Attachment A

DAYFLOW PROGRAM DOCUMENTATION AND

DAYFLOW DATA SUMMARY

USER'S GUIDE

Introduction

DAYFLOW* is a computer program developed in 1978 as an accounting tool for determining historical Delta boundary hydrology. DAYFLOW output is used extensively in studies initiated by the Department of Water Resources (DWR), the Department of Fish and Game (DFG), and less frequently by other State and Federal agencies (e.g., U. S. Bureau of Reclamation (USBR)) and private consultants. The output has been put in STORET, The Environmental Protection Agency's data storage and retrieval system, making it available for use nationally.

The DAYFLOW program presently provides the best estimate of historical mean daily flows: (1) through the Delta Cross Channel and Georgiana Slough; (2) past Jersey Point; and (3) past Chipps Island to San Francisco Bay (net Delta outflow). The degree of accuracy of DAYFLOW output is affected by the DAYFLOW computational scheme and the accuracy and limitations of the input data. The input data include the principal Delta stream inflows, Delta precipitation, Delta exports, and Delta gross channel depletions. These data include both monitored and estimated values as described in this DAYFLOW program documentation. Currently, flows are not routed to account for travel time through the Delta. All calculations involving inflows, depletions, transfers, exports, and outflow are performed using data for the same day. All DAYFLOW summary reports distributed through January 1985, providing flow data through August 1984, and data for September 1984 reported herein were generated according to the algorithm described in the Computational Scheme section.

DAYFLOW program documentation is presented as follows:

- Computational Scheme
- Summary Tables of Monthly Data
- Input Data Documentation
- Methodology for DAYFLOW Data Summary Generation
- Summary of Equations

Computational Scheme

The DAYFLOW computational scheme was developed to derive three types of quantities:

- Net Delta Outflow estimates at Chipps Island
- Interior Delta flow estimates at significant locations
- Summary and fish-related parameters and indices

The DAYFLOW FORTRAN program listing is presented in Attachment E.

*This program has also been referred to as the DAYFLO and DAY FLOW model.

Net Delta Outflow Estimates At Chipps Island

An estimate of net Delta outflow at Chipps Island is derived by performing a water balance about the boundary of the Sacramento-San Joaquin Delta, taking Chipps Island as the western limit (this quantity should not be confused with the total tidal flow, which is much larger). Figure 1 is a map of the area of interest. A flow schematic is shown in Figure 2. In its most general form, the water balance equation is (using DAYFLOW parameters; see Table 1 for a complete listing of DAYFLOW parameters and their definitions):

$$QOUT = QTOT + QPREC - QDEPL - QEXP \tag{1}$$

Where:

- QOUT = Net Delta outflow at Chipps Island
- QTOT = Total Delta inflow
- QPREC = Delta precipitation runoff estimate
- QDEPL = Deltawide gross channel depletion estimate (consumptive use)
- QEXP = Total Delta exports and diversions/transfers

The parameters on the right side of the equation are input data used to calculate net Delta outflow. These input parameters are further defined in the Input Data Documentation Section, including exceptions and changes made to the parameters appearing in the equations presented.

Total Delta Inflow (QTOT). The principal surface water inflows, miscellaneous stream flows, and the Yolo Bypass flow addition near Rio Vista are included in determination of total Delta inflow according to the following equation:

$$QTOT = QSAC + QEAST + QYOLO \tag{2}$$

Eastern Delta inflow (QEAST) includes inflow to the Delta from the northeast, east, and southeast (Marsh Creek is the exception, flowing to the Delta from the southwest). QEAST is defined as:

$$QEAST = QSJR + QCRM + QMOKE + QMISC \tag{3}$$

Miscellaneous stream flow (QMISC) is a composite flow defined as:

QMISC = Calaveras River flow
+ Bear Creek flow
+ Dry Creek flow
+ Stockton Diverting Canal flow
+ French Camp Slough flow
+ Marsh Creek flow
+ Morrison Creek flow (4)

The Yolo Bypass flow addition to the Delta water balance is calculated as:

QYOLO = Yolo Bypass flow at Woodland
+ Sacramento Weir Spill
+ South Fork Putah Creek (5)

