V - DATA COLLECTION AND COMMUNICATION NETWORKS

5-01. Hydrometeorological Stations

a. Facilities. Precipitation, snow, temperature, stream stage, and reservoir pool elevation data are collected at locations both upstream and downstream from Terminus Dam. Plate 4-1 shows the location of stream gages operated by the Corps (USACE), the U.S. Geological Survey (USGS), Southern California Edison (SCE), and the California Department of Water Resources (DWR). Plate 4-5 shows the location of climatological gages operated by the USACE, DWR, and the National Weather Service (NWS).

The Sacramento District Office (CESPK) maintains its own network of Data Collection Platforms (DCP) to collect pertinent hydrometeorological data for Corps projects. This District-wide system is known as the Hydrometeorologic Automatic Data Acquisition (HADA) system. Gages are added to the HADA system when CESPK Water Managers deem a gage site to be necessary for the proper operation of a project. Table 5-1 lists the HADA system gages used by CESPK Water Managers for the real-time flood control regulation of Terminus Dam.

In addition to the hydrometeorological gages listed in Table 5-1, pool elevation staff gages are located on the upstream face of Terminus Dam. The stream gage locations also have staff gages which can be used to confirm the pool or stage instrument reading and to make manual readings, should the automated instrumentation fail.

b. Reporting. Hydrometeorological data at Terminus Dam and Lake Kaweah, and elsewhere in the Kaweah River Basin, are monitored through the Hydrometeorologic Automatic Data Acquisition (HADA) System. The Terminus Dam Project Office Computer (TRMPC) automatically polls the DCP's for parameters listed in Table 5-2. The pool elevation, local river stages (Photo 5-1), and weather station (Photo 5-2) are polled every 15 minutes while the remote precipitation gages (Photo 5-3) are polled/received every hour. Data from TRMPC are transferred via Wide Area Network (WAN) or telephone to the District Office at least once an hour.

Other agencies collect and publish hydrometeorologic data for other sites throughout the Kaweah River Basin and adjacent basins. These sites are shown on Plates 4-1 and 4-5.

c. Maintenance. The Water Management Section is responsible for maintaining the Corps gages listed in Table 5-1. Kaweah Delta Water Conservation District (KDWCD), along with the Corps, is responsible for the maintenance of the flow measuring instruments located at McKay Point, Yokohl Creek, and Cross Creek. All gages have backup battery power and will continue to operate for several days without commercial power. The Sacramento District contracts with private contractors to perform monthly stream flow measurements and maintain most gages in this region.

TABLE 5-1
TERMINUS DAM AND LAKE KAWEAH REAL-TIME
HYDROMETEOROLOGIC DATA COLLECTION SITES

Station Name and Mnemonic		Collected Parameters	Via	Agency
Atwell	ATW	Precipitation Temperature	R	Corps
Beartrap Meadow	BRM	Precipitation Temperature	R	Corps
Cross Creek at Houston	CRS	Stage	P	Corps, KDWCD
Dry Creek near Lemoncove	LCV	Stage	R, P	Corps
Foothill Ditch below Terminus Dam	FTH	Stage	R	Corps
Giant Forest	GNF	Precipitation, Snow Temperature	R	Corps
Hockett Meadow	HCK	Precipitation Temperature	R	Corps
Kaweah River below Terminus Dam	TRMQ	Stage, Water Temperature	R	Corps
Kaweah River at Three Rivers	TRR	Stage	R, P	Corps
Lemoncove Ditch below Terminus Dam	LMN	Stage	R	Corps
McKay Point (Kaweah and St. Johns Rivers)	MK1 / MK2	Stage	R	Corps, KDWCD
Paradise Peak	PR1 / PR2	Temperature	R	Corps
Terminus Dam (Pool)	TRMP	Pool Elevation	R	Corps
Terminus Weather Station	TRMW	Evaporation Precipitation Temperature, Wind	R	Corps
Yokohl Creek at Garcia Bridge	YKL	Stage	P	Corps, KDWCD

KEY
Via: R=Radio
P=Phone
Agency: Indicates the agency responsible for the gage
Corps: U.S. Army Corps of Engineers
KDWCD: Kaweah Delta Water Conservation District

TABLE 5-2
HYDROMETEOROLOGIC DATA COLLECTED AT TERMINUS DAM

Station and Mnemonic		SHEF Physical Element Code										
		ED	HG	HP	PC	SW	TA	TP	TW	UC	UD	US
Terminus Dam	TRMP			x								
Kaweah River below Terminus Dam	TRMQ		x						x			
Foothill Ditch below Terminus Dam	FTH		x									
Lemoncove Ditch below Terminus Dam	LMN		x									
Dry Creek near Lemoncove	LCV		x									
Kaweah River at Three Rivers	TRR		x									
McKay Point	MK1 / MK2		x									
Yokohl Creek at Garcia Bridge	YKL		x									
Cross Creek at Houston	CRS		x									
Terminus Dam Weather	TRMW	x			x		x	x		x	x	x
Atwell	ATW				x		x					
Beartrap Meadow	BRM				x		x					
Giant Forest	GNF				x	x	x					
Hockett Meadow	HCK				x		x					
Paradise Peak	PR1 / PR2						x					

<u>Key to Standard Hydrologic Exchange Format (SHEF) Physical Element Codes:</u>

ED - Evaporation, Pan Depth (in)
HG - Height, River Stage (ft)
HP - Height, Pool Elevation (ft)
PC - Precipitation, Accumulated (in)
SW - Snow, Water Equivalent (in)
TA - Temperature, Air (°F)
TP - Temperature, Evap. Pan (°F)
TW - Temperature, Water (°F)
UC - Wind, Accumulated Wind Travel (mi)
UD - Wind, Direction (Degrees)
US - Wind, Speed (mi/hr)

5-02. Water Quality Stations

a. Facilities. Two types of water quality data are collected for Terminus Dam:

(1) Temperature data are collected from the Kaweah River below Terminus Dam gage site (TRMQ). These data are collected at 15-minute intervals.

(2) Lake Kaweah pool and inflow water samples and measurements are collected by manual field sampling methods. Other agencies that collect and monitor water quality in the surrounding area include USGS and DWR. The Corps of Engineers contracts for water quality measurements, taken every April and August, on the lake and at its inflow. Private, commercial, state-certified laboratories are utilized to perform the lab analysis. An algologist at the University of California at Davis does the biological analysis. Parameter measurements include: temperature, dissolved oxygen, biological oxygen demand, pH, suspended solids, general chemicals, heavy metals, contaminates such as MTBE's, algae enumerations, nutrients, and light transparency (Secchi disk).

b. Reporting. Except for the continuous temperature data, water quality data are not available on a real-time basis at SPK. The water temperature data collected at the outflow and the reservoir water quality analysis are published in the Sacramento District's "Annual Water Quality Report," according to ER 1110-2-8154 "Water Quality and Environmental Management for Corps Civil Works Projects," dated 31 May 1995.

c. Maintenance. The Water Management Section is responsible for maintaining the water temperature gage at the Terminus Dam Outflow gage. The Section fulfills this responsibility through a small private company under contract to the District. Other water quality gages are maintained by various agencies.

5-03. Sediment Stations

a. Facilities. CESPK does not maintain or collect any sediment data on either the upstream or downstream tributaries of Terminus Dam. This type of data is not required for the real-time flood control operation of Terminus Dam. Reservoir sedimentation is discussed in Section 4-04. Sedimentation Ranges are shown on Plate 4-4.

b. Reporting. Sediment data are not currently collected, reported, or maintained by CESPK for Terminus Dam.

c. Maintenance. CESPK has no maintenance responsibilities with respect to sediment stations.

5-04. Recording Hydrologic Data. In general, the agency or organization responsible for a particular gage is also responsible for maintaining the official record for that gage. Therefore, the

Sacramento District maintains the official record for the Corps gages listed in Table 5-1. Kaweah Delta Water Conservation District is responsible for maintaining the official record of flow and stage data collected at Cross Creek at Houston, McKay Point, and Yokohl Creek at Garcia Bridge.

The hydrometeorological parameters listed in Table 5-2, along with additional maintenance information, are initially recorded at the gaging site using the gage's Data Collection Platform. The data loggers log data every 15 minutes and have the capacity to store from 6 months to two years' worth of data. The amount of data that can be stored locally by the data logger is dependent upon the number of parameters collected at the site.

The Terminus Dam Project Office Computer (TRMPC) automatically polls the Data Collection Platform listed in Table 5-1 and stores the data in a local database. Data from TRMPC are transferred, via Wide Area Network (WAN) or telephone, to the District Office at least once an hour.

Once data are transmitted to the District Office, the data are stored and maintained in database files located on the District's Corps Water Management System (CWMS) computers. Both the raw hydrometeorological data listed in Table 5-1 and data computed from the raw data (e.g., reservoir storage, inflow, outflow, precipitation, and stream flows) are maintained in the database. This data will be kept on file, for archival purposes, for the life of the project and beyond.

5-05. Communication Network. Both voice radio, WAN, and telephone communications are maintained between the Sacramento District Office and Terminus Dam. Communication is either by voice radio, WAN, or telephone. Radios in each office have backup power from batteries and standby generators.

The Corps Water Management System can interrogate the project PC's either by WAN or telephone. The Water Control Data System utilizes backup power from an Uninterrupted Power Supply (UPS) and standby generators.

5-06. Communication with Project

a. Regulating Office with Terminus Dam and Lake Kaweah Project Office. Direct communication between the Water Management Section, Sacramento District Office, and the Terminus Dam Project Office is normally conducted via telephone for all matters relating to the single operating purpose of flood control. Communication can be by voice radio or WAN (e-mail). In the event that all communication is interrupted, a set of "Standing Instructions to Project Operators" has been compiled for Terminus Dam, and a copy of these instructions is included in Exhibit A of this manual. Personnel responsible for project operation are listed in the front of this manual and in Exhibit A.

b. Between Regulating Office and Others. Close coordination, via telephone, between the Corps, the Kaweah Delta Water Conservation District (KDWCD), and Tulare Lakebed interests is necessary when transitioning to and from flood operation. Direct communication between the Corps and other local and/or federal agencies is normally conducted via telephone or radio for all matters relating to the operation of the project.

c. Between Terminus Dam Project Office and Others. Direct communication between the Project Office and other local and federal agencies is normally conducted via telephone or WAN for all matters relating to the operation of the project. Pertinent agencies are listed in the front of the manual and in Exhibit A. Exhibit D identifies the various agencies that require notification in the event of a seismic emergency.

5-07. Project Reporting Instructions. Communications between the Water Management Section and the Terminus Dam and Lake Kaweah Project Office may be made to provide special instructions regarding the Terminus Project. The Terminus Dam and Lake Kaweah Project operators should use voice radio, WAN, or telephone communication to report any failure of machinery or other equipment, or to report any other unusual conditions at the dam. Also, hydrologic data should be reported in the same manner, if requested, based on the operational data requirements described in Exhibit A. Personnel responsible for the project operation are listed in the front of this manual and in Exhibit A.

All significant inquiries received from citizens, constituents, or interest groups regarding water control procedures or actions must be referred directly to the Water Management Section. Press inquiries must be referred to the Public Affairs Office (PAO), Sacramento District.

5-08. Warnings. CESPK maintains contact with the local district office of the National Weather Service (NWS) at all times concerning general meteorological conditions.

The Corps of Engineers provides release information at Corps reservoirs; however, the Corps does not issue flood warnings. Flood warnings are the responsibility of the NWS.

Personnel from the NWS Office in Sacramento and the California Department of Water Resources (DWR) are assigned to the Joint Federal-State River Forecast Center in Sacramento, which monitors weather conditions and river stages on a year-round basis. When floods are imminent, the State Flood Operations Center is activated. It operates on a 24-hour basis in conjunction with the River Forecast Center. In addition, among other flood emergency activities, the center advises interested parties of flood situations as they develop. The Joint Operations Center furnishes flood information and flood warnings to the local news media, law enforcement agencies, and other agencies for dissemination to the public.

The Park Manager of Terminus Dam and Lake Kaweah will issue warnings to local agencies by telephone. Exhibit D lists the various agencies that will be notified in the event of a serious seismic emergency. An Emergency Action Plan is kept at the Park Headquarters.

The DWR, through the Joint Operations Center, coordinates flood-fighting activities throughout the state and is authorized to receive requests from local public agencies for assistance during floods. The Corps responds to requests from the DWR Joint Operations Center for flood fighting and rescues, and from the California Office of Emergency Services (OES) when the emergency is beyond the capabilities of state and local government agencies.

Pursuant to the provisions of Section 8589.5, Government Code of California, emergency procedures must be established for the evacuation and control of potential flood areas, in the event of sudden failure of dams. Prior to the increased capacity, the Corps prepared a map showing areas that would be inundated by failure of Terminus Dam. On the basis of the map, the California Office of Emergency Services (OES), in cooperation with DWR, has designated evacuation areas. A revised inundation map based on the spillway raise will be developed at a future date. The local jurisdiction must then adopt emergency procedures that include, among other things, specific routes to be used for evacuation, traffic control measures, movement of people without their own transportation, shelter of evacuees, evacuation and care of people from institutions, and perimeter security, interior security, and re-occupation of evacuation areas.

Photo 5-1. Kaweah River below Terminus Dam stream gaging station

Photo 5-2. Terminus Dam weather station

Photo 5-3. Giant Forest climatological station

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VI - HYDROLOGIC FORECASTS

6-01. General. Most of California is unique in that general rainfloods during the late spring and summer are extremely rare. Therefore, runoff into the reservoirs can be fairly accurately predicted during the spring and summer based on snowmelt in the mountains. This allows the space required for flood control to be varied during snowmelt season based on the forecasted runoff. These snowmelt forecasts are important in optimizing reservoir operation for all project purposes.

Reliable long-term rainflood forecasts are not available at this time. However, short-term precipitation forecasts are useful for anticipating release changes based on increased inflow or changes in downstream conditions. Precipitation forecasting may also aid in the anticipation of damaging flows and allow for the earliest possible warnings. Based on antecedent basin conditions and forecasted runoff, flood control space should be kept at a level that allows storage of an event without releases exceeding downstream channel capacity.

a. Role of the U.S. Army Corps of Engineers. The Corps of Engineers, by regulation, cannot furnish forecasts of flows into Lake Kaweah to the public. That mission is the responsibility of the NWS. However, during flood conditions, the Corps of Engineers provides the Department of Water Resources with flood release forecasts. The DWR then coordinates with the National Weather Service's River Forecast Center, which uses the information to aid in forecasting river flows.

b. Role of Other Agencies

(1) The National Weather Service (NWS) provides Quantitative Precipitation Forecasts (QPF) for the Kaweah River Basin and river flow forecast data for the Kaweah River above Terminus Dam. The QPF is for the succeeding 24-hour period and is broken down into 6-hour increments. These short-term forecasts are updated twice daily at 4:00 a.m. and 4:00 p.m. The NWS also provides freezing levels, an index of loss potential for the basin, and short-term local precipitation forecasts up to 24-hours in advance.

(2) The Joint Federal-State River Forecast Center (RFC) monitors weather conditions and river stages on a year-round basis. The RFC will forecast stages and flows on major river systems; however, only flow forecasts are made for the Kaweah River. The flows are for the succeeding 24-hour period and are broken down into 6-hour increments. These short-term forecasts are updated twice daily at 4:00 a.m. and 4:00 p.m.

(3) The California Department of Water Resources' Snow Surveys provide April through July snowmelt runoff forecasts for the Kaweah River Basin. Forecasts are made 1 February, 1 March, 1 April, and 1 May each year. Updates are provided when conditions change

appreciably from the last forecast. The forecasts are published about 5 days after the date to which they apply. A summary of forecasted runoff compared to actual runoff is shown on Table 4-7 in the Tables Section following Chapter IX of this manual.

(4) The Kaweah Delta Water Conservation District monitors water supply and irrigation demands within the basin.

6-02. Flood Condition Forecasts

a. Requirements. Knowledge of current basin conditions and general basin characteristics aids in forecasting flows during flood conditions. Information from the NWS, real-time climatological data, antecedent basin wetness, inflow recession values, and local flow estimates can all be used to help determine the forecast during flood conditions.

Uncontrolled local flows (occurring downstream during a rainfall flood event) may be substantial and would require that the release from the project be reduced. The release should be adjusted to maintain the combination of project release plus uncontrolled local flow at or below the objective flow of 5,500 cfs (155.8 m^3/s), for as long as possible. For a discussion of downstream channel capacities, see Section 4-09 and Plate A-12.

b. Methods. The forecast of basin mean precipitation over the Kaweah River Basin is conducted by the NWS, and is issued as part of the QPF. The QPF contains 6-hour rainfall forecasts covering river basins all over California. The NWS River Forecast Center also provides information on forecasted flows and the freezing level for the Kaweah River Basin. Real-time stream flow data and the anticipated precipitation amounts can be translated into estimated future flows by means of a unit hydrograph method.

Since the conditional space required for flood control is determined from snowmelt forecasts, they are of primary concern in the operation of the Terminus Dam and Lake Kaweah Project. The Kaweah Delta Water Conservation District and the Corps of Engineers use snowmelt forecasts made by the California Department of Water Resources to maximize the operation of the project.

6-03. Conservation Purpose Forecasts

a. Requirements. The operation of Lake Kaweah for conservation is generally as requested by the Kaweah Delta Water Conservation District. The Corps is not currently required to perform water quality forecasts for Lake Kaweah. Section 5-02, Water Quality Stations, contains further information related to water quality.

b. Methods. The Corps of Engineers relies on irrigation demand estimates from the Kaweah Delta Water Conservation District to evaluate the timeliness of releases when balancing flood control and conservation storage space requirements. The required flood control space for any given time of the year is as shown on the Water Control Diagram, Plate A-13.

6-04. Long-Range Forecasts. Long-range forecasts are snowmelt runoff forecasts, and are characterized by large flow volumes, several months in duration, and low to moderate peak inflows. Other than the snowmelt forecasts discussed above, no long-range forecasts are used by the Corps of Engineers for the Kaweah River basin.

6-05. Drought Forecasts. The Corps of Engineers' Drought Contingency Plan for the Terminus Dam and Lake Kaweah Project is presented in Exhibit C.

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VII - WATER CONTROL PLAN

7-01. General Objectives. The primary operating objectives of the Terminus Dam and Lake Kaweah Project are to protect areas below Terminus Dam from floods and provide maximum possible conservation yield for irrigation. Recreation and hydroelectric power generation, although also provided by the project, are secondary purposes.

7-02. Constraints. The maximum discharge capacity of the outlet works at given elevations are shown in the pertinent data table at the front of this manual and on Plate A-3; known channel capacities below Terminus Dam are shown on Plate A-12 and discussed in Section 4-09. The maximum objective flow of the Kaweah River at McKay Point is 5,500 cfs (155.8 m^3/s).

Lake Kaweah is part of a system of reservoirs contributing water to the Tulare Lakebed. At gross pool elevation of 715.0 feet (217.9 m) Lake Kaweah has a capacity of 185,630 acre-feet (228.8 hm^3). Releases greater than irrigation and spreading demands have the potential to pond on the valuable Tulare Lakebed cropland. Diversion opportunities of unwanted floods are very limited above Tulare Lakebed; most of the water that cannot be used (or placed in groundwater recharge basins) will end up in the lakebed. Since water flowing to the lakebed may be from many sources, releases from Lake Kaweah are coordinated with releases or uncontrolled flows from other sources to the extent possible, giving consideration to downstream storage and diversion capabilities. For a complete description of the Tulare Lakebed system, refer to the Master Water Control Manual for the Tulare Lake Basin.

To the extent possible, non-damaging releases will be made through the outlet works and/or power plant to avoid surcharging the reservoir.

7-03. Overall Plan for Water Control. The Water Control Plan for the Terminus Dam and Lake Kaweah Project coordinates flood control space, irrigation storage, and recreational uses in order to meet the following objectives:

a. Restrict flows in the downstream reaches of the Kaweah River at McKay Point to non-damaging rates of 5,500 cfs (155.8 m^3/s).

b. Provide the maximum practical amount of storage for conservation of irrigation water without impairment of the flood control functions of the reservoir.

c. Minimize damaging flows from the Kaweah River into Tulare Lakebed.

During the rainflood season, the required rainflood space is set for a given date, with variations based on antecedent precipitation. During the snowmelt season, the required flood control space is varied, based on forecasted inflow minus irrigation and spreading demands, to satisfy both flood control and conservation objectives. The irrigation requirements and infiltration capability in the Kaweah River service area play an important role in the flood control operation of the project. Since the Kaweah River has no outlet to the ocean, all flood flows not stored in Lake Kaweah must be utilized or disposed of within the service area, otherwise they enter the Tulare Lakebed as damaging floodwater. When flood releases must be made from Lake Kaweah, all possible diversions for irrigation purposes are made. The normal anticipated irrigation demands are shown on the Water Control Diagram, Plate A-13. In addition, extensive areas of permeable soils have been reserved by local interests for disposal of floodwater by ponding and percolation, with a two-fold purpose of recharging the heavily pumped groundwater storage, while simultaneously preventing inundation of valuable agricultural cropland in Tulare Lakebed. As part of the spillway raise project, a mitigation site has been established in the Tulare Lakebed. The area is discussed in Section 2-04. Flood releases, as designated by the Corps of Engineers, in excess of irrigation and spread demands will be diverted to mitigation areas as required in the mitigation site operation and maintenance manual. The snowmelt portion of the Water Control Diagram (Plate A-13) is designed to fill the reservoir, if runoff and irrigation demands permit, but not spill.

7-04. Standing Instructions to Project Operators. During normal flood periods, Lake Kaweah will be regulated in accordance with the normal regulations for flood control operation, as explained in Paragraph 7-05 and Exhibit A of this manual. Instructions for project operators in the event of a communication outage are presented in Section 7-05b. Exhibit A is designed to function as a separate and complete document, and is to be used as a flood management guide. To facilitate independent use of Exhibit A, plates required for the flood control operation of the Terminus Dam and Lake Kaweah are provided therein.

The storage and release of floodwater in the flood control space is under the control of the Water Management Section, Sacramento District, Corps of Engineers. Standing instructions to Project Operators for flood emergencies are contained in Exhibit A, Paragraph A-03.

7-05. Flood Control. A detailed explanation of flood control operation is included in the text of Exhibit A.

a. Normal Regulation for Flood Control. Flood control regulation begins when storage in Lake Kaweah exceeds the flood control space required at any time, according to the Water Control Diagram, Plate A-13, located in Exhibit A. The Water Control Diagram and this manual are the authorized project documents regarding flood control operations. The diagram is the result of analyses of flood frequency, seasonal flood potential, and downstream channel capacities consistent with project objectives. The diagram requires the following:

(1) Uniformly increasing flood control reservation from a minimum requirement of zero on 1 September to 185,630 acre-feet (228.8 hm^3) by 15 November.

(2) Conditional rainflood reservation up to a maximum of 185,600 acre-feet (228.8 hm^3) from 15 November through 28 February, decreasing to zero as early as 1 May,

depending upon the rainflood parameter (a precipitation index of basin wetness).

(3) Conditional snowmelt flood reservation up to a maximum of 185,630 acre-feet (228.8 hm^3) from 1 March through 31 July, decreasing to zero as early as 1 May and as late as 31 July, depending on the snowmelt runoff forecast.

The basin wetness parameter is computed from daily mean basin precipitation, weighted according to station normal annual precipitation at the five project hydrometeorological system gages. The index is computed by adding previous daily mean basin precipitation values decayed by 3 percent each day to the current date and is reset to a zero parameter at midnight on 31 August. For additional information, see Exhibit A, Section A-02(a)8 and A-02(a)9.

Water stored in Schedule 1 or 2 flood control space will be released in accordance with the schedule that applies to that space. This criteria is established to ensure the timely release of floodwater from flood control space in the reservoir and, therefore, such releases shall not be restricted by the storage and diversion rights under the Kaweah Delta Water Conservation District agreements. The Corps of Engineers may direct that flood control space be increased or decreased from what is required by the Water Control Diagram based on conditions prevailing at the time.

