TULARE
COUNTY
FLOOD
CONTROL
DISTRICT

FLOOD CONTROL MASTER PLAN

FOR THE COUNTY OF TULARE CALIFORNIA

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THE SPINK CORPORATION Engineers, Surveyors, Planners June 1971

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INTRODUCTION

Flooding on the valley floor and along natural water courses of the area now encompassed by Tulare County has occurred for thousands of years as a result of the topography and weather conditions. Geologically, the east side of the southern San Joaquin Valley is formed by the gentle slope of the massive alluvial fans built up of material eroded from the Sierra Nevada by four major rivers, the Kings, Kaweah, Tule and Kern. As these rivers emerged from the foothills of the Sierra, they deposited the sediment they carried, forming fans, and then dispersed across the valley floor, each stream dividing into many channels or distributaries. As the Kings River alluvial fan developed, it extended far enough across the valley to interrupt the south to north drainage toward the Sacramento—San Joaquin Delta, forming the basin in which Tulare Lake is located. At one time the lake covered as much as 700 square miles. The Kings River established its present channel down the southeast side of its fan so that it flowed into the lake along with the waters of Cottonwood—Cross Creek (which circles the toe of the Kaweah fan), the St. Johns River, Mill Creek, Packwood Creek, Cameron Creek and Elk Bayou system (distributaries of the Kaweah), Tule River, Deer Creek, White River, Poso Creek and the Kern River.

FLOODING IN THE TULARE BASIN

In the state-of-nature conditions which existed prior to 1850 in what is now Fresno, Tulare, Kings and Kern Counties, high flows produced by winter rainstorms and snowmelt in the Sierra were sometimes dissipated throughout the complex channel system of the valley floor, and at other times found their way into Tulare Lake, entering the lake in varying amounts each year. As a result, the lake level rose and fell under the influences of varying inflows and summer evaporation. At times the lake rose to a high enough level to overflow to the north toward the San Joaquin River; however, only during periods of successive wet years were the streams of Tulare Basin tributary to the Sacramento—San Joaquin Delta and the sea.

Man has changed all this. About 1850, waters of the four major streams began to be diverted for irrigation purposes. Snowmelt runoff of the Basin streams and also of the San Joaquin River, instead of uselessly flowing into Tulare Lake or the sea, became the very foundation of the region's economy as extensive canal systems were built to distribute water of these streams throughout what has become one of the most productive agricultural areas in the world. Storage reservoirs were built on the Kings, Kaweah, Tule and Kern Rivers, regulating snowmelt so it could be better utilized for irrigation and also providing substantial protection against high runoff from winter rainfall in the Sierra. Major canal systems and numerous ditches flow north-south following the line of the foothills and circling the alluvial fans, thus cutting across the natural drainage pattern. When flood flows overtop the banks of the channels in reaches of inadequate capacity, spreading out over the valley slope as they did historically, they may pond against the embankments of north-south trending canals (and roads and railroads) or flow along the embankment until they reach a crossing. Or the flood waters may back up behind such obstacles until they overtop a canal bank, then flow down the canal to aggravate flooding elsewhere downstream.

Other man-made channels run from east to west, acting as part of the distributary systems of the major streams. Consequently, flood flows may take an unpredictable path through the extremely complicated interconnected systems of natural and man-made channels. Moreover, many of the channels of streams originating in the foothills were altered, moved, constricted or even obliterated in the process of agricultural development of the fertile valley-floor lands and urban development along the water courses, so that flood waters simply spread out over the adjacent area. Thus, small foothill watersheds, as well as major rivers, contribute flood water during intense rainstorms.

FLOODING IN TULARE COUNTY
1966 AND 1969

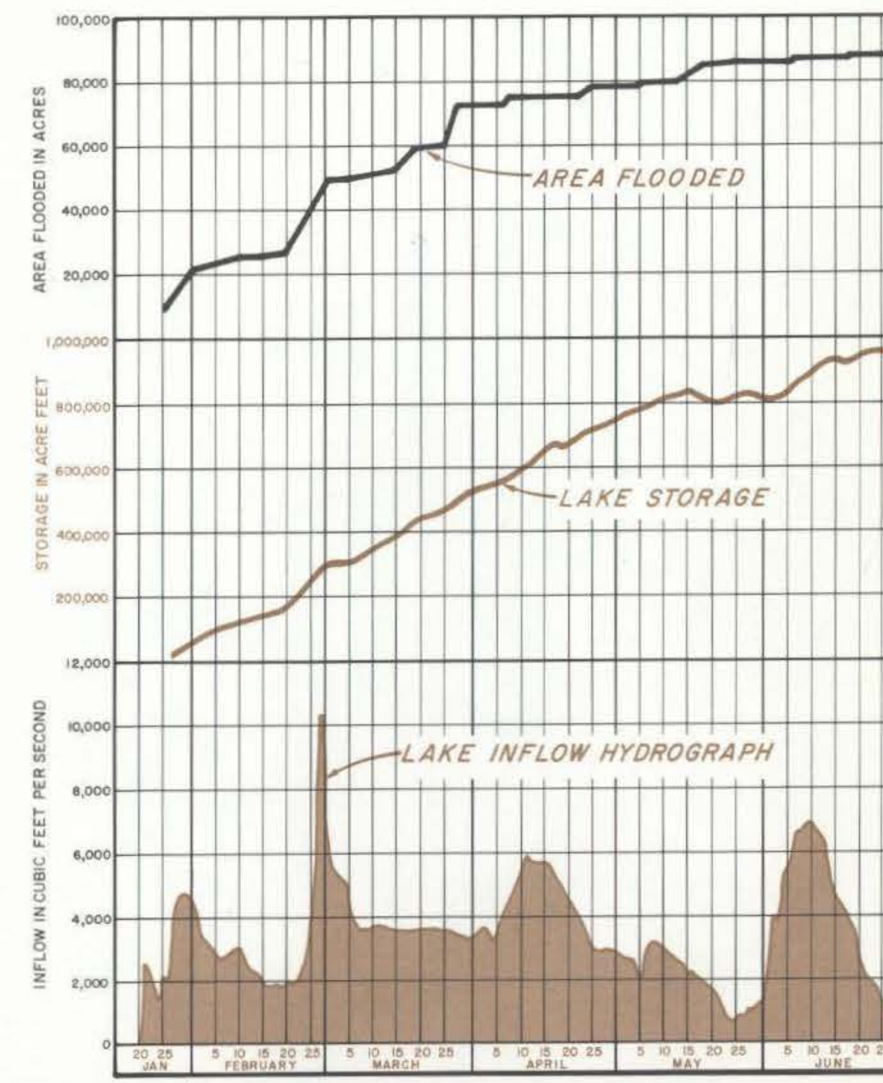
▲ Flooding in northeastern Porterville 1969
(Photo: Farm Tribune, Porterville, Calif.)

▼ Cottonwood Creek west of Friant-Kern Canal 1969
(Photo: Kaweah Delta Water Conservation District)

Consideration of flood problems in Tulare County must encompass an area wide enough to include portions of Fresno, Kings and Kern Counties. Water originating in the foothills of southern Fresno County may flow overland or along man-made obstructions or follow canals to cause damage in Tulare County. In the south, Rag Gulch, for example, causes damage in both Kern and Tulare Counties. Further, water originating in the foothills of Tulare and Fresno Counties may ultimately cause damage in Kings County. Even existing reservoirs on the major streams are not large enough to free residents of the four-county area from damaging flood runoff from those streams. In December 1966, rainfall was so intense over the watershed of the Tule River that it produced uncontrolled spill at Success Dam. Flows of the Kaweah and Tule Rivers (and occasionally even the Kern) which cannot be controlled by the reservoirs and distribution systems will ultimately end up in the Tulare Lake area, along with flows from unregulated foothill streams in excess of the volume which can be dispersed through percolation, channel storage, etc.

In the winters of 1967 and 1969, snowfall was so great that the resulting runoff could not be controlled completely and great volumes of water poured into Tulare Lake and flooded agricultural land. The chart shows the rate of inflow, the volume of water accumulated and the area flooded in Tulare Lake as a result of the January-June 1969 runoff. Although the flooded area steadily diminished in late 1969 and during 1970, 26,800 acres in the lake bed were still under water in April 1971.

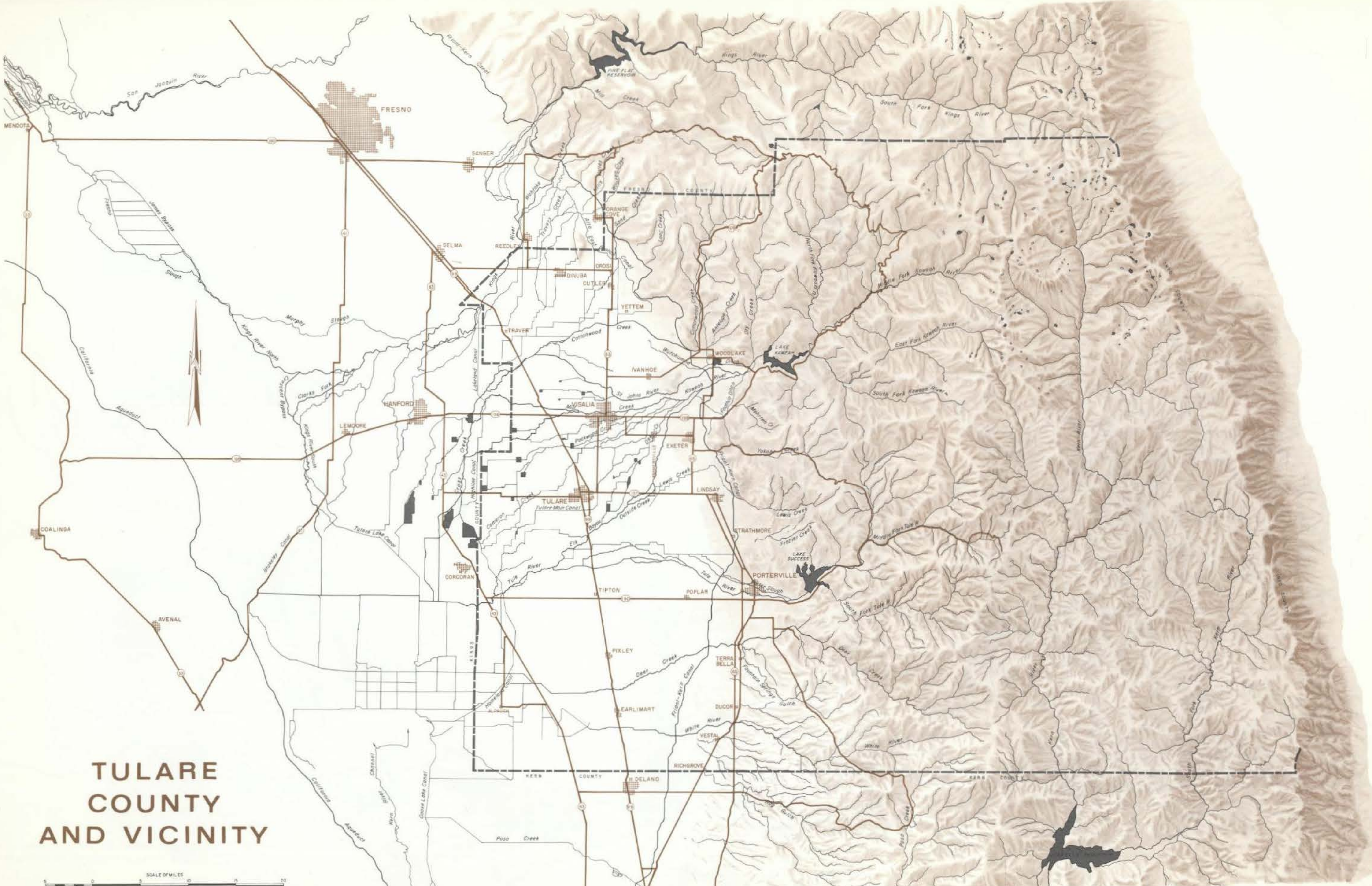
Man's memory of rain-floods is notoriously short. However, the floods of December 1966 and January-February 1969 are recent and illustrate what could be repeated next year, or in any future year. It is certain they will be repeated or exceeded sooner or later. The map of flooding in Tulare County shows those areas which were inundated during the 1966 and 1969 rain-floods. Some 100,000 acres in Tulare County were flooded in 1969, disrupting travel and communications and resulting in about $16,000,000 worth of damage to farms, homes, businesses and publicly owned facilities. Had it been possible to implement the structural and operational changes for control of runoff which are presented in this Master Plan, flooding would have caused no more than minor inconvenience in the areas of southern Fresno, Tulare, northern Kern and eastern Kings Counties shown on the map.



Tulare Lake Flooding 1969


1966 FLOODING — DRY CREEK, TULE RIVER, KAWEAH RIVER, TULARE LAKEBED
1969 FLOODING
SCALE OF MILES
FRESNO COUNTY
KINGS COUNTY
KERN COUNTY
KINGS RIVER
ST. JOHNS RIVER
MILL CREEK
CROSS CREEK
LAKE KAWEAH
LAKE SUCCESS
DRY CREEK
COTTONWOOD CREEK
FRIANT-KERN CANAL
YOKOHL CREEK
LEWIS CR
FRAZIER CREEK
TULE RIVER
PORTER SLOUGH
DEER CREEK
WHITE RIVER
RAG GULCH
POSO CREEK
SAND CREEK
LONG CREEK
LAKELAND CANAL
ELK BAYOU
SOUTHERN PACIFIC RAILROAD

TULARE COUNTY AND VICINITY



This report presents a Flood Control Master Plan for Tulare County and the portions of Fresno, Kings and Kern Counties where flooding problems are related to those in Tulare County. It includes significant meteorologic, hydrologic, geologic and topographic factors important to flooding in the area and the effect of man's activities on distribution of flood waters. Although engineering studies for this report are area-wide in scope, they are in sufficient detail to provide a basis for the further study which will be necessary in planning specific flood control projects.

The report includes:

1. Estimates of peak flows and flood volumes which may occur on each watershed on the average of once in 25 and 50 years.
2. Concepts for control of floods originating on each watershed.
3. A summary of programs and procedures of Federal and State agencies which do or might participate in financing, planning or construction of flood control works.
4. Suggested mechanics through which detailed planning, construction or operation and maintenance might be carried out by Tulare County Flood Control District in cooperation with other local public agencies.
5. Suggested boundaries of zones which might be formed for the limited purpose of accomplishing the required detailed planning.
6. Suggestions as to control of development in flood-prone areas and protection of waterway capacities in some areas.

Summary, Conclusions & Recommendations

It is concluded that physical works can be constructed and operated to control flooding such as that which occurred in 1969; detailed study will have to be given to each runoff source to determine the engineering and economic feasibility of suggested works and to define areas benefitting from their operation. In some cases it will be necessary to control development in flood-prone areas where physical measures are impractical or uneconomic. In some cases also, steps should be taken to protect waterway capacities before they are reduced through land development. Tulare County now has a General Plan which has been and is being followed so far as concerns future development in the County and it is believed that this Flood Control Master Plan should become a part of that General Plan.

It is recommended that:

1. Tulare County Flood Control District take the leadership in exploring effective means of securing coordinated efforts to solve flood problems in the four-county area.
2. Where other agencies cannot plan and construct works to reduce flooding, Tulare County Flood Control District, in cooperation with water-distributing agencies in the four-county area and with the Supervisors of adjacent counties, should conduct detailed planning studies and construct projects for control of flooding.
3. Where physical works to control flooding are impractical or uneconomic, developments in flood-prone areas should be controlled under ordinance to minimize damage and possible loss of life during floods of magnitudes reasonably to be expected.
4. Adequate waterway capacities should be maintained through control of land development, consistent with storm runoff rates which can be expected.

Flooding in East Orosi, 1969
(Photo: U.S. Corps of Engineers and Kaweah Delta Water Conservation District)

Frazier Creek flooding in Strathmore, 1969
(Photo: Farm Tribune, Porterville)

1969 flooding in Woodlake from Antelope Creek and Antelope Mountain runoff
(Photo: Kaweah Delta Water Conservation District)

FLOOD HYDROLOGY

II

Hydrology is the science which deals with the occurrence of water on and in the earth. Hydrology involves or is related to other earth sciences, including meteorology, geology and oceanography and to the topography of the earth itself. Flood hydrology, as the name suggests, involves analyses of the meteorologic, geologic and topographic factors which produce relatively high runoff in stream systems. Flood hydrology also is concerned with hydraulics — the science of fluids in motion — in that flood waters may be stored in, released from and conveyed through natural channels and hydraulic structures. Sediment hydrology is a specialized phase of hydrology that deals with erosion, movement, and deposition of sediments in flowing streams.

Any plan for control of flooding in Tulare County must begin with hydrological analyses of floods. A separate Appendix to this report presents detailed information on the hydrology of the area, including the technical approaches employed to develop anticipated flood peaks and volumes.

METEOROLOGY

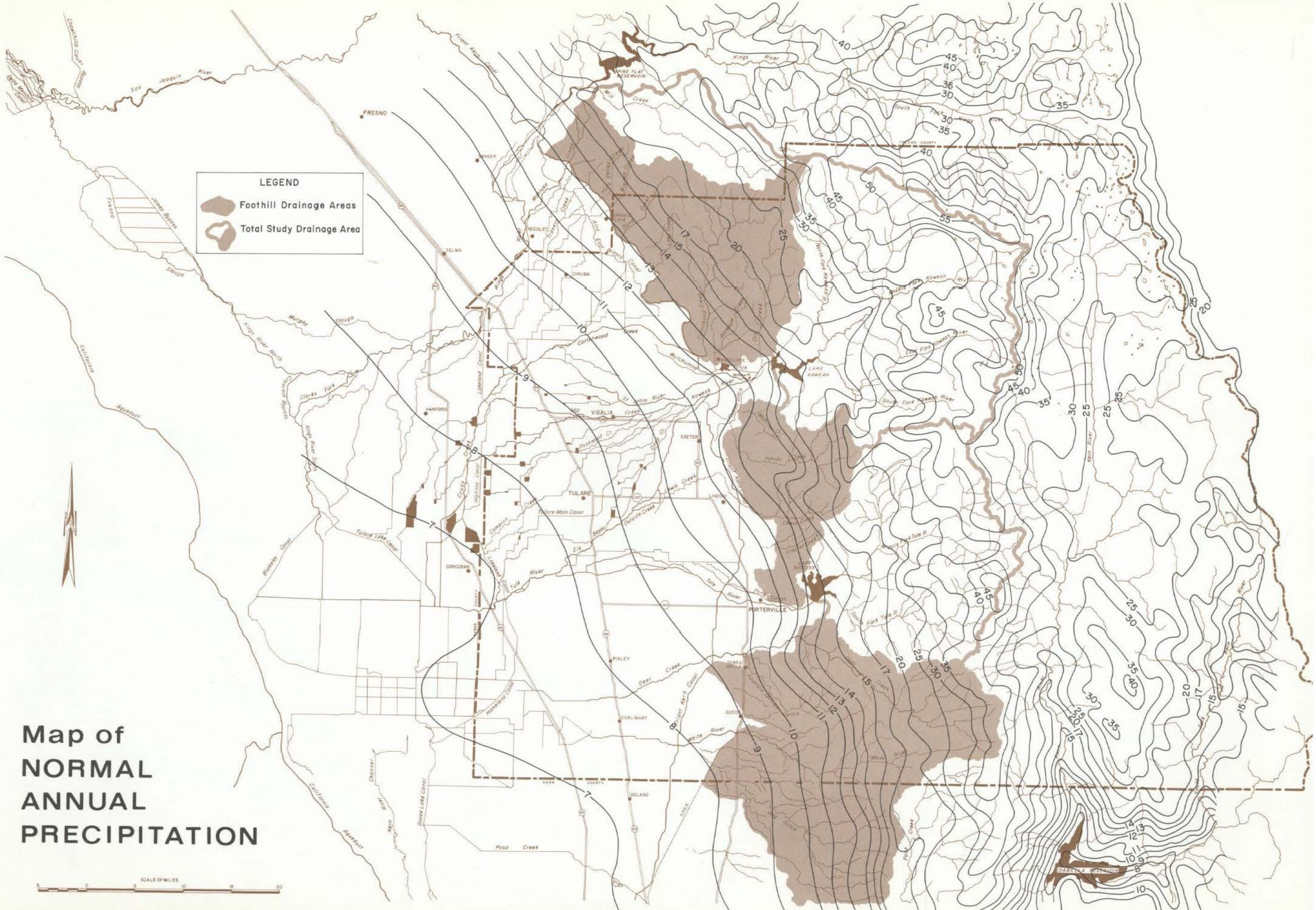
The changeability of the weather has been commented on since the dawn of recorded history. It varies hourly, day to day, month to month, season to season and year to year. Weather systems may bring precipitation and at times the precipitation brings runoff of such intensity and duration that flooding results. Weather patterns are almost continuously changing, but those producing heavy precipitation over the upper San Joaquin Valley have definable characteristics.

Fall rains which mark the start of the storm season may begin from mid-September to December and occur with a southward migration of the polar jet stream — the westerly wind of maximum velocity in the upper atmosphere. This southward swing brings the path of easterly movement of weather fronts into the Central Valley from the Pacific Northwest. Strong fronts may move swiftly or slowly or remain almost stationary, and duration of precipitation in a particular storm will depend on the rate of movement.

The amount of precipitation occurring in a given storm in the Pacific Coast States depends on the moisture content of the air mass, which usually is greatest when warm moist air originating near Hawaii moves eastward in conjunction with a strong flow of cold air from Alaska moving in a cyclonic pattern of west to south to east. Precipitation results when this moist air rises rapidly either because of the internal dynamics of the storm itself (frontal lifting) or as it is driven against and over a topographic barrier such as the Coast Ranges or the Sierra Nevada (orographic lifting).

The location of rain-floods varies with the path of the storm; in December 1955 such a storm struck Northern California and Southern Oregon, while in late January and early February 1969, two successive such storms entered California farther to the south. In 1955, record flows occurred in California-Oregon streams north of Sacramento; in February 1969 very high flows occurred in streams south of Merced, including those in the foothill watersheds in and near Tulare County.

These rain-producing weather patterns may occur at any time from November to April, but are most likely to cause flood runoff in December and January. Throughout the November-April period cold fronts move across the Sierra Nevada at irregular intervals and also produce precipitation, principally in the form of snow. This gradual accumulation of snow usually reaches its greatest depth (in terms of inches of water) in early April when the westerly winds in the upper atmosphere begin to move northerly again toward Canada. Thereafter, and until the next southward migration of the polar jet stream, weather fronts continue to move across California, but they contain minimal moisture with the result that the May-September period is characteristically dry. Sporadic thunder storms in the high Sierras do produce precipitation during the summer, but such storms are of little significance in terms of flood damage caused.



Map of NORMAL ANNUAL PRECIPITATION

PRECIPITATION AND RUNOFF

Individual storms may produce rain, snow, or both, depending on storm characteristics, elevation and temperatures. Temperatures in the air mass generally cause precipitation to occur as snow at higher elevations. Precipitation at lower elevations — and most of the flood-producing drainage areas in Tulare County are at relatively low elevations — occurs as rain. Both forms of precipitation are involved in the planning of flood control measures.

The map shows by isohyetals (lines of equal precipitation) the variation in average — or as the meteorologists and hydrologists say — normal annual precipitation from one location to another in Tulare County and adjacent areas. Along the valley floor near the western boundary of the County normal annual precipitation varies from 7 to 10 inches. At the crests of the Kaweah and Tule River watersheds normal annual precipitation varies from 35 inches in the south to about 55 inches in the north. At the eastern boundary of the County the normal is about 15 inches to 30 inches. A single storm may deposit half a year's "normal" precipitation at any one point; two or three storms in succession may produce total precipitation over a single drainage area amounting to double the "normal" precipitation over the same area; a period of years may go by during each of which only a fraction of a "normal" year's precipitation occurs in the County. Partly because the County had not developed as fully as it has today, but even more because annual and monthly precipitation was below "normal," periods of several years have gone by with literally no flood damage in Tulare County.

No one can predict very far in advance when the next rainstorm will occur — even less, which particular watershed will receive heavy precipitation. Barring a change in the climate of the earth, such storms will occur and will produce rainfall over the drainage areas which are the sources of runoff flooding Tulare County.

Runoff from snow accumulation is the product of gradual melting over time which produces relatively low, non-damaging peak flows. Generally, snowmelt runoff from the high elevation basins occurs at the time of year and at peak flow rates which can be managed without extensive damage in Tulare County. However, large accumulations of snow can yield immense volumes of water which result in flood damages in terminal areas such as Tulare Lake.

The time of occurrence, intensity (amount of precipitation in a given time) and duration of precipitation in individual storms are important factors affecting peak rates and volumes of runoff. The second of two successive rainstorms over a drainage area, even if the same amount of rain fell at the same rate and in the same pattern of distribution, will cause a greater volume of runoff at higher peak rates of flow than the first storm would because the drainage area would already be saturated.

DRAINAGE AREAS

Other significant factors affecting peak rates and volumes of runoff are topography, geology and watershed ground cover. One of the most important of these factors is topography — the elevation, shape, slopes and orientation (south-to-north, east-to-west, etc.) of the drainage area.

The Map of Drainage Areas on the following page shows the boundaries of the 50 separate drainage areas or sub-drainage areas which produce the runoff important to flooding of Tulare County and its adjacent areas. Runoff from each of these drainage areas produces flooding or may contribute to flooding of the areas shown on the map in the Introduction. The western or downstream boundary of each drainage area or sub-drainage area is a point where runoff from the drainage area may concentrate, or where, for the purpose of developing flood control concepts for the watershed and downstream areas, it is assumed to concentrate. Each drainage area and sub-drainage area shown is numbered. Note that some of the larger drainage areas are designated by more than one drainage area number. For example, Cottonwood Creek is identified by three drainage area numbers, 22, 23 and 24. Drainage Area 22, which has its point of concentration at Friant-Kern Canal, includes the total upstream area including Areas 23 and 24. Similarly, Area 23, which has its point of concentration at Elderwood, includes Area 24. Thus, where a drainage area contains more than one number, the numbered area farthest downstream includes all sub-drainage areas upstream.

The table which follows presents the drainage area number for each area shown on the map and identifies briefly the stream or drainage system. Also, for each drainage system, the area and normal annual precipitation are shown together with the peak flow in cubic feet per second (cfs) estimated to occur on the average of once in 25 and 50 years. Finally, for ready comparisons, the table shows, for each location where a record of flow is available, the peak flow which occurred during the floods of December 1966 and January-February 1969 and the amount of peak flow recorded prior to December 1966 together with the date of occurrence. All these data are factual except, of course, the 25- and 50-year peak flow estimates, which are based on application of established hydrological techniques to available data as explained more fully in the Appendix.