FIGURE 1

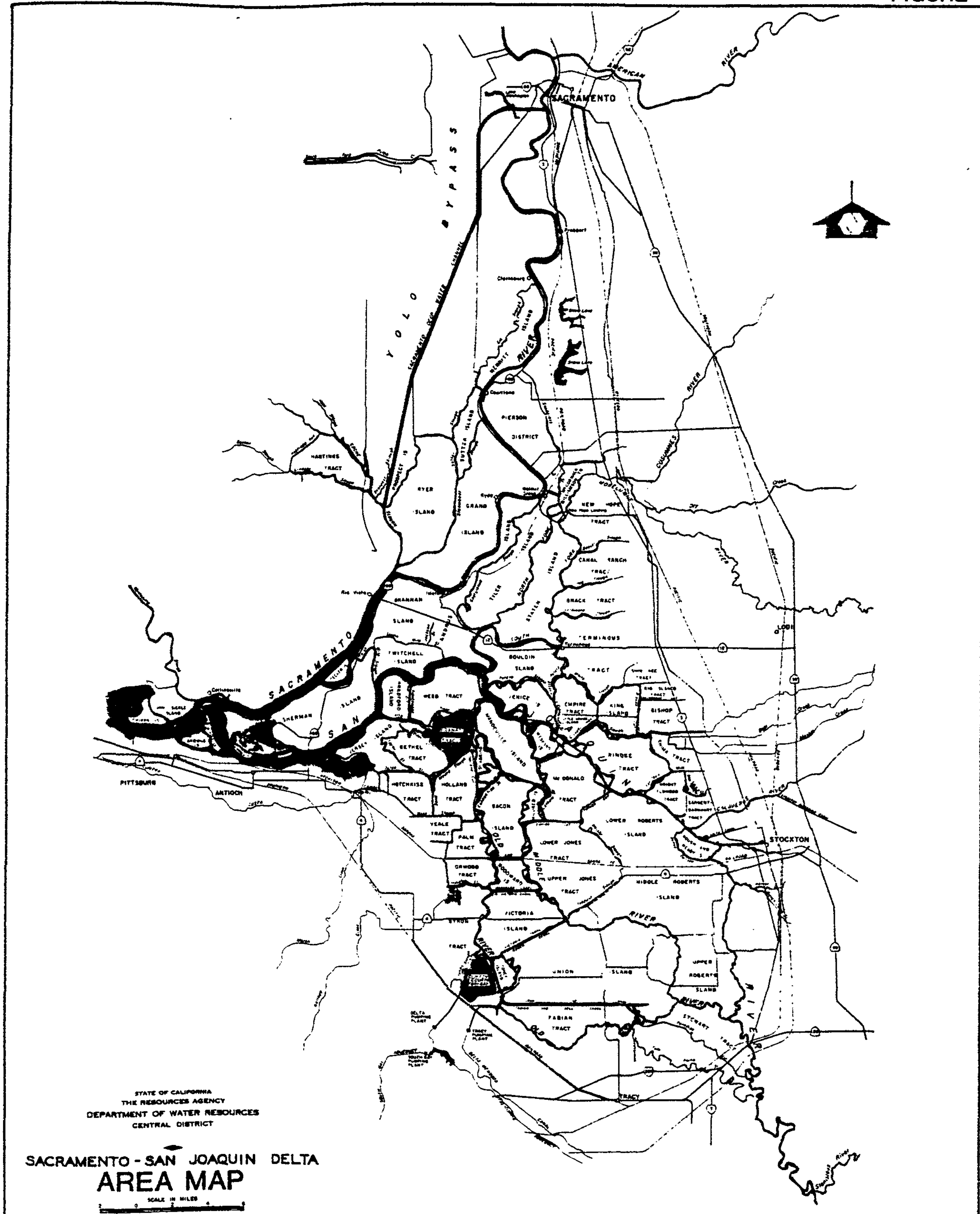

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FIGURE 2

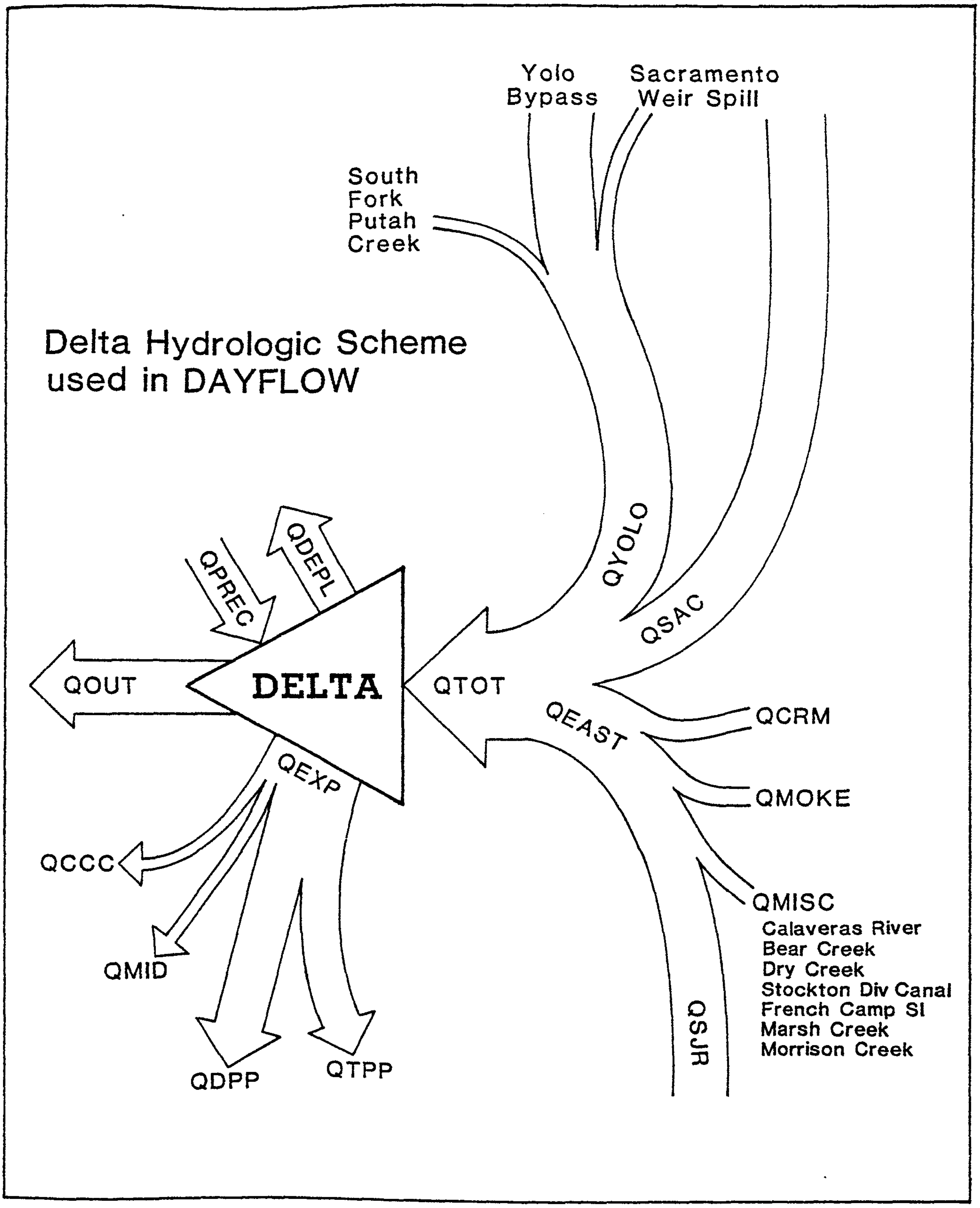

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Table 1

SUMMARY DAYFLOW PROGRAM DOCUMENTATION

Column No. 1/	DAYFLOW Parameter	Description	Pre - Execution Calculation	DAYFLOW Program Calculation	Comments
(1)	QSJR	San Joaquin River at Vernalis	None	None	Measured
(2)	QCRM	Cosumnes River at Michigan Bar	None	None	Measured
(3)	QMOKE	Mokelumne River at Woodbridge	None	None	Measured
(4)	QMISC	Miscellaneous Stream Flow	Sum of Calaveras River, Bear Creek, Marsh Creek, Dry Creek, Stockton Div. Canal, Morrison Creek and French Camp Slough	None	Sum of measured flows; hand calculated or intermediate program used (e.g., DFDAT84)
(5)	QEAST	East Delta Inflow	None	Sum of flows (1) through (4)	Calculated
(6)	QSAC	Sacramento River at Freeport	None	None	Measured
(7)	QYOLO	Yolo Bypass flow	Sum of Yolo Bypass near Woodland, Sacramento Weir Spill and South Fork Putah Creek	None	Sum of measured flows; hand calculated or intermediate program used (e.g., DFDAT84)
(8)	QTOT	Total inflow	None	Sum of flows (5) through (7)	Calculated
(9)	QDEPL	Gross channel depletion	None	None	Estimated by DWR (1965): repeating annual cycle
(10)	QPREC	Delta precipitation runoff	Depth converted to volume; evenly distributed over 5 days from event	None	Measured precipitation; estimated runoff pattern (5-day)
(11)	QCD	Net channel depletion	None	Depl(9) - flow(10)	Calculated
(12)	QTPP	CVP Tracy export	None	None	Operation records
(13)	QDPP	SWP export	BBID pumping subtracted (from 5/01/71)	None	Op. records; Delta PP through 4/30/71, Clifton Court intake from 5/01/71
(14)	QCCC	Contra Costa Canal export	None	None	Operations records
(15)	QMID	Miscellaneous diversions	Determine intensity and duration of event	None	Estimated diversions/transfers (e.g., island flooding/pumping)
(16)	QEXP	Total exports	None	Sum of exports (12) through (15)	Calculated
(17)	QXGEO	Delta Cross Channel and Georgiana Slough	Gate operation code and partial settings determined	Calculated by empirical formula based on gate settings and Sacramento River flow	Estimated; times determined and operations coded by hand
(18)	QWEST	Flow past Jersey Point	None	Flow(5)+flow(17)-exp(16)-65%depl(11)	Calculated
(19)	QOUT	Delta outflow at Chipps Island	None	Flow(8) - depl(11) - exp(16)	Calculated
(20)	QDIVER	Percent diverted	None	[Exp(16) + depl(11)]/ flow(8)	Calculated
(21)	QEFFECT	Effective inflow	None	A. If [exp(16) + 42% depl(11)] >=flow(1), then flow (21) = flow(8) - flow(1) B. If [exp(16) + 42% depl(11)] < flow(1), then flow(21) = Flow(8) - lower [(65% flow(1) + 15% depl(11)) OR (exp(16) + 42% depl(11))]	Calculated
(22)	QEFFDIV	Effective % diverted	None	[Flow(21) - flow(19)]/ flow(21)	Calculated

1/ Column numbers refer to DAYFLOW Data Summary report layout.

Some of the calculations (summarized in Table 1) associated with the determination of total surface water inflow to the Delta are performed prior to the execution of the DAYFLOW program, while others are performed during program execution, as described in the Methodology for DAYFLOW Data Summary Generation section.

Delta Precipitation Runoff Estimate (QPREC). In DAYFLOW, daily Delta precipitation is approximated using precipitation measured at Stockton Fire Station No. 4 in units of inches. It is assumed that the entire Delta receives the same depth when calculating the volume of water precipitated (depth multiplied by the area of the Delta (see pertinent notes in the Input Data Section). It is further assumed that the storm drainage is distributed evenly over five days, the day the precipitation was measured and the following four days. Precipitation is converted to a volumetric flow rate by dividing the volume of water (in cubic feet) by five days (in seconds) making its units consistent with other input data (e.g., streamflow).

Deltawide Gross Channel Depletion Estimate (QDEPL). Gross channel depletion (consumptive use) in the Delta is a difficult quantity to estimate because of the many variables involved. Direct monitoring is impractical at present; therefore, various approximation techniques are used.

Gross channel depletion is a significant parameter in the DAYFLOW program. Each month of the year has been assigned an average value, but the same annual pattern is used regardless of meteorological and hydrological conditions. Daily mean estimates were determined graphically by fitting the monthly averages with a continuous curve (see Input Data Documentation section).