If the reservoir storage is encroached within the flood control reservation, then flood control releases are made as quickly as possible. However, flood control releases have the following limitations, also indicated on the Water Control Diagram, Plate A-13:

(1) Releases from conservation and conditional rainflood space will be for irrigation demands.

(2) Releases from Schedule 1 rainflood space will be for irrigation and spreading demands.

(3) Releases from Schedule 2 rainflood space will be for irrigation and spreading demands, plus a supplemental flood release.

(4) Releases from conditional snowmelt space will be computed based on 1 April-31 July runoff forecast, irrigation demand, and spreading capability.

(5) No flood control reservation is required during the month of August.

(6) Releases shall be limited such that flows in the Kaweah River at McKay Point do not exceed 5,500 cfs (155.8 m^3/s). For detailed information on responsibilities for flood control, refer to Chapter IX.

When the reservoir pool elevation is below gross pool (715 feet) (217.9 m), flood control releases will be made in accordance with the release schedule shown on the Water Control Diagram, Plate A-13. During floods in which the pool level exceeds the spillway crest (715 feet) (217.9 m), the Spillway Rating Curve and Table (shown on Plates A-4 and A-5) should be checked frequently. During small and moderate floods it will be necessary to make only normal flood releases through the outlet gates. However, occasionally during large floods it will be necessary to gradually close the outlet gates as pool elevation rises above gross pool, in order to control total outflow from the spillway and outlet to an objective outflow as long as possible. During such floods, outlet gates will remain closed as long as spillway outflow exceeds required release, to maintain desired flow at McKay Point. Subsequently, as the spillway outflow recedes, the gates will be gradually re-opened to maintain the maximum objective outflow as long as needed, in accordance with the Water Control Diagram, Plate A-13.

b. Emergency Regulation. If communications with the project are disrupted, the following procedures will be followed for project operation:

(1) Continue releases in accordance with the last instructions from the Water Management Section and make every attempt to re-establish communication.

(2) If communications cannot be re-established, make releases in accordance with the Water Control Diagram (Plate A-13) and consult the Spillway Rating Curve and the Spillway Rating Table (Plates A-4 and A-5) frequently and make adjustments to releases as described in Section 7-05a, if spilling is occurring.

c. Constraints. Releases from Terminus Dam, insofar as possible, will be restricted to the non-damaging channel capacity of 5,500 cfs (155.8 m^3/s) at McKay Point. See Section 7-16 for rate-of-release constraints.

7-06. Recreation. The recreation features at Lake Kaweah, shown on Plate 2-9, generally do not require specific control of releases for recreation purposes; however, the marina, boat docks, and portable restrooms require movement when the pool rises or falls quickly.

7-07. Water Quality. Lake Kaweah is not operated for water quality. Although water quality control may not be an authorized project purpose, compliance with Public Law 92-500 requires that all federal facilities be managed, operated, and maintained to protect and enhance the quality of water and land resources through conformance with applicable federal, state, interstate, and local substantive standards. Water quality measurements and water quality of the lake are discussed in Section 4-08.

7-08. Fish and Wildlife. The Terminus Dam and Lake Kaweah Project is not operated specifically for fish and wildlife purposes, although the lake supports a significant and diverse fish, bird and mammal population. Approximately 160 acres (0.6 sq km) immediately west of the Terminus Dam main embankment have been set aside as a wildlife management area. The 160 acres (0.6 sq km) is dominated by a pond upstream of the "Kaweah River below Terminus

Dam" stream-gaging site weir. Approximately 1/3 of the area is comprised of riparian habitat. Five acres have been planted for endangered species mitigation. The remainder is unimproved.

7-09. Water Supply. Space not reserved for flood control is operated for water supply, as directed by the Kaweah Delta Water Conservation District. The user contract, No. 14-06-200-2110A, between the United States (represented by the USBR) and the Kaweah Delta Water Conservation District, provides for operation and maintenance of irrigation space. The Project Coordination Agreement (PCA) dated February 2001 also provides for operation and maintenance of flood control and agricultural supply.

7-10. Hydroelectric Power. In August 1986, the Kaweah River Power Authority was granted FERC license number 3747 to construct and operate a 17 MW capacity power plant at Lake Kaweah. Construction of the Terminus Power Project was initiated in 1987 with completion in 1990. The Terminus Power Project is described fully in paragraph 2-03(f).

The net head for the 20 MW Kaplin turbine can vary between 72 feet and 191 feet (21.9 and 58.2 m). The intake to the power tunnel has an invert elevation of 572 feet MSL (174.3 m). Flow at low reservoir levels must be restricted to avoid vortex problems.

The turbine can generate electricity with flows between 400 cfs (11.3 m^3/s) and 1,500 cfs (42.5 m^3/s). Releases from Lake Kaweah below minimum turbine flow will be made from the Terminus Dam slide gates. Between the minimum and maximum turbine flows, the required releases will be made through the power plant and/or Terminus Dam slide gates. Releases above this value will be made through the turbine bypass and/or slide gate.

7-11. Navigation. Navigation is not a project purpose. However, navigable waters include all "waters of the United States," which are in turn defined by Title 33 CFR Part 329 to include all waters which might be susceptible to use in interstate commerce and all other waters, such as lakes and wetlands, which could affect interstate commerce, including those from which fish could be taken and sold in interstate commerce.

7-12. Drought Contingency Plans. ER 1110-2-1941 (Drought Contingency Plans) requires the development and implementation of drought management plans as part of the overall water control management activities for all projects with controlled storage. A detailed Drought Contingency Plan is included in Exhibit C.

The Governor can declare a statewide drought emergency. The Governor's State Drought Action Team (SDAT) has been formed to address drought planning. This team, established 1 February 1991 by the Governor's Executive Order No. W-3-91, consists of key state and federal personnel who are responsible for overseeing and coordinating state and federal responses to droughts. The Division Engineer is an SDAT member. Any drought declaration, drought forecasts, or drought planning that may impact project operation will be the responsibility of this entity.

7-13. Flood Emergency Action Plans. The Project Office has a copy of the emergency notification plan for serious emergencies and imminent dam failure. Procedures and responsibilities during emergencies are presented in Chapter IX and Exhibit A. The emergency Seismic Action Plan for Terminus Dam and Lake Kaweah is presented in Exhibit D.

The flood emergency activities of the Sacramento District, U.S. Army Corps of Engineers, is divided into the following four phases:

a. Normal Phase (Normal Operations). This phase is in effect during normal day-to-day operations. Emergency functions will be conducted by the normal organizational units assigned to this type of work. The Chief, Water Management Section, will determine the need for obtaining hydrologic and meteorologic data during non-duty hours. If the assistance of reservoir personnel is needed, a request will be sent directly to the Park Manager, or to the Project Operators. Prior to the flood season, personnel assigned to the emergency flood organization will review ER 500-1-1 and District Supplements A, B, and C, and then ready themselves to accomplish their duties.

b. Information Phase. The Chief of the Water Management Section will place the District in Information Phase upon indication of impending floods, flash floods, localized short duration floods, minor floods, and the early stages of major floods, when property damage is not extensive and danger to life is not serious. An alert or warning will be issued to all District personnel, including field offices, and local interests in the area affected. The District may assign liaison personnel to the federal or state center during non-duty hours.

c. Alert Phase. Whenever the flood situation becomes so severe that forecast gage heights indicate that river stages will reach or exceed the bank-full stages, the Chief, Water Management Section, will recommend to the Chief, Engineering Division, to advise the District Engineer to declare an Alert Phase. The Chief, Construction-Operations Division, will activate the Flood Emergency Operations Center (EOC). The EOC will be staffed with personnel necessary to maintain a close, continuous check on weather and hydrological conditions, and issue situation reports to all District elements concerned. Liaison Engineers will be assigned to the Federal/State Flood Center.

d. Mobilization Phase. The District Engineer will order Mobilization Phase whenever major flooding appears imminent, and when the District may be called to furnish major emergency assistance. Notification will be given to all parties as rapidly as possible, and flood emergency activities will be given priority over all other District activities for the duration of the mobilization period. In addition, the District's flood emergency organization will be fully activated.

7-14. Other. There are no other project purposes.

7-15. Deviation from Normal Regulation. Deviations from approved Water Control Plans occur because every possible circumstance cannot be accounted for in a Water Control Plan. Because of the often competing goals and complex interactions of interested groups/agencies, even seemingly inconsequential deviations from an approved plan can lead to unforeseen environmental and legal complications. Deviations from approved Water Control Plans are intended, therefore, to address unforeseen and unique circumstances. They are not intended as a means for identifying or initiating new opportunities to reoperate or reallocate storage in response to new and changing public needs. Exhibit B of this manual provides general information for preparing all deviations.

7-16. Rate of Release Change. Release changes should not be made without prior notification to the Kaweah Delta Water Conservation District. There are numerous irrigation structures downstream from the dam which may require adjustments prior to any release change. In addition, during periods of high releases, the Kaweah River channel must be patrolled for debris removal and to assure proper functioning of flood control works. This is done in order to permit orderly evacuation of people and personal property in advance of rising water downstream, and to minimize bank caving after extended periods of high water flows. In the absence of any downstream constraints, releases from Terminus Dam should not be increased or decreased by more than 500 cfs (14.2 m^3/s) per hour.

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VIII - EFFECT OF WATER CONTROL PLAN

8-01. General. The Terminus Dam and Lake Kaweah Project regulates flood flows in the Kaweah River Basin to obtain the maximum practical reduction in flood damages, increase water available for irrigation during irrigation season, and increase the recreational opportunities within the Kaweah River Basin. The flood control storage in Lake Kaweah is sufficient to impound up to 185,630 acre-feet (228.9 hm^3) of floodwater from the 561 square mile (1,453.0 km^2) drainage area of the Kaweah River above Terminus Dam. The Historical Operation of Lake Kaweah is shown graphically on Plate 4-6.

8-02. Flood Control. The main objectives of the flood control plan are to prevent the inundation of areas in the lower Kaweah River Basin and to function as part of a system of reservoirs that provide flood protection to the Tulare Lakebed and adjacent areas.

a. Spillway Design Flood. The original Spillway Design Flood (SDF) for Lake Kaweah was based on a storm averaging 32.2 inches (81.8 cm) of precipitation and the equivalent of 6.7 inches (17.0 cm) of snowmelt over the entire basin, resulting in a total runoff of 24.8 inches (69.0 cm). The SDF had a peak inflow of 290,000 cfs (8,212.8 m^3/s) and a 5-day volume of 740,000 acre-feet (912.4 hm^3). The flood was routed through the reservoir using the initial storage of 107,000 acre-feet (131.9 hm^3), 43,000 acre-feet (53.0 hm^3) less than gross pool, and 5,500 cfs (155.8 m^3/s) release through the outlets, which was progressively reduced to zero as the spillway discharge reached 5,500 cfs (1,55.8 m^3/s). The initial storage was based on the reservoir being full 7 days prior to the beginning of the flood and subsequent releases being made in accordance with the Water Control Diagram. The reservoir pool peaked at an elevation of 745.1 feet (227.1 m), with a corresponding freeboard of 4.9 feet (1.5 m). The maximum outflow was 274,000 cfs (7,759.8 m^3/s).

In 1971, the Probable Maximum Flood (PMF) was revised using HMR 36. The revised PMF was based on a storm averaging 37.1 inches (94.2 cm) of precipitation and the equivalent of 5.0 inches (12.7 cm) of snowmelt over the entire basin, resulting in a total runoff of 23.9 inches (60.9 cm). The revised PMF had a peak inflow of 330,000 cfs (9,345.6 m^3/s) and a 5-day volume of 713,000 acre-feet (879.1 hm^3). The flood was routed through Lake Kaweah assuming the reservoir was at gross pool at the start of the flood due to preceding storms. The reservoir pool peaked at an elevation of 747.4 feet (227.1 m), with a corresponding freeboard of 2.6 feet (0.8 m). The maximum outflow was 295,600 cfs (8,371.4 m^3/s).

In 1998, the Probable Maximum Flood (PMF) was again revised using HMR 58. The revised PMF was based on a storm averaging 37.3 inches (94.7 cm) of precipitation and the equivalent of 4.1 inches (10.4 cm) of snowmelt over the entire basin, resulting in a total runoff of 21.8 inches (55.4 cm). This revised PMF had a peak inflow of 337,500 cfs (9,558.0 m^3/s) and a 5-day volume of 652,256 acre-feet (804.2 hm^3). The flood was routed through the enlarged Lake Kaweah assuming the reservoir was at gross pool at the start of the flood due to preceding storms. The reservoir pool peaked at an elevation of 747.12 feet (227.7 m), with a corresponding freeboard of 2.88 feet (0.9 m). The maximum outflow was 308,400 cfs (8733.9 m^3/s). A routing of the SDF flood, using the revised PMF, is shown on Plate 8-1.

b. Reservoir Design Flood. Selection of the storage capacity of Lake Kaweah was based primarily on the following flood control requirements:

(1) Protection of the urban area of the city of Visalia against all reasonable probable floods, including the Standard Project Flood. At that time, a flow of 22,000 cfs (623.0 m^3/s) was considered non-damaging to the area. The non-damaging flow to the urban area is now considered to be 10,000 cfs (283.2 m^3/s). Reevaluated flood frequency analysis and increased Standard Project Flood potential developed subsequent to the December 1966 flood event (see 8-02c below) indicate that Visalia is actually only protected from the 2.5 percent flood, due to uncontrolled local flows below Terminus Dam.

(2) Protection of agricultural lands in the Kaweah River floodplain by controlling the floods of record and the Reservoir Design Flood to 5,500 cfs (155.8 m^3/s) at McKay Point.

(3) Prevention of damaging flows into Tulare Lakebed area, in all except the extreme flood years, and minimizing damaging flows in those extreme years.

(4) Provision of 8,000 acre-feet (9.9 hm^3) of space for sedimentation. The 1977 reservoir sediment survey revealed that 7,000 acre-feet (8.6 hm^3) of sediment had accumulated in Lake Kaweah since completion of the project.

In 2003, the spillway was raised by 21 feet (6.6 m), increasing the gross pool and flood control pools to 185,630 acre-feet (228.9 hm^3). The Reservoir Design Flood (RDF) represents the maximum flood controllable to project objective outflows of 5,500 cfs (155.8 m^3/s) utilizing 173,630 acre-feet (214.1 hm^3) of flood control space. The RDF was derived from using 59.5 percent of the Standard Project Flood. Routings of the RDF and the 1 Percent Flood through Terminus Dam and Lake Kaweah are shown on Plates 8-2 and 8-3.

c. Standard Project Flood. The Standard Project Flood (SPF) used in design studies for Terminus Dam defined standard project runoff at the dam site based on the largest recorded event at that time, the December 1955 storm. A reevaluation subsequent to the December 1966 flood event indicates a somewhat greater potential runoff from the Kaweah River basin above the dam and a much larger coincident accretion between the dam and the downstream damage areas, principally from the Dry Creek drainage area. The recomputed Standard Project Flood, developed in 1970, was developed by transposing the center of the December 1966 storm (on the basis of percent of mean annual precipitation) directly over the drainage basin and computing the resulting flood by unit hydrograph methods. Loss curves used allow for variation of loss rate with accumulated total loss and rainfall intensity. They were based on analysis of the 1955 and 1966 floods, and indicate losses averaging 0.22 inches (0.6 cm) per hour during the standard project storm. The resulting Kaweah River SPF hydrograph had a peak flow of 119,000 cfs (3,370.1 m^3/s) and a four-day volume of 248,000 acre-feet (305.8 hm^3). The standard project runoff from Dry Creek has a peak flow of 20,500 cfs (580.6 m^3/s) and a four-day volume of 32,000 acre-feet (39.5 hm^3). Routing of the revised SPF through Lake Kaweah demonstrates the effect of larger local flows entering the river between Terminus Dam and McKay Point on Terminus Dam releases. Impairment of release capability during periods when the coincident local flows preempt all or an appreciable portion of available channel capacity results in an earlier loss of control during the SPF.

The Standard Project Flood used for the raised spillway is from the "Kaweah River Basin Hydrology Report," dated August 1990. This office report was prepared in support of the Kaweah River Feasibility Study. This SPF was centered over the Kaweah River basin above Terminus Dam with a total basin mean precipitation, including snowmelt, of 23.42 inches (59.5 cm) over 5 days. The SPF volume is 245,000 acre-feet (302.1 hm^3) and the peak flow is 117,700 cfs (3,333.3 m^3). A concurrent flood, developed for Dry Creek near Lemoncove, has a peak flow and volume of 16,768 cfs (472.9 m^3/s) and 25,435 acre-feet (31.4 hm^3), respectively.

The routing of the SPF through Terminus Dam and Lake Kaweah is shown on Plate 8-4.

d. Floods of Record. Hypothetical flood routings of the December 1966 rainflood are shown on Plate 8-5. Plate 8-6 presents hypothetical flood routings of the 1906 and 1969 snowmelt floods. Historical Operation for the period 1962-2004 is shown in Plate 4-6.

8-03. Recreation. Table 2-1 shows the estimated annual visitation hours since 1962. Lake Kaweah provides opportunities for many types of recreation. A description of the recreational development at the lake is presented in Paragraph 2-06.

8-04. Water Quality. Water quality sampling and testing are conducted in April and August of every year. The results of the water quality testing program are presented in Paragraph 4-08 and Table 4-15. Although the recreational activities at the lake and the warming of the ponded water may have some detrimental affect on water quality, Lake Kaweah provides water for recreation and irrigation at times when there would otherwise be none. The quality of water is "good to excellent" relative to its beneficial uses.

8.05. Fish and Wildlife. Lake Kaweah supports an excellent warm water fishery with bass, crappie, bluegill, and catfish being the predominant species. This is a considerable enhancement, given that the natural flow in the Kaweah River often falls to zero. Wildlife habitat mitigation areas associated with the spillway raise are discussed in Paragraph 2-04.

8-06. Water Supply. Under natural conditions, a large portion of annual runoff may occur during one or more relatively short flood events. Nearly all rainflood events occur from early winter through early spring (December through March). Approximately 66 percent of the annual runoff generally occurs during the snowmelt season (April through July). The annual natural runoff is highly variable, so relatively dry periods can occur over several years. Historical inflows to Lake Kaweah can be found in Table 4-12 in the Tables Section immediately following Chapter IX of this manual. Prior to the spillway raise, Lake Kaweah provided approximately 100,000 acre-feet (123.3 hm^3) of additional irrigation water annually. With the spillway raise, approximately 8,490 acre-feet (10.5 hm^3) of additional irrigation water will be provided annually for use within the upper Kaweah service area below Terminus Dam.

8-07. Hydroelectric Power. The Kaweah River Power Authority completed construction of a 17 MW power plant at Lake Kaweah in 1990. The power plant, which is now capable of generating 20 MW, is designed to take advantage of the present project operation and does not impact other project objectives.

8-08. Navigation. Navigation is not a project purpose. However, navigable waters include all "waters of the United States," which are in turn defined by Title 33 CFR Part 329 to include all waters which might be susceptible to use in interstate commerce and all other waters, such as lakes and wetlands, which could affect interstate commerce, including those from which fish could be taken and sold in interstate commerce.

8-09. Drought Contingency Plans. A detailed explanation of the Drought Contingency Plan is included in Exhibit C.

8-10. Flood Emergency Action Plans. During flood emergencies, project operation provides benefits by defining procedures for warning downstream interests. Benefits can also be expected during non-flood emergencies, such as pollution abatement. Procedures and responsibilities during emergencies are presented in Chapter IX, Exhibit A, and Exhibit D.

8-11. Frequencies

a. Unregulated Flow Frequency. Unregulated rain flows and statistical parameters representing the peak, 1-day, 3-day, 7-day, 15-day, and 30-day flows were developed for the Kaweah River below Terminus Dam and for Dry Creek near Lemoncove. The unregulated rainflood frequency curves for the Kaweah River below Terminus Dam and for Dry Creek near Lemoncove are shown on Plates 8-7 and 8-8. The computed and adopted statistics supporting Plates 8-7 and 8-8 are presented in tabular form in Tables 8-1 and 8-2 in the Table Section. Unregulated snowmelt flows and statistical parameters, representing the 1-day, 15-day, 30-day, 60-day, 90-day, and 120-day flows, were developed for the Kaweah River below Terminus Dam. The unregulated snowmelt flood frequency curves for the Kaweah River below Terminus Dam are shown on Plate 8-9. The computed and adopted statistics supporting Plate 8-9 are presented in tabular form in Table 8-3 in the Table Section following Chapter IX.

Flow records on the Kaweah River near Three Rivers began in April 1903. The flow record for the Kaweah River below Terminus dam was extended back to water year 1904 based on the Three Rivers data. Rainfall season flows at the Kaweah River near Three Rivers gage were increased by 4 percent to account for drainage area. The rainflood curves for the Kaweah River below Terminus Dam were computed based on the 100-year period from 1905 through 2004, while the snowmelt curves for the Kaweah River below Terminus Dam were computed based on the 101-year period from 1904 through 2004.

These curves were derived using procedures contained in Bulletin 17B, "Guidelines for Determining Flood Flow Frequency," published by the U.S. Water Resources Council. The final statistics have been adjusted to allow for orderly transition between curves of different durations.

b. Regulated Flow Frequency. Regulated rainflood and snowmelt flow frequency curves for the Kaweah River below Terminus Dam are shown on Plates 8-10 and 8-11, respectively. These curves reflect the historical operation of Terminus Dam from 1963-2004. The curves were extended to reflect very rare events by routing hypothetical floods through Lake Kaweah.

c. Pool Elevation, Duration, and Frequency. Elevation-Duration and Elevation-Frequency curves of reservoir storage frequency for Lake Kaweah are shown on Plates 8-12 and 8-13. These curves reflect the historical operation of Lake Kaweah from 1963-2003. Data for water year 2004 was not included on these plates, as operational changes occurred during the water year due to the completion of the spillway raise in February.

d. Seasonal Variation of Storage. The historical seasonal variation of storage frequency is shown on Plate 8-14. The level of storage is highest from late spring through mid-summer (May through July) as a result of snowmelt runoff stored for water supply and flood control. Subsequent releases made through the summer for water supply and downstream rights draw the reservoir system down for the beginning of the winter flood season. Data for water year 2004 was not included on this plate, as operational changes occurred during the water year due to the completion of the spillway raise in February.

8-12. Other Studies. The Corps of Engineers does not have any studies in progress for the Terminus Dam and Lake Kaweah Project.

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IX - WATER CONTROL MANAGEMENT

9-01. Responsibilities and Organization

a. Role of the U.S. Army Corps of Engineers. The primary responsibility for operating Terminus Dam and Lake Kaweah Project is delegated to units of the Water Management Section (Engineering Division) and Operations and Readiness Branch (Construction-Operations Division) of the Sacramento District, U.S. Army Corps of Engineers, as outlined below. The Sacramento District's Public Affairs Office (PAO) coordinates with local press regarding floods and other aspects of the project operation. Names, addresses, and telephone numbers of those individuals whose responsibilities are outlined in the following paragraphs are listed in the front of this manual and in Exhibit A.

(1) Water Management Section (Engineering Division). The Water Management Section responsibilities are as follows:

(a) Obtaining current hydrometeorological data and weather forecasts for the region.

(b) Analyzing current reservoir information, hydrometeorologic data, and weather forecasts for the region, making regulation decisions which are in accordance with the approved water control plan, and issuing appropriate operating instructions to the designated damtender.

(c) Providing training to the Project Operators in the Water Control Plan, operations procedures, and instrumentation.

(d) Providing maintenance for hydrometeorological instrumentation and gage control equipment at the project, and supervising its operation.

(e) Preparing monthly operation reports and other reports about the operation of the project as requested by the Office, Chief of Engineers, and as needed for operational purposes.

(f) Making revisions to this Water Control Manual and distributing them.

(g) Advising the District Engineer whenever there has been a departure from operating instructions, or when there is a need for making a temporary modification to those instructions.

(h) Staying informed at all times of downstream channel conditions and making periodic field inspections.

(i) Arranging with local interests for collection of flow and diversion data.

