US Army Corps
of Engineers
Sacramento District

July 1996

SOUTH SACRAMENTO COUNTY STREAMS

Morrison Creek Stream Group, California

Feasibility-Level Hydrology

D-003547

D-003547

TABLE OF CONTENTS

Section	Subject	Page
1.	Authorization	1
2.	Purpose and Scope	1
3.	Descriptive Hydrology	
A.	Basin Description	1
B.	Topography	2
C.	Soils	2
D.	Vegetation	2
E.	Climate	
1.	Temperature	3
2.	Precipitation	3
F.	Storm Characteristics	6
G.	Flood Characteristics	6
H.	Stream and Precipitation Gages	7
4.	Land Use	
A.	Existing	8
B.	Future	8
5.	HEC-1 Model	
A.	January 1995 Flood	
1.	Precipitation	9
2.	Loss Rates	9
3.	Unit Hydrographs	9
4.	Baseflow	14
5.	Routing Parameters	
a.	Modified Puls	14
b.	Muskingum	14
6.	Pump Stations	15
7.	Trans-basin Flows	21
8.	Results	22
B.	Synthetic Floods	
1.	Precipitation	23
2.	Loss Rates	25
3.	Unit Hydrographs	26
4.	Baseflow	30
5.	Routing Parameters	30
6.	Pump Stations	31

7. Trans-basin Flows 31
8. Results
a. Synthetic Flood Hydrographs 31
b. 10-year 800 cfs Limits 36

6. Future Flow Mitigation 36

7. DWOPER Model
A. Overview 38
B. Specific Morrison Creek Floods with Concurrent Delta Flows 39
C. Specific Delta Floods with Concurrent Morrison Creek Flows 40
D. Boundary Hydrographs
1. Upstream 46
2. Downstream 46
E. Results
1. Beach Lake Peak Stage-frequency Curves 48
2. Beach Lake Flow and Stage Concurrency 48

D—003549

D-003549

LIST OF TABLES

Table		Page
1	Average Monthly Temperatures	4
2	Average Monthly Precipitation	5
3	Historic 24-hour Precipitation	6
4	Historic Peak Flows	8
5	January 8-11, 1995 Precipitation Depths	10
6	Clark T_c and R Values	11
7	Routing Parameters	15
8	Pump Station Modified Puls Parameters	20
9	Diversion Ratings	21
10	January 8-11, 1995 Peak Flows	22
11	100-year Precipitation Depths	24
12	Subarea 7-day Precipitation Depths	25
13	Initial Losses	26
14	Clark T_c and R Values, Future Condition	27
15	Projected Channelized Reaches	31
16	Existing Condition Peak Flows	32
17	Future Condition Peak Flows	34
18	10-year 800 cfs Limits	36
19	Comparison of County and Corps Computed Peak Flows	37
20	Sacramento County Detention Basin and Channel Improvement Projects	37
21	Morrison Creek near Sacramento, Maximum Annual Flows	41
22	Cosumnes River at Michigan Bar, Flows Concurrent with the Maximum Annual Flows of Morrison Creek near Sacramento	42
23	Delta Flows Concurrent with the Maximum Annual Flows of Morrison Creek near Sacramento	43
24	Delta Maximum Annual Flows	44
25	Morrison Creek near Sacramento, Flows Concurrent with the Maximum Annual Delta Flows	45
26	Specific and Concurrent Flows	47
27	Beach Lake Peak Flows and Concurrent Stages	49

LIST OF CHARTS

Chart	Name
1	General Map
2	Subarea Map, Existing Condition
3	Subarea Map, Future Condition
4	Topographic Map
5	Normal Annual Precipitation Map
6	Peak Flow-frequency Curve, Morrison Creek near Sacramento
7	Volume Flow-frequency Curves, Morrison Creek near Sacramento
8	Sacramento County Stream and Precipitation Gages
9	Land Use Map, Existing Condition
10	Land Use Map, Future Condition
11	January 8-11, 1995 Isohyetal Map
12	T_c+R versus Drainage Area
13	Routing Diagram
14	Reconstitution of January 8-11, 1995 Flood Hydrographs
15	Synthetic Peak Flow-frequency Curve versus Analytical Peak Flow-frequency Curve, Morrison Creek near Sacramento
16	Precipitation Distribution of General Rain Storms
17	Future Condition (with Mitigation) Peak Flow-frequency Curves
18	DWOPER Cross-sections
19	Peak and Volume Flow-frequency Curves, Delta
20	Peak and Volume Flow-frequency Curves, Cosumnes River at Michigan Bar
21	Specific Upstream Boundary Hydrographs, Existing and Future Conditions
22	Concurrent Upstream Boundary Hydrographs, Existing and Future Conditions
23	Peak Stage-frequency Curve, Georgiana Slough at Mokelumne River
24	February 1986 Stage Hydrograph, Georgiana Slough at Mokelumne River
25	Specific Downstream Boundary Hydrographs, Existing and Future Conditions
26	Concurrent Downstream Boundary Hydrographs, Existing and Future Conditions
27	Beach Lake Peak Stage-frequency Curve, Specific Morrison Creek Floods
28	Beach Lake Peak Stage-frequency Curve, Specific Delta Floods

D-003551

D-003551

1. AUTHORIZATION

Congressional authorization of the Morrison Creek Stream Group Project is contained in a May 8, 1964 resolution of the House Committee on Public Works. Several Morrison Creek hydrology studies have been conducted since the congressional authorization. Results from the Corps of Engineers' two primary hydrology studies are found in "Morrison Creek Stream Group, California", Hydrology Design Memorandum, July 1985 (Reference 1); and in "Morrison Creek Stream Group, California", Reconnaissance Level Hydrology, September 1993 (Reference 2). Reference 2 updates the hydrology in Reference 1.

2. PURPOSE AND SCOPE

This is a feasibility-level hydrology report that presents the results of two computer models- HEC-1 and DWOPER. The HEC-1 model encompasses the Morrison Creek Basin above Lambert Road. The accuracy of the HEC-1 model was checked by reconstituting the January 1995 flood. The HEC-1 model accurately reconstituted all of the observed 1995 flood hydrographs, and was used to compute existing and future condition synthetic flood hydrographs. Computed synthetic flood hydrographs for Morrison Creek below Laguna Creek and for Beach/Stone Lakes local were used in the DWOPER model.

The DWOPER model encompasses the North Delta, including the Beach/Stone Lakes and Meadowview/Pocket areas. The DWOPER model computed existing and future condition synthetic flow and stage hydrographs throughout the North Delta. The computed stage hydrographs at Beach Lake were used at the downstream boundary of a UNET model of the Morrison Creek Basin. The computed synthetic flow hydrographs from the HEC-1 model also were used in the UNET model, which computed existing and future condition synthetic floodplains that were inventoried for damageable property. The UNET model and the computed floodplains will be discussed in a separate document.

A risk-based analysis was conducted to compute existing and future condition expected annual damages and levee reliability. The results of the risk-based analysis will be used to formulate Morrison Creek project features. With-project hydrology will be addressed after the project features are identified. This report addresses without-project hydrology only.

3. DESCRIPTIVE HYDROLOGY

A. Basin Description

The Morrison Creek Basin is located in Sacramento County, primarily southeast of the City of Sacramento, as shown on the General Map (Chart 1). Morrison Creek has three principal tributaries- Elder, Unionhouse, and Laguna Creeks, and several smaller tributaries- Florin and Gerber Creeks (tributary to Elder Creek), Strawberry Creek (tributary to Unionhouse Creek), and Whitehouse, Frye, Elk Grove, and Jacinto Creeks (tributary to Laguna Creek). Morrison Creek drains into the Sacramento-San Joaquin Delta via Beach and Stone Lakes, Snodgrass Slough, and the Mokelumne River.

The Morrison Creek Basin has two distinct subbasins- the upper and lower subbasins. The upper subbasin includes the area above Beach Lake, and the lower subbasin includes Beach and Stone Lakes, which are permanent freshwater lakes. The basin has a drainage area of about 180 square miles, of which about 131 square miles is in the upper subbasin.

The Morrison Creek Basin contains primarily residential and industrial areas. Agricultural, commercial, and recreational areas also are in the basin. The basin includes part of the City of Sacramento, the former Sacramento Army Depot, Mather Field, and the communities of Laguna West, Elk Grove, Florin, Franklin, Point Pleasant, and Hood.

Charts 2 and 3 show Morrison Creek Basin subarea maps that delineate existing and future condition drainage areas, respectively. The HEC-1 model of the Morrison Creek Basin is divided into these subareas. Many of the subarea identifiers refer to the location of the mouth of the subareas. For example, the mouth of subarea 683219 is in Range 6, Township 8, Section 32, Quadrant 1. Quadrants 1, 2, 3, and 4 are the northeast, northwest, southwest, and southeast quadrants, respectively. The "9" in 683219 is an additional subarea descriptor.

B. Topography

The upper Morrison Creek subbasin extends from the headwaters of Morrison Creek to Beach Lake, and is about 20 miles long and a maximum of 12 miles wide. The terrain slopes gently from northeast to southwest, with elevations ranging from about 300 feet Mean Sea Level (MSL) at the headwaters to about MSL at Beach Lake. Almost 200 feet (two-thirds) of the elevation drop occurs in the eastern one-third of the upper subbasin. Chart 4 is a topographic map of the upper subbasin.

The lower Morrison Creek subbasin includes Beach and Stone Lakes, and is about 8 miles long and a maximum of 8 miles wide. The lower subbasin slopes predominantly from east to west and slightly from north to south, with elevations ranging from about 40 feet MSL on Highway 99 to below MSL in Beach and Stone Lakes. Morrison Creek drains southerly through Beach and Stone Lakes, and small tributaries drain westerly.

C. Soils

Soils in the Morrison Creek Basin are predominantly clay with mixtures of sand, gravel, and silt. Much of the clay and silt in the northeastern part of the basin were washed from the upper soil layer during hydraulic mining, exposing mostly cobble and gravel. The lower soil layers are dense and tightly cemented. Negligible seepage occurs throughout most of the basin.

D. Vegetation

Much of the native vegetation in the upper Morrison Creek subbasin was drastically

modified by residential, industrial, and agricultural development. The vegetation today is characteristic of the Central Valley- scattered oaks and willows, various types of brush, marsh-type growths along waterways, and native and planted grasses. Vegetation in the lower Morrison Creek subbasin is characteristic of riparian forest and marsh land. The higher ground supports willows, cottonwoods, oaks, and an understory of vines and shrubs. The water and shoreline areas support dense growth of cattails, tules, and water weeds.

E. Climate

1. Temperature

The climate in the Morrison Creek Basin is semiarid and temperate with hot, dry summers and cool, damp winters. Temperature records for Sacramento begin in 1877. The maximum and minimum recorded temperatures are 114 and 17 degrees Fahrenheit, respectively. Average monthly temperatures for downtown Sacramento are shown in Table 1.

2. Precipitation

Normal Annual Precipitation (NAP) ranges from 15.5 inches in the lower Stone Lake area to 20 inches in the Morrison Creek headwaters. Chart 5 is an NAP map of the Morrison Creek Basin. Precipitation falls generally as rain and rarely as snow in the Winter. Precipitation records for Sacramento begin in 1849. Annual precipitation (July 1 to June 30) in downtown Sacramento ranges from a low of 4.71 inches in 1850-1851 to a high of 37.49 inches in 1982-1983. Average monthly precipitation at the downtown Sacramento and Executive Airport gages is shown in Table 2. Historic 24-hour precipitation at these and four other gages in the Morrison Creek Basin is shown in Table 3.

Table 1
Average Monthly Temperatures, degrees Fahrenheit

January	46.1
February	50.9
March	54.4
April	59.6
May	65.3
June	71.3
July	75.9
August	74.9
September	72.5
October	64.5
November	54.3
December	47.0
Annual	61.4

Table 2
Average Monthly Precipitation, inches

Month	Downtown Sacramento	Executive Airport
January	3.76	3.64
February	3.23	2.80
March	2.37	2.18
April	1.45	1.35
May	0.46	0.42
June	0.13	0.10
July	0.03	0.04
August	0.05	0.06
September	0.21	0.20
October	0.92	0.98
November	2.00	2.16
December	3.17	2.94
Annual	17.78	16.87

Table 3
Historic 24-hour Precipitation, inches

Date	Downtown Sacramento	Executive Airport	Eagles Nest Road	Rancho Cordova	Gerber Road	Elk Grove Fish Hatchery
12-13 Oct 1962	5.07	5.59				
20-21 Jan 1967	3.12	3.41				
25-26 Jan 1969	1.46	1.46				
27 Feb 1973	2.11	1.81				
18-19 Feb 1980	1.69	1.56				
4-5 Jan 1982	3.50	3.35	4.25	3.30	3.09	2.79
12-13 Mar 1983	2.63	2.09	2.41	2.83	2.10	2.40
24-25 Dec 1983	2.85	2.23				
16-17 Feb 1986	3.64	3.01				
9-10 Jan 1995	4.47		2.54	5.36		3.90

F. Storm Characteristics

Major flood-producing storms over central California generally are storms that originate between 30 and 50 degrees north latitude and develop a moist air influx at about the latitude of the Hawaiian Islands. The moist air mass lifts and cools as it moves easterly over the coastal mountain ranges, and the moisture condenses and falls as precipitation. This orographic lifting effect combined with the lifting effect of converging air masses accounts for the majority of precipitation in the Sacramento area.

G. Flood Characteristics

Large floods in the Morrison Creek Basin occur during general rain storms. The flood hydrographs typically have steep rising limbs, high peak flows, and slow recessions for one or two days. Large floods occurred in 1952, 1955, 1958, 1962, 1963, 1967, 1969, 1973, 1982, 1983, 1986, and 1995. The peak flow of record at the United States Geological Survey (USGS) stream gage on Morrison Creek near Highway 99, 2730 cfs, occurred during the February 1986 flood. The drainage area above the gage is about 53 square miles (40% of the upper Morrison Creek subbasin), and has both rural and urban areas. The gage was discontinued in 1987 and was reestablished by the County of Sacramento near Florin Road sometime later. The number of recorded peak flows since 1987 is unknown, although a peak flow of 4000 cfs was estimated during the January 1995 flood using recorded stage data.

Charts 6 and 7 show peak and volume flow-frequency curves at the gage, respectively. The frequency curves were constructed from flows recorded between 1960 and 1987, and should be updated to include the flows recorded between 1988 and 1996, if available.

Much of the stormwater runoff from the area above the gage is pumped into Morrison Creek. The area above the gage has a fast rainfall-runoff time of concentration, as indicated by the steep rise of recorded runoff hydrographs, and will get faster as urbanization increases and more pumps are added.

Morrison Creek floods are affected by large flows in the Mokelumne River, which cause high stages in Snodgrass Slough. Flapgates on the downstream side of the Lambert Road bridge structure close when the stage in Snodgrass Slough downstream of Lambert Road is higher than the stage upstream of Lambert Road. The flapgates prevent Mokelumne River backwater from flowing upstream, but also prevent Morrison Creek runoff from draining into the Delta.

Mokelumne River backwater flows over Lambert Road into Beach and Stone Lakes during rarer-than-25-year floods. A small volume of Cosumnes River water flows north along the east side of Franklin Boulevard to South Stone Lake just north of Lambert Road during rarer-than-50-year floods. Water ponds eastward as the stage rises in Beach and Stone Lakes. Flooding occurs east of Interstate 5 when the culverts under Interstate 5 become filled with water, preventing local runoff from draining. About 37 of the 49 square miles in the lower Morrison Creek subbasin are east of Interstate 5.

H. Stream and Precipitation Gages

Sacramento County has implemented a flood alert stream monitoring system complete with telemetry and a modem-accessed database. Stream stage and flow data, and precipitation data are available at several gages in the Morrison Creek Basin. Data from these gages were used with the HEC-1 model of the basin to reconstitute the January 1995 flood. Chart 8 shows the location of the stream and precipitation gages. Table 4 shows historic peak flows at some of the stream gages.

Table 4
Historic Peak Flows, cfs

Date	Morrison Cr at Elk Grove-Florin Rd	Morrison Cr at USGS Gage	Elder Cr at Bradshaw Rd	Elder Cr at Gerber Rd	Laguna Cr at Eagles Nest Rd	Laguna Cr at Waterman-Bond Rds
10/14/62		1320				
1/21/67		1500				
1/26/69		1610				
2/27/73		1380				
2/19/80		1440				
1/5/82	**2300**	2520	**550**	1700	2020	2770
3/13/83	1020	1840	220	600	1130	1710
12/25/83		1530				
2/17/86		2730				
1/10/95	**2020**	**4000**	**670**	**1480**	**1580**	1700

Note: Flows in **big bold** are estimates.

4. LAND USE

A. Existing

Existing and future land use are considered in this feasibility study. The existing land use was determined from a Sacramento County land use map, aerial photographs, and field observations. Chart 9 shows the existing land use, which is classified as either residential-commercial or agricultural.

B. Future

The future land use assumes a high density use based on extrapolation of California Department of Water Resources population projections and Sacramento County estimates of land use in the year 2045. Most of the area subject to surface mining was assumed to have been mined and fully developed, and was classified as residential-commercial. Chart 10 shows the future land use, which is classified as residential-commercial, agricultural, or surface mining.

5. HEC-1 MODEL

A. January 1995 Flood

1. Precipitation

The accuracy of the HEC-1 model was checked by reconstituting the January 1995 flood. The HEC-1 model contains precipitation, loss rates, unit hydrographs, base flow, routing parameters, pump stations, and trans-basin flows.

Recorded precipitation depths at 11 of Sacramento County's precipitation gages were used to construct an isohyetal map of the January 8-11, 1995 storm (Chart 11). Chart 11 was used to distribute the recorded precipitation depths over 10 Morrison Creek subareas. The Eagles Nest Road, Rancho Cordova, Stockton Boulevard, Elk Grove Fish Hatchery, Alpine Frost Drive, Branch Center, and Praire City precipitation gages were used for the time distribution of the precipitation. Table 5 lists, for each of the subareas, the precipitation depth and which precipitation gages were used for the time distribution. The precipitation gages were weighted equally when more than one gage was used for the time distribution.

2. Loss Rates

Loss rates were selected so that all of the observed flow hydrographs would be reconstituted accurately. The initial losses ranged from 0.1 inches in urbanized areas to 0.7 inches in unurbanized areas of Elder Creek. The constant loss rates ranged from 0.01 inches/hour in urbanized areas to 0.1 inches/hour in unurbanized areas of Unionhouse Creek.

3. Unit Hydrographs

The Clark method was used to compute unit hydrographs in all of the subareas in the HEC-1 model. Clark T_c+R values were taken from Chart 12, which was constructed from the reconstitution of the January 1982 Morrison Creek flood (see Reference 1). Lines 1-5 of Chart 12 indicate the different response times of the subareas in the Morrison Creek Basin. The response times of most of the subareas were defined by lines 1 and 4, which are for urban and agricultural areas, respectively. Lines 3 and 2 are for steep and steeper agricultural areas with densely packed clay, respectively. Line 5 is for agricultural areas subject to extensive surface storage. The ratios $R/T_c+R=0.45$ and $R/T_c+R=0.35$, which were adopted for the January 1982 flood reconstitution, were used with the T_c+R values taken from lines 1-4 and line 5, respectively, to compute T_c and R values for all of the subareas. T_c and R values for a subarea with both agricultural and urban land were computed by weighting the agricultural and urban T_c and R values by the proportion of agricultural and urban land in the subarea. Table 6 shows the Clark T_c and R values.

Table 5
January 8-11, 1995 Precipitation Depths, inches

Subarea	Depth	Distribution
Morrison Creek above Elk Grove-Florin Road	5.1	Praire City, Rancho Cordova, Branch Center
Morrison Creek below Elk Grove-Florin Road	5.5	Stockton Boulevard, Alpine Frost Drive
Elder Creek above Bradsahw Road	4.8	Stockton Boulevard, Alpine Frost Drive
Elder Creek between Bradshaw and Gerber Road	4.7	Stockton Boulevard, Alpine Frost Drive
Elder Creek below Gerber Road	5.5	Stockton Boulevard, Alpine Frost Drive
Laguna Creek above Eagles Nest Road	3.4	Eagles Nest Road
Laguna Creek between Eagles Nest and Bond Roads	4.1	Eagles Nest Road
Laguna Creek below Bond Road	4.9	Elk Grove Fish Hatchery
Florin Creek	5.5	Stockton Boulevard
Unionhouse Creek	5.5	Stockton Boulevard, Alpine Frost Drive

Table 6
Clark T_c and R Values

Morrison Creek

Subarea	Drainage Area (sq. mi.)	Line[1]	T_C	R
MC35	0.91	4	3.4	1.9
MC15	0.26	4	2.0	1.6
MC20	1.13	4	3.2	2.6
MC25	0.61	4	2.5	2.1
MC05	4.51	4	5.2	4.3
MC10	2.83	4	4.4	3.6
MC40	0.26	4	2.0	1.6
MC45	0.87	4	3.4	1.9
MC50	6.27	4	6.4	5.3
MC55	0.83	4	2.9	2.3
MC30	2.43	4	4.2	3.4
MC60	4.79	4	5.4	4.4
PMP116	0.15	1	.88	.72
PUMP66	0.82	1	1.7	1.4
582530	0.91	4	2.9	2.4
582630	0.98	4	3.0	2.5
582240	0.61	1	1.5	1.2
582631	0.43	1	1.3	1.1
582730	0.53	1	1.4	1.2
PUMP96	2.58	1	2.6	2.1
583510	0.39	1	1.3	1.0
583520	0.52	1	1.4	1.2
583310	1.17	1	1.9	1.6
PMPD33	1.50	1	2.1	1.7
583220	1.33	1	2.0	1.7
582930	2.95	1	2.7	2.2
583221	0.51	1	1.4	1.2
PMPD45	0.63	1	1.5	1.3
570530	0.36	1	1.3	1.0
PMP128	0.79	1	1.7	1.3
PUMP89	2.00	4	2.4	1.9
472430	3.12	4	4.6	3.7

1 Numbered lines in Chart 12

Florin Creek

Subarea	Drainage Area (sq. mi.)	Line[1]	T_c	R
583540	1.90	4	3.8	3.1
570220	0.65	4	2.6	2.1
570320	0.69	1	1.6	1.3
570420	0.58	1	1.4	1.2
570810	0.74	1	1.6	1.3

Laguna Creek

Subarea	Drainage Area (sq. mi.)	Line[1]	T_c	R
782810	3.29	3	4.0	3.3
770630	9.82	3	5.8	4.9
671130	4.90	5	8.1	4.3
671630	1.74	5	5.7	3.0
672920	2.77	5	6.7	3.6
672921	5.91	5	8.6	4.6
672930	3.47	4	4.8	3.9
23635	0.59	4	2.6	2.1
HW99	1.53	4	3.6	2.9
572711	2.05	4	2.5	1.9
572710	0.96	4	3.0	2.5
EG1	1.61	4	3.6	3.0
EG2	0.34	4	2.1	1.7
NEG1	1.01	4	3.0	2.5
EG3	0.84	1	1.8	1.4
EG4	0.57	1	1.5	1.2
EG5	0.69	1	1.6	1.3
EG6	0.97	4	3.0	2.4
LC5	2.0	4	3.9	3.2
572240	0.76	4	2.8	2.2
572120	1.70	4	3.7	3.1
572020	0.72	4	2.7	2.2
571840	0.58	4	2.5	2.0

1 Numbered lines in Chart 12

D—003563

D-003563

Elder Creek

Subarea	Drainage Area (sq.mi.)	Line[1]	T_c	R
682730	3.73	2	3.6	2.9
683210	1.29	2	2.5	2.0
670610	2.78	4	5.0	4.1
670631	0.36	4	2.1	1.7
670330	1.48	4	3.5	2.9
670530	2.34	4	4.1	3.3
670531	1.03	4	3.1	2.5
571120	1.57	1	2.2	1.8
570910	1.23	1	2.0	1.6
PUMP67	1.31	1	2.0	1.6

Unionhouse Creek

Subarea	Drainage Area (sq.mi.)	Line[1]	T_c	R
671220	1.72	1	2.3	1.8
571030	1.39	1	2.1	1.7
672410	3.35	4	4.7	3.9
571540	2.42	1	2.5	2.1
571530	0.48	4	2.3	1.9
PUMP69	1.71	1	2.2	1.8
PUMP68	0.37	1	1.2	1.0
PMP139	0.96	1	1.8	1.4
571720	0.55	4	2.5	2.0

1 Numbered lines in Chart 12

Beach/Stone Lakes

Subarea	Drainage Area (sq. mi.)	Line[1]	T_c	R
572940	1.06	4	3.0	2.6
472510	1.19	4	3.3	2.7
472610	0.75	4	2.8	2.2
573230	0.83	4	2.9	2.3
460110	1.61	4	3.6	3.0
560510	5.68	4	5.8	4.7
560740	1.91	4	3.8	3.1
460210	1.65	4	3.7	2.9
461310	2.78	4	4.4	3.6
561720	15.49	4	8.0	6.6
561830	2.58	4	4.3	3.5
563010	5.71	4	5.7	4.7
463520	7.61	4	6.3	5.2

1 Numbered lines in Chart 12

4. Baseflow

A review of historic flows indicated that a baseflow of 3 cfs per square mile is appropriate.

5. Routing Parameters

a. Modified Puls

Modified Puls and Muskingum routing parameters were used to route flows through natural and improved channels, respectively. The Modified Puls parameters were developed from HEC-2 backwater computations, which underestimated the overbank storage in reaches where the cross-sections did not extend far enough. Supplemental Muskingum routings were added in these reaches to simulate the effect of additional overbank storage.

b. Muskingum

The Muskingum routing parameters were developed from calibrations of the routing effect in the improved reach of Morrison Creek between Elk Grove-Florin Road and the USGS gage (see Reference 1). The optimized Muskingum parameters- one routing step, K=0.8, and X=0.2, were used for improved 2-mile reaches in the Morrison Creek Basin. Larger K values were used for longer improved reaches. Chart 13 is a routing diagram that shows the location

of the Modified Puls and Muskingum routing reaches, and Table 7 lists the Modified Puls and Muskingum routing parameters.

6. Pump Stations

The 20 pump stations in the Morrison Creek Basin were modeled using Modified Puls storage and outflow values. The Modified Puls storages were selected to be larger than the actual pump station sump storages to eliminate oscillating flow computations, without compromising the accuracy of the computations. The Modified Puls outflows are the pump station outflow capacities. The failure of the pump station in the Valley Hi area was not modeled because pending litigation precluded the release of detailed information about the pump station. Table 8 lists the Modified Puls storage and outflow values for each pump station.

Table 7
Routing Parameters

Index Points		Muskingum Parameters			Modified Puls Parameters	
from	to	subreaches	k (hr)	x		
MC15	MC20				storage (ac-ft)	0 .48 1.24 2.1 3.09 4.22 5.48 7.5 12.35 20.12
					flow (cfs)	0 3 15 34 59 91 129 179 258 382
MC20	MCR2				storage (ac-ft)	0 4.87 20.04 171 729 1162
					flow (cfs)	0 93 375 868 5000 : 10000
MCR2	MCDF3				storage (ac-ft)	.11 4.5 10 19 28.5 38.5 49 60 70.9 82 1000
					flow (cfs)	0 30 88 162 245 335 431 530 633 739 740
MCDF3	MCR4				storage (ac-ft)	267 301 345 400 460 545 635 750 880 1000
					flow (cfs)	0 18 40 73 134 192 294 314 366 416
MCR4	MC10				storage (ac-ft)	0 50 63 76 91 112 134 154 167
					flow (cfs)	0 210 410 620 820 1030 1230 1440 1650
MC05	MCDF1				storage (ac-ft)	0 37 189 255 1568 3076
					flow (cfs)	0 77 196 428 2500 5000
MCDR1A	MCDF2				storage (ac-ft)	0 14.5 59 71 132 225
					flow (cfs)	0 52 95 155 300 500
MCDF1	MC10				storage (ac-ft)	0 47 79 109 140 174 209 238 246
					flow (cfs)	0 270 540 800 1070 1340 1610 1880 2140
MC10	MC30				storage (ac-ft)	0 58 103 137 175 213 248 281 314 374
					flow (cfs)	0 500 1000 1500 2000 2500 3000 3500 4000 5000
MC40	MC45				storage (ac-ft)	.02 1 2.3 4.4 6.6 8.9 11.3 13.8 16.3 18.9 25.2 29.6 34 38
					storage (ac-ft)	1000
					flow (cfs)	0 7 20 37 56 77 99 122 145 170 233 284 336 390
					flow (cfs)	395
MC45	MCR9				storage (ac-ft)	0 4 7 8 11 12 14 16 20 1000
					flow (cfs)	0 60 110 170 230 290 340 400 460 465
MCR9	MC50				storage (ac-ft)	0 17 27 39 48 59 65 87 96
					flow (cfs)	0 200 390 590 780 980 1180 1370 1570

MC50	MCR10A				storage (ac-ft) flow (cfs)	0 137 260 365 460 564 669 758 855 1035 0 500 1000 1500 2000 2500 3000 3500 4000 5000
MCR10A	MC30	1	2.0	.2		
MC30	MCR12A				storage (ac-ft) flow (cfs)	0 137 260 365 460 564 669 758 855 1035 0 500 1000 1500 2000 2500 3000 3500 4000 5000
MCR12A	MC60	1	2.0	.2		
MC60	MCR13A				storage (ac-ft) flow (cfs)	0 5 15 30 60 70 107 0 2000 2500 3000 3500 4000 5000
MCR13A	582519	1	1.0	.2		
PMP116	582519				storage (ac-ft) flow (cfs)	See Table 8
PUMP66	582519				storage (ac-ft) flow (cfs)	See Table 8
582519	582530				storage (ac-ft) flow (cfs)	0 17 60 80 115 154 189 245 280 374 0 500 1000 1500 2000 2500 3000 3500 4000 5000
582530	582630	1	0.8	.2		
582240	582244				storage (ac-ft) flow (cfs)	See Table 8
582244	582630				storage (ac-ft) flow (cfs)	0 .32 .7 1.14 1.65 2.21 2.84 3.53 4.27 5.08 0 4 13 26 43 64 89 119 153 192
582631	582630				storage (ac-ft) flow (cfs)	See Table 8
582630	583319	1	1.0	.2		
PUMP96	583319				storage (ac-ft) flow (cfs)	See Table 8
583520	583510				storage (ac-ft) flow (cfs)	See Table 8
583510	583319				storage (ac-ft) flow (cfs)	0 35 75 140 230 580 685 1110 1475 2170 0 1000 2000 2750 3000 3650 4400 5200 6000 8000
583310	583319				storage (ac-ft) flow (cfs)	See Table 8
583319	583229	1	1.0	.2		
PMPD33	583229				storage (ac-ft) flow (cfs)	See Table 8
583220	583229				storage (ac-ft) flow (cfs)	See Table 8
582930	583229				storage (ac-ft) flow (cfs)	0 3.49 7.44 11.85 16.71 22.03 27.82 34.05 40.75 47.9 0 73 228 445 723 1059 1455 1912 2433 3020
583221	583229				storage (ac-ft) flow (cfs)	See Table 8
583229	570829	1	1.0	.2		
PMPD45	570829				storage (ac-ft) flow (cfs)	See Table 8
570530	570829				storage (ac-ft) flow (cfs)	See Table 8

PMP128	570829				storage (ac-ft) flow (cfs)	See Table 8
583540	570220				storage (ac-ft) flow (cfs)	0 12 29 45 60 73 84 0 300 600 900 1200 1500 1800
570220	570329				storage (ac-ft) flow (cfs)	0 22 38 79 115 134 169 0 300 600 900 1200 1500 1800
570320	570329				storage (ac-ft) flow (cfs)	See Table 8
570329	570420				storage (ac-ft) flow (cfs)	0 12 31 52 84 124 138 0 300 600 900 1200 1500 1800
570420	570829				storage (ac-ft) flow (cfs)	0 19 35 50 64 75 85 0 300 600 900 1200 1500 1800
570810	570829				storage (ac-ft) flow (cfs)	See Table 8
682730	683210				storage (ac-ft) flow (cfs)	0 44 100 145 178 216 246 274 299 323 0 400 800 1200 1600 2000 2400 2800 3200 3600
683210	670617				storage (ac-ft) flow (cfs)	0 76 145 201 257 302 366 409 461 499 0 400 800 1200 1600 2000 2400 2800 3200 3600
670617	670610	1	1.0	.2		
670610	670637				storage (ac-ft) flow (cfs)	0 36 72 101 126 154 185 204 222 340 0 400 800 1200 1600 2000 2400 2800 3200 3600
670637	670631	1	1.0	.2		
670330	670530				storage (ac-ft) flow (cfs)	0 51 104 111 115 117 119 121 124 126 0 400 800 1200 1600 2000 2400 2800 3200 3600
CCTRR	670530	2	2.0	.2		
670530	670531				storage (ac-ft) flow (cfs)	0 100 130 150 200 265 320 0 100 250 500 1000 2000 3000
670531	670631	1	1.0	.2		
670631	571127				storage (ac-ft) flow (cfs)	0 59 113 168 215 262 316 362 411 459 0 400 800 1200 1600 2000 2400 2800 3200 3600
571127	571120	1	1.0	.2		
571120	570917				storage (ac-ft) flow (cfs)	0 60 103 135 163 214 264 0 1600 2000 2400 2800 3200 3600
570917	570910	1	1.0	.2		
570910	570929				storage (ac-ft) flow (cfs)	0 2 4 6 15 43 49 57 64 72 0 400 800 1200 1600 2000 2400 2800 3200 3600
PUMP67	570929				storage (ac-ft) flow (cfs)	See Table 8
570929	570817				storage (ac-ft) flow (cfs)	0 1 2 3 4 6 30 79 87 94 0 400 800 1200 1600 2000 2400 2800 3200 3600
570817	570829	1	1.0	.2		
570829	571737				storage (ac-ft) flow (cfs)	0 20 33 58 91 113 174 233 307 0 500 1000 2000 3000 4000 6000 8000 10000
571737	470000	1	0.8	.2		

671220	570137				storage (ac-ft) flow (cfs)	0 10 50 100 251 305 362 427 473 526 0 350 700 1050 1400 1750 2100 2450 2800 3150
570137	571030	1	1.0	.2		
571030	571530				storage (ac-ft) flow (cfs)	0 20 65 87 109 135 149 164 0 1050 1400 1750 2100 2450 2800 3150
672410	571530				storage (ac-ft) flow (cfs)	0 11 19 30 47 77 106 124 161 283 0 50 100 150 200 300 400 500 600 750
571530	571649				storage (ac-ft) flow (cfs)	0 33 44 53 63 76 0 1750 2100 2450 2800 3150
PUMP69	571649				storage (ac-ft) flow (cfs)	See Table 8
571649	571717				storage (ac-ft) flow (cfs)	0 1 2 3 4 20 66 78 90 100 0 350 700 1050 1400 1750 2100 2450 2800 3150
571717	571719	1	0.8	.2		
PUMP68	571719				storage (ac-ft) flow (cfs)	See Table 8
571719	571712				storage (ac-ft) flow (cfs)	0 1 2 3 4 9 19 22 24 27 0 350 700 1050 1400 1750 2100 2450 2800 3150
PMP139	571712				storage (ac-ft) flow (cfs)	See Table 8
571712	470000				storage (ac-ft) flow (cfs)	0 1 5 15 25 27 30 33 0 1050 1400 1750 2100 2450 2800 3150
782810	782816				storage (ac-ft) flow (cfs)	0 34.25 42.75 75 180 303 353 462 555 0 4 5 8 12 36 1449 7700 16348
782816	770630	2	2.0	.3		
770630	671130				storage (ac-ft) flow (cfs)	0 86 151 205 243 329 409 524 608 687 781 0 250 500 750 1000 1500 2000 2500 3000 3500 4000
671130	671630				storage (ac-ft) flow (cfs)	0 90 176 267 361 451 542 634 728 921 0 500 1000 1500 2000 2500 3000 3500 4000 5000
671630	672926				storage (ac-ft) flow (cfs)	0 201 381 548 709 864 994 1117 1235 1470 0 500 1000 1500 2000 2500 3000 3500 4000 4500
672926	672920	1	2.0	.2		
672923	672921	1	1.0	.2		
672921	672920	1	2.0	.2		
672920	672937				storage (ac-ft) flow (cfs)	0 24 45 66 87 106 124 144 165 213 0 500 1000 1500 2000 2500 3000 3500 4000 5000
672937	672930	1	1.0	.2		
672930	23635				storage (ac-ft) flow (cfs)	0 26 43 63 82 115 144 173 199 253 307 362 0 250 500 750 1000 1500 2000 2500 3000 4000 5000 6000
23635	HW99				storage (ac-ft) flow (cfs)	0 64 90 129 167 225 295 352 404 514 623 737 0 250 500 750 1000 1500 2000 2500 3000 4000 5000 6000
572711	HW99				storage (ac-ft) flow (cfs)	0 38 95 159 178 230 306 388 0 100 310 500 600 800 1000 1300