The DAYFLOW parameter net channel depletion (QCD) is an estimate of the quantity of water removed from Delta channels to meet consumptive use (QDEPL).

QCD is defined as:

$$QCD = QDEPL - QPREC \qquad (6)$$

The assumption is made that all of the precipitation runoff is available to meet consumptive use.

Total Delta Exports and Diversions/Transfers (QEXP). The primary purpose of including the total exports parameter is to account for all water diverted from the Delta by the Federal and State governments to meet water agreements and contracts. These include Central Valley Project pumping at Tracy (QTPP) and Contra Costa Canal (QCCC) and State Water Project exports (Banks Pumping Plant or Clifton Court Intake, QDPP). In addition, other water transfers between Delta channels and islands have been included in the parameter QEXP when applicable (e.g., island flooding and pumpage, QMID). The equation for total exports is:

$$QEXP = QTPP + QCCC + QDPP + QMID \qquad (7)$$

It should be noted that since Clifton Court Forebay came on line, the SWP export (QDPP) has been taken as Clifton Court Forebay intake minus the Byron-Bethany Irrigation District diversion (explained in the Input Data Documentation section).

Interior Delta Flow Estimates

The DAYFLOW program has been used to evaluate flow at three interior Delta locations: (1) flow through the Delta Cross Channel and Georgiana Slough (QXGEO), (2) San Joaquin River flow past Jersey Point (QWEST), and (3) Sacramento River flow past Rio Vista (QRIO, used exclusively by the Department of Fish and Game). The derivations of these flow estimates are described below.

Delta Cross Channel and Georgiana Slough Flow Estimate. To obtain an approximation for cross-Delta flow (north Delta water reaching the central and southern Delta channels), the amount of water reaching the Mokelumne River system from the Sacramento River via the Delta Cross Channel and Georgiana Slough must be known. Because there are no streamflow gaging stations on either channel, empirical relationships have been developed to estimate Delta Cross Channel and Georgiana Slough flow given the Sacramento River flow at I Street Bridge in Sacramento. Since the Delta Cross Channel has two separately operated gates, three relationships are needed, for conditions when (1) both gates are closed (i.e., only Georgiana Slough flow), (2) one gate is open, and (3) both gates are open. The amount of time that each condition exists during a day is used to estimate the mean daily flow. It should be noted that even though the Sacramento River flow gaging station was moved to Freeport in October 1979, the relationships have not been reverified. Details of the empirical relationships now used, which were revised in 1978, are presented in the Input Parameter Documentation section.

San Joaquin River Flow Estimate Past Jersey Point. The amount and direction of San Joaquin River flow past Jersey Point is indicative of the water balance about the central and southern Delta. In particular, net reverse flow past Jersey Point indicates that higher salinity water (ocean) is being drawn into the interior Delta as a result of high depletions and exports with respect to stream inflows, precipitation, and cross-Delta flows. The following is used to determine this flow (using DAYFLOW parameters):

$$QWEST = QSJR + QCRM + QMOKE + QMISC + QXGEO - QEXP - 0.65\,(QDEPL - QPREC) \quad (8)$$

It is assumed that 65 percent of the net Delta channel depletions occur in the central and southern Delta (i.e., San Joaquin River system).

Sacramento River Flow Estimate Past Rio Vista. Assuming that 28 percent of the net Delta channel depletions (QDEPL - QPREC) occur along the Sacramento River between Freeport and Rio Vista, the following equation has been used to provide DFG with estimated flows past Rio Vista (using DAYFLOW Parameters):

$$QRIO = QSAC + QYOLO - QXGEO - 0.28\,(QDEPL - QPREC) \quad (9)$$

In other DWR studies, the depletions allocated to this area have been as high as 35 percent of the Deltawide net channel depletion.

Summary and Fish-Related Parameters and Indices

The DAYFLOW data base was developed by DWR in 1964 at the request of DFG. The data base was originally intended for fish and fisheries studies and, for many years, was used solely by DFG and DWR (primarily in biological work). The computational scheme used to generate the data base was partially automated (computerized) in 1978. The following are parameters or indices used by DFG:

- Percent water diverted from the Delta (QDIVER)
- Effective inflow to the western/central Delta (QEFFECT)
- Effective precent diverted from the western/central Delta (QEFFDIV)

A brief description of each parameter follows.

Percent Water Diverted (QDIVER). This index is calculated to quantify the portion of Delta water diverted for internal use and exports. In the most general form, it can be defined as:

$$QDIVER = \frac{(QTOT - QOUT)}{QTOT} \times 100 \qquad (10)$$

Expressing net Delta outflow (QOUT) by its components (see equations 1 and 6), the percent water diverted can be expressed as:

$$QDIVER = \frac{(QCD + QEXP)}{QTOT} \times 100 \qquad (11)$$

Effective Western/Central Delta Inflow (QEFFECT). This parameter was developed for the purpose of striped bass studies. Since striped bass are primarily in the western/central Delta, a water balance for this region would be more informative than a similar balance for the entire Delta. The parameter QEFFECT was defined to factor out from total Delta inflow (QTOT) the portion of San Joaquin River water not reaching the western/central Delta. This portion is the water diverted either by southern Delta water users or for exports. Therefore, QEFFECT is defined as:

$$QEFFECT = QTOT - QSJ4SD \qquad (12)$$

Where:

QSJ4SD = amount of San Joaquin River water used in, or diverted from, the southern Delta (i.e., not reaching the western/central Delta; this is not a parameter in DAYFLOW).

QTOT = as defined in equation 2.

To determine the amount of San Joaquin River water not reaching the western/central Delta (QSJ4SD), three general southern Delta flow patterns or cases are considered. Several flow quantities used to describe these cases are defined in Table 2. The three flow patterns and their associated equations for determining QSJ4SD are (the symbolic expressions are presented here and defined in Table 2):

Table 2

DEFINITION OF QUANTITIES
USED TO DETERMINE PARAMETER QEFFECT

Quantity	Definition
0.42 (QCD)	It is assumed that about 42 percent of Deltawide net channel depletions occur in the southern Delta.*
0.65 (QSJR)	It is assumed that 65 percent of the San Joaquin River flow splits into Old River (just upstream of Mossdale) and toward CVP and SWP export sites during certain hydrologic conditions.**
0.15 (QCD)	It is assumed that 15 percent of Deltawide net channel depletions occur along the San Joaquin River from the Old River split to the central Delta.*
QEXP + 0.42 (QCD)	Total amount of water either exported from or used in the southern Delta.
0.65 (QSJR) + 0.15 (QCD)	The amount of San Joaquin River water (1) flowing into Old River, and (2) diverted for use along the San Joaquin River from the Old River split to the central Delta.

* See Figure III-6 of the Draft EIR PC Project, Department of Water Resources, August 1974.

** See the Salinity Incursion and Water Resources Appendix to DWR Bulletin 76, April 1962.

Case 1.

If $QSJR \leq [QEXP + 0.42\ (QCD)]$,

then $QSJ4SD = QSJR$ (13)

Case 2.

If $QSJR > [QEXP + 0.42\ (QCD)] > [0.65\ (QSJR) + 0.15\ (QCD)]$,

then $QSJ4SD = [0.65\ (QSJR) + 0.15\ (QCD)]$ (14)

Case 3.

If $QSJR > [QEXP + 0.42\ (QCD)] \leq [0.65\ (QSJR) + 0.15\ (QCD)]$,

then $QSJ4SD = [QEXP + 0.42\ (QCD)]$ (15)

Effective Percent Western/Central Delta Water Diverted (QEFFDIV). This index used for striped bass studies is defined as:

$$QEFFDIV = \frac{(QEFFECT - QOUT)}{QEFFECT} X100 \qquad (16)$$

Substituting into equation 16 the equations defining QEFFECT for each of the three cases described above (equations 13, 14, and 15 into 12) and equations 1 and 6 for QOUT, the following observations are made regarding net diversions from the western/central Delta:

Case 1. Water is needed from the western/central Delta to meet the difference between Delta net channel depletions plus exports and San Joaquin River flow.