(j) Obtaining from local interests each month a summary of requested flows, and maintaining a record of the instructions issued, data transmitted to other agencies, and requests received from other agencies.

(k) Keeping the Kaweah Delta Water Conservation District (KDWCD) and other local interests continuously advised of the operation of the project.

(2) Terminus Dam and Lake Kaweah Park Manager (Construction-Operations Division) has the following responsibilities:

(a) Keeping well informed of the operating rules contained in this Water Control Manual and bringing to the attention of the Water Management Section any feature of the manual that may require clarification or revision.

(b) Keeping familiar with the operation of all recording and communication equipment and keeping informed of current hydrological and meteorological conditions (i.e., pool elevation, river flows, precipitation, etc.). Reporting by radio, telephone, or e-mail to the Water Management Section the data outlined in Exhibit A.

(c) Accomplishing the physical operation of the dam in accordance with instructions contained in this manual, or as issued by the Water Management Section. During storms, this may require 24-hour attendance at the dam.

(d) Calculating and maintaining a continuous record of inflow, outflows, storage, Dry Creek flow, weather data, and other data specified by the Water Management Section.

(e) Reporting any unusual conditions of the dam embankment, the reservoir, and the downstream channel of the Kaweah River that might interfere with the planned operation of the reservoir.

(f) Obtaining necessary information on scheduled downstream irrigation and downstream spreading activities, and keeping local interests continually advised of the routine operation of the reservoir.

(g) Maintaining a log of gate operation containing the following information: change in position of gates, date and time when such changes are made, reservoir water level, and initials of the individual accomplishing the change.

(h) Maintaining records of instructions received from the Water Management Section and requests from the Kaweah Watermaster.

(i) Making and recording weekly checks on reservoir and flow gage readings to assure proper operation of all recording equipment.

(j) Immediately after the end of each month, transmitting to the Water Management Section the data specified in Exhibit A.

(k) Making emergency operational changes when contact with the Water Management Section is broken and a clearly defined change occurs that warrants immediate action.

(l) Assisting with obtaining samples for water quality and sedimentation analysis as required.

(3) Operations and Readiness Branch (Construction-Operations Division) has the responsibly of budgeting project operation and maintenance funds.

b. Other Federal Agencies

(1) The Bureau of Reclamation (BOR) acts as the agent for the United States in the execution of the repayment contract (14-06-200-1729A), wherein water users repay a percentage of the capital for the construction of Terminus Dam with annual operational and maintenance costs. The final payment was made 1 May 2004.

(2) The National Oceanic and Atmospheric Administration (NOAA), through its National Weather Service (NWS), maintains year-round surveillance of weather conditions. NOAA weather and storm forecasts, pertinent to the area, are furnished to the NWS office in Sacramento for distribution to agencies responsible for flood protection. The NWS furnishes meteorological data and weather forecasts on a 24-hour basis. When the meteorological situation indicates general area precipitation, NWS furnishes Quantitative Precipitation Forecasts (QPF). (See Paragraph 6-01b.)

(3) Personnel from the NWS office in Sacramento and the California Department of Water Resources are assigned to the Joint Federal-State River Forecast Center (RFC), which monitors weather conditions and river stages on a year-round basis. The RFC forecasts stages and flows on major river systems, including inflow to Lake Kaweah on the Kaweah River.

(4) The Federal-State Flood Operations Center furnishes flood warnings and forecasts of river stages and flows to the local news media, law enforcement agencies, and other responsible agencies for their use and for dissemination to the public.

c. State and County Agencies

(1) The California Department of Fish and Game enforces fish and game laws on the lake and within the wildlife area. They also stock the lake with fish.

(2) The California Division of Forestry is responsible for firefighting on project land.

(3) The County of Tulare provides normal law enforcement at the project and patrol of the lake by boat. During periods of peak visitation, additional law enforcement is provided under a contract with the Corps.

(4) The Kaweah Delta Water Conservation District directs the use of conservation storage in Lake Kaweah and manages the mitigation areas that are not located on U.S. Army Corps of Engineers property.

d. Private Organizations. None

9-02. Interagency Coordination. To ensure that the flood control operation of Terminus Dam will be as effective as possible, it is essential that the Corps be continually apprised of possible flood hazards, weather conditions, inflow to the reservoir, and flows at key locations in the Kaweah River. This requires close liaison between the U.S. Army Corps of Engineers, the National Weather Service (NWS), the Federal-State River Forecast Center (RFC), the California Department of Water Resources (DWR), Kaweah Delta Water Conservation District (KDWCD), U.S. Bureau of Reclamation (USBR), and the Tulare Lake interests.

a. Local Press and Corps Bulletins. The Sacramento District, U.S. Army Corps of Engineers, Public Affairs Office (PAO), coordinates with the local press regarding floods and other aspects of project operation. The Water Management Section, Sacramento District, maintains official records on Corps projects. Current reservoir status information is available on the Corps' Sacramento District Water Control Data Systems web site: <http://www.spk-wc.usace.army.mil/>.

b. National Weather Service. Congress has given the National Weather Service responsibility for providing flood warnings to the public. The NWS office in Sacramento maintains a year-round surveillance of weather conditions. The National Weather Service also prepares and distributes weather forecasts to agencies responsible for flood protection, and to the public by way of the local news media. The NWS furnishes meteorological data and weather forecasts on a 24-hour basis. Regular forecasts are made twice a day. When the meteorological situation indicates general area precipitation, Quantitative Precipitation Forecasts are also furnished.

c. U.S. Geological Survey. The U.S. Geological Survey (USGS) operates and maintains gaging stations on a cooperative basis with local, state, and federal agencies. The USGS publishes records of their own measurements and those furnished by other agencies, such as the Bureau of Reclamation and the Corps of Engineers. Complete records of flows for Corps of Engineers flow gages were published by USGS prior to water year 1991. Since 1991, the Corps has operated and serviced these gages and now maintains the complete official record for gaging stations used in the operation of Terminus Dam. Refer to Plate 4-1 for the gaging station locations operated by various agencies within and around the basin.

d. California Department of Water Resources. The Corps of Engineers furnishes the Department of Water Resources (DWR) with precipitation and temperature data from climatological stations it maintains in the Kaweah River Basin (Atwell, Bear Trap Meadow, Giant Forest, Hockett Meadow, and Terminus Dam). Lake Kaweah pool elevation and flow data at Corps sites are also provided to DWR. The DWR publishes most of this data.

e. Kaweah Delta Water Conservation District. All releases from Lake Kaweah should be coordinated with the Kaweah Delta Water Conservation District, since they have first-hand knowledge of downstream conditions and may have to operate downstream structures to accommodate a release change. Kaweah Delta Water Conservation District owns and operates the McKay Point Diversion Structure downstream from the dam and many gaging stations below this structure.

f. Other Agencies. The Terminus Dam and Lake Kaweah Project is operated so that flows do not exceed 5,500 cfs (141.6 m^3/s) at McKay Point. Under certain conditions, it may be necessary to consider critical conditions in the Tulare Lakebed. Major releases from Pine Flat Dam and Lake, Success Dam and Lake, and Isabella Dam and Lake (all operated by the Corps of Engineers) have the potential to release floodwaters to the Tulare Lakebed. The flood control operation of these reservoirs must be coordinated with that of Lake Kaweah to take advantage of any opportunity to minimize flood damage.

During floods and other high releases, seepage and erosion along the Kaweah and St. Johns rivers should be a considered while operating Terminus Dam.

(1) Federal-State River Forecast Center. Personnel from the California-Nevada River Forecast Center, the National Weather Service Office in Sacramento, and the California Department of Water Resources are assigned to the Joint Federal-State Forecast Center (RFC), which monitors weather conditions and river stages on a year-round basis. The RFC forecasts stages and flows on major river systems, including flows on the Kaweah River.

(2) Federal-State Flood Operations Center. The Federal-State Flood Operations Center is activated when floods on major streams become imminent. This center operates on a 24-hour basis and, among other flood emergency activities, advises all interested parties of flood situations as they develop. The center furnishes flood warnings and forecasts of river stages to local news media, law enforcement agencies, and other responsible agencies for their use and for

dissemination to the public.

9-03. Interagency Agreements. The provisions for payment of project, operations, and maintenance costs by local interests are set forth in the Bureau of Reclamation contract number 14-06-200-1729A as well as the Department of Army Cooperative Agreement dated February 9, 2001.

9-04. Commissions, River Authorities, Compacts, and Committees. None.

9-05. Non-Federal Hydropower. The Kaweah River Power Authority operates the Terminus Power Project at Terminus Dam.

9-06. Reports. The Kaweah and St. Johns River Association publishes an annual report listing precipitation, discharges, unit entitlements, storages, and water diversions. Other reports required for the operation of the Terminus Dam and Lake Kaweah Project are listed in Exhibit A.

ATTACHMENT 7 – TECHNICAL JUSTIFICATION

APPENDIX D

1973 Tulare County Flood Control District Master Plan

TULARE
COUNTY
FLOOD
CONTROL
DISTRICT

FLOOD CONTROL MASTER PLAN

FOR THE COUNTY OF TULARE CALIFORNIA

MURRAY, BURNS & KIENLEN Consulting Civil Engineers Sacramento, California
THE SPINK CORPORATION Engineers, Surveyors, Planners
June 1971

Letter of Transmittal

MURRAY, BURNS & KIENLEN
Consulting Civil Engineers

Angus Norman Murray, C.E.
Joseph I. Burns, C.E.
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MURRAY, BURNS & KIENLEN — 600 Forum Building, 1107 Ninth Street — Consulting Civil Engineers, Sacramento, California

THE SPINK CORPORATION — 720 F Street — Sacramento, California

June 4, 1971

Honorable Board of Supervisors
Tulare County Flood Control District
County Civic Center
Visalia, California 93277

Gentlemen:

In accordance with an agreement dated June 23, 1970, as awarded, we are pleased to transmit our proposed Flood Control Master Plan for Tulare County, together with the Hydrology Appendix.

Throughout the period our work was in progress we received outstanding cooperation and assistance from every quarter in Tulare County. County officials at all levels, managers and engineers of municipalities, water and soil conservation agencies and numerous individuals assisted in many ways. We found everyone with whom we worked deeply concerned with the flood problems of the County and the related portions of Fresno, Kern and Kings Counties.

The specific data and advice so willingly given were indispensable to production of this Master Plan. We trust it will provide a sound basis for decision making and action to reduce or eliminate flooding in the County.

We will be pleased to discuss the Master Plan and underlying studies with you and the Planning Commission.

MURRAY, BURNS and KIENLEN

By: *Joseph I. Burns*
Joseph I. Burns

THE SPINK CORPORATION

By: *Robert C. Hall*
Robert C. Hall

McKays Point on the Kaweah and St. Johns Rivers during the 1966 floods (Photo: Kaweah Delta Water Conservation District)

TULARE COUNTY FLOOD CONTROL DISTRICT

Board of Supervisors

Raymond J. Muller, Chairman
Fred A. Batkin
Charles J. Cummings
Robert E. Harrell
Donald M. Hillman

L.B. Augustson, Road Commissioner and
Director of Flood Control Activities
Jack L. Carlsen, Flood Control Engineer

TABLE OF CONTENTS

I
INTRODUCTION

THE SETTLERS DITCH

Oh, we've now got our ditches dug,
And now let's have some fun,
We'll celebrate and jubilate
O'er labors we have done.

The work was long and tiresome,
But we pushed it right along;
So we'll celebrate, then irrigate,
And this shall be our song:

Then blow, ye winds, aye-ho,
Let fall the rain and snow;
Through old Cross Creek and the Settlers' Ditch
The waters now may flow—
With melted snow and rain,
With melted snow and rain,
We'll all get rich with the Settlers' Ditch,
To grow the Golden Grain!

— Pioneer song from the Dinuba Advocate

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.

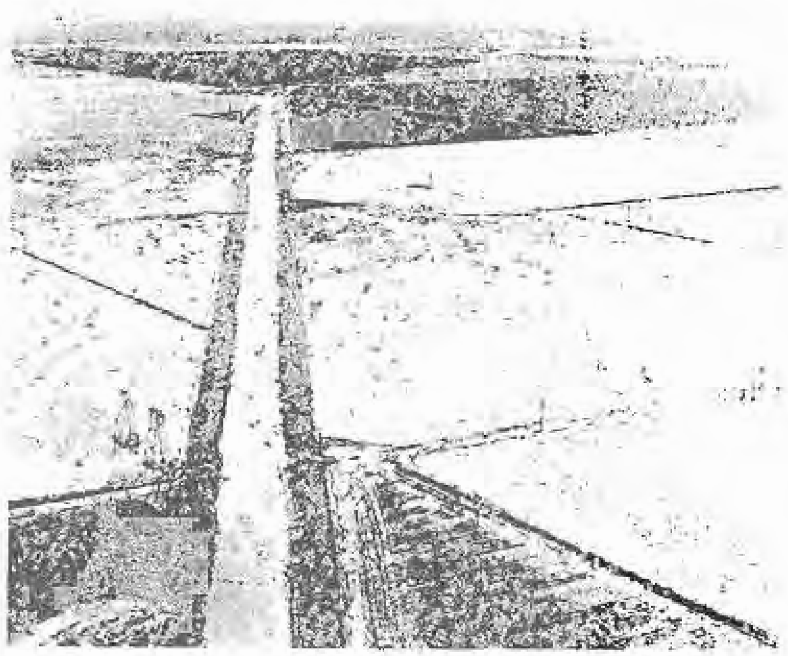
Man has changed all this. About 1850, waters of the four major streams began to be diverted for irrigation purposes. Snowmelt runoff of the Basin streams and also of the San Joaquin River, instead of uselessly flowing into Tulare Lake or the sea, became the very foundation of the region's economy as 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.)

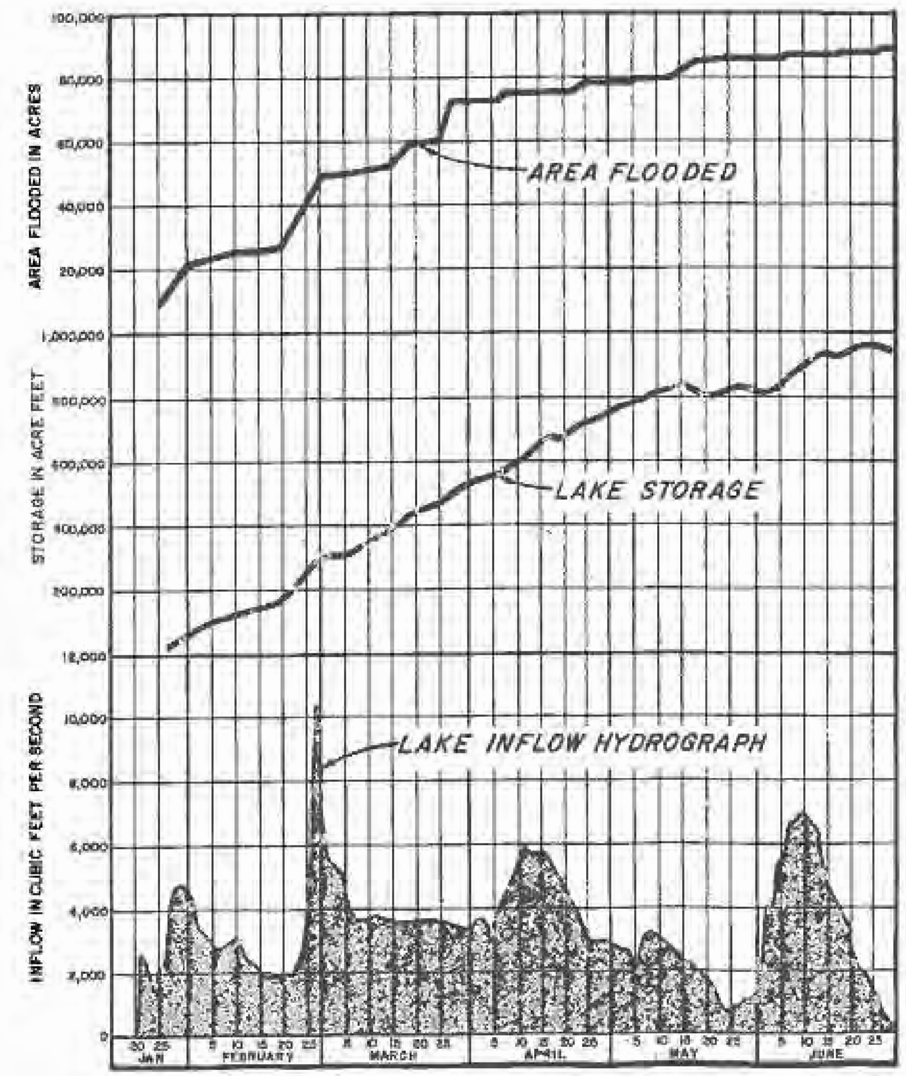
▼ Cottonwood Creek west of Friant-Kern Canal 1969 (Photo: Kaweah Delta Water Conservation District)



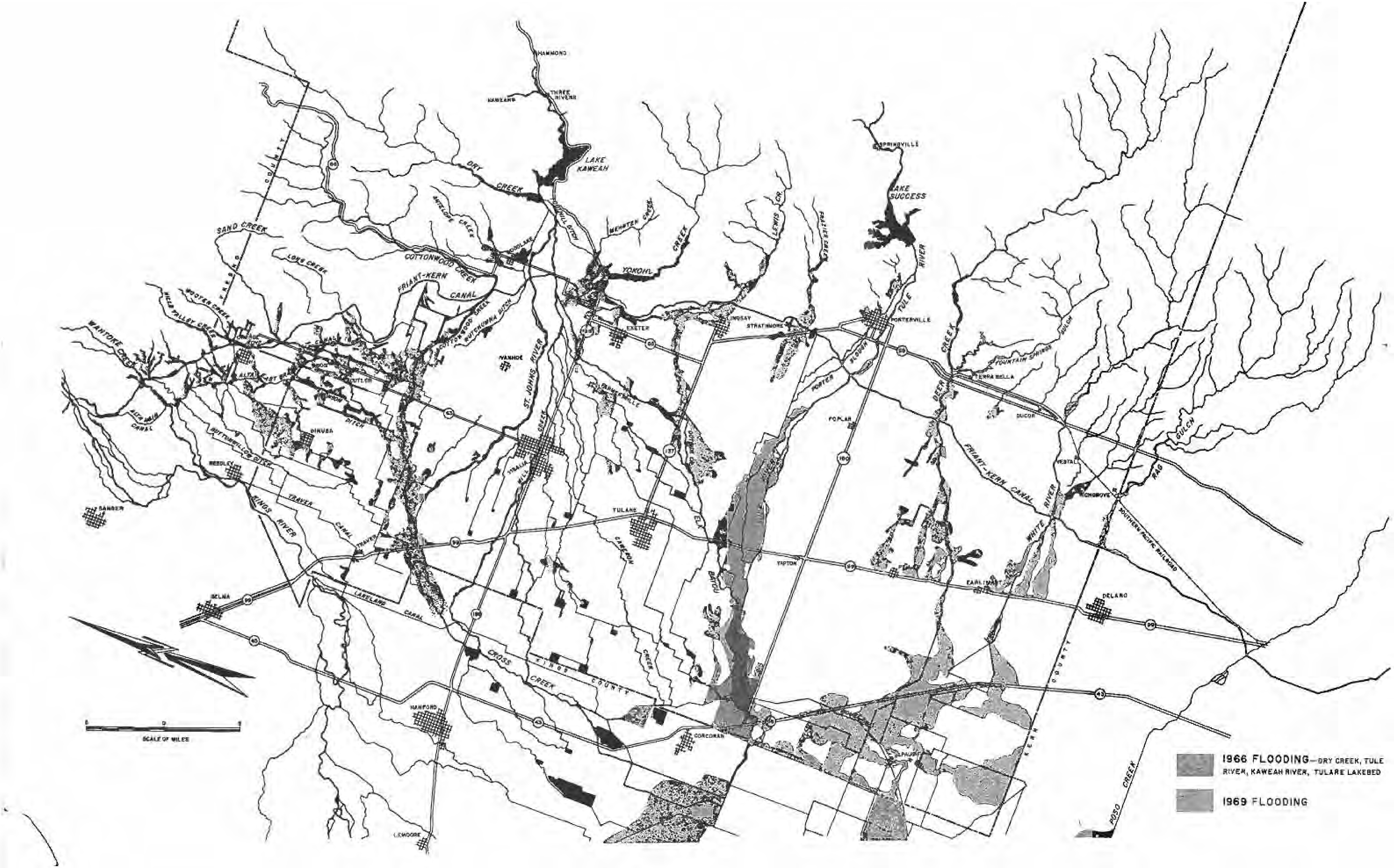
Consideration of flood problems in Tulare County must encompass an area wide enough to include portions of Fresno, Kings and Kern Counties. Water originating in the foothills of southern Fresno County may flow overland or along man-made obstructions or follow canals to cause damage in Tulare County. 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.

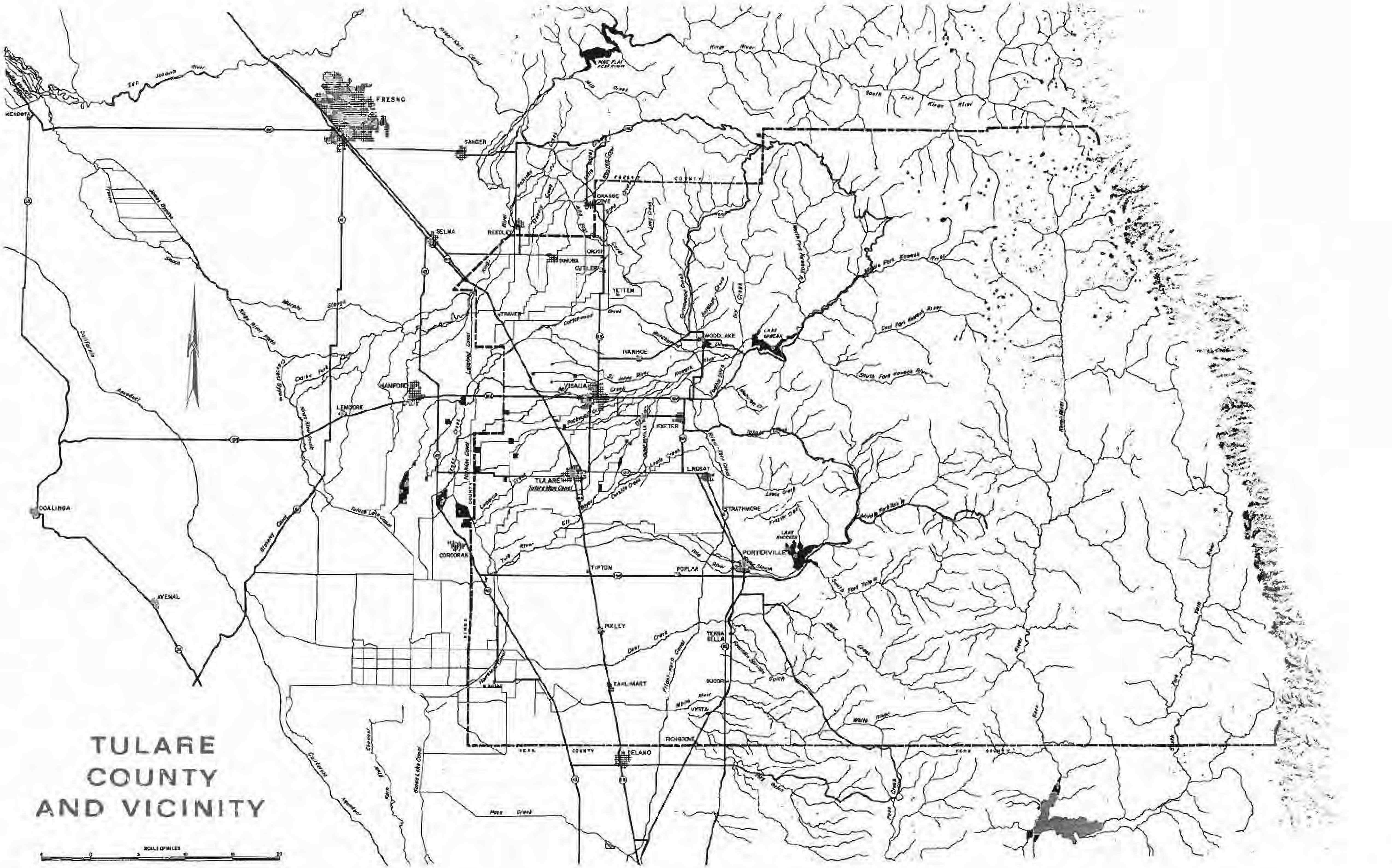
In the winters of 1967 and 1969, snowfall was so great that the resulting runoff could not be controlled completely and great volumes of water poured into Tulare Lake and flooded agricultural land. The chart shows the rate of inflow, the volume of water accumulated and the area flooded in Tulare Lake 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


HAMMOND
KAWEAH
THREE RIVERS
LAKE KAWEAH
DRY CREEK
SAND CREEK
LONG CREEK
COTTONWOOD CREEK
FRIANT-KERN CANAL
YOKOHL CREEK
MEHRTEN CREEK
LEWIS CR.
FRAZIER CREEK
SPRINGVILLE
LAKE SUCCESS
TULE RIVER
WAHTOKE CREEK
WOOTEN CREEK
ALTA
EXETER
LINDSAY
STRATHMORE
PORTERVILLE
IVANHOE
ST. JOHNS RIVER
FARMERSVILLE
PORTER SLOUGH
DEER CREEK
FOUNTAIN SPRINGS GULCH
TERRA BELLA
DUCOR
POPLAR
DINUBA
ALTA MAIN CANAL
REEDLEY
VISALIA
TULARE
KINGS RIVER
TRAVER CANAL
TRAVER
SANGER
ELK BAYOU
CAMERON CREEK
TIPTON
FRIANT-KERN CANAL
WHITE RIVER
RICHGROVE
RAG GULCH
SOUTHERN PACIFIC RAILROAD
EARLIMART
DELANO
SELMA
LAKELAND CANAL
CROSS CREEK
KINGS COUNTY
KERN COUNTY
TULARE COUNTY
FRESNO COUNTY
HANFORD
CORCORAN
ALPAUGH
LEMOORE
POSO CREEK
SCALE OF MILES
1966 FLOODING—DRY CREEK, TULE RIVER, KAWEAH RIVER, TULARE LAKEBED
1969 FLOODING



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 co-operation 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.