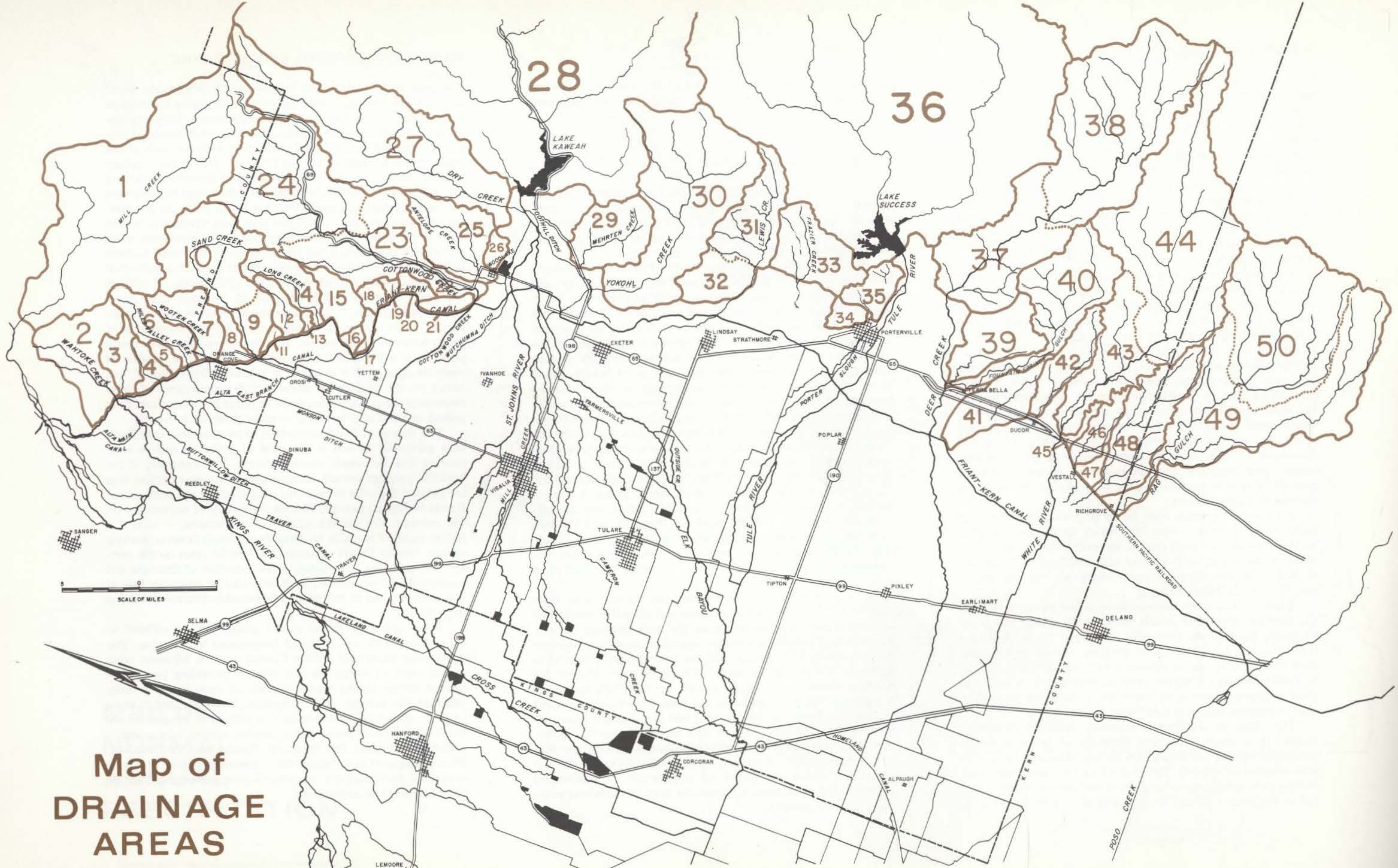
FLOOD FREQUENCIES OR RETURN PERIODS

The peak flows for 25- and 50-year return periods shown in the Table of Drainage Areas are of value in gaging the relative magnitude of peak flows on different streams. They are useful to the engineer in comparing the economic merits of providing a given degree of flood protection with the costs of the improvements. However, peak flows for given "return periods" should not be misunderstood or misused. Peak flow "return period" means that the given flow may be exceeded (or have a "return period") of once in 25 years on the average and another larger peak flow may have a return period of once in 50 years on the average. As time passes and more experience is gained, flows which are now estimated to have return periods of 25 and 50 years may change. One individual in Tulare County remarked after the 1969 floods, "I've lived here over 40 years and in the last 15 I've seen three once-in-100-year floods." It is important to remember "return period" does not imply that there will be a given number of years *between* flood events. It only means that over many years such a flood will occur *on the average* the number of years designated. For example, a "once-in-10-year flood" will occur on the average 10 times in 100 years. Three of these times may be in successive years or occur in a very short time period or there may be many years between such events.

The degree of flood protection to be provided from flows of a particular stream is a matter of policy as well as engineering and economic considerations. For example, if the benefits (average annual damages prevented) to an urban area are greater than the annual cost of protecting the area against floods having a once-in-100-year frequency of occurrence on the average, the project might be undertaken — even if a higher ratio of benefits to costs would result from protecting against smaller floods occurring once in 50 years on the average. Beyond this, of course, is the question of damages not susceptible of evaluation, such as actual or potential loss of life, personal loss of livelihood and possible detrimental social impacts.

There are only broad guides which can be offered in connection with use of flood frequencies in planning. The developing nature of Tulare County and its adjacent areas would tend to weigh on the side of providing protection against floods having return periods of once in 50 or more years on the average. It is recognized, however, that in some cases — especially where urban or industrial properties are involved and widespread and intangible effects may occur — protection against less frequent floods may be justified. Where judgment as to future development indicates, and hard economic facts support, once-in-25-year protection may be all that should be undertaken.

Map of DRAINAGE AREAS



Map of DRAINAGE AREAS

No.	Location	Drainage (Sq. Mi.)	Normal Annual Precipitation (Inches)	Peak Discharge – cfs: Return Period 25-Year	50-Year	1966 Flood	1969 Flood	Maximum Previous Flood	
1	Mill Creek nr. Piedra	127	24.7	–	–	11,000	9,860	1955 –	6,000
2	Wahtoke Creek at Friant-Kern Canal	21.5	15.4	1,680	2,400		1,760(a)		
3	Citrus Cove Drainage at Friant-Kern Canal	8.3	14.3	680	970				
4	Granite Hill Drainage at Friant-Kern Canal	3.6	13.8	380	540				
5	Surprise Creek at Friant-Kern Canal	2.3	13.8	270	390				
6	Hills Valley Creek at Friant-Kern Canal	10.7	15.6	950	1,360				
7	Wooten Creek at Friant-Kern Canal	11.3	15.2	1,050	1500		265(b)		
8	Orange Cove Drainage at Friant-Kern Canal	3.7	13.7	380	540				
9	Sand Creek at Friant-Kern Canal	38.8	17.4	3,020	4,320				
10	Sand Creek nr. Orange Cove	31.6	18.2	2,670	3,820	2,100	3,520	1955 –	1,320
11	Curtis Mtn. Drainage at Friant-Kern Canal	1.0	13.2						
12	Negro Creek at Friant-Kern Canal	5.3	14.1	510	730				
13	Avenue 424 Drainage at Friant-Kern Canal	0.7	13.3	95	130				
14	Long Creek at Friant-Kern Canal	11.2	15.4	950	1,360				
15	Avenue 416 Drainage at Friant-Kern Canal	8.4	13.5	650	930				
16	Stokes Mountain-West Drainage at Friant-Kern Canal	1.3	12.4	155	220				
17	Stokes Mountain-South Drainage into Friant-Kern Canal	1.8	12.6	–	–				
18	Stone Corral Canyon Drainage at Friant-Kern Canal	2.7	13.4	300	430				
19	Road 180 Drainage at Friant-Kern Canal	1.0	13.4	135	190				
20	Avenue 384 Drainage at Friant-Kern Canal	2.3	13.2	265	380				
21	Colvin Mountain Drainage into Friant-Kern Canal	2.4	12.4	–	–				
22	Cottonwood Creek at Friant-Kern Canal	88.1	18.4	–	–				
23	Cottonwood Creek at Elderwood	83.4	18.8	6,170	8,820	4,650	4,670		
24	Cottonwood Creek above Highway 69	52.2	20.9	4,750	6,780	5,420		1958 –	2.460
25	Antelope Creek at Woodlake	20.7	14.3	1,340	1,920		1,050		
26	Antelope Mountain-Woodlake Drainage at Bravo Lake	3.0	13.2	315	450				
27	Dry Creek nr. Lemoncove	80.4	23.4	7,520	10,700	14,500	5,710	1955 –	6,070
28	Kaweah River at Terminus Dam	561	39.0	–	–	5,740(c)	4,250(c)	1955 –	80,700(d)
29	Mehrten Creek at Foothill Ditch	19.0	13.8	1,070	1,530				
30	Yokohl Creek at Hamilton Ranch	70.6	17.5	3,960	5,660	3,400(e)			
31	Lewis Creek nr. Strathmore	18.3	15.9	1,270	1,820	1,900(f)	1,480		
32	Lewis Creek at Road 236	32.1	14.7	1,850	2,650				
33	Frazier Creek ½ mile East of Road 256	18.1	12.9	1,010	1,440				
34	Lewis Hill Drainage at Porterville	3.6	10.8	315	450				
35	Rocky Hill Drainage at Porter Slough	7.9	11.6	515	740				
36	Tule River at Success Dam	393	31.0	–	–	9,050(g)	3,210(g)	1950 –	32,000(h)
37	Deer Creek at Hungry Hollow	124	22.2	7,730	11,000	6,050			
38	Deer Creek nr. Fountain Springs (Kilbreth)	83.3	25.7	7,300	10,500	5,330	3,340	1943 –	8,000
39	Fountain Springs North Drainage at Deer Creek	19.3	11.1	840	1,200				
40	Fountain Springs Gulch at Deer Creek	35.0	11.8	1,400	2,000				
41	Terra Bella-Ducor Drainage at Friant-Kern Canal	16.9	9.4	610	870				
42	Ducor East Drainage at SPRR	13.9	9.9	540	770				
43	White River nr. Vestal	120	15.1	4,150	5,950		4,560		
44	White River nr. Ducor	92.9	16.5	3,760	5,370	1,204		1943 –	2,300
45	Orris East Drainage at SPRR	1.8	8.9	180	260				
46	Vestal East Drainage at SPRR	7.8	8.8	440	630				
47	Vestal Southeast Drainage at SPRR	2.6	8.3	245	350				
48	Richgrove East Drainage at SPRR	28.4	9.0	905	1,300				
49	Rag Gulch at SPRR	138	11.4	3,280	4,680		2,240(i)		
50	Rag Gulch nr. Villard Ranch	71.2	12.4	2,100	3,000				

(a) Near Centerville
(b) Near Orange Cove
(c) Below Terminus Dam
(d) Near Three Rivers
(e) Near Exeter
(f) Near Lindsay
(g) Below Success Dam
(h) Below Success Dam and prior to regulation by Lake Success
(i) Near Richgrove

Table of Drainage Areas, Precipitation and Peak Discharges

FLOOD VOLUMES AND DETENTION STORAGE

Reservoirs for detention of peak flows are desirable structures for control of floods. They are especially desirable in areas like Tulare County where they may perform the storage function now performed by uncontrolled flooding of large areas, thus preventing damage in such areas. Detention reservoirs may also reduce peaks to amounts which can be managed and conserved either through direct irrigation use, diversions to valley-floor detention basins and spreading grounds or percolation to groundwater basins in natural channels for later extraction through wells. Where damsite and reservoir topography and geology permit, higher dams store greater volumes of water and, other things being equal, are more costly. These considerations — and of equal importance in many cases, the economical and safe carrying capacities of downstream channels through which releases must pass after each flood occurrence — are directly involved in the hydrological and economic aspects of protecting areas downstream of a detention site.

Hydrologically, too, the relationship between the volume of water in a flood and the peak flow of that flood may vary a great deal. The most direct such variation can be seen in a comparison of snowmelt and rain-floods. The mean daily flow in cubic feet per second on the day the peak snowmelt flood occurs is practically the same as the peak flow on that day; the mean daily flow on the day a peak rain-flood occurs is a fraction of that peak flow. Snowmelt flooding is primarily important in the Tulare Lake area and would be even more serious if large diversions were not made to irrigation systems diverting from Kaweah and Tule Rivers; such flooding can be reduced further, principally by augmenting the volume of storage space available for Kaweah and Tule River runoff. Rain-floods also require storage space for their control by detention reservoirs, but relatively small space can reduce large peak flows dramatically.

Hydrologic studies for this report have developed estimates of the volumes of water occurring on each of the watersheds for return periods of 25 and 50 years and for 1-, 2-, 3- and 5-day maximum volumes during rain-floods. Development of the estimates is presented in the Appendix. These estimates of volumes provide bases for calculating the approximate *minimum* amount of storage required for controlling rain-floods of these frequencies on each of the watersheds where topographic conditions suggest that dam and reservoir sites may exist. In Chapter 3, these *minimum* amounts of storage are described and are related to differing rates of releases for the reservoirs, since further detailed studies will be required for each stream to balance the size and cost of detention reservoirs against capacity and cost of channels conveying regulated flows.

A fixed outlet opening, which probably is desirable for small detention reservoirs intended to control rain-floods of unpredictable occurrence and accordingly designed for assured automatic operation, cannot discharge water at the same rate when the reservoir is partially full as when it is full. For this study the average release rates during a flood period have been assumed to be 75 percent of the selected maximum release. Thus, in the concepts presented in Chapter 3, if a downstream channel is considered to have a capacity of 100 cfs, the reservoir volume shown for a given flood is that necessary to control releases to an average of 75 cfs.

The capacities shown in Chapter 3 for reservoirs to control rain-floods are predicated on the assumption that a dam and reservoir could be constructed at the suggested location. Obviously, in some cases, topographic and geologic considerations may dictate that a dam be located higher on the watershed than the suggested site. In such cases, to allow for runoff from the watershed area below the upstream damsite while maintaining the same degree of control as indicated for the suggested location, it may be necessary to make smaller releases from the upstream site; this will require a proportionately larger reservoir capacity at the upstream site.

Sediment-hydrology has not been considered in the studies leading to this report. In many of the Tulare County watersheds, soil mantle is relatively stable and even intense precipitation does not produce large sediment movement. In other cases, there is evidence that significant quantities of silts, sand, gravels and other debris are moved. Sediment storage space may be needed in the detention basins suggested in Chapter 3 for two reasons: to maintain the basin capacities needed to control floods and to permit maximum sediment settlement in those cases where releases must enter canal systems for disposal. In the course of detailed study of individual streams, consideration should be given to their sediment-producing potential.

The debris-removal function of detention reservoirs is especially significant for major canal systems in Tulare County, including the Alta Irrigation District's East Branch Canal, the Bureau of Reclamation's Friant-Kern Canal and the Consolidated Peoples Ditch—Outside Creek system, which are capable of conveying large quantities of water from Kings, San Joaquin and Kaweah Rivers. The canal systems convey water from north to south along the foothill contours and thus cross many of the east-to-west streams. They frequently receive flood waters because of their location and structural characteristics at these stream crossings. In some cases (usually involving small drainage areas) they are deliberately designed to accept flood waters.

Operators of many of these major north-to-south canal systems understandably are reluctant to accept substantial quantities of cross-drainage into their canals for operational reasons, because of potential increases in liability, and because of increased operating costs which result from sediment input to the canals. Operational factors, including annual maintenance shut-down, usually at the height of the rain-flood season, are particularly significant on Friant-Kern Canal.

OTHER FUNCTIONS OF RESERVOIRS

Reservoirs providing flood protection to downstream areas frequently are useful for other purposes, such as regulating stream flows for irrigation, power production, and maintenance of minimum flows for fishery preservation and enhancement. Where minimum water levels can be maintained during the spring, summer and fall months — especially where water temperatures and quality are satisfactory for fishing — recreational opportunities are available and are exploited heavily.

Reservoirs serving such multiple purposes generally involve compromises. A single-purpose flood control reservoir will be empty except when storing water which would cause downstream damage. A single-purpose irrigation or power reservoir will be as full as inflows permit consistent with meeting downstream irrigation needs or demands for power output. A single-purpose recreation reservoir will be as full as possible throughout at least the main part of the recreation season.

Except for reservoirs regulating the principal Tulare Basin streams, most of the detention reservoirs suggested in this report offer little opportunity for multiple-purpose development. This situation is primarily due to the runoff characteristics of the area, although water rights limitations have some significance. Stream flows are not sufficiently regular to permit economic operation of power plants. Deliberate inclusion of reservoir space for irrigation purposes is of doubtful value on most of the foothill watersheds because of sporadic runoff which may be negligible in amount over periods of two or more years in succession.

Reservoir storage space for flood control purposes must be available from about November 1 to about April 1 to control rain-floods. Water supplies after April 1 on most of the foothill streams are quite unreliable; thus, rain-flood space generally cannot be filled after the rainy season as is possible on streams where snowmelt runoff may occur during the April-July period.

Maintenance of minimum water levels for recreation at the foothill sites also appears impractical due to unreliable flows after April 1. It is possible, in the case of one or two of the potential reservoirs, that some recreational use (golf courses, parks) could be made of the reservoir land since inundation will occur only during the rainy season. This possibility should be studied in connection with further planning, especially on the larger detention basins.

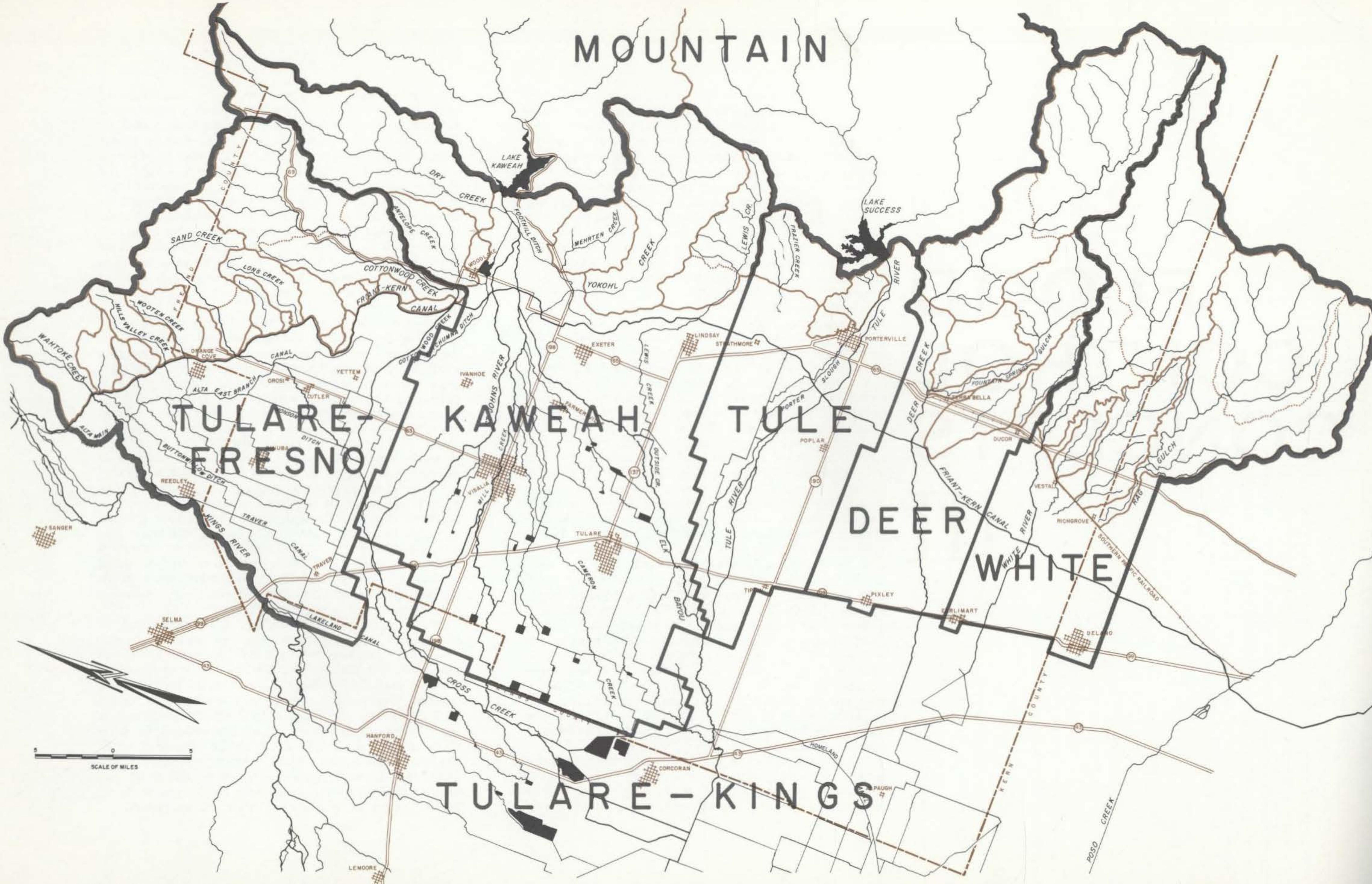
FLOOD CONTROL CONCEPTS III

Flood control concepts for Tulare County must take into account the hydrology, geography and topography of a wider area than the County itself. To some extent, the entire Tulare Lake Basin and the San Joaquin River to and including the Delta are involved with Tulare County flood problems and their solution. Basin-wide studies currently under way can, and should, lead to increases in flood storage capacity on the Kings, Kaweah, Tule and Kern Rivers with a view to reducing inflows to Tulare Lake from those streams and of minimizing flows of Kings River to the San Joaquin River at Mendota, especially at times the latter river is in flood. Studies also are being made of possible introduction of Kern River flood flows into the California Aqueduct. These measures, if consummated, will produce benefits chiefly during snowmelt floods. However, additional storage space at Lakes Success and Kaweah may enable releases from those reservoirs to be reduced during rain-floods, thus facilitating disposal of rain-flood flows originating on the foothill watersheds in Tulare County. The concepts presented herein accordingly assume that a regional approach, rather than a single-county approach, is taken toward the flood problems of Tulare County. Institutional relationships necessary to such a regional approach will require further exploration, but such relationships should be established to advance the common good. The regional approach must be at two levels, one of which recognizes the long range need for minimizing inflows to Tulare Lake and the other dealing with the local drainage areas in Tulare County and the portions of Fresno and Kern Counties treated in this report. Some of the floodwaters which produce damage within Tulare County originate in Fresno County on the north and Kern County on the south. Also, waters passing through Tulare County cause flooding in Kings County and may eventually come to rest in Tulare Lake. Reduction of damages from flooding in Tulare County may require physical measures in Fresno County and such measures may benefit lands in that County. Reduction of flood damages in portion of Kings County will require properly designed physical works in Tulare County — and in some cases in Fresno County. Lands in both Kern and Tulare Counties can benefit from projects in the Rag Gulch watershed, most of which is in Kern County. Thus, county governments and many of the local districts and landowners in Tulare, Fresno, Kern and Kings Counties have common interests in control of flood flows in the general area.

Flood damages can be minimized either through physical works, control of development in flood-prone areas or a combination of the two. Physical works may involve channel improvement to convey larger quantities of storm water without damage, detention reservoirs or a combination of improved channels and reservoirs. Detention reservoirs, if partially or wholly filled during a winter storm, must be emptied as rapidly as downstream channel conditions permit in order to provide space for control of possible flood runoff occurring in a following storm. Finally, irrespective of the physical works installed for flood control purposes, the flood waters must reach terminal points or areas where their damage potential is at a minimum. Since the San Joaquin Valley, including Tulare County, has insufficient natural water supplies for full development, it is desirable that these flood flows terminate either in direct crop use, in spreading areas, or in valley floor reservoirs from which they can be diverted for later beneficial use or percolation to the groundwater basins.

Flood control concepts for Tulare County and the related Fresno, Kern, and Kings County areas also must recognize the extensive canal systems which traverse the region in a complex and frequently interconnected network. The region relies heavily on groundwater pumping during dry seasons and dry cycles. Much of the surface supply originating in the region is used directly for irrigation and, when irrigation requirements are at a minimum, for spreading to induce recharge of underground aquifers. Many of the systems are physically capable of, and are, operated to distribute what otherwise would be damaging flood flows to areas where they can be used for irrigation or groundwater recharge. During many severe storms, however, the systems are not capable of providing these benefits and may, in fact, enlarge the area inundated by causing water to pond against canal banks or to enter canals and then flow to some point where capacity is inadequate. Nevertheless, these systems, whether consisting of natural or man-made channels, are indispensable elements of any plan for eliminating or reducing flood damage in Tulare County and its neighboring areas.

Water rights must be considered in the development of any flood control project. California case law is replete with water rights litigation flowing out of stream-flow modifications, including possible modifications similar to those outlined in some of the concepts discussed in this Chapter. Each situation is unique in some respects. It is not possible for this or any other report to suggest solutions to all such situations, many of which may not arise at all. It is believed that water rights complications alone will not make impractical any of the flood control concepts presented. Nevertheless, it is suggested that the water rights implications of each of the concepts, and of alternates which may be considered, be reviewed as a part of detailed study of each stream system.


MOUNTAIN
TULARE-FRESNO
KAWEAH
TULE
DEER
WHITE
TULARE-KINGS
LAKE KAWEAH
LAKE SUCCESS
DRY CREEK
SAND CREEK
LONG CREEK
COTTONWOOD CREEK
FRIANT-KERN CANAL
WOOTEN CREEK
HILLS VALLEY CREEK
WAHTOKE CREEK
ALTA EAST BRANCH CANAL
ALTA MAIN
FOOTHILL DITCH
MEHRTEN CREEK
YOKOHL CREEK
LEWIS CR.
FRAZIER CREEK
TULE RIVER
DEER CREEK
FOUNTAIN SPRINGS GULCH
RAG GULCH
WHITE RIVER
KINGS RIVER
TRAVER CANAL
LAKELAND CANAL
CROSS CREEK
CAMERON CREEK
ELK BAYOU
OUTSIDE CR.
POSO CREEK
SOUTHERN PACIFIC RAILROAD
EXETER
LINDSAY
STRATHMORE
PORTERVILLE
IVANHOE
YETTEM
OROSI
CUTLER
ORANGE COVE
REEDLEY
SANGER
SELMA
TULARE
POPLAR
DUCOR
VESTAL
RICHGROVE
PIXLEY
EARLIMART
DELANO
HANFORD
CORCORAN
LEMOORE
HOMELAND
PAUGH
SCALE OF MILES

FLOOD CONTROL UNITS

For purposes of presenting flood control concepts, a portion of the four-county area is divided into units. The unit boundaries encompass areas whose flood problems in general are closely related either by source, conveyance or ultimate disposal of flood flows or by physical plans for control. To some extent, however, boundaries of the units are arbitrary in that flooding problems are not so related; in these cases boundaries are adopted for convenience only in presenting the concepts. Some of the units could be subdivided — especially for purposes of identifying areas benefitting from specific improvements.

TULARE-KINGS UNIT

The eastern boundary of Tulare-Kings Unit forms the western boundary of the other five valley-floor units and is assumed to extend westerly to include all of the area potentially subject to flooding in Tulare Lake. The Unit is identified as a separate unit because flood flows originating in the other units may enter it and, depending on their occurrence and magnitude, may increase water management and flooding problems in western Tulare and Kings Counties. Unfortunately, it is true that flooding of Fresno, Tulare and Kern County land under present conditions is of some benefit to land in the Tulare-Kings Unit. The common enemy doctrine established by decisions of the California Supreme Court might permit reduction of these upstream flooded areas with resulting increases in flood damages in the Tulare-Kings Unit. On the other hand, the concepts envisaged for the other valley-floor units can, if properly implemented, improve water management and minimize flooding conditions in the Tulare-Kings Unit as compared to those conditions today.

Two key points on the eastern boundary of the Tulare-Kings Unit are the junction of Cottonwood Creek and St. Johns River and the junction of Elk Bayou and Tule River. Below these junctions, the commingled flows of the two pairs of streams cause flood damage in western Tulare County and in Kings County.

TULARE-FRESNO UNIT

Tulare-Fresno Unit covers the area generally north of the Kaweah River irrigation service area and includes the Wahtoke Creek and other small drainage areas north of Cottonwood Creek as well as Cottonwood Creek. Flooding conditions in the Tulare-Fresno Unit are influenced significantly by the canal system of Alta Irrigation District. This system discharges water directly to Cottonwood Creek and Kings River through terminal spill facilities. Also, flood flows originating easterly of the Alta East Branch Canal may enter this canal and subsequently flow to points where they escape to flow overland to Cottonwood Creek. Any plan for control of flood flows of Cottonwood Creek must take into account the reduction in flooded areas north of that creek. For these reasons, the Tulare-Fresno Unit includes the drainage area of Cottonwood Creek as far west as the junction of that creek with St. Johns River, a principal distributary of Kaweah River, and also includes the southwest corner of Alta Irrigation District.