Case 2. Water is needed from the western/central Delta to meet the difference between 85 percent of Delta net channel depletions plus exports and 65 percent of San Joaquin River flow.

Case 3. Water is needed from the western/central Delta to meet 58 percent of Delta net channel depletions.

Summary Tables of Monthly Data

Summary tables were generated for DAYFLOW mean monthly Delta inflow and net Delta outflow (in cubic feet per second) and total monthly Delta inflow and net Delta outflow (in thousands of acre-feet). These tables are presented in Attachment F. The data are presented for each month of water years 1955-56 through 1983-84 along with the water year type assigned by the State Water Resources Control Board.

Refer to Attachment B for a discussion on other data bases of historical Delta hydrology.

Input Data Documentation

The calculations described in the Computational Scheme Section can be performed once the necessary input data have been acquired and assembled in a data base. The methodology for constructing the input data base and generating the Data Summary report is outlined in the next section. The input data parameters used to run the DAYFLOW program are briefly described herein. References for more detailed documentation are also provided.

The input data parameters are the principal streamflows to the Delta, Delta precipitation, exports and diversions from the Delta, and Delta consumptive use (gross channel depletions). The input data include both monitored and estimated values. These parameters are listed in Table 3, along with the DAYFLOW parameter(s) affected, data type (monitored, estimated, etc.), the source agency and reference, the station or parameter code used by the source agency, and comments.

The streamflow and precipitation stations are designated on the map in Figure 3. The labels (numbers) used on the map appear in Table 3 under the DWR Station Number column to allow cross referencing. The source agency references reported in Table 3 can be used to obtain additional information about data monitoring history and methodology and techniques used to collect the streamflow and precipitation data.

Estimated input parameters requiring further explanation are discussed below.

Delta Gross Channel Depletion Estimates (QDEPL)

Estimates for mean monthly gross channel depletion currently used to run the DAYFLOW program were derived at the Central District office. These values are:

Month	Gross Channel Depletion* (cfs month)	Month	Gross Channel Depletion* (cfs month)
October	1,865	April	1,880
November	1,730	May	2,434
December	2,081	June	3,747
January	1,210	July	4,352
February	883	August	3,785
March	1,310	September	2,632

Estimates for daily mean gross channel depletions were determined graphically using the above monthly mean estimates. These values are reported in Table 4. The data in Table 4 are used for all water years regardless of meteorological and hydrological conditions.

*The Byron-Bethany ID diversion is included in the mean monthly gross channel depletion value. Mean monthly gross channel depletion is monthly total cubic feet per second divided by the number of days in the month.

Table 3

INPUT DATA DOCUMENTATION

Input Data/ DWR Station Name	DAYFLOW Parameter Affected[1/]	Data Type	Source Agency[2/]	DWR Station Number[3/]	USGS Station Number	Comments
Bear Creek-Lodi	QMISC	Stream gage	CD	B0-2010		
Byron-Bethany ID Pumping	QDPP	Operation records	O&M			Included from 5/01/71; monitored by BBID
Calaveras River-Stockton	QMISC	Stream gage	CD	B0-2520	11-3107.00	
Clifton Court Forebay Intake	QDPP	Operations records	O&M			Included from 5/01/71
Contra Costa Canal Pumping	QCCC	Operations records	USBR			
Cosumnes River-McConnell	QCRM	Stream gage	USGS	B0-1125	11-3360.00	Discontinued 9/30/82
Cosumnes River-Michigan Bar	OCRM	Stream gage	USGS	B1-1150	11-3350.00	Included from 10/01/82
Cross Channel Gates Open	QXGEO	Operations records	USBR			Converted to gate operation code
Cross Channel Gate Change Time	QXGEO	Operations records	USBR			Account for partial gate settings
Delta (Banks) Pumping Plant	QDPP	Operations records	O&M			Included through 4/30/71
Dry Creek-Galt	QMISC	Stream gage	USGS	B0-1520	11-3295.00	
French Camp Slough-French Camp	QMISC	Stream gage	CD	B0-2805	11-3046.00	
Gross Channel Depletion	QDEPL	Derived estimate	CD			Repeating annual cycle; C. 1965
Marsh Creek-Byron	QMISC	Stream gage	USGS	B8-9100	11-3375.00	Discontinued 9/30/83
Mokelumne River-Woodbridge	QMOKE	Stream gage	USGS	B0-2105	11-3255.00	
Morrison Creek-Sacramento	QMISC	Stream gage	USGS	A0-0020	11-3365.80	Included through 9/30/79
Sacramento River-Freeport	QSAC	AVM monitoring	USGS	B9-1840	11-4476.50	Included from 10/01/79
Sacramento River-Sacramento	QSAC	Stream gage	USGS	A0-2100	11-4475.00	Included through 9/30/79
Sacramento Weir Spill	QYOLO	Weir discharge	CD	A0-2903	11-4260.00	

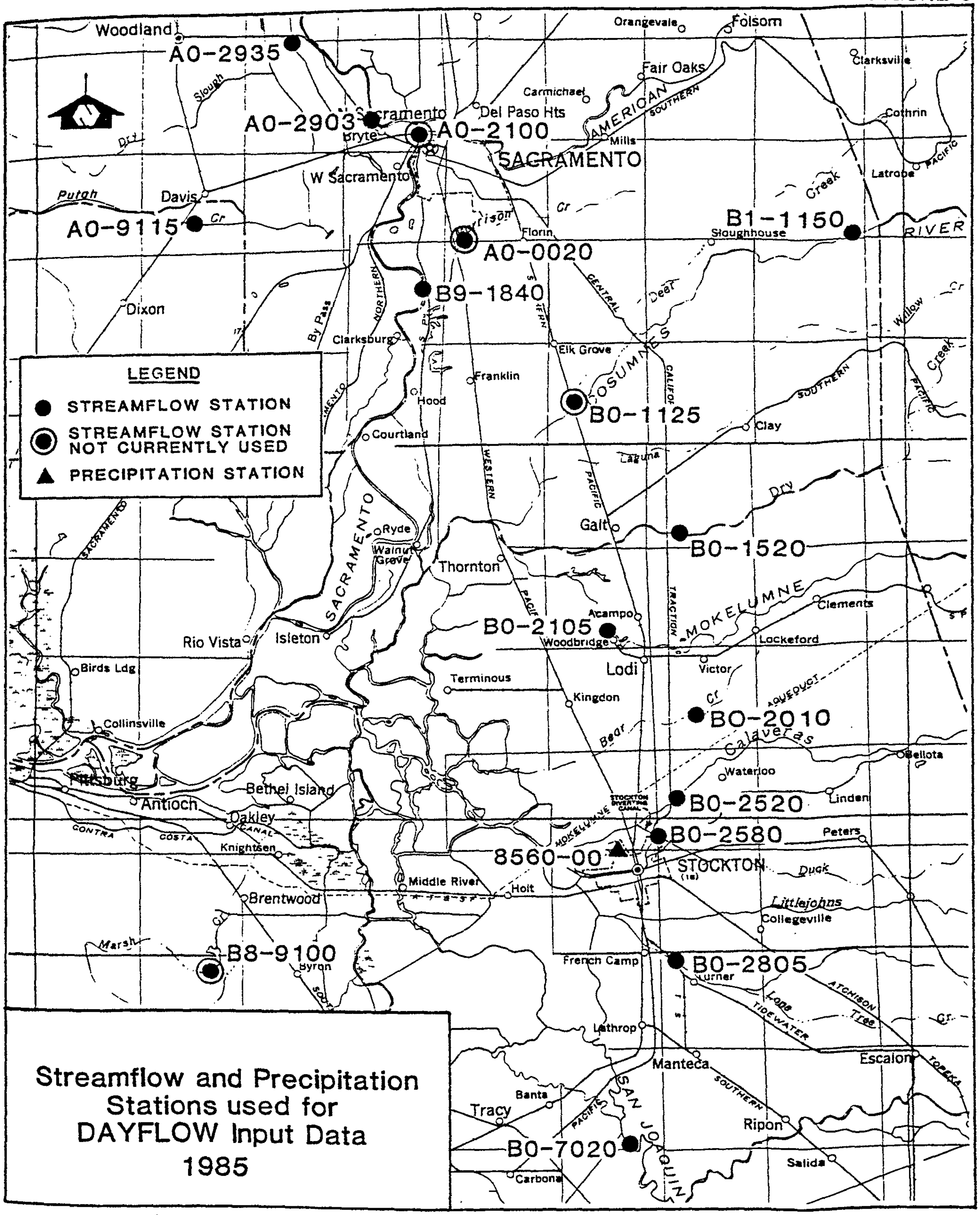
Table 3 (Continued)