HW99	572710				storage (ac-ft) storage (ac-ft) flow (cfs) flow (cfs)	0 52 86 116 155 220 284 335 389 531 652 784 847 939 0 250 500 750 1000 1500 2000 2500 3000 4000 5000 6000 7000 8000
EG1	NEG1				storage (ac-ft) flow (cfs)	0 13 14 15 19 32 43 55 0 275 365 405 525 1000 1400 1800
NEG1	EG3				storage (ac-ft) flow (cfs)	0 21 27 30 46 73 88 138 0 330 440 485 670 1000 1200 1800
EG3	EG4				storage (ac-ft) flow (cfs)	0 23 29 32 43 60 78 0 530 705 775 1030 1400 1800
EG4	EG5				storage (ac-ft) flow (cfs)	0 28 39 43 63 88 0 605 830 915 1210 1800
EG5	572710				storage (ac-ft) flow (cfs)	0 24 29 31 38 56 0 660 905 1000 1290 1800
EG6	572710				storage (ac-ft) flow (cfs)	0 63 78 84 99 130 0 705 965 1065 1405 1800
572710	572240				storage (ac-ft) flow (cfs)	0 5 9 22 40 69 99 122 147 171 190 235 0 110 500 1000 2000 3000 4000 5000 6000 6880 7800 8000
572240	LCR5A				storage (ac-ft) flow (cfs)	0 31 40 70 102 177 229 262 298 329 354 388 0 110 500 1000 2000 3000 4000 5000 6000 6880 7800 8000
LCR5A	572120	1	2.0	.2		
572120	LCR7A				storage (ac-ft) flow (cfs)	25 31 52 85 149 255 280 307 335 350 388 0 110 500 1000 2000 3000 4000 5000 6000 6880 7800
LCR7A	572020	1	2.0	.2		
572020	470000				storage (ac-ft) storage (ac-ft) flow (cfs) flow (cfs)	0 20 34 45 53 75 84 100 106 126 144 160 176 190 202 0 250 500 750 1000 1500 2000 2500 3000 4000 5000 6000 7000 8000 9000
PUMP89	470000				storage (ac-ft) flow (cfs)	See Table 8

Table 8
Pump Station Modified Puls Parameters

Subarea	Parameter	Value							
PMP116	Storage (ac-ft)	0	.42	.84	1.26	1.68	100		
	Outflow (cfs)	0	10	20	30	40	45		
PUMP66	Storage (ac-ft)	0	2.5	5.0	8.4	100			
	Outflow (cfs)	0	60	120	200	205			
582240	Storage (ac-ft)	0	1.25	2.55	3.94	5.28	100		
	Outflow (cfs)	0	30	61	94	126	130		
582631	Storage (ac-ft)	0	.76	1.52	2.28	3.04	100		
	Outflow (cfs)	0	18	36	54	72	75		
PUMP96	Storage (ac-ft)	0	4.14	8.28	12.5	17.2	200		
	Outflow (cfs)	0	100	200	300	412	420		
583520	Storage (ac-ft)	0	2.61	2.82	3.04	3.25	3.56	100	
	Outflow (cfs)	0	63	68	73	78	85	87	
583310	Storage (ac-ft)	0	8.06	10.14	12.21	100			
	Outflow (cfs)	0	195	245	295	297			
PMPD33	Storage (ac-ft)	0	4.96	7.45	10.36	100			
	Outflow (cfs)	0	120	180	250	255			
583220	Storage (ac-ft)	0	7.03	7.45	7.88	8.3	100		
	Outflow (cfs)	0	170	180	190	200	202		
583221	Storage (ac-ft)	0	2.48	3.93	5.22	6.44	7.9	9.6	100
	Outflow (cfs)	0	60	95	126	155	190	231	235
PMPD45	Storage (ac-ft)	0	1.66	3.32	4.98	6.64	100		
	Outflow (cfs)	0	40	80	120	160	165		
570530	Storage (ac-ft)	0	1.04	2.08	3.1	50			
	Outflow (cfs)	0	25	50	73	75			
PMP128	Storage (ac-ft)	0	1.45	2.9	4.4	5.9	7.6	100	
	Outflow (cfs)	0	35	70	105	140	178	180	
570320	Storage (ac-ft)	0	.96	1.92	2.88	3.84	4.8	100	
	Outflow (cfs)	0	23	46	69	92	115	118	
570810	Storage (ac-ft)	0	1.24	2.49	3.73	4.99	100		
	Outflow (cfs)	0	30	60	90	120	123		
PUMP67	Storage (ac-ft)	0	2.35	4.71	7.04	100			
	Outflow (cfs)	0	56	113	169	175			
PUMP69	Storage (ac-ft)	0	1.53	3.06	4.55	6.08	7.61	100	
	Outflow (cfs)	0	37	74	110	147	184	190	
PUMP68	Storage (ac-ft)	0	.62	1.24	1.86	2.48	100		
	Outflow (cfs)	0	15	30	45	60	65		
PMP139	Storage (ac-ft)	0	.97	1.86	2.75	200			
	Outflow (cfs)	0	23	44	65	70			
PUMP89	Storage (ac-ft)	0	4.14	8.28	12.5	17.2	100		
	Outflow (cfs)	0	100	200	300	412	420		

7. Trans-basin Flows

Overland trans-basin flows have been observed at several locations in the Morrison Creek Basin during large floods, including the January 1995 flood. The trans-basin flows were modeled by diversion ratings which were developed from estimates of channel capacities. Table 9 is a list of the diversion ratings, and Chart 13 shows the location of the diversions.

Table 9
Diversion Ratings

Diversion	Inflow/Diverted flow (cfs)	Value						
Mather Lake Trib to Folsom South Canal	Inflow Diverted flow	0 0	740 0	1000 260	2000 1260	1000 9260		
Morrison Cr above Mather Lake Trib to Folsom South Canal	Inflow Diverted flow	0 0	423 0	1000 577	2000 1577	10000 9577		
Morrison Cr above Mather Lake Trib to Folsom South Canal	Inflow Diverted flow	0 0	130 0	1000 870	2000 1870	10000 9870		
Mather Drain above Mather Air Force Base to detention ponds	Inflow Diverted flow	0 0	370 0	500 130	1000 630	1500 1130		
Morrison Cr local at Power Inn Rd to Pump Station 96	Inflow Diverted flow	0 0	100 0	120 0	200 80	500 380		
Unionhouse Cr below Power Inn Rd to detention basin	Inflow Diverted flow	0 0	699 0	2000 1301				
Middle Fork Strawberry Cr at Southern Pacific Railroad to detention basin	Inflow Diverted flow	0 0	220 0	800 580				
Gerber Cr at Central California Traction Railroad to Unionhouse Cr above Southern Pacific Railroad	Inflow Diverted flow	0 0	300 0	370 12	571 51	812 167	1067 253	1920 802
Laguna Cr below Excelsior Rd to Main Trib	Inflow Diverted flow	0 0	2500 0	3450 171	4000 180			
Laguna Cr at Central California Traction Railroad to Gerber Cr at Central California Traction Railroad	Inflow Diverted flow	0 0	800 0	875 9	1334 177	1675 324	2150 575	3244 1477

8. Results

The HEC-1 model accurately reconstituted all of the observed January 8-11, 1995 flow hydrographs. Chart 14 shows the computed hydrographs versus the observed hydrographs at seven of Sacramento County's stream gages in the Morrison Creek Basin. Table 10 shows the computed peak flows throughout the basin during the January 8-11, 1995 flood. The computed peak flows include the effect of two detention basins- a dual purpose flood control/water quality detention basin on the middle fork of Strawberry Creek just east of the Southern Pacific Railroad, and a flood control detention basin on Unionhouse Creek between Power Inn Road and Stockton Boulevard. The HEC-1 model was deemed accurate and was used to compute existing and future condition synthetic flow hydrographs throughout the basin.

Table 10
January 8-11, 1995 Peak Flows, cfs

Index	Location	Drainage Area (sq.mi.)	Flow
	MORRISON CREEK		
MCC10	Jackson Road	20.91	1950
MCC11	Elk Grove-Florin Road	25.70	2020
582519	CCTRR	26.67	2060
582632	SPRR	28.56	2140
582639	Power Inn Road	30.13	2270
583317	Stockton Blvd	32.71	2650
583229	Hiway 99 (USGS Gage)	41.08	3970
MOR	Abv. Junction w/ Elder	42.86	4140
570829	Blw. Elder Creek	64.51	6400
571739	Blw. Unionhouse Creek	76.91	8100
571849	Blw. Laguna Creek	126.28	11060
470000	I-5 (Inflow to Beach Lake)	131.40	11970
	FLORIN CREEK		
583540	SPRR	1.90	330
570229	Power Inn	2.55	440
570429	Hiway 99	3.82	540
FLOR	Mouth	4.56	660
	ELDER CREEK		
683219	Bradshaw Road	4.99	670
670619	CCTRR	7.77	870
670639	Florin Road	8.13	840
571129	Gerber Road	14.55	1480
570919	Hiway 99	15.78	1490
570929	Franklin Road	17.09	1650
ELDER	Abv. Jnct w/ Morrison	21.65	2280
	GERBER CREEK		
670538	CCTRR (without overflow)	3.82	520
670539	CCTRR (with overflow)	3.82	600
670539	Abv. Junction w/Elder	4.85	760

D-003573

D-003573

Index	Location	Drainage Area (sq. mi.)	Flow
	STRAWBERRY CREEK		
571532	Bruceville Road	6.25	900
	UNIONHOUSE CREEK		
571039	Above Strawberry	3.11	770
571539	Bruceville Rd (blw Strawberry)	9.36	1600
571649	Center Parkway	11.07	1720
BEAC	Mouth	12.40	1810
	LAGUNA CREEK		
770639	Eagles Nest Road	13.11	1580
671139	Excelsior Road	18.01	1940
671632	CCTRR (Before Diversion)	19.75	1790
671638	CCTRR (After Diversion)	19.75	1410
672922	Abv. Main Trib	22.52	1210
672939	Bond Road	31.90	1820
COMB4	Abv. Elk Grove Cr	37.03	2450
EGC7	Blw. Elk Grove Cr	43.06	3350
EGC9	Blw. Jacinto Cr	45.82	3800
572129	Franklin Road	47.52	3600
572029	WPRR	48.24	3460
LAG	Mouth	48.82	3470
	ELK GROVE CREEK		
EGC2	SPRR	2.96	540
EGC3	Elk Grove-Florin Road	3.80	640
EGC5	Hiway 99	5.06	800
EGC6	Mouth	6.03	990
	JACINTO CREEK		
572240	Mouth	2.0	160
	LAGUNA CREEK TRIB #1		
672921	Mouth	5.91	760
	WHITEHOUSE CREEK		
RT1	Mouth	2.05	310

B. Synthetic Floods

1. Precipitation

Seven-day general rain storms were used to compute existing and future condition synthetic flood hydrographs. Seven days was selected because that is the duration of the February 1986 general rain storm, which produced the largest recorded volume of water passing through Morrison Creek. Six general rain storms were modeled- 10-, 25-, 50-, 100-, 200-, and 500-year. Precipitation depths for durations of 1 hour, 2 hours, 3 hours, 6 hours, 12 hours, 1 day, 2 days, 3 days, 4 days, 5 days, 6 days, and 7 days were taken from a recent depth-duration-frequency analysis of downtown Sacramento precipitation records. These precipitation depths were multiplied by 0.9 to account for areal distribution of point precipitation.

The 100-year precipitation depths (without the 0.9 areal adjustment) were used to construct the time

distribution of all of the 7-day general rain storms, and are shown in Table 11. One-hour incremental precipitation was determined using Table 11 and was positioned in a skewed triangular pattern with the most intense precipitation occurring on the second day. This precipitation distribution was selected because the resulting synthetic peak flow-frequency curve closely approximates the analytical peak flow-frequency curve at the USGS gage on Morrison Creek (Chart 15). Chart 16 shows the adopted incremental precipitation distribution.

The 7-day precipitation depths for all of the general rain storms were distributed over 11 Morrison Creek subareas based on the ratio of the subarea's NAP to the total basin NAP. Table 12 lists the subareas and the 7-day precipitation depths.

Table 11
100-year Precipitation Depths, inches

Duration (hours)	Depth
1	1.05
2	1.48
3	1.77
6	2.46
12	3.30
24	4.38
48	6.19
72	7.10
96	7.68
120	8.15
144	8.50
168	8.84

D-003575

D-003575

Table 12
Subarea 7-day Precipitation Depths, inches

Subarea	10-year	25-year	50-year	100-year	200-year	500-year
Morrison Creek above Elk Grove-Florin Road	5.80	6.84	7.59	8.29	8.99	10.99
Morrison Creek below Elk Grove-Florin Road	5.40	6.37	7.07	7.72	8.38	10.24
Elder Creek above Bradshaw Road	5.65	6.67	7.40	8.08	8.77	10.72
Elder Creek between Bradshaw and Gerber Roads	5.51	6.50	7.22	7.88	8.55	10.45
Elder Creek below Gerber Road	5.40	6.37	7.07	7.72	8.38	10.24
Laguna Creek above Eagles Nest Road	5.87	6.92	7.68	8.38	9.10	11.12
Laguna Creek between Eagles Nest and Bond Roads	5.57	6.57	7.29	7.96	8.64	10.56
Laguna Creek below Bond Road	5.40	6.37	7.07	7.72	8.38	10.24
Florin Creek	5.40	6.37	7.07	7.72	8.38	10.24
Unionhouse Creek	5.40	6.37	7.07	7.72	8.38	10.24
Beach-Stone Lakes Area	5.40	6.37	7.07	7.72	8.38	10.24

2. Loss Rates

The Morrison Creek Basin was divided into three land types to determine the initial losses in the basin-urban, rural, and native vegetation. A subarea with both rural and native vegetation land types were weighted by the proportion of each land type in the subarea to obtain an average initial loss. Table 13 shows the adopted initial losses for each land type and for each synthetic flood. The initial losses were estimated from flood reconstitutions (see Reference 1) and from approximation of the analytical peak flow-frequency curve at the USGS gage on Morrison Creek (Chart 15). The future condition initial losses are less than the existing condition initial losses because a greater proportion of land is classified as urban. The constant loss rate was between 0.01 and 0.03 inches/hour for the existing condition floods, and was 0.01 inches/hour for the future condition floods. These low constant loss rates are confirmed by field observations that indicate the soil is densely packed and wet throughout the rainy season. Beach and Stone Lakes were modeled as impervious areas to simulate rain falling on water.

Table 13
Initial Losses, inches

Land type	10-year	25-year	50-year	100-year	200-year	500-year
Urban	0.4	0.35	0.15	0.1	0.1	0
Rural	1.2	0.85	0.55	0.4	0.4	0
Native vegetation	2.0	1.35	1.0	0.6	0.6	0

3. Unit Hydrographs

The Clark T_c and R values in Table 6 were used to compute existing condition unit hydrographs for subareas in the Morrison Creek Basin. The Clark T_c and R values in Table 14 were used to compute the future condition unit hydrographs. Subareas where land use remains unchanged have the same T_c and R values for both existing and future conditions. Subareas that are developed have different T_c and R values.

D-003577

D-003577

TABLE 14
Clark T_c and R Values
Future Condition

Morrison Creek

Subarea	Drainage Area (sq. mi.)	Line[1]	T_c	R
MC60	5.63	1	3.4	2.8
PMP116	0.15	1	.88	.72
PUMP66	0.82	1	1.7	1.4
582530	0.91	1	1.8	1.4
582630	0.98	1	1.9	1.4
582240	0.61	1	1.5	1.2
582631	0.43	1	1.3	1.1
582730	0.53	1	1.4	1.2
PUMP96	2.58	1	2.6	2.1
583510	0.39	1	1.3	1.0
583520	0.52	1	1.4	1.2
583310	1.17	1	1.9	1.6
PMPD33	1.50	1	2.1	1.7
583220	1.33	1	2.0	1.7
582930	2.95	1	2.7	2.2
583221	0.51	1	1.4	1.2
PMPD45	0.63	1	1.5	1.3
570530	0.36	1	1.3	1.0
PMP128	0.79	1	1.7	1.3
PUMP89	2.00	4	2.4	1.9
472430	3.12	4	4.6	3.7

Florin Creek

Subarea	Drainage Area (sq. mi.)	Line[1]	T_c	R
583540	1.90	1	2.3	1.9
570220	0.65	1	1.5	1.3
570320	0.69	1	1.6	1.3
570420	0.58	1	1.4	1.0
570810	0.74	1	1.6	1.3

1 Numbered lines in Chart 12

Laguna Creek

Subarea	Drainage Area (sq. mi.)	Line[1]	T_c	R
782810	3.29	1	2.9	2.3
770630	9.82	1	4.2	3.4
671130	4.90	1	3.3	2.7
671630	1.74	1	2.3	1.8
672920	2.77	1	2.6	2.2
672921	5.91	1	3.5	2.9
672930	3.47	1	2.9	2.3
23635	0.59	1	1.5	1.3
HW99	1.53	1	2.1	1.8
572711	2.05	1	2.4	1.8
572710	0.96	1	1.8	1.5
EG1	1.61	1	2.2	1.8
EG2	0.34	1	1.3	1.0
NEG1	1.01	1	1.8	1.5
EG3	0.84	1	1.7	1.4
EG4	0.57	1	1.5	1.2
EG5	0.69	1	1.6	1.3
EG6	0.97	1	1.8	1.5
LC5	2.0	1	2.4	1.9
572240	0.76	1	1.7	1.3
572120	1.70	1	2.2	1.8
572020	0.72	4	2.7	2.2
571840	0.58	4	2.5	2.0

1 Numbered lines in Chart 12

Elder Creek

Subarea	Drainage Area (sq.mi.)	Line[1]	T_c	R
682730	3.73	1	3.0	2.4
683210	1.26	1+4[2]	2.0	1.6
670610	2.78	1	2.6	2.2
670631	0.36	1	1.3	1.0
670330	1.48	1	2.1	1.7
670530	2.34	1	2.5	2.1
670531	1.03	1	1.8	1.5
571120	1.57	1	2.2	1.8
570910	1.23	1	2.0	1.6
PUMP67	1.31	1	2.0	1.6

Unionhouse Creek

Subarea	Drainage Area (sq.mi.)	Line[1]	T_c	R
671220	1.72	1	2.3	1.8
571030	1.39	1	2.1	1.7
672410	3.35	1	2.9	2.3
571540	2.42	1	2.5	2.1
571530	0.48	1	1.4	1.1
PUMP69	1.71	1	2.2	1.8
PUMP68	0.37	1	1.2	1.0
PMP139	0.96	1	1.8	1.4
571720	0.55	1+4[2]	2.3	1.8

1 Numbered lines in Chart 12

2 Average of values on lines 1 and 4

Beach/Stone Lakes

Subarea	Drainage Area (sq. mi.)	Line[1]	T_c	R
572940	1.06	4	1.9	1.5
472510	1.19	4	3.3	2.7
472610	0.75	4	2.8	2.2
573230	0.83	4	1.7	1.4
460110	1.61	4	3.6	3.0
560510	5.68	1+4[2]	5.0	4.1
560740	1.91	4	3.8	3.1
460210	1.65	4	3.7	2.9
461310	2.78	4	4.4	3.6
561720	15.49	4	8.0	6.6
561830	2.58	4	4.3	3.5
563010	5.71	4	5.7	4.7
463520	7.61	4	6.3	5.2

1 Numbered lines in Chart 12
2 Average of values on lines 1 and 4

4. Baseflow

The baseflow is the same as for the January 1995 flood reconstitution- 3 cfs per square mile.

5. Routing Parameters

The Modified Puls and Muskingum routing parameters in Table 7 were used to route the existing condition synthetic floods. Optimized Muskingum parameters (Section 5.A.5.b) were used instead of Modified Puls parameters to route the future condition synthetic floods through channelized reaches that Sacramento County officials projected will exist by the year 2045. The projected channelized reaches in Table 15 represent full channelization. The actual channelized reaches in the year 2045 will depend on the amount of urban development.

Table 15
Projected Channelized Reaches

Morrison Creek below Mather Drain
Florin Creek below the Southern Pacific Railroad
Elder Creek below 3100 feet downstream of Excelsior Road
Gerber Creek below Gerber Road
Unionhouse Creek below the Southern Pacific Railroad
Strawberry Creek below the Southern Pacific Railroad
Laguna Creek below Eagles Nest Road
Elk Grove Creek below the Southern Pacific Railroad

6. Pump Stations

The Modified Puls storage and outflow values in Table 8 were used to route the existing and future condition synthetic floods through each pump station.

7. Trans-basin Flows

The diversion ratings in Table 9 were used to model overland trans-basin flows for the existing and future condition synthetic floods.

8. Results

a. Synthetic Flood Hydrographs

Existing and future condition synthetic flood hydrographs were developed throughout the Morrison Creek Basin using the precipitation, loss rates, unit hydrographs, base flow, routing parameters, pump stations, and trans-basin flows in this section. Computed synthetic flood hydrographs for Morrison Creek below Laguna Creek and for Beach/Stone Lakes local were used in the DWOPER model of the North Delta to determine flow and stage hydrographs throughout the North Delta (Section 7). Tables 16 and 17 list computed existing and future condition peak flows throughout the basin, respectively.

Table 16
Existing Condition Peak Flows, cfs

Index	Location	Drainage Area (sq.mi.)	500 yr Flow	200 yr Flow	100 yr Flow	50 yr Flow	25 yr Flow	10 yr Flow
				MORRISON CREEK				
MCC10	Jackson Road	20.91	3000	2380	2140	1870	1540	1050
MCC11	Elk Grove-Florin Road	25.70	3130	2500	2270	1970	1610	1070
582519	CCTRR	26.67	3170	2540	2300	2000	1640	1100
582632	SPRR	28.56	3270	2620	2380	2070	1700	1150
582639	Power Inn Road	30.13	3360	2690	2440	2130	1750	1200
583317	Stockton Blvd	32.71	3760	2890	2550	2230	1840	1320
583229	Hiway 99 (USGS Gage)	41.08	4570	3610	3410	3160	2860	2510
MOR	Abv. Junction w/ Elder	42.86	4640	3940	3730	3420	3050	2630
570829	Blw. Elder Creek	64.51	8190	6230	5830	5250	4630	3950
571739	Blw. Unionhouse Creek	76.91	9410	8020	7540	6800	5980	4910
571849	Blw. Laguna Creek	126.28	14460	11540	10410	9040	7520	5700
470000	I-5 (Inflow to Beach Lake)	131.40	14780	12020	10830	9700	8060	6120
				FLORIN CREEK				
583540	SPRR	1.90	550	450	410	380	340	280
570229	Power Inn	2.55	720	590	540	500	450	380
570429	Hiway 99	3.82	840	730	680	640	580	500
FLOR	Mouth	4.56	960	840	800	750	700	610
				ELDER CREEK				
683219	Bradshaw Road	4.99	1290	1020	940	820	650	240
670619	CCTRR	7.77	1720	1360	1240	1070	850	400
670639	Florin Road	8.13	1690	1340	1210	1040	820	400
571129	Gerber Road	14.55	2880	2300	2100	1780	1410	730
570919	Hiway 99	15.78	2910	2320	2110	1780	1400	760
570929	Franklin Road	17.09	3080	2500	2220	1820	1450	800
ELDER	Abv. Jnct w/ Morrison	21.65	3560	2710	2430	2020	1640	1320
				GERBER CREEK				
670538	CCTRR (without overflow)	3.82	1010	820	750	670	550	320
670539	CCTRR (with overflow)	3.82	2130	1560	1360	1060	710	350
670539	Abv. Junction w/Elder	4.85	1270	1050	970	840	620	360

D-003583

D-003583

Index	Location	Drainage Area (sq. mi.)	500 yr Flow	200 yr Flow	100 yr Flow	50 yr Flow	25 yr Flow	10 yr Flow
				STRAWBERRY CREEK				
571532	Bruceville Road	6.25	1180	980	910	830	700	390
				UNIONHOUSE CREEK				
571039	Above Strawberry	3.11	1010	790	740	690	620	470
571539	Bruceville Rd (blw Strawberry)	9.36	1880	1680	1610	1510	1320	840
571649	Center Parkway	11.07	1970	1790	1720	1620	1510	1020
BEAC	Mouth	12.40	1990	1870	1800	1710	1540	1130
				LAGUNA CREEK				
770639	Eagles Nest Road	13.11	3180	2560	2340	2080	1740	1250
671139	Excelsior Road	18.01	3860	3120	2880	2580	2140	1530
671632	CCTRR (Before Diversion)	19.75	3610	3010	2800	2480	2050	1470
671638	CCTRR (After Diversion)	19.75	1830	1730	1690	1630	1530	1230
672922	Abv. Main Trib	22.52	1930	1770	1710	1600	1440	1130
672939	Bond Road	31.90	3590	2990	2780	2500	2170	1650
COMB4	Abv. Elk Grove Cr	37.03	3960	3300	3050	2720	2350	1780
EGC7	Blw. Elk Grove Cr	43.06	4530	3760	3430	3030	2600	1950
EGC9	Blw. Jacinto Cr	45.82	5020	4120	3680	3240	2720	2040
572129	Franklin Road	47.52	5110	4190	3760	3320	2770	2070
572029	WPRR	48.24	5060	4170	3750	3300	2790	2080
LAG	Mouth	48.82	5100	4200	3780	3330	2800	2090
				ELK GROVE CREEK				
EGC2	SPRR	2.96	890	770	670	620	520	380
EGC3	Elk Grove-Florin Road	3.80	1050	880	790	720	630	450
EGC5	Hiway 99	5.06	1310	1130	1010	920	800	550
EGC6	Mouth	6.03	1600	1370	1230	1120	990	670
				JACINTO CREEK				
572240	Mouth	2.0	260	220	200	180	160	120
				LAGUNA CREEK TRIB #1				
672921	Mouth	5.91	1300	1060	970	890	790	600
				WHITEHOUSE CREEK				
RT1	Mouth	2.05	490	410	370	290	290	190

D-003584

D-003584

Table 17
Future Condition Peak Flows, cfs

Index	Location	Drainage Area (sq.mi.)	500 yr Flow	200 yr Flow	100 yr Flow	50 yr Flow	25 yr Flow	10 yr Flow
				MORRISON CREEK				
MCC10	Jackson Road	30.69	3910	3220	2980	2740	2450	2050
MCC11	Elk Grove-Florin Road	36.32	4990	4110	3790	3470	3110	2590
582519	CCTRR	37.29	5160	4280	3940	3560	3190	2660
582632	SPRR	39.18	5160	4260	3910	3540	3210	2690
582639	Power Inn Road	40.75	5410	4510	4120	3710	3350	2780
583317	Stockton Blvd	43.33	5800	4860	4480	4090	3740	2970
583229	Hiway 99 (USGS Gage)	51.70	6970	5860	5450	5050	4610	3830
MOR	Abv. Junction w/ Elder	53.48	7190	5950	5530	5150	4680	3940
570829	Blw. Elder Creek	75.13	12510	10600	9870	9130	8330	7090
571739	Blw. Unionhouse Creek	87.53	14280	12170	11420	10640	9710	8400
571849	Blw. Laguna Creek	136.90	21450	18250	16860	15550	13970	11450
470000	I-5 (Inflow to Beach Lake)	142.02	22470	19140	17580	16080	14500	11690
				FLORIN CREEK				
583540	SPRR	1.90	690	560	520	470	430	360
570229	Power Inn	2.55	880	720	660	600	540	460
570429	Hiway 99	3.82	1020	860	800	740	680	590
FLOR	Mouth	4.56	1130	970	910	850	790	700
				ELDER CREEK				
683219	Bradshaw Road	4.99	1600	1300	1200	1090	980	830
670619	CCTRR	7.77	2420	1970	1820	1660	1490	1260
670639	Florin Road	8.13	2490	2030	1870	1710	2570	1300
571129	Gerber Road	14.55	4460	3630	3350	3060	2750	2320
570919	Hiway 99	15.78	4620	3770	3470	3170	2850	2400
570929	Franklin Road	17.09	4690	3860	3560	3270	2960	2520
ELDER	Abv. Jnct w/ Morrison	21.65	5790	4800	4450	4100	3720	3150
				GERBER CREEK				
670538	CCTRR	3.82	1400	1150	1060	970	870	730
670539	Abv. Junction w/Elder	4.85	1790	1460	1340	1230	1110	930

D-003585

D-003585

Index	Location	Drainage Area (sq. mi.)	500 yr Flow	200 yr Flow	100 yr Flow	50 yr Flow	25 yr Flow	10 yr Flow
				STRAWBERRY CREEK				
571532	Bruceville Road	6.25	1230	1040	980	910	840	750
				UNIONHOUSE CREEK				
571039	Abv. Strawberry Creek	3.11	1150	940	860	790	710	600
571539	Bruceville Rd (blw Strawberry)	9.36	1930	1740	1680	1610	1540	1350
571649	Center Parkway	11.07	2110	1930	1860	1800	1730	1530
571712	Mouth	12.40	2210	2020	1950	1890	1810	1620
				LAGUNA CREEK				
770639	Eagles Nest Road	13.11	3900	3180	2930	2680	2400	2020
671139	Excelsior Road	18.01	4410	3570	3280	3030	2760	2310
671632	CCTRR	19.75	4680	3780	3480	3220	2920	2440
672922	Abv. Main Trib	22.52	5100	4160	3850	3530	3180	2650
672939	Bond Road	31.90	7470	6110	5640	5150	4620	3850
COMB4	Abv. Elk Grove Cr	37.03	8250	6760	6210	5690	5110	4270
EGC7	Blw. Elk Grove Cr	43.06	9540	7860	7160	6540	5860	4890
EGC9	Blw. Jacinto Cr	45.82	10120	8340	7590	6930	6210	5160
572129	Franklin Road	47.52	9480	8020	7330	6700	6000	5000
572029	WPRR	48.24	9270	7790	7090	6470	5790	4800
LAG	Mouth	48.82	9310	7840	7110	6490	5810	4830
				ELK GROVE CREEK				
EGC2	SPRR	2.96	1160	980	870	800	720	610
EGC3	Elk Grove-Florin Road	3.80	1510	1270	1140	1040	940	790
EGC5	Hiway 99	5.06	1900	1600	1430	1310	1180	1000
EGC6	Mouth	6.03	2050	1730	1540	1410	1270	1070
				JACINTO CREEK				
572240	Mouth	2.0	330	280	250	220	200	170
				LAGUNA CREEK TRIB #1				
672921	Mouth	5.91	1810	1480	1360	1240	1120	940
				WHITEHOUSE CREEK				
RT1	Mouth	2.05	490	420	370	340	310	260

D-003586

D-003586

b. 10-year 800 cfs Limits

The 10-year 800 cfs limits for the existing and future condition synthetic floods are listed in Table 18. Only stream reaches below the 10-year 800 cfs limits are eligible for Federal sponsorship of a flood improvement project.

Table 18
10-year 800 cfs Limits

Stream	10-year 800 cfs Limit	
	Existing Condition	Future Condition
Morrison Creek	Below Mather Drain	Below Mather Lake Trib
Mather Lake Trib	None	None
Mather Drain	None	Folsom South Canal
Florin Creek	None	None
Laguna Creek	Eagles Nest Road	Eagles Nest Road
Elk Grove Creek	None	Below Elk Grove-Florin Road
Elder Creek	Center Parkway	Bradshaw Road
Gerber Creek	None	Below Central California Traction Railroad
Strawberry Creek	None	None
Unionhouse Creek	Below Strawberry Creek	Below Strawberry Creek

6. FUTURE FLOW MITIGATION

The County of Sacramento will mitigate future condition peak flows on Morrison Creek and its tributaries where they cross the Sacramento City-County border. The County will mitigate by diverting runoff into several detention basins throughout the Morrison Creek Basin. Diversion typically will begin between the County's existing condition 10- and 25-year water surface elevations. Significant mitigation typically will begin and end at the County's existing condition 25- and 100-year peak flows, respectively. Rare future condition peak flows will be unmitigated since the detention basins will be overwhelmed. The County and Corps existing and future condition HEC-1 models of the Morrison Creek Basin have differences, as indicated by the different computed peak flows in Table 19. The County's Elder Creek peak flows are preliminary, and will be finalized after adjusting the diversion rating from Laguna Creek to Gerber Creek.

The County included the detention basin and channel improvement projects that are shown in Table 20 in their existing and future condition HEC-1 models of the Morrison Creek Basin. The Corps of Engineers included only a dual purpose flood control/water quality detention basin on Strawberry Creek (part of the

Table 19
Comparison of County and Corps Computed Peak Flows, cfs

Creek	Mitigation Index Point	Existing Condition				Future Condition			
		County 25-yr	Corps 25-yr	County 100-yr	Corps 100-yr	County 25-yr	Corps 25-yr	County 100-yr	Corps 100-yr
Morrison	USGS gage	2880	2860	3560	3410	3600	4610	4260	5450
Florin	Highway 99	610	580	760	680	790	680	860	800
Elder	Highway 99	1280	1400	1850	2110	1830	2850	2450	3470
Unionhouse	Highway 99	600	620	740	740	820	710	910	860
Strawberry	Highway 99	1000	600	1230	780	1150	740	1410	860
Jacinto	Mouth	170	160	250	200	260	200	340	250
Laguna	Downstream of Elk Grove Cr	2250	2600	2980	3430	2930	5860	3680	7160

Table 20
Sacramento County Detention Basin and Channel Improvement Projects

Creek	Detention Basin Projects	Channel Improvement Projects
Morrison	Miners Part A	Miners Part A
Florin		
Elder/Gerber		
Unionhouse	Price Club	Price Club
Strawberry	Drainage Master Plan- Flood Control	Closing Reach Improvements
Jacinto	Drainage Master Plan- Water Quality	
Upper Laguna		
Lower Laguna		Bypass Channel
Whitehouse		Upper Reach Improvements
Elk Grove	Drainage Master Plan- Flood Control	

Strawberry Creek Drainage Master Plan) and a flood control detention basin on Unionhouse Creek (part of the Price Club project) in their existing and future condition HEC-1 models of the basin. The Strawberry and Unionhouse Creek detention basins were modeled using the County diversion ratings in Table 9. The diversion ratings overestimate the peak flow reduction for floods that overwhelm the detention basins, and do not return diverted water to Strawberry and Unionhouse Creeks. However, the diversion ratings do not significantly affect the computed peak flows in potential project reaches, nor the computed volumes in the Beach/Stone Lakes area. The detention basins should be modeled using Modified Puls storage-outflow relationships when they become available.

The Corps did not include any other County projects in their existing and future condition HEC-1 models because at the beginning of this feasibility study they still had not been constructed, and when or if the projects will be constructed is unknown. The Corps included the projected channelized reaches (Table 15) in their future condition HEC-1 model to simulate a worst-case future condition.

