METHODOLOGY FOR FLOW AND SALINITY ESTIMATES IN THE SACRAMENTO-SAN JOAQUIN DELTA AND SUISUN MARSH

FIFTEENTH ANNUAL PROGRESS REPORT TO THE STATE WATER RESOURCES CONTROL BOARD IN ACCORDANCE WITH WATER RIGHT DECISION 1485, ORDER 9

JUNE 1994

CHAPTER 4

Delta Island Consumptive Use Analysis: Twitchell Island

[Editor's Note: The following report is an electronic reproduction of the fourth chapter from the15th annual progress report to the State Water Resources Control Board. The original text and structure of this chapter was left the same, however, the font styling and positioning of the figures within the report have been modified.]

Agricultural water use data from Delta islands is needed to calculate the salt and organic contaminate loads entering the Delta channels from farming practices on each island. Therefore, DWR Division of Local Assistance and the U.S. Geologic Society are conducting a joint feasibility study to determine inflows and outflows from Delta islands. The plan is to study water use in the Delta by focusing on one island. Twitchell Island has been selected. After determining the water balance on Twitchell Island, extrapolation methods could be used to estimate the water balance on other Delta islands.

The Delta Island Consumptive Use (DICU) is used to help define the factors that dominate the water balance. The DICU model and associated routines were developed by DWR to estimate agricultural diversion and drainage volumes and salinity concentrations relative to DWRDSM nodes. This information is essential to studying flow and quality using models such as DWRDSM.

DICU

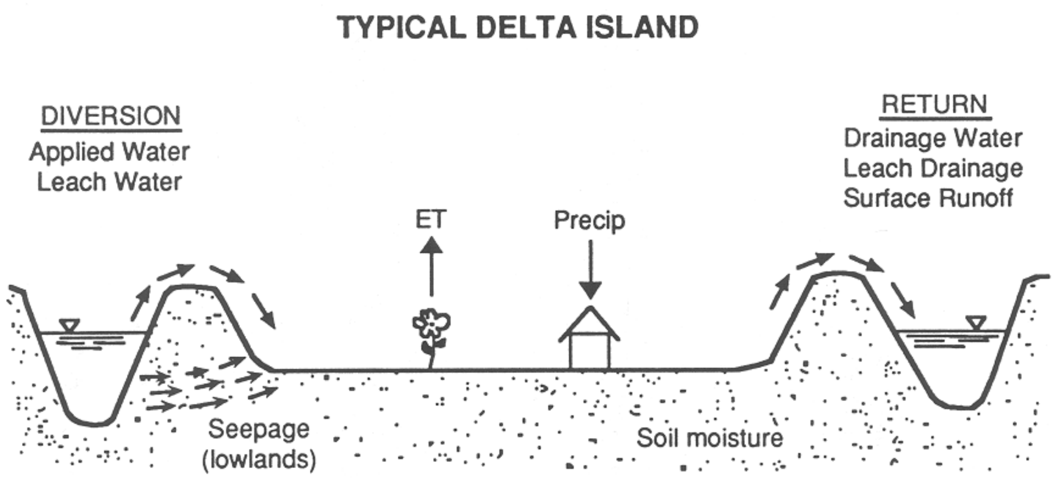
Figure 4-1 shows a simplified version of the water balance for a typical Delta Island used by the DICU model and associated routines. The DICU model is essentially a bookkeeping system (see Figure 4-2) which keeps track of water that enters, leaves, or is stored on each of the 142 Delta subareas on a monthly time step. Factors such as precipitation, seepage, evapotranspiration (ET), irrigation, soil moisture storage, leach water, runoff, crop type, and acreage are used. The DICU model determines total consumptive use, consumptive use of precipitation, consumptive use of seepage, and consumptive use of applied water on each of the 142 subareas. Once this is done, an associated routine uses the results to calculate diversion and return flows for each subarea and allocates them to DWRDSM nodes (approximately 250 diversion nodes and 200 drainage nodes). The routine also assigns representative total dissolved solids and chloride concentrations to the nodal return flows. These results, in turn, are used as input to the DWRDSM model for verification and planning studies. Input to DICU include:

- Acreage for 142 Delta subareas
- Acreage for 20 possible land use categories
- Noncritical and critical water year Delta land use
- Historic monthly total precipitation for 7 Delta stations (1922-1991)
- Historic monthly total pan evaporation (1956-1991)
- Mean ET for each land use category
- Estimated soil moisture accounting
- Typical monthly irrigation schedule for each irrigated crop and water year type
- Estimated schedule of monthly lowlands leaching/ponding
- Estimated irrigation efficiency

Twitchell Island Diversion and Return Flow Estimates

Twitchell Island is one of the 142 DICU subareas. The input data used for analyzing Twitchell Island consumptive use is displayed in Figures 4-3 to 4-5 and Tables 4-1 to 4-4.

Output data from DICU modeling is shown in Figures 4-6 through 4-10. Figure 4-6 shows monthly diversion and return flow estimates for Twitchell Island for water years 1970 through 1992 with a 70 percent irrigation efficiency. A database of similar values exists for water years 1922 through 1992 for each of the 142 Delta subareas. Figure 4-7 shows average, minimum and maximum monthly diversion and return flows over the period water year 1922-1992 (with a 70 percent irrigation efficiency). Figure 4-8 compares the information from Figure 4-6 to similar estimates generated with an irrigation efficiency of 50 percent. Figures 4-9 and 4-10 show the difference between average, minimum and maximum diversions and returns for a 50 percent versus a 70 percent irrigation efficiency. The plots show that changing the irrigation efficiency does have a significant impact in the summer months but not in the winter months. More details on sensitivity analysis tests are documented in a report soon to be released by the Delta Modeling Section.



$$\text{Diversion} = \text{Seepage} + \text{Applied leachwater} + \frac{\text{Required applied irrigation water}}{\text{irrigation efficiency}}$$

$$\text{Return} = \text{Precip runoff} + \text{Leach drainage} + \text{Excess applied irrigation water}$$

$$\text{Precip Runoff} = \text{Precipitation} - \text{Total Consumptive Use} \ (\geq 0)$$

$$\text{Excess applied irrigation water} = \frac{\text{Required applied irrigation water}}{\text{irrigation efficiency}} - \text{Required applied irrigation water}$$

Figure 4.1: Water Balance for a Typical Delta Island.