KAWEAH UNIT

The Kaweah Unit encompasses the watersheds of Antelope, Dry, Mehrten, Yokohl and Lewis Creeks and all the distributaries of Kaweah River below Terminus Dam. Many of these distributaries terminate at, and may deliver water into, the Tulare-Kings Unit on the west either through St. Johns River on the north or through Elk Bayou on the south. Since the latter channel also carries flood flows originating in the Lewis Creek drainage area and could carry controlled flows originating in the Mehrten and Yokohl Creek drainage areas, the southern boundary of Kaweah Unit includes the drainage areas of Lewis Creek and Elk Bayou as far west as the junction of the Bayou with Tule River. Both Antelope and Dry Creek drainage areas are included in Kaweah Unit since they either do, or under controlled conditions may, influence flows in distributaries of Kaweah River.

TULE UNIT

The Tule Unit consists essentially of the drainage areas of Tule River between Success Dam and the junction of the river with Elk Bayou. It also includes the Frazier Creek drainage area which lies between the drainage areas of Lewis Creek and the Tule River. The hills immediately north and easterly of Porterville enclose a portion of the Tule River drainage area which also is included in the Tule Unit.

DEER UNIT

The Deer Unit consists of the drainage area of Deer Creek and includes the low foothill drainage areas of Fountain Springs Gulch and Terra Bella—Ducor. The western boundary of the Unit is taken at State Highway 99.

WHITE UNIT

The White Unit is the southernmost Unit and includes the drainage area of White River, the Orris, Vestal and Richgrove drainages and the drainage area of Rag Gulch, a stream originating in Kern County which inundates a small area near Richgrove at the south Tulare County boundary.

MOUNTAIN UNIT

The Mountain Unit contains the drainage areas of the Kaweah and Tule Rivers upstream of Terminus and Success Dams.

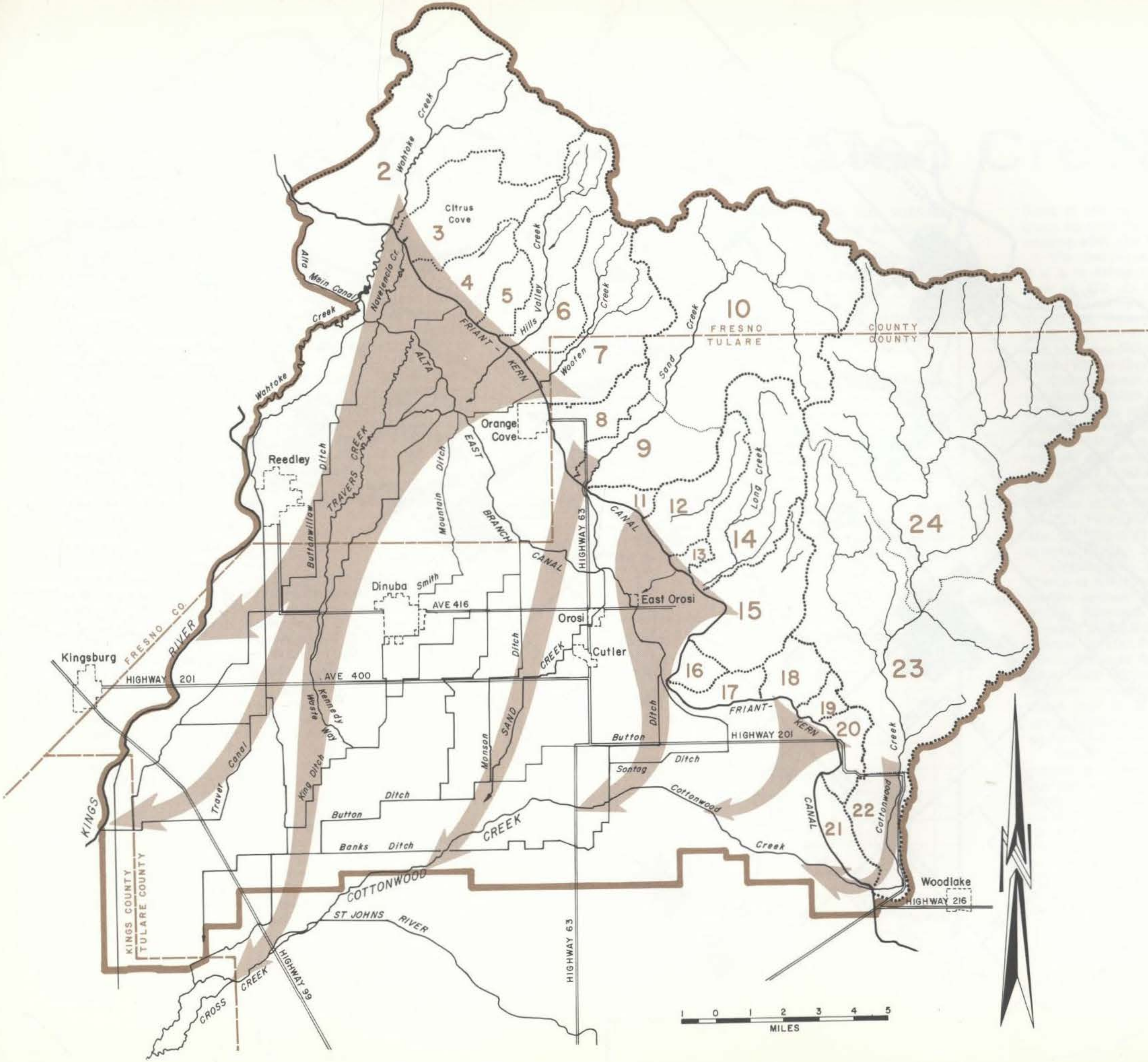
TULARE-FRESNO UNIT

Flood problems in this Unit and their solutions are of concern to landowners in both Fresno and Tulare Counties. Solutions also are of concern to landowners in Kings County since flood flows originating in the Unit may reach that County either through Kings River or the Cottonwood—Cross Creek system. Further studies aimed at implementing the concepts for this Unit accordingly should be approached, if possible, on a bi- or tri-county basis.

Runoff of Wahtoke Creek (Area 2), Citrus Cove (Area 3), Granite Hill (Area 4), Surprise Creek (Area 5), Hills Valley Creek (Area 6), Wooten Creek (Area 7) and Orange Cove (Area 8) produces flooding of Fresno County lands and contributes to flooding in Tulare County. Extensive flooding occurs east of the Friant-Kern Canal and between this canal and the Alta East Branch Canal. To the east of Friant-Kern Canal the flooding results from inadequate channel capacity and, to some extent, obliteration of drainage channels by land development. The flood waters from some of these drainage areas are concentrated by Friant-Kern Canal at siphons or overchutes which enable their flood flows to flow westward toward the Alta East Branch Canal. Flooding between the Friant-Kern and Alta East Branch Canals results from inadequate channel capacity downstream of Friant-Kern Canal crossings and by ponding against the Alta East Branch Canal. The Alta East Branch Canal banks may breach, admitting part of this ponded water to the Canal, in which it will flow southward.

Wooten Creek and Orange Cove drainages also cause direct flooding in Tulare County north and east of the town of Orange Cove by waters which then flow into Fresno County before re-entering Tulare County. Runoff from the drainage areas between Sand Creek (Areas 9-10) and Cottonwood Creek (Areas 22-24) produce flooding which is all within Tulare County.

Basically, the concepts for this Unit would provide for disposal of a maximum of floodwaters in Kings River, with the remainder entering Cottonwood Creek. Flood flows originating in and southerly of Sand Creek drainage area must necessarily be disposed of in Cottonwood Creek due to the distance to Kings River and availability of existing channels. Most of the flows originating in the main drainage area of Wooten Creek and in streams northerly of that creek can be directed through existing or improved channels to Kings River.



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Citrus Cove
Orange Cove
Reedley
Dinuba
Orosi
East Orosi
Cutler
Kingsburg
Woodlake
FRESNO COUNTY
TULARE COUNTY
KINGS COUNTY
FRESNO CO.
KINGS RIVER
FRIANT - KERN CANAL
ALTA
EAST BRANCH CANAL
TRAVERS CREEK
SAND CREEK
COTTONWOOD CREEK
CROSS CREEK
ST JOHNS RIVER
HIGHWAY 201
HIGHWAY 63
HIGHWAY 99
HIGHWAY 216
AVE 416
AVE 400
Wahtoke Creek
Alta Main Canal
Navelencia Cr.
Hills Valley Creek
Wooten Creek
Long Creek
Buttonwillow Ditch
Mountain Ditch
Smith Ditch
Kennedy Waste Way
King Ditch
Traver Canal
Monson
Button Ditch
Santag Ditch
Banks Ditch
MILES
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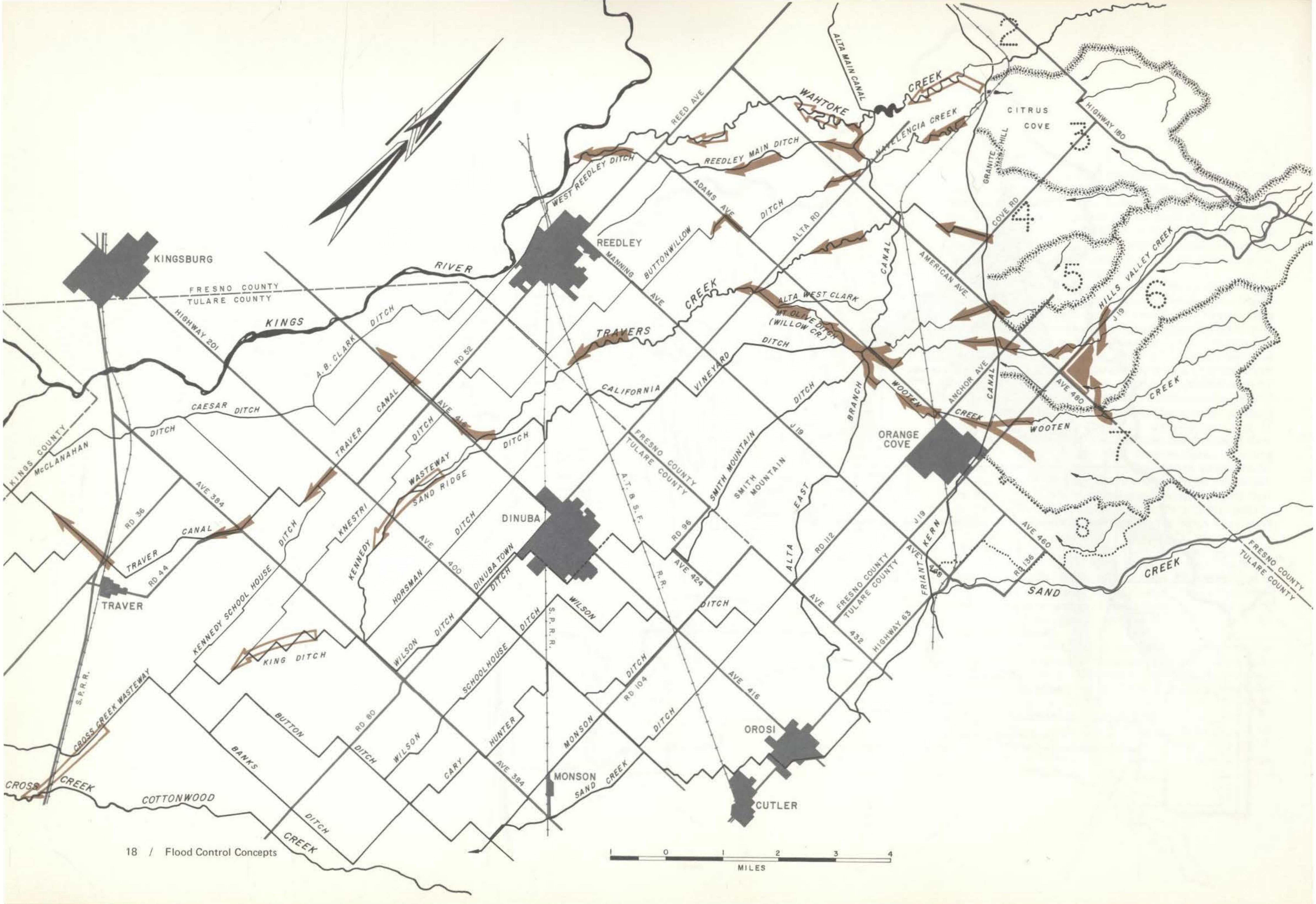
KINGSBURG
REEDLEY
DINUBA
ORANGE COVE
TRAVER
OROSI
CUTLER
MONSON
CITRUS COVE
KINGS RIVER
FRESNO COUNTY
TULARE COUNTY
KINGS COUNTY
HIGHWAY 201
HIGHWAY 180
HIGHWAY 63
WAHTOKE CREEK
ALTA MAIN CANAL
VALENCIA CREEK
REEDLEY MAIN DITCH
WEST REEDLEY DITCH
REED AVE
ADAMS AVE
DITCH
ALTA RD
GRANITE HILL
COVE RD
AMERICAN AVE
CANAL
MANNING AVE
BUTTONWILLOW
TRAVERS CREEK
ALTA WEST CLARK
MT OLIVE DITCH (WILLOW CR.)
HILLS VALLEY CREEK
J 19
ANCHOR AVE
AVE 480
WOOTEN CREEK
BRANCH
VINEYARD
CALIFORNIA DITCH
A. B. CLARK DITCH
RD 52
TRAVER CANAL
CAESAR DITCH
McCLANAHAN
AVE 416
SMITH MOUNTAIN
SMITH MOUNTAIN DITCH
WASTEWAY
SAND RIDGE
KENNEDY
KNESTRI
HORSMAN
AVE 400
DINUBA TOWN DITCH
A.T. & S.F. R.R.
RD 96
AVE 424
ALTA EAST
RD 112
AVE 432
FRIANT KERN
AVE 448
AVE 460
RD 136
SAND CREEK
AVE 384
RD 36
RD 44
KENNEDY SCHOOL HOUSE
KING DITCH
WILSON DITCH
SCHOOL HOUSE
S.P.R.R.
WILSON
RD 104
CROSS CREEK WASTEWAY
CROSS CREEK
BUTTON
BANKS
RD 80
HUNTER
CARY
COTTONWOOD CREEK
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Wahtoke Creek to Wooten Creek

WAHTOKE CREEK (AREA 2)

The channel of Wahtoke Creek between Alta Main Canal and Kings River has a capacity of more than 2,000 cfs. It is reported to have carried 2,000 cfs without damage during the flood of February 1969. Detailed study of Wahtoke Creek channel may reveal that its capacity would have to be increased at a few points between Friant-Kern Canal and Alta Main Canal if flows are introduced from other streams as described below.

The estimated once-in-50-year and once-in-25-year flows of Wahtoke Creek at Friant-Kern Canal are, respectively, 2,400 cfs and 1,680 cfs. These concentrations probably will not occur at these frequencies under present conditions due to ponding east of Friant-Kern Canal. However, flood control measures may be taken in the future to eliminate this ponding; such measures can proceed independently of the concepts discussed below except for possible enlargement of Wahtoke Creek channel at a few points upstream of Alta Main Canal.

CITRUS COVE DRAINAGE (AREA 3)

Channels in Citrus Cove which join to form Navelencia Creek at Friant-Kern Canal may have concentrations of flow of 680 and 970 cfs at the crossing of that canal on the average of once in 25 and 50 years, respectively, if those channels are improved. Some channel improvement of Navelencia Creek is required to carry expected flows in the reach between Friant-Kern and Alta East Branch Canals. Detention storage upstream of the East Branch is considered impractical.

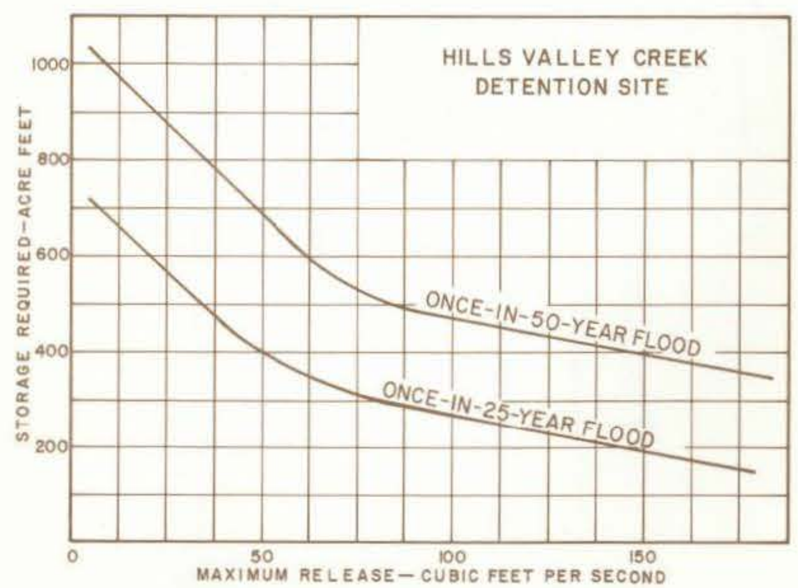
Two alternate concepts are suggested for conveyance of Navelencia Creek flows to Kings River. In one, the creek flood-flow would be diverted as close as possible to the downstream side of the Friant-Kern Canal siphon to Wahtoke Creek for conveyance to Kings River. In the second concept, flows arriving at the Alta East Branch Canal would be distributed by that canal. The Alta East Branch structures would be modified or improved to cause Navelencia Creek water to flow into Buttonwillow Ditch (within its existing or improved capacity) and up the Alta East Branch to Reedley Main Ditch (within the existing or improved capacity of West Reedley Ditch, which can deliver water to Wahtoke Creek). Navelencia Creek flows in excess of quantities which can be diverted to Buttonwillow and West Reedley Ditches would be backed farther up the Alta East Branch Canal to a point where excess water can be spilled directly into Wahtoke Creek. Such a spillway could be located about one-quarter mile north of the Reedley Main Ditch headgate.

The goal of these measures should be to eliminate or minimize the quantity of Navelencia Creek water flowing to the south in the Alta East Branch Canal.

GRANITE HILL DRAINAGE (AREA 4), SURPRISE CREEK (AREA 5), HILLS VALLEY CREEK (AREA 6) AND WOOTEN CREEK (AREA 7)

Granite Hill Drainage and Surprise, Hills Valley and Wooten Creeks are considered together because solutions to the flood problems of all may be related. The basic flood control concept for these drainage areas is the reduction of flood peaks with detention storage where feasible and the collection of releases from detention reservoirs and unregulated flood runoff into Travers Creek for disposal, insofar as possible, in the Kings River.

Flows from Granite Hill Drainage cross Friant-Kern Canal in a culvert and are channelized to the Alta East Branch Canal at the head of Travers Creek. This channel will require improvement to convey even the estimated once-in-25-year flood of 380 cfs. Travers Creek channel appears to have adequate capacity for this flow between Alta East Branch and its crossing with Alta Road.



The channel of Surprise Creek may require improvement if it is to safely convey even the estimated once-in-25-year flow of 270 cfs from Friant-Kern Canal to the Alta East Branch Canal near Adams Avenue. Flows from Surprise, Hills Valley and Wooten Creeks converge on the Alta East Branch Canal near this location. The combined flow of these creeks can be conveyed westward through an enlarged Mt. Olive Ditch (Willow Creek) to Travers Creek at Alta Road.

There appears to be a potential detention reservoir site at the Fresno-Tulare County line in Hills Valley to which flows of Hills Valley and Wooten Creeks could be diverted. Such a reservoir would have a low dike along the north side of Avenue 480 (American Avenue) for a distance of about one-half mile and for a distance of about one mile along the east side of Road J19 (Hills Valley Road). Diversions into the detention area would be made at the north and east ends of the dike with controlled releases being made to the channel of Hills Valley Creek about one-half mile north of the Avenue 480—Road J19 intersection. The reservoir site is presently unimproved.

Coincidental peak flows of Hills Valley and Wooten Creeks at the proposed detention site will be about 1,700 cfs on the average of once in 50 years. A graph for the Hills Valley detention site presents the relationship between required detention basin capacity in acre feet and controlled releases in cfs. For example, a basin having a capacity of about 690 acre feet could control the once-in-50-year combined flow of both creeks to 50 cfs. while a basin of 570 acre-foot capacity could control the once-in-25-year combined flow to 25 cfs. Present uses of the land within the proposed detention basin could continue almost unimpaired under flowage easement arrangements.

Detailed economic studies relating reservoir and release capacities to ability of downstream channels to handle reservoir releases will be needed before the capacities of both can be determined. With some improvement of Hills Valley Creek channel westerly of Friant-Kern Canal it may be possible to deliver low controlled flows into Alta East Branch and through an improved Mt. Olive Ditch (Willow Creek) channel to Travers Creek. It does not appear that Wooten Creek runoff originating south of Avenue 480 will be very large but some channel work will be required between Alta East Branch Canal and the foothill line. Alta East Branch structures will require modifications to limit canal flows to the south and to direct flow into the improved Mt. Olive Ditch channel through the California Vineyard Ditch or any new channel that may be required to implement this concept.

If it is not possible to secure this storage, channel modifications along Hills Valley Creek, Wooten Creek and Mt. Olive Ditch will become much more difficult as will the lower Travers Creek and Traver Canal problems discussed below. Nevertheless, the concept of conveying as much of the flood flow of these creeks to Travers Creek and Kings River, and of relieving Alta East Branch of their flows, should be followed.

TRAVER CANAL

In 1969 Travers Creek is reported to have carried, without damage, a flow of 1,130 cfs as measured at a point east of Reedley. Traver Canal, which starts at Avenue 416, is the head of various Alta Irrigation District ditches, some of which can convey at least small quantities of water to either Kings River or Cross Creek. Water of Travers Creek after crossing Avenue 416 to the west of Dinuba and entering Traver Canal may flow to the west in the Canal or, in small part, south through Alta system canals to Cross Creek Wasteway. However, neither Traver Canal nor its distributary ditches have capacity adequate to convey the flows of Travers Creek if those flows are augmented by flows (even if regulated) of Wooten, Hills Valley and Surprise Creeks and Granite Hill Drainage. Detailed study of disposal of Travers Creek water crossing the Fresno-Tulare County line should include analyses of two basic disposal routes: direct to Kings River and to Cross Creek. Kings River routing is more desirable because there is more opportunity for percolation in the channel of that river, and routing to Cross Creek does not eliminate completely the flood problem along that creek and in Tulare-Kings Unit. Traver Canal, if extended to Kings River, might be used to convey Travers Creek water to Kings River, but in any detailed study the costs of other conveyance facilities, including pipe, with routes north of Avenue 416 should be analyzed even though much of the area is completely developed to permanent crops.

Any plan for improving distribution of water flowing in lower Travers Creek should include consideration of disposal of drainage water originating in the City of Reedley.

Orange Cove & Sand Creek

ORANGE COVE DRAINAGE (AREA 8)

Considerable ponding now occurs to the southeast of Orange Cove from flood runoff of the area designated Orange Cove Drainage (Area 8). This area drains the low foothills northwesterly of Sand Creek (Areas 9 and 10). Wooten Creek now adds to this ponding, a situation which can be alleviated or eliminated under the concepts described above. There is a small pump now installed in a sump at Avenue 460 which drains water into Friant-Kern Canal; however, it is too small to eliminate the present ponding, with the result that excess water flows across the canal into the City, and then southwesterly across developed land to Alta East Branch in the vicinity of the Orange Cove sewage ponds.

Several alternative drainage schemes, in addition to the Wooten Creek modifications, should be studied to eliminate this ponding. A larger pump could be installed and appears to be practical; however, detailed field surveys may show that the existing small drain along Friant-Kern Canal could convey the relatively small flows involved to the first culvert under the canal southeast of Orange Cove. Flow from this culvert and the culvert about one-half mile farther south, which are drainage collection points for areas to the east, can be conveyed to the Alta East Branch Canal and then southward to Monson Ditch, which can convey the flow to Sand Creek at Avenue 400.

SAND CREEK (AREAS 9 AND 10)

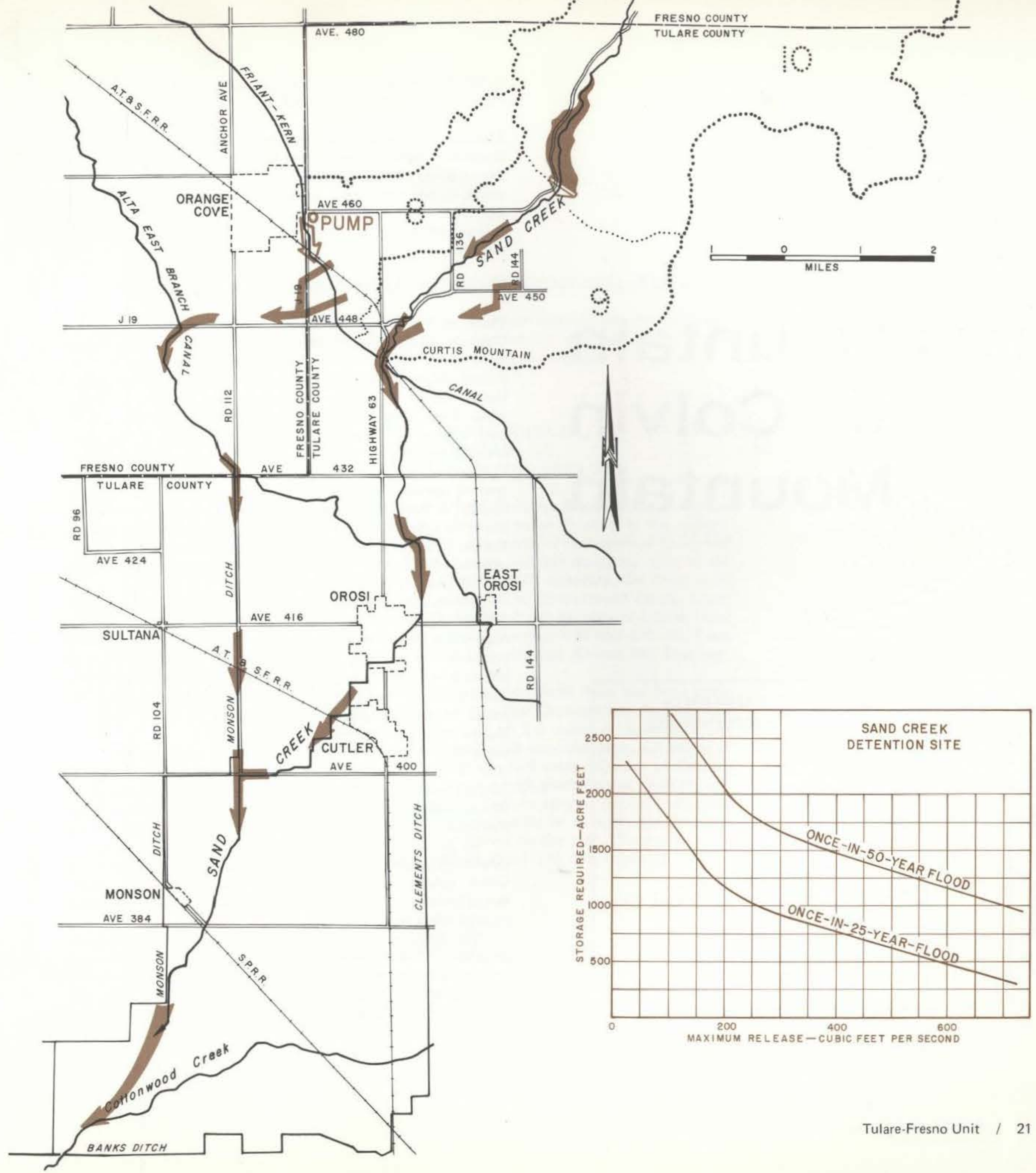
Sand Creek is a major contributor to flooding an area of some 30 square miles east of Road 104 and southerly to Cottonwood Creek. Some of the water flooding this area is carried from the north by the Alta East Branch Canal, but control of Sand Creek, together with the measures suggested previously for more northerly streams, is a key to reduction of flood damage in this area which includes Sultana, Orosi, East Orosi, Cutler and Monson.