INPUT DATA DOCUMENTATION

Input Data/ DWR Station Name	DAYFLOW Parameter Affected[1/]	Data Type	Source Agency[2/]	DWR Station Number[3/]	USGS Station Number	Comments
San Joaquin River-Vernalis	QSJR	Stream gage	USGS	B0-7020	11-3035.00	
South Fork Putah Creek-Davis	QYOLO	Stream gage	CD	A0-9115	11-4550.50	
Stockton Diverting Canal	QMISC	Stream gage	CD	B0-2580	11-3109.90	
Stockton Fire Station 4	QPREC	Precipitation gage	NWS	8560-00		Representative station; Delta = 738,000 acres (10/55-9/80) Delta = 682,230 acres (10/80-9/84)
Tracy Pumping Plant	QTPP	Operations records	USBR			
Yolo Bypass-Woodland	QYOLO	Stream gage	USGS	A0-2935	11-4530.00	

1/ See Table 1 for DAYFLOW parameter definitions.
2/ CD - Central District, DWR; computer printout or data forms.
O&M - Operations and Maintenance, DWR, Dispatcher's Daily Report; computer printout.
USBR - U. S. Bureau of Reclamation, Sacramento, CA; data acquired from O&M.
USGS - U. S. Geological Survey, Sacramento and Merced, CA; magnetic computer tape.
NWS - U. S. National Weather Service; data acquired from CD.
3/ See DWR Bulletin 230-81 (December 1981) for details; refer to Figure 3 for locations.

FIGURE 3



Streamflow and Precipitation Stations used for DAYFLOW Input Data 1985

TABLE 4

DELTA-WIDE GROSS CHANNEL DEPLETION ESTIMATES
MEAN DAILY VALUES IN CFS

19:25 WEDNESDAY, JUNE 26, 1985 1

FROM DAYFLOW DATA SUMMARY
DEVELOPED IN 1965 --- USED FOR ALL YEARS

CALIFORNIA DEPARTMENT OF WATER RESOURCES
CENTRAL DISTRICT

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	2150	1700	2000	1700	900	950	1750	2000	3050	4300	4200	3200
2	2100	1700	2000	1650	900	1000	1750	2000	3100	4300	4200	3200
3	2050	1700	2000	1600	900	1000	1750	2050	3150	4350	4150	3150
4	2050	1700	2050	1550	900	1000	1800	2100	3200	4350	4150	3100
5	2000	1700	2100	1500	900	1050	1800	2100	3250	4400	4100	3050
6	2000	1700	2100	1450	900	1050	1800	2100	3300	4400	4100	3000
7	1950	1700	2150	1400	900	1050	1800	2150	3350	4400	4050	2950
8	1950	1650	2150	1400	900	1100	1850	2150	3400	4400	4050	2900
9	1950	1650	2150	1350	900	1100	1850	2200	3450	4400	4000	2900
10	1900	1650	2200	1300	850	1100	1850	2200	3500	4400	4000	2850
11	1900	1650	2200	1300	850	1150	1850	2250	3550	4400	3950	2800
12	1900	1650	2200	1250	850	1150	1850	2300	3600	4400	3950	2750
13	1900	1650	2200	1250	850	1200	1900	2300	3650	4400	3900	2700
14	1850	1650	2200	1200	850	1250	1900	2350	3700	4400	3850	2650
15	1850	1700	2200	1200	850	1250	1900	2350	3750	4400	3850	2600
16	1850	1700	2200	1150	850	1300	1900	2400	3800	4400	3300	2600
17	1850	1700	2200	1150	850	1350	1900	2450	3850	4400	3800	2550
18	1800	1700	2150	1100	850	1350	1900	2450	3900	4400	3750	2500
19	1800	1700	2150	1100	850	1400	1900	2500	3950	4400	3700	2450
20	1800	1750	2150	1100	850	1400	1900	2550	4000	4350	3700	2450
21	1800	1750	2100	1050	900	1450	1900	2550	4050	4350	3650	2400
22	1800	1750	2100	1050	900	1500	1900	2600	4100	4350	3600	2350
23	1750	1750	2050	1000	900	1500	1900	2650	4100	4350	3600	2350
24	1750	1750	2050	1000	900	1550	1950	2700	4150	4350	3550	2300
25	1750	1800	2000	1000	900	1550	1950	2750	4200	4300	3500	2250
26	1750	1800	2000	1000	900	1600	1950	2750	4200	4300	3450	2250
27	1750	1850	1950	950	900	1600	1950	2800	4250	4300	3450	2200
28	1750	1900	1950	950	900	1650	2000	2850	4250	4250	3400	2200
29	1700	1900	1900	950	950	1650	2000	2900	4300	4250	3350	2150
30	1700	1950	1850	950	.	1650	2000	2950	4300	4250	3300	2150
31	1700	.	1800	900	.	1700	.	3000	.	4200	3250	.

TABLE 5

MISCELLANEOUS DIVERSIONS
MEAN MONTHLY VALUES IN CFS

13:49 THURSDAY, OCTOBER 24, 1985 1

FROM DAYFLOW PROGRAM SUMMARY
PROGRAM VERSION : JAN. 1985 RUN DATE : FEB. 1985

CALIFORNIA DEPARTMENT OF WATER RESOURCES
CENTRAL DISTRICT

WATER YEAR	YEAR TYPE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5556	W	0	0	0	0	0	0	0	0	0	0	0	0
5657	BN	0	0	0	0	0	0	0	0	0	0	0	0
5758	W	0	0	0	0	0	0	0	0	0	0	0	0
5859	D	0	0	0	0	0	0	0	0	0	0	0	0
5960	BN	0	0	0	0	0	0	0	0	0	0	0	0
6061	D	0	0	0	0	0	0	0	0	0	0	0	0
6162	BN	0	0	0	0	0	0	0	0	0	0	0	0
6263	W	0	0	0	0	0	0	0	0	0	0	0	0
6364	D	0	0	0	0	0	0	0	0	0	0	0	0
6465	W	0	0	0	0	0	0	0	0	0	0	0	0
6566	BN	0	0	0	0	0	0	0	0	0	0	0	0
6667	W	0	0	0	0	0	0	0	0	0	0	0	0
6768	BN	0	0	0	0	0	0	0	0	0	0	0	0
6869	W	0	0	0	1464	-119	-280	-280	-280	-280	-130	-80	-46
6970	W	0	0	0	0	0	0	0	0	0	0	0	0
7071	W	0	0	0	0	0	0	0	0	0	0	0	0
7172	BN	0	0	0	0	0	0	0	0	2761	-73	-914	-904
7273	W	-565	-238	-20	0	0	0	0	0	0	0	0	0
7374	W	0	0	0	0	0	0	0	0	0	0	0	0
7475	AN	0	0	0	0	0	0	0	0	0	0	0	0
7576	C	0	0	0	0	0	0	0	0	0	0	0	0
7677	C	0	0	0	0	0	0	0	0	0	0	0	103
7778	W	91	107	70	40	0	0	0	0	0	0	0	0
7879	D	0	0	0	0	0	0	0	0	0	0	0	0
7980	W	0	0	0	0	0	0	0	0	0	0	0	0
8081	D	0	0	0	0	0	0	0	0	0	0	0	0
8182	W	0	0	0	0	0	0	0	0	0	0	0	0
8283	W	0	0	0	0	0	0	0	0	0	0	0	0
8384	W	0	0	0	0	0	0	0	0	0	0	0	0

Preliminary evaluations indicate that refinement of the input data for gross channel depletions to reflect annual as well as seasonal variations would result in significant changes in estimates of net Delta outflow. This refinement is in progress. By using existing land-use survey and pan evaporation data from 1955 as input to the DWR Division of Planning consumptive use model, a data base of historical monthly total gross channel depletion estimates for the Delta has been developed. Work is underway to document this data base and to quantitatively evaluate how its use as input to the DAYFLOW program would affect estimates of net Delta outflow. This data base will also be made available for other studies requiring better estimates of historical Delta gross channel depletions.