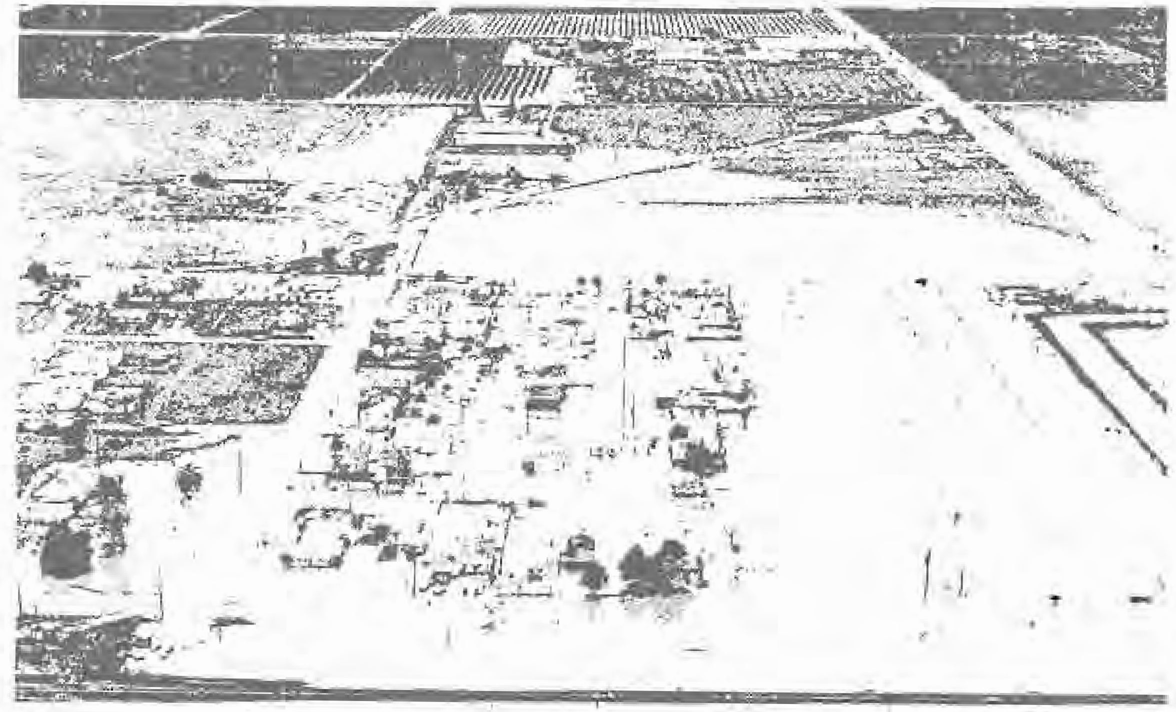
Summary, Conclusions & Recommendations

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.

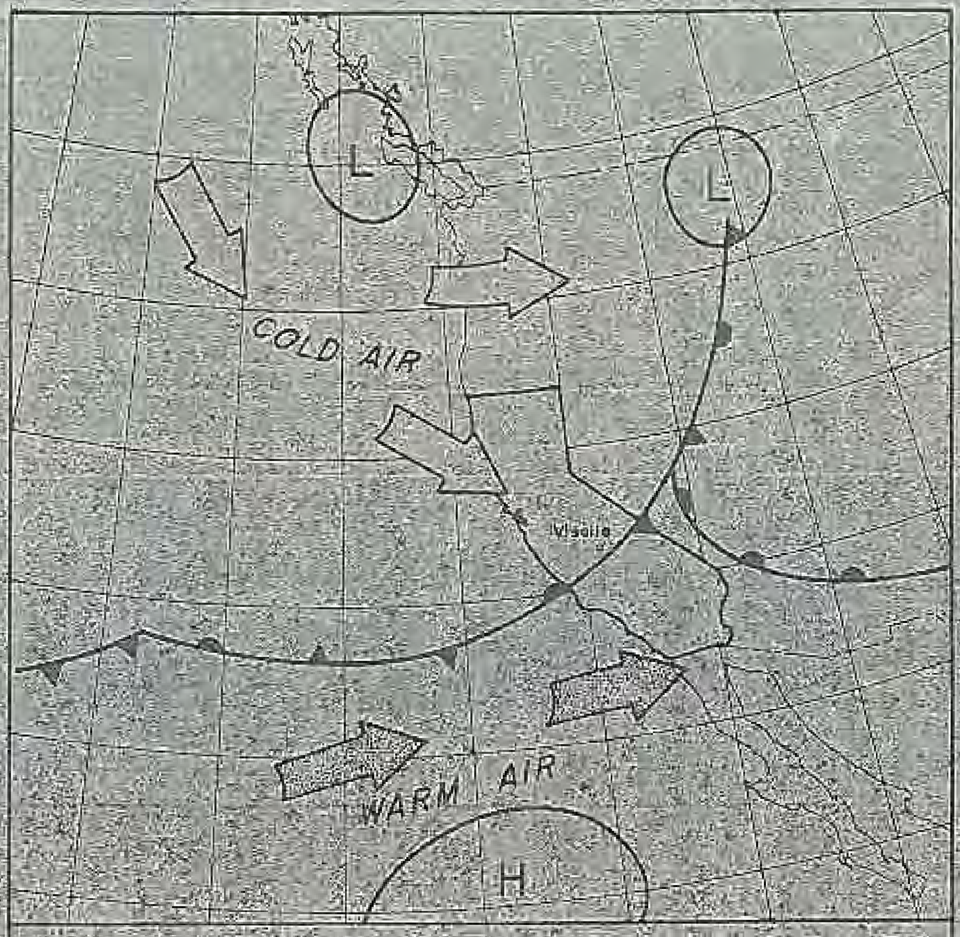
Flooding in East Orosi, 1969
(Photo: U.S. Corps of Engineers and Kaweah Delta Water Conservation District)



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



WEATHER MAP
AT 1000 PST
DECEMBER 5, 1966

WEATHER MAP
AT 1000 PST
DECEMBER 6, 1966

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

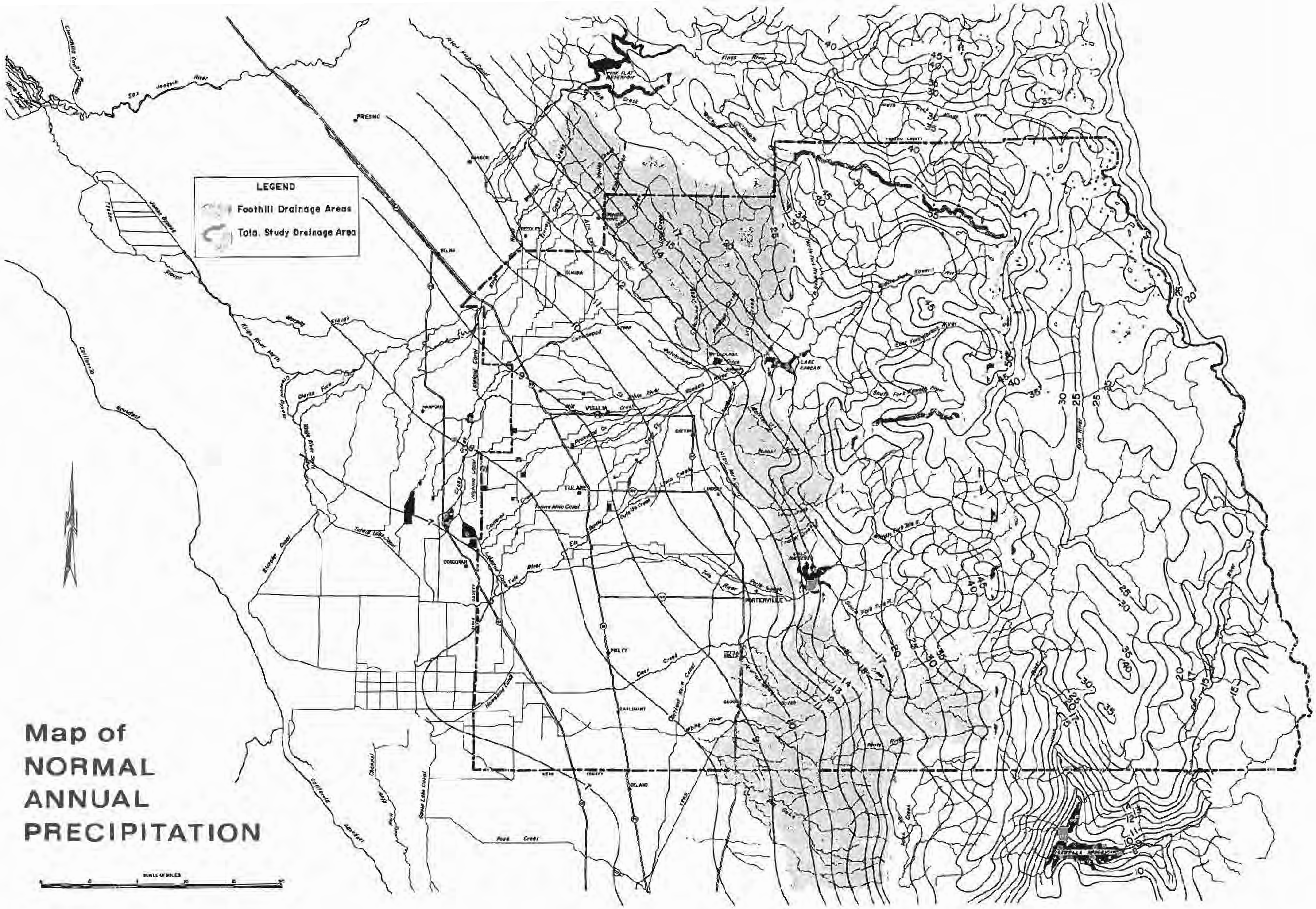
The changeability of the weather has been commented on since the dawn of recorded history. It varies hourly, day to day, month to month, season to season and year to year. Weather systems may bring precipitation and at times the precipitation brings runoff of such intensity and duration that flooding 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, nondamaging 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 subdrainage 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.

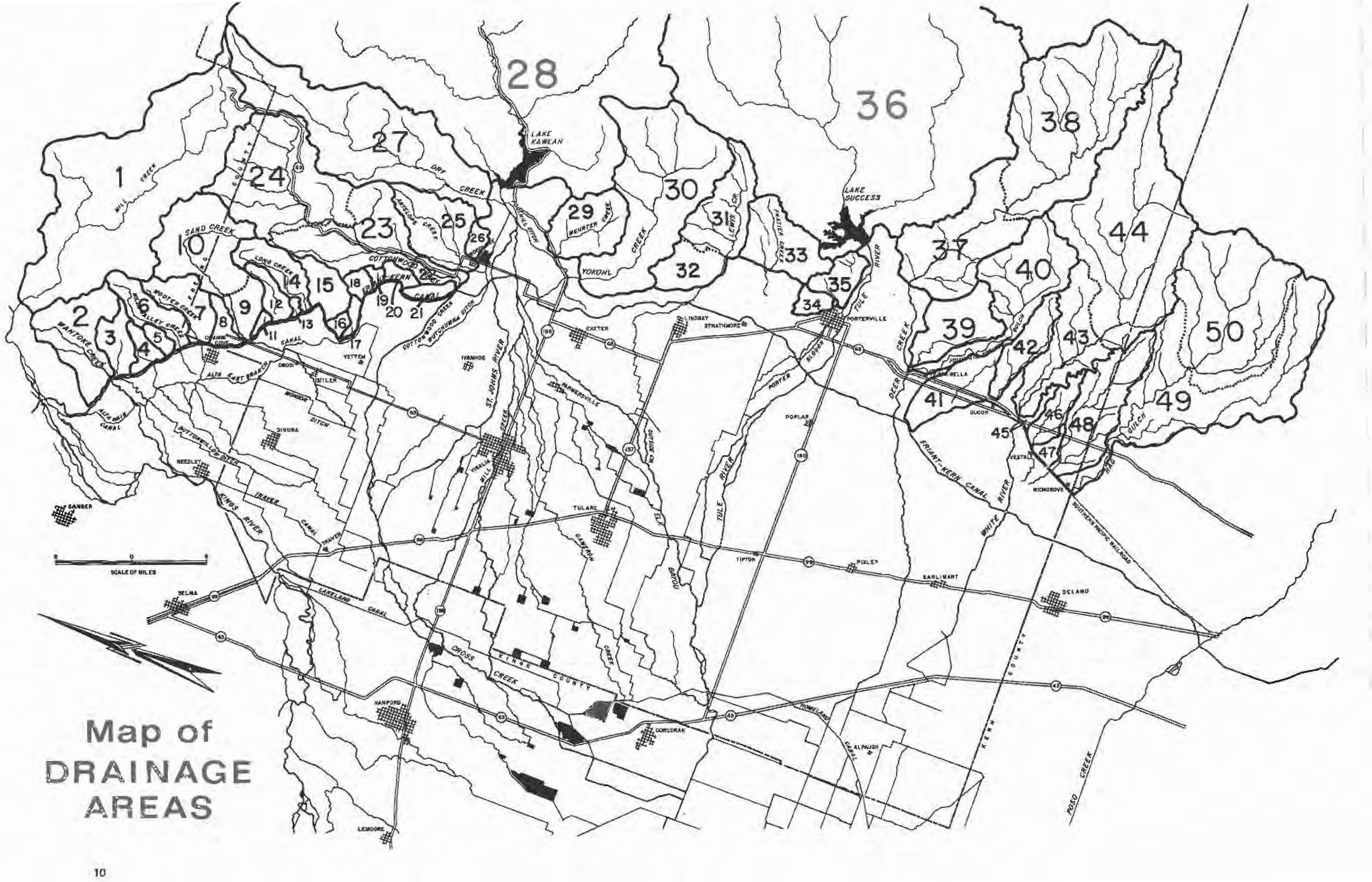
The table which follows presents the drainage area number for each area shown on the map and identifies briefly the stream or drainage system. Also, for each drainage system, the area and normal annual precipitation are shown together with the peak flow in cubic feet per second (cfs) estimated to occur 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.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LAKE KAWEAH
LAKE SUCCESS
MILL CREEK
DRY CREEK
SAND CREEK
LONG CREEK
COTTONWOOD CREEK
FRIANT-KERN CANAL
WAHTOKE CREEK
YOKOHL CREEK
LEWIS CR.
TULE RIVER
DEER CREEK
WHITE RIVER
ST. JOHNS RIVER
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VISALIA
LEMOORE
TIPTON
PIXLEY
EARLIMART
ALPAUGH
DUCOR
RICHGROVE
SCALE OF MILES
SOUTHERN PACIFIC RAILROAD
KINGS COUNTY
KERN COUNTY
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	1956 —	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 (d) Near Three Rivers (g) Below Success Dam
(b) Near Orange Cove (e) Near Exeter (h) Below Success Dam and prior to regulation by Lake Success
(c) Below Terminus Dam (f) Near Lindsay (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.

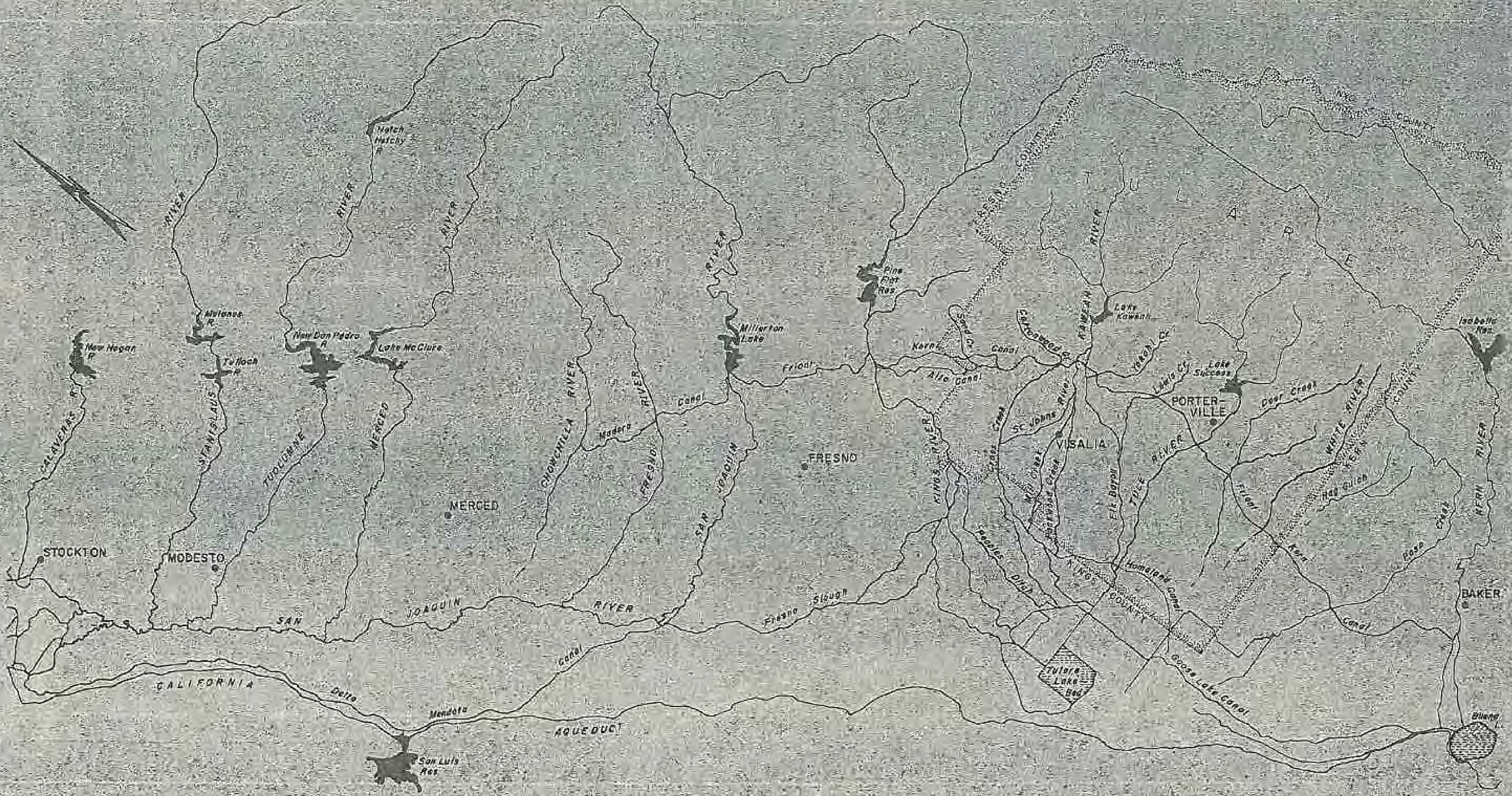
Reservoirs serving such multiple purposes generally involve compromises. A single-purpose flood control reservoir will be empty except when storing water which would cause downstream damage. A single-purpose irrigation or power reservoir will be as full as inflows permit consistent with meeting downstream 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


STOCKTON
MODESTO
MERCED
FRESNO
VISALIA
PORTERVILLE
BAKER
New Hogan R.
CALAVERAS R.
STANISLAUS
RIVER
Tulloch R.
New Don Pedro
TUOLUMNE
Hetch Hetchy R.
Lake McClure
MERCED
RIVER
CHOWCHILLA RIVER
FRESNO RIVER
Madera Canal
Millerton Lake
SAN JOAQUIN
RIVER
Friant
Pine Flat Res.
Kern Canal
Alta Canal
KINGS RIVER
St. Johns River
KAWEAH RIVER
Lake Kaweah
Lake Success
TULE RIVER
Deer Creek
WHITE RIVER
Poso Creek
KERN RIVER
Isabella Res.
Tulare Lake Bed
KINGS COUNTY
Goose Lake Canal
Homeland Canal
Fresno Slough
SAN JOAQUIN RIVER
CALIFORNIA AQUEDUCT
Delta Mendota Canal
San Luis Res.
Buena

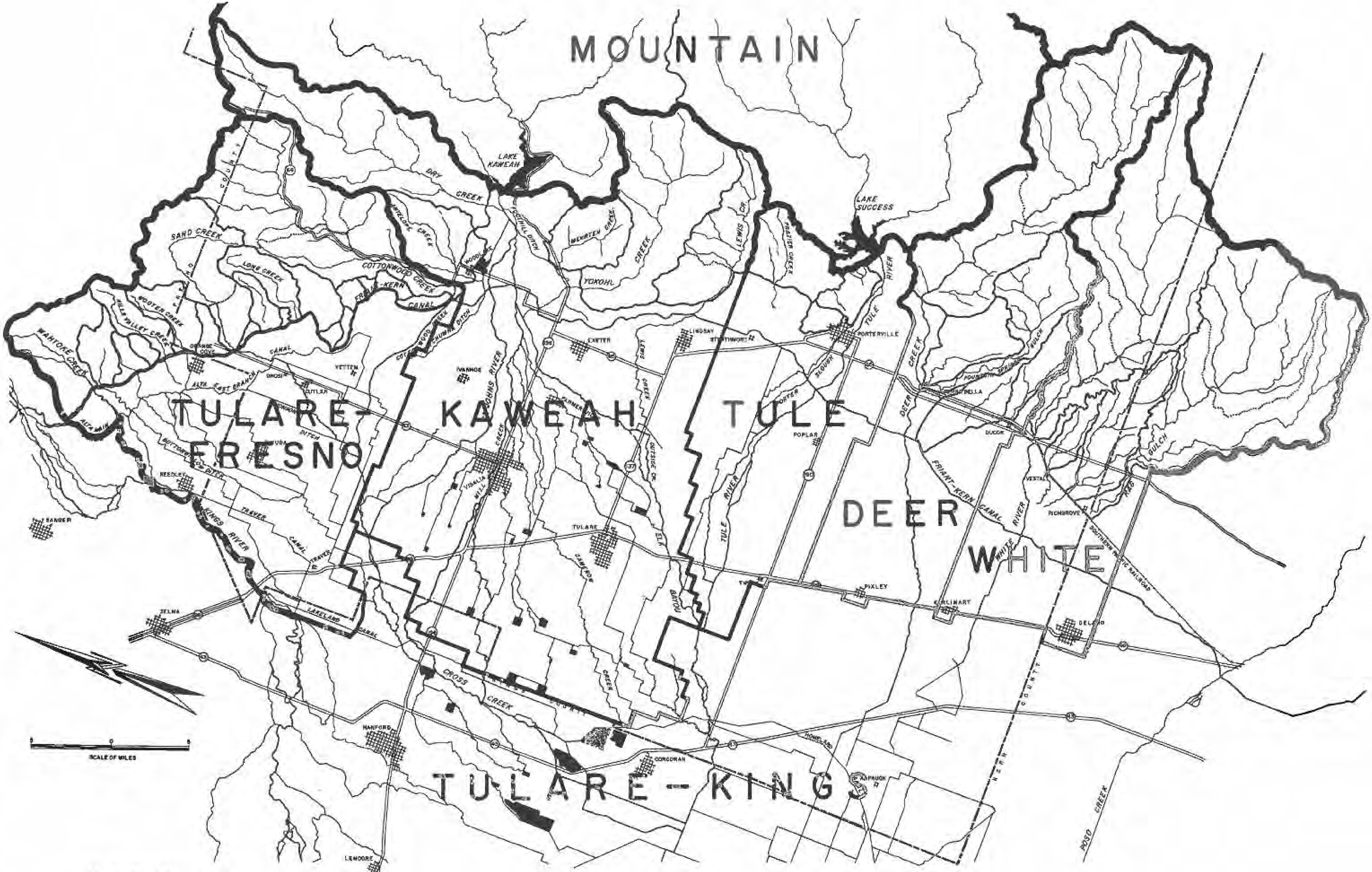
FLOOD CONTROL CONCEPTS III

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
LONE CREEK
COTTONWOOD CREEK
FRIANT-KERN CANAL
WAHTOKE CREEK
WOOTEN CREEK
HILLS VALLEY CREEK
ANTELOPE CREEK
FOOTHILL DITCH
MEHRTEN CREEK
YOKOHL
CREEK
LEWIS CR
FRAZIER CREEK
TULE RIVER
DEER CREEK
FOUNTAIN SPRINGS GULCH
RAG GULCH
ORANGE COVE
OROSI
CUTLER
YETTEM
IVANHOE
WOODLAKE
EXETER
LINDSAY
STRATHMORE
PORTERVILLE
DUCOR
POPLAR
VISALIA
TULARE
PIXLEY
EARLIMART
DELANO
RICHGROVE
VESTAL
REEDLEY
SANGER
SELMA
HANFORD
CORCORAN
LEMOORE
ALPAUGH
KINGS RIVER
TRAVER CANAL
ELK BAYOU
TULE RIVER
WHITE RIVER
CROSS CREEK
CAMERON
OUTSIDE CR.
LAKELAND CANAL
ALTA EAST BRANCH
ALTA MAIN
SOUTHERN PACIFIC RAILROAD
POSO CREEK
HOMELAND
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.