A peak flow of 3,520 cfs was recorded in Sand Creek near Orange Cove (about three and one-half miles above its crossing of Friant-Kern Canal) in January 1969. This is almost the once-in-50-year flow of 3,820 cfs. Sand Creek channel needs very little improvement to carry such flows for about one and one-half miles downstream of the Friant-Kern crossing, but below that point capacity of the channel probably is no more than 1,000 cfs. Almost the entire creek channel has been improved and relocated between this point and the vicinity of Cottonwood Creek. Detailed hydraulic study should be made of the channel between Friant-Kern Canal and Cottonwood Creek, but the channel probably cannot be enlarged significantly because of its proximity to Orosi and Cutler. Flows should not exceed more than 500 cfs in this channel upstream of the intersection of Road 112 and Avenue 400 southwest of Cutler. At this intersection it may be advisable to transfer water to Sand Creek from Monson Ditch, which is so located that it can carry water conveyed from the north in the Alta East Branch Canal.

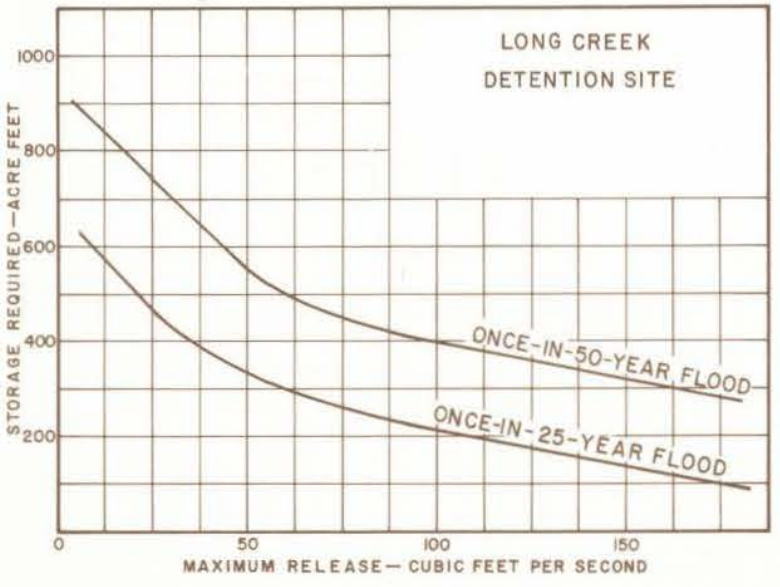
Reduction of anticipated peak flows of Sand Creek by detention east of Friant-Kern Canal is essential. The amount of such storage is directly related to the amount of flow permitted to pass downstream. The relationships between detention basin capacity and controlled releases for once-in-25-year and once-in-50-year flows are presented in graph form. As shown, a basin having a capcity of about 1,300 acre feet could control once-in-50-year flows to 500 cfs.

There are several sites east of Friant-Kern Canal where relatively low dams could be constructed to provide flood storage space of this magnitude. Each of these sites involves different problems of dam volume, foundations, and road relocations and all should be examined in any detailed study of controlling Sand Creek flood flows. The site shown is the one farthest downstream and therefore is the most effective for flood control.

The area between Sand Creek and Curtis Mountain in the vicinity of Avenue 450 is detrimentally affected by flooding and a high groundwater condition. The U.S. Department of Agriculture, Soil Conservation Service, has recommended construction of a drainage ditch commencing at the junction of Avenue 450 and Road 144 and terminating at Sand Creek about one-fourth mile upstream of the Friant-Kern Canal. This drainage ditch will assist in alleviating these problems.



Curtis Mountain to Colvin Mountain



CURTIS MOUNTAIN DRAINAGE AT FRIANT-KERN CANAL (AREA 11)

About ninety percent of the runoff originating in the Curtis Mountain Drainage is now discharged directly into the Friant-Kern Canal through drainage inlets. The balance, which is not significant in terms of flooding, originates in the west end of the area and is dissipated at the railroad crossing of the canal. No flood control works are required for this area.

NEGRO AND LONG CREEKS (AREAS 12 AND 14)

These creeks contribute to flooding in the East Orosi area. Westerly of the culverts conveying their flows under Friant-Kern Canal the channels of both creeks are almost obliterated. Negro Creek may concentrate 510 and 730 cfs at the Canal culvert on the average of once in 25 and 50 years, while Long Creek and its principal tributary, Story Creek, may deliver 950 and 1,360 cfs at the Canal at the same average return periods. These peak flows should be reduced to the minimum capable of being carried in existing or improved ditches between Friant-Kern and Alta East Branch Canals. If Alta East Branch is relieved of flows originating north of East Orosi under the concepts described previously, Button Ditch, extended directly south from Yettem, may be utilized to convey regulated flows of Negro and Long Creeks to Cottonwood Creek.

Regulation of Negro and Long Creeks may be possible and should be given detailed study. The flow of Negro Creek originating above about elevation 950 may be divertable to a reservoir site on Long Creek immediately downstream of its junction with Story Creek. Another reservoir site capable of controlling diverted Negro Creek water and Long Creek water exists on Long Creek above the mouth of Story Creek. As shown in the graph of the relationship between reservoir capacity at the lower site and controlled releases, about 740 acre feet of storage could control the combined once-in-50-year peak flow of Negro, Long and Story Creeks to about 25 cfs. The resulting releases would have to be conveyed past the Friant-Kern Canal to the Alta East Branch Canal.

As an alternative or supplement to such a reservoir, consideration might be given to reducing the size of the Long Creek culvert under Friant-Kern Canal and, with some strengthening of the canal bank, creating added detention storage along the Canal.

The flood runoff from the Negro Creek drainage area not diverted to Long Creek can be collected at the culvert under Friant-Kern Canal south of Avenue 432. Channel work will be required to convey this flow westward to the Alta East Branch Canal northwest of East Orosi.

AVENUE 424 DRAINAGE (AREA 13)

The flood flow from the 0.7 square mile Avenue 424 Drainage may reach peaks of 95 and 130 cfs at 25- and 50-year intervals at Friant-Kern Canal. While there are no data to indicate that 1969 flows from this drainage area inundated land west of Friant-Kern Canal, topography in the vicinity suggests that the runoff may have added to flooding near East Orosi. Utilization of the existing channel and possibly connecting it to ditches which can convey water to Alta East Branch near East Orosi should be studied.

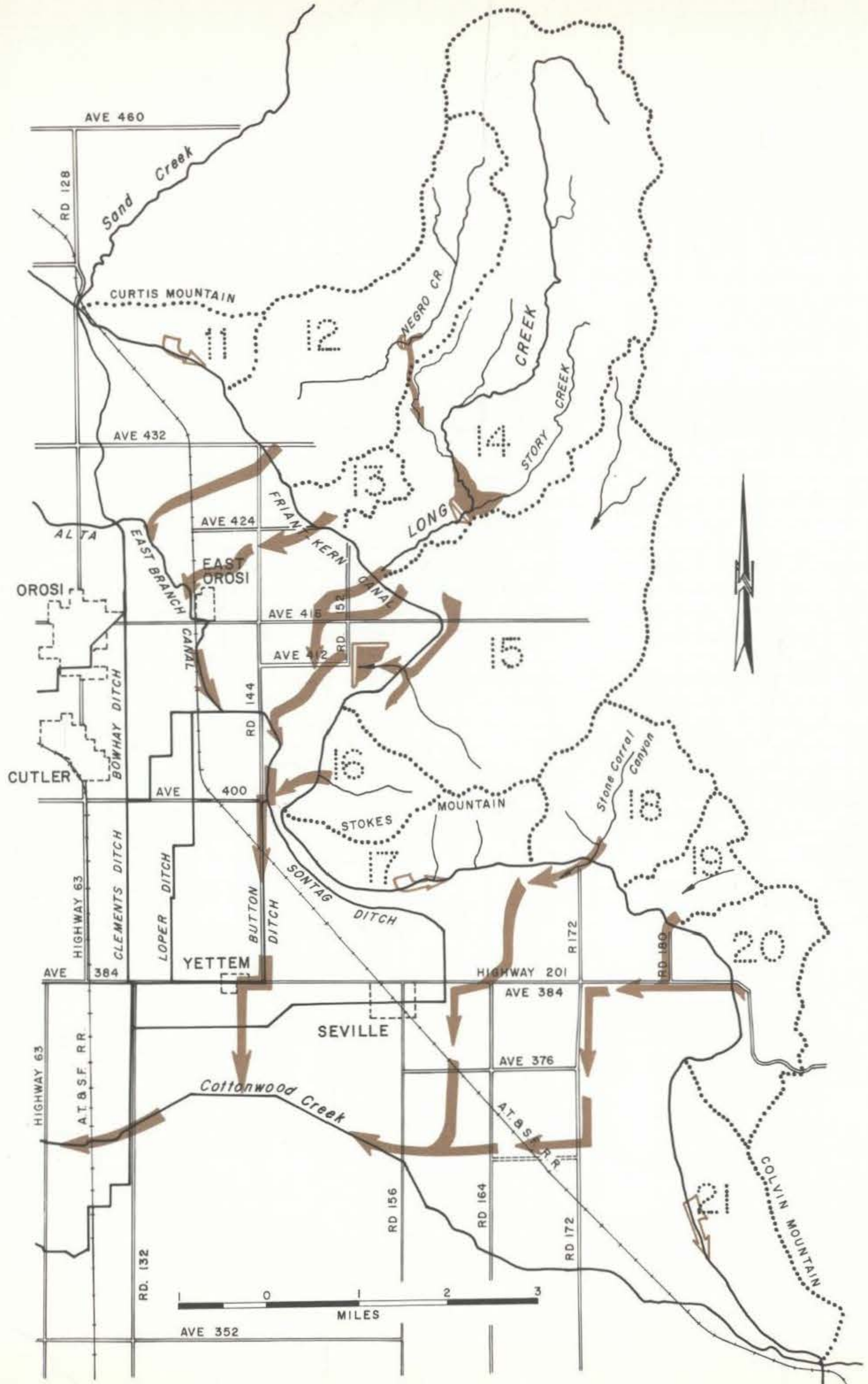
AVENUE 416 DRAINAGE (AREA 15)

Runoff from this 8.4 square mile area, which lies between the crests of Stokes Mountain on the south and east and the Long Creek drainage area on the north, has contributed to flooding west of Friant-Kern Canal. Peak runoff from the area, if concentrated at the canal, could exceed 650 and 930 cfs on the average once in 25 and 50 years, respectively. The area is drained by two large culverts under Friant-Kern Canal, one north and one south of Avenue 416; however, the southern culvert handles runoff from over 95 percent of the area. The Bureau of Reclamation has a right-of-way and maintains a channel from the northern culvert to Avenue 416 and similarly maintains a channel from the southern culvert to Road 152. Beyond the ends of these channels the water courses have been obliterated. Water from the north culvert can be conveyed in an improved roadside ditch along Avenue 416 and joined to the channel conveying Long Creek releases.

Detention storage might be developed on the relatively unimproved land east of Road 152 at Avenue 412 to provide regulation for flows crossing Friant-Kern Canal at the southern culvert. Storage of 375 acre feet can be obtained by constructing a dike about three-fourths of a mile long and to a maximum height of about 12 feet. This detention storage could control once-in-50-year runoff to about 25 cfs, which might be routed with Long Creek releases to Alta East Branch Canal and then down Button Ditch to Cottonwood Creek.

STOKES MOUNTAIN—WEST DRAINAGE (AREA 16)

Runoff from this 1.3 square mile area crosses the Friant-Kern Canal at a culvert about one-fourth mile north of Avenue 400 and may contribute to flooding east of Road 144. There is no defined channel west of the Canal, but consideration should be given to constructing a ditch between the culvert and Alta East Branch Canal.



STOKES MOUNTAIN—SOUTH DRAINAGE (AREA 17)

All runoff from this long narrow drainage area enters Friant-Kern Canal through a number of drainage inlets; consequently no flood control works are required.

STONE CORRAL CANYON (AREA 18),
ROAD 180 DRAINAGE (AREA 19)
AND AVENUE 384 DRAINAGE (AREA 20)

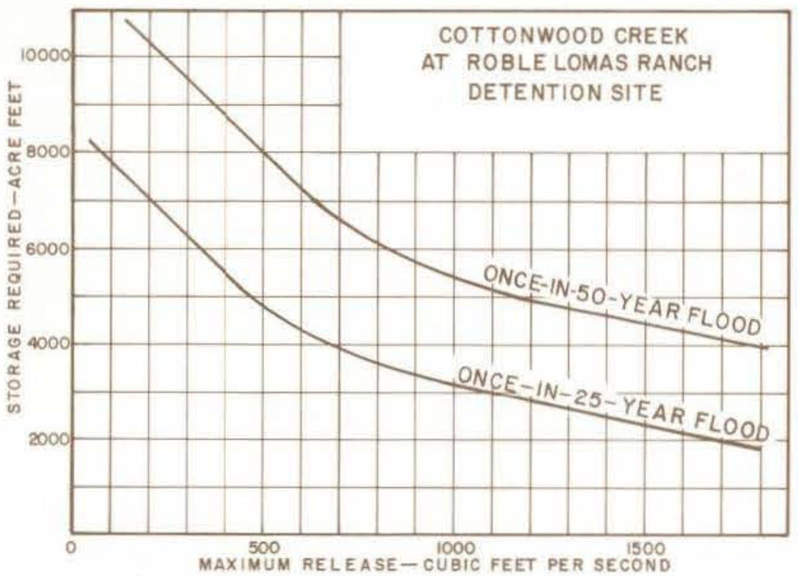
Runoff from Stone Corral Canyon, Road 180 and Avenue 384 Drainage areas causes extensive flooding in the approximately 11 square mile area north of Cottonwood Creek and east of Seville. There are no suitable detention sites in the area to regulate the flood runoff; therefore, the flows must be channelized and conveyed to Cottonwood Creek. Once-in-25- and 50-year flows which can be expected from these drainages are: Stone Corral Canyon, 300 and 430 cfs; Road 180 Drainage, 135 and 190 cfs; and Avenue 384 Drainage, 265 and 380 cfs.

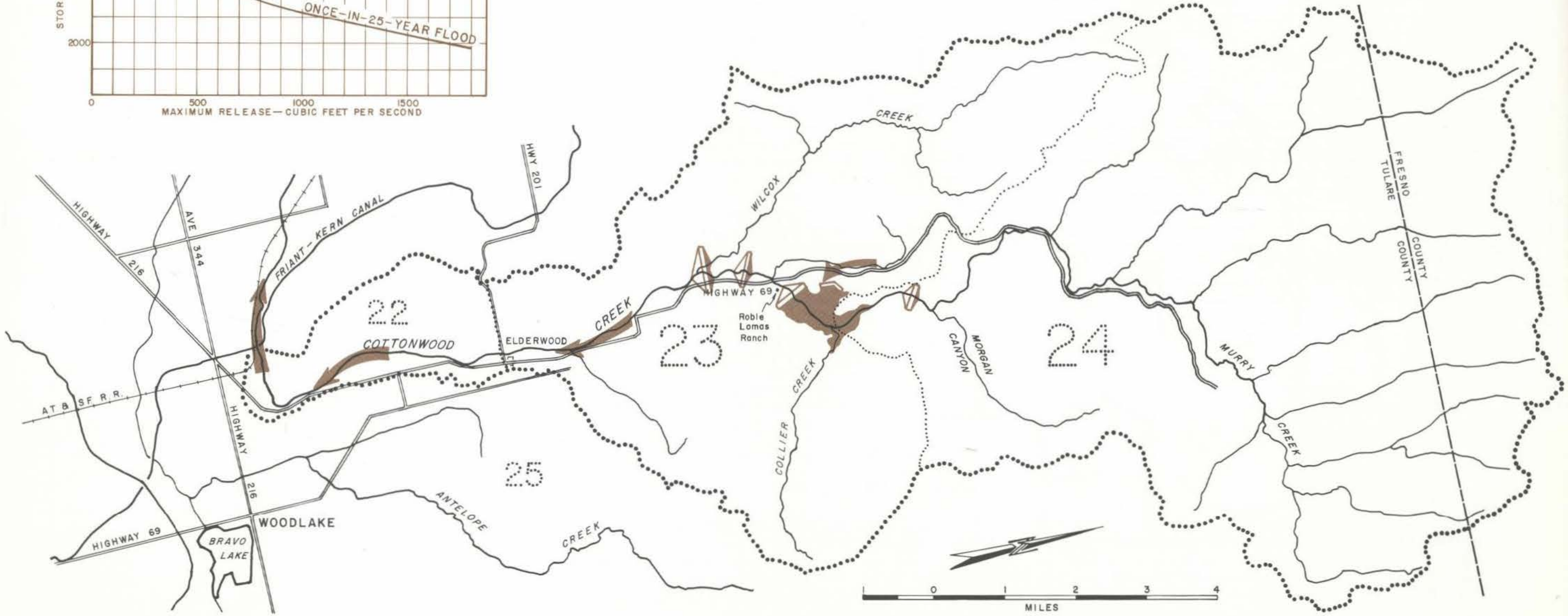
A Public Law 566 Watershed Work Plan has been formulated for this area by the Soil Conservation Service. The plan includes construction of 2.6 miles of open-joint tile drains, 6.4 miles of reinforced concrete pipe, 4.0 miles of open channel and a 230-acre-foot sump adjacent to Cottonwood Creek to ameliorate a high groundwater problem and provide protection against once-in-10-year floods. Under this plan the principal channels would be in approximately the same locations as those shown on the map. The sump would be located to the west of Road 156 and north of Cottonwood Creek.

COLVIN MOUNTAIN DRAINAGE (AREA 21)

This long narrow 2.4 square mile drainage area drains into Friant-Kern Canal through a number of drainage inlets and consequently no flood control works are required.

Cottonwood Creek





ALTA IRRIGATION DISTRICT SYSTEM AND COTTONWOOD CREEK

Prior to discussing flood control concepts for Cottonwood Creek above its junction with St. Johns River, it is appropriate to review the functions of the Alta Irrigation District's system in any plan for control of flooding in the Tulare-Fresno Unit. At present the system provides extensive flood control benefits, epsecially during periods of heavy snowmelt runoff of the Kings and San Joaquin Rivers. It provides these benefits by distributing runoff of the two rivers to farms within the District for direct irrigation and groundwater recharge, thus reducing flood flows along Kings and San Joaquin Rivers and into Tulare Lake. Also, the system probably alters flooding conditions during rain-floods, both within and outside the District boundaries: these alterations are caused by ponding against canal and ditch banks, and by conveyance of water toward the south and west where breaks in canals may produce extensive flooding in combination with flooding from local streams near the breaks. This ponding and flooding provides detention storage which reduces peak flows into Cottonwood Creek, ultimately reducing flows into the Tulare-Kings Unit. Operation, maintenance and reconstruction activities by the District during and after such rain-floods result in increased costs to District landowners.

The physical existence and operational capability of the Alta system should be recognized and utilized fully in any planning for flood control in the Tulare-Fresno Unit. Numerous structural alterations will be required to enable many of the concepts for the Tulare-Fresno Unit to be carried out. Moreover, since significant rain storms may occur on relatively short notice from about November 1 to about April 1 of each season, structure settings should be made and operational procedures established to enable the system to perform flood control functions at any time during the rainy season. The primary operational goal should be to interrupt north-to-south flow in the East Branch Canal at selected points, diverting as much of the canal flow as possible toward the Kings River in order to permit introduction of rain-floods originating easterly of the canal. Of course, peak flows of such rain-floods should be reduced wherever possible through use of detention reservoirs.

During rain-floods much of the tailwater from the Alta system enters Cottonwood Creek above its junction with St. Johns River. The tailwater would be modified in time and amount if the concepts and operational planning described above were implemented. Presently tailwater combines with overland flood flows from the Orosi, East Orosi, Yettem and Monson vicinities, but these latter flows will be modified under the measures previously discussed. However, controlled tailwater will still enter the channel of Cottonwood Creek, joining the St. Johns River at Cross Creek and flowing ultimately into the Tulare-Kings Unit.

The channel of Cottonwood Creek has been improved over the years and levees exist over a part of its length westerly of Friant-Kern Canal. However, these levees are not designed to accommodate inflows from channels and ditches to the north such as Sand Creek; as a result, extensive flooding occurs on both sides of the creek. While much of the flood-prone land along the westerly reaches of Cottonwood Creek is less productive than lands to the east, it is gradually being developed.

Comprehensive planning for Cottonwood Creek should include consideration of the upstream storage discussed below, the necessity of backwater levees along Alta ditches and other channels contributing water from the north, and the effect of flood control measures in the area north of Cottonwood Creek on flows in the Cottonwood Creek—Cross Creek system.

COTTONWOOD CREEK (AREAS 22-24)

The lower reaches of Cottonwood Creek are reported to have a capacity of about 1,200 cfs. Cottonwood Creek at Elderwood has estimated once-in-25- and 50-year peak flows of about 6,170 and 8,820 cfs, respectively. Augmentation of channel capacity west of Friant-Kern Canal sufficient to carry flows of such magnitude is impractical. Also, since elimination of flooding in areas north of the creek through the concepts described previously depends on modifying flood runoff from the north, part of the existing channel capacity west of Seville will be needed to convey the modified flows. Further, as discussed below under the Tulare-Kings and Kaweah Units, flows of Cottonwood Creek and St. Johns River should, insofar as possible, be limited to amounts which will alleviate flooding conditions along Cross Creek in Tulare-Kings Unit. All these considerations dictate need for storage to reduce Cottonwood Creek peak flows at the Friant-Kern Canal crossing. The amount of such reduction will depend on the amount of upstream flood control space provided.

Economic considerations developed in detailed study of the Cottonwood Creek system will be important in determining the frequency and amount of controlled release warranted. Four potential reservoir sites, located three to six miles north of Elderwood, have been identified. Drainage areas tributary to these sites range from 75.6 to 51.4 square miles, as compared to the total drainage area of Cottonwood Creek at Friant-Kern Canal of 88.1 square miles.

A logical storage site appears to be the one located immediately east of State Highway 69 at the Roble Lomas Ranch. In addition to the runoff from the 60.9 square miles of drainage area above the damsite, runoff from the small drainage area to the west of the site could be diverted into the reservoir. Reservoirs lower on the watershed would be more desirable for detention purposes, but may be too costly or otherwise impractical. A graph presents the relationships between storage and releases from a reservoir at the Roble Lomas Ranch site and shows, for example, that storage of about 8,000 acre feet could control once-in-50-year peak inflows to an outflow of about 500 cfs, and that about 10,000 acre feet could control inflows of that frequency to about 250 cfs.

The 17.2 square miles of Cottonwood Creek drainage area below the Roble Lomas Ranch site could contribute peak flows about equal to the capacity of the creek channel immediately west of Friant-Kern Canal. Also, under the previously discussed concepts, it is possible that at times flood runoff from the north may enter Cottonwood Creek at rates of flow higher than occurred during the 1966 and 1969 storms. However, the average coincidence of these two events probably will be less frequent than once in 50 years. Further detailed study of flood control measures in Tulare-Fresno Unit will be necessary to establish the required capacity of the Cottonwood Creek channel.

KAWEAH UNIT

Flood problems in this Unit and their solutions are of concern to landowners in both Tulare and Kings Counties. The natural and man-made channels of the Kaweah River system dominate the Unit and are key elements in present flood control operations in this Unit. One of these channels, St. Johns River, joins Cottonwood Creek and contributes to flooding along Cross Creek in Tulare and Kings Counties and in Tulare Lake. Many of the Kaweah Delta ditches terminate in Elk Bayou and water from those ditches, together with Tule River water, floods land in western Tulare County and can aggravate water management problems in the Tulare Lake area. Other Kaweah Delta ditches, although feeding spreading grounds and reservoirs in western Tulare County, also deliver tailwater into Kings County areas and affect water management problems there. Antelope, Mehrten, Yokohl and Lewis Creeks all have specialized rain-flood problems, but also must be considered in planning flood control measures for the Kaweah River system. Apart from localized flooding, water in these streams literally has "no place to go" at times of large flows in Dry (Limekiln) Creek or large releases from Terminus Reservoir.

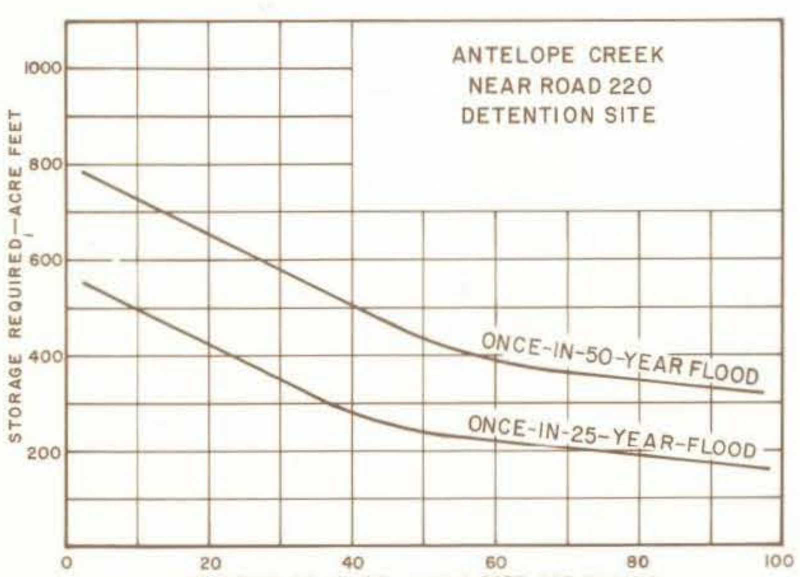
Dry Creek itself is critically important to flood control measures below Terminus Dam; it is reported to have had a peak flow of 14,500 cfs in 1966 about one-half mile upstream of its junction with Kaweah River, an amount to be compared with the objective flow of 5,500 cfs at McKays Point control structure, which divides the flow between St. Johns and Kaweah River channels. Dry Creek also carries large quantities of debris which, in lodging against the control structure at McKays Point, threaten its security and ability to function properly.

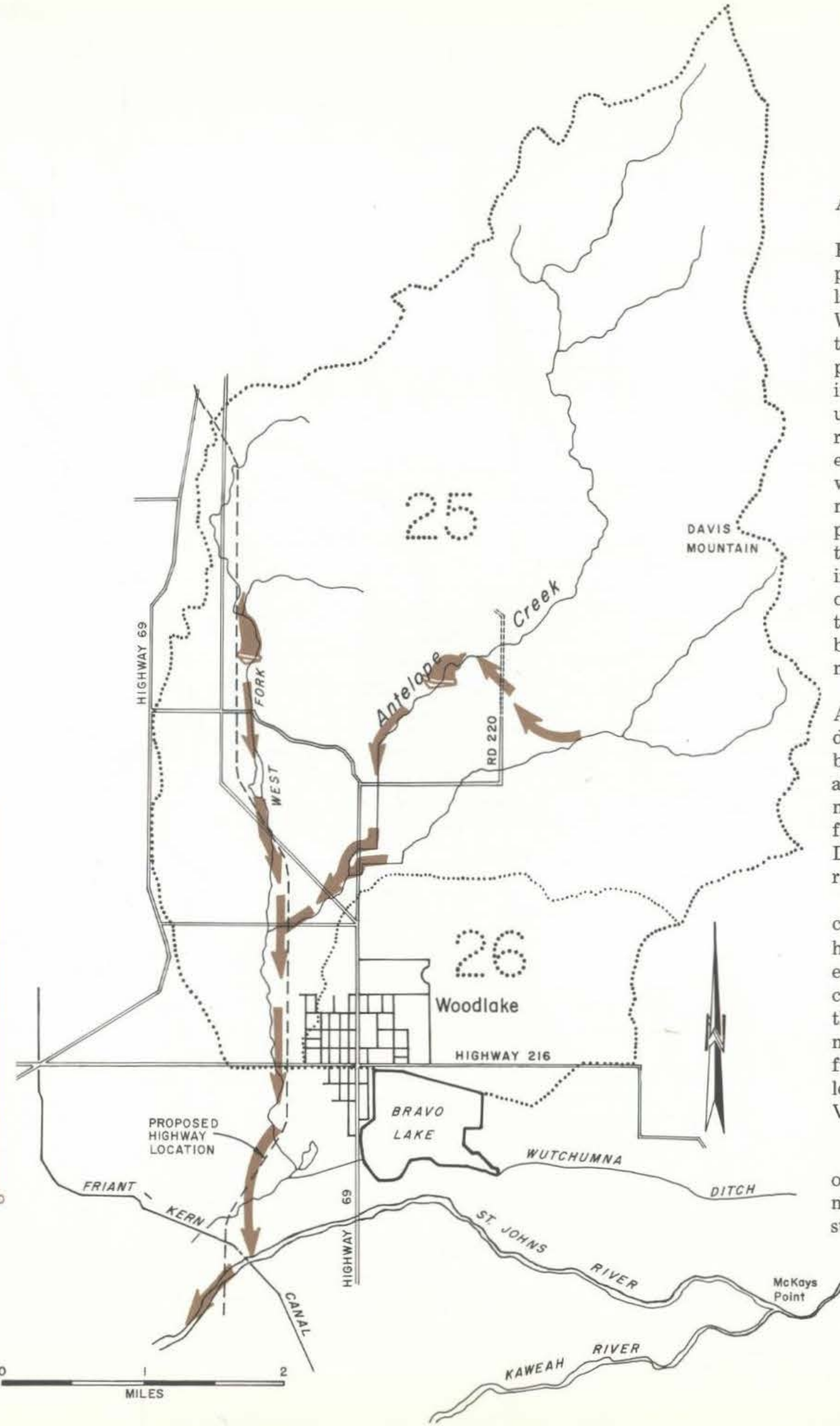
Flows in excess of 5,500 cfs pose serious operational problems at the McKays Point structure. As a result, serious flooding in Visalia is a definite hazard under present conditions. Currently, the Corps of Engineers is studying means of alleviating this problem. Until river flows reaching the structure can be controlled to less than 5,500 cfs (and such control should be the long-range goal as discussed below) correction of the existing hazardous condition is urgently required. Accordingly, every encouragement should be given to early completion of the Corps study and to subsequent corrective measures at the McKays Point structure.