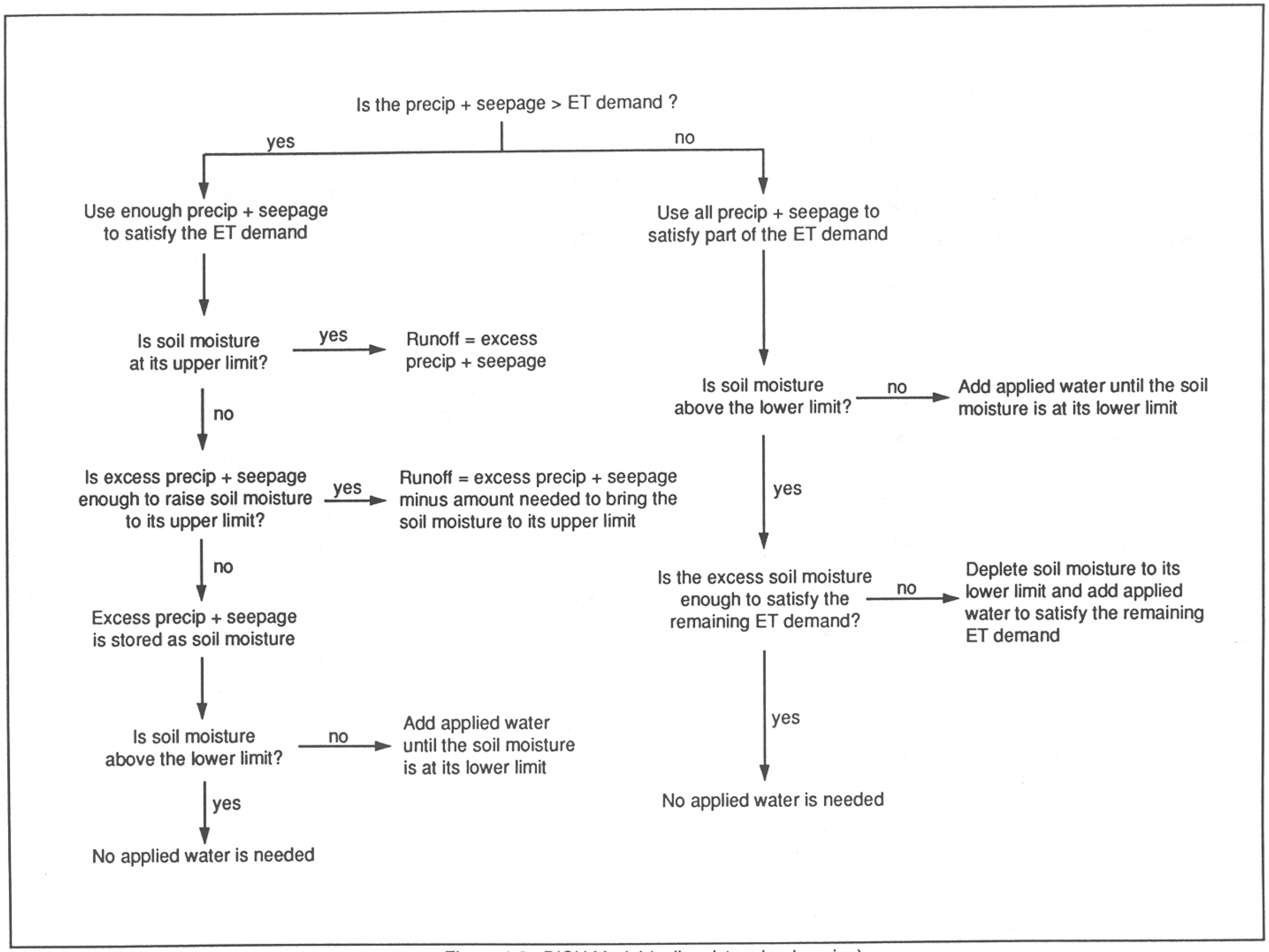
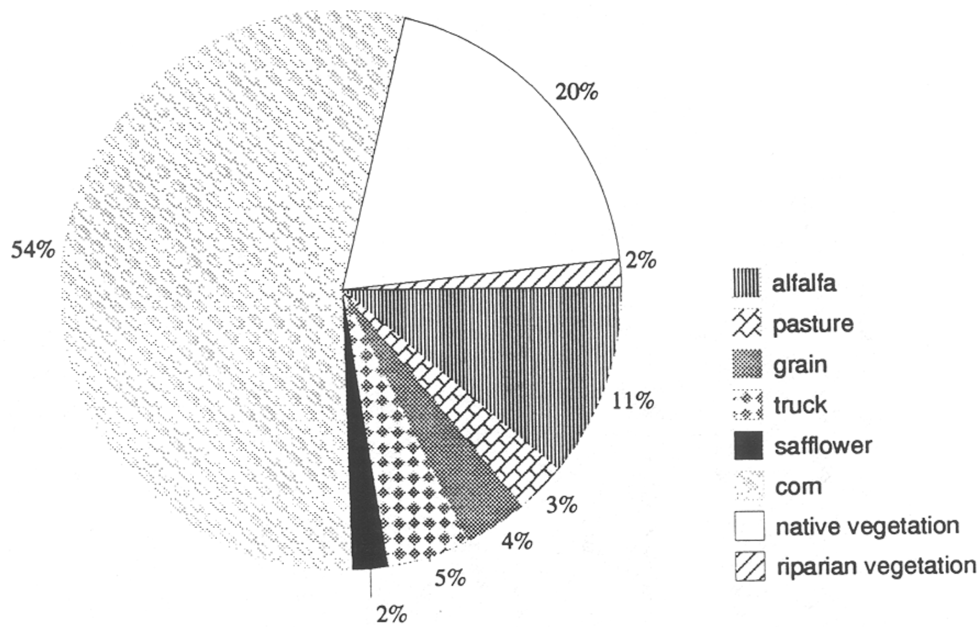


Figure 4-2. DICU Model (soil moisture bookkeeping).