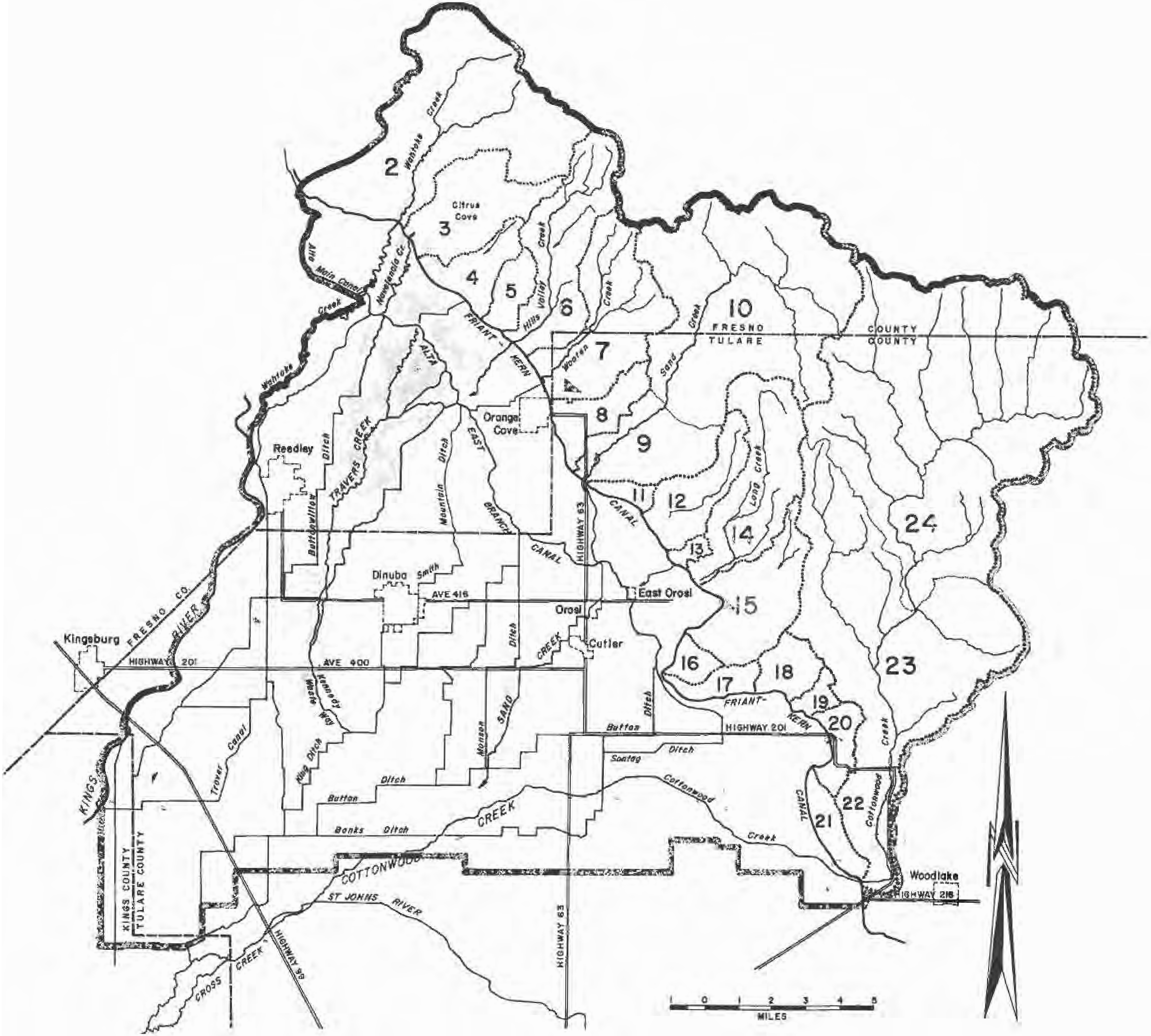
TULARE-FRESNO UNIT

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.

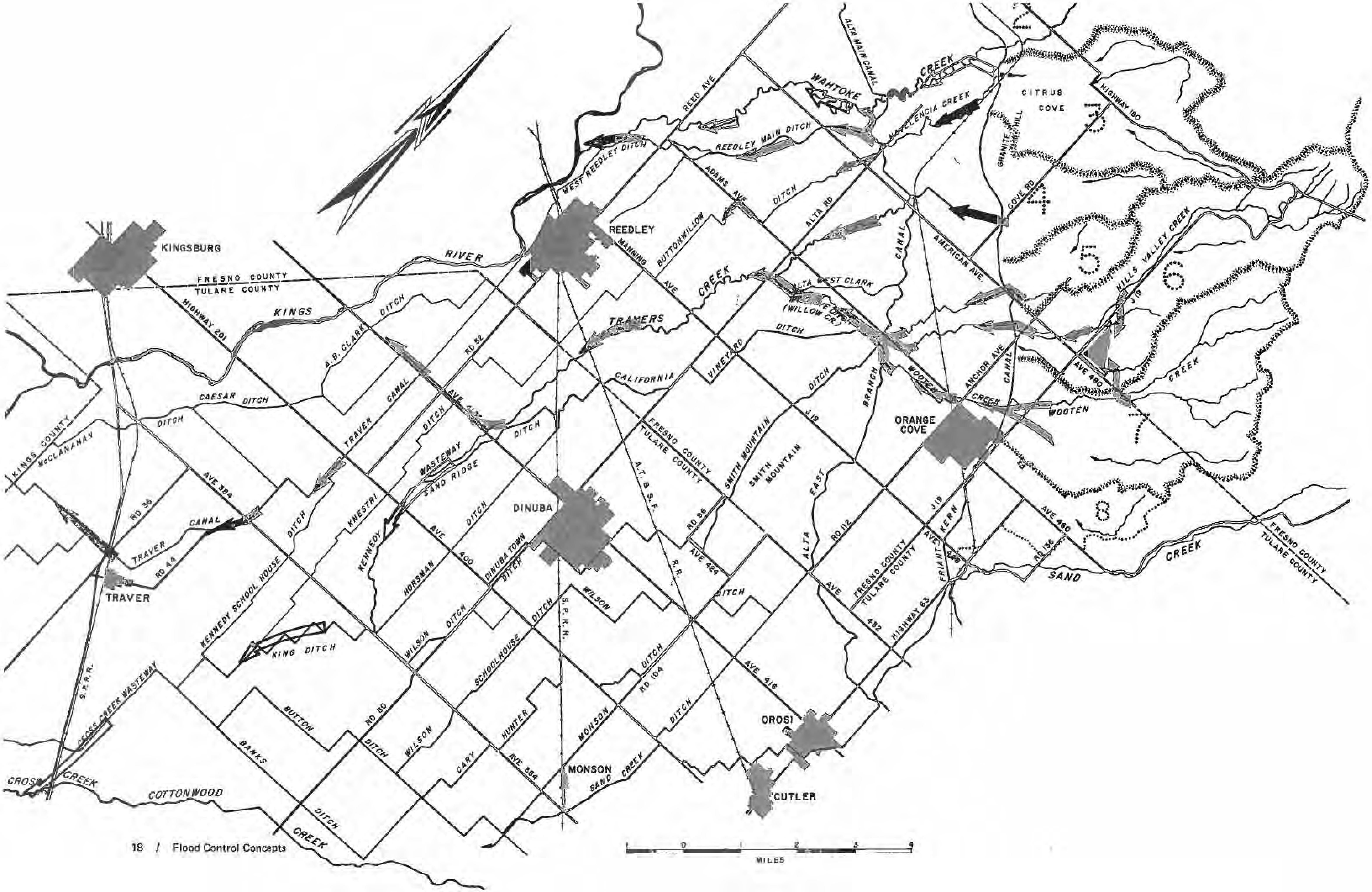
Runoff of Wahtoke Creek (Area 2), Citrus Cove (Area 3), Granite Hill (Area 4), Surprise Creek (Area 5), Hills Valley Creek (Area 6), Wooten Creek (Area 7) and Orange Cove (Area 8) produces flooding of Fresno County lands and contributes to flooding in Tulare County. Extensive flooding occurs east of 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.



Citrus Cove
Orange Cove
Reedley
Dinuba
Orosi
East Orosi
Cutler
Kingsburg
Woodlake
FRESNO COUNTY
TULARE COUNTY
KINGS COUNTY
TULARE COUNTY
FRESNO CO.
KINGS RIVER
FRIANT-KERN CANAL
HIGHWAY 63
HIGHWAY 201
HIGHWAY 99
HIGHWAY 216
AVE 416
AVE 400
MILES


KINGSBURG
REEDLEY
DINUBA
ORANGE COVE
OROSI
CUTLER
MONSON
TRAVER
CITRUS COVE
KINGS RIVER
FRESNO COUNTY
TULARE COUNTY
KINGS COUNTY
HIGHWAY 201
HIGHWAY 180
HIGHWAY 63
WAHTOKE CREEK
ALTA MAIN CANAL
REEDLEY MAIN DITCH
WEST REEDLEY DITCH
ADAMS AVE
ALTA RD
BUTTONWILLOW
MANNING AVE
AMERICAN AVE
COVE RD
HILLS VALLEY CREEK
TRAVERS CREEK
CALIFORNIA DITCH
CAESAR DITCH
McCLANAHAN DITCH
A. B. CLARK DITCH
TRAVER CANAL
SAND RIDGE WASTEWAY
KENNEDY DITCH
KNESTRI DITCH
HORSMAN DITCH
AVE 400
DINUBA TOWN DITCH
KENNEDY SCHOOL HOUSE DITCH
KING DITCH
WILSON DITCH
SCHOOLHOUSE DITCH
HUNTER DITCH
CARY DITCH
MONSON DITCH
BUTTON DITCH
BANKS DITCH
AVE 384
RD 80
RD 104
RD 96
RD 112
RD 136
AVE 416
AVE 424
AVE 432
AVE 460
AVE 480
RD 52
RD 36
RD 44
J 19
A.T. & S.F. R.R.
S.P.R.R.
SMITH MOUNTAIN DITCH
ALTA EAST
BRANCH
WOOTEN CREEK
ANCHOR AVE
CANAL
FRIANT KERN
SAND CREEK
CROSS CREEK
CROSS CREEK WASTEWAY
COTTONWOOD CREEK
ALTA WEST CLARK
VINEYARD
GRANITE HILL
MILES
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1
2
3
4
5
6
7
8

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.

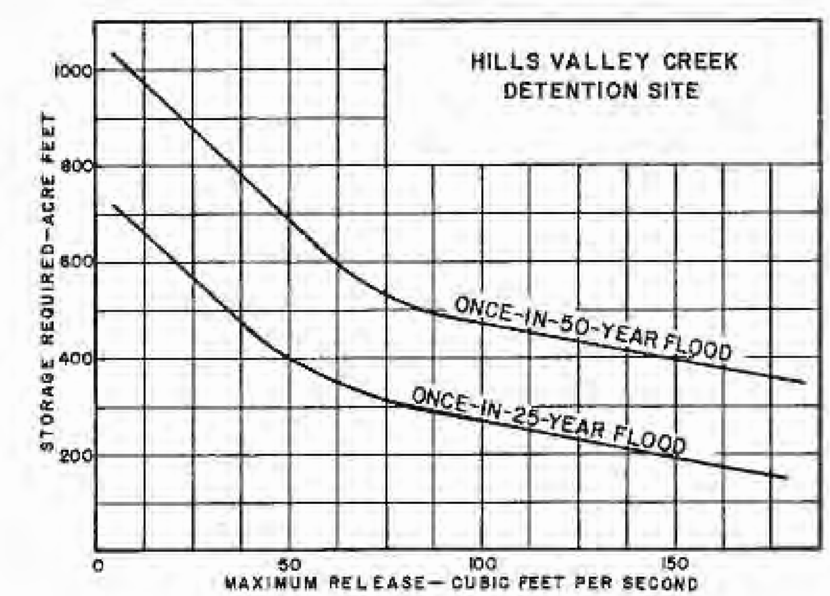
Two alternate concepts are suggested for conveyance of Navelencia Creek flows to Kings River. In one, the creek flood-flow would be diverted as close as possible to the downstream side of the Friant-Kern Canal siphon to Wahtoke Creek for conveyance to Kings River. In the second concept, flows arriving 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)

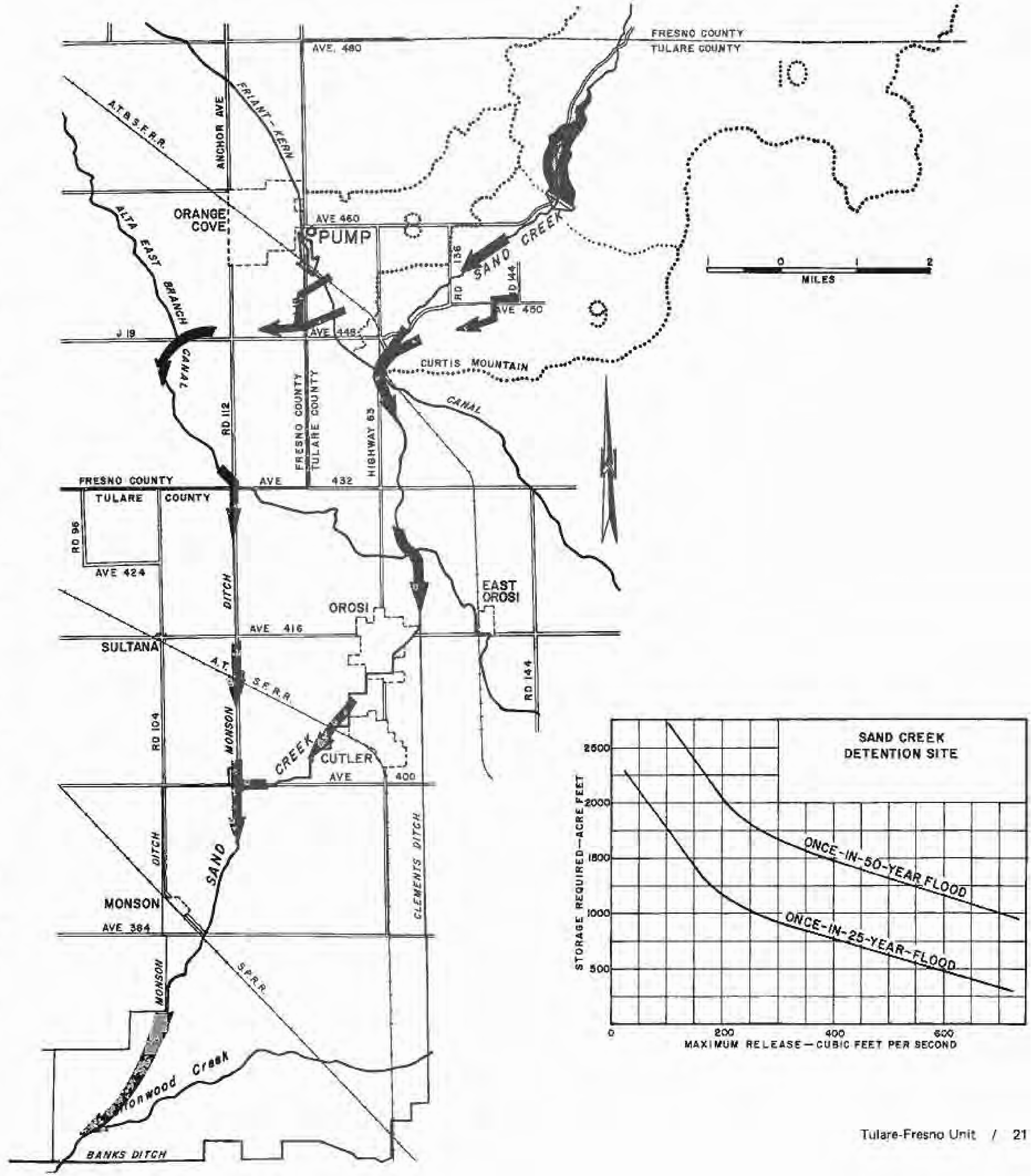
Sand Creek is a major contributor to flooding an area of some 30 square miles east of Road 104 and southerly to Cottonwood Creek. Some of the water flooding this area is carried from the north by the Alta East Branch Canal, but control of Sand Creek, together with the measures suggested previously for 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.

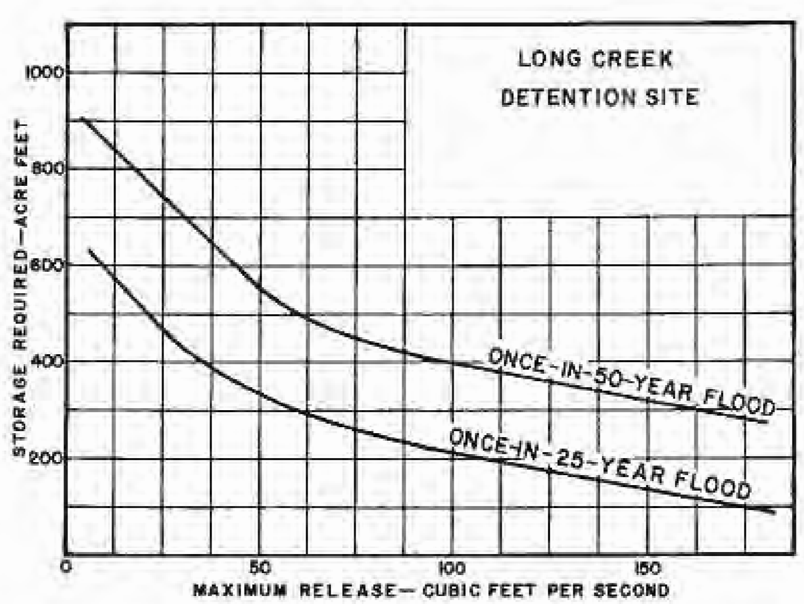
Reduction of anticipated peak flows of Sand Creek by detention east of Friant-Kern Canal is essential. The amount of such storage is directly related to the amount of flow permitted to pass downstream. The relationships between detention basin capacity and controlled releases for once-in-25-year and 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.

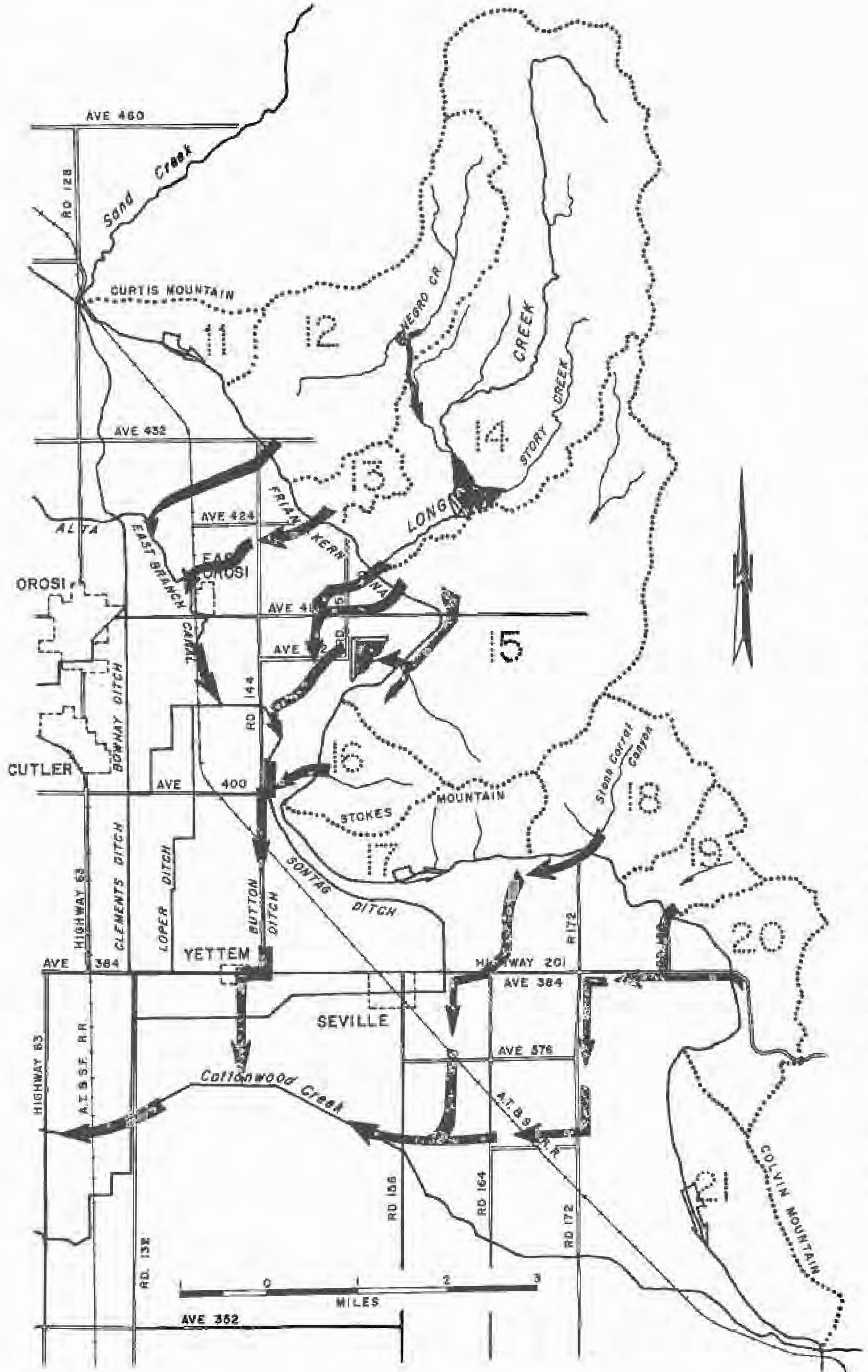
AVENUE 416 DRAINAGE (AREA 15)

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.