Construction of a large reservoir on Dry Creek, possibly with a tunnel connecting it with Terminus Reservoir, and increasing the size of Terminus Reservoir through gating of the overflow spillway, are currently being studied. These studies should be encouraged and supported since projects which result may eliminate the existing Dry Creek problem, improve control of snowmelt runoff to the benefit of land throughout the Kaweah Unit, reduce flooding in Kings County — especially Tulare Lake — and reduce necessary rain-flood releases from Terminus Reservoir, which would enable the use of Consolidated Peoples Ditch and Outside Creeks to convey controlled rain runoff of Mehrten and Yokohl Creeks.

To summarize, there are three key steps to improved flood control in the Unit: a combined Tulare-Kings County effort to augment flood storage space on Dry Creek and Kaweah River, localized improvements in the Antelope, Mehrten, Yokohl and Lewis Creek watersheds, and continued and improved use of Kaweah Delta ditches and creeks for conveyance and distribution of rain runoff from these low foothill watersheds, both to minimize flood damage and to conserve water through direct crop use and spreading.


FRESNO CO.
TULARE CO.
MILES
FRESNO COUNTY
KINGS COUNTY
TULARE COUNTY
COTTONWOOD CREEK
Cottonwood Creek
Elbow Creek
Wutchumna Ditch
HIGHWAY 63
IVANHOE
HIGHWAY 216
WOODLAKE
25
26
27
28
29
30
31
32
Antelope Creek
DRY CREEK
Lake Kaweah
CROSS CREEK
North Mill Cr.
GOSHEN
ST. JOHNS RIVER
KAWEAH RIVER
McKays Point
HWY 69
VISALIA
MILL CREEK
Foothill Ditch
South Mill Creek
Consolidated Peoples Ditch
HIGHWAY 198
PACKWOOD CREEK
FARMERSVILLE
MEHRTEN CREEK
EXETER
Deep Creek
CAMERON CREEK
TULARE
HIGHWAY 99
MAIN CANAL
Outside Creek
HIGHWAY 65
FRIANT-KERN CANAL
YOKOHL CREEK
LEWIS CREEK
TULARE
HIGHWAY 137
Round Valley
LINDSAY
LEWIS CREEK
Lakeland Canal
ELK BAYOU
TULE RIVER





ANTELOPE CREEK

Runoff from the 20.7 square mile Antelope Creek watershed produces extensive ponding north and northwest of Woodlake; however, Antelope Creek produces flooding within Woodlake city boundaries only in the northwest corner of the City. Antelope Creek is reported to have discharged a peak flow of 1,050 cfs across Highway 216 west of Woodlake in February 1969, although extensive ponding occurred upstream of the highway and a small part of the streamflow reportedly entered the main part of the City of Woodlake east of Highway 69. Since 1969, work has been accomplished which will prevent Antelope Creek water from entering the main part of Woodlake above Bravo Lake. The extensive ponding upstream of Highway 69 indicates that peak flows at the highway during 1969 might have approached the once-in-50-year peak of 1,920 cfs had overflow and ponding not occurred. It also appears that urbanization in the area dictates that detailed planning for flood protection should be based on floods having a frequency of once in 50 years or more.

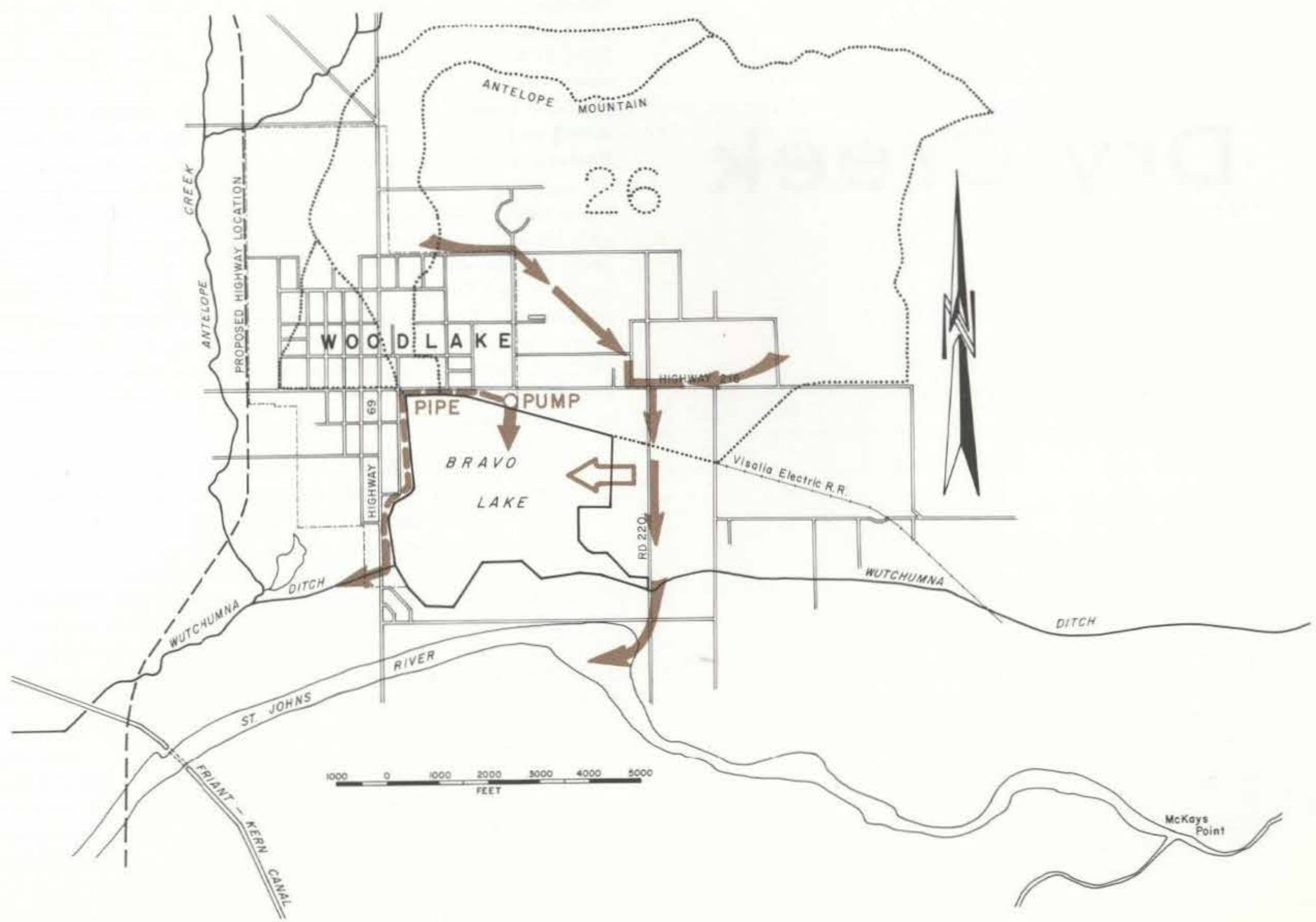
It is highly desirable to provide detention storage in the Antelope Creek drainage, especially on the main creek, which drains the higher portion of the watershed and thus yields the bulk of peak runoff. Only one such detention site appears at all practical. This site west of Road 220 has a probable maximum capacity of 500 acre feet. Additional control of flood runoff can be attained by diverting the flow from the Davis Mountain area northerly into this proposed detention reservoir.

The graph shows the relationship between reservoir capacity at the main-creek site and controlled releases. Four hundred fifty acre feet of storage at this site could reduce the estimated once-in-50-year peak flow of 1,170 cfs from the combined drainage areas to 50 cfs. Below the detention site the existing channels can be improved to deliver the regulated main-creek flow to conveyance facilities along the proposed future alignment for Highway 69. Unregulated flow from below the Davis Mountain diversion structure in Antelope Valley also can be introduced into this improved channel.

Peak flows of several hundred cubic feet per second may occur in the West Fork of Antelope Creek, which joins the main channel northwest of Woodlake. Sites for detention storage on the West Fork are quite limited, there appearing to

Antelope Creek and Woodlake

be only one of about 400 acre foot capacity as shown on the map. Even this small capacity reservoir should be considered in detailed studies since it may be useful in reducing peak flows of the West Fork to a rate which, together with West Fork flow below the detention site, can be channelized along the proposed highway right-of-way to the location of the main Antelope Creek channel. From this location the combined flow can be directed southerly adjacent to the highway right-of-way to the St. Johns River.



ANTELOPE MOUNTAIN—WOODLAKE DRAINAGE (AREA 26)

Past flooding in Woodlake above Bravo Lake has been caused by a combination of Antelope Creek overflow north of the city and runoff from the hills to the east. As noted above, Antelope Creek flows are not now likely to contribute to flooding in Woodlake north of Bravo Lake. The flows from the east are guided by Highway 216 and the Visalia Electric embankment into Woodlake. As shown on the map, interceptor channels could collect flow from the north and east of Woodlake and convey it into Bravo Lake, if feasible, or to St. Johns River. The remaining runoff in the immediate vicinity of Woodlake could be handled by enlargement of the existing pump station and utilization of the 36" pipe around Bravo Lake to Wutchumna Ditch.

Dry Creek

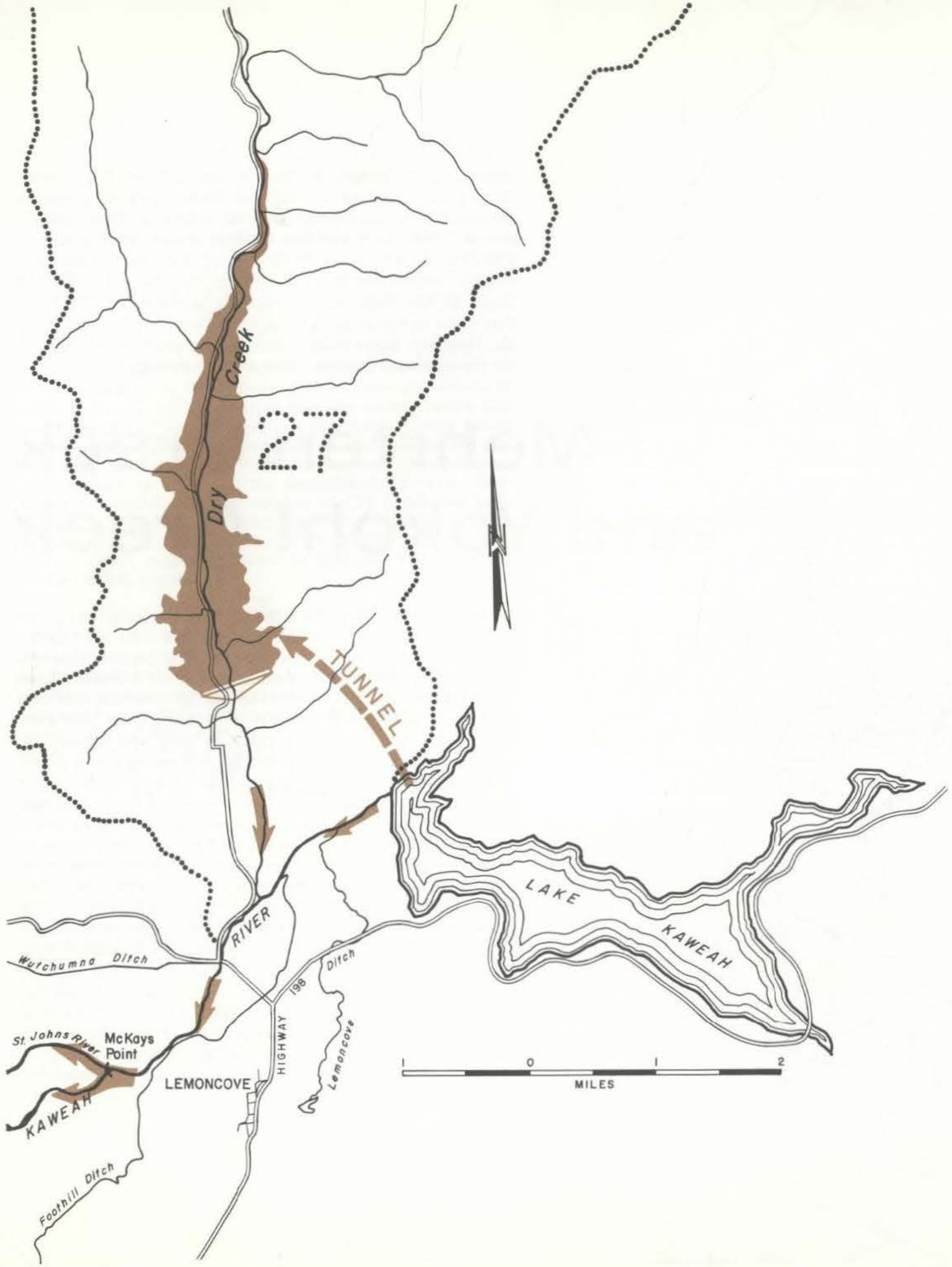
DRY CREEK (AREA 27)

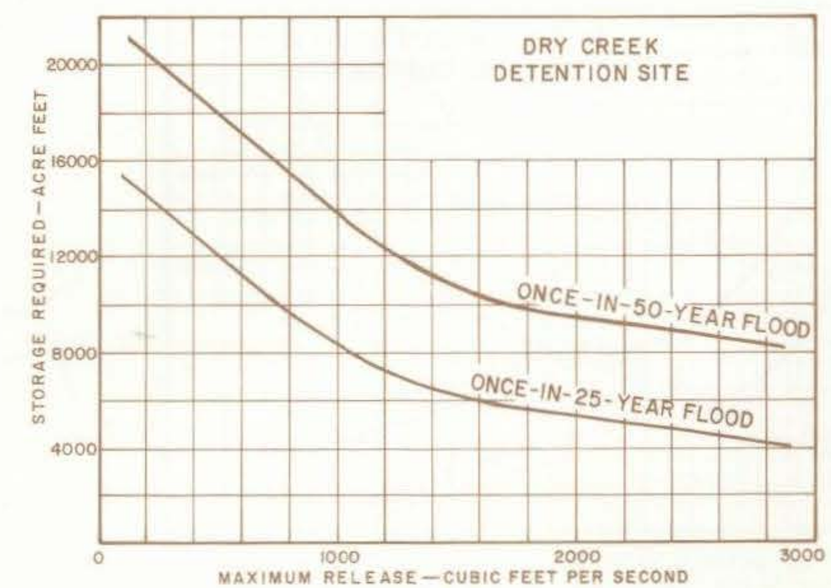
Detention storage on this watershed is essential to all the concepts of flood control in the Kaweah Unit. During the rain-flood of December 1966 releases from Lake Kaweah were minimized so as to aid in reducing peak flows at McKays Point, and although the peak flows of Dry Creek were attenuated considerably through channel storage, flows at the McKays Point weir are reported to have ranged between 8,000 and 9,000 cfs. While there is no assurance that Lake Kaweah rain-flood releases can be controlled as effectively at all times as in 1966, it is obvious that rain-flood flows of more than 5,500 cfs will occur at McKays Point fairly frequently and probably more frequently than once in every 25 years on the average. Furthermore, since the essential concept of rain-flood control in most of the Kaweah Unit requires use of existing Kaweah Delta distribution channels, whose capacity is taxed when flows reach 5,500 cfs at McKays Point, it is clear that the objective flow at this location during the rainy season should be well under that presently established.

Long range studies now underway by the Corps of Engineers include evaluating the merits of increasing the capacity of Lake Kaweah. Increased capacity in the Lake can not only provide urgently needed additional rain-flood protection, but can better control snowmelt-flood runoff to Tulare Lake and can regulate it for improved distribution on the valley floor. Also under study is the possible construction of a large reservoir on Dry Creek connected by tunnel to Lake Kaweah. The wide fluctuations in natural flows of Dry Creek militate against the economic feasibility of a Dry Creek reservoir constructed only to conserve the creek flows and to provide control of its flood runoff. However, combining these purposes with the ability to store Kaweah River water in a Dry Creek reservoir will augment the total benefits through better conservation of Kaweah River snowmelt runoff and reduction of snowmelt damage in Tulare Lake. Reduction of overall rain-flood releases from such a multipurpose project would be a key element in a coordinated system for reducing winter flood damage over a substantial part of the Kaweah Unit. Such a coordinated system must reduce the combined peak rain-flood runoff from Kaweah River, Antelope, Dry, Mehrten, Yokohl and Lewis Creeks to amounts which could be distributed throughout the St. Johns, Kaweah, and Elk Bayou channels at rates which can be managed successfully in both the Kaweah and Tulare-Kings Units.

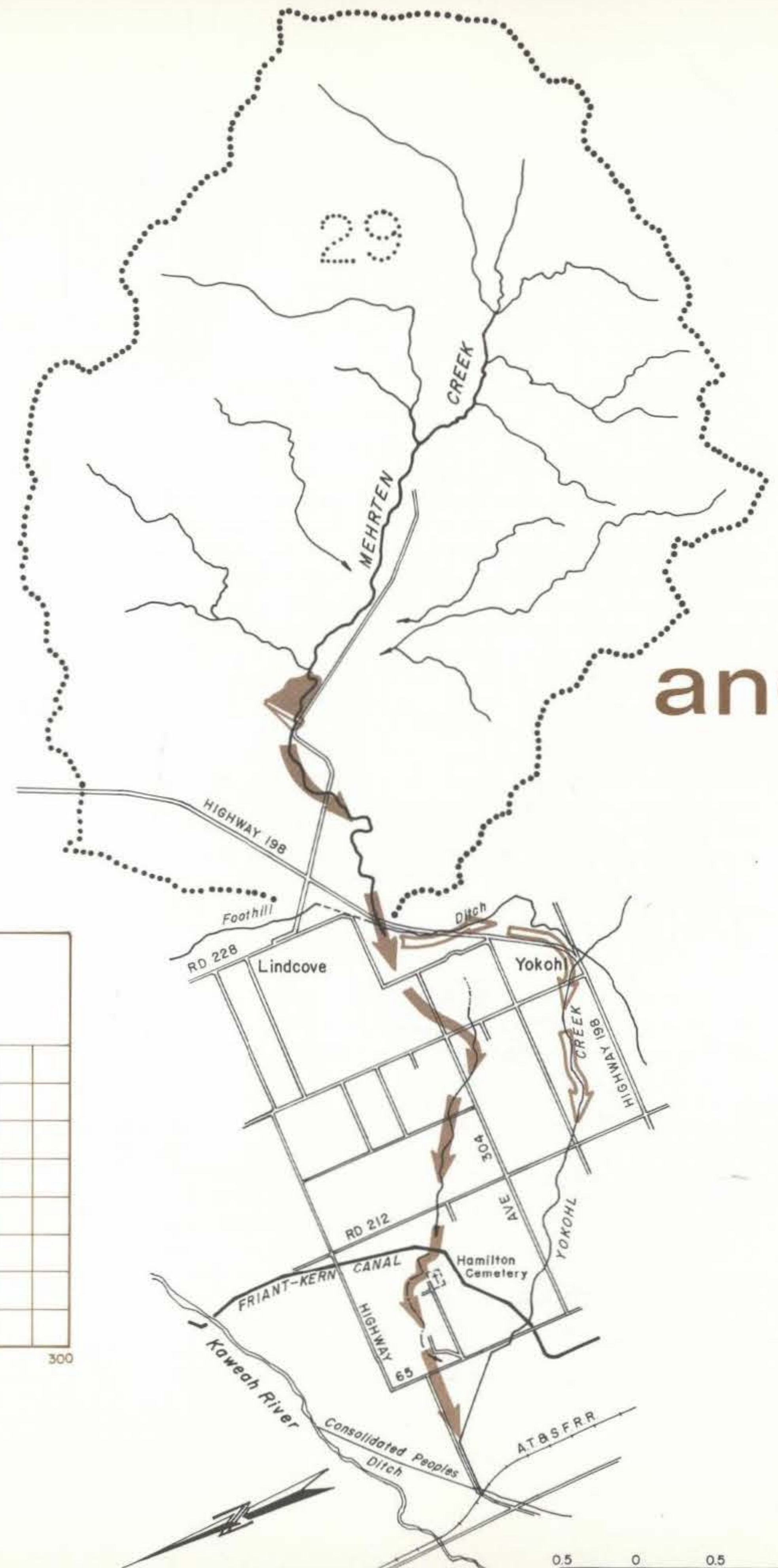
Although flood control storage on Dry Creek is critically needed, and may ultimately be secured best in a large reservoir which can effectively regulate part of Kaweah River snowmelt runoff, it will probably be a number of years before such a project can materialize. In the interim, the hazardous conditions below McKays Point will continue to exist and reduction of flood damages from flows of Mehrten, Yokohl and Lewis Creeks will be more difficult unless detention storage is provided on Dry Creek. Under these practical circumstances, consideration might be given to construction of a single-purpose flood control dam on Dry Creek designed to anticipate eventual incorporation in a much larger dam, such as is now being considered by the Corps of Engineers. The size of such a single-purpose reservoir would depend on the desired amount of control of Dry Creek inflows to the Kaweah River. Relationships between reservoir capacity and controlled releases are shown on the graph for the Dry Creek detention site at the location proposed for the larger reservoir.

If such a single-purpose Dry Creek reservoir is considered in detailed studies of Kaweah Unit, its size must reflect the probability that Terminus Dam releases alone may exceed the 5,500 cfs objective flow at McKays Point perhaps once in 40 years. Also, the reservoir would have to have gated outlets, since it would be necessary to operate it in conjunction with Terminus Dam.


Dry
Creek
27
TUNNEL
LAKE
KAWEAH
RIVER
Wutchumna Ditch
Ditch
HIGHWAY 198
Lemoncove
St. Johns River
McKays Point
LEMONCOVE
KAWEAH
Foothill Ditch
MILES


DRY CREEK
DETENTION SITE
STORAGE REQUIRED—ACRE FEET
MAXIMUM RELEASE—CUBIC FEET PER SECOND
ONCE-IN-50-YEAR FLOOD
ONCE-IN-25-YEAR FLOOD

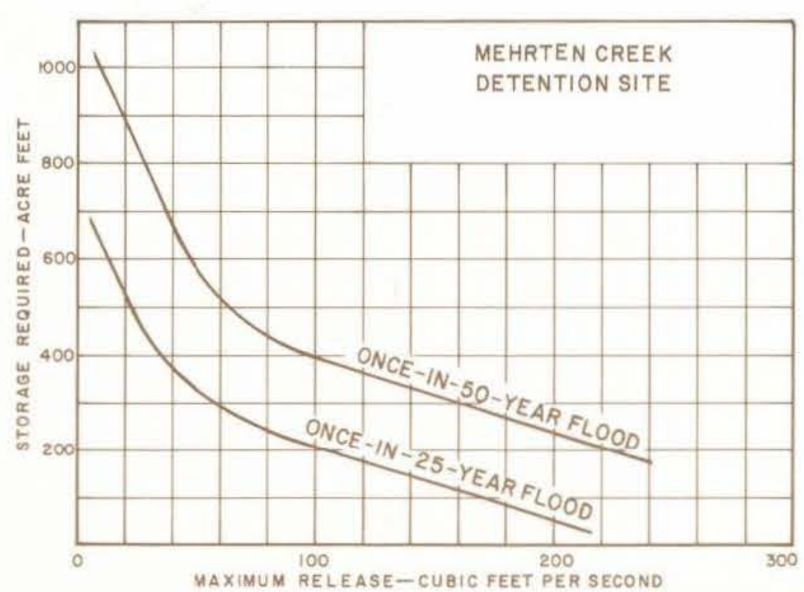
Flood flows of Mehrten and Yokohl Creeks cause extensive inundation of developed orchards east of Friant-Kern Canal, flood property to the outskirts of Exeter by ponding against man-made obstructions, and on entering Consolidated Peoples Ditch, may overflow to other areas to the southwest. The channel of Mehrten Creek west of Highway 198 has been virtually obliterated by land-leveling. The channel of Yokohl Creek at the Highway 198 crossing is restricted, but from that point to Friant-Kern Canal has a capacity of about 2,000 cfs. However, flows of this magnitude cannot be managed in the Consolidated Peoples Ditch without damage.



Mehrten Creek and Yokohl Creek

MEHRTEN CREEK (AREA 29)

As with other detention and channel modification concepts presented in this report, detailed study of Mehrten Creek should explore various combinations of reservoir size and channel capacities and routings to determine the plan most satisfactory from the viewpoints of cost and impact on existing improvements. A graph for a Mehrten Creek detention site located east of Highway 198 shows the relationship between detention storage capacities and controlled releases of flows of Mehrten Creek. As shown, about 860 acre feet of detention storage at this site could control peak flows of Mehrten Creek, expected once in every 50 years on the average, to about 25 cfs at Highway 198. A reservoir with low dikes, having a capacity of 1,000 acre feet, is topographically possible at the site and could reduce such peaks to as little as 10 cfs. It may be possible to convey controlled flows of these magnitudes along the east side of Highway 198 to Yokohl Creek or in conveyance channels to the Mehrten Creek culvert at Friant-Kern Canal then to Yokohl Creek near Consolidated Peoples Ditch. Conveyance even of severely reduced Mehrten Creek flows to points where they will cause no damage will require detailed study because of developments west of Highway 198.