Chart 17 shows the existing condition, the future condition, and the future condition (with mitigation) peak flow-frequency curves at the seven mitigation index points in Table 19. Each future condition (with mitigation) peak flow-frequency curve was constructed by plotting the County's existing condition 25-year peak flow on the Corps' future condition peak flow-frequency curve, plotting the County's existing condition 100-year peak flow on the Corps' existing condition peak flow-frequency curve, and drawing a line between the two points. Each future condition (with mitigation) peak flow-frequency curve follows the Corps' future condition peak flow-frequency curve for peak flows less than the County's existing condition 25-year peak flow, and for peak flows greater than the County's existing condition 100-year peak flow.

7. DWOPER MODEL

A. Overview

The DWOPER model of the North Delta includes the Beach/Stone Lakes and Meadowview/Pocket areas. The computed existing and future condition synthetic flood hydrographs for Morrison Creek below Laguna Creek and for Beach/Stone Lakes local (Section 5) were used in the DWOPER model to determine flow and stage hydrographs throughout the North Delta. The computed stage hydrographs at Beach Lake were used at the downstream boundary of a UNET model of the Morrison Creek Basin. Computed existing and future condition synthetic flood hydrographs throughout the basin (Section 5) also were used in the UNET model, which computed existing and future condition synthetic floodplains, and computed stage-frequency curves at several index points for a risk-based analysis that will be used to formulate Morrison Creek project features.

Several levee breach locations throughout the North Delta and along the North Beach Lake Levee were identified from surveyed levee crown elevation data. Two levee failure scenarios were modeled to determine the impacts on stages in the Beach/Stone Lakes area- failure at levee crowns and failure 2.5 feet below levee crowns. The latter failure scenario was selected because 2.5 feet below the North Beach Lake Levee crown is above the February 1986 stage of 14.2 feet MSL at Beach Lake, and the levee held in 1986. Two types of floods were modeled- Morrison Creek specific floods (with concurrent Delta flows), and Delta specific floods (with concurrent Morrison Creek flows). The timing of these floods was patterned after the timing of the

February 1986 flood.

Eighteen levee breach locations were identified on Mccormack-Williamson Tract, 10 on New Hope Tract, 5 on Glanville Tract, 4 on Tyler Island, 6 on Staten Island, 6 on Canal Ranch Tract, 5 on Brack Tract, 3 on Bouldin Island, and 2 on the North Beach Lake Levee. DWOPER simulated overtopping at some of these locations because when breaching was simulated a converging solution to the unsteady flow equations could not be reached. The number of breaching and overtopping locations is dependant on the type of flood (Morrison Creek or Delta specific, existing or future condition), the magnitude of the flood (10-, 25-, 50-year, etc), and the levee failure scenario (failure at levee crowns or 2.5 feet below levee crowns). The breaches generally reached 200 feet wide in 12 hours, and failed down to the landside grade. These breach parameters were selected because similar breach parameters were observed during the February 1986 levee failures.

The eastern levee of the Sacramento River adjacent to Beach Lake would fail and flood Beach Lake during rarer-than-150-year floods. The areas protected by the North Beach Lake and Sacramento Regional Wastewater Treatment Plant Levees would flood, and flow from Morrison Creek and its tributaries would be impeded. However, Sacramento River and Morrison Creek/Beach Lake floods usually are not coincident because of the areal distribution of rainfall and the different flood wave travel times. A coincidence analysis should be completed to determine the probability of the Sacramento River Levee failing during Morrison Creek/Beach Lake floods. Failure of the Sacramento River Levee was not included in the DWOPER model, but will be included if the coincidence analysis deems that the probability is large enough.

Chart 18 shows the location of all of the cross-sections in the DWOPER model. The upstream boundaries of the model are Morrison Creek below Laguna Creek, the Cosumnes River below Twin Cities Road, the Mokelumne River below Dry Creek, and Stone Lake local above Lambert Road. The downstream boundary of the model is Georgiana Slough at the Mokelumne River. The Lambert Road bridge structure has flapgates on the downstream side, a low chord elevation of 9.9 feet MSL, and a deck elevation of 11.2 feet MSL.

B. Specific Morrison Creek Floods with Concurrent Delta Flows

Reference 2 describes how the same concurrent Delta flows (February 1986 flows) were modeled with 10-, 25-, 50-, 100-, and 500-year specific Morrison Creek floods, and how the computed Beach and Stone Lake stages might be artificially high for the smaller specific Morrison Creek floods. Reference 2 also recommends that a detailed concurrency analysis be conducted at the feasibility level to determine more appropriate concurrent Delta flows. A detailed concurrency analysis was conducted during this feasibility study and is explained below.

Streamflow data at four USGS gages- Morrison Creek near Sacramento, Cosumnes River at Michigan Bar, Mokelumne River at Woodbridge, and Dry Creek near Galt were analyzed to determine appropriate concurrent flows during specific Morrison Creek and Delta floods. The streamflow data of the Cosumnes River at Michigan Bar were translated below Twin Cities Road, an upstream boundary of the DWOPER model, by multiplying by 1.26, the approximate ratio of flood hydrographs during the February 1986 flood.

The streamflow data of the Cosumnes River below Twin Cities Road, the Mokelumne River at Woodbridge, and Dry Creek near Galt were combined to reflect a total Delta flow. Peak annual, and maximum annual 1-, 3-, and 7-day flows were compiled at the four USGS gages and at the "Delta" gage for water years (October 1 to September 30) 1960-1987, the period of record of the Morrison Creek gage.

The dates of the peak annual and maximum annual 1-, 3-, and 7-day flows at the Morrison Creek gage were recorded, and the concurrent 1-, 3-, and 7-day flows at the Cosumnes River and "Delta" gages were identified. The concurrent peak flows were estimated using the concurrent 1-day flows and peak/1-day flow correlations. Tables 21-23 contain the specific Morrison Creek flows and the concurrent Cosumnes River and Delta flows for the peak, 1-, 3-, and 7-day durations, respectively.

Regression lines relating the specific Morrison Creek flows to the concurrent Cosumnes River and Delta flows were developed for the peak, 1-, 3-, and 7-day durations using the flows in Tables 21-23. The regression lines had correlation coefficients ranging from 0.75 (peak duration) to 0.87 (7-day duration), and were used to predict concurrent Cosumnes River and Delta flows from a specific Morrison Creek flow. For example, concurrent Cosumnes River and Delta 100-year 7-day flows of 19,020 and 37,440 cfs were predicted from the specific Morrison Creek 100-year 7-day flow of 1260 cfs. Concurrent Cosumnes River and Delta flows were predicted from specific Morrison Creek flows for 10-, 25-, 50-, 100-, 200-, and 500-year floods and for the peak, 1-, 3-, and 7-day durations. The specific Morrison Creek flows were taken from Charts 6 and 7, the Morrison Creek peak and volume flow-frequency curves.

The concurrent Cosumnes River flows were multiplied by 1.26 and were subtracted from the concurrent Delta flows to obtain concurrent flows of the Mokelumne River below Dry Creek, an upstream boundary of the DWOPER model. The concurrent flows of the Mokelumne River below Dry Creek were adjusted to reflect spillway flows from Camanche Dam. The objective release from Camanche Dam is 5000 cfs, but spillway flows occur during rarer-than-50-year floods. The concurrent flows of the Mokelumne River below Dry Creek were increased by estimates of the spillway flows for the 100-, 200-, and 500-year specific Morrison Creek floods.

C. Specific Delta Floods with Concurrent Morrison Creek Flows

The dates of the peak annual and maximum annual 1-, 3-, and 7-day flows at the "Delta" gage were recorded, and the concurrent 1-, 3-, and 7-day flows at the Morrison Creek gage were identified. The concurrent peak flows were estimated using the concurrent 1-day flows and a peak/1-day flow correlation. Tables 24 and 25 contain the specific Delta flows and the concurrent Morrison Creek flows for the peak, 1-, 3-, and 7-day durations, respectively.

Table 21
Morrison Creek near Sacramento
Maximum Annual Flows, cfs

WATER YEAR	PEAK	DATE	1-DAY	DATE	3-DAY	DATE	7-DAY	DATE
1960	347	2/8	197	2/8	157	2/8	94	2/5
1961	168	1/31	80	1/31	61	1/31	48	1/29
1962	985	2/10	869	2/10	570	2/9	448	2/9
1963	1320	10/14	1000	10/14	677	10/13	320	10/12
1964	628	1/20	305	1/21	204	1/20	110	1/20
1965	1040	12/23	790	12/23	524	12/22	308	12/21
1966	298	11/17	140	1/30	96	1/30	66	1/29
1967	1500	1/21	991	1/22	605	1/21	397	1/21
1968	394	2/21	219	1/30	104	1/30	60	2/16
1969	1610	1/26	1110	1/20	820	1/19	623	1/20
1970	1110	1/16	609	1/21	403	1/15	317	1/16
1971	1200	11/29	664	11/29	375	11/28	267	11/28
1972	348	12/25	176	12/25	124	12/25	96	12/22
1973	1380	2/27	724	1/18	573	1/16	377	1/12
1974	682	11/17	283	12/1	187	12/27	125	1/14
1975	946	2/13	523	2/13	270	2/12	191	2/8
1976	307	8/15	95	4/8	52	4/8	31	10/25
1977	304	1/2	113	3/16	54	3/16	27	12/30
1978	1330	1/14	992	1/14	801	1/14	535	1/13
1979	979	1/15	630	1/15	337	1/14	229	1/11
1980	1440	2/19	824	2/19	621	2/19	451	2/16
1981	603	1/27	295	1/27	244	1/27	124	1/23
1982	2520	1/5	1940	1/5	1030	1/4	500	12/31
1983	1840	3/13	1380	3/13	707	3/12	404	1/24
1984	1530	12/25	1190	12/25	717	12/24	358	12/24
1985	597	10/11	339	2/8	144	2/8	81	11/7
1986	2730	2/17	1830	2/17	1763	2/17	1240	2/16
1987	1130	2/13	445	2/13	227	2/11	126	2/11

Table 22
Cosumnes River at Michigan Bar
Flows Concurrent with the Maximum Annual Flows of Morrison Creek near Sacramento, cfs

WATER YEAR	PEAK	DATE	1-DAY	DATE	3-DAY	DATE	7-DAY	DATE
1960	**11200**	2/8	**6300**	2/8	**4117**	2/8	**2199**	2/5
1961	144	1/31	106	1/31	116	1/31	111	1/29
1962	**7440**	2/10	5000	2/10	2870	2/9	3123	2/9
1963	9062	10/14	5750	10/14	2809	10/13	1326	10/12
1964	2171	1/20	2780	1/21	2124	1/20	**1323**	1/20
1965	**37500**	12/23	**28500**	12/23	**19263**	12/22	11773	12/21
1966	197	11/17	1520	1/30	1012	1/30	647	1/29
1967	6179	1/21	**6860**	1/22	3990	1/21	2949	1/21
1968	3685	2/21	1200	1/30	1097	1/30	1587	2/16
1969	17224	1/26	13200	1/20	**14067**	1/19	9270	1/20
1970	13224	1/16	**11300**	1/21	7283	1/15	**7610**	1/16
1971	5213	11/29	2920	11/29	1734	11/28	2479	11/28
1972	**3840**	12/25	**3050**	12/25	**1783**	12/25	1213	12/22
1973	4302	2/27	4560	1/18	**5820**	1/16	**4819**	1/12
1974	2225	11/17	2920	12/1	3300	12/27	2946	1/14
1975	4261	2/13	2220	2/13	1607	2/12	2044	2/8
1976	7	8/15	132	4/8	151	4/8	155	10/25
1977	24	1/2	56	3/16	52	3/16	47	12/30
1978	5580	1/14	3190	1/14	3990	1/14	3375	1/13
1979	3323	1/15	1530	1/15	1079	1/14	1425	1/11
1980	21234	2/19	14700	2/19	12113	2/19	7804	2/16
1981	2425	1/27	870	1/27	1450	1/27	710	1/23
1982	24906	1/5	17400	1/5	9727	1/4	5739	12/31
1983	**26100**	3/13	**18400**	3/13	11077	3/12	7169	1/24
1984	**19800**	12/25	11900	12/25	10077	12/24	**8223**	12/24
1985	50	10/11	**2990**	2/8	**1909**	2/8	282	11/7
1986	**45100**	2/17	**34400**	2/17	**32967**	2/17	20521	2/16
1987	**1950**	2/13	1040	2/13	426	2/11	577	2/11

Notes: 1. Peak flows are estimates, except for the flows in **big bold** which are observed.

2. Flows in **big bold** are the maximum annual flows.

Table 23

Delta Flows Concurrent with the Maximum Annual Flows of Morrison Creek near Sacramento, cfs

WATER YEAR	PEAK	DATE	1-DAY	DATE	3-DAY	DATE	7-DAY	DATE
1960	**15893**	2/8	**9138**	2/8	**6885**	2/8	3510	2/5
1961	519	1/31	468	1/31	506	1/31	**468**	1/29
1962	**12094**	2/10	8083	2/10	5003	2/9	5722	2/9
1963	12955	10/14	8306	10/14	4142	10/13	2081	10/12
1964	3566	1/20	5266	1/21	4911	1/20	**3364**	1/20
1965	**62805**	12/23	**47989**	12/23	**31643**	12/22	19184	12/21
1966	3989	11/17	3595	1/30	2574	1/30	1834	1/29
1967	9731	1/21	**16381**	1/22	8521	1/21	5793	1/21
1968	6436	2/21	1777	1/30	2345	1/30	2632	2/16
1969	32711	1/26	18755	1/20	20130	1/19	**18568**	1/20
1970	22056	1/16	19784	1/21	13190	1/15	**14282**	1/16
1971	8514	11/29	5100	11/29	3278	11/28	4773	11/28
1972	**7512**	12/25	**5380**	12/25	**3313**	12/25	2188	12/22
1973	7860	2/27	10218	1/18	**12151**	1/16	**9804**	1/12
1974	6478	11/17	5374	12/1	7242	12/27	5813	1/14
1975	7260	2/13	5382	2/13	3723	2/12	4635	2/8
1976	24	8/15	179	4/8	202	4/8	1353	10/25
1977	77	1/2	101	3/16	97	3/16	99	12/30
1978	10327	1/14	6144	1/14	7732	1/14	6074	1/13
1979	5950	1/15	3185	1/15	2300	1/14	2773	1/11
1980	36137	2/19	24938	2/19	**24741**	2/19	16145	2/16
1981	3615	1/27	1527	1/27	3018	1/27	1442	1/23
1982	57916	1/5	39380	1/5	22169	1/4	13673	12/31
1983	**51458**	3/13	**36112**	3/13	24279	3/12	16637	1/24
1984	**38072**	12/25	25048	12/25	21411	12/24	17422	12/24
1985	749	10/11	**4940**	2/8	**3581**	2/8	1019	11/7
1986	**93113**	2/17	**66230**	2/17	**62443**	2/17	39789	2/16
1987	4543	2/13	2697	2/13	1083	2/11	1276	2/11

Notes: 1. Flows before water year 1965 do not include regulation by Camanche Dam.

2. Flows in **big bold** are the maximum annual flows.

3. All flows are estimates.

Table 24
Delta Maximum Annual Flows, cfs

WATER YEAR	PEAK	DATE	1-DAY	DATE	3-DAY	DATE	7-DAY	DATE
1960	15893	2/8	9138	2/8	6885	2/8	3722	2/8
1961	1956	11/10	733	11/10	582	2/2	468	1/29
1962	12094	2/10	10891	2/15	8859	2/14	6768	2/10
1963	60042	2/1	41752	2/1	22208	2/1	13680	1/31
1964	10802	1/22	7876	1/22	5501	1/21	3364	1/20
1965	62805	12/23	47989	12/23	31643	12/22	19998	12/22
1966	5287	12/29	4046	12/31	3628	12/29	2331	11/15
1967	32015	1/22	16381	1/22	8812	1/29	6129	5/17
1968	6680	2/20	5099	2/21	4666	2/20	3615	2/20
1969	37139	1/21	30098	1/21	22988	1/20	18568	1/20
1970	28636	1/21	20432	1/22	17437	1/21	14282	1/16
1971	14389	3/26	8568	3/26	6922	3/26	5311	11/29
1972	7512	12/25	5380	12/25	3313	12/25	2267	12/23
1973	24740	1/16	15999	1/12	12151	1/16	9804	1/12
1974	14866	3/2	10578	4/2	8927	3/2	7078	3/2
1975	18717	3/25	12083	3/25	8563	3/25	6365	3/22
1976	2059	10/29	1867	10/31	1823	10/31	1783	10/30
1977	894	11/1	382	11/1	229	10/30	156	10/30
1978	12005	3/4	11411	3/5	8752	1/15	6236	1/14
1979	10970	1/11	9982	2/23	9170	2/21	6573	2/19
1980	48681	1/13	32368	1/14	24741	2/19	17482	1/12
1981	8589	3/25	5691	3/26	4205	3/25	3103	3/20
1982	72588	2/16	48700	2/16	28358	2/15	17265	2/15
1983	51458	3/13	36112	3/13	25327	3/13	17725	3/12
1984	38072	12/25	28874	12/26	24965	12/25	17401	12/25
1985	11787	2/8	4940	2/8	3581	2/8	2053	2/8
1986	93113	2/17	66230	2/17	62443	2/17	39913	2/15
1987	4774	3/6	4009	3/6	2250	3/5	1407	3/11

Notes: 1. Flows before water year 1965 do not include regulation by Camanche Dam.
2. All flows are estimates.

Table 25
Morrison Creek near Sacramento
Flows Concurrent with the Maximum Annual Delta Flows, cfs

WATER YEAR	PEAK	DATE	1-DAY	DATE	3-DAY	DATE	7-DAY	DATE
1960	**347**	2/8	**197**	2/8	**157**	2/8	81	2/8
1961	5	11/10	5	11/10	41	2/2	**48**	1/29
1962	**985**	2/10	715	2/15	461	2/14	443	2/10
1963	1110	2/1	691	2/1	305	2/1	211	1/31
1964	521	1/22	204	1/22	198	1/21	**110**	1/20
1965	**1040**	12/23	**790**	12/23	**524**	12/22	304	12/22
1966	204	12/29	45	12/31	70	12/29	31	11/15
1967	1473	1/22	**991**	1/22	424	1/29	7	5/17
1968	258	2/20	125	2/21	97	2/20	51	2/20
1969	1151	1/21	725	1/21	780	1/20	**623**	1/20
1970	1011	1/21	314	1/22	347	1/21	**317**	1/16
1971	382	3/26	89	3/26	40	3/26	249	11/29
1972	**348**	12/25	**176**	12/25	**124**	12/25	87	12/23
1973	990	1/16	592	1/12	**573**	1/16	**377**	1/12
1974	430	3/2	99	4/2	68	3/2	46	3/2
1975	435	3/25	133	3/25	48	3/25	51	3/22
1976	27	10/29	30	10/31	15	10/31	15	10/30
1977	5	11/1	5	11/1	4	10/30	5	10/30
1978	752	3/4	296	3/5	642	1/15	525	1/14
1979	693	1/11	207	2/23	306	2/21	182	2/19
1980	757	1/13	475	1/14	**621**	2/19	331	1/12
1981	343	3/25	50	3/26	42	3/25	49	3/20
1982	740	2/16	385	2/16	305	2/15	146	2/15
1983	**1840**	3/13	**1380**	3/13	668	3/13	403	3/12
1984	**1530**	12/25	390	12/26	580	12/25	284	12/25
1985	468	2/8	**339**	2/8	**144**	2/8	68	2/8
1986	**2730**	2/17	**1830**	2/17	**1763**	2/17	1205	2/15
1987	504	3/6	190	3/6	165	3/5	41	3/11

Notes: 1. Peak flows are estimates, except for the flows in **big bold** which are observed.

2. Flows in **big bold** are the maximum annual flows.

Regression lines relating the specific Delta flows to the concurrent Morrison Creek flows were developed for the peak, 1-, 3-, and 7-day durations using the flows in Tables 24 and 25. The regression lines had correlation coefficients ranging from 0.78 (1-day duration) to 0.88 (3-day duration), and were used to predict concurrent Morrison Creek flows from specific Delta flows. Concurrent Morrison Creek flows were predicted from specific Delta flows for 10-, 25-, 50-, 100-, 200-, and 500-year floods and for the peak, 1-, 3-, and 7-day durations. The specific Delta flows were taken from Chart 19 which contains Delta flow-

frequency curves for the peak, 1-, 3-, and 7-day durations. Specific Cosumnes River flows were taken from Chart 20 which contains Cosumnes River flow-frequency curves for the peak, 1-, 3-, and 7-day durations. Table 26 shows the peak, 1-, 3-, and 7-day specific and concurrent flows at the upstream boundaries of the DWOPER model for the 10-, 25-, 50-, 100-, 200-, and 500-year floods (existing and future conditions).

D. Boundary Hydrographs

1. Upstream

The Cosumnes and Mokelumne River upstream boundary hydrographs were constructed by reshaping the February 1986 hydrographs of the Cosumnes River at Michigan Bar and Dry Creek near Galt, respectively. The reshaped hydrographs are 10-, 25-, 50-, 100-, 200-, and 500-year specific and concurrent hydrographs that approximate the specific and concurrent flows in Table 26. The 10-, 25-, 50-, 100-, 200-, and 500-year specific Morrison Creek upstream boundary hydrographs were computed in the HEC-1 model, and were multiplied by 0.83, the concurrent/specific flow ratio, to obtain 10-, 25-, 50-, 100-, 200-, and 500-year concurrent Morrison Creek upstream boundary hydrographs. This flow ratio was adopted after comparing the specific Morrison Creek peak, 1-, 3-, and 7-day flows to the concurrent Morrison Creek peak, 1-, 3-, and 7-day flows that were predicted using the regression lines. The 10-, 25-, 50-, 100-, 200-, and 500-year specific Stone Lake local upstream boundary hydrographs were taken from Ensign and Buckley's DWOPER model of the North Delta. These hydrographs are relatively insignificant and were used as concurrent Stone Lake local upstream boundary hydrographs also. The specific and concurrent upstream boundary hydrographs (existing and future conditions) are shown on Charts 21 and 22, respectively.

2. Downstream

The downstream boundary of the DWOPER model is the Georgiana Slough at Mokelumne River gage. The 10-, 25-, 50-, 100-, 200-, and 500-year specific downstream boundary hydrographs were determined by finding the 10-, 25-, 50-, 100-, 200-, and 500-year peak stages at the gage on the computed peak stage-frequency curve (Chart 23), and multiplying the February 1986 stage hydrograph at the gage (Chart 24) by the ratios of those peak stages to the 1986 peak stage. The 10-, 25-, 50-, 100-, 200-, and 500-year concurrent downstream boundary hydrographs were determined by finding the return periods of the concurrent Delta peak flows on the computed Delta peak flow-frequency curve (Chart 19), entering the computed peak stage-frequency curve at those return periods and finding the corresponding peak stages, and multiplying the February 1986 stage hydrograph by the ratios of those peak stages to the 1986 peak stage. The specific and concurrent downstream boundary hydrographs (existing and future conditions) are shown on Charts 25 and 26, respectively.

Table 26
Specific and Concurrent Flows, cfs

	Specific				Concurrent			
	peak	1-day	3-day	7-day	peak	1-day	3-day	7-day
Morrison Cr below Laguna Cr (existing condition)								
10-yr	6120	5020	3210	1680	5080	4170	2660	1390
25-yr	8060	7080	4330	2200	6690	5880	3590	1830
50-yr	9700	8500	5130	2580	8050	7060	4260	2140
100-yr	10830	9710	5840	2930	8990	8060	4850	2430
200-yr	12020	10730	6450	3240	9980	8910	5350	2690
500-yr	14780	13220	8010	4060	12270	10970	6650	3370
Morrison Cr below Laguna Cr (future condition)								
10-yr	11690	8300	4700	2380	9700	6890	3900	1980
25-yr	14500	10110	5770	2920	12040	8390	4790	2420
50-yr	16080	11280	6470	3310	13350	9360	5370	2750
100-yr	17580	12240	7050	3630	14590	10160	5850	3010
200-yr	19140	13330	7700	3980	15890	11060	6390	3300
500-yr	22470	16190	9410	4950	18650	13440	7810	4110
Stone Lake local (existing and future conditions)								
10-yr	1850	990	610	340	1850	990	610	340
25-yr	1850	990	610	340	1850	990	610	340
50-yr	1850	990	610	340	1850	990	610	340
100-yr	1850	990	610	340	1850	990	610	340
200-yr	2580	1380	860	470	2580	1380	860	470
500-yr	2580	1380	860	470	2580	1380	860	470

	Specific				Concurrent			
	peak	1-day	3-day	7-day	peak	1-day	3-day	7-day
Mokelumne River below Dry Cr (existing and future conditions)								
10-yr	16800	15150	11420	7780	15890	12600	9790	6200
25-yr	24460	22000	16400	10840	22010	17460	13040	9940
50-yr	30600	29240	21600	13550	25870	20530	16290	11110
100-yr	51100	47430	32400	21380	44210	35070	27090	18750
200-yr	82300	73120	48980	33220	70540	55970	43220	29930
500-yr	129600	117300	76790	51160	111710	88630	68440	47390
Cosumnes River below Twin Cities Rd (existing and future conditions)								
10-yr	31500	28850	21170	13990	29490	20030	19500	10990
25-yr	43720	40010	30240	20160	40150	26900	26150	17830
50-yr	53300	48760	37040	25450	47260	33760	32800	19980
100-yr	61740	56570	43600	30620	54370	40630	38340	23890
200-yr	69800	63880	50020	35780	61470	45770	43200	27790
500-yr	79380	72700	58210	42840	70360	54350	52740	33650

E. Results

1. Beach Lake Peak Stage-frequency Curves

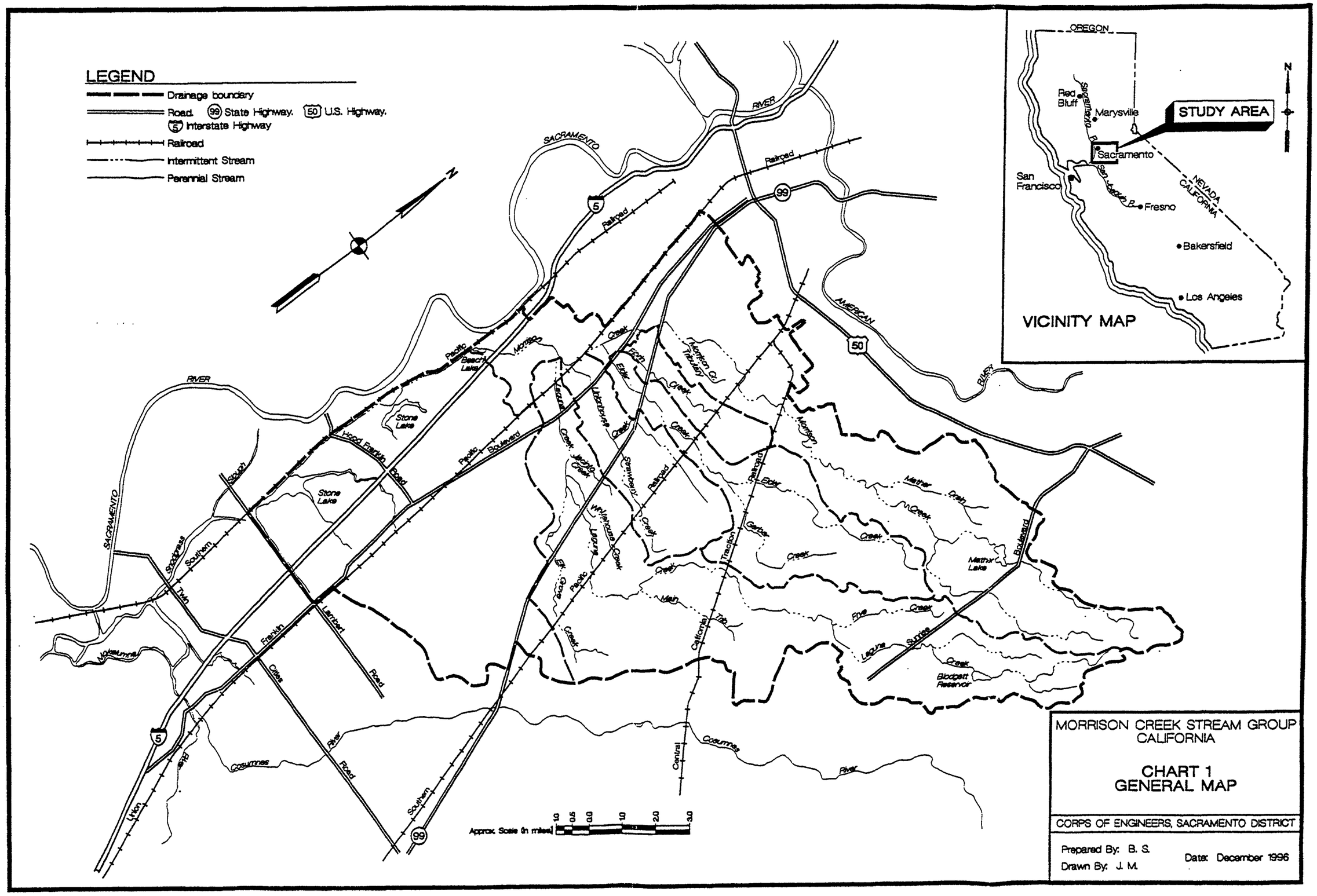
Charts 27 and 28 are the computed existing and future condition peak stage-frequency curves at Beach Lake for specific Morrison Creek and Delta floods, respectively. The peak stage-frequency curves reflect the two levee failure scenarios- failure at levee crowns and failure 2.5 feet below levee crowns.

2. Beach Lake Flow and Stage Concurrency

The concurrency of the computed flows and stages at Beach Lake from the HEC-1 and DWOPER models affects the computed flows and stages in the Morrison Creek UNET model, which was used to determine existing and future condition floodplains, and will be used to determine feasible channel design configurations. Table 27 shows the 10-, 25-, 50-, 100-, 200-, and 500-year peak flows and concurrent stages at Beach Lake for existing and future conditions.

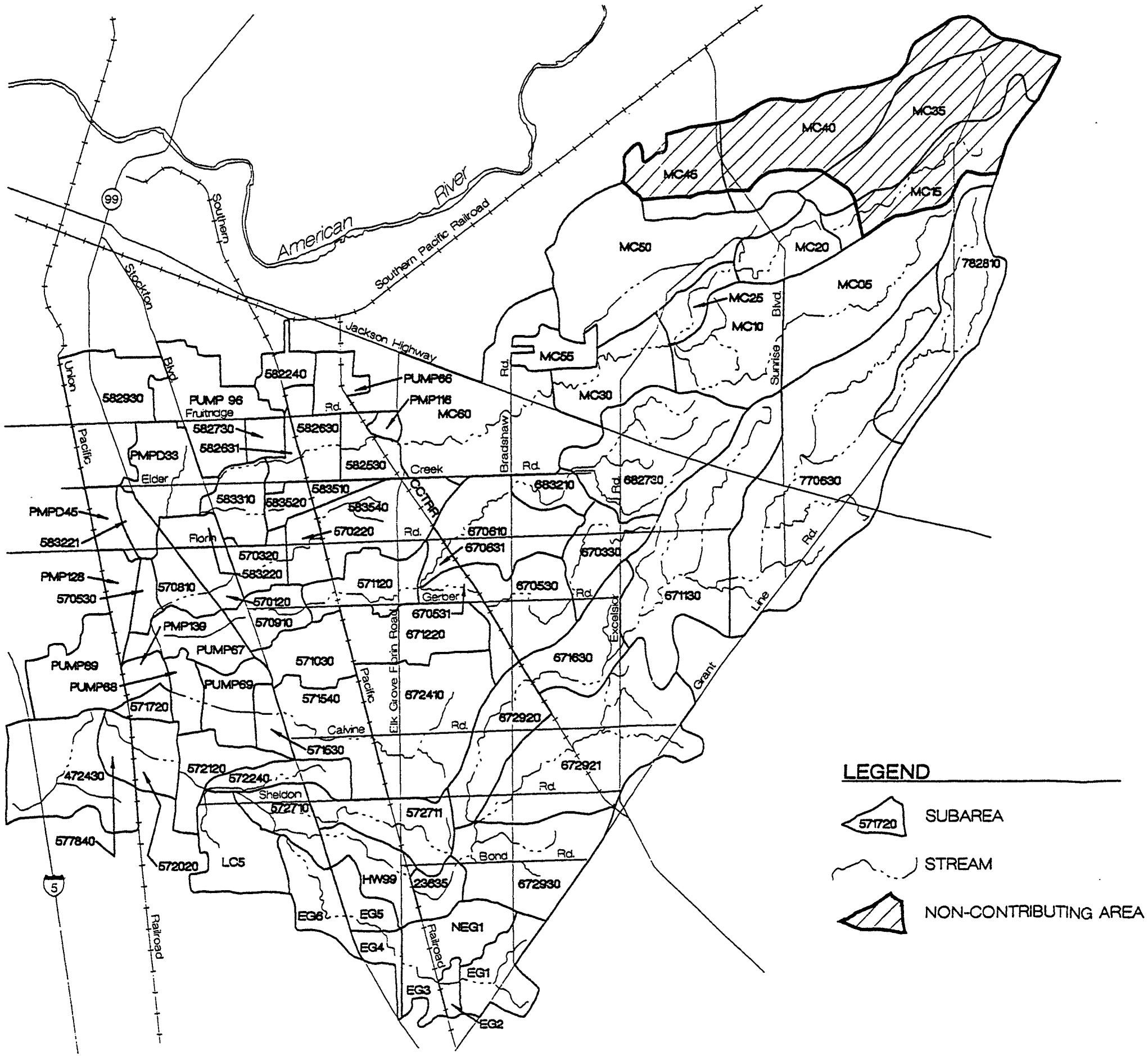
Table 27
Beach Lake Peak Flows, cfs, and Concurrent Stages, ft MSL

Flood	Existing Condition			Future Condition		
	Stage Failures at Levee Crown	Stage Failures 2.5 Feet Below Levee Crown	Flow	Stage Failures at Levee Crown	Stage Failures 2.5 Feet Below Levee Crown	Flow
10-year	7.2	7.2	6120	9.4	9.4	11690
25-year	8.0	8.0	8060	10.3	10.3	14500
50-year	8.6	8.6	9700	10.8	10.8	16080
100-year	9.8	9.8	10830	11.2	11.2	17580
200-year	10.3	10.3	12020	11.7	11.7	19140
500-year	15.3	14.7	14780	13.2	12.9	22470



D-003601

D-003601



LEGEND

571720 SUBAREA

STREAM

NON-CONTRIBUTING AREA

MORRISON CREEK STREAM GROUP
CALIFORNIA

CHART 2
SUBAREA MAP
EXISTING CONDITIONS

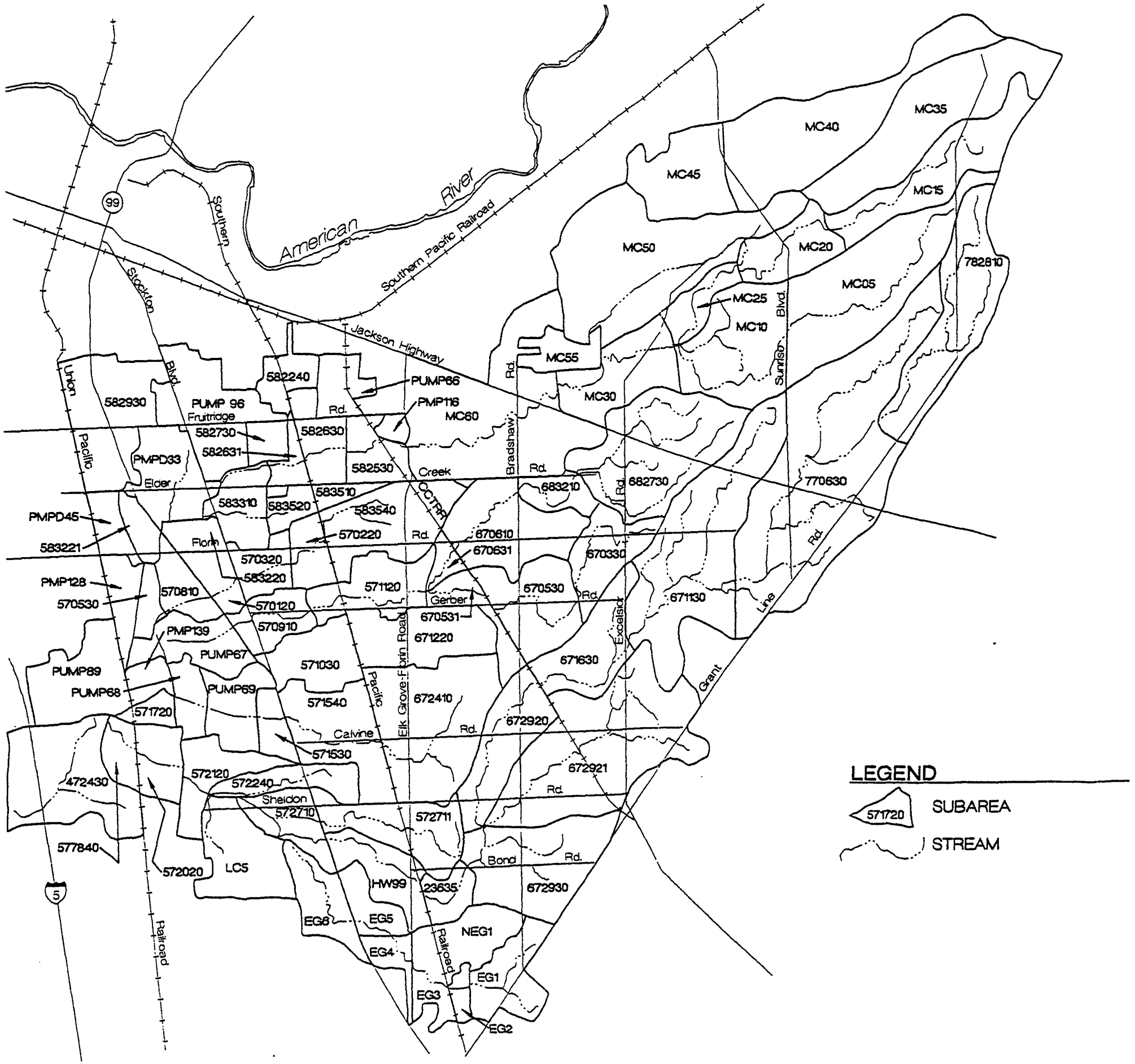
CORPS OF ENGINEERS, SACRAMENTO DISTRICT

Prepared By: B. S.
Drawn By: J. M.