Figure 4-3

Non-critical water year land use for Twitchell Island



Critical water year land use for Twitchell Island

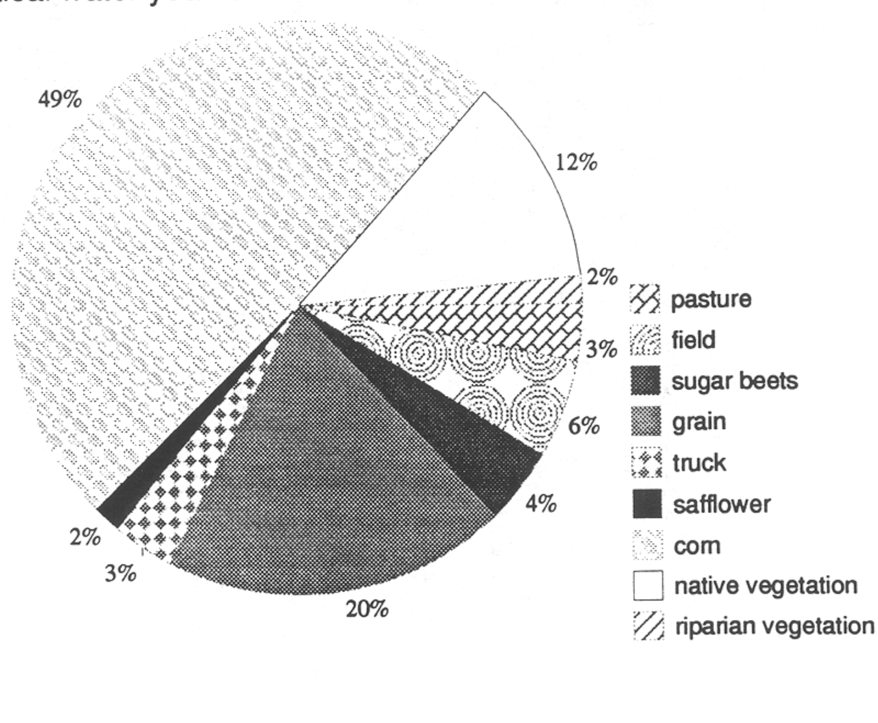
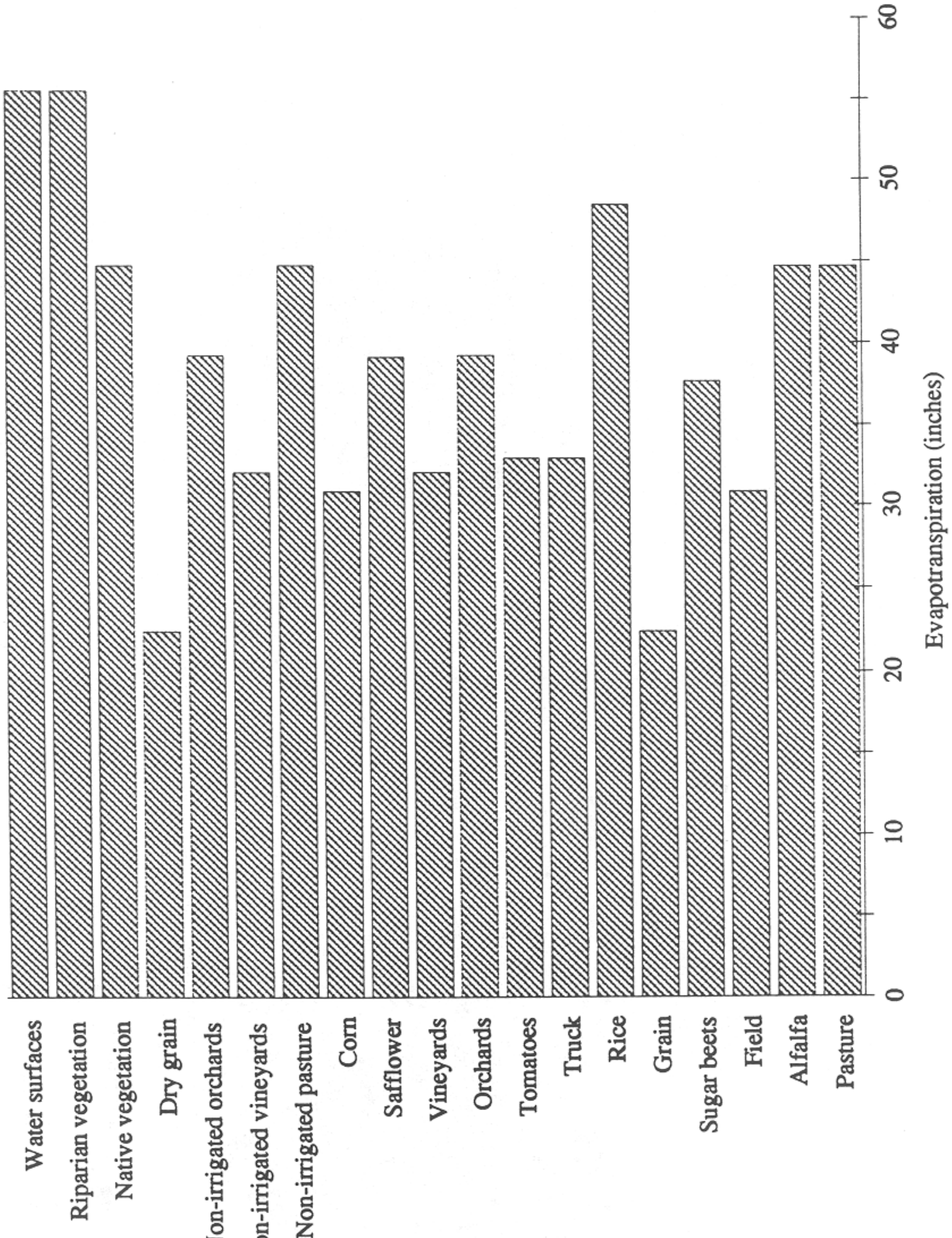


Figure 4-4

DICU model annual ET per crop per unit area (inches)