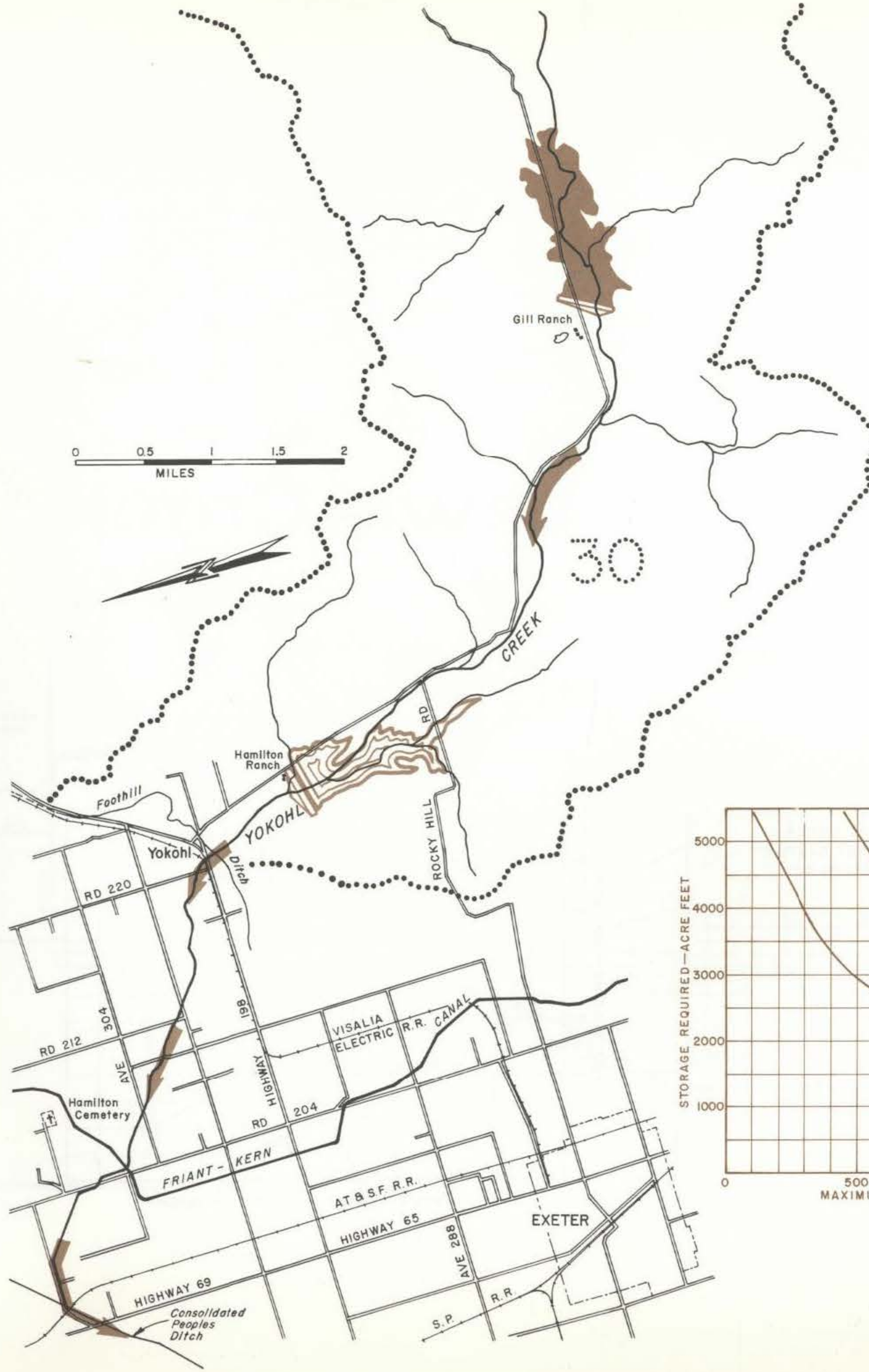


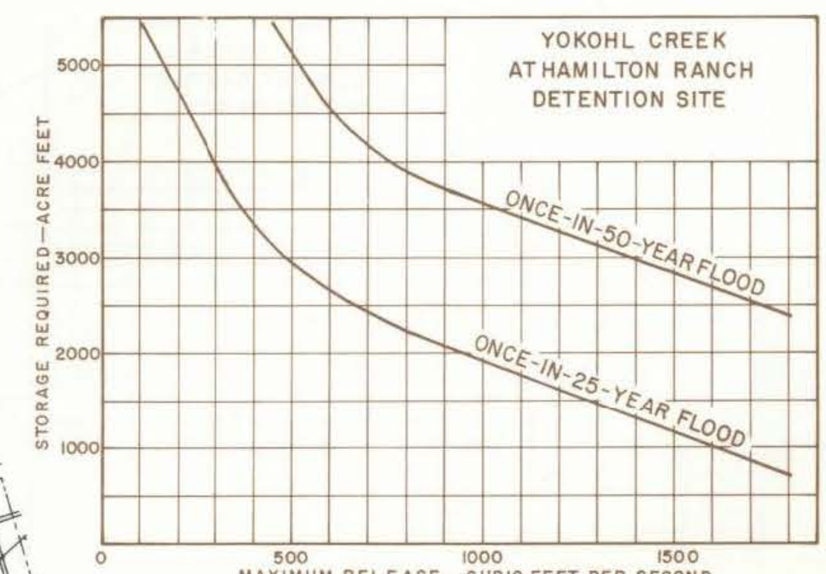
YOKOHL CREEK (AREA 30)

Disposal of regulated Yokohl Creek water poses less difficult problems since such flows can be managed by modification of Consolidated Peoples Ditch, assuming the practicality of the concepts related to McKays Point flows developed in the Dry Creek section above. There are several storage sites physically available on Yokohl Creek, including one near Hamilton Ranch and one near Gill Ranch. The Hamilton Ranch site is lower on the watershed, hence could control more runoff, but the Gill Ranch site appears, topographically, to be less costly. Relationship between required storage capacity and controlled releases at the Hamilton Ranch detention site is shown in the graph. Essentially the same storage volume at the Gill Ranch site is required because runoff below Gill Ranch could not be regulated and additional storage would therefore be required at that site to compensate for the necessarily smaller releases from the reservoir. Depending on the reduction of inflow to the Consolidated Peoples Ditch from the Kaweah River by control of Dry Creek and Lake Kaweah, it appears that a detention reservoir of about 3,000 to 5,000 acre-foot capacity should be capable of controlling Yokohl Creek rain-flood flows to amounts which can be handled in this ditch.

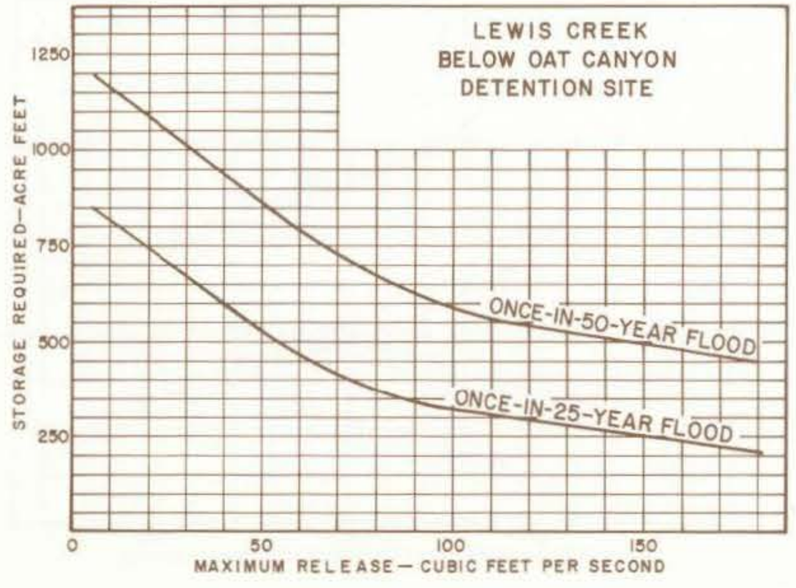
MULTI-PURPOSE PROJECTS ON MEHRTEN AND YOKOHL CREEKS

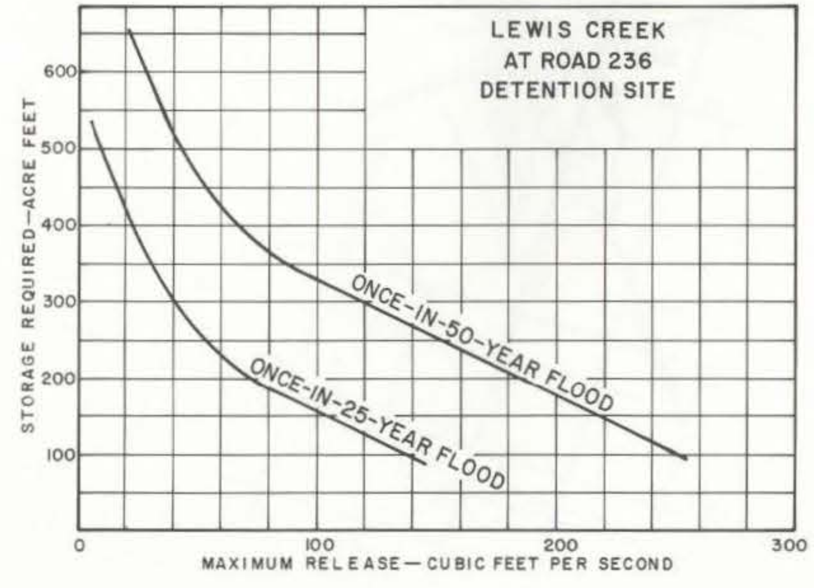
Suggestions have been made that large conservation reservoirs be considered on one or both of these creeks and the sites mentioned previously are topographically capable of such development. Water to be conserved in such larger reservoirs would be pumped into them from the proposed East Side Canal since the dependable supplies of the two creeks are small. The Secretary of the Interior is now considering a report on the East Side Project, Initial Phase, in which consideration is given to the development of several off-channel reservoirs along the proposed East Side Canal, including one in Tulare County on Deer Creek. It is possible that large reservoirs on Mehrten or Yokohl Creeks might be incorporated in final plans of an East Side Project, Ultimate Phase. The small amount of space required for control of rain-floods on the two creeks might be secured more economically as part of a large conservation reservoir than as a separate, single-purpose project. It is likely, however, that the urgency of controlling floods on the two creeks will require such single-purpose construction much earlier than a large reservoir on either creek. It is suggested that in any further planning of a single-purpose detention reservoir, efforts be made to provide for its eventual incorporation into a larger structure or to so locate it as not to preempt the site for a larger dam.





Lewis Creek





LEWIS CREEK (AREAS 31 AND 32)

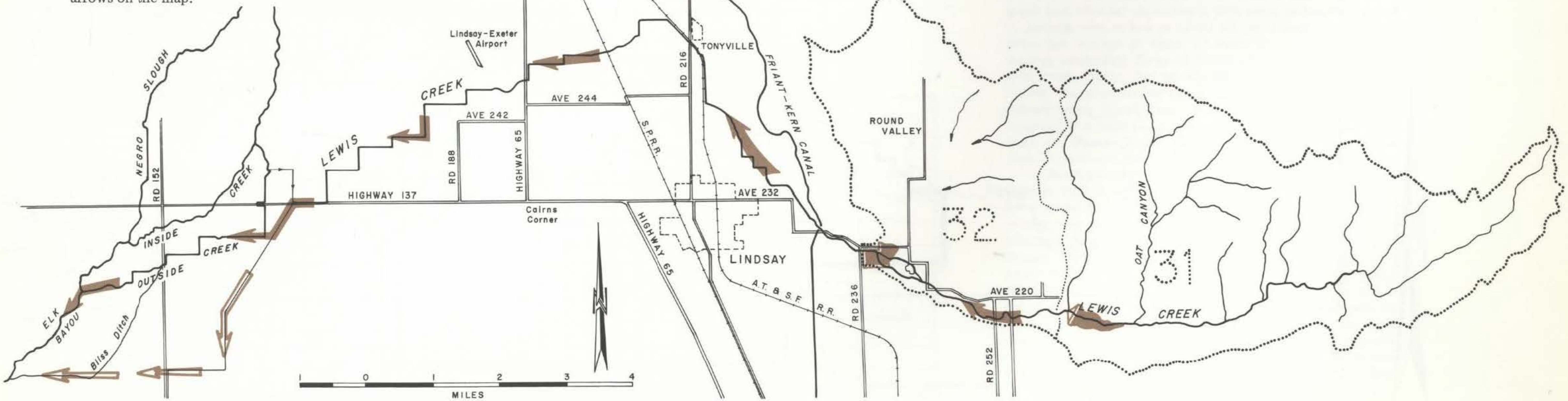
Peak flows of about 1,850 and 2,650 cfs may be expected in Lewis Creek near its crossing of Friant-Kern Canal on the average of once in 25- and 50-years, respectively. The channel capacity is not much more than 250 cfs downstream of this point which is about three miles east of Lindsay. The channel is particularly constricted in the vicinity of Lindsay and Tonyville and is abutted by many improvements, including residences. From Tonyville westward, Lewis Creek has been almost completely realigned during land development. The realigned channel capacity for the most part is believed to be about 250 cfs to its crossing of Highway 137. South of Highway 137 the Lewis Creek channel disappears, resulting in widespread flooding. Flood potentials are best illustrated by the results of the December 1966 and February 1969 storms when 1,900 cfs and 1,480 cfs, respectively, are estimated to have flowed in Lewis Creek about five miles east of Lindsay. These peak flows do not include the substantial runoff contribution from the Round Valley area. From analyses of the flood runoff characteristics of the Lewis Creek watershed, it is estimated that peak flows downstream of Round Valley in the 1966 and 1969 storms were in the order of 2,000 to 2,500 cubic feet per second.

Because of the highly developed land in the vicinity of Lindsay, it would be extremely difficult to obtain the greatly increased channel capacity needed to convey the high rates of runoff produced by the Lewis Creek drainage area. The state of development along Lewis Creek, particularly in the Lindsay-Tonyville area, would indicate at least once-in-50-year protection should be the goal. Detention storage on Lewis Creek is essential if a reasonable degree of flood control is to be obtained.

The upper 16.6 square miles of the Lewis Creek drainage area can be controlled by a dam located below Oat Canyon Creek. Peak flows at this site are estimated to be about 1,130 and 1,620 cfs on the average of once in 25 and 50 years, respectively. The relationship between storage capacity and downstream releases is shown on the graph for this detention site. However, even with no flow passing the Oat Canyon site, the 15.5 square miles of drainage area between this site and Lewis Creek—Road 236 crossing can produce estimated peak flows in Lewis Creek of 1,050 and 1,470 cfs with average frequencies of occurrence of 25 and 50 years, respectively. Additional detention storage can be obtained immediately to the east of Road 236 by construction of about one mile of embankment. The graph showing the relationship between storage capacity and downstream releases for this lower site was prepared assuming no flow passing the Oat Canyon site. As a practical matter, releases would have to be made from the upper site and would pass through the lower detention site to add to the flow of Lewis Creek to the west. The combined effect of releases from both detention sites on the downstream channel must be considered in detailed planning studies of the overall Lewis Creek flood problem.

Because of the critical location of the downstream detention site, it appears essential that outlet facilities be provided at this site capable of passing up to 200 cfs with a minimum of head. Also, during detailed planning the sustained carrying capacity of the entire Lewis Creek channel should be determined.

At present Lewis Creek is not actually connected to the Outside Creek—Elk Bayou system. To implement flood control throughout the Lewis Creek system such a connection will have to be made. Two possibilities of connecting Lewis Creek with Outside Creek and Elk Bayou are shown on the map. The most direct connection is to Outside Creek; however, the ability of Outside Creek to handle this flow in addition to the flows from the north would have to be determined. An alternate possibility would be to direct Lewis Creek flows directly to Elk Bayou as shown by the open arrows on the map.



TULE UNIT

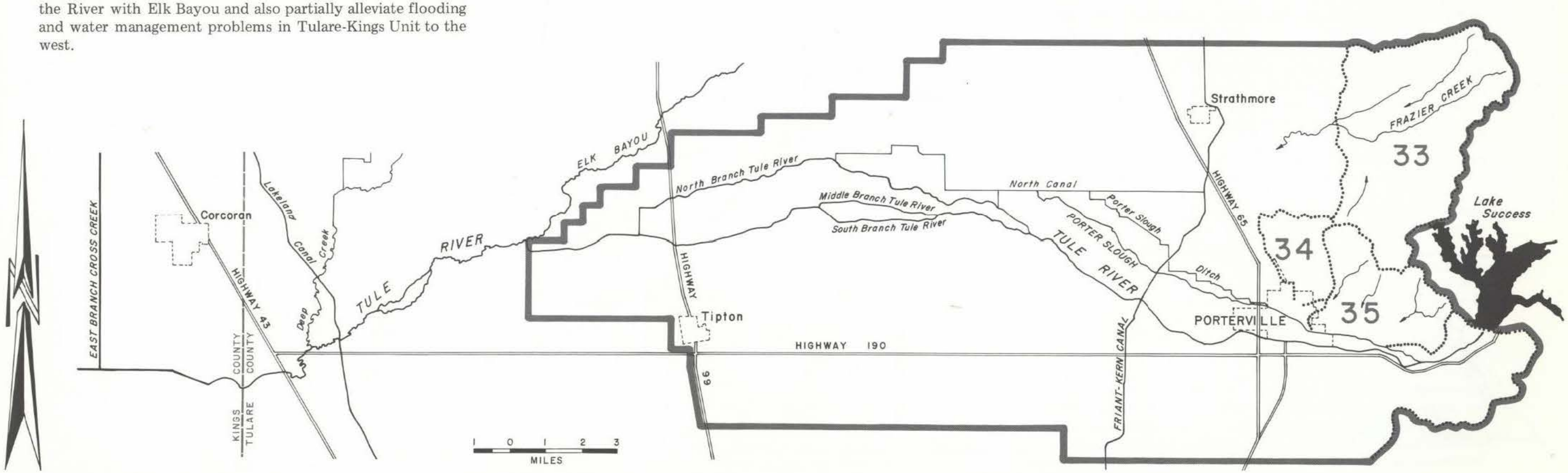
GENERAL

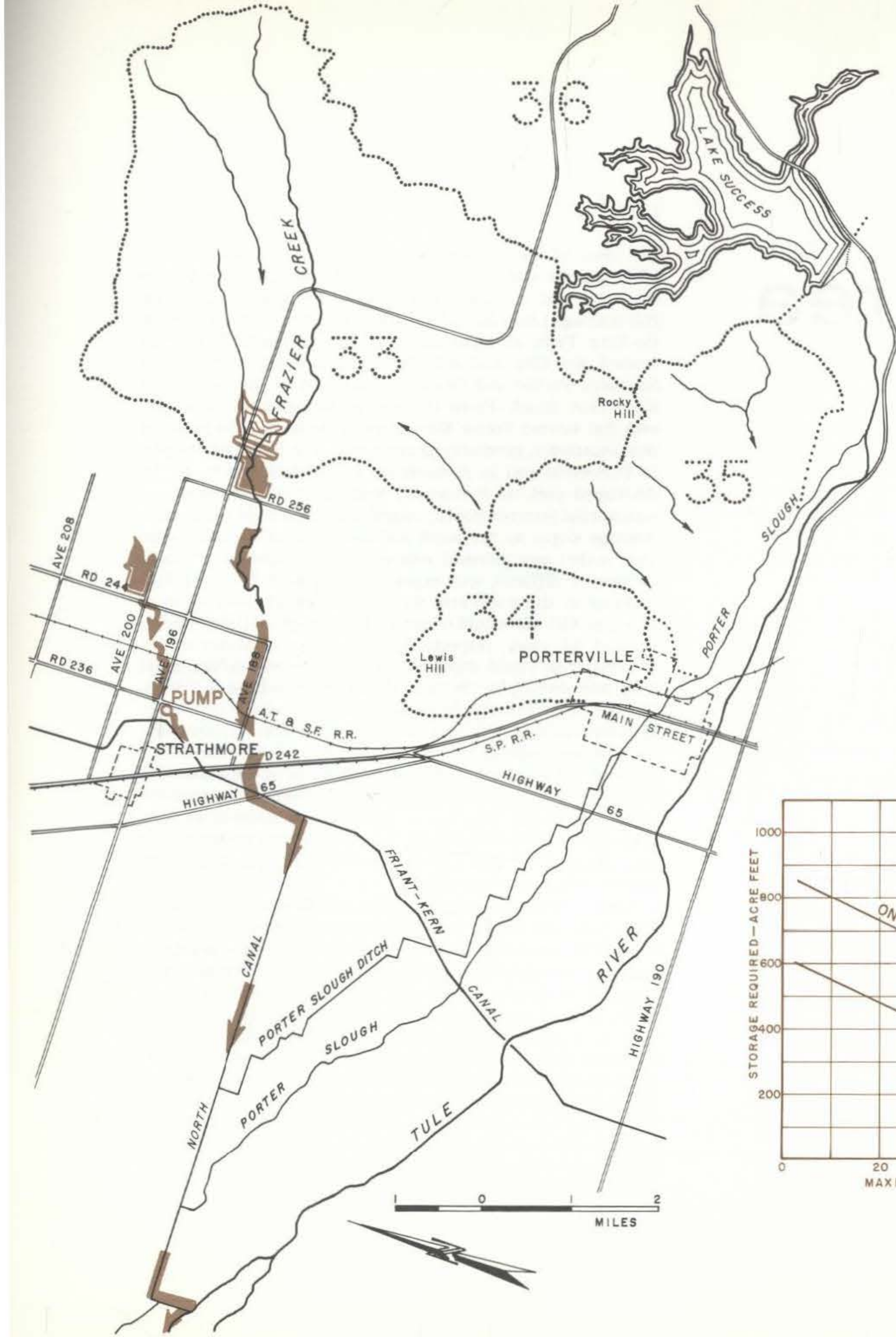
As in the Kaweah Unit, flooding in the Tule Unit and solutions therefor are of interest to landowners in both Tulare and Kings Counties. Success Reservoir provides regulation of rain-floods on Tule River, but as a result of the December 1966 flood and in the interest of better controlling snowmelt runoff, consideration is being given to increasing the capacity of the reservoir. Reduction of peak flows can assist in eliminating flooding near Highway 99 and below the junction of the River with Elk Bayou and also partially alleviate flooding and water management problems in Tulare-Kings Unit to the west.

TULE RIVER

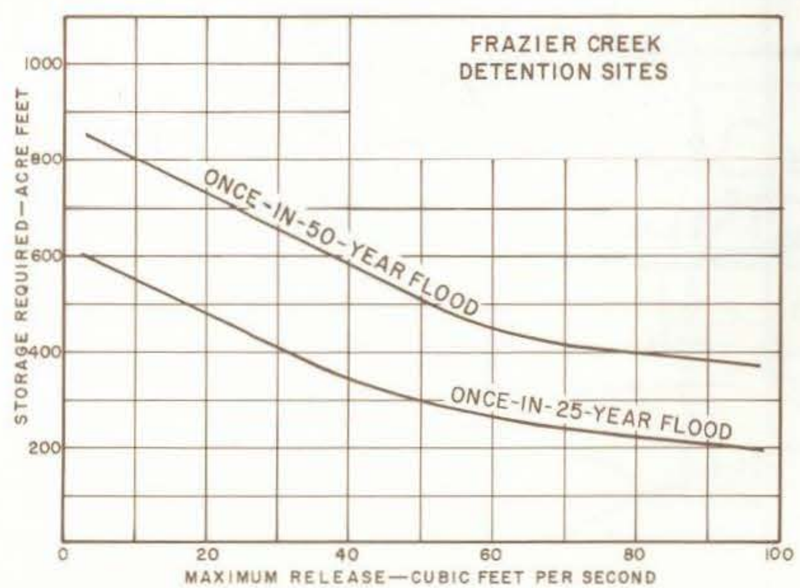
Lake Success provides rain-flood protection to Porterville and most other areas along Tule River especially since considerable channel improvement work has been accomplished. Nevertheless, the objective maximum rain-flood release from Lake Success of 3,200 cfs was unavoidably exceeded in December 1966 when a maximum discharge of 9,050 cfs occurred. The 3,200 cfs objective release was reached in the February 1969 flood. As shown on the Flooded Area Map in the Introduction, some 18,000 acres of land near Tule River above its junction with Elk Bayou were flooded in December 1966. In spite of substantial channel work having been done after that flood, the 1969 storm produced some channel overflow along both branches east of Highway 99. River flows westerly of Highway 99 in 1969, in combination with flows in Elk Bayou, also produced flooding from the junction of the two streams to the vicinity of the Lakeland Canal, a distance of about six miles.

Increased storage capacity in, and reduced rain-flood releases from, Lake Success appear to be the physical solution to the present rain-flood problems on the Tule River. Economic justification for such a solution probably would rest principally on better control and conservation of snowmelt runoff, benefits of which would extend into Tulare Lake.





Frazier Creek



FRAZIER CREEK (AREA 33)

Frazier Creek channel has been obliterated west of Road 256 to Friant-Kern Canal. Where Frazier Creek crosses Road 256, peak flows of 1,010 and 1,440 cfs may occur on the average of once in 25- and 50-years, respectively. There is little question that measures to control such flows to non-damaging rates must include detention, since there are literally no channels to which uncontrolled peak flows of the expected rate can be conveyed without incurring high costs.

At present, only one culvert, located just north of Highway 65 crossing of Friant-Kern Canal, permits drainage to pass under the canal in the vicinity of Strathmore. Although flood waters do tend to pond at the intersection of the Southern Pacific Railroad embankment and the Friant-Kern Canal, the principal cause of flooding both east and west of the railroad crossing is the obliteration of natural drainage channels by land development.

The low hills between which Frazier Creek flows about one-half mile east of Road 256 might form abutments for a low dike across the creek, or detention storage can be obtained at Road 256. Either site could be used to form a reservoir of adequate capacity to control creek flows to rates which could be disposed of in Friant-Kern Canal or, as a possibly more desirable alternative, in North Canal of Lower Tule Irrigation District. The extent of development between the detention site and Friant-Kern Canal probably will require that channel capacities in this reach be less than 50 cfs — perhaps even as low as 10-20 cfs. As shown on the graph, detention storage at either of these two sites necessary to achieve controlled flows of 10-20 cfs is 550 and 800 acre feet, respectively, for once-in-25-year and once-in-50-year floods. These controlled flows could be directed through the culvert under Friant-Kern Canal (north of the Highway 65 crossing) to a ditch along the western side of that canal to the head of North Canal, which should always have excess capacity available during the rain-flood season.

A flood problem also exists east of Friant-Kern Canal at Avenue 196. A siphon under the canal at this location has been closed to reduce flooding in Strathmore and water collecting here is pumped into the canal. Some relief can be afforded by a detention dam east of Road 244. Detention storage at this site could regulate the runoff from a 3.3 square-mile area. If the flow from the east of this site is channelized, peak flows of 340 and 490 cfs can be anticipated once in 25 and once in 50 years on the average. An embankment with a maximum height of about 13 feet could develop about 150 acre feet of storage and control the once-in-50-year flood runoff to releases of about 5 cfs or less, which could be conveniently pumped into the Friant-Kern Canal and greatly alleviate the ponding at Avenue 196.

Porterville Area

LEWIS HILL (AREA 34)

The crest of Scenic Heights trends north from the outskirts of Porterville and, with the east-west crest of Lewis Hill to the north and a north-south ridge to the east, forms Lewis Hill drainage (Area 34) which drains into the northern part of the City. From all three crests, topography gradually flattens toward the City and actually forms a sump between the Southern Pacific and Santa Fe Railroads in the vicinity of Henderson Road. From this sump, topographic slopes are very flat toward Porter Slough and Tule River. The result of this situation is inevitably heavy ponding in the northern part of Porterville and in its northern and eastern outskirts. The developed part of Porterville, with its streets, houses and commercial improvements, occupies the relatively flat natural drainage slopes to the south and southwest of the sump area. This makes any physical solution to the flooding of north Porterville difficult and expensive. If runoff from the hills draining to the sump area were concentrated, peak flows of 315 and 450 cfs would occur on the average of once in every 25 and 50 years, respectively. The urban character of the flooded area would appear to warrant protection against at least once-in-50-year concentrations, but pipelines and drainage channels to carry peak flows of these magnitudes from the sump area would be quite large and therefore expensive.

Pioneer Ditch and Porter Slough pass through Porterville. However, the capacity of each is small in comparison with the peak flow into the sump area. It is considered that the ditch and slough may be taxed to convey flows originating in the part of the City south, east and west of the sump area and cannot be relied on to carry water originating in the watershed north of the City.