Date: December 1996

D-003602

D-003602



MORRISON CREEK STREAM GROUP
CALIFORNIA

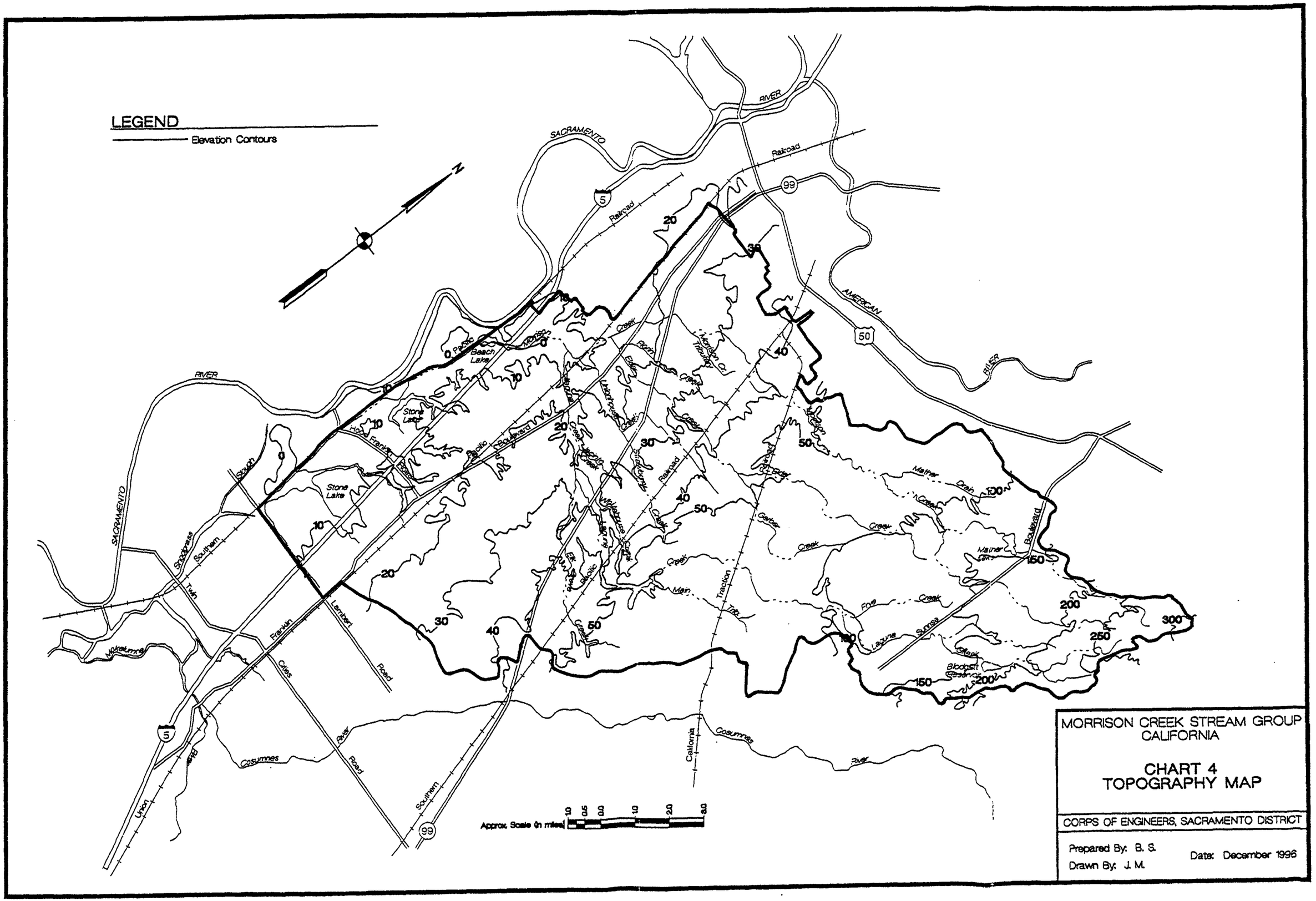
CHART 3
SUBAREA MAP
FUTURE CONDITIONS
(YEAR 2045)

CORPS OF ENGINEERS, SACRAMENTO DISTRICT

Prepared By: B. S.
Drawn By: J. M.
Date: December 1996

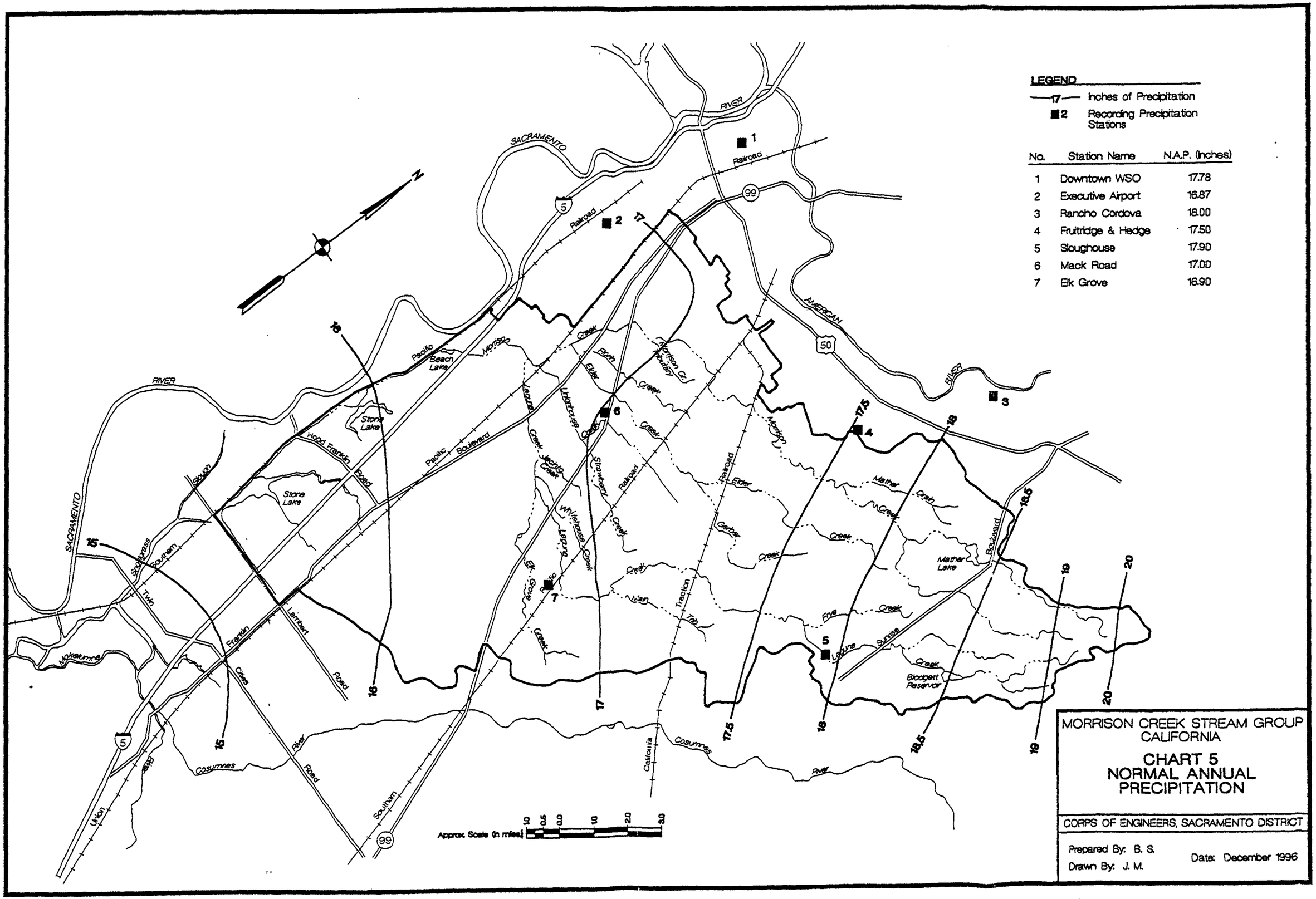
D-003603

D-003603



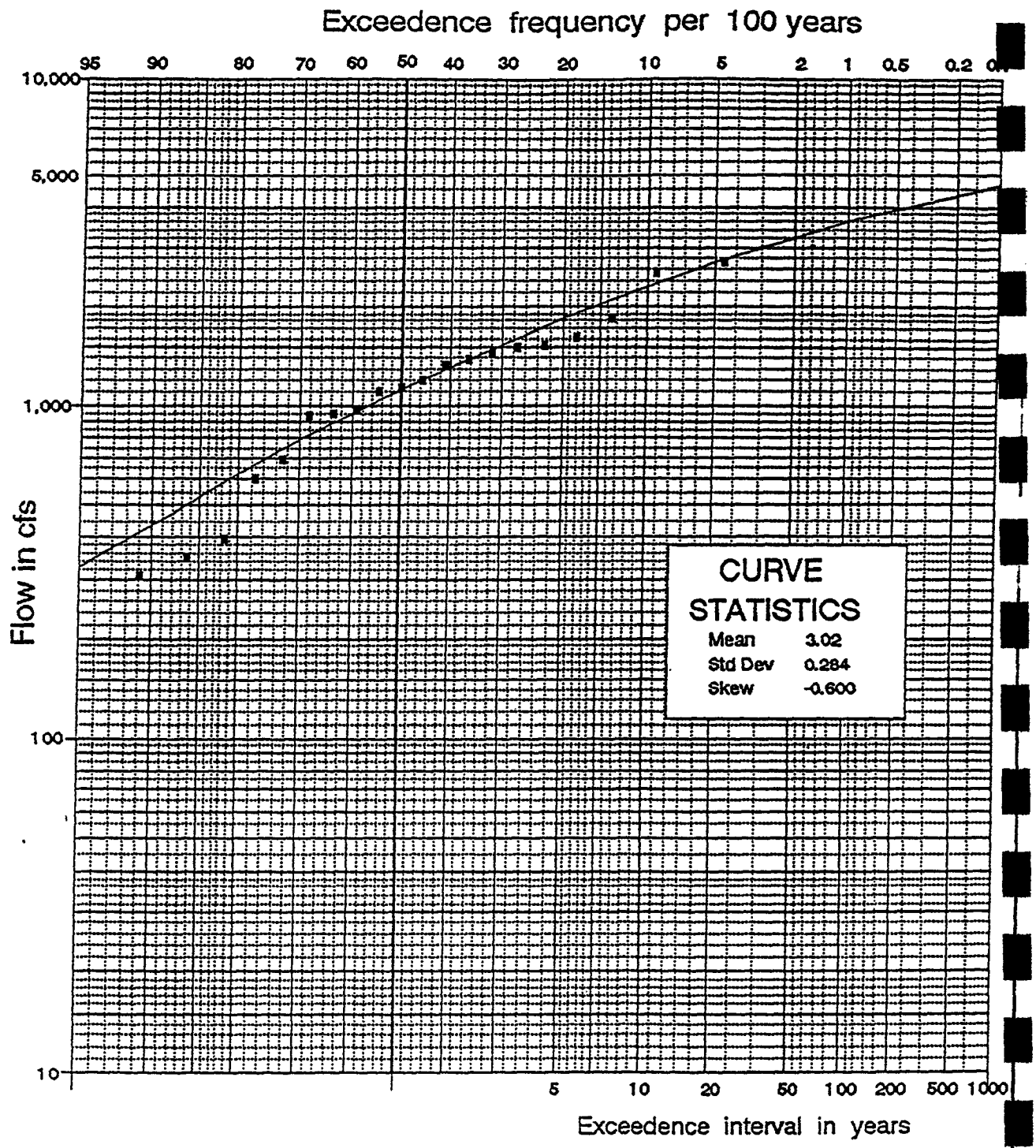
D-003604

D—003604



D-003605

D-003605



SOUTH SACRAMENTO STREAMS

PEAK FREQUENCY CURVE
MORRISON CREEK
NEAR SACRAMENTO
USGS STATION 11336580

NOTES:

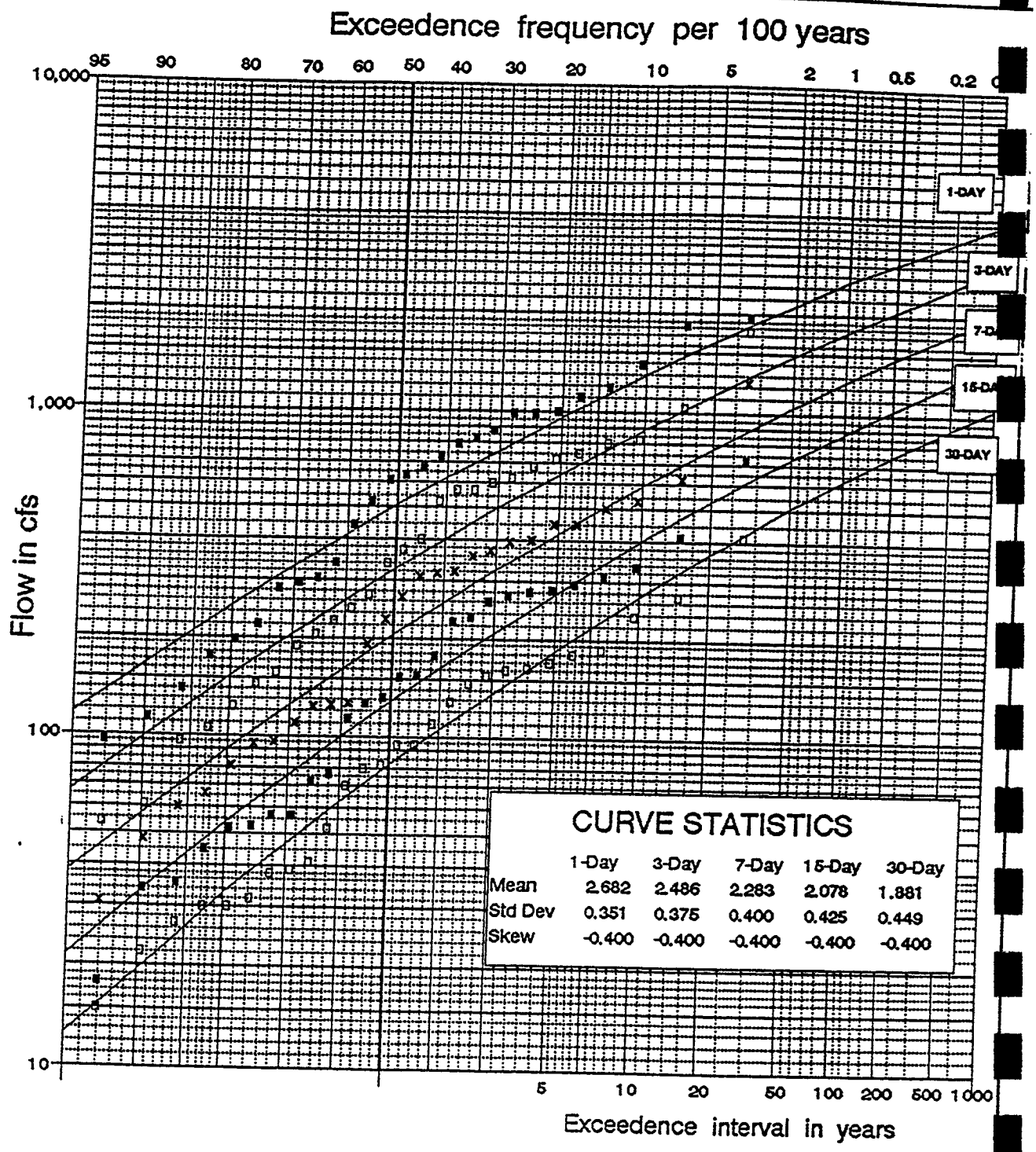
1. Drainage Area: 53.4 square miles.
2. Period of record: 1967-1987.
3. Weibull Formula used for plotting positions.
4. No Expected Probability adjustment was used.

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared by: JH Date: SEPT. 1993

Drawn by:JH File : MORPEAK.WQ1

CHART 6



CURVE STATISTICS

	1-Day	3-Day	7-Day	15-Day	30-Day
Mean	2.682	2.486	2.283	2.078	1.881
Std Dev	0.351	0.375	0.400	0.425	0.449
Skew	-0.400	-0.400	-0.400	-0.400	-0.400

SOUTH SACRAMENTO STREAMS

VOLUME- FREQUENCY CURVES
MORRISON CREEK
NEAR SACRAMENTO
USGS STATION 11336580

NOTES:

1. Drainage Area: 53.4 square miles.
2. Period of record: 1960-1987.
3. Weibull Formula used for plotting positions.
4. No Expected Probability adjustment was used.

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared by: JH Date: SEPT. 1993

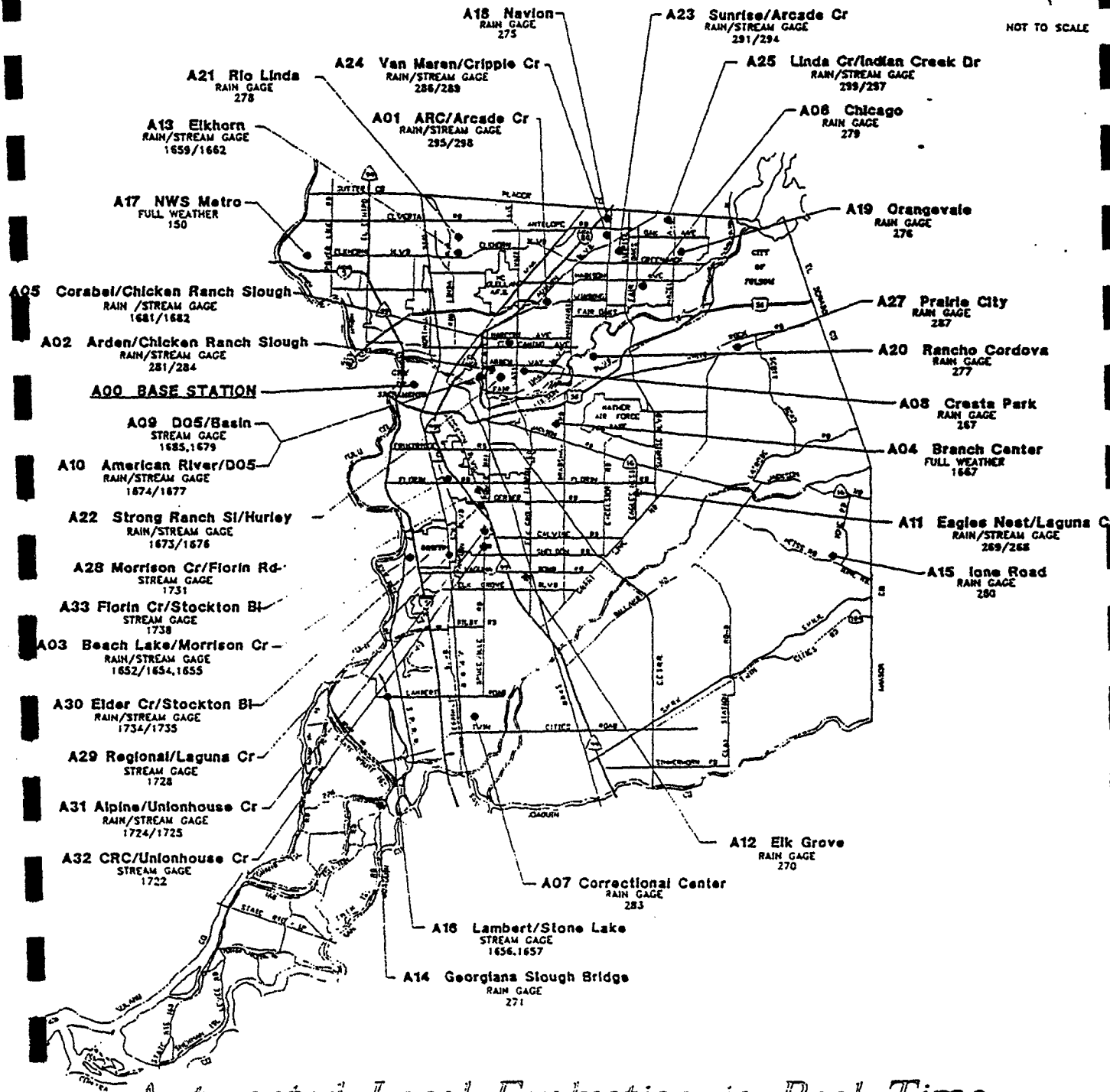
Drawn by:JH File : MORVOL.WQ1

CHART 7

Flood ALERT Monitoring
Automated Local Evaluation in Real Time

ALERT System

NOT TO SCALE



Automated Local Evaluation in Real Time

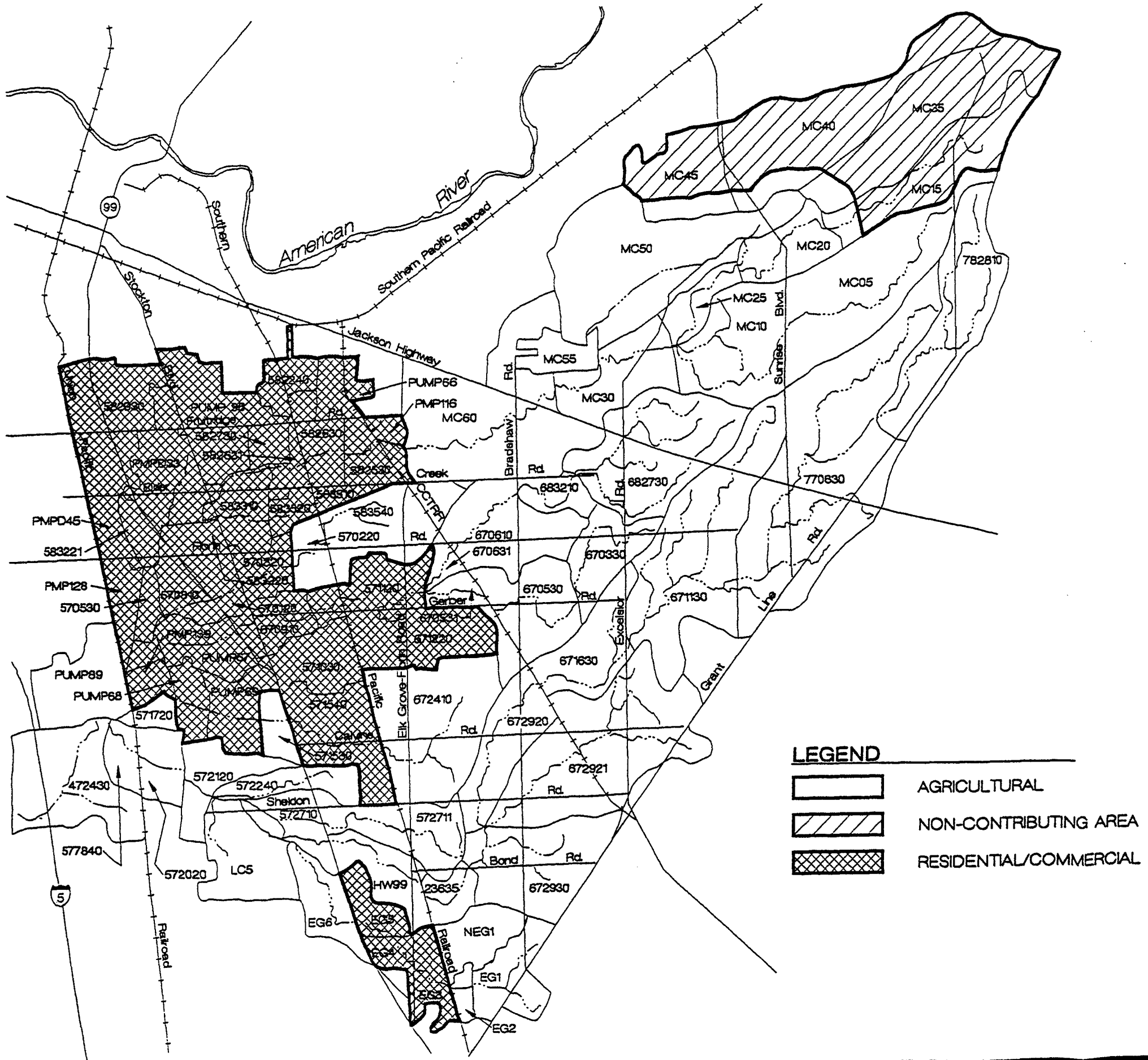
Sacramento County
Public Works Agency
Water Resources Division

CHART 8

Rev: Sep 1994 by JPHuber
Drawn By: J. Fischer

D—003608

D-003608



LEGEND

- AGRICULTURAL
- NON-CONTRIBUTING AREA
- RESIDENTIAL/COMMERCIAL

MORRISON CREEK STREAM GROUP
CALIFORNIA

CHART 9
LAND USE MAP
UPPER BASIN
EXISTING CONDITIONS

CORPS OF ENGINEERS, SACRAMENTO DISTRICT

Prepared By: B. S.
Drawn By: J. M.
Date: December 1996

D-003609

D-003609

N

LEGEND

- AGRICULTURAL
- SURFACE MINING
- RESIDENTIAL/COMMERCIAL

MORRISON CREEK STREAM GROUP
CALIFORNIA

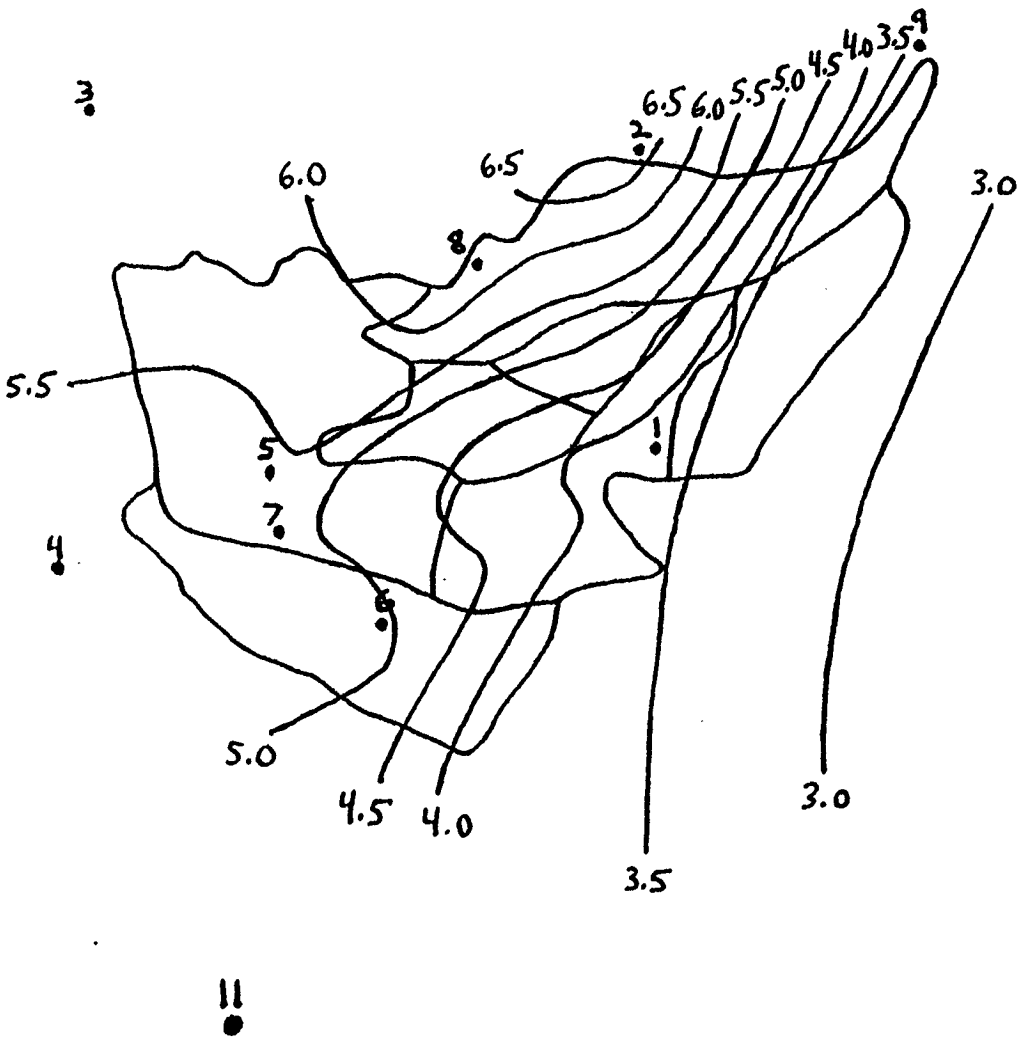
CHART 10
LAND USE MAP
UPPER BASIN
FUTURE CONDITIONS

CORPS OF ENGINEERS, SACRAMENTO DISTRICT

Prepared By: B. S.
Drawn By: J. M.
Date: December 1996

D-003610

D-003610



RECORDING PRECIPITATION STATIONS

1.	EAGLES NEST ROAD	3.60 IN.
2.	RANCHO CORDOVA F.S.	6.72 IN.
3.	SAC WB CITY	5.67 IN.
4.	BEACH LAKE	5.38 IN.
5.	STOCKTON BLVD	5.43 IN.
6.	ELK GROVE FISH HATCHERY	5.06 IN.
7.	ALPINE FROST DRIVE	5.16 IN.
8.	BRANCH CENTER	6.27 IN.
9.	PRAIRIE CITY	3.36 IN.
10.	IONE ROAD	2.05 IN.
11.	CORRECTIONAL CENTER	4.61 IN.

10

CHART 11

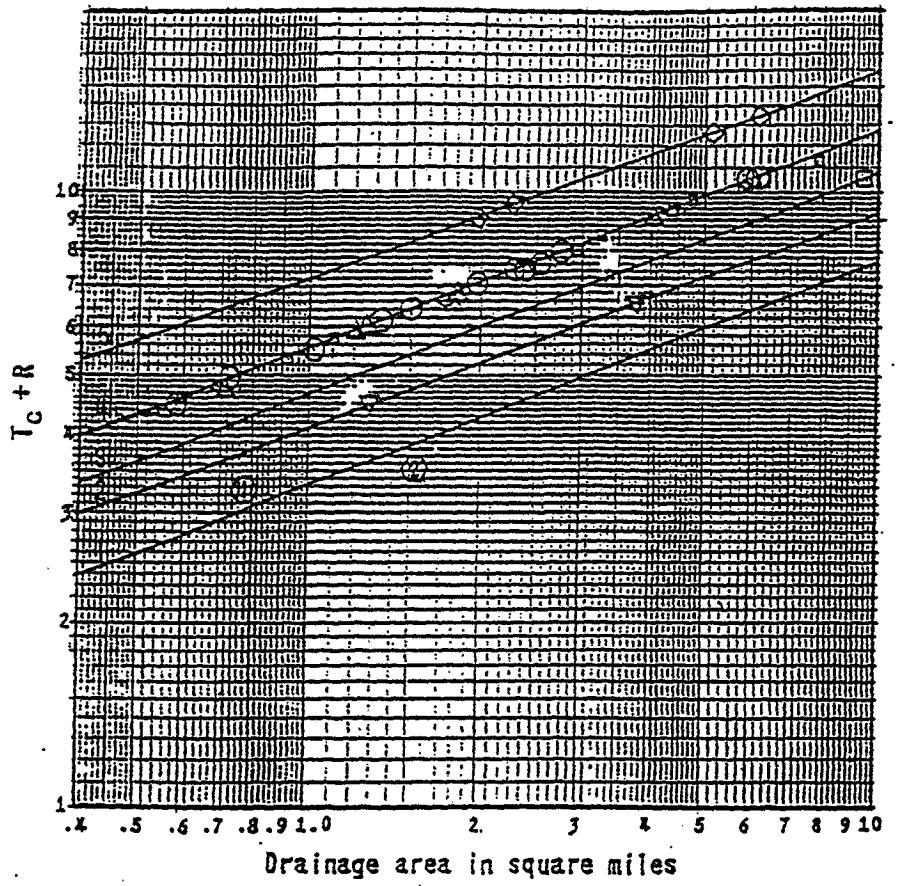
ISOHYETAL MAP

08-11 JANUARY 1995

SCALE 1:250,000

D-003611

D-003611



LEGEND:

- ◇ Laguna Creek between Eagles Nest and Bond Roads.
- □ Morrison Creek.
- ○ Laguna Creek below Bond Road.
- △ Elder Creek below Bradshaw Road.
- ▽ Elder Creek above Bradshaw Road.
- □ Laguna Creek above Eagles Nest Road.
- ① Random Slough (11 Jan 73).
- ② Coyle Creek (12 Jan 69).

NOTE:

Tc + R relationships are based on January 1982 flood reproduction.

