77 percent (about 850 acres), while field-crop acreage increased by about 44 percent (about 780 acres).

REFERENCES CITED

California Department of Water Resources, 1956, Quantity and quality of waters applied to and drained from the delta lowlands: California Department of Water Resources Investigation of the Sacramento-San Joaquin Delta Report no. 4, 30 p.

_____ 1971, Land use in California: Bulletin 176, 16 p.

_____ 1993, Sacramento-San Joaquin Delta Atlas: Division of Planning, 121 p.

_____ 1995, Estimation of delta island diversions and return flows: California Department of Water Resources, Division of Planning, 134 p.

Diamond, Jonathan, and Williamson, A.K., 1983, A summary of ground water pumpage in the Central Valley, California: 1961-77: U.S. Geological Survey Water-Resources Investigations Report 83-4037, 70 p.

Ogilbee, William, and Mitten, H.T., 1970, A continuing program for estimating ground-water pumpage in California: U.S. Geological Survey Open-File Report, 22 p.

Schwankl, L.J., and Hanson, B.R., 1993, Flow meter performance: California Committee on the Relation of Energy to Agriculture, CREA Report no. 92-02. 30 p.