Delta Precipitation Runoff estimates (QPREC)

Only the precipitation station at Stockton Fire Station No. 4 has been used to represent Deltawide precipitation. The assumption is made that runoff from precipitation during a particular day takes place uniformly over that day and the following four days. Also, the precipitation occurring naturally on water surfaces in the Delta (7 to 8 percent of the total Delta area) is not routed explicitly. Finally, it is assumed that all of the precipitation runoff occurring daily is available for consumptive use for the same day (i.e., gross channel depletions; net channel depletion = gross channel depletion - precipitation runoff).

The volume of water precipitated is calculated by multiplying the depth of precipitation measured at Stockton Fire Station 4 during a day by the area of the watersheds making up the Delta. For October 1, 1955, through September 30, 1980, this area was taken to be 738,000 acres. For October 1, 1980 through September 30, 1984, this area was changed to 682,230 acres, an area about 7.6 percent smaller than the former. Documentation for this change is not available, and Delta precipitation runoff (QPREC) has not been revised using a single value for the area of the Delta. Therefore, the values for QPREC reported in the DAYFLOW Data Summary reflect this discrepancy in Delta watershed area.

Work has been initiated to develop a data base of total daily precipitation for seven stations in the Delta to provide a better estimate of available precipitation. These stations are used in the DWR Division of Planning consumptive use model discussed in the previous section. They are: Brentwood (Contra Costa County), Davis 2 WSW Experimental Farm, Galt Fire Station, Lodi, Rio Vista, Stockton Fire Station 4, and Tracy-Carbona. When data from these stations are used, the Delta watershed area will be the total area of the Theissen polygons applyed to these stations (678,200 acres).

The following evaluations need to be made.

- Whether the runoff distribution pattern now used is valid.
- How the explicit routing of precipitation on water surfaces would affect the runoff distribution pattern.
- Whether all runoff is available for meeting consumptive use.

C-034485

Delta Cross Channel and Georgiana Slough Flow Estimate (QXGEO)

Flows through the Delta Cross Channel and Georgiana Slough are not gaged. Therefore, empirical equations were developed in 1978 using historical data to relate these flows to Sacramento River flow (QSAC) at I Street Bridge in Sacramento. Two independently operated gates control flow through the Delta Cross Channel. Consequently, three equations are needed, one for each of the following conditions:

- Both gates closed; flow only through Georgiana Slough
  $$QXGEO = 0.133\ (QSAC) + 829 \qquad (17)$$

- One gate open plus flow through Georgiana Slough
  $$QXGEO = 0.216\ (QSAC) + 2660 \qquad (18)$$

- Both gates open plus flow through Georgiana Slough
  $$QXGEO = 0.293\ (QSAC) + 2090 \qquad (19)$$

Available definition plots are presented in Figure 4.

These equations have not been checked for accuracy after Sacramento River flow measurements were taken at Freeport in October 1979. The magnitude of the error introduced into flow estimates for the Delta Cross Channel and Georgiana Slough since October 1979 should be evaluated.

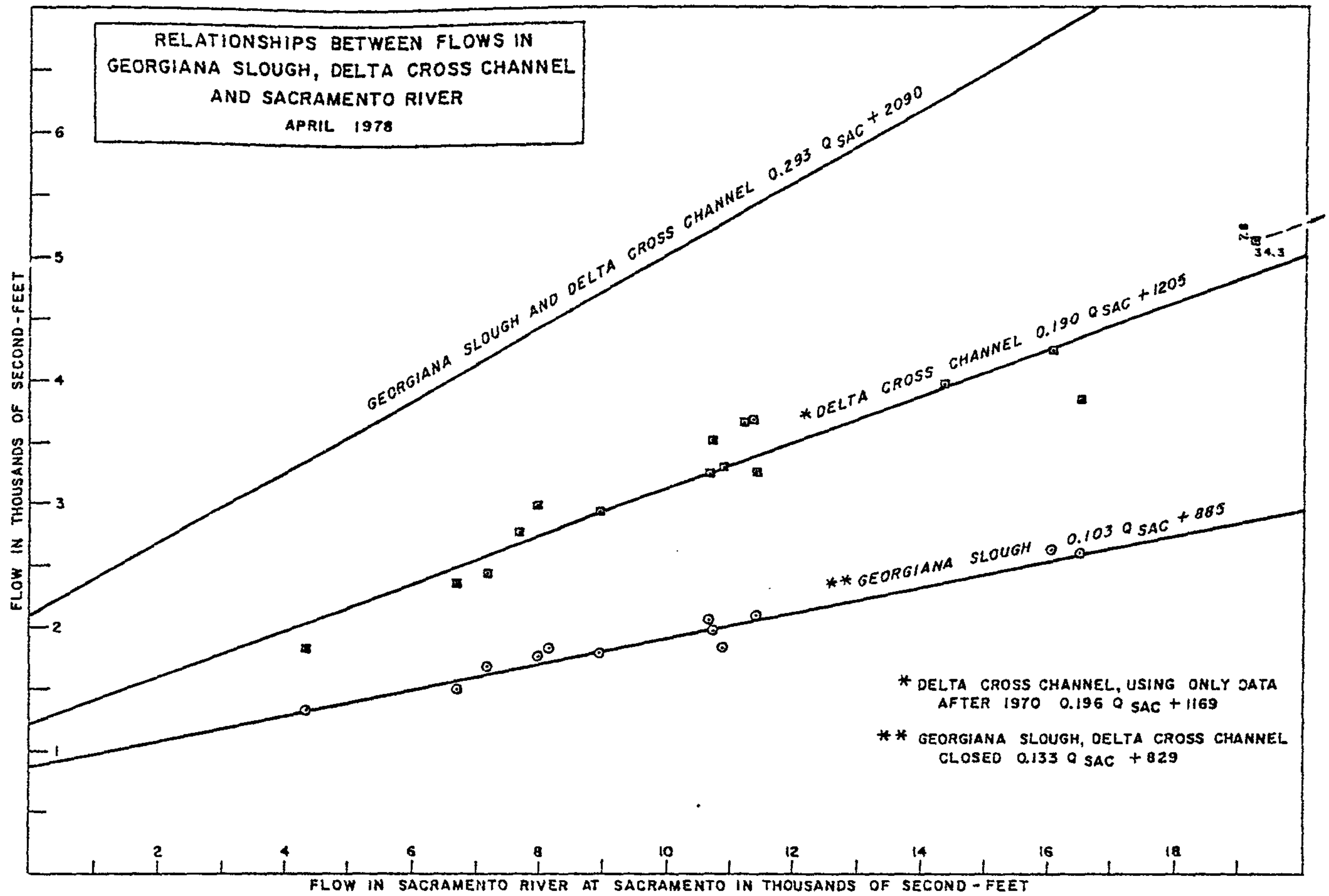
State Water Project Exports (QDPP)

The parameter QDPP (representing Banks Pumping Plant flow) has been used in the DAYFLOW program to account for daily exports from the Delta by the State Water Project. In the DAYFLOW data base, QDPP represents daily mean pumping rates at the Harvey O. Banks Delta Pumping Plant (formerly Delta Pumping Plant) from October 1, 1967, through April 30, 1971. During this period, SWP export pumping was direct from Delta channels.

Since Clifton Court Forebay came on line, SWP exports have been taken from the forebay and not directly from Delta channels. Consequently, estimates of net Delta outflow are affected by the amount of water diverted into Clifton Court Forebay (intake) from Old River at West Canal. Therefore, values for QDPP used in the DAYFLOW data base for May 1, 1971, through September 30, 1984, represent daily mean Clifton Court Forebay intake flows after a necessary correction.