SOUTH SACRAMENTO STREAMS, CALIFORNIA

$T_c + R$ RELATIONSHIPS

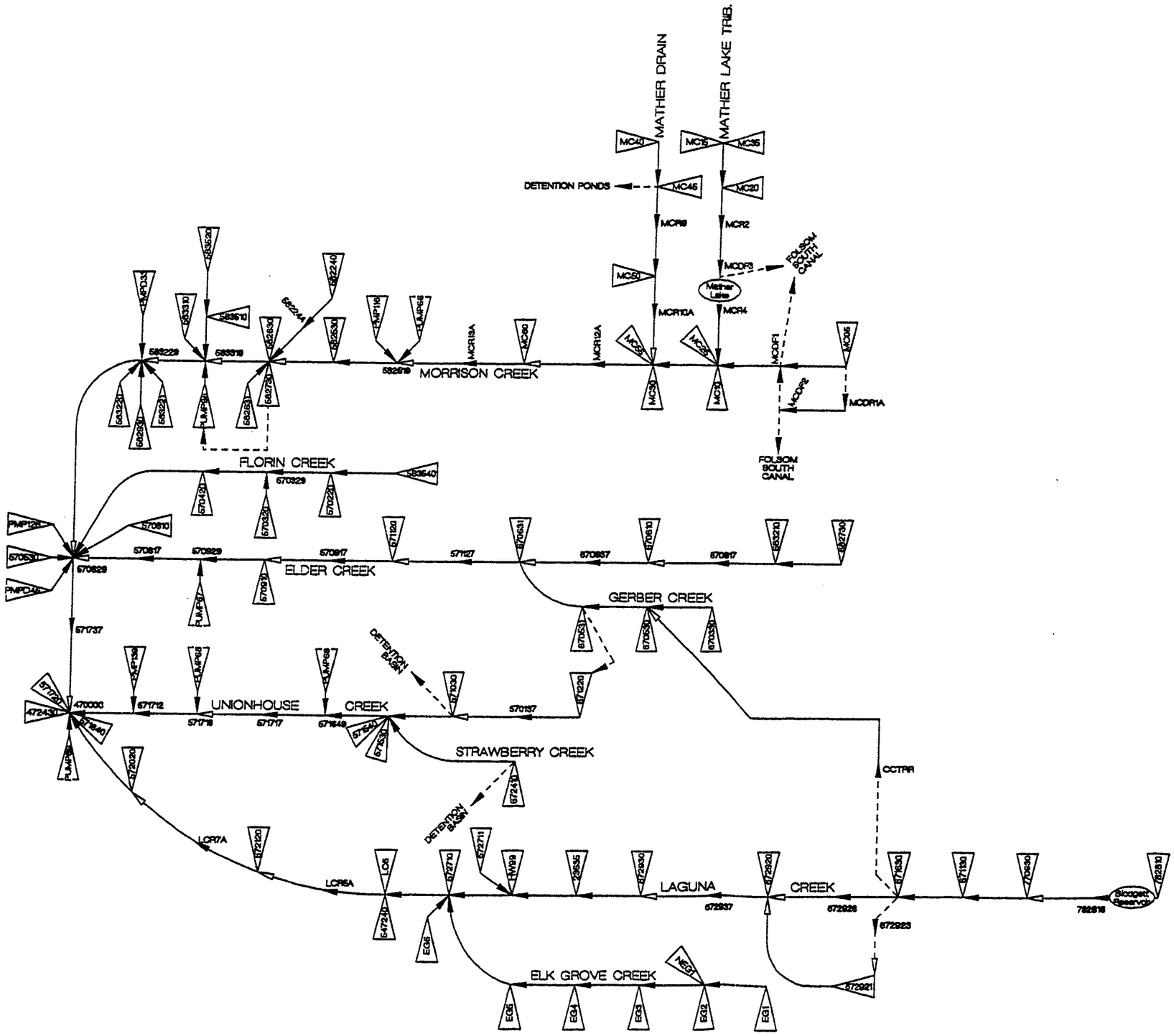
CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: J.H.
Drawn: C.A.P.
Date: SEPT. 1993

SHEET 13

D-003612

D-003612



LEGEND

- Subarea
- Trans-Basin Flow/Diversion
- Modified Puls Routing
- Muskingum Routing
- Index Point

MORRISON CREEK STREAM GROUP
CALIFORNIA

CHART 13
ROUTING DIAGRAM

CORPS OF ENGINEERS, SACRAMENTO DISTRICT

Prepared By: B. S.
Drawn By: J. M.
Date: August 1996

D-003613

D-003613

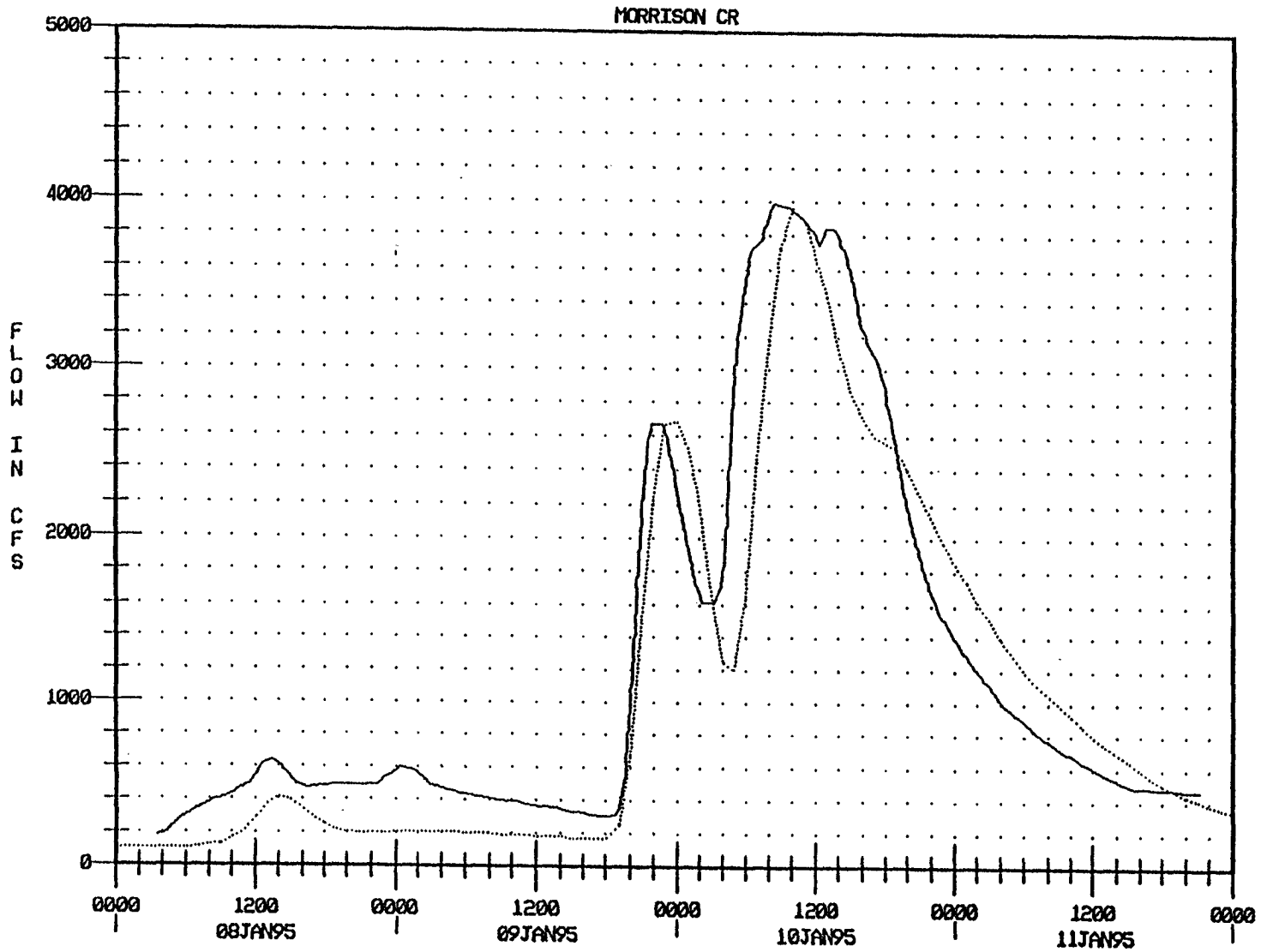


CHART 14 (sheet 1 of 7)

USGS GAGE COMPUTED FLOW
FLORIN RD SENSOR 1731 FLOW

D-003614

D-003614

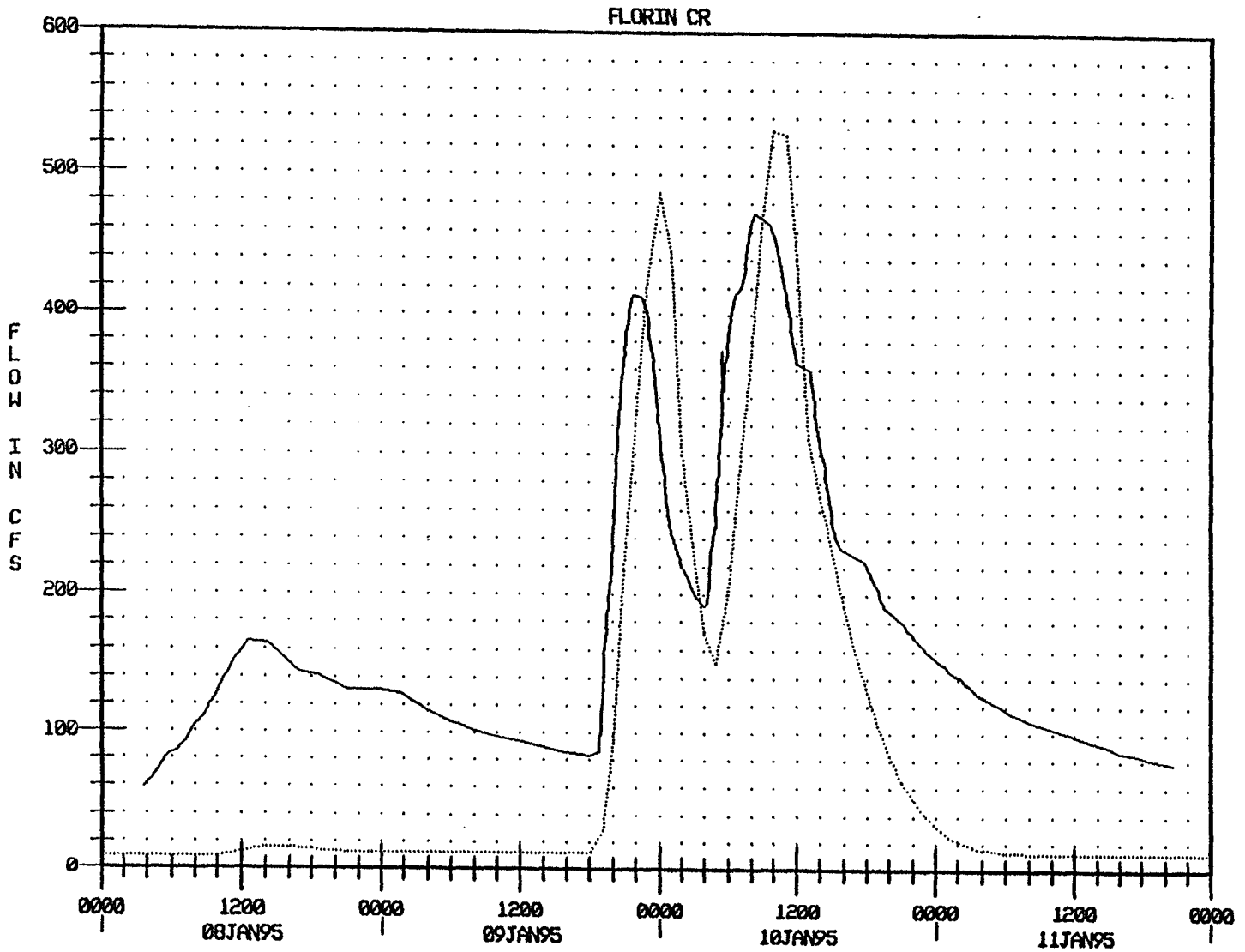


CHART 14 (sheet 2 of 7)

STOCKTON BL COMPUTED FLOW
STOCKTON BL SENSOR 1738 FLOW

D-003615

D-003615

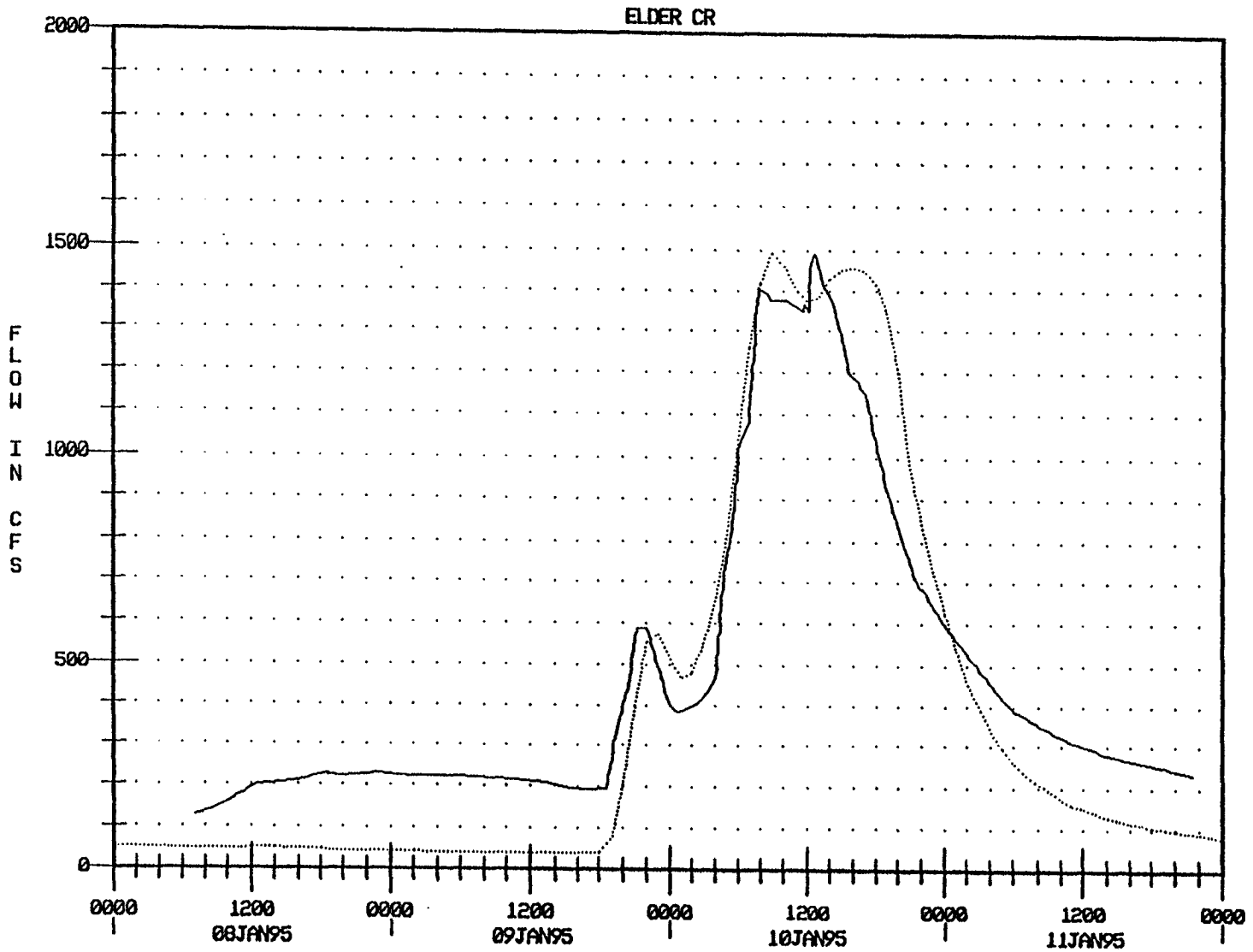


CHART 14 (sheet 3 of 7)

HWY 99 COMPUTED FLOW
STOCKTON BL SENSOR 1735 FLOW

D-003616

D-003616

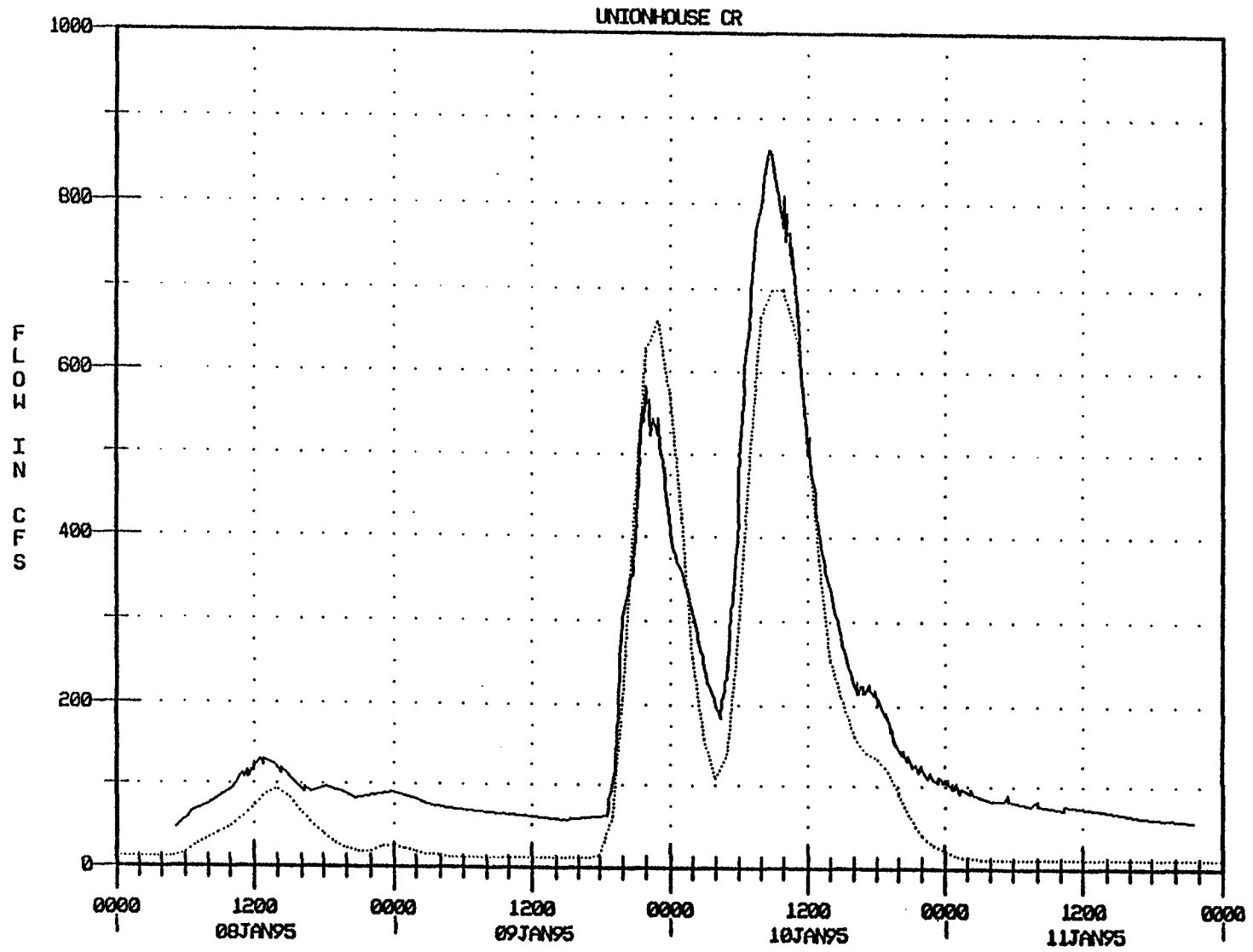


CHART 14 (sheet 4 of 7)

..... ABOVE STRAWBERRY CR COMPUTED FLOW
——— ALPINE SENSOR 1725 FLOW

D-003617

D-003617

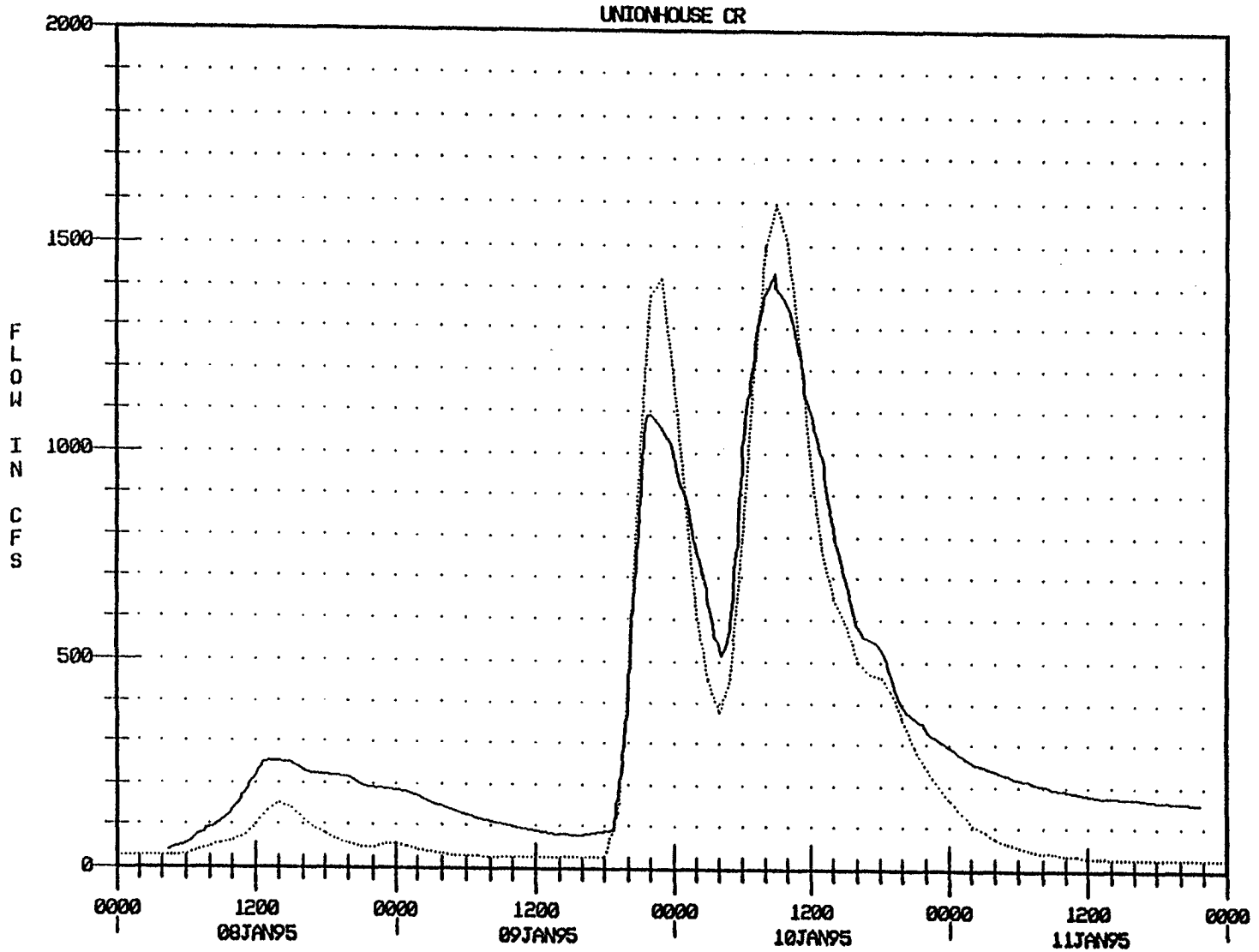


CHART 14 (sheet 5 of 7)

BELOW STRAWBERRY CR COMPUTED FLOW
CRC SENSOR 1722 FLOW

D-003618

D-003618

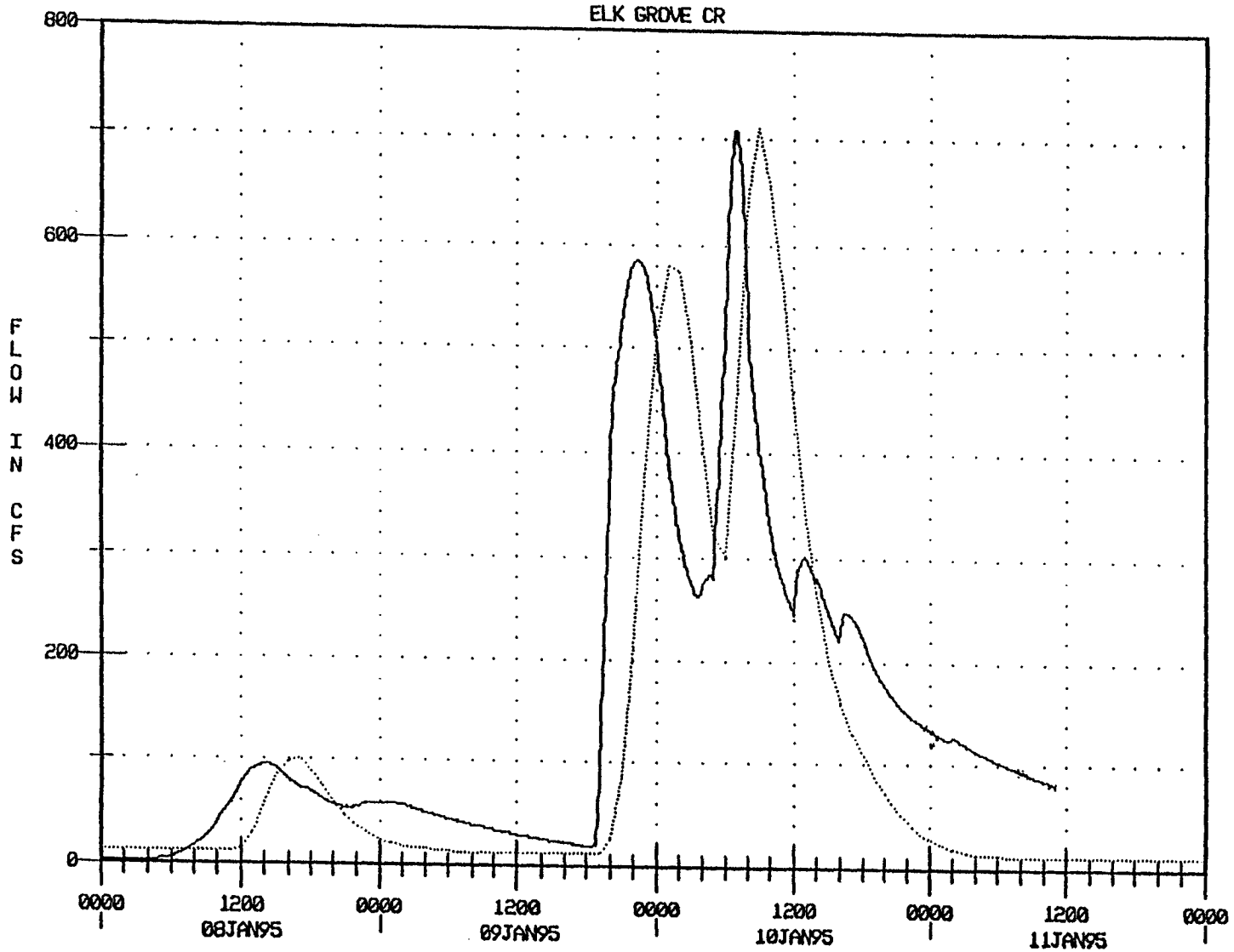


CHART 14 (sheet 6 of 7)

..... ELK GROVE BL COMPUTED FLOW
——— ELK GROVE BL OBS FLOW

D-003619

D-003619

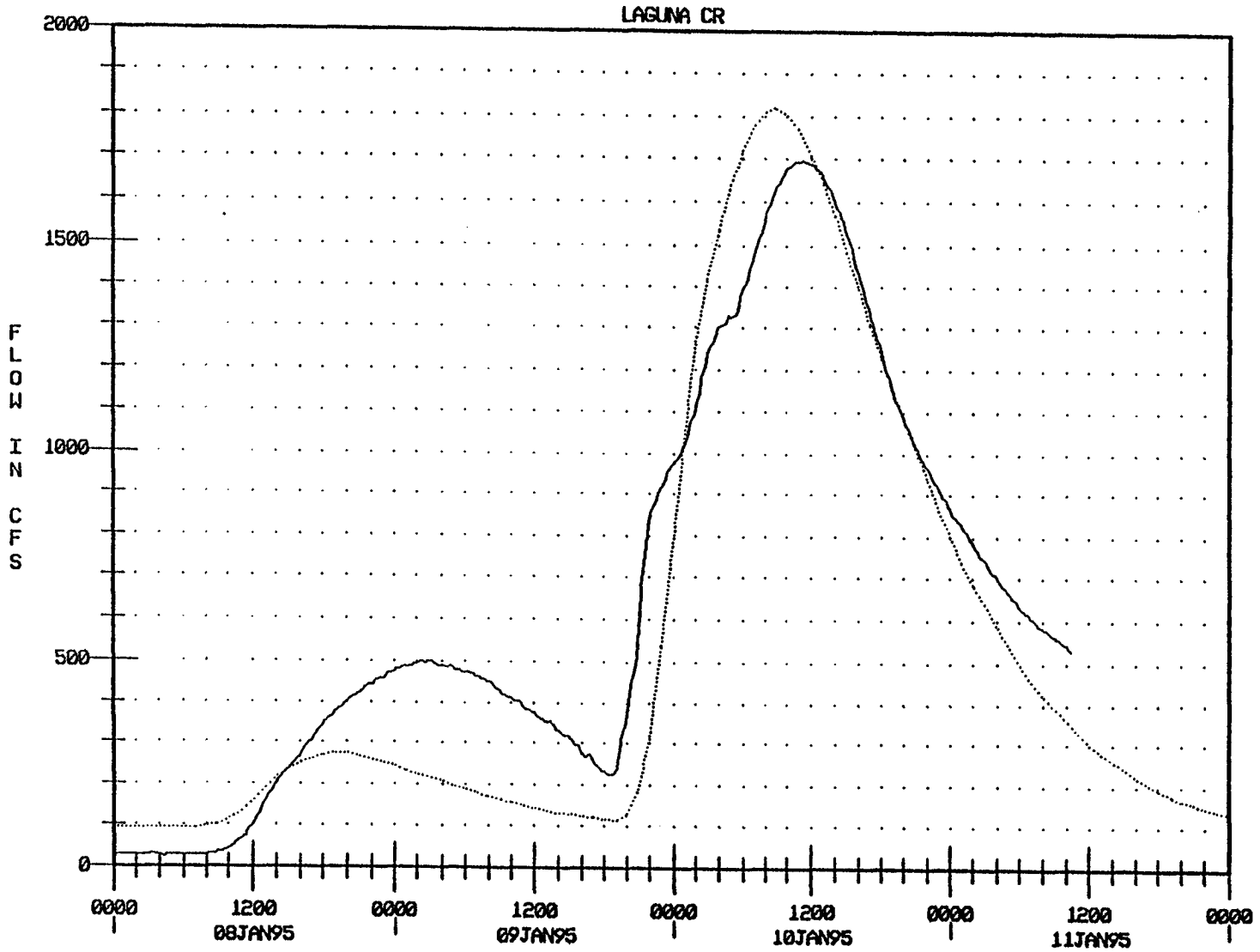
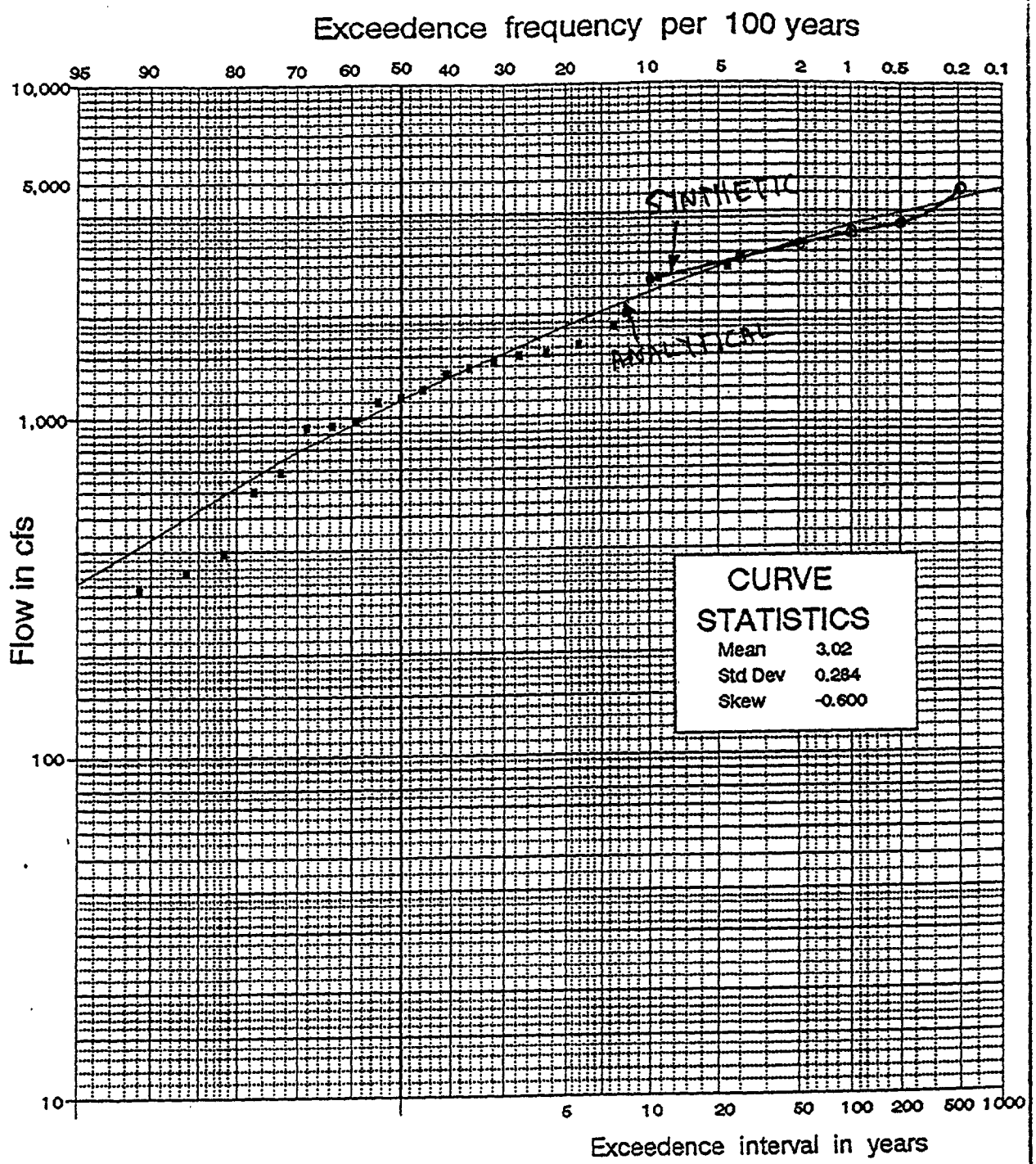


CHART 14 (sheet 7 of 7)

WATERMAN BOND COMPUTED FLOW
WATERMAN BOND OBS FLOW

D-003620

D-003620



SOUTH SACRAMENTO STREAMS

PEAK FREQUENCY CURVE
MORRISON CREEK
NEAR SACRAMENTO
USGS STATION 11336580

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared by: JH Date: SEPT. 1993

Drawn by:JH File : MORPEAK.WQ1

CHART 15

NOTES:

1. Drainage Area: 53.4 square miles.
2. Period of record: 1967-1987.
3. Weibull Formula used for plotting positions.
4. No Expected Probability adjustment was used.