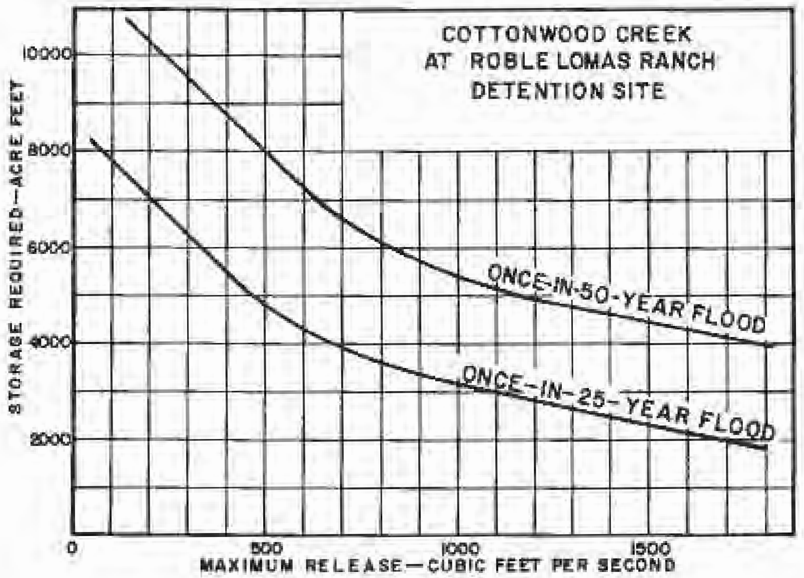
STONE CORRAL CANYON (AREA 18), ROAD 180 DRAINAGE (AREA 19) AND AVENUE 384 DRAINAGE (AREA 20)

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.

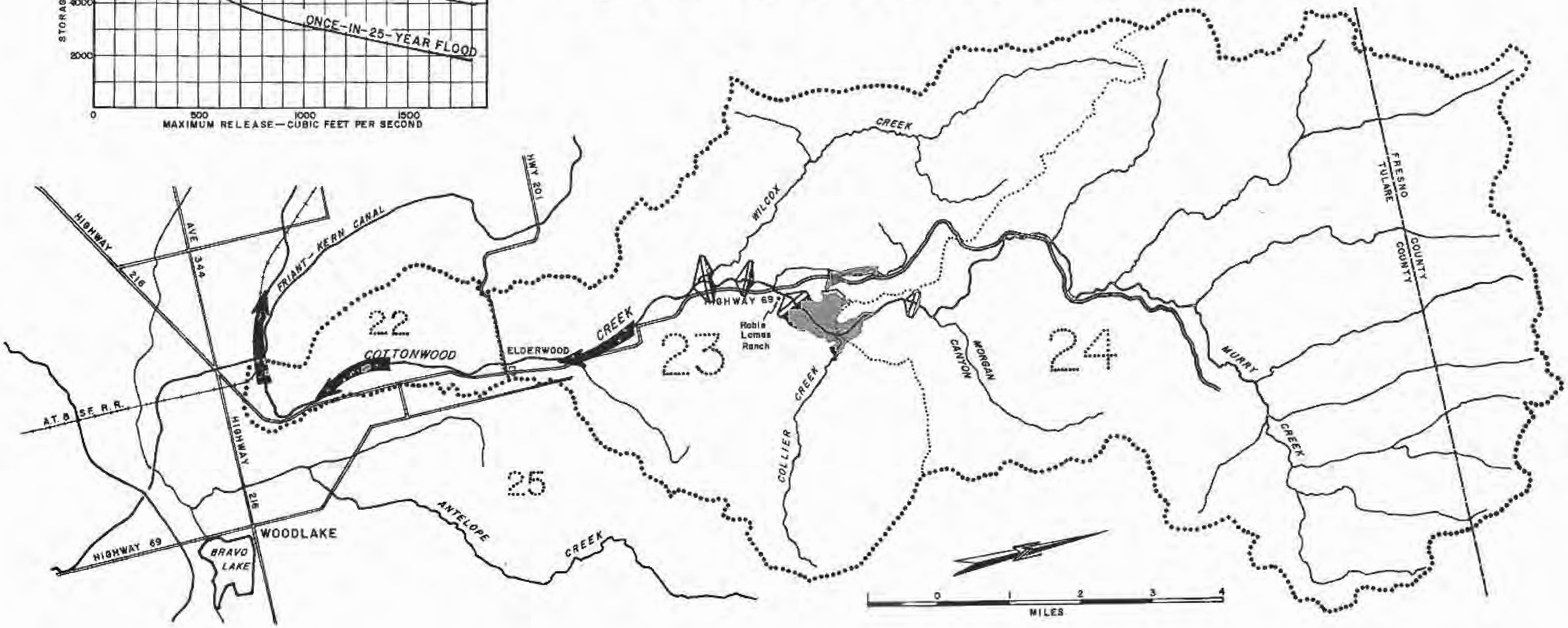
A Public Law 566 Watershed Work Plan has been formulated for this area by the Soil Conservation Service. The plan includes construction of 2.6 miles of open-joint tile drains, 6.4 miles of reinforced concrete pipe, 4.0 miles of open channel and a 230-acre-foot sump adjacent to Cottonwood Creek to ameliorate 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.

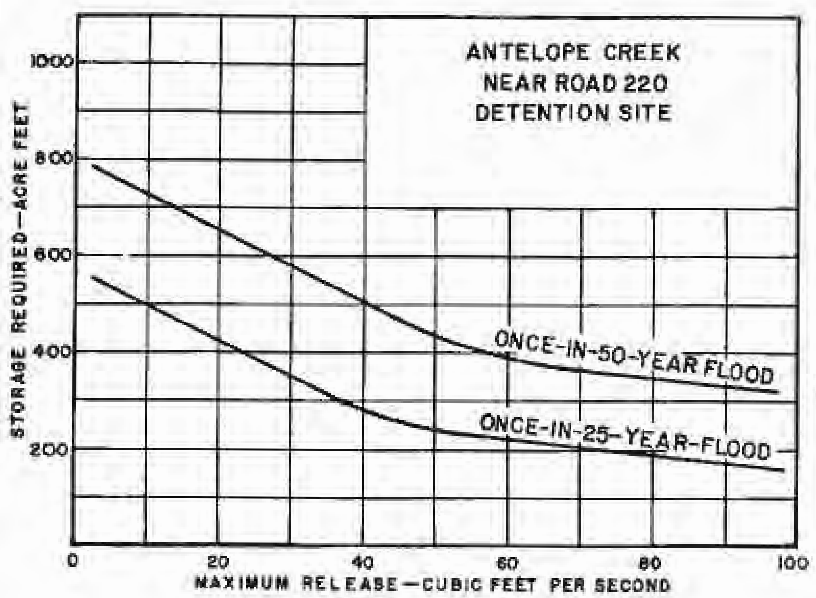
Dry Creek itself is critically important to flood control measures below Terminus Dam; it is reported to have had a peak flow of 14,500 cfs in 1966 about one-half mile upstream of its junction with Kaweah River, an amount to be compared with the objective flow of 5,500 cfs at McKays Point control structure, 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.

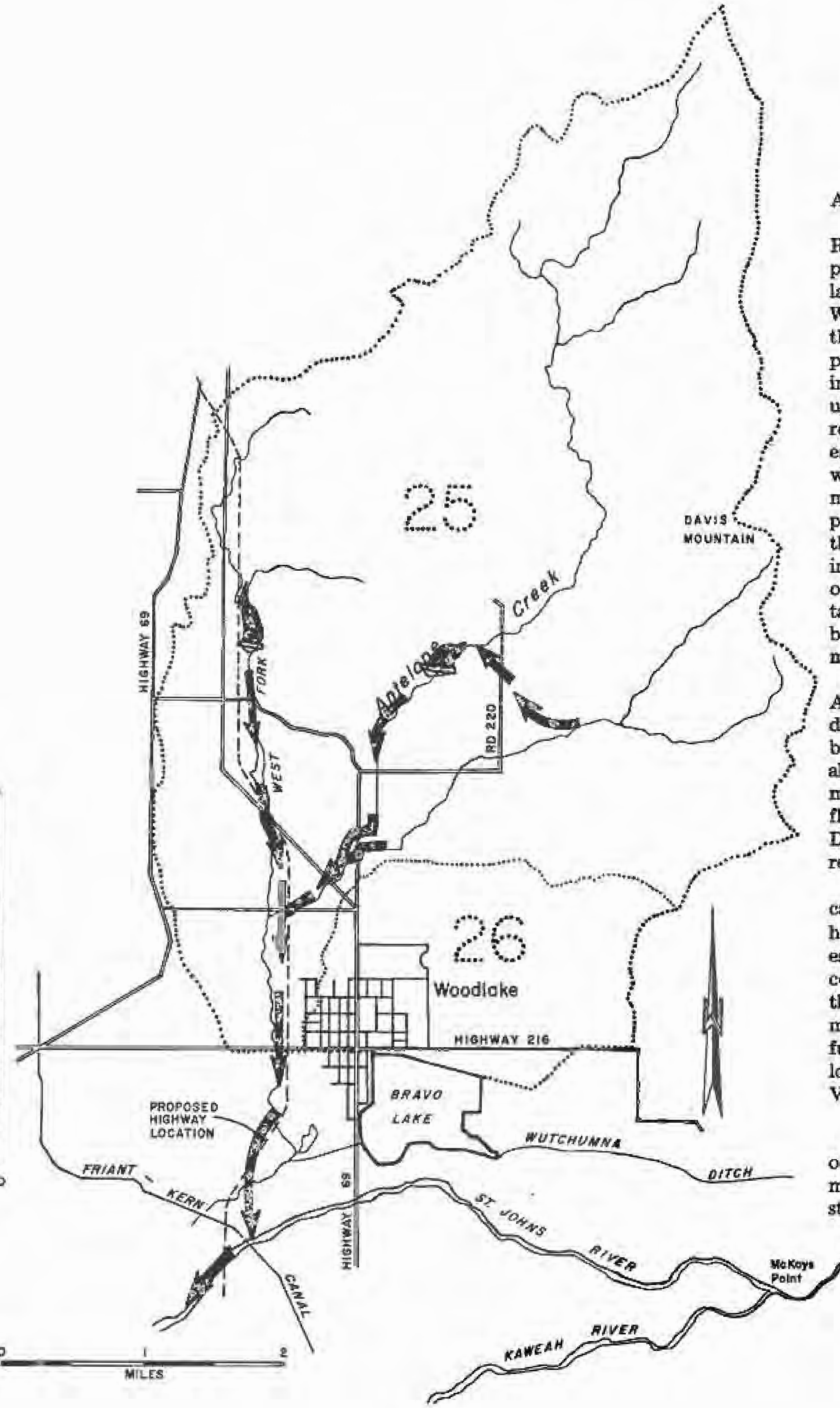
Flows in excess of 5,500 cfs pose serious operational problems at the McKays Point structure. As a result, serious flooding in Visalia is a definite hazard under present conditions. Currently, the Corps of Engineers is studying means of alleviating this problem. Until river flows reaching the structure 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 COUNTY
KINGS COUNTY
TULARE COUNTY
MILES
FRESNO CO.
TULARE CO.
COTTONWOOD CREEK
Elbow Creek
HIGHWAY 63
Wutchumna Ditch
IVANHOE
HIGHWAY 216
Cottonwood Creek
Antelope Creek
DRY CREEK
WOODLAKE
25
26
27
28
29
30
31
32
Lake Kaweah
McKays Point
HWY 69
ST. JOHNS RIVER
KAWEAH RIVER
North
Mill Cr.
GOSHEN
MILL
VISALIA
CREEK
CROSS CREEK
South Mill Creek
PACKWOOD CREEK
Consolidated Peoples Ditch
HIGHWAY 198
Foothill Ditch
MEHRTEN CREEK
FARMERSVILLE
EXETER
Deep Creek
CAMERON CREEK
HIGHWAY 99
TULARE
MAIN CANAL
Outside Creek
LEWIS CREEK
HIGHWAY 65
FRIANT KERN CANAL
YOKOHL CREEK
TULARE
HIGHWAY 137
LINDSAY
Round Valley
LEWIS CREEK
BAYOU
ELK
Lakeland Canal
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.

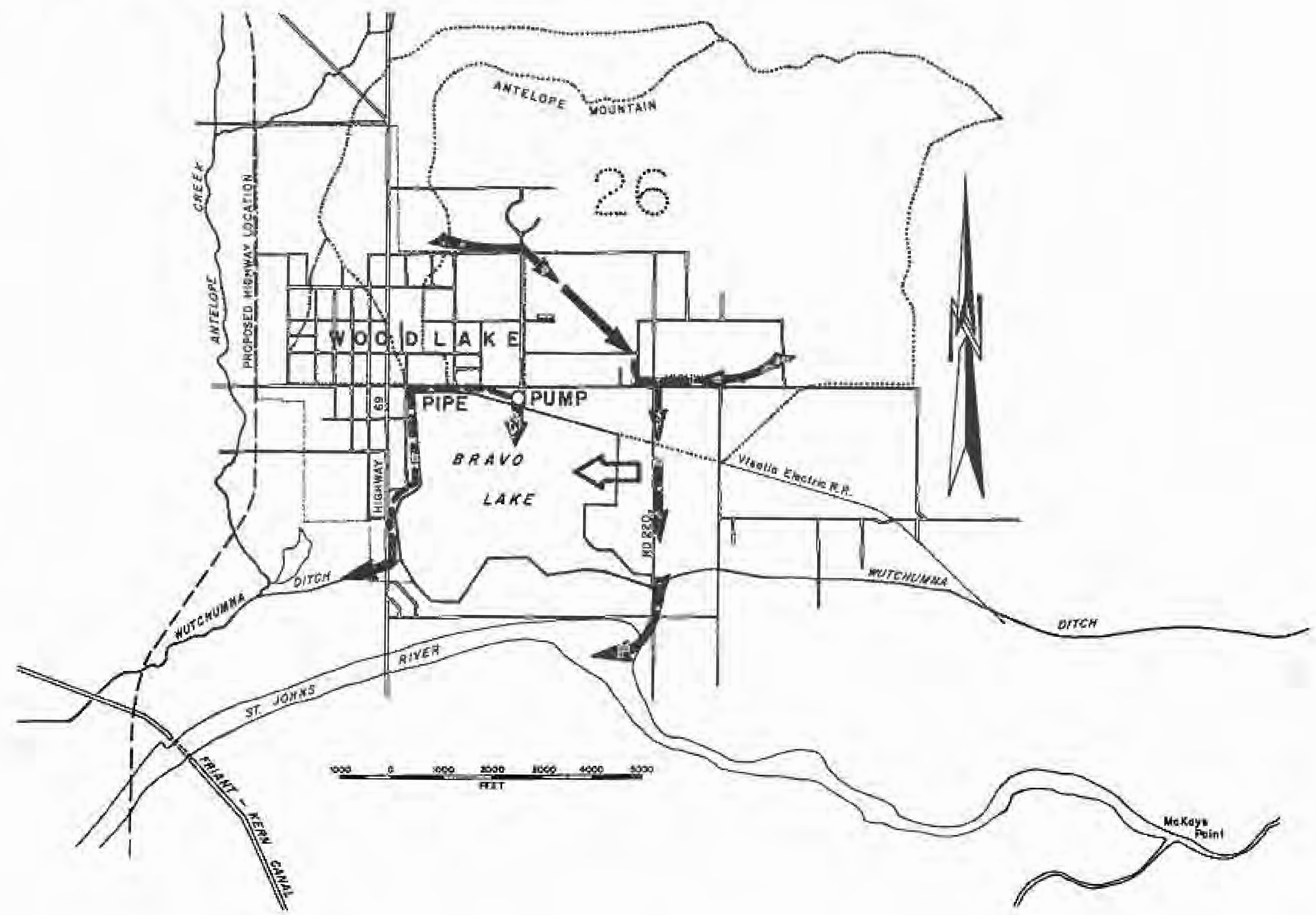
Peak flows of several hundred cubic feet per second may occur in the West Fork of Antelope Creek, which joins the main channel northwest of Woodlake. Sites for detention storage on the West Fork are quite limited, there appearing to

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

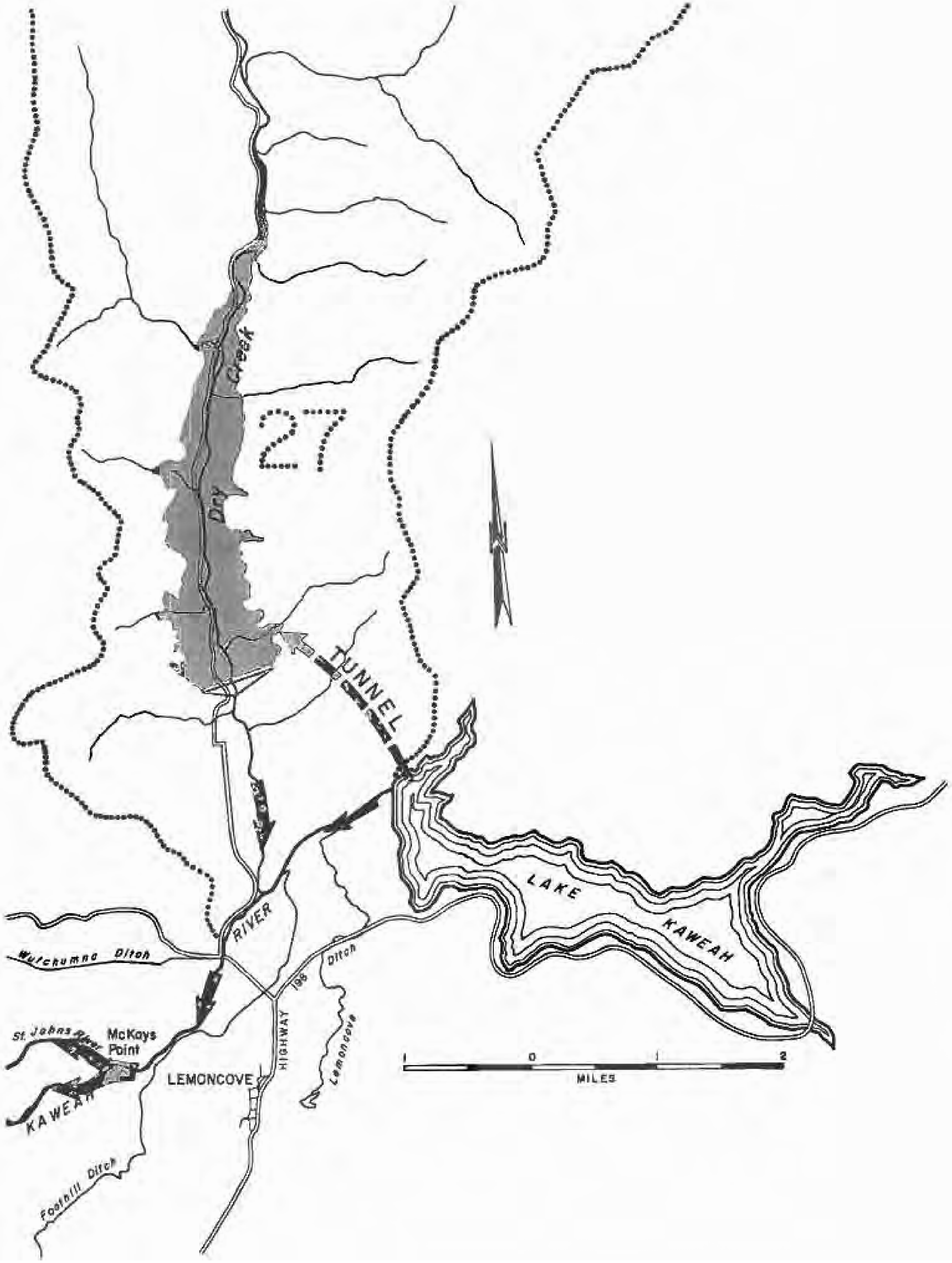
DRY CREEK (AREA 27)

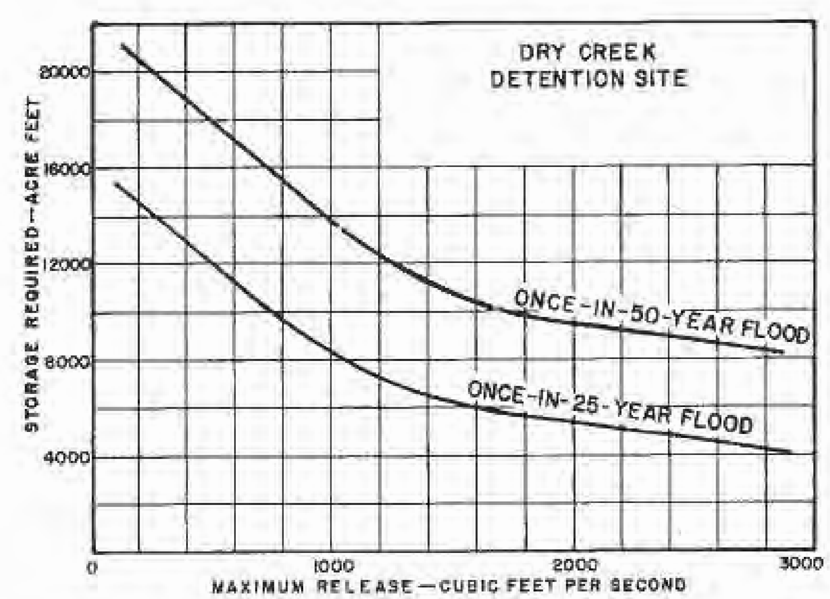
Detention storage on this watershed is essential to all the concepts of flood control in the Kaweah Unit. During the rain-flood of December 1966 releases from Lake Kaweah were minimized so as to aid in reducing peak flows at McKays Point, and although the peak flows of Dry Creek were attenuated considerably 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.