Before Clifton Court Forebay came on line, Byron-Bethany Irrigation District (BBID) withdrawals were channel depletions. As noted in the documentation for gross channel depletions (see QDEPL above), an average value for the BBID withdrawal was included in QDEPL estimates as a portion of gross channel depletions (i.e., the BBID withdrawal was not explicitly accounted for). Since Clifton Court Forebay has been on line, BBID diversions have been taken out of the forebay and are no longer a direct channel depletion. To correct for the current inclusion of BBID withdrawals in QDEPL values, actual BBID withdrawals from Clifton Court Forebay (as reported by DWR operations) are subtracted from the Clifton Court Forebay intake (QDPP) to prevent double-counting. As a result, the value reported for QDPP from May 1, 1971, through September 30, 1984, is actually Clifton Court Forebay intake minus the BBID withdrawal.

FIGURE 4



C-034487

C-034487

Once the estimates for historical gross channel depletion (see QDEPL above) are used in running the DAYFLOW program, this correction will not be needed.

Miscellaneous Water Diversions/Transfers (QMID)

The parameter QMID was added to the DAYFLOW program when it was partially automated in 1978. It was included to account for water diversions and transfers other than consumptive use (gross channel depletions, QDEPL) and exports (QCCC, QTPP, and QDPP) that would affect daily estimates of historical net Delta outflow. Mean monthly values for QMID are reported in Table 5. To date, QMID has been used to simulate:

- Sherman Island flooding (diversion in January 1969) and pumping (inflow from February to September 1969).
- Andrus and Brannan Island flooding (diversion in June 1972) and pumping (inflow from July to December 1972).
- Water transfers from Middle River to the East Bay Aqueduct (diversion from Delta from September 1977 to January 1978).

Daily quantities assigned to simulate these events were determined by Central District staff using available flood management and operations records.

Listed in Table 6 are other water diversions and transfers occurring in the Delta from October 1955 through September 1984 (DAYFLOW data base period of record) that have not been accounted for. These events need to be evaluated with respect to their effect on estimates of net Delta outflow for possible inclusion in the DAYFLOW data base as QMID.

Methodology for DAYFLOW Data Summary Generation

The procedure used to generate the DAYFLOW data summary for water year 1983-84 involved:

- Acquiring input data
- Creating the DAYFLOW Program input data deck
- Executing the DAYFLOW program

A brief discussion of this procedure is presented herein as a concrete example of the steps involved in generating and reporting results from the DAYFLOW program. This discussion documents the generation of hydrologic data for the latest water year added to the DAYFLOW data base (see the DAYFLOW Summary Addendum, DWR, January 1985, for details).

DAYFLOW data were hand calculated prior to 1978. The general method of input data acquisition and hydrologic data generation has not changed. Details of prior DAYFLOW data generation and report preparation are not available.

Table 6

DELTA ISLANDS FLOODED FROM 1955-1984

Island (Tract)	Year(s) Flooded
Bradford	1983
Deadhorse	1955, 1980
Empire	1955
Holland	1980
Jones	1980
New Hope	1955
McCormack-Williamson	1955, 1958, 1964
McDonald	1982
Mildred	1969, 1983
Quimby	1955
Shima	1983 (twice)
Shin Kee	1958
Terminous	1958
Venice	1982
Webb	1980

Source: Sacramento-San Joaquin Delta Investigation, USCE Sacramento District, July 1979. Delta Levees Investigation, DWR Bulletin 192-82, December 1982.

Input Data Acquisition

Input data were acquired from three sources: DWR Central District, DWR Division of Operations and Maintenance, and U. S. Geological Survey Sacramento office. The data were received on data forms, computer printouts, or computer tapes. After being keyed in or transmitted via modem, the input data (see Table 3) were organized and placed in individual computer files using an IBM-XT microcomputer. Specific changes and assumptions are summarized in the notes below pertaining to the 1983-84 water year.

All available major inputs were acquired for October 1983 through August 1984; no data for Mokelumne River were available for September 1984; no data were available for Dry Creek; and Marsh Creek was not monitored during water year 1983-84. However, since these streamflows are relatively small when compared to total inf' /, the DAYFLOW output are still meaningful, particularly the estimates c. Delta outflow. In addition, Morrison Creek is no longer included in the calculation for miscellaneous stream inflow (OMISC) since its flow is ponded along the east side of the Sacramento River at Freeport and only a portion is pumped into the Sacramento River downstream of Freeport.

Input Data Deck Creation

Use of the DAYFLOW program in its present form requires that various input data be manipulated and combined before executing the program. A brief description of DAYFLOW input and output parameters, pre-execution calculations, and program calculations is presented in Table 1. The column numbers in the table refer to the sample DAYFLOW data summary report for August 1984 shown in Figure 5 (see Note 5 below). The report shown was prepared using the DAYFLOW SAS data set -- Statistical Analysis System -- and two SAS programs presented in Attachment E.

The process of creating the DAYFLOW input data deck consisted of several steps. Once the input data were acquired, precipitation and Delta Cross Channel gate operation codes were hand-calculated or determined, and unit conversions (acre-feet to cubic feet per second) were made using spreadsheet software. Individual computerized data files were then made for the input data (see Table 3). Finally, a FORTRAN program (DFDAT84; see Attachment E for listing) was executed on an IBM-XT to: (1) read the individual input data files; (2) perform the pre-execution calculations for QMISC and QYOLO (QDPP was determined using spreadsheet software); and (3) write the DAYFLOW input data deck in the format required.

DAYFLOW Program Execution

The DAYFLOW Program (FORTRAN) residing on DWR's mainframe computer (CDC 720) was down-loaded to an IBM-XT and, with only minor adjustments, successfully executed using the input data deck for water year 1982-83 (see DAYFLOW program listing in Attachment E). During this process, an error was discovered in the read format statement for the Delta Cross Channel gate operation codes. This affected the values reported in the June 1984 DAYFLOW Data Summary for the Cross Channel and Georgiana Slough (QXGEO), as well as the estimate of flow past Jersey Point (QWEST). Specifically, values were incorrect for day 12 and day 23 of each month when both gates were closed. In addition, values reported are incorrect for days from the twelfth to the end of the month when gate settings were changed. This format error was corrected before final execution. (See Note 4 below for details on water year 1982-83 revisions.) DAYFLOW was executed using the water year 1983-84 input data deck (October 1983 through August 1984, data for September 1984 was later generated in February 1985); the output is reported in Attachment G.

Notes

In using the DAYFLOW data reported for water year 1983-84, certain information is essential for proper interpretation.

1. All input data acquired for water year 1983-84 is preliminary and subject to revision following final screening by the respective sources (see Table 3).

2. The DAYFLOW program was run for water year 1983-84 only through August, because data for Mokelumne River were not available at time of execution. Also, the program was run without data for Marsh Creek (not monitored) and Dry Creek (not available).

3. Certain input parameter records were missing data for various days. The specific parameters, the dates for which data are missing, and the estimated or assumed values substituted are presented in Table 3 of the DAYFLOW Data Summary Addendum (January 1985). The DAYFLOW program was executed for water year 1983-84 with these substituted values.

4. The read statement format error (mentioned in the previous section) was corrected, and the DAYFLOW program was run using the input data deck for water year 1982-83. For water years prior to 1982-83, revisions were made in February 1985. The changes for water years prior to 1983-84 are documented in Attachment C and reported in Attachment G.