28SEP95 4:29

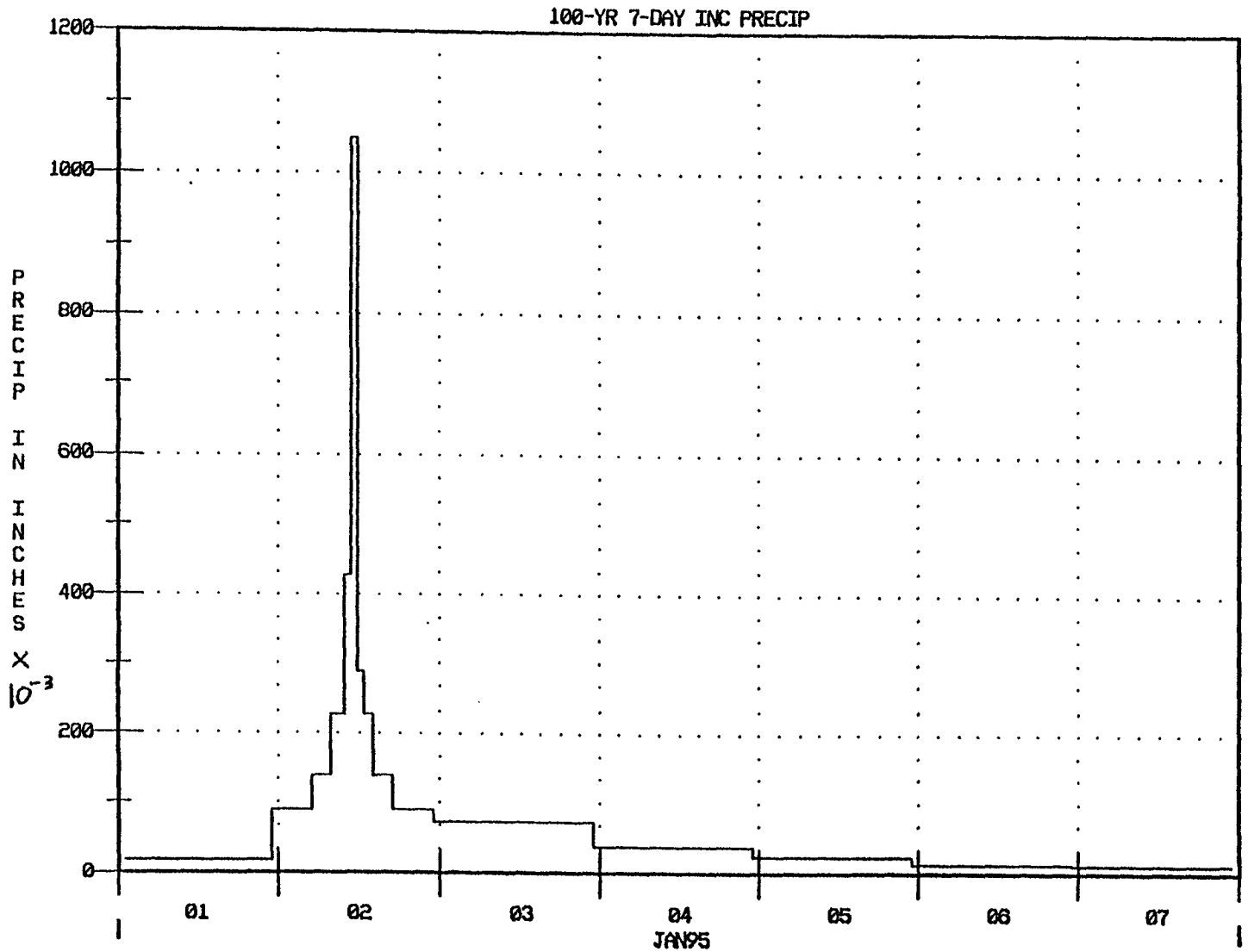


CHART 16

SAC PRECIP

D-003622

D-003622

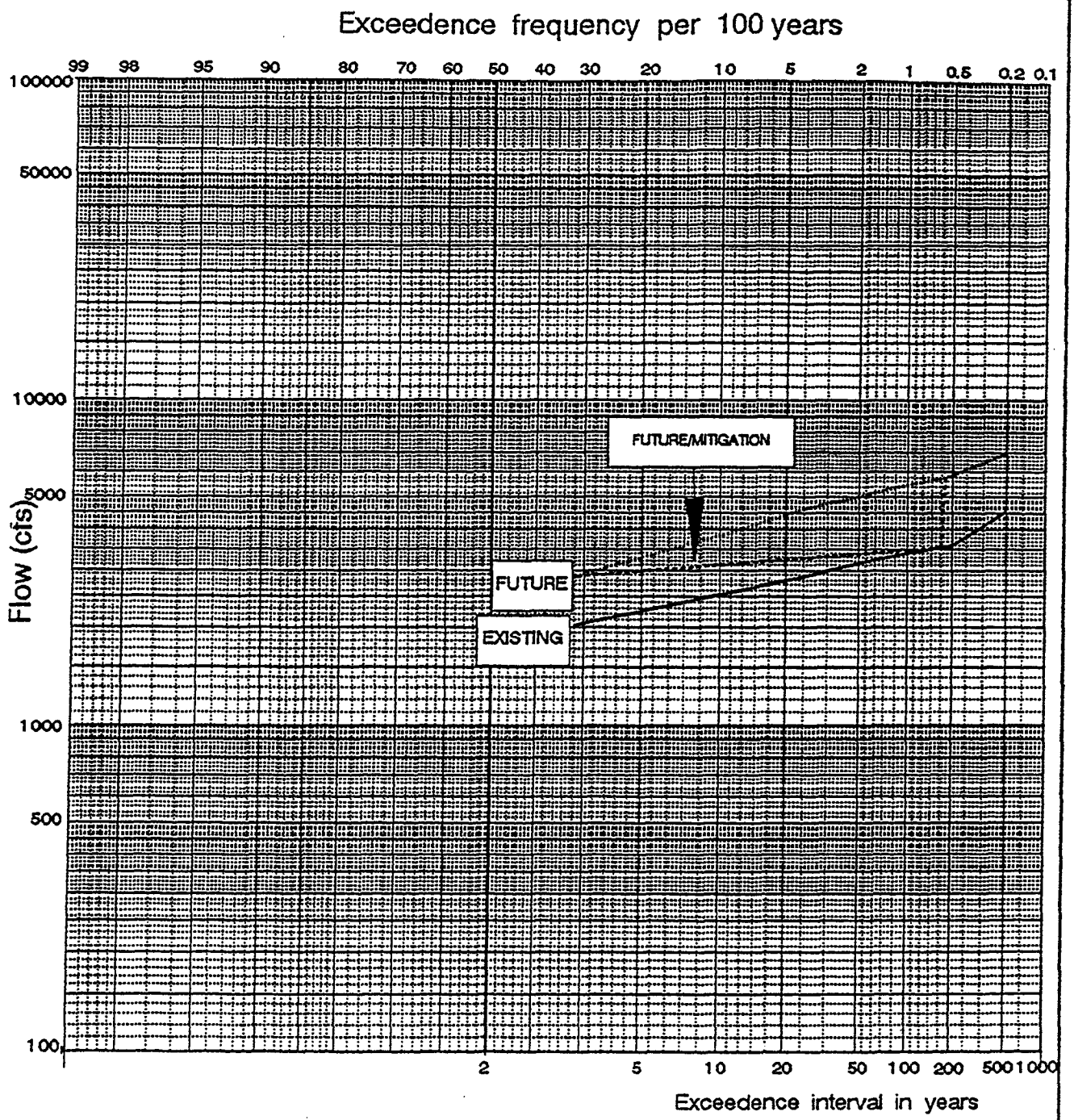


CHART 17 (SHEET 1 OF 7)
MORRISON CREEK AT USGS GAGE
EXISTING AND FUTURE CONDITION FLOW-FREQUENCY CURVES

CORPS OF ENGINEERS, SACRAMENTO DISTRICT
Prepared: BS Date: June 1996

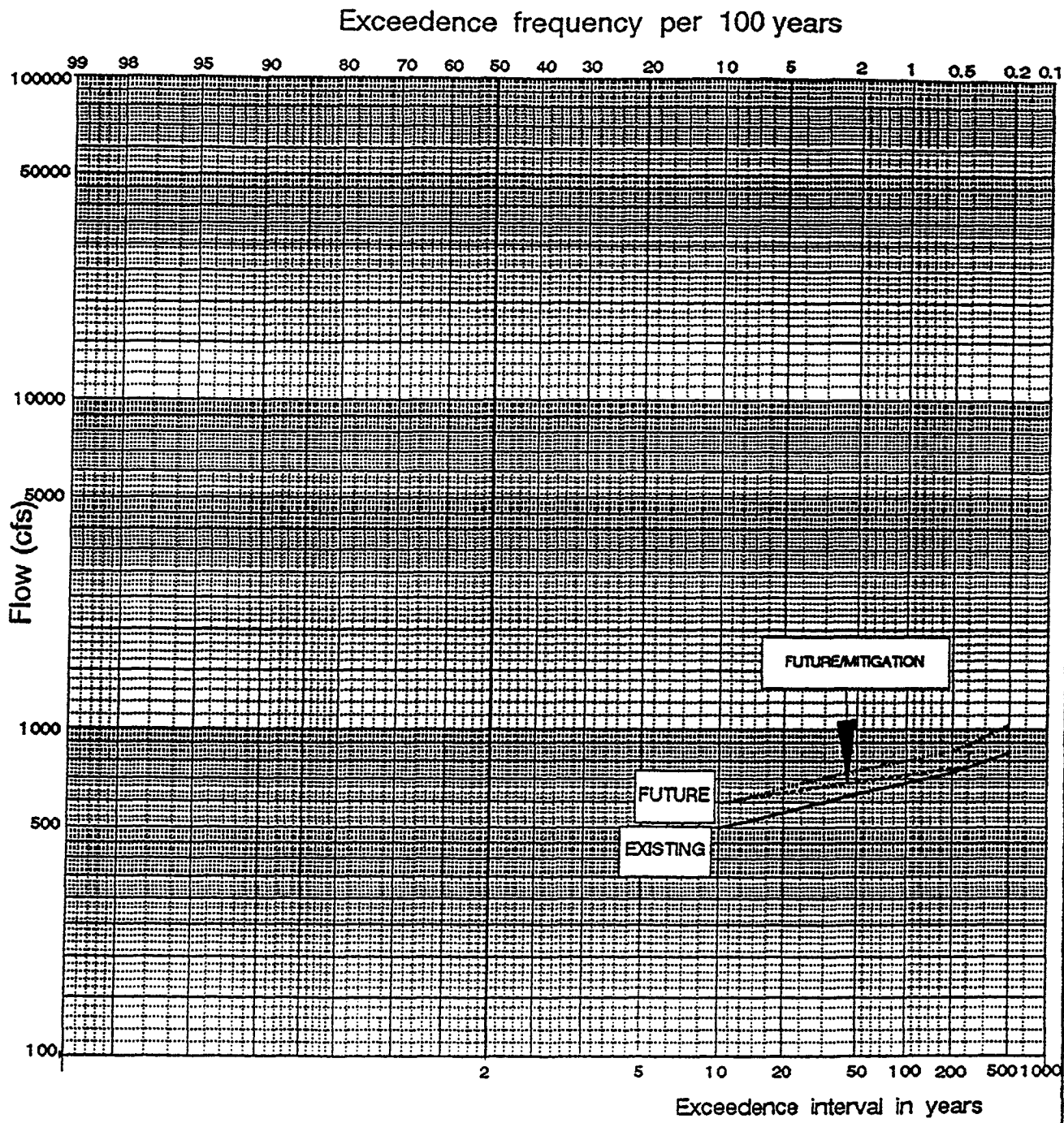


CHART 17 (SHEET 2 OF 7)
FLORIN CREEK AT HIGHWAY 99
EXISTING AND FUTURE CONDITION FLOW-FREQUENCY CURVES

CORPS OF ENGINEERS, SACRAMENTO DISTRICT
Prepared: BS Date: June 1996

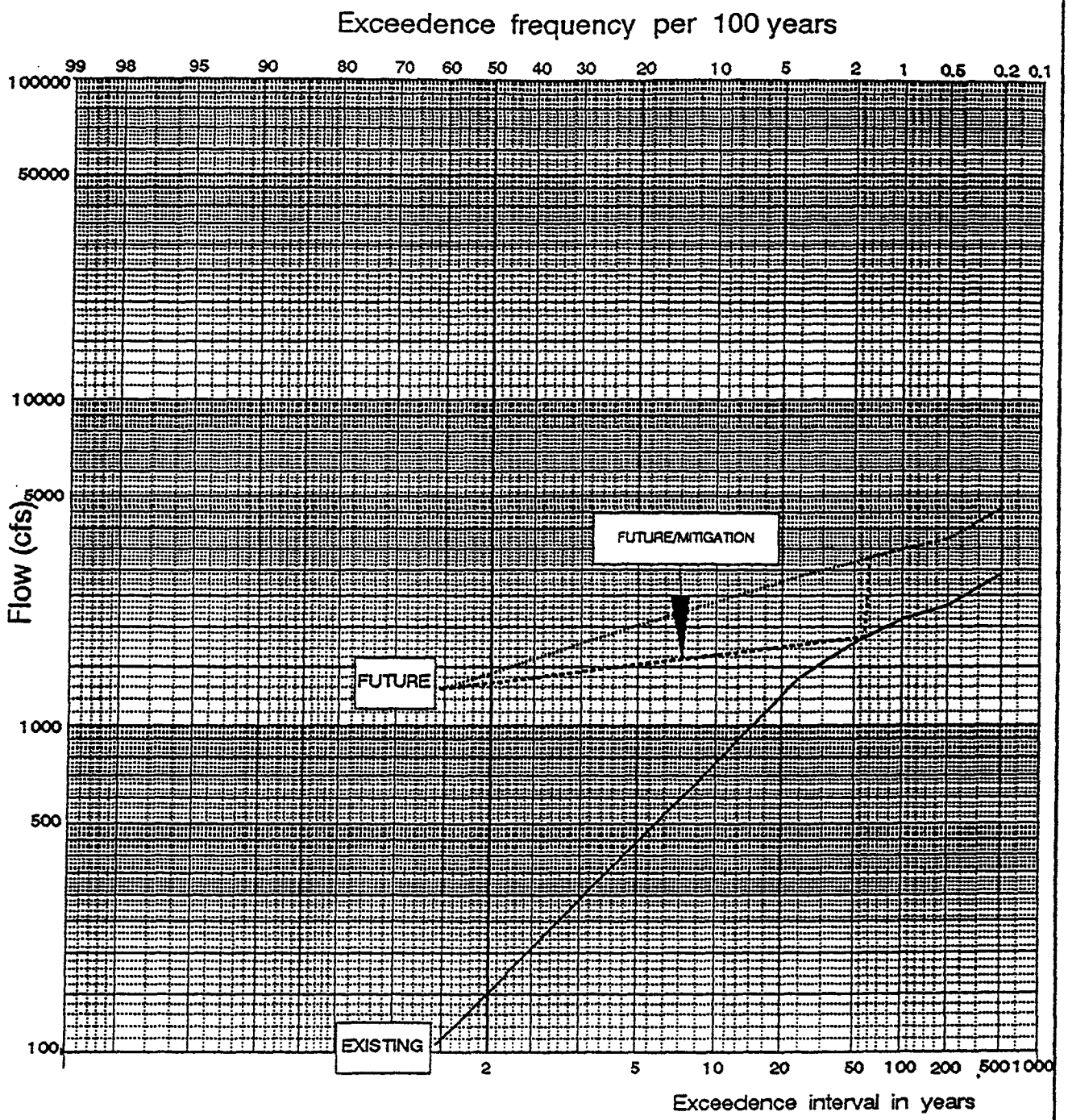


CHART 17 (SHEET 3 OF 7)
ELDER CREEK AT HIGHWAY 99
EXISTING AND FUTURE CONDITION FLOW-FREQUENCY CURVES

CORPS OF ENGINEERS, SACRAMENTO DISTRICT
Prepared: BS Date: June 1996

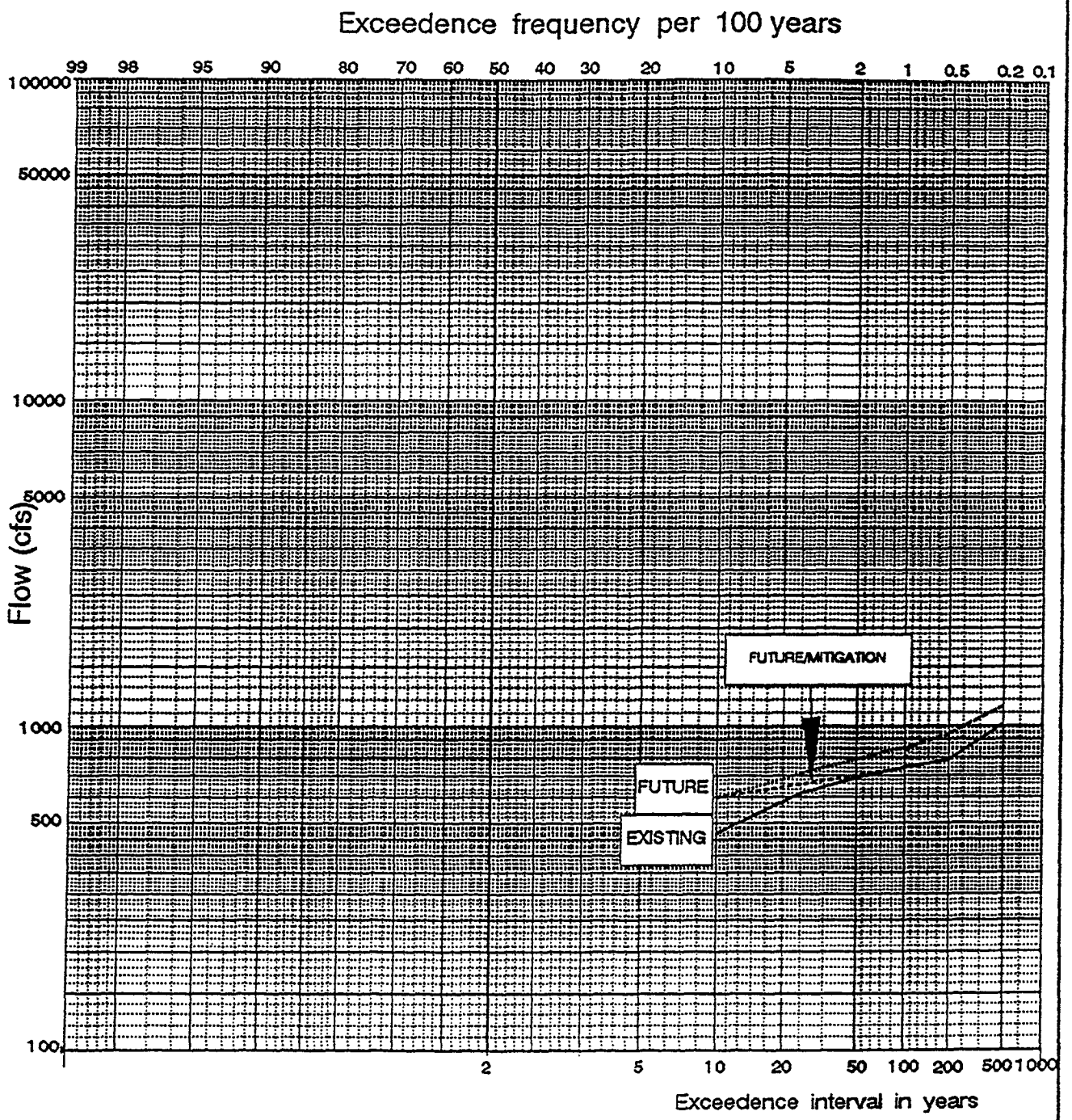


CHART 17 (SHEET 4 OF 7)
UNIONHOUSE CREEK AT HIGHWAY 99
EXISTING AND FUTURE CONDITION FLOW-FREQUENCY CURVES

CORPS OF ENGINEERS, SACRAMENTO DISTRICT
Prepared: BS Date: June 1996

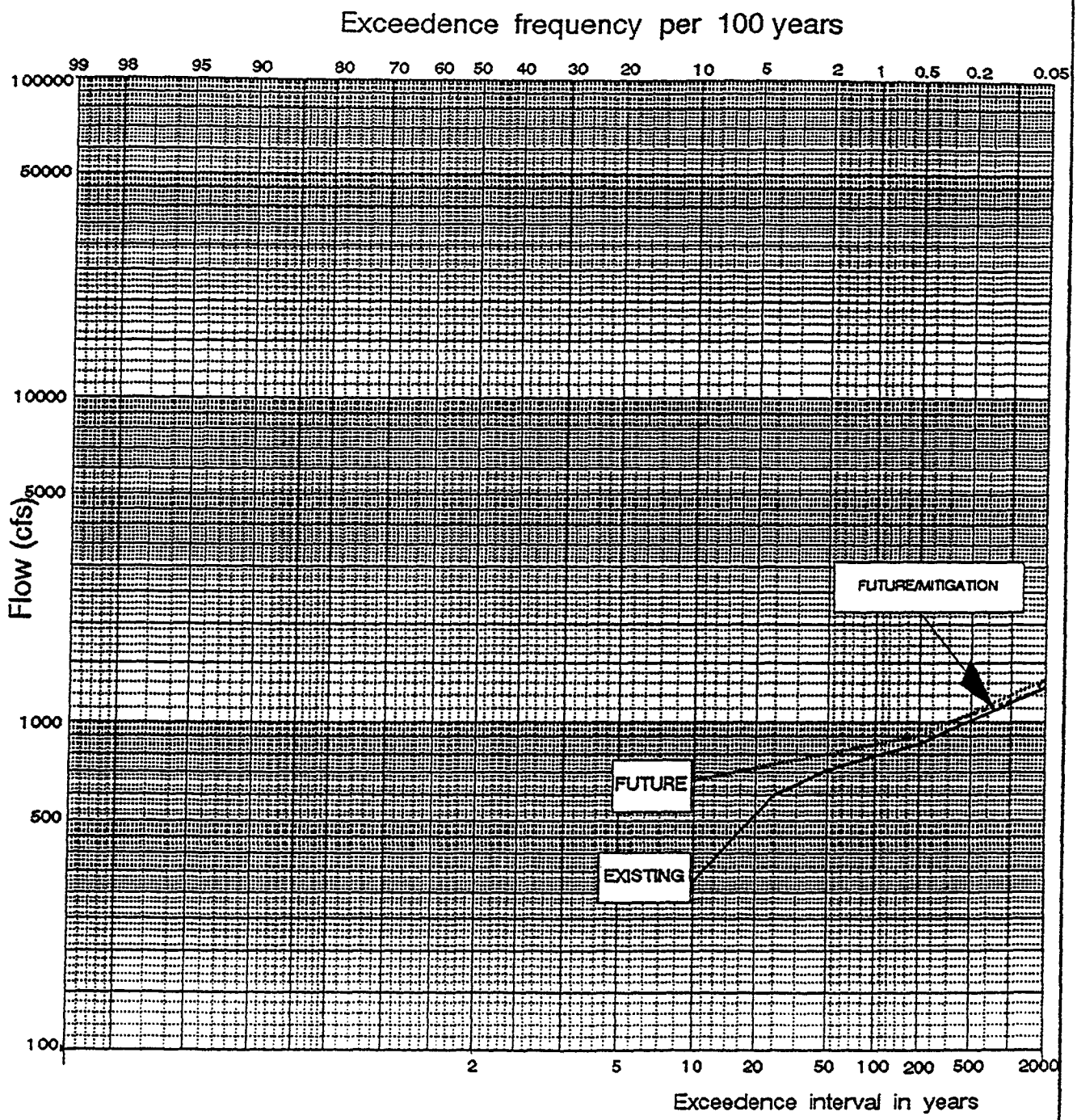


CHART 17 (SHEET 5 OF 7)
STRAWBERRY CREEK AT HIGHWAY 99
EXISTING AND FUTURE CONDITION FLOW-FREQUENCY CURVES

CORPS OF ENGINEERS, SACRAMENTO DISTRICT
Prepared: BS Date: June 1996

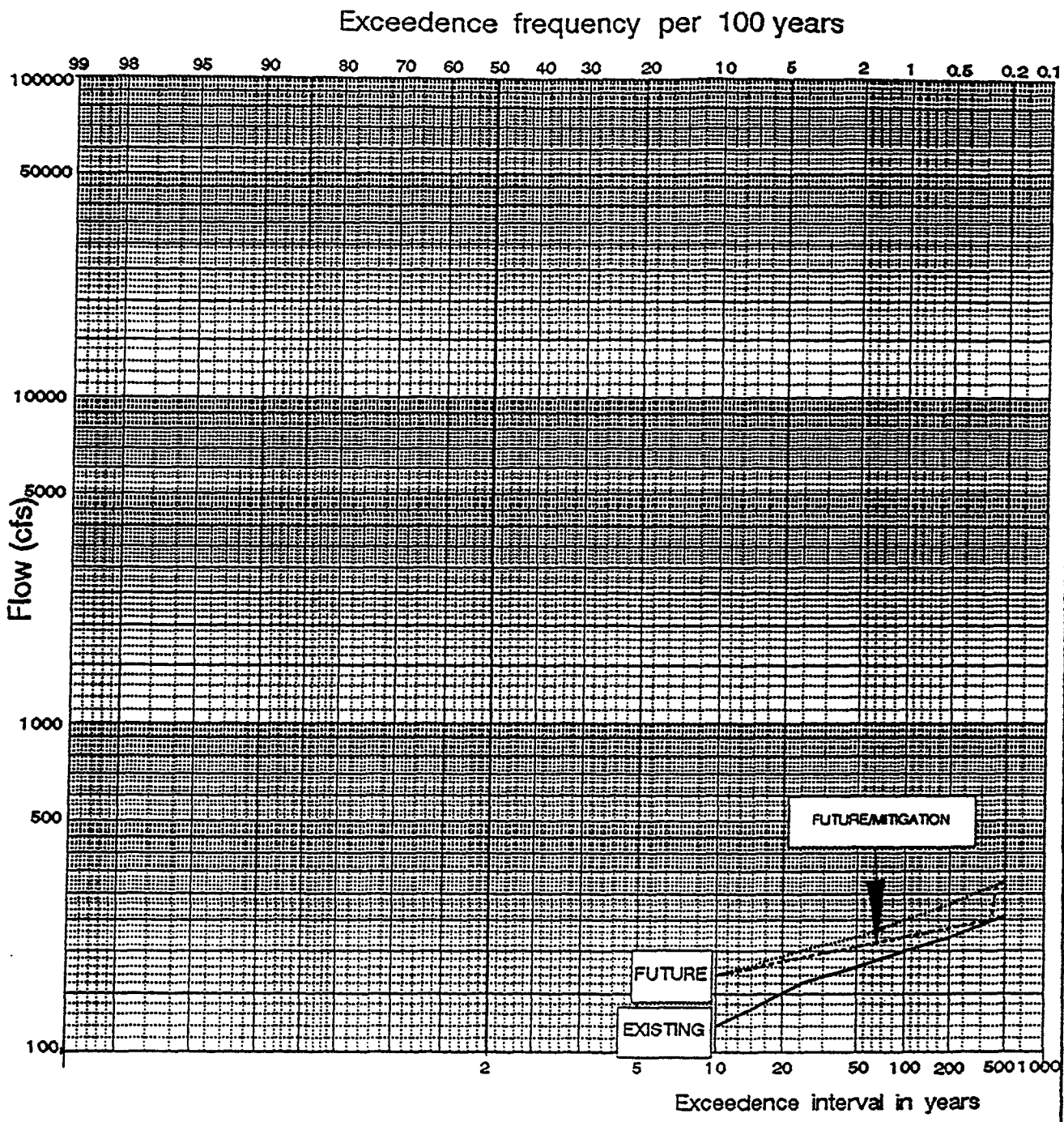


CHART 17 (SHEET 6 OF 7)
JACINTO CREEK AT MOUTH
EXISTING AND FUTURE CONDITION FLOW-FREQUENCY CURVES

CORPS OF ENGINEERS, SACRAMENTO DISTRICT
Prepared: BS Date: June 1996

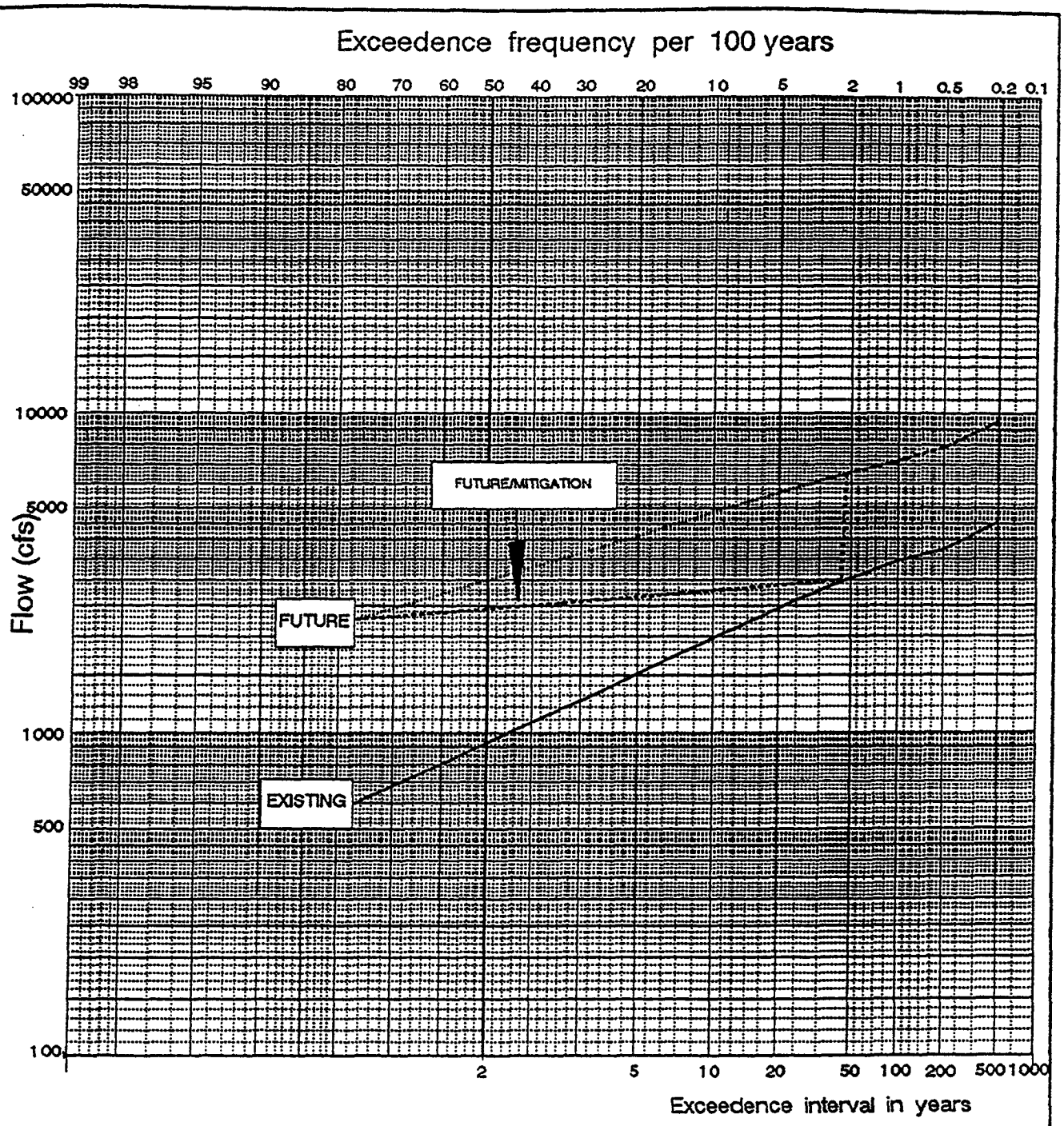
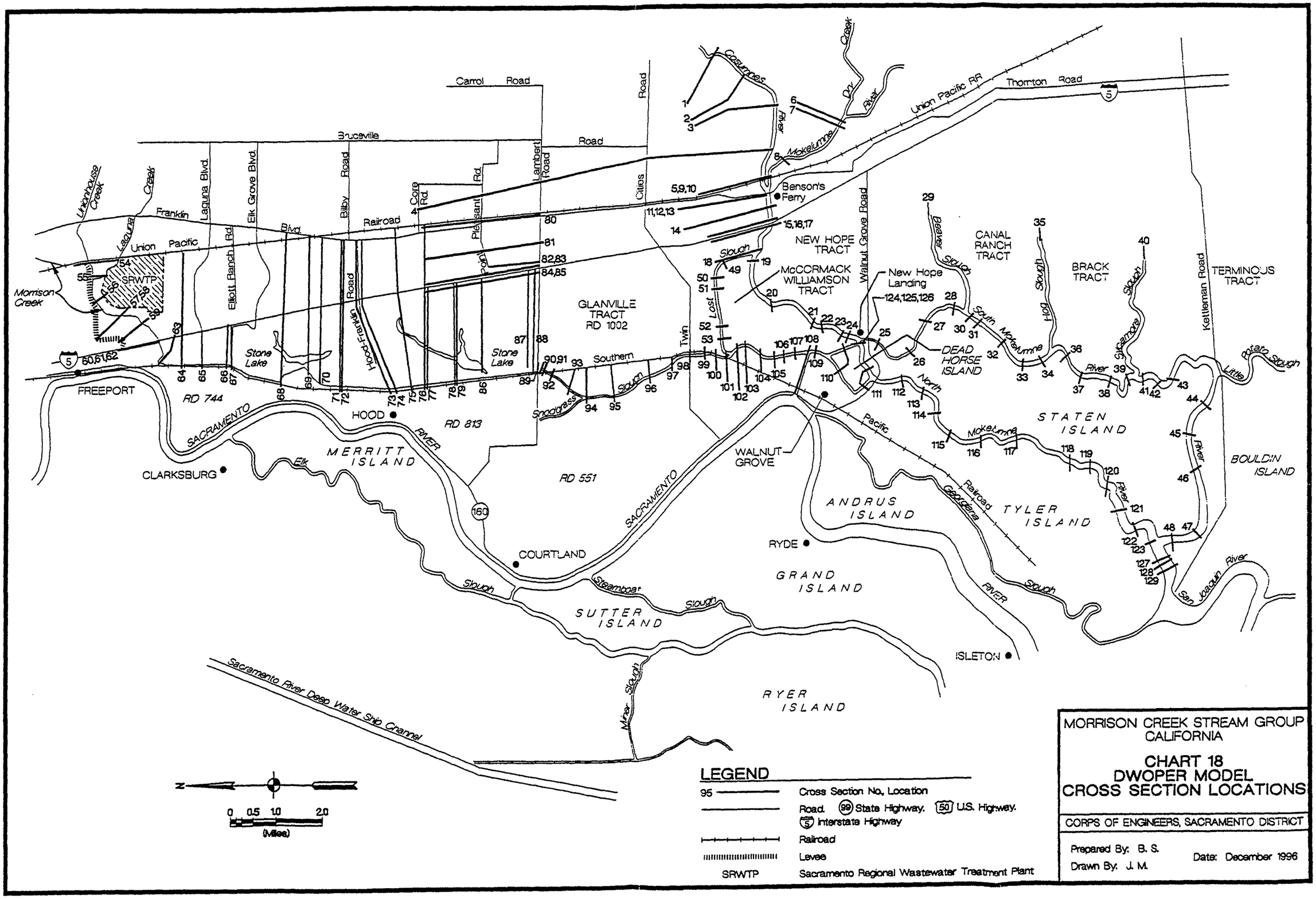