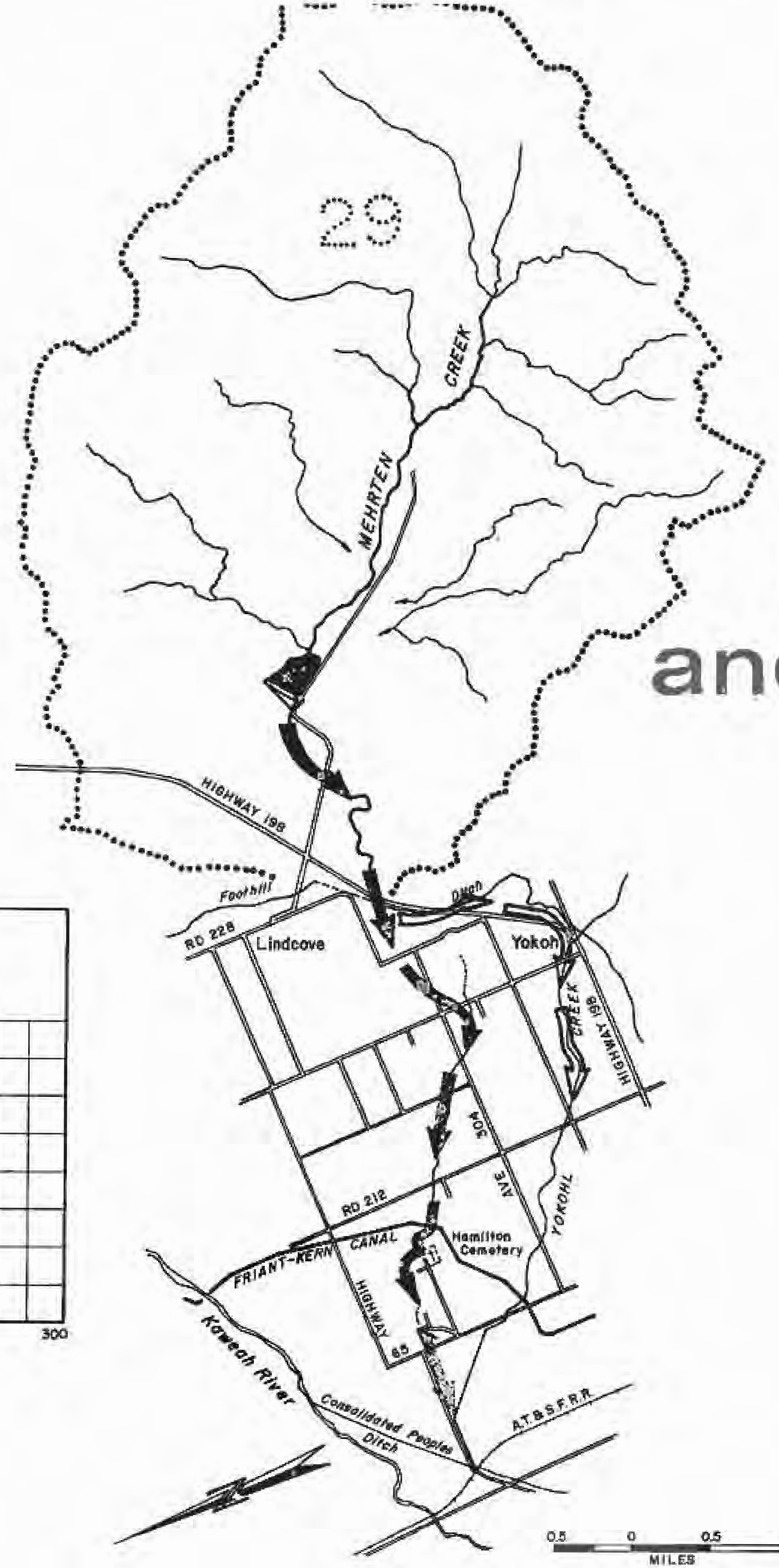
Long range studies now underway by the Corps of Engineers include evaluating the merits of increasing the capacity of Lake Kaweah. Increased capacity in the Lake can not only provide urgently needed additional rain-flood protection, but can better control snowmelt-flood runoff to Tulare Lake and can 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
St. Johns River
McKays Point
KAWEAH
LEMONCOVE
HIGHWAY 198
Ditch
Lemoncove
Foothill Ditch
1 0 1 2
MILES


DRY CREEK
DETENTION SITE
STORAGE REQUIRED—ACRE FEET
20000
16000
12000
8000
4000
0
1000
2000
3000
MAXIMUM RELEASE—CUBIC FEET PER SECOND
ONCE-IN-50-YEAR FLOOD
ONCE-IN-25-YEAR FLOOD

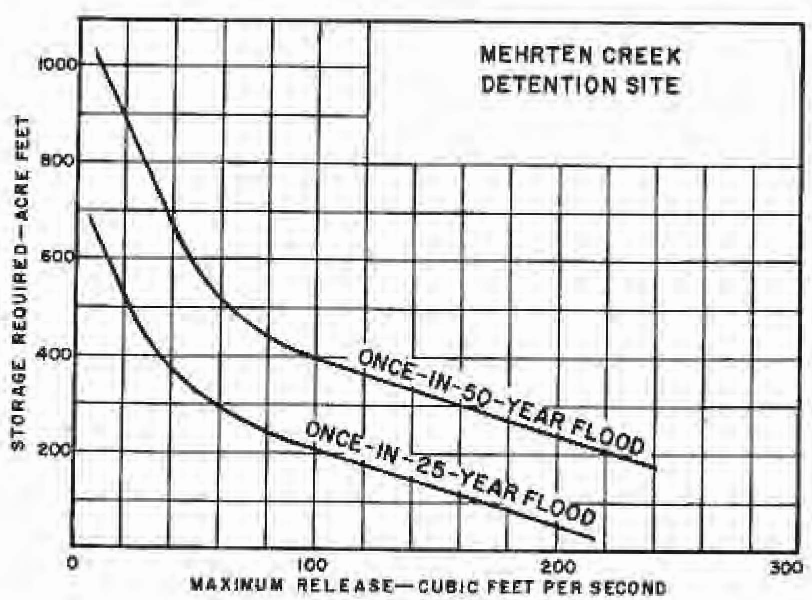


Flood flows of Mehrten and Yokohl Creeks cause extensive inundation of developed orchards east of Friant-Kern Canal, flood property to the outskirts of Exeter by ponding against man-made obstructions, and on entering Consolidated Peoples Ditch, may overflow to other areas to the southwest. The channel 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.

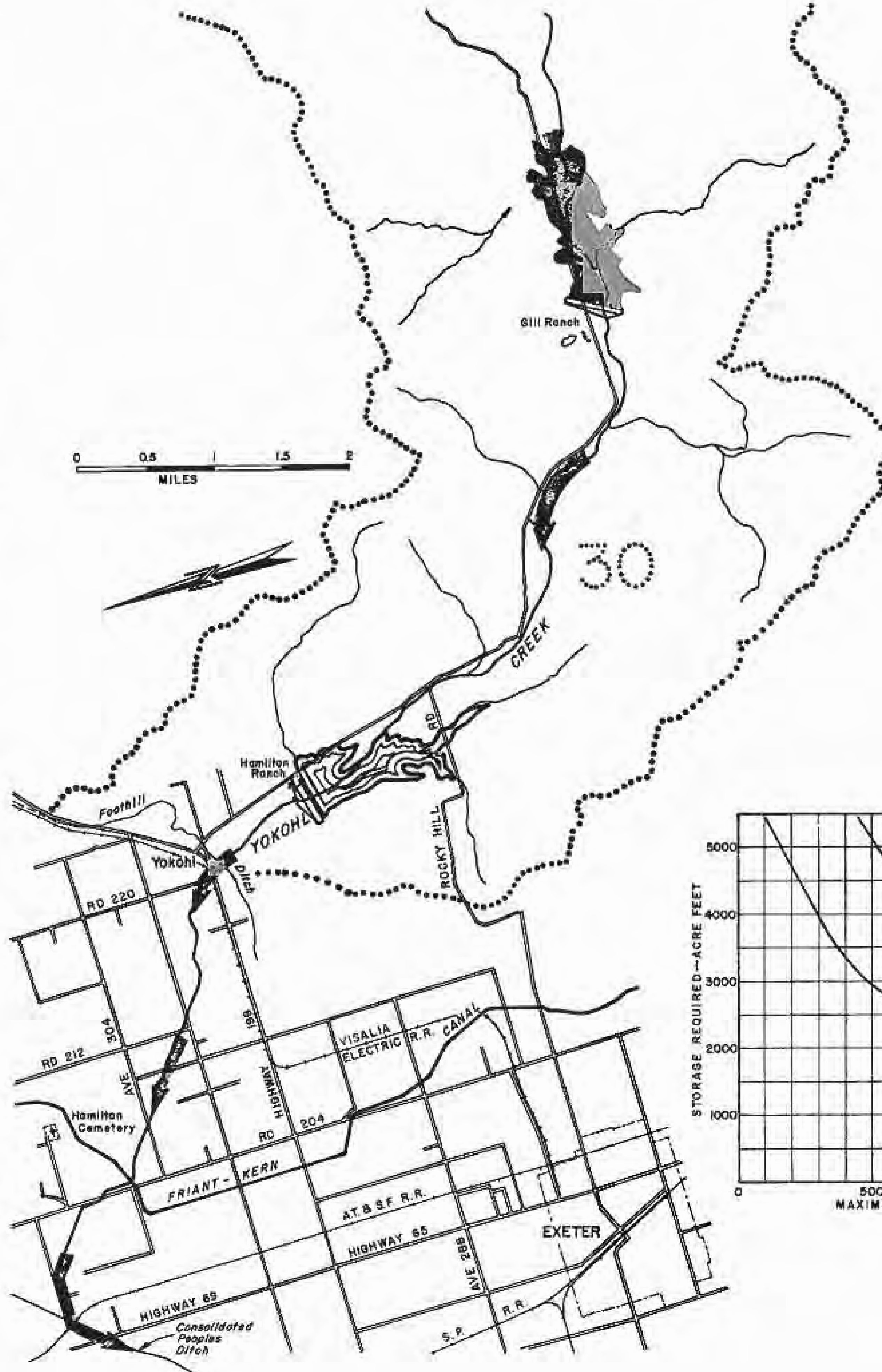


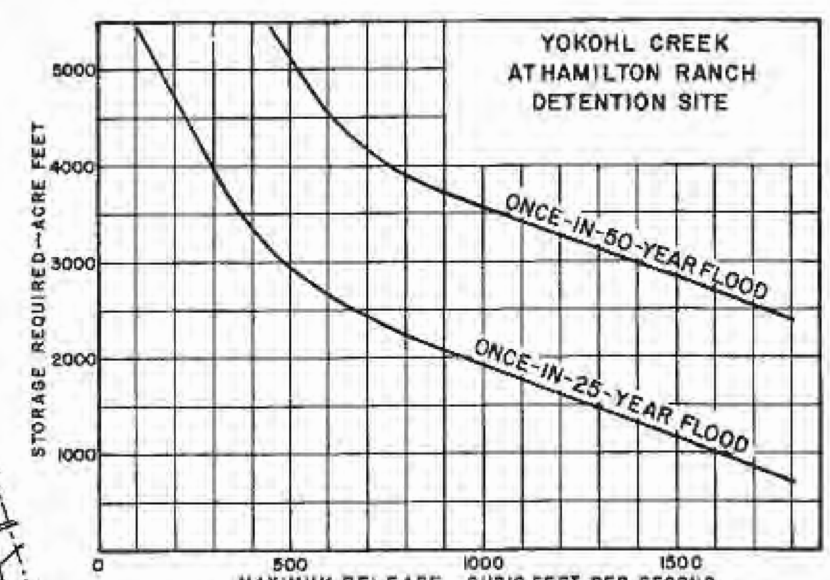
YOKOHL CREEK (AREA 30)

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.

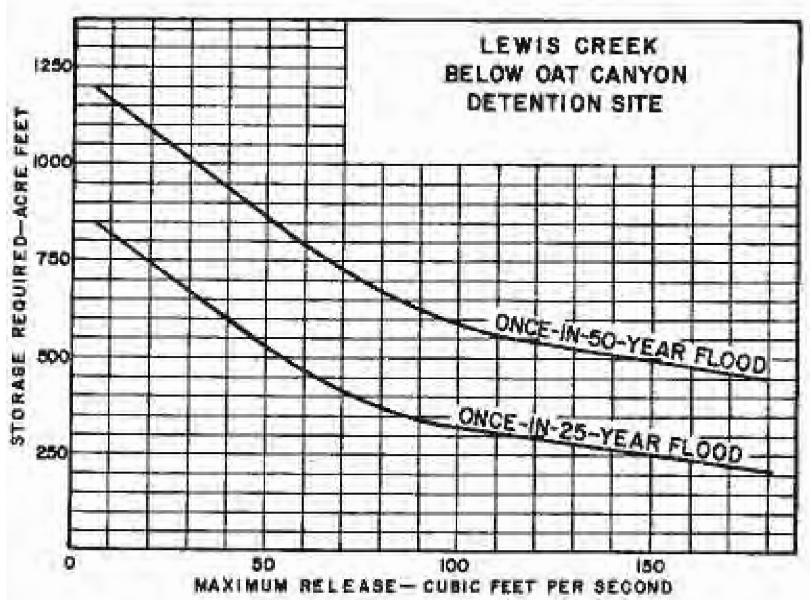
MULTI-PURPOSE PROJECTS ON MEHRTEN AND YOKOHL CREEKS

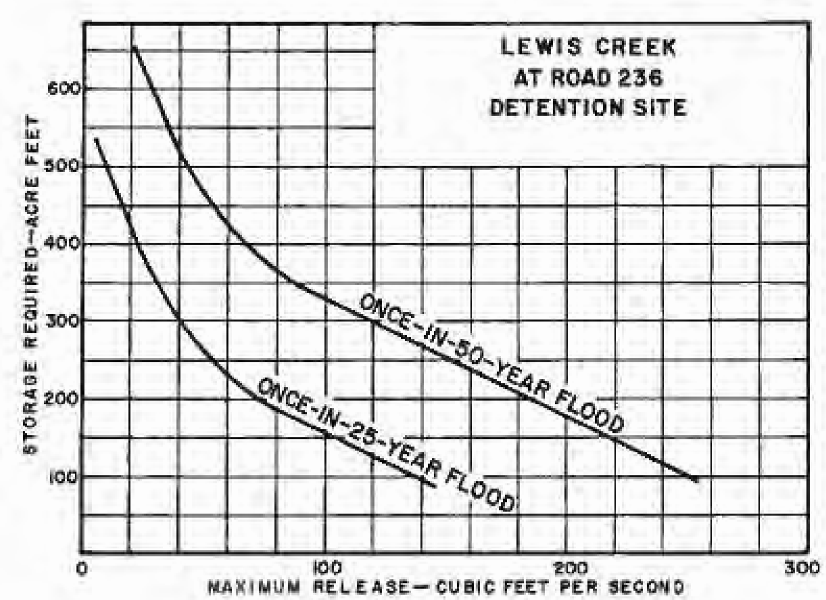
Suggestions have been made that large conservation reservoirs be considered on one or both of these creeks and the sites mentioned previously are topographically capable of such development. Water to be conserved in such larger reservoirs would be pumped into them from the proposed East Side Canal since 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)

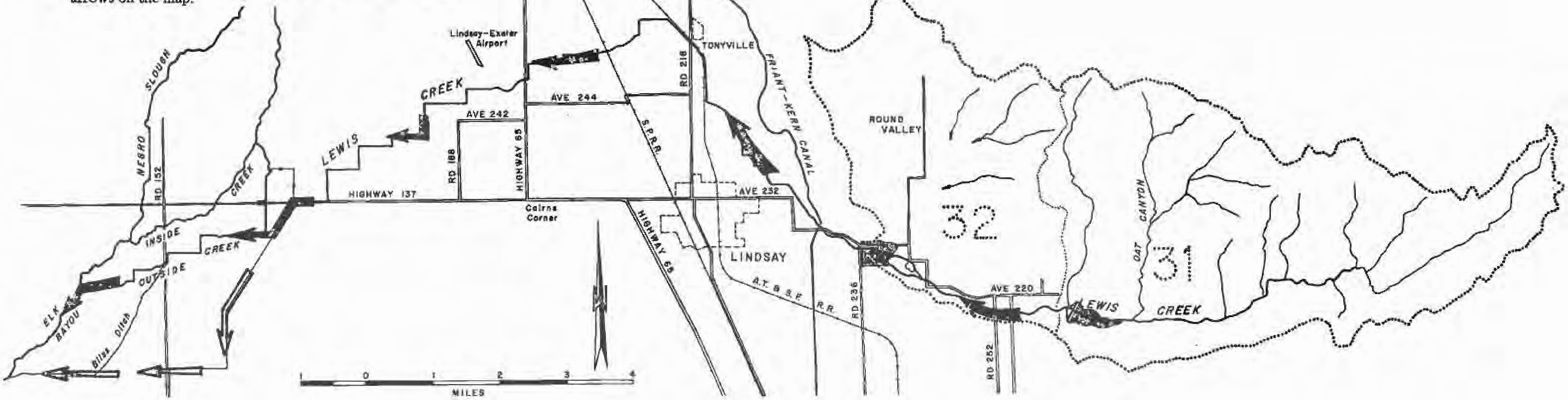
Peak flows of about 1,850 and 2,650 cfs may be expected in Lewis Creek near its crossing of Friant-Kern Canal on the average of once in 25- and 50-years, respectively. The channel capacity is not much more than 250 cfs downstream of this point which is about three miles east of Lindsay. The channel is 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

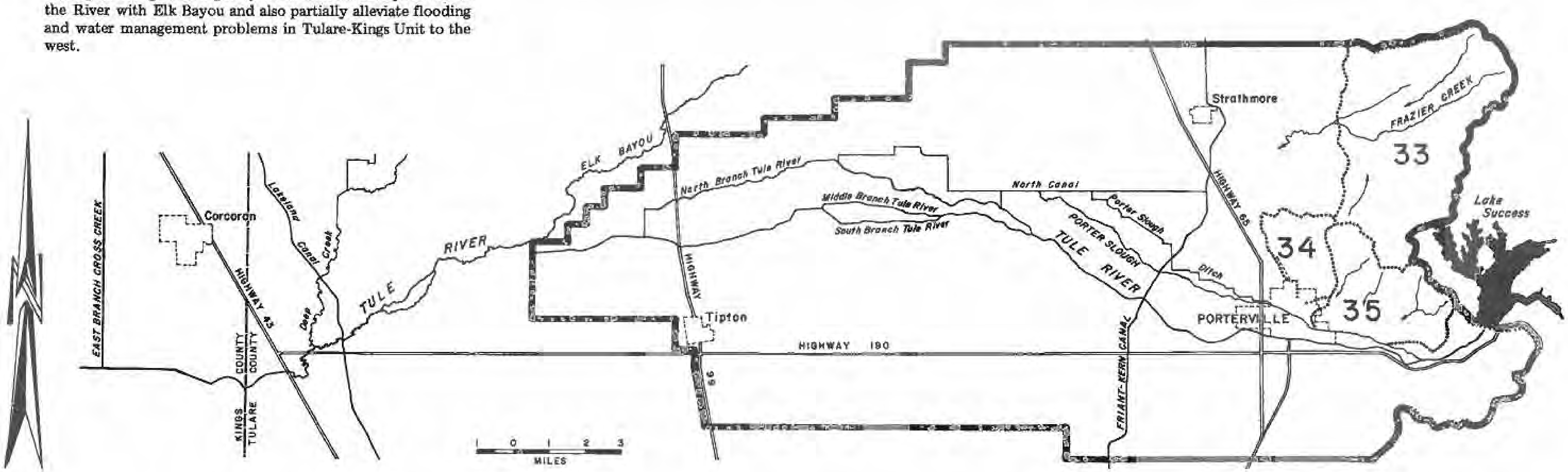
GENERAL

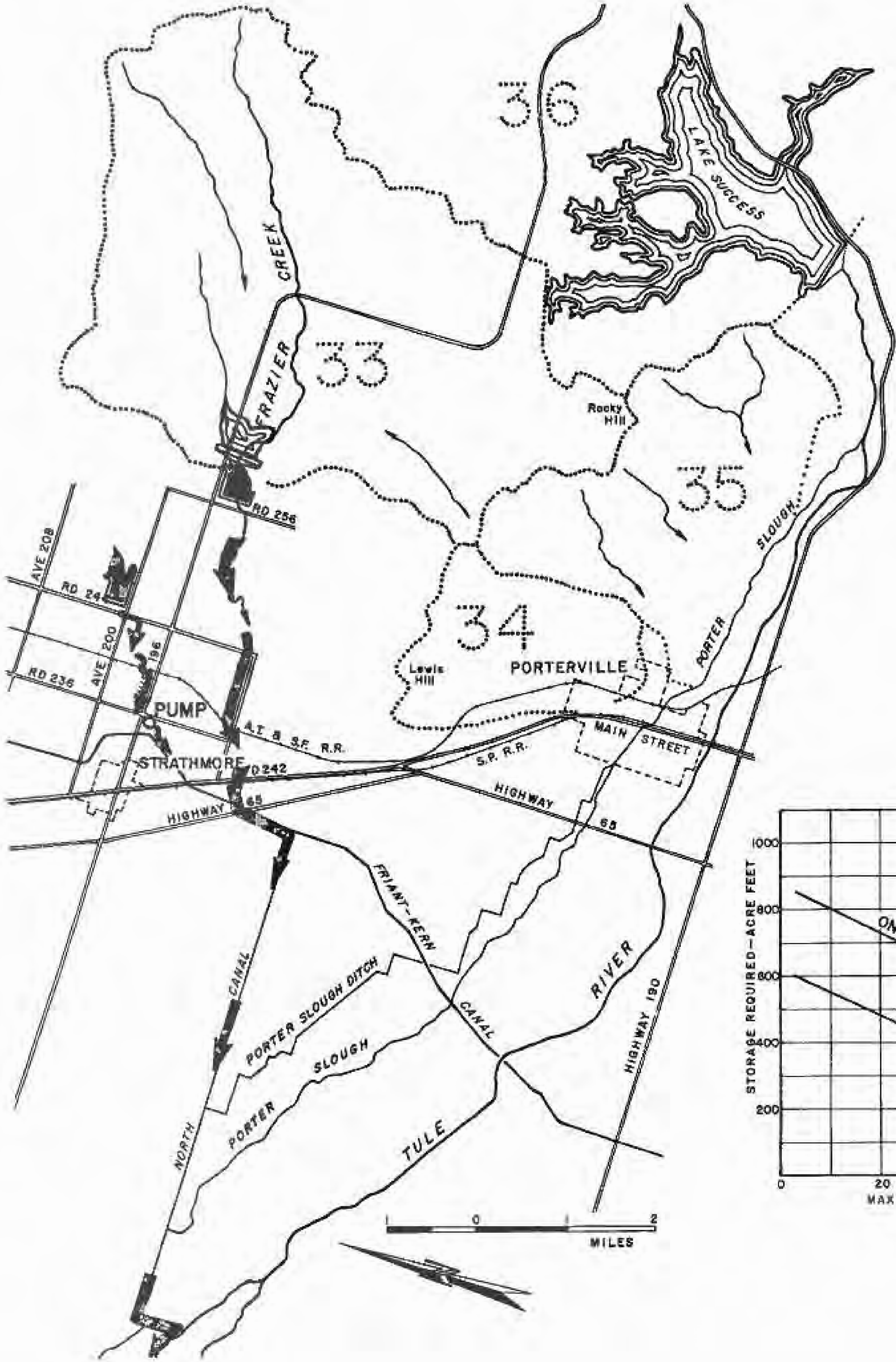
As in the Kaweah Unit, flooding in the Tule Unit and solutions therefor are of interest to landowners in both Tulare and Kings Counties. Success Reservoir provides regulation of rain-floods on Tule River, but as a result of the December 1966 flood and in the interest of better controlling snowmelt runoff, 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

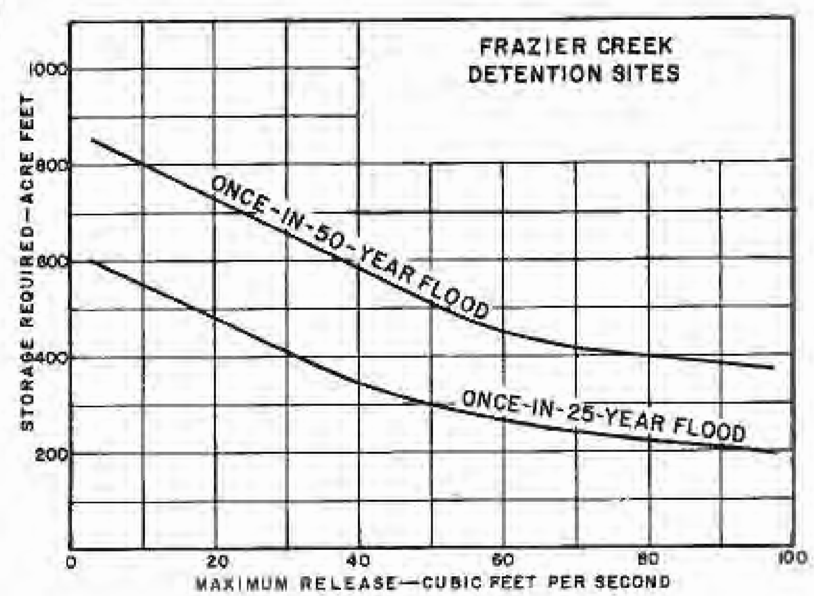
Lake Success provides rain-flood protection to Porterville and most other areas along Tule River especially since considerable channel improvement work has been accomplished. Nevertheless, the objective maximum rain-flood release from Lake Success of 3,200 cfs was unavoidably exceeded in December 1966 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)