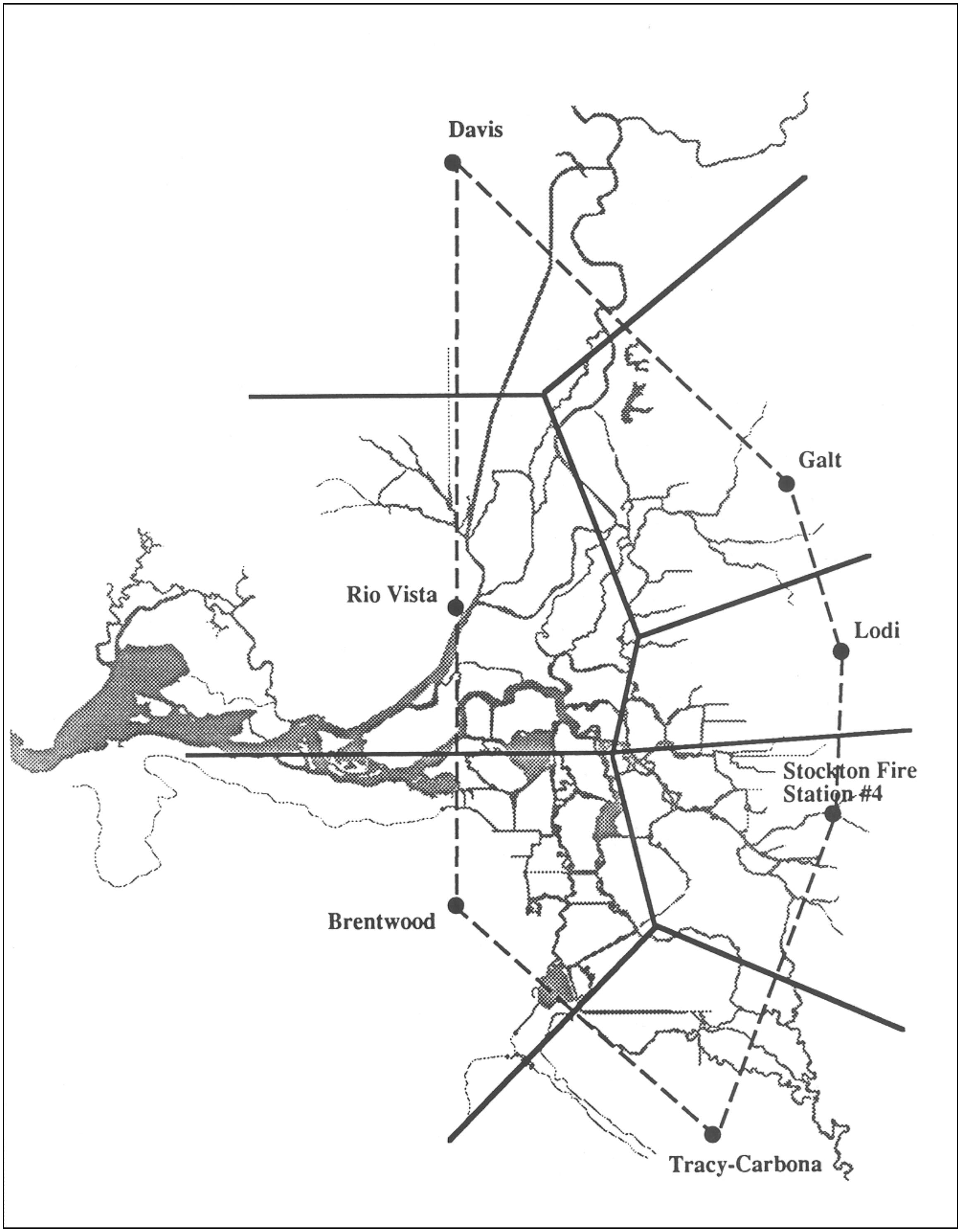


Figure 4.5: Precipitation Stations and Theissen Polygon Boundaries.

Figure 4-6

Irrigation flows for Twitchell Island based on the DICU model (70% efficiency)

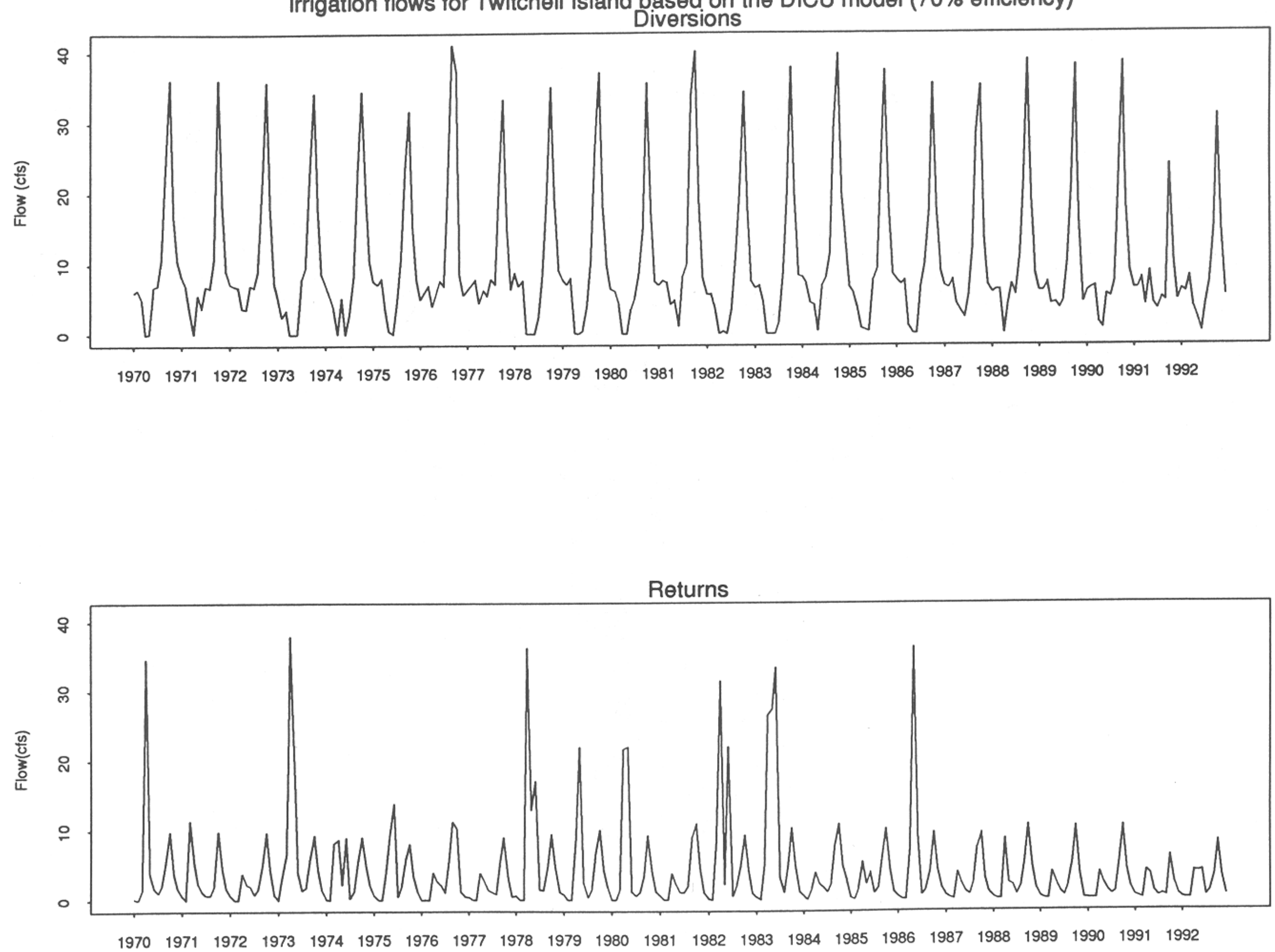
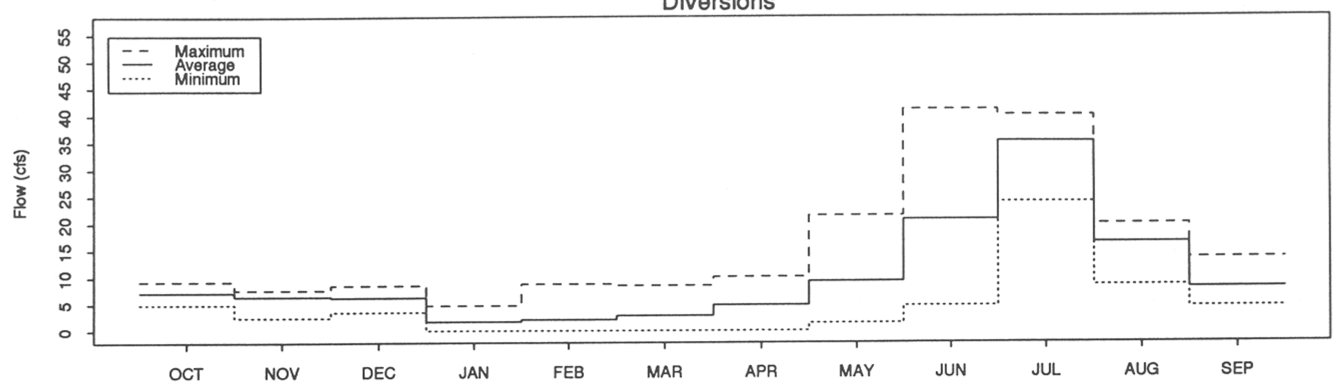