CHART 17 (SHEET 7 OF 7)
LAGUNA CREEK BELOW ELK GROVE CREEK
EXISTING AND FUTURE CONDITION FLOW-FREQUENCY CURVES

CORPS OF ENGINEERS, SACRAMENTO DISTRICT
Prepared: BS Date: June 1996



D-003630

D-003630

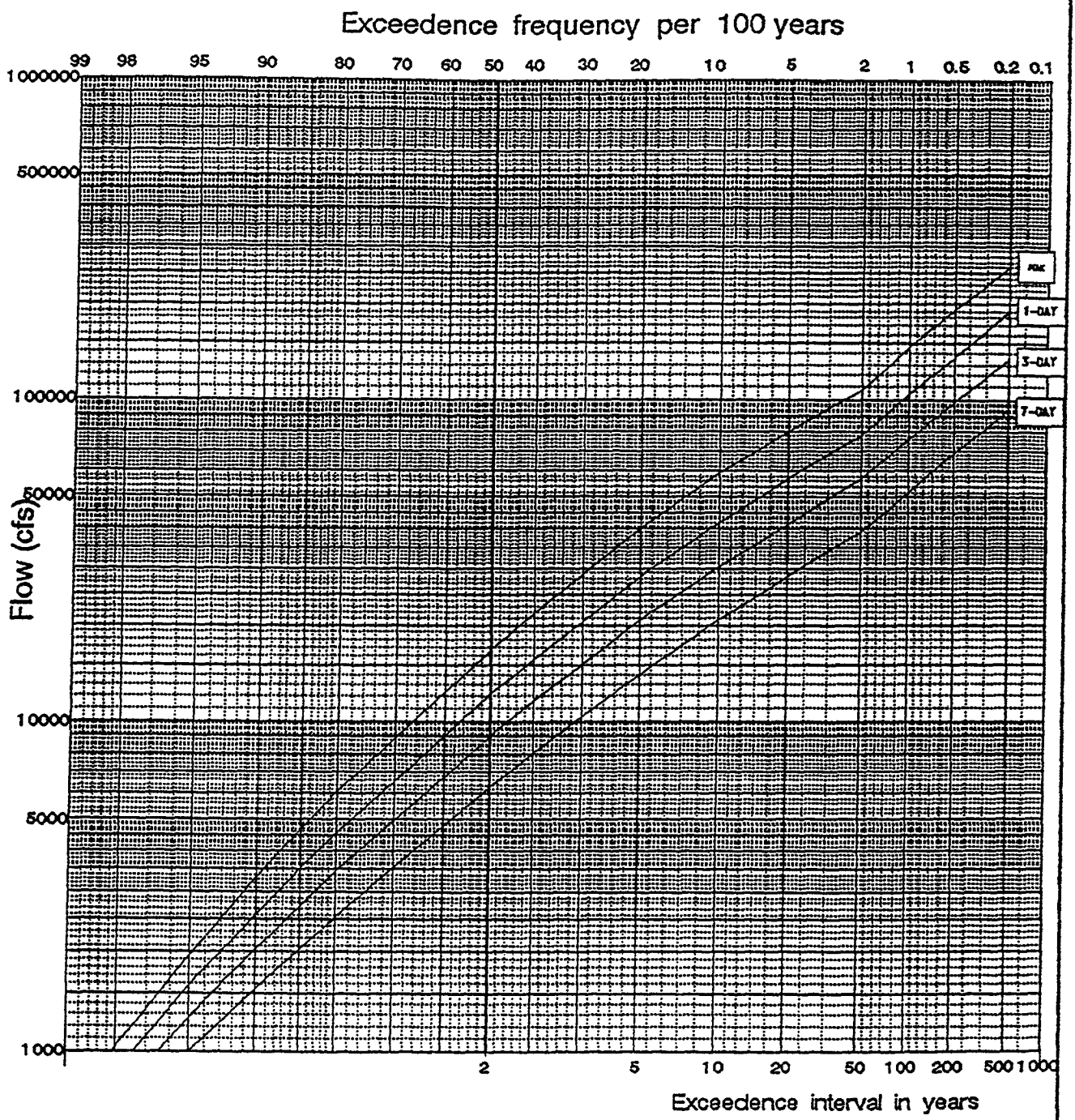


CHART 19
DELTA FLOW-FREQUENCY CURVES

CORPS OF ENGINEERS, SACRAMENTO DISTRICT
Prepared: BS Date: July 1995

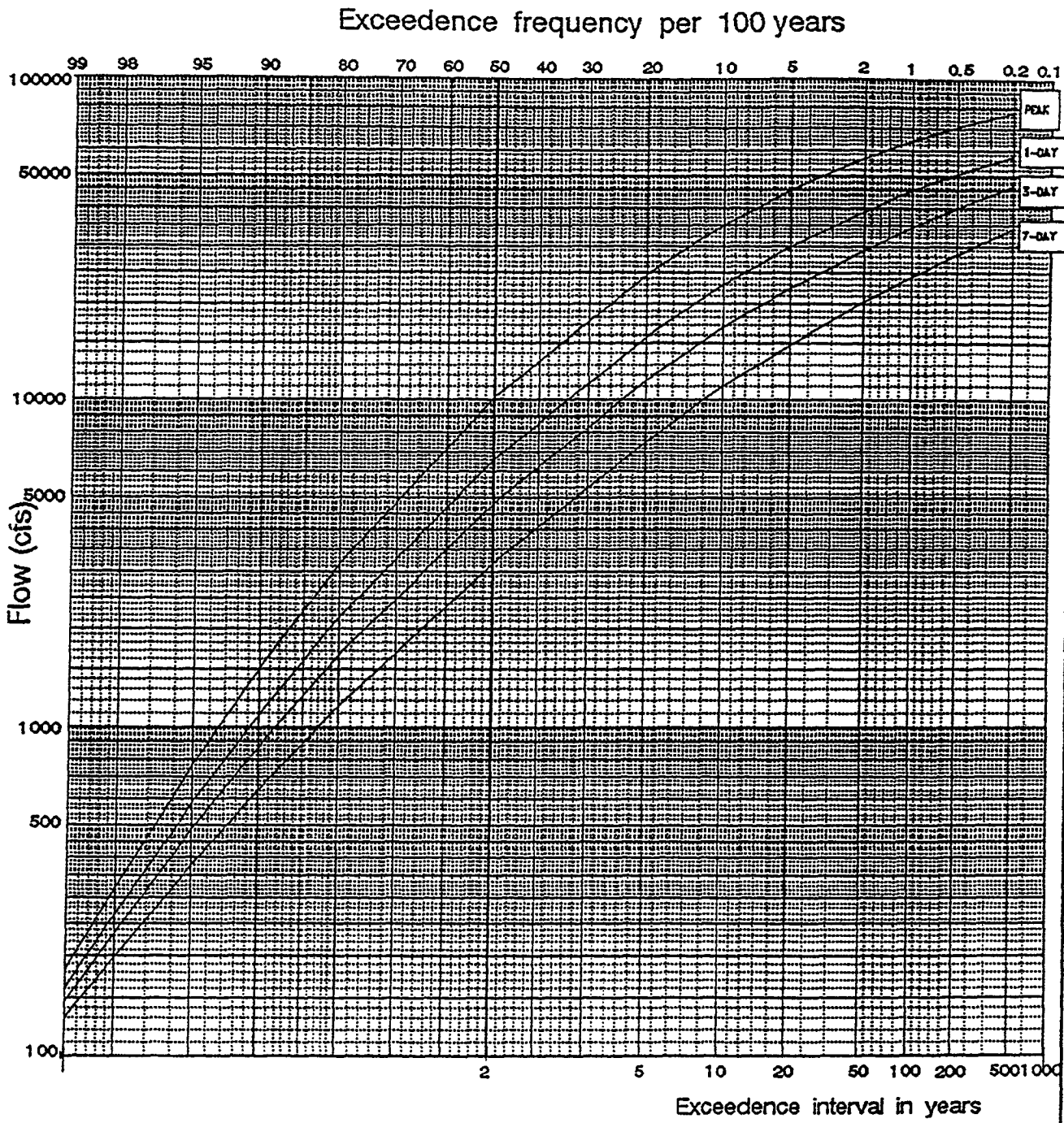


CHART 20
COSUMNES RIVER AT MICHIGAN BAR
FLOW-FREQUENCY CURVES

CORPS OF ENGINEERS, SACRAMENTO DISTRICT
Prepared: BS Date: August 1995

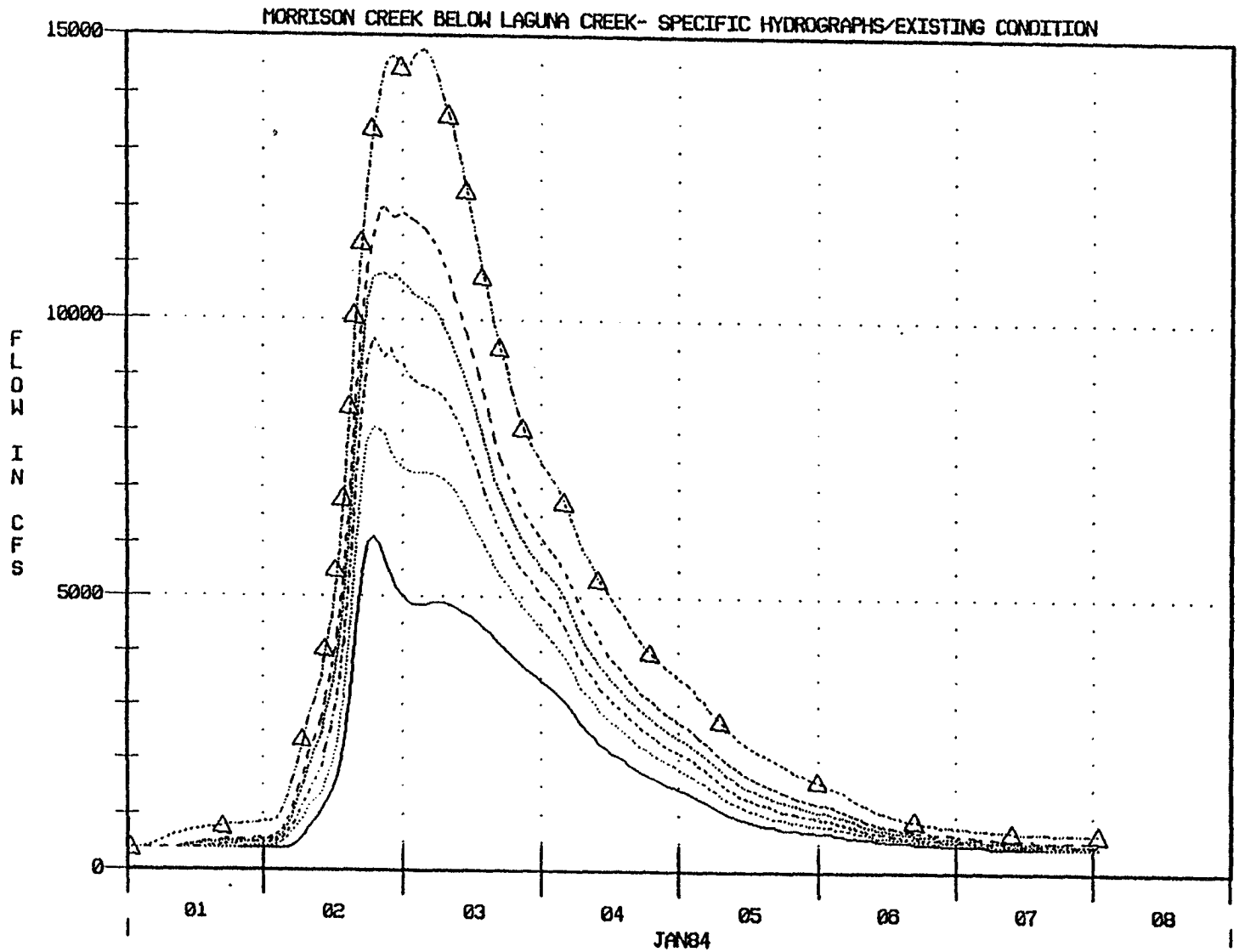


CHART 21 (sheet 1 of 5)

10YR
25YR
50YR
100YR
200YR
500YR

D-003633

D-003633

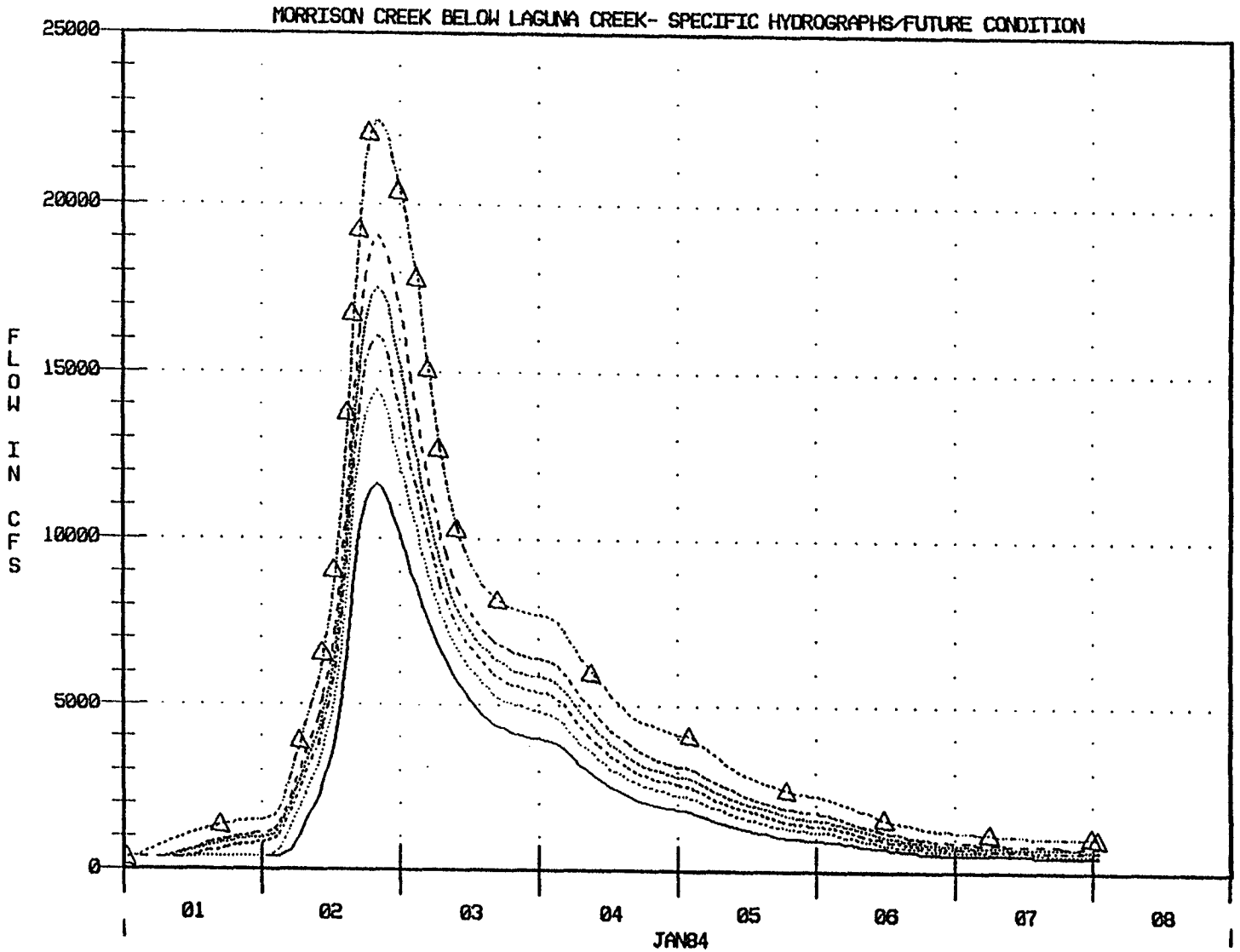


CHART 21 (sheet 2 of 5)

10YR
25YR
50YR
100YR
200YR
500YR

D-003634

D-003634

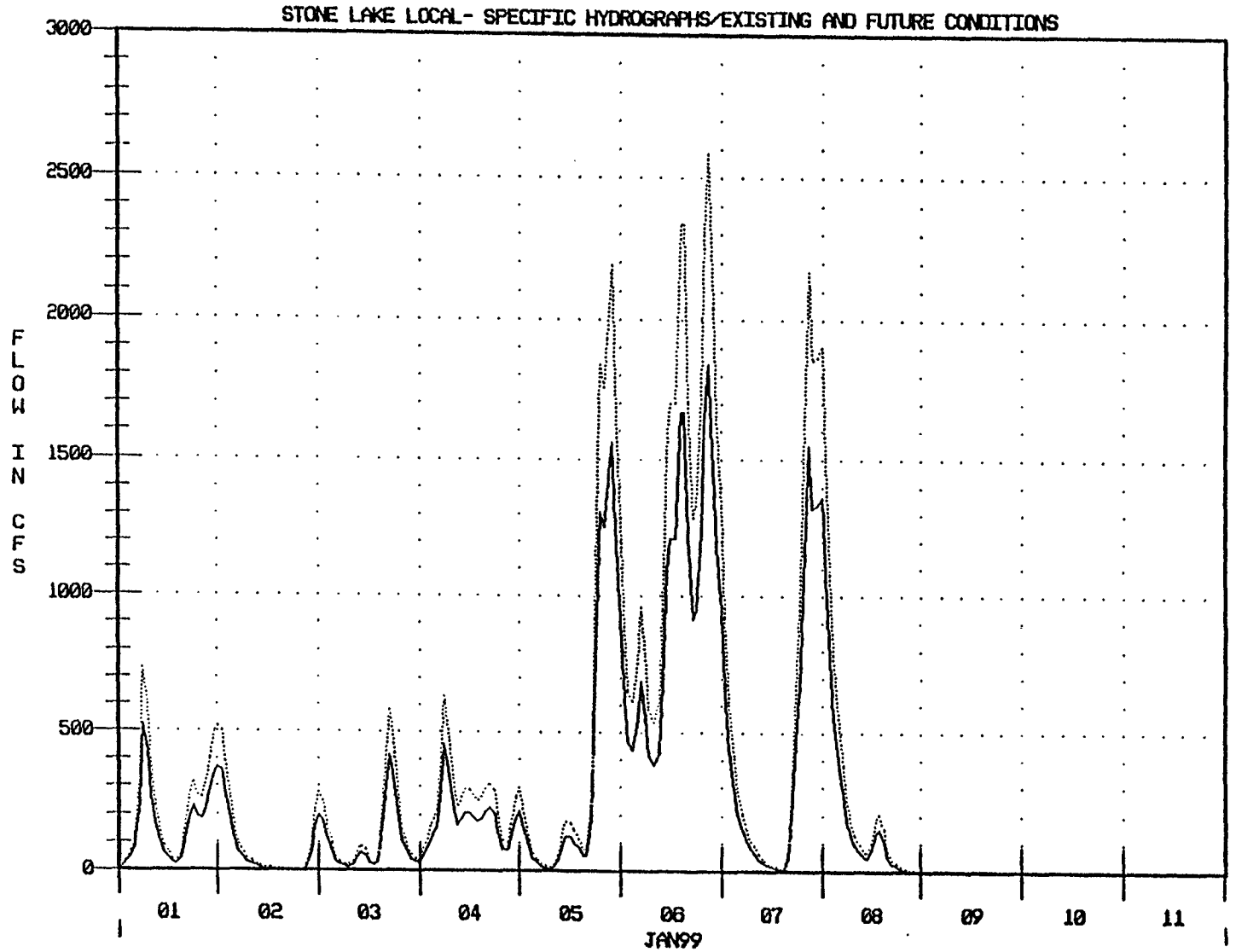


CHART 21 (sheet 3 of 5)

——————— 10YR, 25YR, 50YR, 100YR
..... 200YR, 500YR

D-003635

D—003635

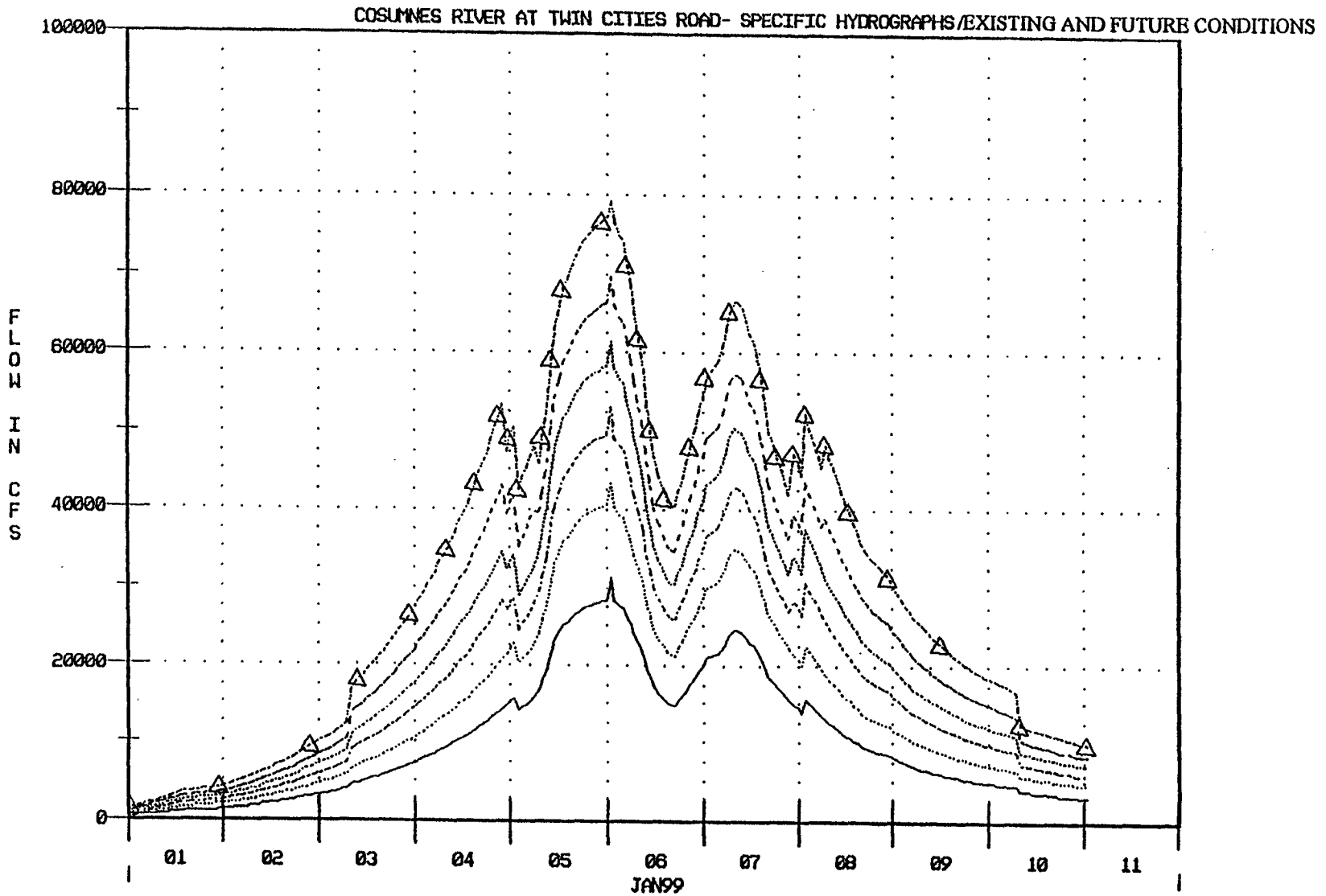


CHART 21 (sheet 4 of 5)

10YR
25YR
50YR
100YR
200YR
500YR

D-003636

D-003636

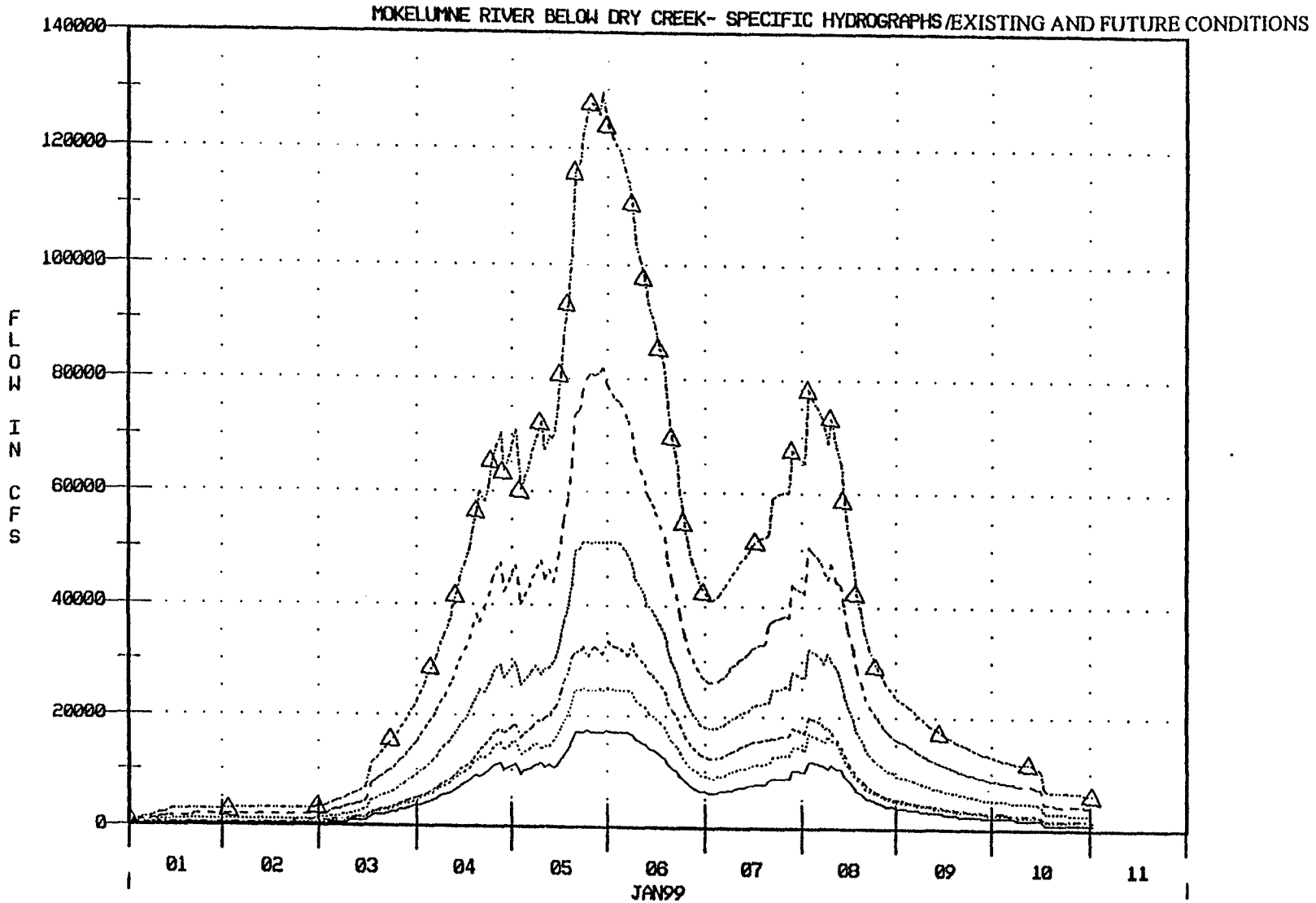


CHART 21 (sheet 5 of 5)

10YR
25YR
50YR
100YR
200YR
500YR

D-003637

D-003637

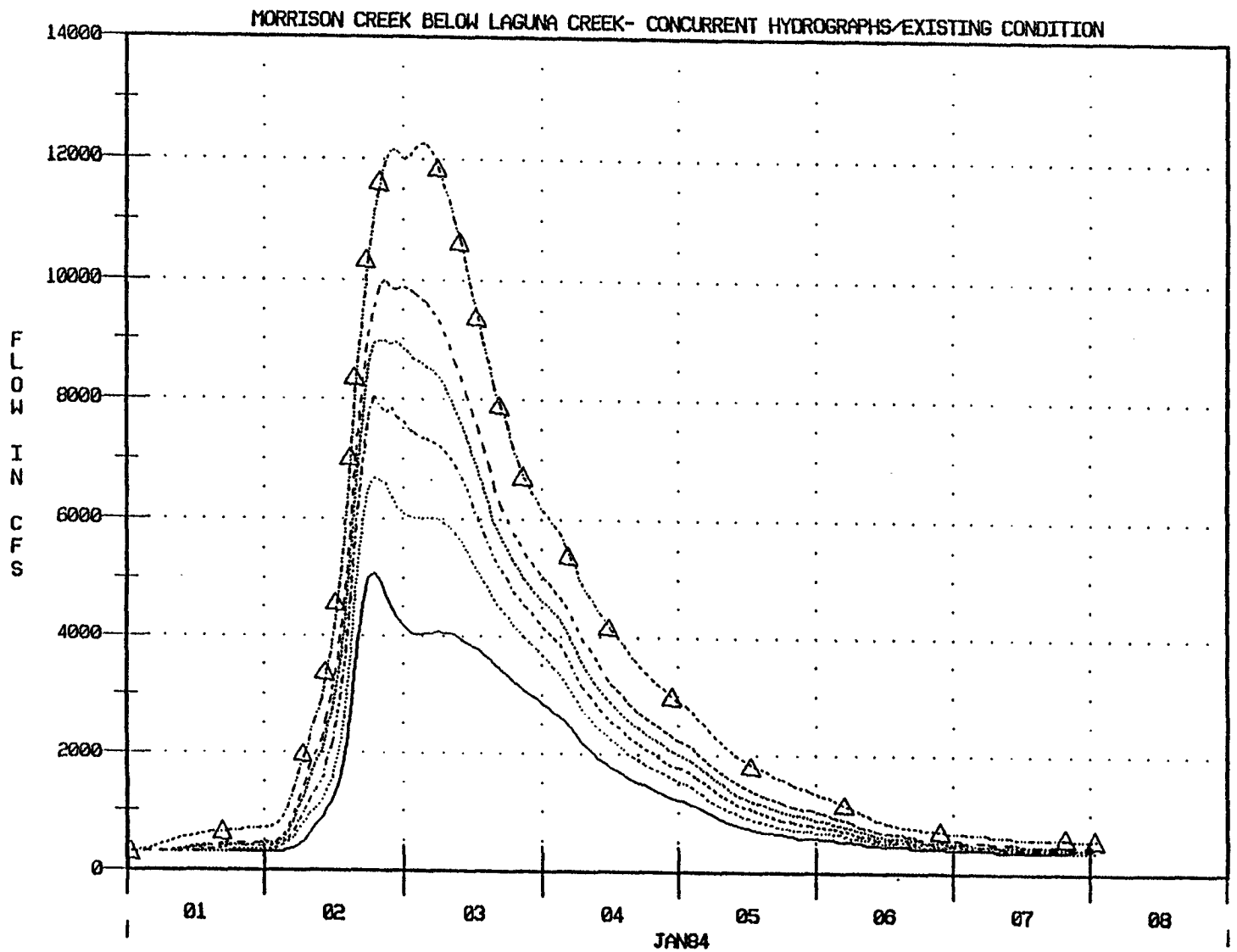


CHART 22 (sheet 1 of 5)

10YR
25YR
50YR
100YR
200YR
500YR

D-003638

D-003638

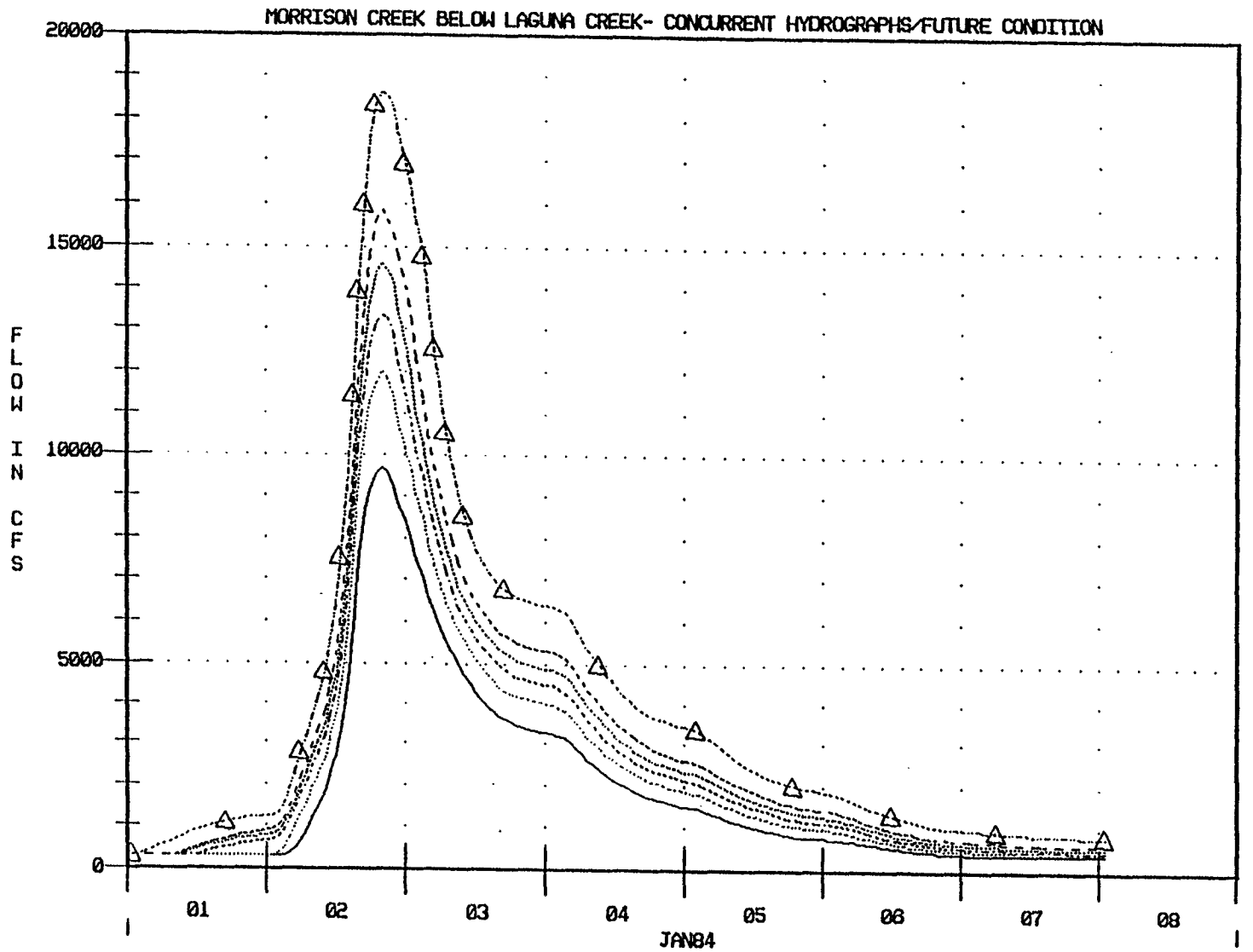


CHART 22 (sheet 2 of 5)