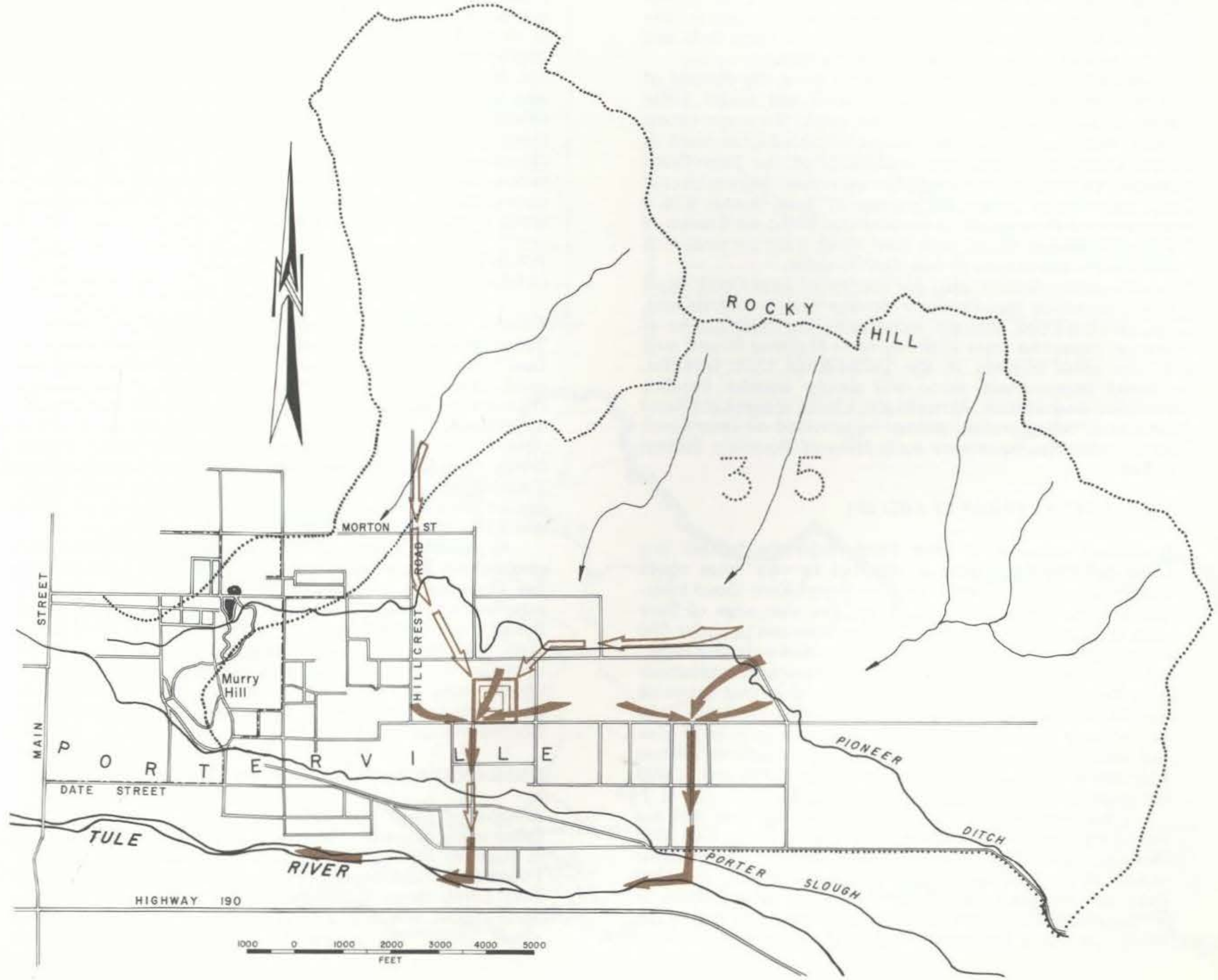
Over five years ago an ultimate drainage system for Porterville was suggested as a part of the General Plan of the City. This drainage system contemplated two detention basins in the general sump area near Henderson Avenue, with disposal in Porter Slough and in Tule River via improved existing ditch systems and, principally, new large open channels. Conceptually, detention storage is essential to control flooding in northern Porterville; conceptually also, draining of detention reservoirs to Tule River following the westerly- and northwesterly-trending land slopes appears to be without reasonable alternative. From hydrology studies made in connection with this report, it appears that some combination of detention reservoirs and main disposal channels might adequately control once-in-50-year floods.

ROCKY HILL (AREA 35)

A separate flooding-drainage problem exists in the eastern outskirts of Porterville. This problem also was studied in some detail during development of the 1965 Master Plan. Flooding in this area results from runoff originating on Rocky Hill to the east of Porterville. Under the 1965 plan interceptor ditches, shown by open arrows, would feed a proposed detention reservoir located east of Hillcrest Road with disposal in Tule River.

It is also possible to intercept the Rocky Hill drainage by a collecting system without utilizing detention storage and dispose of this runoff in the Tule River, as shown on the map in solid arrows. However, Murry Hill drainage to Porter Slough would continue to flow southwesterly as it does today. Some remedial work in the vicinity of Murry Park would be required to eliminate flooding in this area.

As indicated in the 1965 Master Plan, Porterville areas other than the north and east portions also have problems of inadequate drainage. These areas include those south and southwest of the City. The 1965 report suggested three detention reservoirs in these areas which are south of the Tule River, a concept considered appropriate and necessary with disposal of water from the detention reservoirs to Tule River.



DEER UNIT

The Deer Unit encompasses the drainage area of Deer Creek, including Fountain Springs Gulch and the foothill drainage between Terra Bella and Ducor. Extensive flooding occurs along Deer Creek and on the branches of Fountain Springs Gulch in the vicinity of Terra Bella. The only appreciable area of flooding reported in 1969 between Terra Bella and Ducor was about 500 acres west of Highway 65.

Numerous diversion weirs exist all along the channel of Deer Creek west of Friant-Kern Canal and divert water into ditches leading away from the creek. To some extent these weirs may direct flood waters into the ditches north of Deer Creek. To ensure the availability of the Deer Creek channel to carry flood waters, the weirs must be constructed and operated to permit the passage of flood waters with a minimum of obstruction. It is noted that at the confluence of Fountain Springs Gulch with Deer Creek there are numerous man-made obstructions to free flow of water.

No comprehensive plan for control of Deer Creek flood flows, including the Fountain Springs Gulch contribution, can be developed without recognizing the inadequacies of channel capacities from Highway 65 to Highway 99 and west of the latter highway in the Tulare-Kings Unit; however, channel improvement alone will simply transfer flooding problems downstream. Accordingly, a basic concept for flood control is that detention storage be provided on Deer Creek and, preferably, on one or both forks of Fountain Springs Gulch.

DEER CREEK (AREAS 37 AND 38)

In-channel capacity of Deer Creek from the foothill line northwest of Terra Bella is reported to vary from about 4,000 cfs to about 5,000 cfs at the Friant-Kern Canal crossing. Between Friant-Kern Canal and the west edge of Deer Unit at Highway 99, channel capacity decreases to about 350 cfs, although the highway bridge is reported to have a capacity of 2,000 cfs. Flows exceeded these capacities substantially in the February 1969 flood with the result that extensive over-bank flow occurred from Highway 65 near Terra Bella all the way to Highway 99. The estimated once-in-25-year and once-in-50-year flood flows of Deer Creek at Avenue 120, about six miles east of Terra Bella, are 7,730 and 11,000 cfs, respectively.

A reservoir having a capacity of 800,000 acre feet has been proposed on Deer Creek as a feature of the East Side Division, Initial Phase, Central Valley Project. This reservoir would derive its water supply almost entirely by pumping from the proposed East Side Canal since natural flows of Deer Creek vary widely from year to year and cannot be relied upon as a firm water supply. If such a large reservoir were to be constructed in the near future, capacity to regulate Deer Creek rain-flood runoff could be secured economically. However, it may be that 10 or even 20 or more years may elapse before the proposed Hungry Hollow reservoir is completed; accordingly, consideration should be given in detailed studies of Deer Unit to construction of a small, single-purpose detention reservoir near the Hungry Hollow site. If the Hungry Hollow site proves too expensive or otherwise impractical, consideration might be given to providing detention storage on Deer Creek farther upstream where there are several potential dam and reservoir sites. Required detention capacities on Deer Creek at Hungry Hollow for various controlled flows are shown on the graph. To control a once-in-25-year flood to a release of 200 cfs would require about 17,000 acre feet of storage.

FOUNTAIN SPRINGS GULCH (AREAS 39 AND 40)

Fountain Springs Gulch watershed lies east and south of Terra Bella and contributes significant rain-flood runoff to Deer Creek, thus aggravating flooding problems along that creek west of Highway 65. The Gulch itself has two principal channels which join and then enter Deer Creek east of Highway 65. The principal channel is the main Gulch, shown as Area 40, and a second channel drains the Fountain Springs North Drainage, Area 39. Peak runoffs expected from the Fountain Springs Gulch and Fountain Springs North Drainage for once-in-25-year and once-in-50-year floods are 1,400 and 2,000 cfs and 840 and 1,200 cfs, respectively.

A possible detention site on Fountain Springs Gulch exists about five miles southeast of Terra Bella. The graph for the Fountain Springs Gulch detention site shows that 640 acre feet of storage is required to control releases to 50 cfs during a once-in-25-year flood. There is also a possible detention site on the North Drainage located immediately upstream of its confluence with the main Gulch near Deer Creek; under present conditions, storage of about 500 acre feet could be developed at this site to control runoff from North Drainage into Deer Creek.

DEER CREEK WEST OF HIGHWAY 65

Analysis of flood flow data makes it clear that further detailed study of control of Deer Creek rain-flood runoff west of Highway 65 may require combinations of Deer Creek and Fountain Springs Gulch measures. Even with storage of all Deer Creek flows at Hungry Hollow damsite, downstream flood runoff would still result in flows west of Highway 99 which exceed the present limited channel capacity. Even higher uncontrolled peak flows would occur at Highway 65 Bridge over Deer Creek if the storage sites upstream of Hungry Hollow were used. Thus, detention storage on either or both Fountain Springs Gulch or its North Drainage is desirable.

From the foregoing, it is concluded that storage on the Deer Creek channel in the vicinity of the Hungry Hollow site and at the Fountain Springs Gulch site, with some channel rectification work along Deer Creek, could give a reasonable degree of protection west of Highway 65 for the current level of development. Detailed planning of storage on Deer Creek should recognize that significant amounts of snowmelt runoff occur from the watershed in some years and that much of such runoff will enter Tulare Lake unless it is controlled. Substantial snowmelt runoff enters the lake from all Tulare Basin streams in such years and any Deer Creek inflows should be reduced if possible. If single-purpose detention storage is provided on Deer Creek, consideration should be given to gated outlets which could be left completely open during the rain-flood season and used to regulate snowmelt inflow to a reasonably useful irrigation pattern without adding to flooding of Tulare Lake.

TERRA BELLA—DUCOR DRAINAGE (AREA 41)

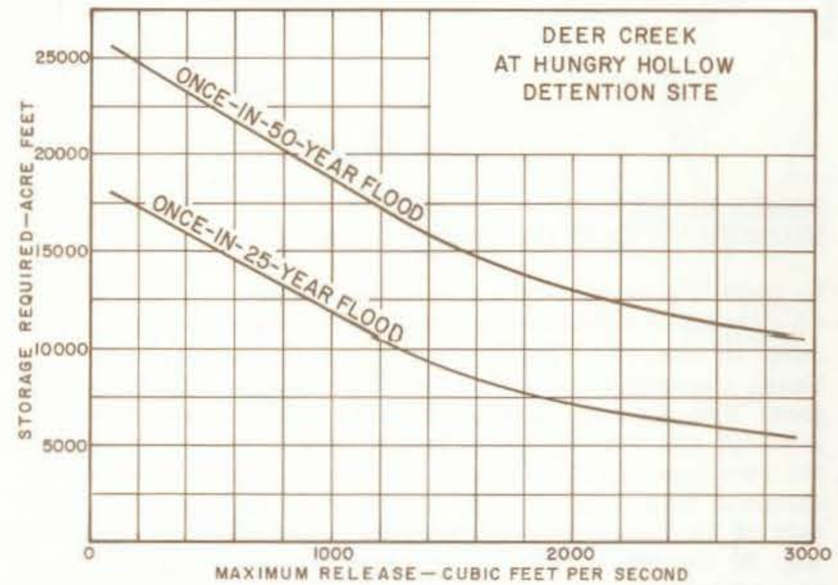
This 16.9 square mile drainage area lies between the Fountain Springs Gulch and White River watersheds. In February 1969 several hundred acres of land between Highway 65 and Friant-Kern Canal were inundated by runoff from Terra Bella—Ducor drainage. Concentrations of 610 and 870 cfs at Friant-Kern Canal can be expected from this watershed on the average of once in 25 and once in 50 years, respectively, if the flows are channelized to this location. However, the channel is ill-defined or obliterated over most of the distance west of Highway 65 and if conditions east of the highway remain the same as they are today, it is probable that the peak flows at Friant-Kern Canal will be less than those indicated since the runoff is dissipated in flooding above the Canal.

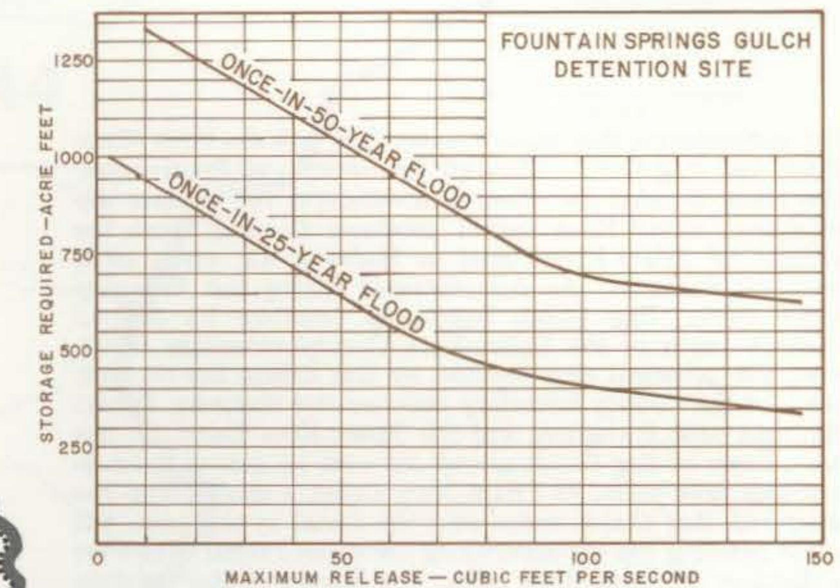
Detailed studies of the Terra Bella—Ducor drainage should consider zoning and/or land development controls adjacent to defined channels, detention storage, and channel dedication and improvement. Volumetric data indicate that detention storage of about 200 acre foot capacity combined with downstream disposal-channel capacity of about 25 cfs might be considered at the site shown in Area 41 on the map. However, the contributing area to this detention site is relatively small. There are several other sites for detention storage in and upstream of the area inundated in 1969 which should be examined in detailed studies.

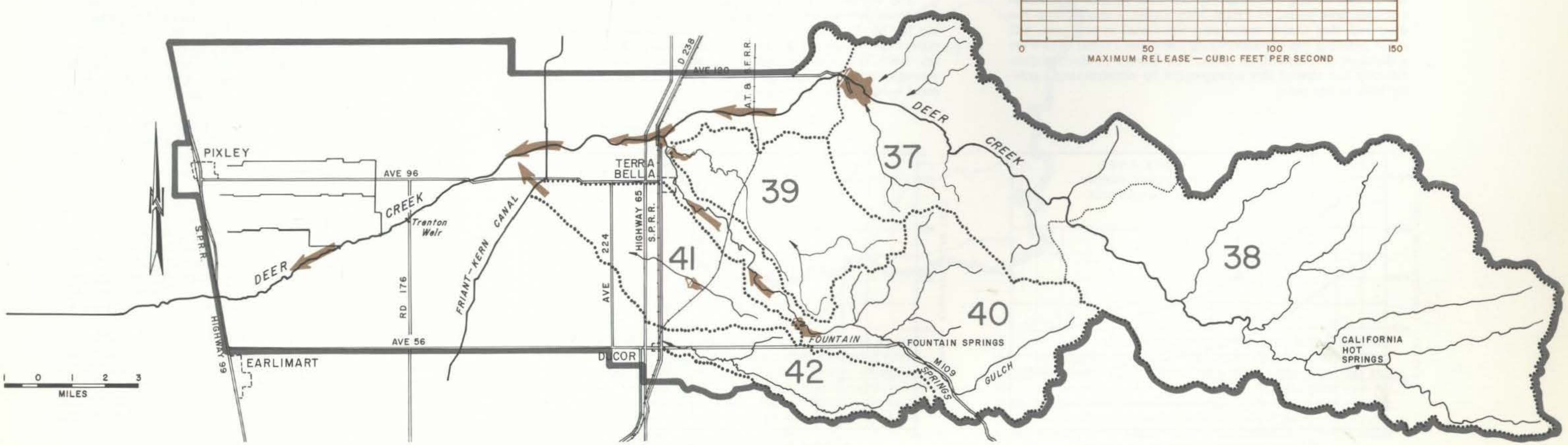
DUCOR EAST DRAINAGE (AREA 42)

The 13.9 square mile Ducor East Drainage Area is drained by a poorly defined channel. In addition, the drainage characteristics of the watershed are such as to produce a relatively slow runoff rate. The peak flows of 540 and 770 cfs for once in 25 and once in 50 years, respectively, assume the runoff is channelized.

In a way, this drainage area is presently close to the state-of-nature condition of lower foothill watersheds in Tulare County and can be considered typical of such areas prior to land development and other activities of man. So long as the water course east of Highway 65 is not obliterated by land development it is not likely that storms over the watershed will cause major damage. However, unless the flood potential in the area is recognized and planned for, it is probable that uncontrolled developments inevitably will result in increased flood damage in coming decades.

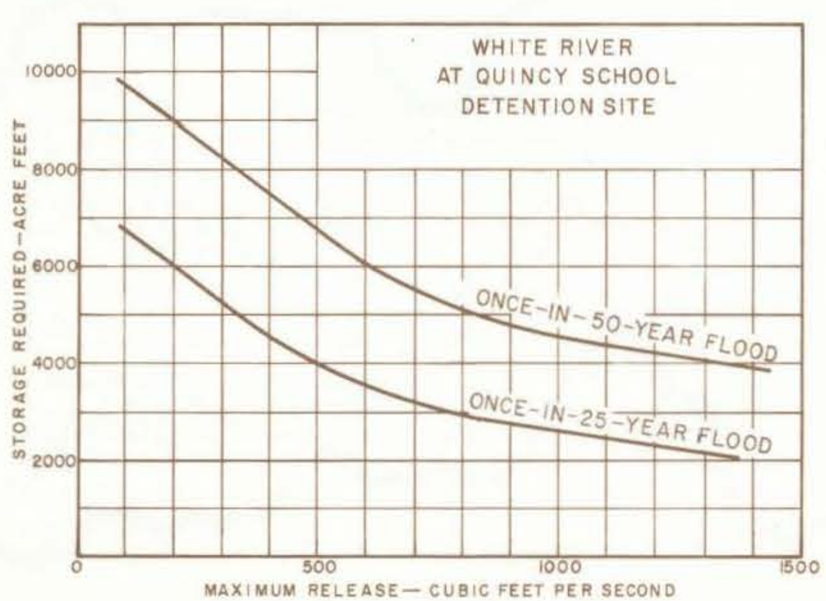






WHITE UNIT

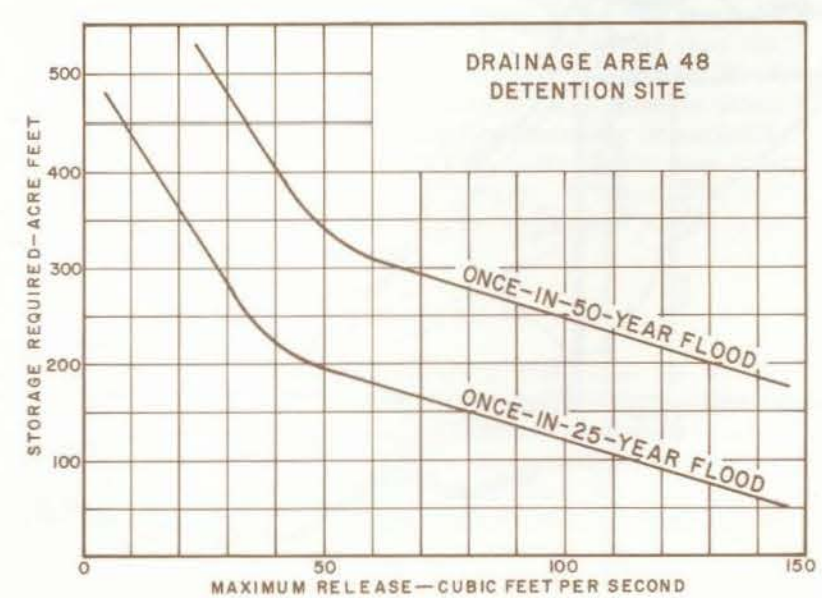
For convenience, this southernmost Unit includes both White River and Rag Gulch, although the sources of floodwaters, the areas flooded by them and concepts for control are separable. White River runoff produces flooding from the vicinity of Friant-Kern Canal to Highway 43, seven miles west of Earlimart. As demonstrated during the February 1969 storm, Rag Gulch begins to overflow its defined channel south of the Tulare-Kern County boundary. However, the principal area flooded by this stream lies on both sides of the County boundary between the Southern Pacific Railroad near Richgrove and the Friant-Kern Canal. In this area, flows of Rag Gulch spread out over an area as much as one-half mile wide. At Friant-Kern Canal, a small pump has delivered Rag Gulch water into the Canal in the past, but some ponding has occurred along the eastern canal bank over a distance of about three miles. The Bureau of Reclamation recently has altered this arrangement by constructing a gravity inlet to the canal.



WHITE RIVER (AREAS 43 AND 44)
RICHGROVE EAST DRAINAGE (AREA 48)

In 1969, a peak flow of 4,560 cfs measured at the Highway 65 crossing of the White River caused little overflow for four miles to the west. From this location to the Friant-Kern Canal, a combination of flows in White River and from Richgrove East Drainage inundated about 1,200 acres of land, much of which is intensively farmed. The combined flows of the two sources, after passing the Canal, inundated several thousand acres east of Highway 99, including the southern part of Earlimart. Between the Friant-Kern Canal and Highway 99 the White River is considered to have a capacity of about 1,000 cfs.

The Corps of Engineers, in a 1967 preliminary report, estimated average annual damages due to White River flooding to be $130,000. The Corps study, however, did not reflect the effects of the floods of December 1966 or February 1969. It is possible that if the 1967 report were updated, average annual damages under today's conditions of development would be considerably higher.

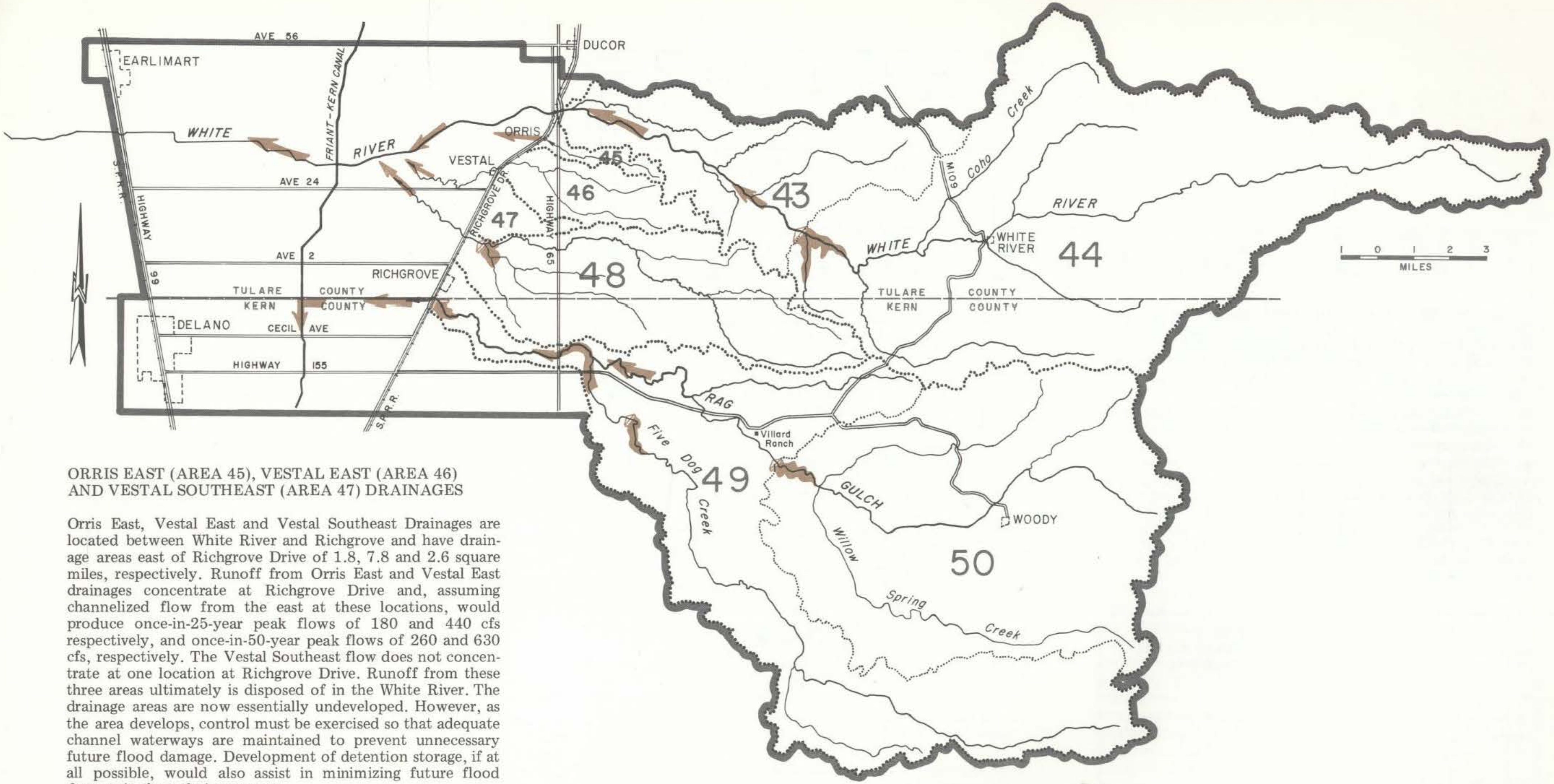


In the study the Corps considered several alternative concepts of flood control for White River, including channelization only, diversions to Deer Creek, storage in a large percolation pond on the valley floor, and detention storage in the foothills about 10 miles southeast of Ducor at what is termed the Quincy School site. The last concept appeared most practical and, although the Corps concluded its development was uneconomic at that time, further study at a later time was recommended. Review of the Corps report and further study of the hydrology, topography and present development in the area confirms the merit of a White River concept based on detention storage and that the best site for such storage probably is at the Quincy School site.

Peak flows for White River near Ducor (Quincy School site) and White River near Vestal for once-in-25-year and once-in-50-year events are 3,760 and 4,150 cfs and 5,370 and 5,950 cfs, respectively. The Richgrove East Drainage may generate peak flows at the Richgrove Drive crossing of 905 and 1,300 cfs with average recurrence periods, respectively, of 25 and 50 years. With some channelization work west of Richgrove Drive these quantities could be delivered into White River above the Friant-Kern Canal crossing. These estimates indicate that detailed planning to control flooding adjacent to White River downstream of a point about two miles east of its crossing of Friant-Kern Canal should consider both runoff sources.

Although White River flows of 1,000 cfs may be nondamaging between Friant-Kern Canal and Highway 99, such flows produce flooding west of that highway. Thus, unless detention storage can be provided in the Richgrove East Drainage close to Richgrove Drive, larger amounts of storage might be required at the Quincy School site to enable White River flows to be interrupted completely during heavy runoff from the other downstream drainage areas. This is not entirely impractical, but it does illustrate the need for coordinating the detailed planning of projects for control of White River and Richgrove East Drainage. The graph for the Quincy School detention site shows that about 5,000 acre feet of storage is required to control releases to 750 cfs during a once-in-50-year flood.

Examination of Richgrove East Drainage topography does not reveal any satisfactory detention sites that are not intensively farmed. A low dike across the principal watercourse about one-half mile upstream of its crossing of Richgrove Drive could provide 250 acre feet of storage which could control a once-in-25-year flood to a release of 35 cfs as shown by the graph for Drainage Area 48 detention site.