Figure 4-7

Irrigation flows for Twitchell Island based on the DICU model (1922-1992) (70% irrigation efficiency)



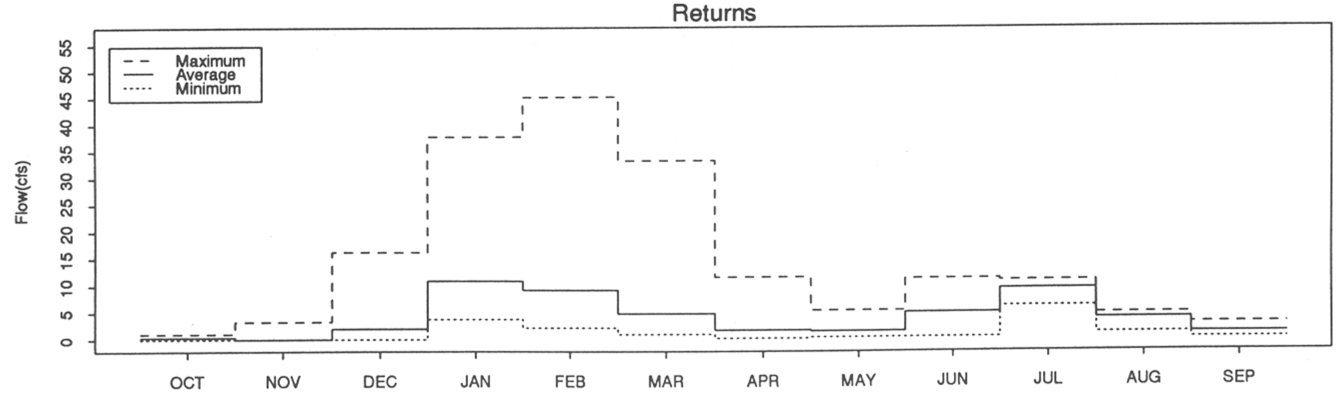


Figure 4-8

Irrigation flows for Twitchell Island based on the DICU model