10YR
25YR
50YR
100YR
200YR
500YR

D-003639

D-003639

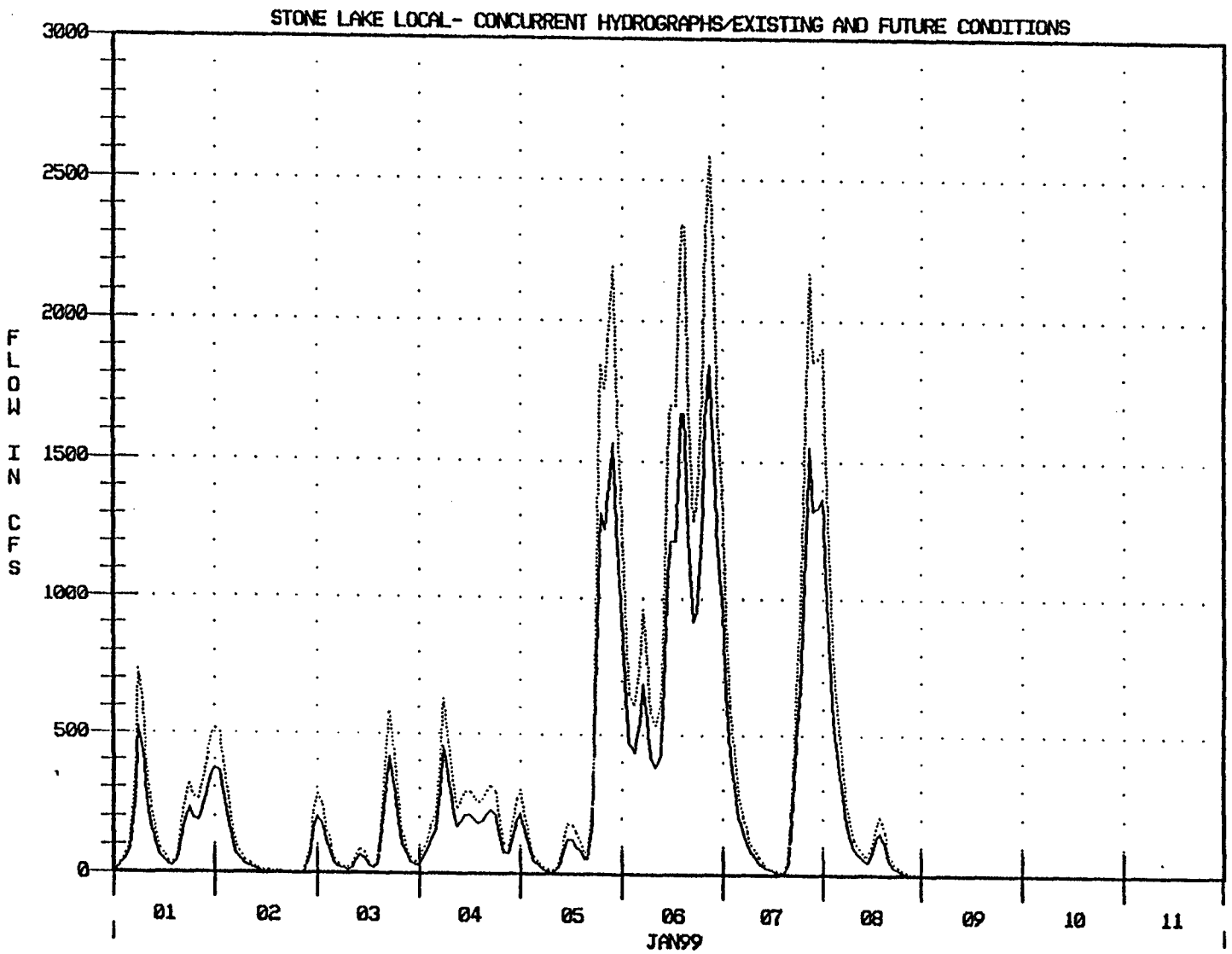


CHART 22 (sheet 3 of 5)

——————— 10YR, 25YR, 50YR, 100YR
..... 200YR, 500YR

D-003640

D-003640

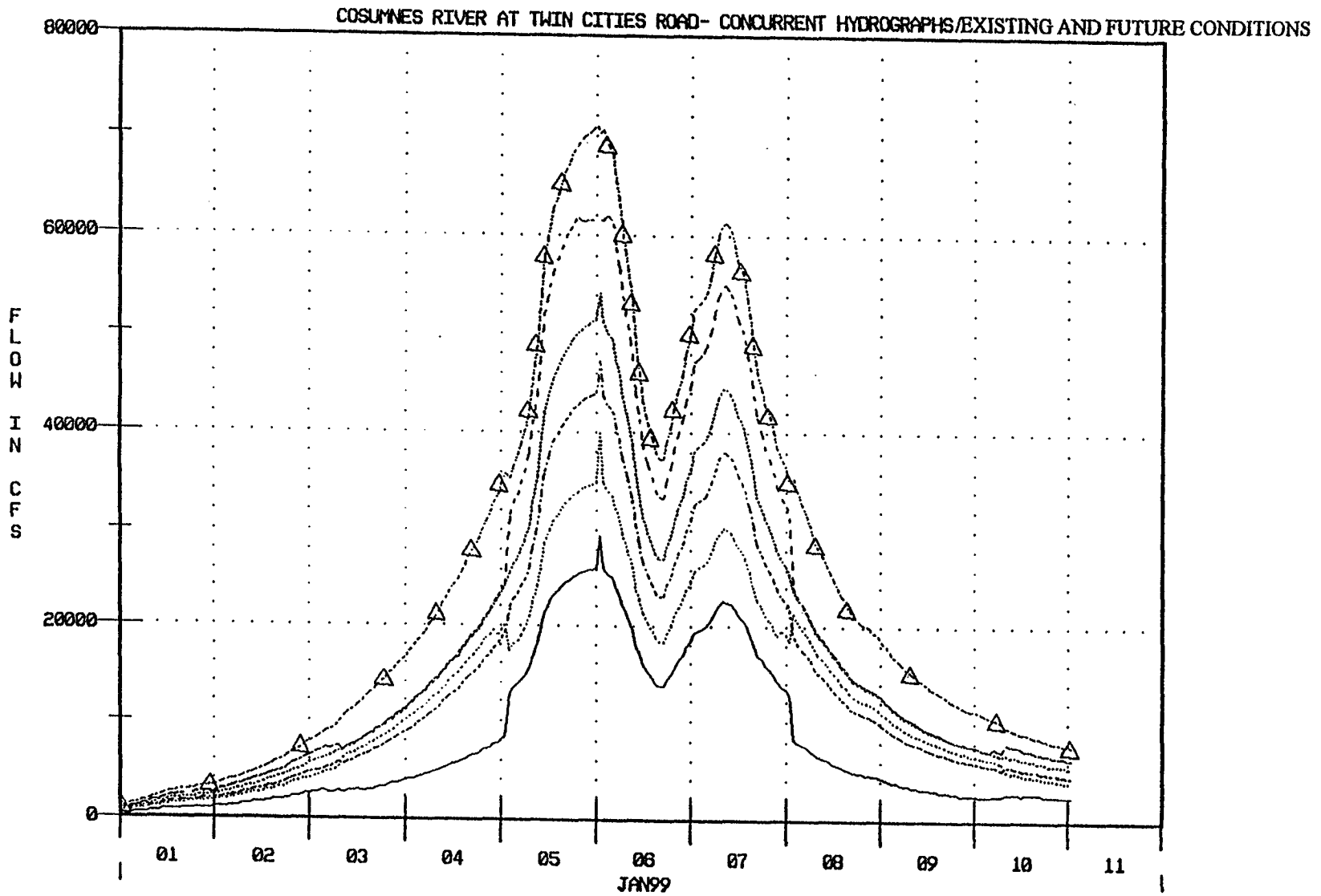


CHART 22 (sheet 4 of 5)

10YR
25YR
50YR
100YR
200YR
500YR

D-003641

D-003641

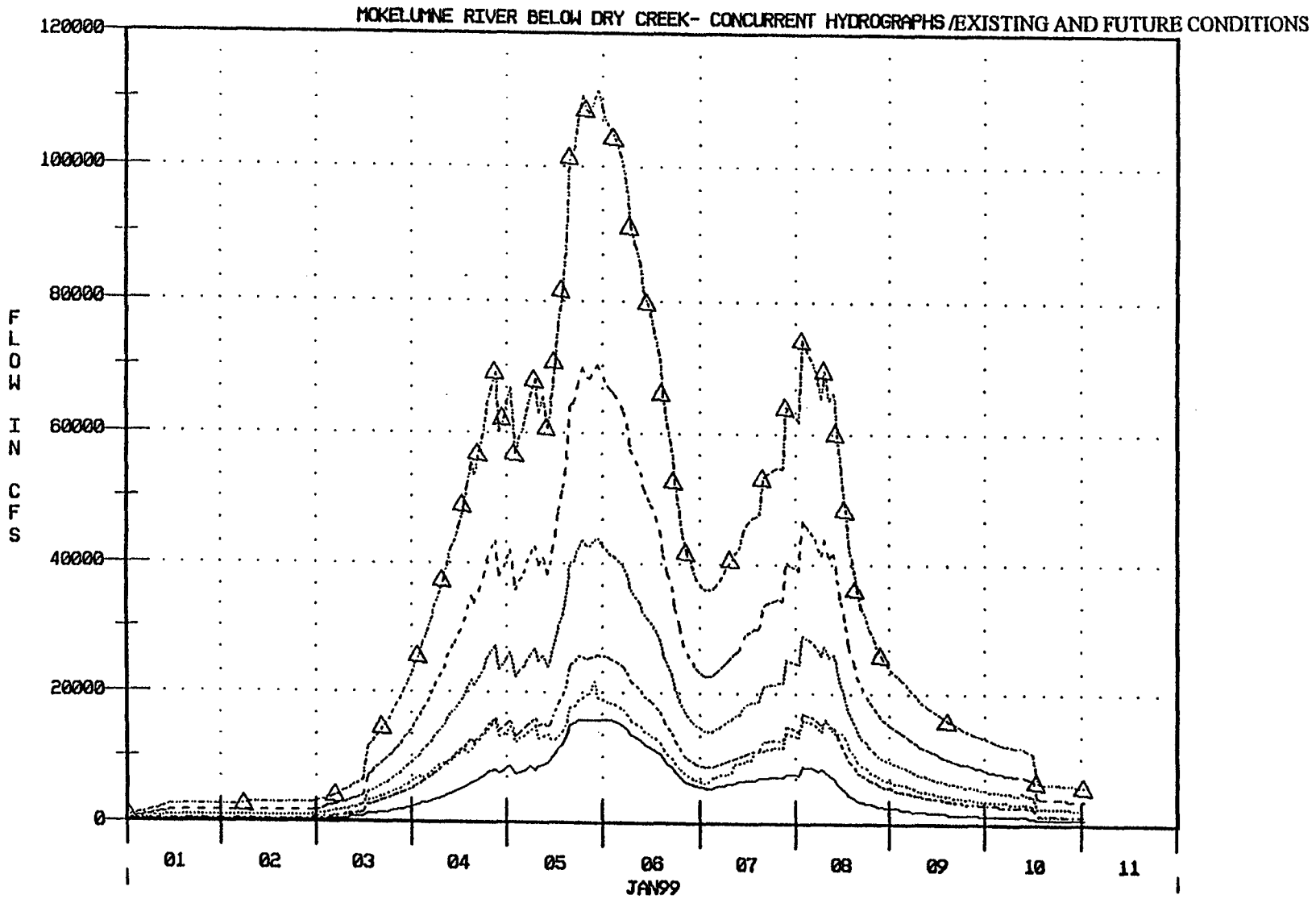
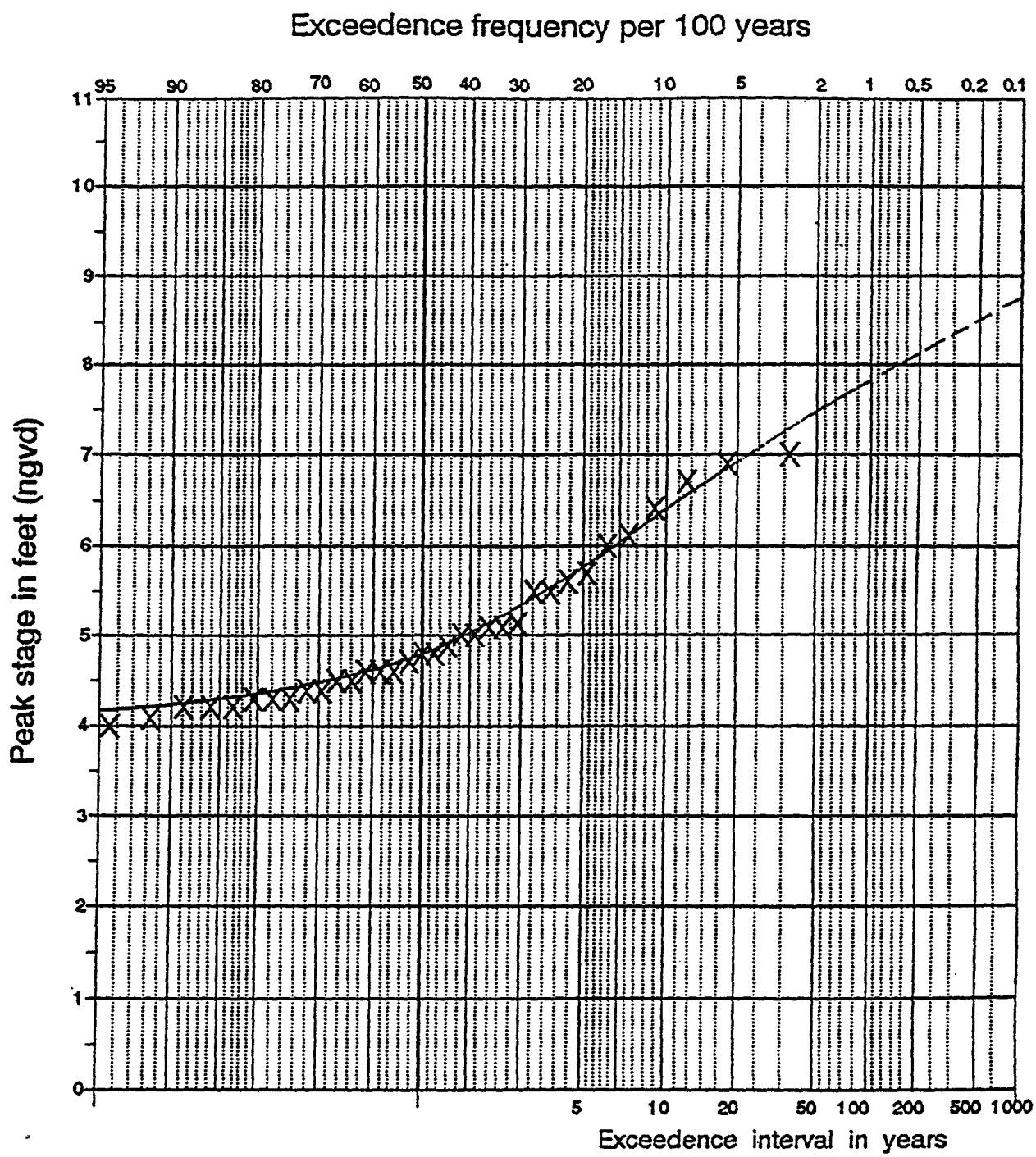


CHART 22 (sheet 5 of 5)

10YR
25YR
50YR
100YR
200YR
500YR

D-003642

D-003642



NOTES:

PLOTTED POINTS ARE ANNUAL PEAK STAGES
CURVE PLOTTED GRAPHICALLY
PERIOD OF RECORD 1945-1988
MISSING DATA 1953 AND 1966-1973
POINTS BEYOND 95% EXCEEDENCE FREQUENCY NOT SHOWN
PLOTTED POINTS REPRESENT 35 YEARS OF DATA

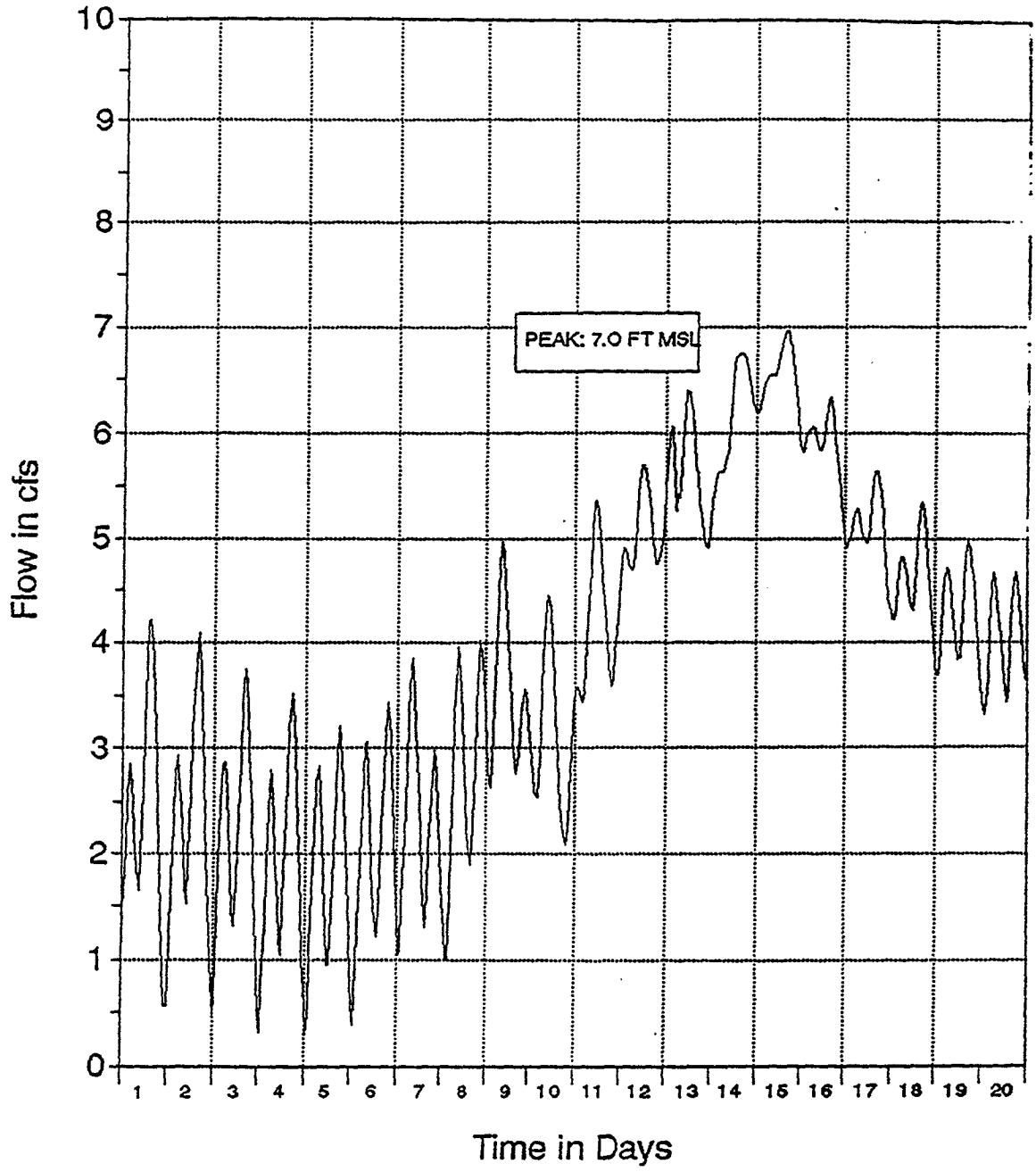
SACRAMENTO - SAN JOAQUIN DELTA

STAGE FREQUENCY CURVE
GEORGIANA SLOUGH AT
MOKELUMNE RIVER

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: February 1992

CHART 23



NOTE:
Starting time of this hydrograph is February 7th at 1:00 am.

SOUTH SACRAMENTO STREAMS

1986 STAGE HYDROGRAPH GEORGIANA SLOUGH AT MOKELUMNE RIVER

Prepared: J.H. Date: SEPT. 1993
Drawn: J.H. GEORGE.WQ1

CHART 24

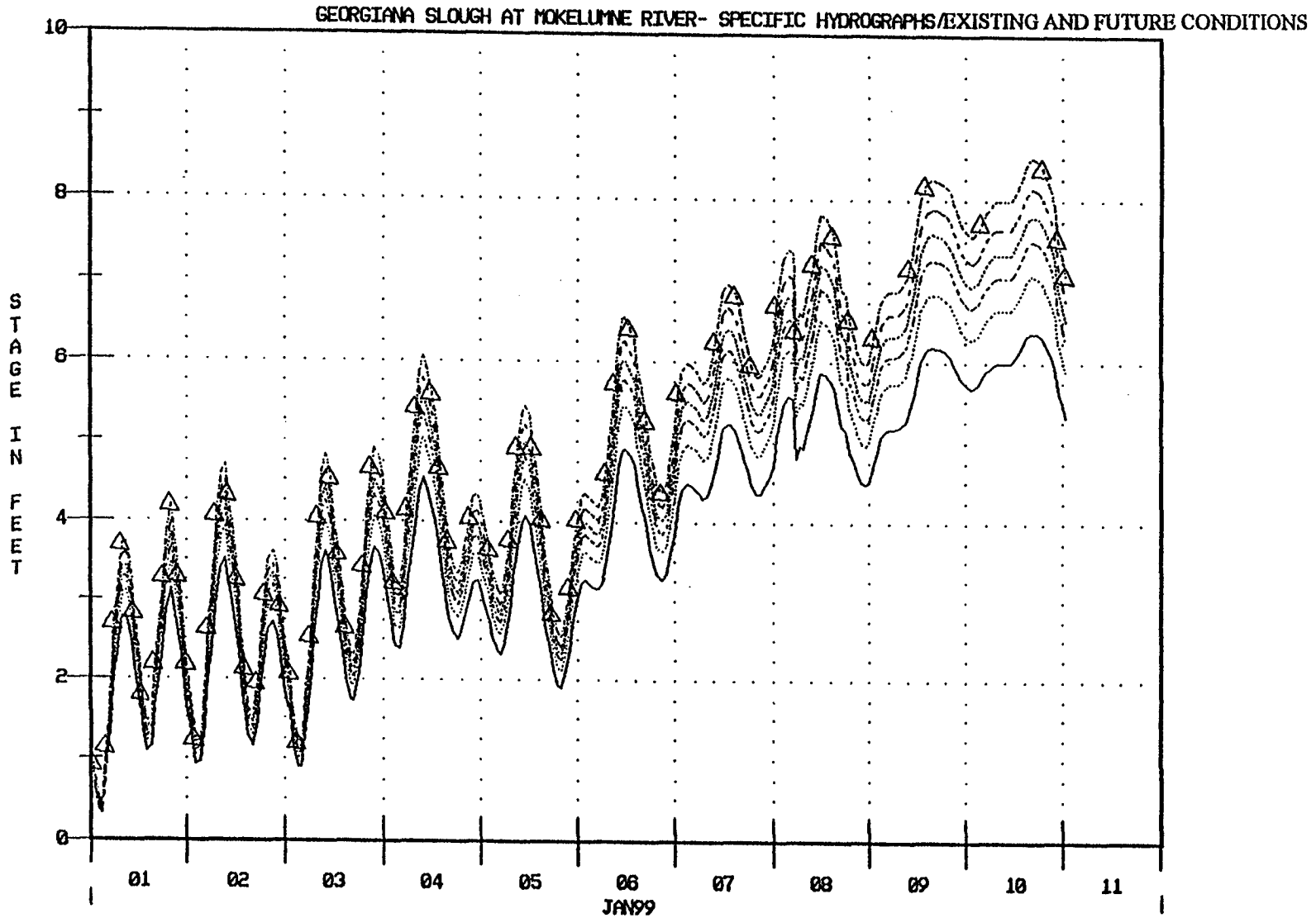


CHART 25

10YR
25YR
50YR
100YR
200YR
500YR

D-003645

D-003645

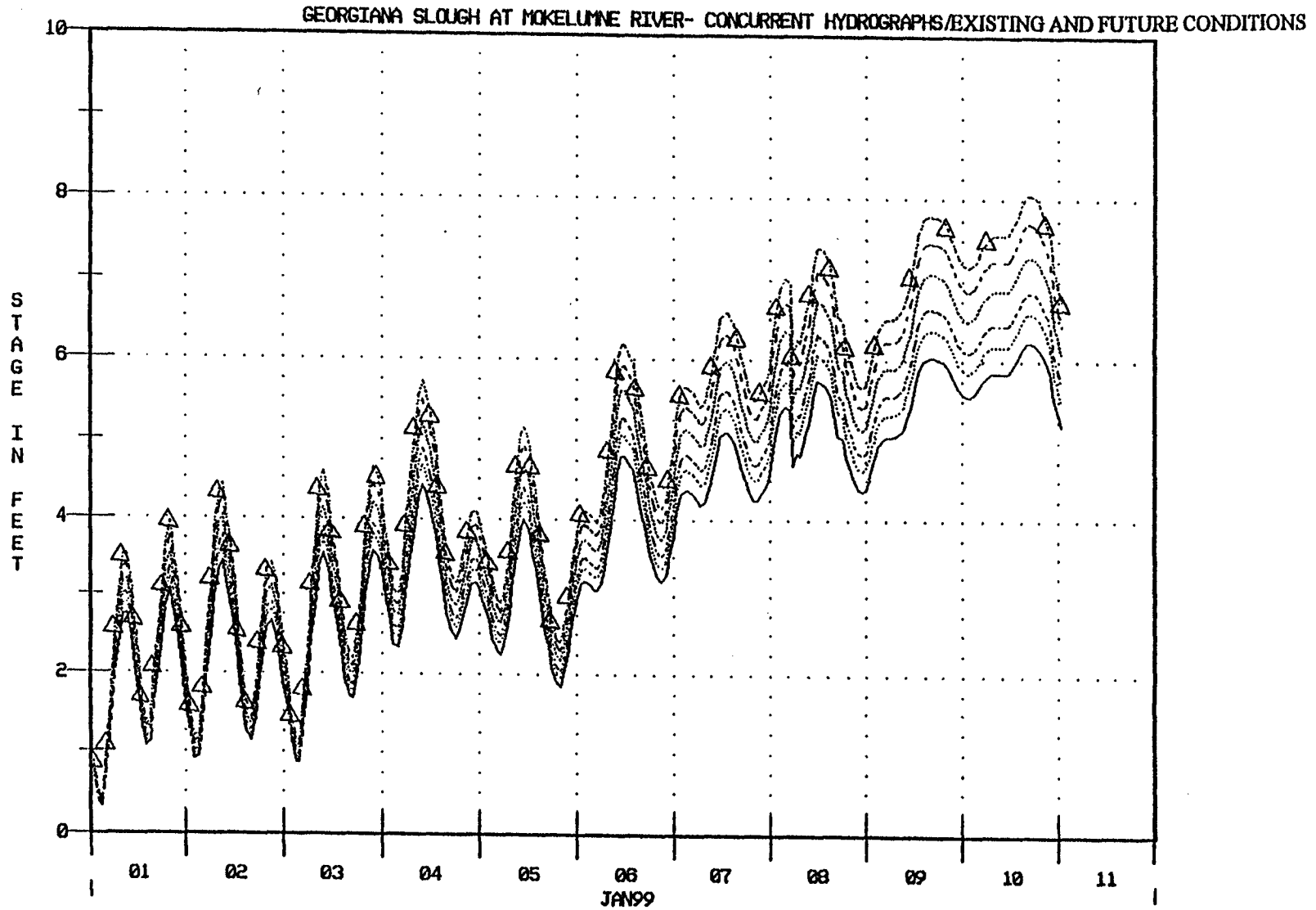
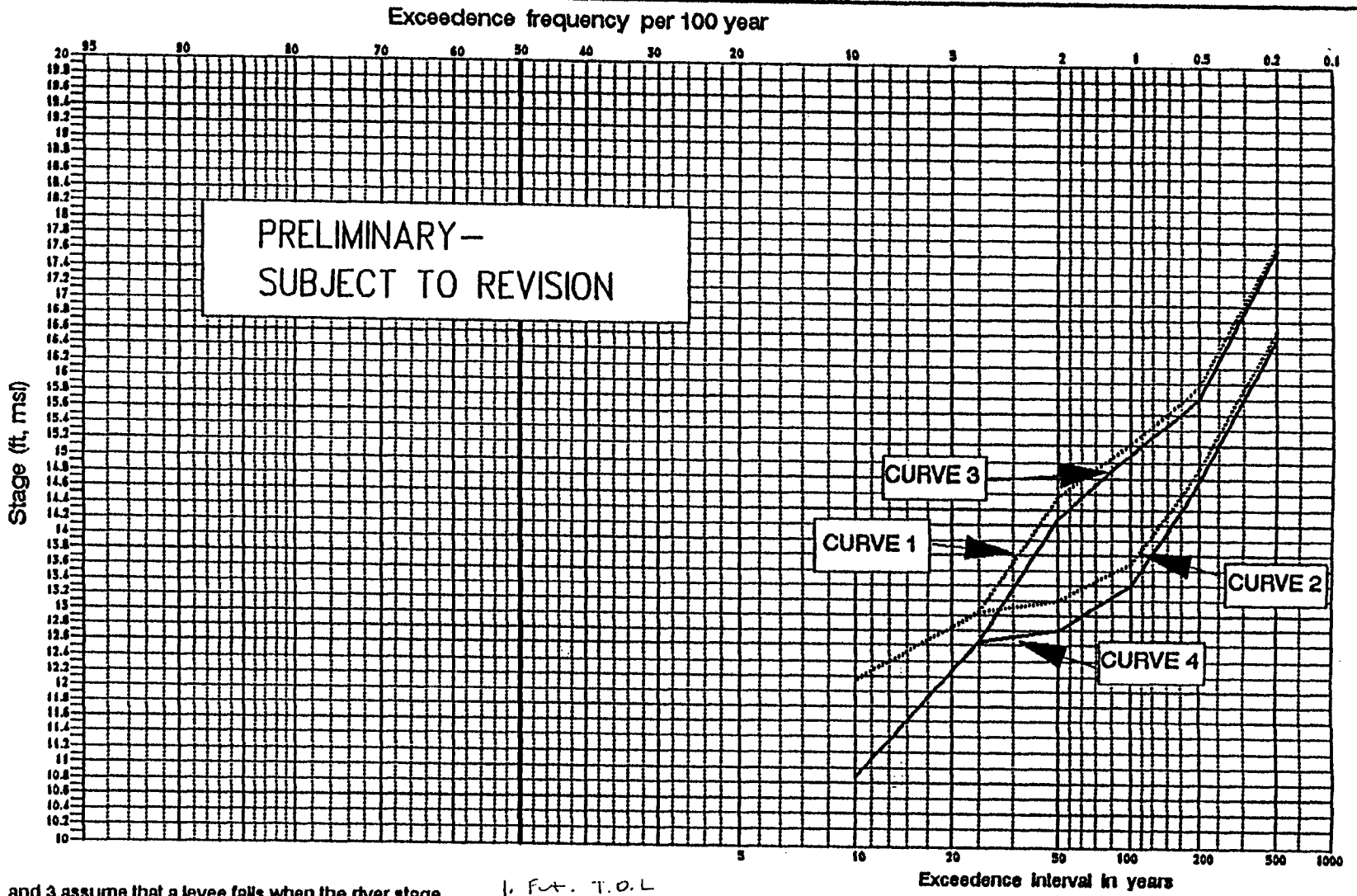


CHART 26

10YR
25YR
50YR
100YR
200YR
500YR

D-003646

D-003646



Notes:

Curves 1 and 3 assume that a levee fails when the river stage reaches the levee crown. Curves 2 and 4 assume that a levee fails when the river stage reaches 2.5 feet below the levee crown. Curves 1 and 2 are future condition curves, and curves 3 and 4 are existing condition curves.

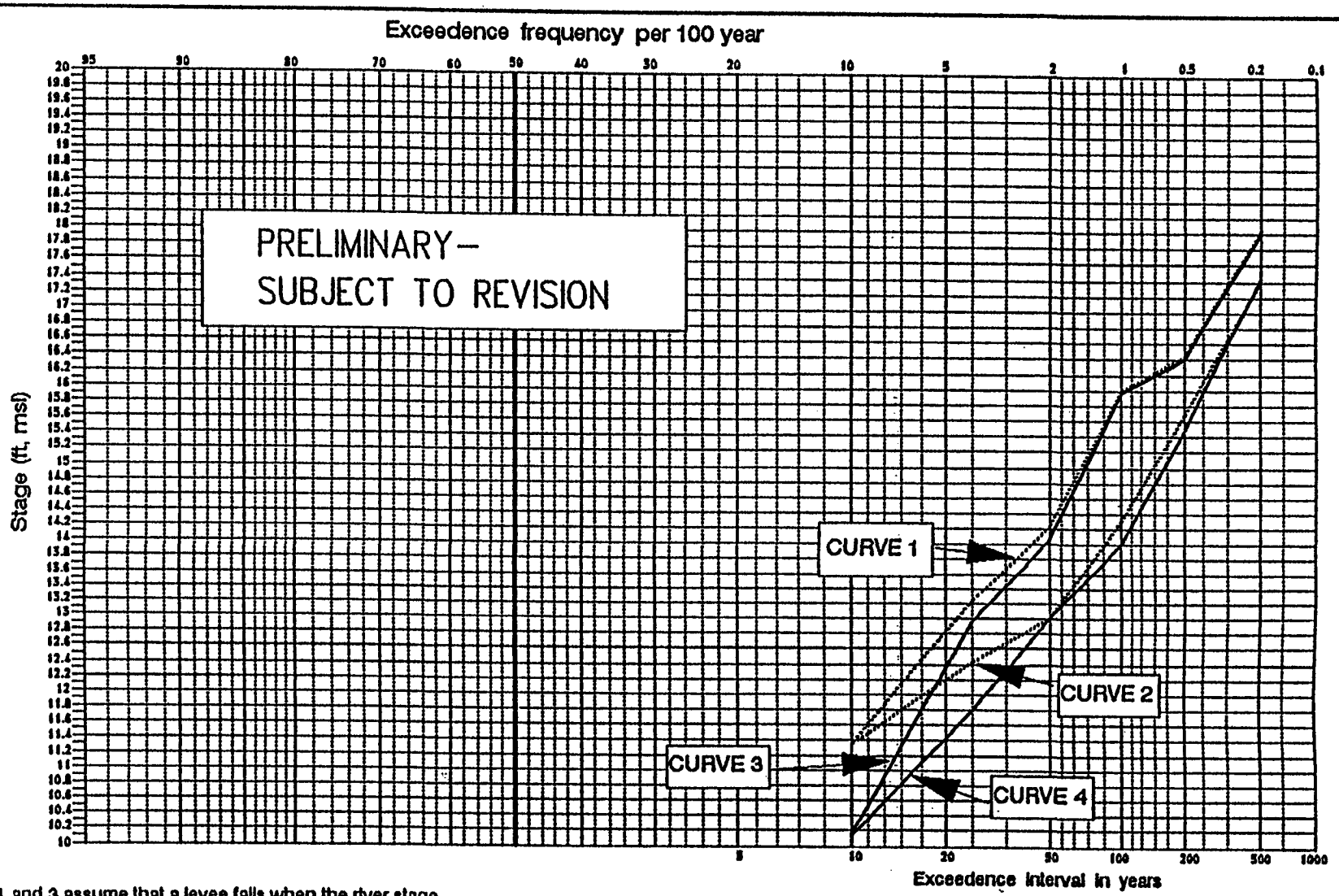
1. Fut. T.O.L
2. Fut 2.5'
3. Exist T.O.L.
4. Exist 2.5'

CHART 27
MORRISON CREEK AT BEACH LAKE
STAGE-FREQUENCY CURVES
SPECIFIC MORRISON CREEK FLOODS

CORPS OF ENGINEERS, SACRAMENTO DISTRICT
Prepared by: BS
Drawn by: BS
Date: Jan. 1996
File: MORSTGE2

D-003647

D-003647



Notes:

Curves 1 and 3 assume that a levee fails when the river stage reaches the levee crown. Curves 2 and 4 assume that a levee fails when the river stage reaches 2.5 feet below the levee crown. Curves 1 and 2 are future condition curves, and curves 3 and 4 are existing condition curves.

CHART 28
MORRISON CREEK AT BEACH LAKE
STAGE-FREQUENCY CURVES
SPECIFIC DELTA FLOODS

CORPS OF ENGINEERS, SACRAMENTO DISTRICT
Prepared by: BS
Drawn by: BS
Date: Jan. 1996
File: MORSTOE

D-003648

D-003648

Printed by
Department of Water Resources
Reprographics