ORRIS EAST (AREA 45), VESTAL EAST (AREA 46) AND VESTAL SOUTHEAST (AREA 47) DRAINAGES

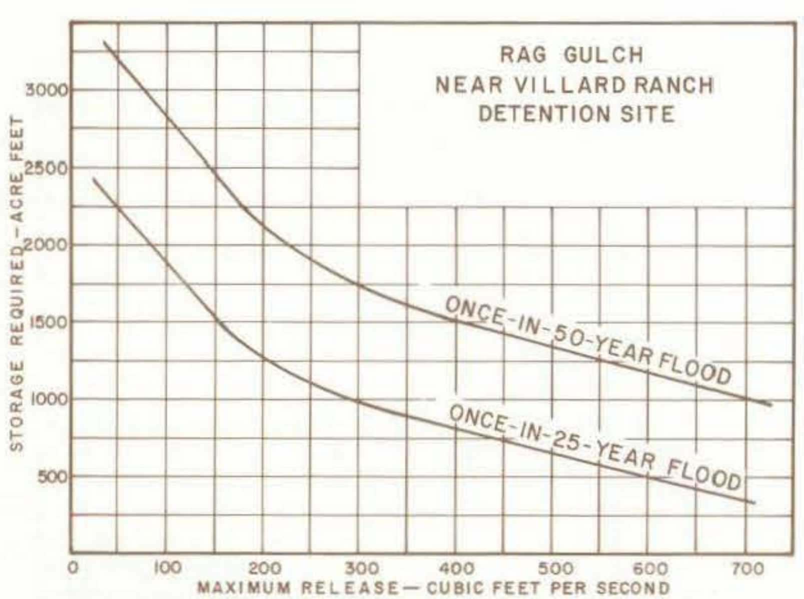
Orris East, Vestal East and Vestal Southeast Drainages are located between White River and Richgrove and have drainage areas east of Richgrove Drive of 1.8, 7.8 and 2.6 square miles, respectively. Runoff from Orris East and Vestal East drainages concentrate at Richgrove Drive and, assuming channelized flow from the east at these locations, would produce once-in-25-year peak flows of 180 and 440 cfs respectively, and once-in-50-year peak flows of 260 and 630 cfs, respectively. The Vestal Southeast flow does not concentrate at one location at Richgrove Drive. Runoff from these three areas ultimately is disposed of in the White River. The drainage areas are now essentially undeveloped. However, as the area develops, control must be exercised so that adequate channel waterways are maintained to prevent unnecessary future flood damage. Development of detention storage, if at all possible, would also assist in minimizing future flood damage in these drainage areas.

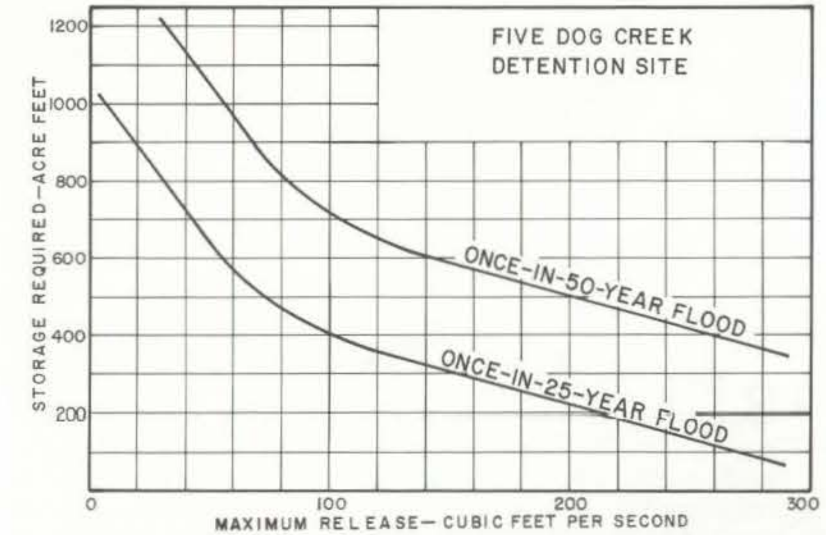
RAG GULCH (AREAS 49 AND 50)

Peak flows, assuming moderate channel improvement for about one and one-half miles east of the Rag Gulch crossing of Richgrove Drive and the Southern Pacific Railroad, may reach 3,280 and 4,680 cfs on the average of once in 25 and once in 50 years, respectively. The Rag Gulch channel immediately to the east of Richgrove Drive has been obliterated. This condition, together with water ponding against the Southern Pacific Railroad embankment, produced ponding in the area during the 1969 floods. Clearly, detention storage is required on Rag Gulch to reduce or eliminate the flooding easterly of Friant-Kern Canal and to reduce to manageable rates the flows reaching the new inlet structure at the Friant-Kern Canal.

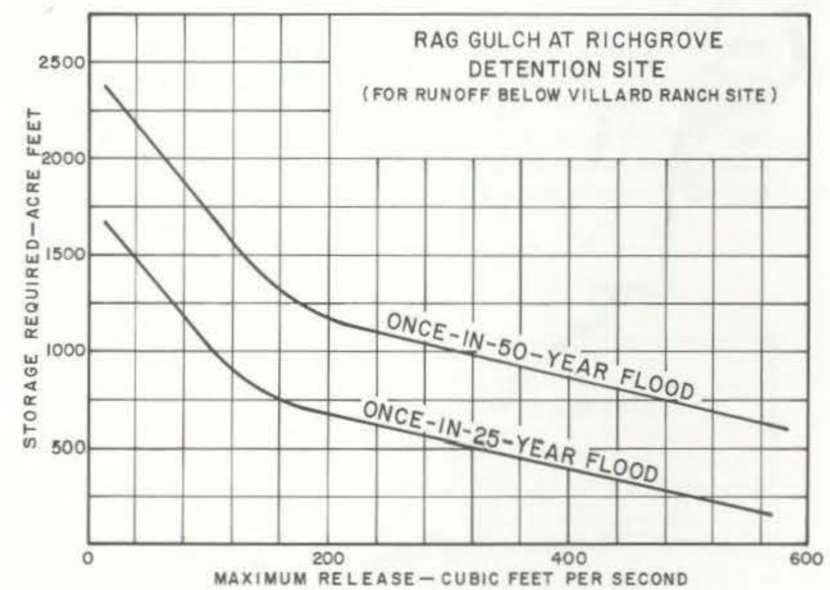
There are few detention storage sites on Rag Gulch and its principal tributary, Five Dog Creek. Two sites on the main Gulch and one on Five Dog Creek offer some potential and should be examined further in detailed studies; other sites on both streams also should be sought. The upper site on Rag Gulch, located near Villard Ranch, would provide the principal detention by regulating 71 out of the 138 square miles in the drainage basin. The graph shows the reservoir capacities required at the upper site near Villard Ranch to regulate flows of Rag Gulch to various amounts during floods occurring once in 25 and once in 50 years on the average. Approximately 1,900 acre feet of storage could control the once-in-25-year flood to releases of 100 cfs.

However, with a single detention reservoir on Rag Gulch near Villard Ranch, flows at Richgrove Drive cannot be controlled to non-damaging amounts even with flows from such a reservoir reduced to zero. Also, development between Richgrove and Friant-Kern Canal is such that flows following County Line Road to the Canal must be controlled to low rates to avoid expensive conveyance works. For these reasons, separate detention storage should be provided for Five Dog Creek flood flows or, alternatively, for all flows originating below the Villard Ranch site including those on Five Dog Creek.





Detention storage may be obtainable on Five Dog Creek at the site shown on the map; 400 acre feet of capacity could control once-in-25-year flood flows to 100 cfs.



A reservoir just east of Richgrove Drive could control flood flows originating on the Rag Gulch watershed below the Villard Ranch site including those of Five Dog Creek. The graph shows that 1,000 acre feet of capacity at the Richgrove site could control to 100 cfs the once-in-25-year flood flows originating on this part of the Rag Gulch watershed. Detailed studies of the three potential detention reservoirs should examine various combinations of controlled releases, uncontrolled flows and channel capacities west of Richgrove Drive.

Only the eastern boundary of the Tulare-Kings Unit which is common to the western boundaries of the other five valley-floor Units is indicated on the map shown on page 14. The junction of Cottonwood Creek and St. Johns River at Cross Creek and of Elk Bayou and Tule River provide two definite eastern boundary points. All areas of Tulare Lake subject to flooding by snowmelt or rain-flood runoff are assumed to be included in the Unit.

TULARE - KINGS UNIT

Because flooding in one part of the Unit may not be related causally to flooding in another and solutions to flooding in one part of the Unit may not affect flooding in another, some division into sub-Units might be appropriate in further studies. For example, flood waters entering the Unit through Cross Creek from the Tulare-Fresno or Kaweah Units have little or no effect on lands and improvements west of Earlimart; flood flows from Deer Creek and White River do not affect areas along Cross Creek. However, a single unit is presented here because the flood waters which produce damage in this area originate in one or more of the other six units.

Snowmelt runoff originating in the higher elevation watersheds of the Tulare Basin produces water management and flooding problems in the Tulare-Kings Unit. These problems can be reduced by implementing the long range concept of controlling snowmelt runoff from the larger watersheds to useable, nondamaging amounts by securing increased storage on the Kings, Kaweah, Tule and Kern Rivers. In addition, consideration should be given to the concept of diverting excessive Kern River snowmelt runoff into the California Aqueduct, thus eliminating this source of flood water from the Unit. Implementation of such snowmelt control measures is essential; however, additional action is also required to minimize the rain-flood problem.

For the Tulare-Kings Unit there are three concepts for reduction of rain-flood damage such as occurred in December 1955, December 1966 and February 1969: (1) reduced rain-flood releases from enlarged reservoirs on Kings, Kaweah and Tule Rivers and provision of new detention reservoirs wherever practicable on foothill watersheds from Wahtoke Creek in the north to White River in the south, (2) structural and operational changes in existing distribution systems in the other five valley-floor Units to minimize flood flows entering the Unit, and (3) operational changes, if required, in Lakeland, Homeland and other canals within Tulare-Kings Unit and along natural channels such as Cross Creek and Tule River, possibly accompanied by some structural modifications.

Structural changes in the canal systems would be those necessary to permit introduction of flows during the winter season and to direct them in appropriate distributaries to disposal areas (valley-floor percolation ponds and farm land) where they will not cause damage. Operational changes may be required to enable rain-flood flows entering the Unit to be managed effectively. Such flows may come on short notice (although not as short as in the areas closer to the foothills), and effective operations will require dependable communications among water management agencies in the Unit and in areas to the east, including adoption of efficient notification procedures. If all the concepts for Tulare-Fresno, Kaweah, Tule, Deer and White Units presented in this chapter were implemented at once, control of rain-flood runoff from those Units would be assured and flooding in Tulare-Kings Unit from such runoff would occur much less frequently. Obviously, many years will pass before all the concepts can be implemented. In the interim, improved operational procedures based on a well-planned communication system would provide the opportunity to handle flood flows and reduce rain-flood damage in Tulare-Kings Unit as well as elsewhere in Tulare County.

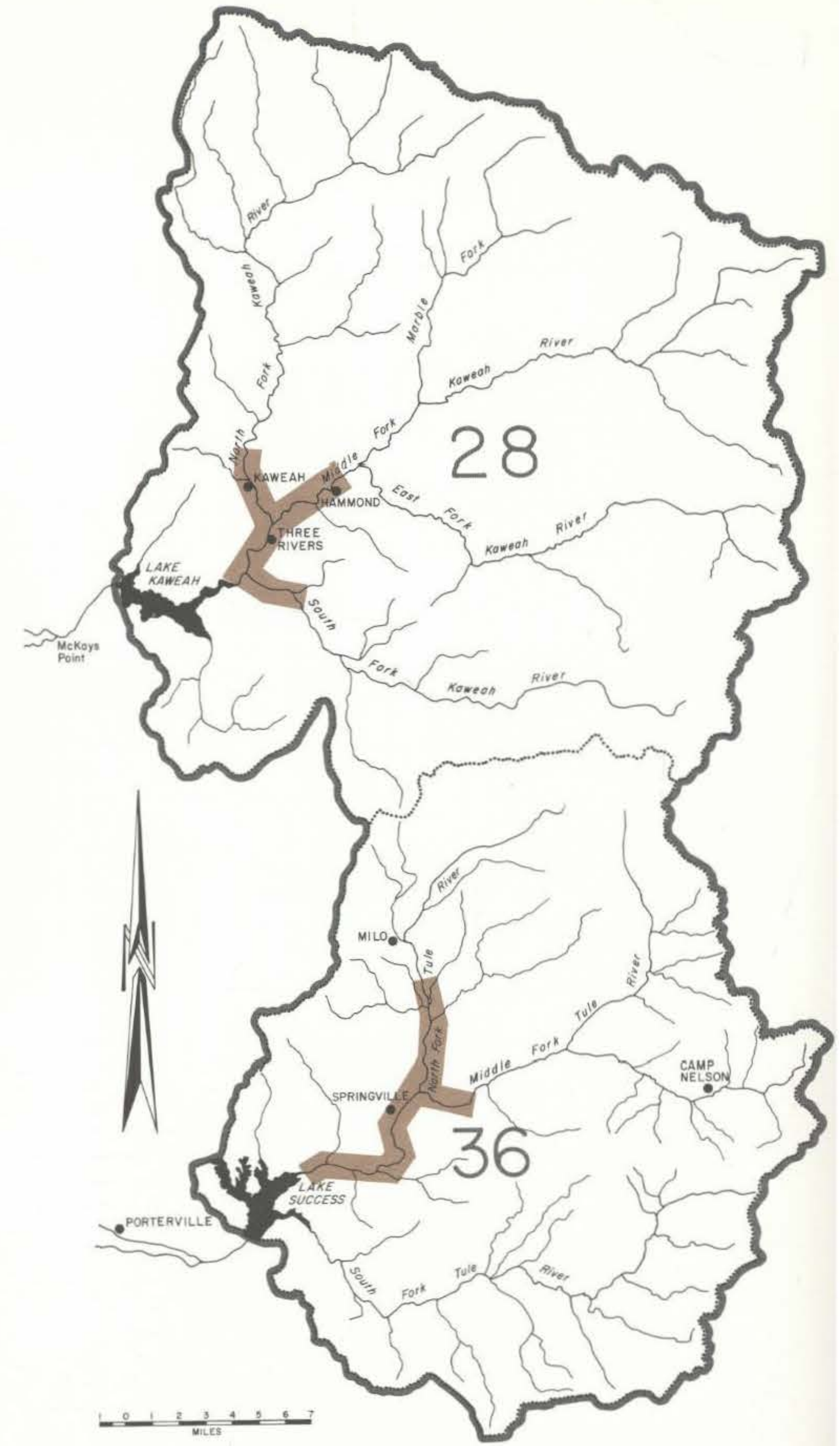
To the extent that flows from other Units which now terminate in the Tulare-Kings area can be controlled by upstream storage or diversion out of the area and by careful distribution in existing, improved or new channels to percolation ponds and to farm lands, flood damages in the Tulare-Kings Unit can be reduced. Therefore, all landowners in the Unit have a community of interest with others in Fresno, Tulare and Kern Counties in flood control measures implemented outside the Unit.

Both existing development and probable future growth in recreation activities in the Upper Kaweah and Tule River Basins justify consideration of flood control concepts for those areas. Flood problems in the two basins are similar and accordingly the basins are combined in a single Unit.

MOUNTAIN UNIT

The mountainous terrain limits locations of buildings and roads to areas adjacent to the streams in both basins. Esthetic attraction of flowing streams makes waterside homesites even more desirable. These physical and esthetic characteristics are at the heart of the flood problems in both the upper Tule and Kaweah River areas above Lakes Success and Kaweah, since improvements near streams can be inundated at frequent intervals. Both the Three Rivers and Springville areas suffered heavy damages in the floods of 1950, 1955, 1963, 1966 and 1969 and it is known that floods of the same and possibly greater magnitude have occurred at intervals since 1844. Studies of the Corps of Engineers indicate that a flood of the magnitude of that of December 1966 will probably occur, on the average, once in about 100 years. However, even larger floods can occur and future floods may provide data indicating that flood peaks such as those of 1966 will occur more frequently than is estimated on the basis of present records.

Snowmelt runoff does not cause significant flooding in the Kaweah and Tule River Basins above the two foothill reservoirs, although melting snow, especially at lower elevations, may contribute to rain-flood damage. Intense rains cause rapid rises in stages of the rivers and their tributaries. Velocities of flow are very high (in the order of 10 to 15 miles per hour) due to the steep gradients of the streams. Thus, only a part of the damage occurring during floods is that due to inundation; a major share of flood damage results from the force of the moving water itself. Between floods, trees fall adjacent to the streams and brush grows in the channels; these are carried in the flood waters and lodge against buildings and bridges, thus tending to make river stages even higher as debris dams are formed. Detailed studies on the extent of the flood plains in the vicinity of Three Rivers and Springville are available in reports of the Corps of Engineers for the areas shown in brown on the map.



KAWEAH BASIN (AREA 28)

The October 1967 Flood Plain Information Report of the Corps depicts the flood plain of Kaweah River and its North, Middle and South Forks. The area included in that report is adjacent to the Kaweah River upstream from the headwater of Lake Kaweah and along the lower reaches of the North, Middle and South Forks. The area also includes the town of Three Rivers and the vicinities of Kaweah and Hammond. Fairly detailed topographic and photographic maps are presented in the report along with extensive data on historical floods prior to those of January-February, 1969, including the highest flow of record, that of December 1966.

As noted in the Corps report, exact limits of the flood plain for flows of a given magnitude may vary due to channel changes which occur from time to time. Nevertheless, the information in the report can be highly useful to Tulare County officials and to individuals planning improvements in the area.

Also, Blair-Westfall Associates, Consulting Engineers, made a report to the Three River Soil Conservation District in 1962 which reflects consideration of flood problems in the vicinity of Three Rivers. The authors of this report reviewed 26 possible storage sites upstream of the mouth of the South Fork and analyzed them from a flood control viewpoint to a sufficient extent to suggest the most economical ones on each of the forks.

Analysis of data in the two reports and field inspections indicate that flood damage occurs in the vicinity of Three Rivers when flows exceed about 40,000-50,000 cfs and that such flows will occur once in about 20 to 25 years on the average. The Corps report estimates a flow of 80,000 cfs (about that of December 1966) may occur once in about 100 years on the average. The Corps also estimates that flows of 102,000 cfs will occur at Three Rivers less frequently and notes that such flows would produce river stages about three feet higher than occurred during the 1966 flood. Flood hazards in the vicinity can be gaged from these estimates.

Like rain-floods elsewhere in California, flood peaks in the vicinity of Three Rivers are sharp and of short duration and the volume of water in such floods is relatively small compared to the volumes occurring during the snowmelt season. For example, during December 5 and 6, 1966, when flows exceeded 40,000 cfs at Three Rivers, the volume of water in excess of that flow was approximately 21,000 acre feet. Thus, if combined storage capacity of about 30,000 acre feet were provided on the North and Middle Forks, it would be possible to control flows of this magnitude below the mouth of the North Fork to non-damaging amounts.

Review of North and Middle Fork topography makes it abundantly clear that reservoir sites are poor and that developing detention storage of the amounts indicated would require relatively high dams and large outlays of money. The 1962 report to the Soil Conservation District concluded that none of the 26 sites considered was economically justified at that time and there is no reason to conclude that they are economically justified now. Uncontrolled improvements in the flood plain might result, at some future indefinite date, in a situation where investments in protective reservoirs could be justified, but such improvements should not be permitted.

Detailed analysis based on field surveys might indicate that some parts of the flood plain in the Three Rivers area could justifiably be protected through channel improvements and levee work. However, from available information, economic justification of such work is not probable.

Therefore, reduction of flood damage in the Kaweah Basin must rest on control of development in the flood plain. This is currently being done through Tulare County ordinances. At present the population in the Three Rivers area is about 1,000 and it can be expected to increase to 4,000 or 5,000 over the next 50 years. All present trends indicate that most of the increased population will be retirees, vacationers and workers in occupations providing services to residents in the area. Esthetic considerations will lead many of the new residents to want streamside homes just as such homes are desired today. Also, of course, to the extent topography and soils determine housing sites, the flood plains offer advantages to the builder. However, as is abundantly clear from the records of flooding in recent years, occupation of flood plains with homes and businesses brings inevitable damage or destruction of such improvements. Important also is the fact that the severity of flood damage fades from memory as the years pass and the inevitability of another flood coming — some day — must be kept in public view.

TULE BASIN (AREA 36)

With the exception of location and peak flood magnitude, the general commentary and the concepts of flood control for the Tule Basin parallel those of the Kaweah Basin. The principal part of the Tule Basin extends about 10 miles up the main river and the Middle Fork from highwater level in Lake Success and along the lower four miles of the North Fork. Springville, a community of about 1,500 people, is the only population center in the basin.

In July 1968, the Corps of Engineers prepared a Flood Plain Information Report on the part of the Tule River Basin which is shown on the map. The recorded peak flow of the river near Springville, according to information given in the report, occurred about midnight December 5-6, 1966, and amounted to 49,600 cfs. Peak flows of this magnitude are estimated by the Corps to occur less often than once in 100 years on the average. Even larger floods, having peak stages about one foot higher than was reached in 1966, are expected to occur less frequently still.

The Corps report presents topographic and photographic maps depicting the areas inundated in once-in-100-year floods and in less frequent floods having a peak flow at Springville of 53,000 cfs. The report notes that these flood plain limits may vary over time due to changing channel conditions. The information on the report is highly useful for planning purposes.

As in the Kaweah Basin, satisfactory reservoir sites on Middle and North Fork Tule River above Springville do not appear to exist. Detention storage to control once-in-100-year floods (which seems a desirable degree of protection in view of the urban development) is probably not justified economically. From the Corps report, Tule River Drive appears to follow a ridge between the river and low ground to the west; this ridge is close to the elevation the water would reach in a once-in-100-year flood. Study might be given to the cost and hydraulic effects of installing a levee on this ridge, which might necessitate raising the level of Tule River Drive over part of its length. Such a levee, if connected to high ground in the vicinity of the sewage treatment plant and near the place the Drive ascends the bluff toward Highway 190, might provide protection to a substantial part of the area flooded in December 1966. However, such a levee could raise river stages on the east side of Tule River Drive, a condition that might be unacceptable.

As in the case of the Three Rivers area, control of flood plain development is probably the only practical method of reducing periodic flood damages. Present Tulare County ordinances can provide such controls.

Flood Plain Management and Waterway Capacity Protection

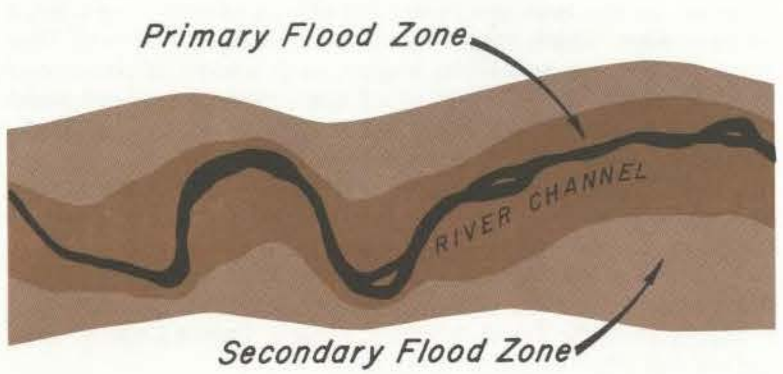
FLOOD PLAIN MANAGEMENT

The concepts suggested for the two basins of the Mountain Unit warrant general discussion since they may have applicability elsewhere in flood-prone areas of Tulare County. The concept of controlling development in such areas, or flood plain management as it is frequently called, is being used increasingly, both nation-wide and in California, as a definite part of flood control programs. Many counties and cities have applied the concept in part for many years through normal zoning procedures in areas known to be subject to flooding. Flood plain management applies the same principle to all parts of a stream or stream system whose adjacent banks may be overflowed to varying degrees and with varying frequency.

Development along the overflow areas adjacent to streams may be controlled permanently or until such time as projects prevent overflow during floods or reduce the extent of overflow. Flood plain management does not preclude use of land, but only limits use to the extent of the flood hazard.

Ordinarily, flood plains are managed under ordinances which define flood zones and the types of developments which may take place in them. The zonal boundaries are established after careful hydraulic studies are made to define the limits of flooding during the occurrence of a flood of a definite magnitude. Frequently, two or more zones may be established with permissible types of developments varying in each zone.

A section of river having primary and secondary flood zones is illustrated. The first step in defining the outer boundaries of the secondary zone is to select the magnitude of flood to be used; usually this is done after study of historical floods and the frequency of occurrence of floods of different magnitude. Variations in width of overflow along the river with flows of the selected magnitude are then determined by hydraulic study, taking into account the topography adjacent to the river and the hydraulic properties of the channel and the overflow area.



Frequently a primary flood zone also is defined, with boundaries being the minimum width of floodway needed to carry flood flows of the selected magnitude. Such a primary zone might be established in anticipation of eventual construction of levees which would confine flood flows and prevent overflow into the secondary zone. Or a primary flood zone might be that area which would be inundated by releases made from a future detention reservoir designed to control a flood of the selected magnitude.

The type of development permitted in each zone is based on the nature and permanence of the flood hazard. Agricultural activities normally are permitted in all zones, although at times the density of certain types of orchard plantings may be controlled. Structures in primary flood zones usually are limited to those which will not endanger life or impair the free flow of water during floods of the selected magnitude — a control which may eliminate most buildings. Structures for shelter of animals, machinery and equipment normally are permitted in secondary flood zones, but houses or other structures for human habitation are not permitted unless they are flood-proofed or protected by levees or have their living areas elevated above the water level expected to be reached during the selected flood. Where primary and secondary flood zones are established pending construction of levees, secondary zone restrictions on development may be modified or eliminated once levees of appropriate size and location are completed.

Control of development of flood plains by local agencies has been encouraged or required by State and Federal governments, especially during the past 20 or 30 years. For example, in the Congressional authorization of a bank improvement project in Tehama, Glenn and Butte Counties, construction by the Corps of Engineers was made contingent upon enactment of flood plain zoning ordinances. Under the Cobey-Alquist Act of 1965 (California Water Code Section 8400, et seq.) procedures are outlined for defining flood zones and, under certain circumstances, State funds for acquisition of lands, easements and rights-of-way for Federal flood control projects may be denied. Federal flood insurance at subsidized premium rates is available to defined categories of property owners where local agencies of government have adopted flood plain management ordinances; such insurance is now available to eligible property owners in unincorporated areas of Tulare County.

Under Water Code Section 8723 the State Reclamation Board has the authority to control certain activities in and adjacent to stream channels in the Central Valley Basin where the Board or the Legislature has adopted a plan of flood control. Currently the Board is carrying out a program of designating floodways on streams of the Basin. A floodway has been designated in the Upper Sacramento Valley and designation of other floodways, including Kings River, are pending. Floodways adopted by the Board under this program correspond closely with primary flood zones as discussed above. Once a floodway has been adopted as a plan of flood control, plans for proposed structural or other modifications within the limits of the floodway must be submitted to the Board for its approval, as provided in Water Code Section 8710.

PROTECTION OF WATERWAY CAPACITIES

Related to the concept of flood plain management is the concept of protecting or maintaining adequate waterways for smaller collecting drainage areas and for distributary channels. Obliteration of collecting or distributary waterways can result in flooding just as damaging as overflow from a major stream.

Many of Tulare County's flood problems are the result of the obliteration of collecting or distributary channels during land development. An essential concept to be included in an overall Tulare County flood program is the protection or maintenance of adequate waterways as land development takes place. In more intensively developed areas of the County, only a few such waterways remain to be protected but reduction in their capacities should not be permitted. In other areas, where land development has not progressed as far, the concept, if implemented, can insure the maintenance of adequate waterway capacity and thus prevent or reduce future flood damage.