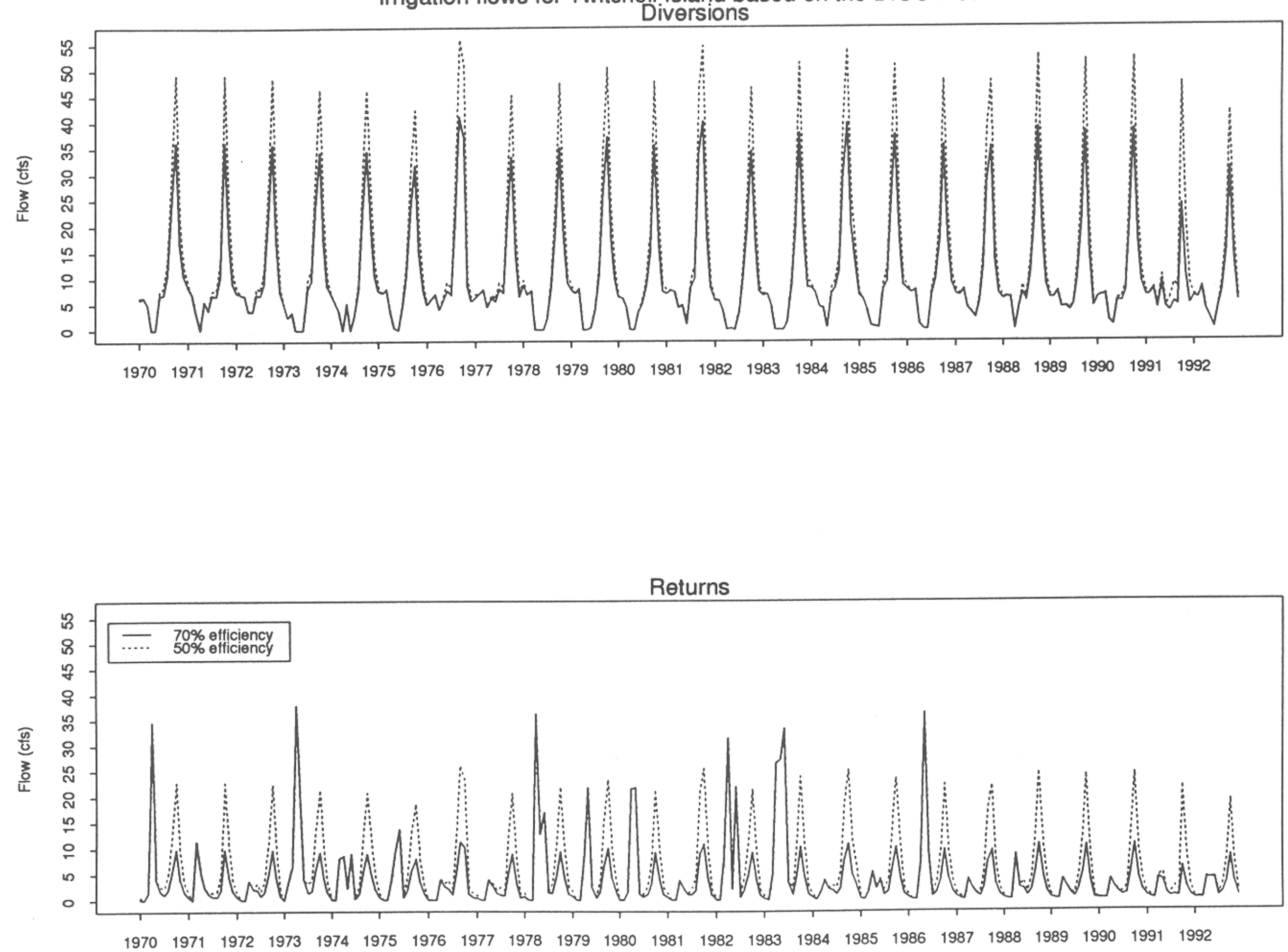
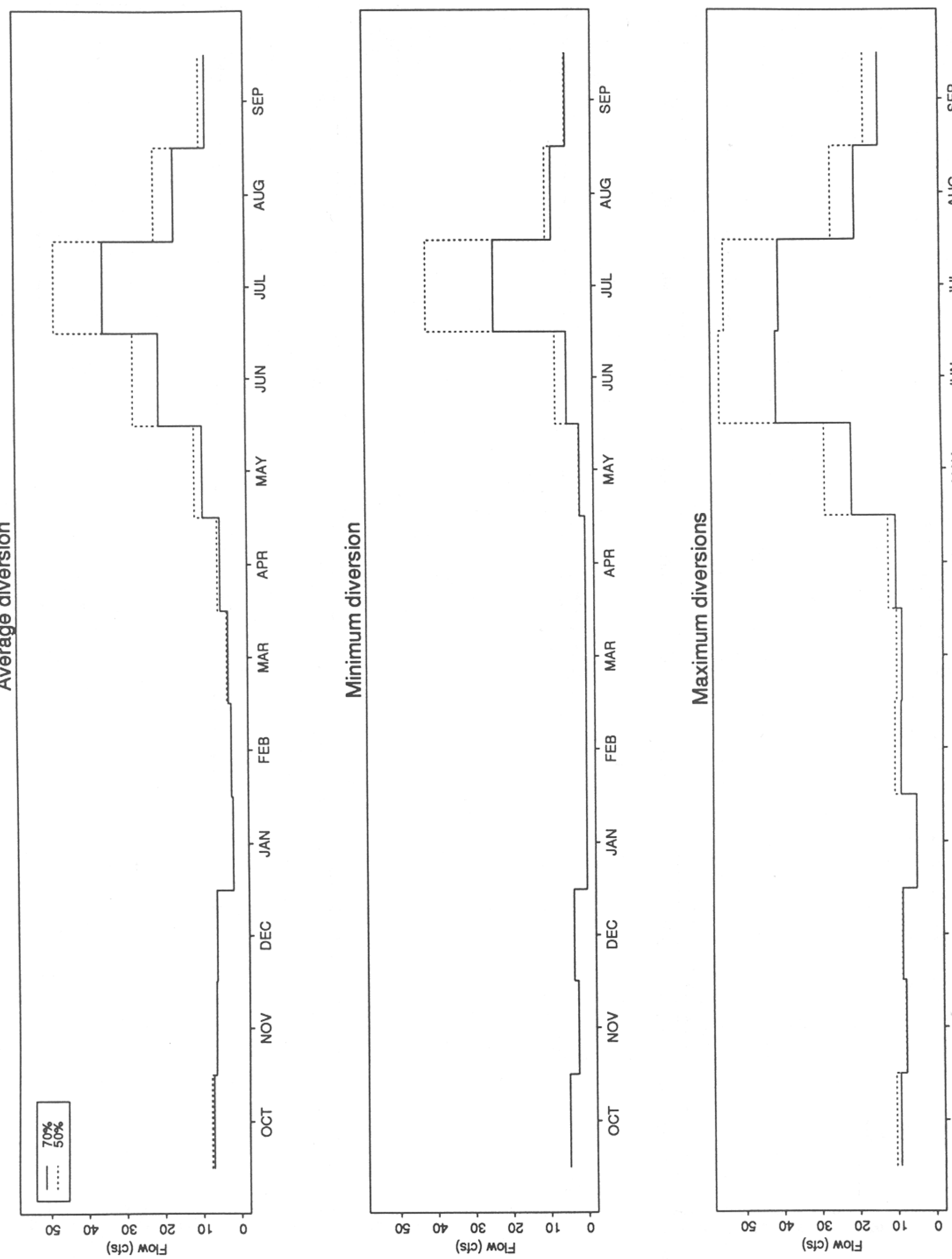


Figure 4-9

Diversions for Twitchell Island based on the DICU model (1922-1992) (50 vs 70% irrigation efficiency)