5. Outdated headings used in prior DAYFLOW output listings were revised, as shown in Figure 5.

FIGURE 5

HYDROLOGIC DATA FOR THE SACRAMENTO-SAN JOAQUIN ESTUARY (CFS)
DAYFLOW PROGRAM SUMMARY

PROGRAM VERSION : JAN. 1985 RUN DATE : FEB. 1985
* SEE DOCUMENTATION FOR PARAMETER DESCRIPTIONS AND REVISIONS *

CALIFORNIA DEPARTMENT OF WATER RESOURCES
CENTRAL DISTRICT

AUG 1984

DAY	(1) SAN JOAQ RIVER -- MEASRD	(2) COSUMNES RIVER -- MEASRD	(3) MOKELUMNE RIVER -- MEASRD	(4) MISC FLOWS -- MEAS SUM	(5) E. DELTA INFLOW -- CALC	(6) SAC RIVER -- MEASRD	(7) YOLO BYPASS -- MEAS SUM	(8) TOT DELT INFLOW -- CALC	(9) DELTA CONSUMP'N -- ESTMTD	(10) PRECIP RUNOFF -- MEAS EST	(11) CHANNEL DEPLE'N -- CALC
1	1950	48	303	80	2351	22000	16	24397	4200	0	4200
2	1930	46	309	66	2351	21300	16	23667	4200	0	4200
3	1910	46	342	86	2384	21000	15	23399	4150	0	4150
4	1910	45	380	84	2419	20700	15	23134	4150	0	4150
5	1930	45	367	111	2453	20300	15	22768	4100	0	4100
6	2030	44	389	124	2587	20400	14	23001	4100	0	4100
7	1950	43	377	88	2458	20500	14	22972	4050	0	4050
8	1830	42	348	78	2298	20100	14	22412	4050	0	4050
9	1830	40	331	71	2272	19800	14	22086	4000	0	4000
10	1850	40	345	74	2309	19300	11	21620	4000	0	4000
11	1880	38	370	88	2376	18900	13	21289	3950	0	3950
12	1970	37	387	101	2495	18100	12	20607	3950	0	3950
13	2110	37	413	104	2664	17200	15	19879	3900	0	3900
14	2100	37	404	96	2637	16700	16	19353	3850	0	3850
15	2010	36	460	124	2630	16500	18	19148	3850	0	3850
16	2010	36	466	162	2674	16700	17	19391	3800	0	3800
17	2090	36	451	148	2725	16700	18	19443	3800	0	3500
18	2210	36	463	170	2879	16800	16	19695	3750	0	3750
19	2230	36	471	146	2883	17100	13	19996	3700	0	3700
20	2300	34	444	147	2925	17600	13	20538	3700	0	3700
21	2240	34	458	132	2864	17800	15	20679	3650	0	3650
22	2360	33	440	155	2988	18200	15	21203	3600	0	3600
23	2440	32	442	147	3061	18400	17	21478	3600	0	3600
24	2490	32	448	178	3148	18400	17	21565	3550	0	3550
25	2470	32	490	138	3130	18700	17	21847	3500	0	3500
26	2490	31	485	192	3198	18800	20	22018	3450	0	3450
27	2750	32	497	212	3491	19400	20	22911	3450	0	3450
28	2630	33	489	174	3326	19500	21	22847	3400	0	3400
29	2520	32	451	157	3160	19000	19	22179	3350	0	3350
30	2570	32	491	183	3276	18300	20	21596	3300	0	3300
31	2570	31	524	168	3293	18100	18	21411	3250	229	3021
TOTAL CFS	67560	1156	13035	3984	85735	582300	494	668529	117350	229	117121
MONTHLY MEAN	2179	37	420	129	2766	18784	16	21565	3785	7	3778

DAY	(12) CVP EXPORT -- MEASRD	(13) SWP EXPORT -- MEASRD	(14) CCC EXPORT -- MEASRD	(15) MISC DIVER'N -- ESTMTD	(16) TOT DELT EXPORTS -- CALC	(17) X-CHNL GEORG SL -- ESTMTD	(18) JERSEY PT FLOW -- CALC	(19) DELTA OUTFLOW -- CALC	(20) PERCENT DIVERTED -- CALC	(21) EFFECTIV INFLOW -- CALC	(22) EFFECTIV % DIVRTD -- CALC
1	4647	5196	238	0	10081	8536	-1894	10116	59	22447	55
2	4675	4873	247	0	9795	8331	-1843	9672	59	21737	56
3	4643	4874	250	0	9767	8243	-1838	9482	59	21489	56
4	4650	5198	257	0	10105	8155	-2228	8879	62	21224	58
5	4632	5321	257	0	10210	8038	-2384	8458	63	20838	59
6	4648	5478	257	0	10383	8067	-2394	8518	63	20971	59
7	4656	5408	247	0	10311	8096	-2390	8611	63	21022	59
8	4650	5410	254	0	10314	7979	-2669	8048	64	20582	61
9	4451	5818	249	0	10518	7891	-2955	7568	66	20256	63
10	4678	4996	243	0	9917	7745	-2463	7703	64	19770	61
11	4682	5381	240	0	10303	7628	-2867	7036	67	19409	64
12	4656	5378	216	0	10250	7393	-2929	6407	69	18637	66
13	4642	5416	257	0	10315	7130	-3056	5664	72	17769	68
14	4647	5401	279	0	10327	6983	-3209	5176	73	17253	70
15	4636	5407	288	0	10331	6925	-3280	4967	74	17138	71
16	4625	5167	283	0	10075	6983	-2888	5516	72	17381	68
17	4569	4633	269	0	9471	6983	-2233	6172	68	17353	64
18	4612	4916	270	0	9798	7012	-2344	6147	69	17485	65
19	3971	5384	279	0	9634	7100	-2056	6662	67	17766	63
20	4239	5302	257	0	9798	7247	-2031	7040	66	18238	61
21	4513	4955	246	0	9714	7305	-1917	7315	65	18439	60
22	4458	4401	243	0	9102	7423	-1031	8501	60	18843	55
23	4449	4529	248	0	9226	7481	-1024	8652	60	19038	55
24	4439	4643	236	0	9318	7481	-996	8697	60	19075	54
25	4425	4898	239	0	9562	7569	-1138	8785	60	19377	55
26	4390	4216	224	0	8830	7598	-276	9738	56	19528	50
27	4121	5086	238	0	9445	7774	-422	10016	56	20161	50
28	3378	4958	241	0	8577	7804	343	10870	52	20217	46
29	3027	3732	244	0	7003	7657	1637	11826	47	19659	40
30	3222	2926	231	0	6379	7452	2204	11917	45	19026	37
31	3690	2198	220	0	6108	7393	2615	12282	43	18841	35
TOTAL CFS	135721	151499	7747	0	294967	235404	-49953	256441		600969	
MONTHLY MEAN	4378	4887	250	0	9515	7594	-1611	8272	62	19386	57

Summary of Equations

$$QOUT = QTOT + QPREC - QDEPL - QEXP \quad (1)$$

$$QTOT = QSAC + QEAST + QYOLO \quad (2)$$

$$QEAST = QSJR + QCRM + QMOKE + QMISC \quad (3)$$

QMISC = Calaveras River flow
+ Bear Creek flow
+ Dry Creek flow
+ Stockton Diverting Canal flow
+ French Camp Slough flow
+ Marsh Creek flow
+ Morrison Creek flow (4)

QYOLO = Yolo Bypass flow at Woodland
+ Sacramento Weir Spill
+ South Fork Putah Creek (5)

$$QCD = QDEPL - QPREC \quad (6)$$

$$QEXP = QTPP + QCCC + QDPP + QMID \quad (7)$$

$$QWEST = QSJR + QCRM + QMOKE + QMISC + QXGEO - QEXP - 0.65\ (QDEPL - QPREC) \quad (8)$$

$$QRIO = QSAC + QYOLO - QXGEO - 0.28\ (QDEPL - QPREC) \quad (9)$$

$$QDIVER = \frac{(QTOT - QOUT)}{QTOT} \times 100 \quad (10)$$

$$QDIVER = \frac{(QCD + QEXP)}{QTOT} \times 100 \quad (11)$$

$$QEFFECT = QTOT - QSJ4SD \quad (12)$$

If $QSJR \leq [QEXP + 0.42\ (QCD)]$,

then $QSJ4SD = QSJR$ (13)

If QSJR > [QEXP + 0.42 (QCD)] > [0.65 (QSJR) + 0.15 (QCD)],

then QSJ4SD = [0.65 (QSJR) + 0.15 (QCD)] (14)

If QSJR > [QEXP + 0.42 (QCD)] $\leq$ [0.65 (QSJR) + 0.15 (QCD)],

then QSJ4SD = [QEXP + 0.42 (QCD)] (15)

$$QEFFDIV = \frac{(QEFFECT - QOUT)}{QEFFECT} X100 \qquad (16)$$

- Both gates closed; flow only through Georgiana Slough
  QXGEO = 0.133 (QSAC) + 829 (17)

- One gate open plus flow through Georgiana Slough
  QXGEO = 0.216 (QSAC) + 2660 (18)

- Both gates open plus flow through Georgiana Slough
  QXGEO = 0.293 (QSAC) + 2090 (19)