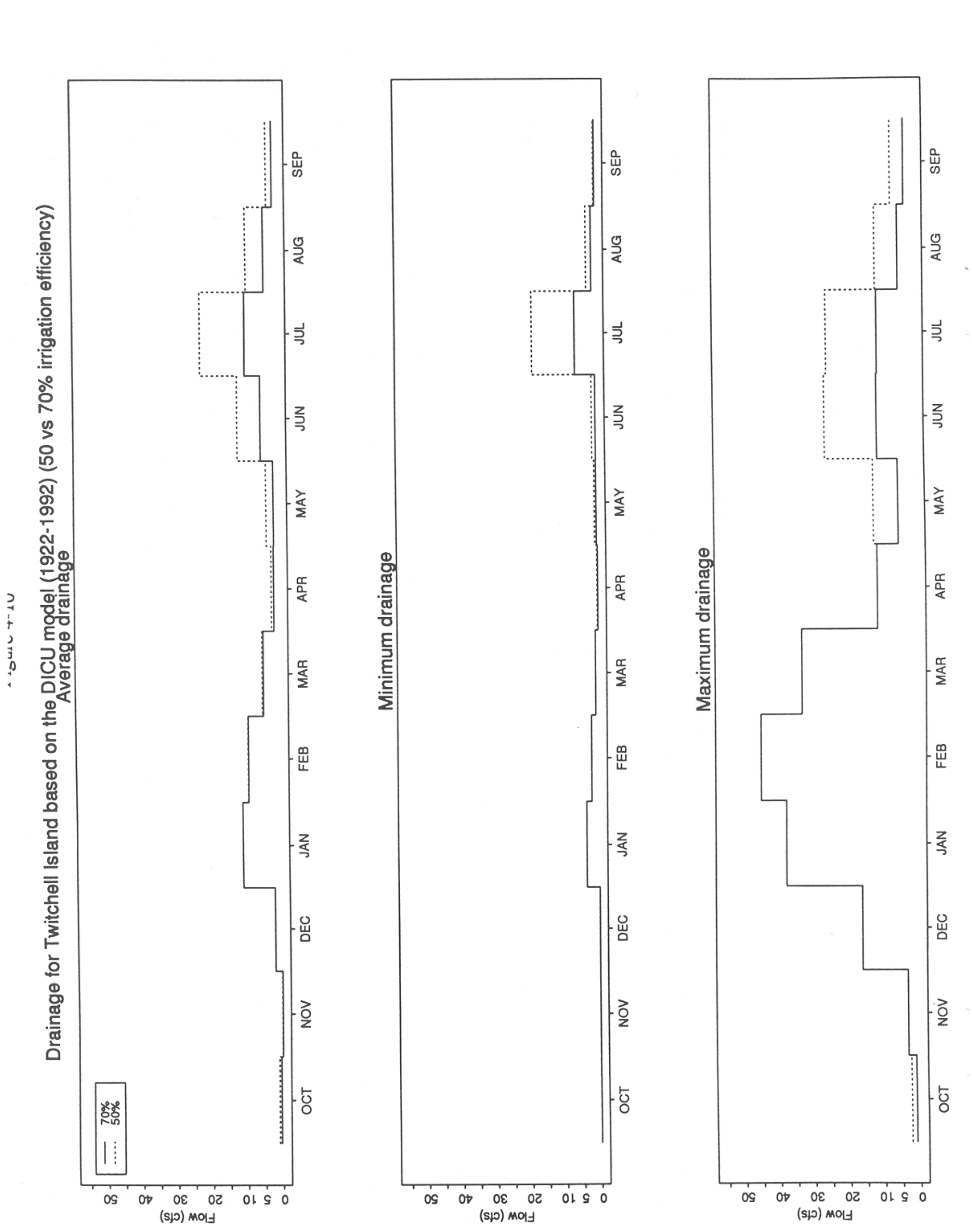

Drainage for Twitchell Island based on the DICU model (1922-1992) (50 vs 70% irrigation efficiency)
Average drainage
Minimum drainage
Maximum drainage
70%
50%
Flow (cfs)
0
5
10
20
30
40
50
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP

TABLE 1
DICU MODEL INPUT : TWITCHELL ISLAND
LAND USE ACREAGE AND SEEPAGE

Land use category	Land use acreage		Root depth (feet)	Seepage (acre-ft)	
	Non-critical water years	Critical water years		Non-critical water years	Critical water years
urban	0	0	-	-	-
alfalfa	399	0	4.0	478	0
pasture	105	114	2.0	63	68
field	0	200	2.0	0	120
sugar beets	0	152	4.0	0	182
grain	133	703	2.0	79	421
rice	0	0	-	0	0
truck	171	124	4.0	205	148
vineyards	0	0	-	0	0
tomatoes	0	0	-	0	0
non-irrigated pasture	0	0	-	0	0
safflower	76	57	4.0	91	68
non-irrigated vineyards	0	0	-	0	0
orchards	0	0	-	0	0
non-irrigated orchards	0	0	-	0	0
corn	1938	1748	3.0	1744	1573
water surface	0	0	-	0	0
native vegetation	701	425	2.5	525	318
riparian vegetation	57	57	-	-	-
dry grass	0	0	2.0	0	0
TOTAL	3580	3580		3185	2898

Seepage = (0.3 x root depth) x acreage

TABLE 2
DICU MODEL TOTAL MONTHLY ET PER CROP PER UNIT AREA
(inches)

LAND USE CATEGORY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
Pasture	2.80	1.40	0.60	0.70	1.50	2.70	4.10	5.50	6.40	7.60	6.60	4.80	44.7
Alfalfa	2.80	1.40	0.60	0.70	1.50	2.70	4.10	5.50	6.40	7.60	6.60	4.80	44.7
Field	1.10	1.10	0.60	0.70	1.50	1.70	1.60	2.60	5.50	7.30	4.90	2.20	30.8
Sugar beets	2.30	1.10	0.60	0.70	1.50	1.70	1.30	3.20	6.00	7.90	6.60	4.80	37.7
Grain	1.00	1.10	0.60	0.70	1.50	2.70	4.60	5.00	2.20	1.00	1.00	1.00	22.4
Rice	1.90	1.40	0.60	0.70	1.50	2.10	2.10	6.40	8.20	9.70	8.40	5.40	48.4
Truck	1.00	1.10	0.60	0.70	1.50	1.60	1.30	3.20	6.40	8.30	5.50	1.70	32.9
Tomatoes	1.00	1.10	0.60	0.70	1.50	1.60	1.30	3.20	6.40	8.30	5.50	1.70	32.9
Orchards	2.50	1.20	0.60	0.70	1.50	1.70	2.70	4.90	5.90	7.00	6.10	4.40	39.2
Vineyards	1.10	1.10	0.60	0.70	1.50	1.70	1.50	3.60	4.90	6.40	5.30	3.60	32.0
Safflower	1.90	1.50	1.00	0.70	1.50	1.90	2.50	4.80	8.70	7.70	4.40	2.50	39.1
Corn	1.10	1.10	0.60	0.70	1.50	1.70	1.60	2.60	5.50	7.30	4.90	2.20	30.8
Non-irrigated pasture	2.80	1.40	0.60	0.70	1.50	2.70	4.10	5.50	6.40	7.60	6.60	4.80	44.7
Non-irrigated vineyards	1.10	1.10	0.60	0.70	1.50	1.70	1.50	3.60	4.90	6.40	5.30	3.60	32.0
Non-irrigated orchards	2.50	1.20	0.60	0.70	1.50	1.70	2.70	4.90	5.90	7.00	6.10	4.40	39.2
Dry grain	1.00	1.10	0.60	0.70	1.50	2.70	4.60	5.00	2.20	1.00	1.00	1.00	22.4
Native vegetation	2.80	1.40	0.60	0.70	1.50	2.70	4.10	5.50	6.40	7.60	6.60	4.80	44.7
Riparian vegetation	3.70	1.70	0.90	1.00	1.90	3.40	5.10	6.90	7.90	9.00	8.00	5.90	55.4
Water surfaces	3.70	1.70	0.90	1.00	1.90	3.40	5.10	6.90	7.90	9.00	8.00	5.90	55.4

TABLE 3
DICU MODEL SOIL MOISTURE AND IRRIGATION SEASON LIMITS

Delta Lowlands

Crop Identification	PA	AL	FI	SB	GR	RI	TR	TO	OR	VI	SF	CR	PP	VV	OO
Effective rooting depth (feet)	2.0	4.0	2.0	4.0	2.0	1.0	4.0	4.0	5.0	4.0	4.0	3.0	2.0	4.0	5.0
Maximum soil moisture (inches) *	6.0	12.0	6.0	12.0	6.0	3.0	12.0	12.0	15.0	12.0	12.0	9.0	6.0	12.0	15.0
Minimum soil moisture (inches)															
Jan	0.0	0.0	0.0	0.0	3.0	1.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	0.0
Feb	0.0	0.0	0.0	0.0	4.0	1.0	0.0	0.0	0.0	0.0	8.0	0.0	0.0	0.0	0.0
Mar	6.0	12.0	0.0	0.0	3.0	1.0	0.0	0.0	15.0	0.0	12.0	0.0	0.0	0.0	0.0
Apr	6.0	11.0	4.0	12.0	0.0	9.0	12.0	12.0	14.0	12.0	11.0	4.0	0.0	0.0	0.0
May	5.0	10.0	4.0	11.5	0.0	10.5	12.0	12.0	13.5	12.0	10.0	4.0	0.0	0.0	0.0
Jun	4.5	9.0	6.0	11.0	0.0	12.0	12.0	12.0	13.0	11.0	6.0	5.0	0.0	0.0	0.0
Jul	4.0	8.0	5.0	10.0	0.0	12.0	10.0	10.0	12.0	10.0	3.0	5.0	0.0	0.0	0.0
Aug	3.5	7.0	3.0	8.0	0.0	10.5	8.0	8.0	10.0	9.0	0.0	6.0	0.0	0.0	0.0
Sep	3.0	6.0	2.0	7.0	0.0	3.0	8.0	8.0	9.0	6.0	0.0	2.0	0.0	0.0	0.0
Oct	4.0	6.0	1.0	7.0	0.0	1.0	1.0	1.0	9.0	7.0	0.0	1.0	0.0	0.0	0.0
Nov	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dec	0.0	0.0	0.0	0.0	1.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Delta Uplands

Crop identification	PA	AL	FI	SB	GR	RI	TR	TO	OR	VI	SF	CR	PP	VV	OO
Effective rooting depth (feet)	2.0	6.0	4.0	5.0	4.0	2.0	5.0	5.0	6.0	5.0	5.0	4.0	2.0	5.0	6.0
Maximum soil moisture (inches) ♣	3.0	9.0	6.0	7.5	6.0	3.0	4.5	7.5	9.0	7.5	7.5	6.0	3.0	7.5	9.0
Minimum soil moisture (inches)															
Jan	1.0	2.0	1.0	2.0	3.0	1.0	1.0	1.0	2.0	2.0	3.5	1.0	0.0	0.0	0.0
Feb	1.0	2.0	1.0	2.0	3.0	1.0	1.0	1.0	2.0	2.0	5.0	1.0	0.0	0.0	0.0
Mar	2.0	6.0	4.0	4.0	3.0	1.0	1.0	1.0	5.0	2.0	7.5	4.0	0.0	0.0	0.0
Apr	2.0	6.0	4.0	4.0	3.0	9.0	3.0	3.0	8.0	5.0	7.0	4.0	0.0	0.0	0.0
May	3.0	9.0	4.0	7.5	1.0	10.5	4.0	7.5	9.0	7.5	6.0	4.0	0.0	0.0	0.0
Jun	2.5	8.0	6.0	7.5	1.0	12.0	4.5	7.5	8.0	7.0	3.5	5.0	0.0	0.0	0.0
Jul	2.0	7.0	4.5	6.0	1.0	12.0	4.0	6.5	7.0	6.0	2.0	4.5	0.0	0.0	0.0
Aug	2.0	6.0	3.0	5.0	1.0	10.5	4.0	5.5	6.0	6.0	0.0	3.0	0.0	0.0	0.0
Sep	2.0	5.0	2.0	4.0	1.0	3.0	2.0	3.0	5.0	4.0	0.0	2.0	0.0	0.0	0.0
Oct	1.5	4.0	1.0	3.0	1.0	1.0	1.0	1.0	4.0	3.0	0.0	1.0	0.0	0.0	0.0
Nov	1.0	2.0	1.0	2.0	1.0	1.0	1.0	1.0	2.0	2.0	0.0	1.0	0.0	0.0	0.0
Dec	1.0	2.0	1.0	2.0	2.0	1.0	1.0	1.0	2.0	2.0	0.0	1.0	0.0	0.0	0.0

* Computed by multiplying soil depth by 3 inches per foot
♣ Computed by multiplying soil depth by 1.5 inches per foot

Lightly shaded area indicates limit of the critical water year irrigation season
Darkly shaded area indicates limit of the non-critical water year irrigation season

TABLE 4
LEACH WATER VOLUMES BASED ON GEORGE SATO'S 1981 MEMO

	Delta Lowlands					Twitchell Island
Day	Flooded area derived from areal observations (acres)	Change in area flooded (acres)	Leach water adjustment (volume in AF, based on 2 ft water depth)	% of water applied/drained	% of lowlands area flooded	Leach water applied/drained (acre-ft)
September 30	0	0	0	0	0%	0
October 31	5,600	+5,600	+11,200	20% applied	1.6%	+87
November 30	13,600	+8,000	+16,000	30% applied	3.9%	+125
December 31	26,800	+13,200	+26,400	50% applied	7.6%	+206
January 31	11,800	-15,000	-30,000	56% drained	3.4%	-234
February 28	4,000	-7,800	-15,600	29% drained	1.1%	-122
March 30	300	-3,700	-7,400	14% drained	less than 1%	-58
April 30	0	-300	-600	1% drained	0%	-5

The volume of leach water assigned to each sub-area is based on the acreage of that sub-area divided by the total acreage flooded.
i.e. leach water applied to Twitchell island leach in October = (3580 acres /462000 acres) x 11200 AF = 87 AF