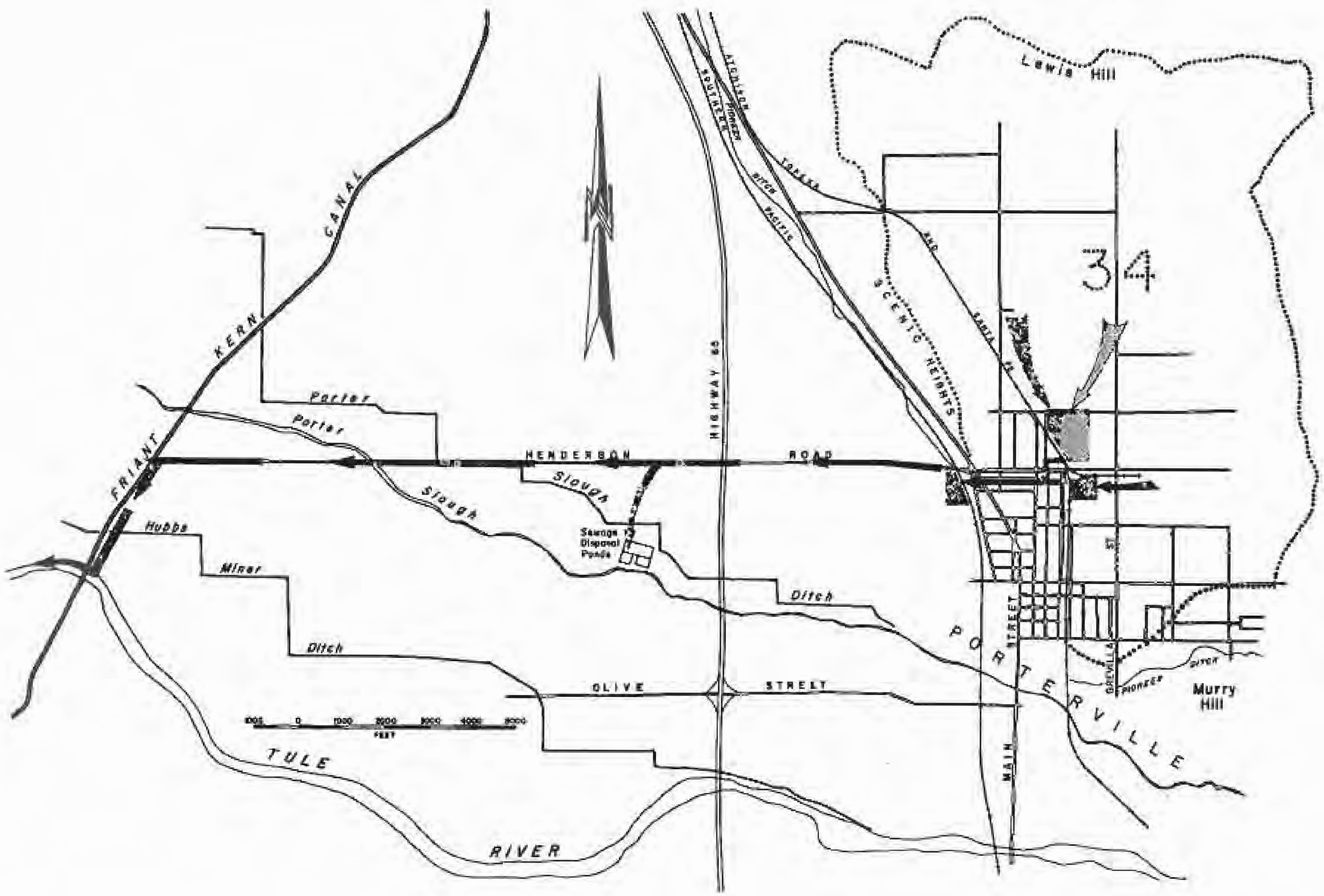
Frazier Creek channel has been obliterated west of Road 256 to Friant-Kern Canal. Where Frazier Creek crosses Road 256, peak flows of 1,010 and 1,440 cfs may occur on the average of once in 25- and 50-years, respectively. There is little question that measures to control such flows to non-damaging rates 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.

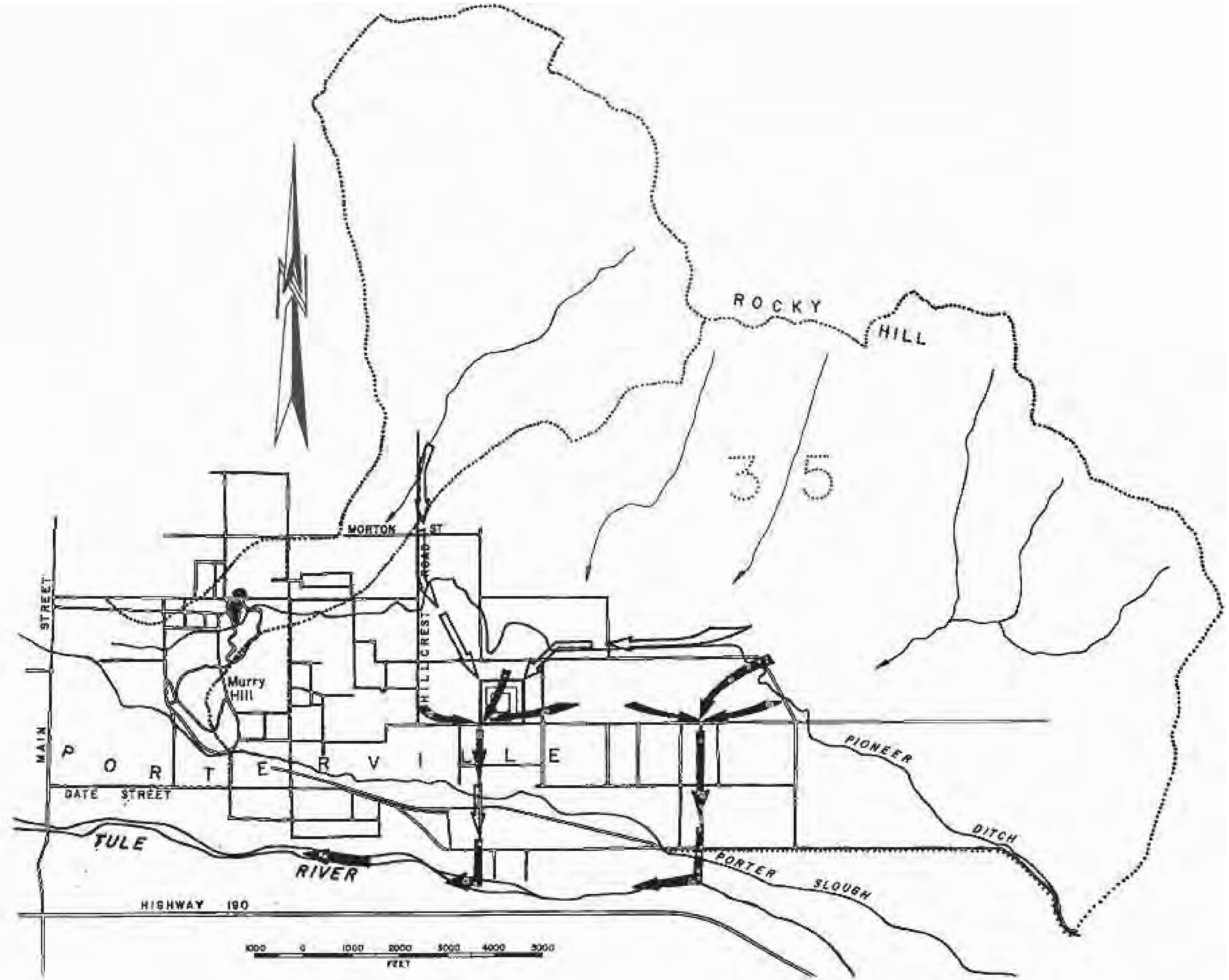
Over five years ago an ultimate drainage system for Porterville was suggested as a part of the General Plan of the City. This drainage system contemplated two detention basins in the general sump area near Henderson Avenue, with disposal in Porter Slough and in Tule River via improved existing ditch 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)

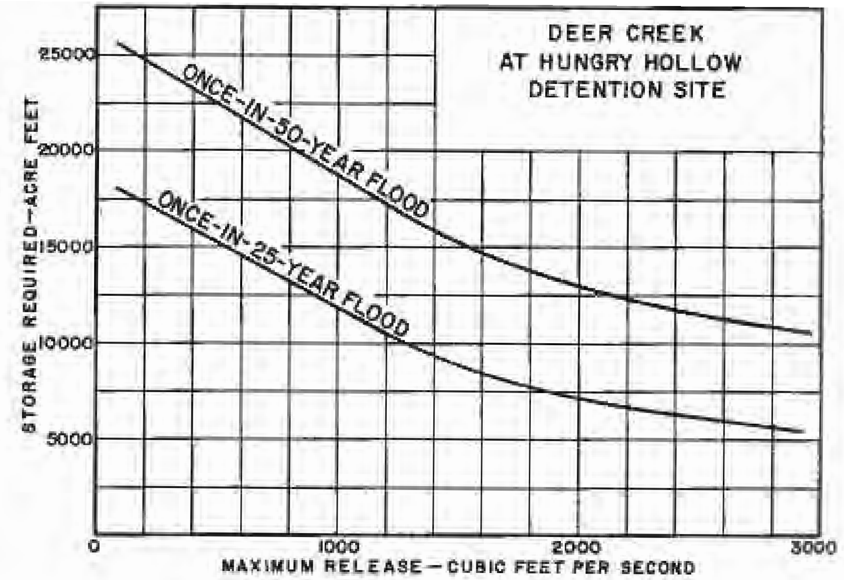
This 16.9 square mile drainage area lies between the Fountain Springs Gulch and White River watersheds. In February 1969 several hundred acres of land between Highway 65 and Friant-Kern Canal were inundated by runoff from Terra Bella—Ducor drainage. Concentrations of 610 and 870 cfs at Friant-Kern Canal 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.

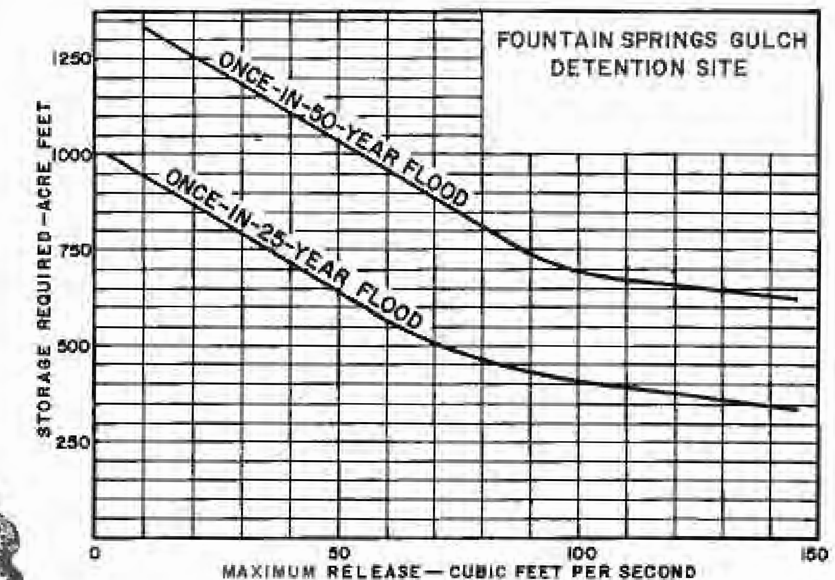
Detailed studies of the Terra Bella—Ducor drainage should consider zoning and/or land development controls adjacent to defined channels, detention storage, and channel dedication and improvement. Volumetric data indicate that detention storage of about 200 acre foot capacity combined with downstream 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.

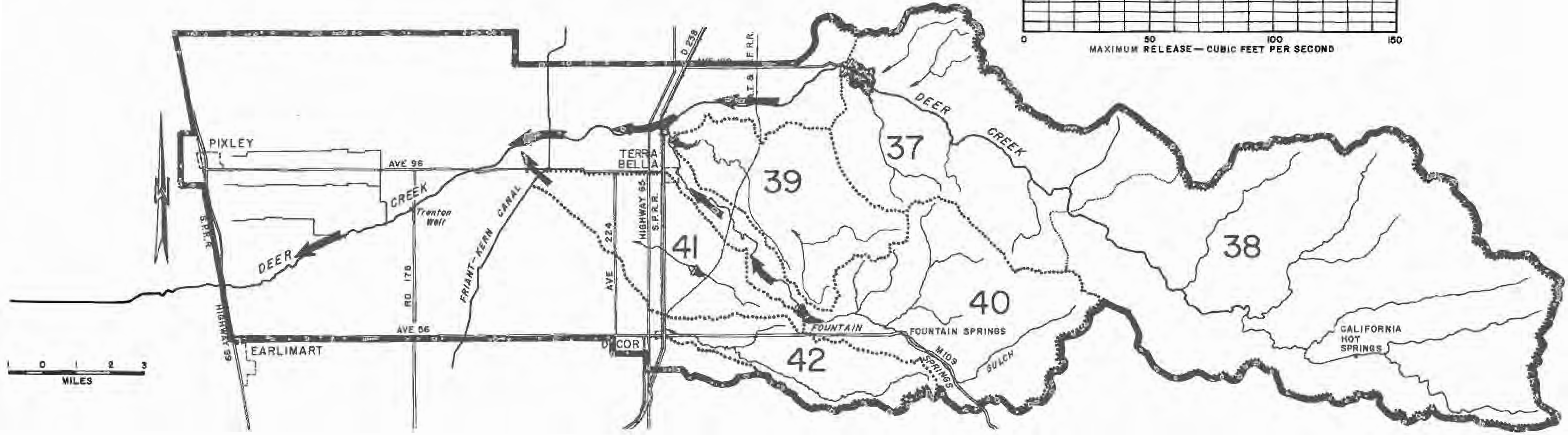
DUCOR EAST DRAINAGE (AREA 42)

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.

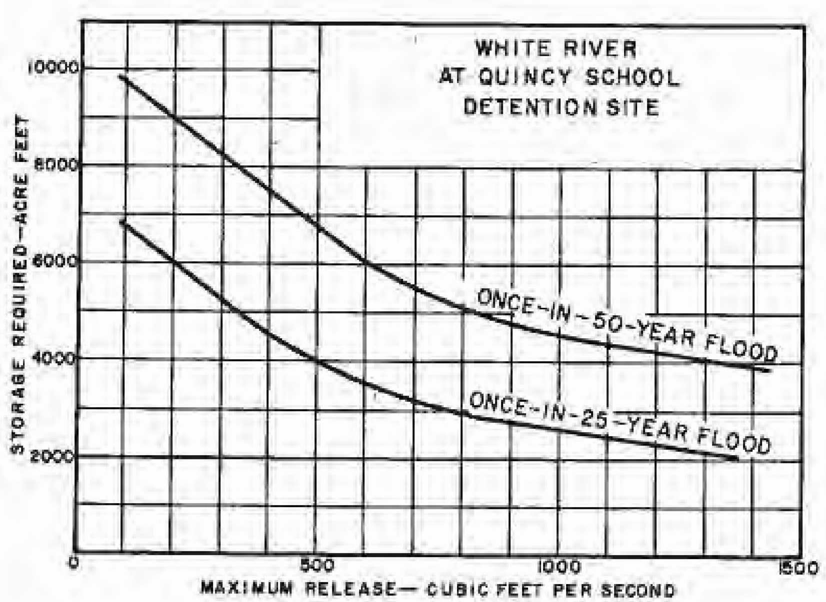






WHITE UNIT

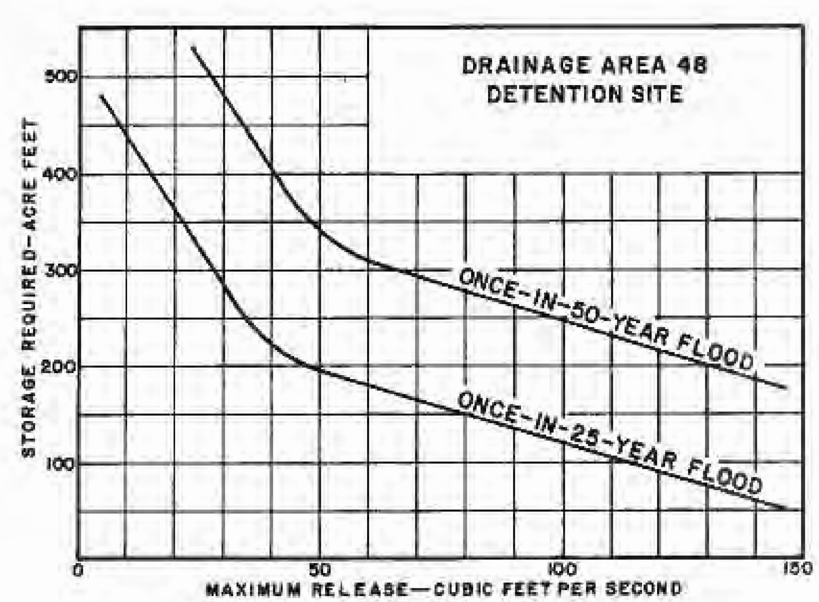
For convenience, this southernmost Unit includes both White River and Rag Gulch, although the sources of floodwaters, the areas flooded by them and concepts for control are separable. White River runoff produces flooding from the vicinity of Friant-Kern Canal to Highway 43, seven miles west of Earlimart. 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.

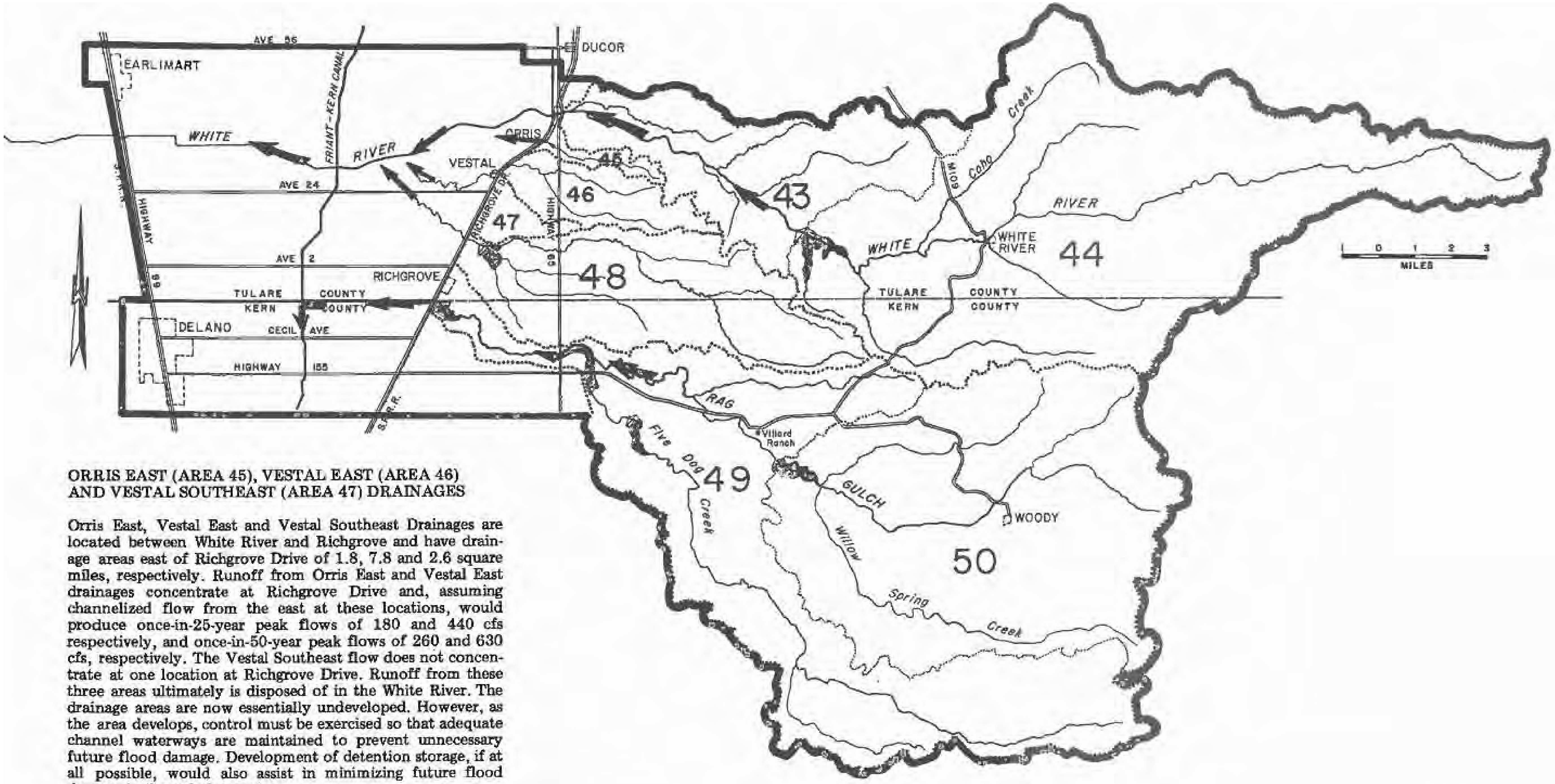


In the study the Corps considered several alternative concepts of flood control for White River, including channelization only, diversions to Deer Creek, storage in a large percolation pond on the valley floor, and detention storage in the foothills about 10 miles southeast of Ducor at what is termed 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 non-damaging 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

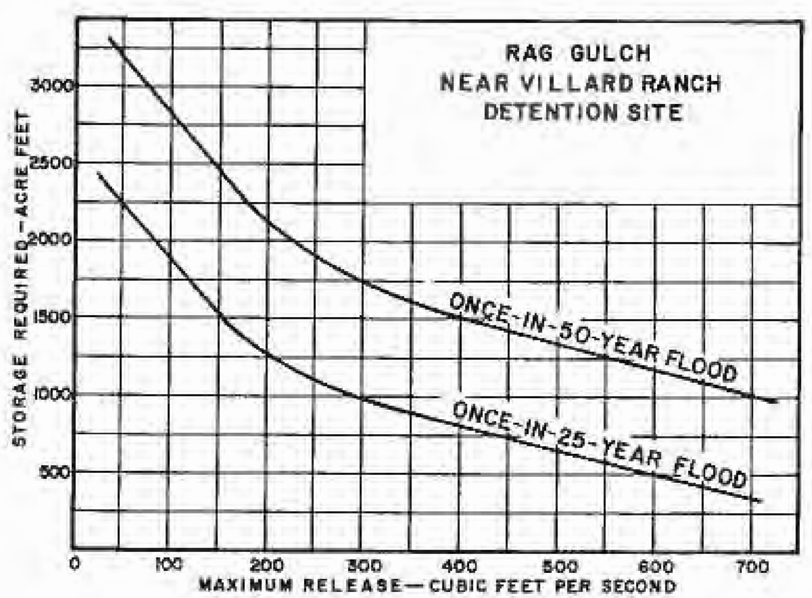
Orris East, Vestal East and Vestal Southeast Drainages are located between White River and Richgrove and have drainage areas east of Richgrove Drive of 1.8, 7.8 and 2.6 square miles, respectively. Runoff from Orris East and Vestal East drainages concentrate at Richgrove Drive and, assuming channelized 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.

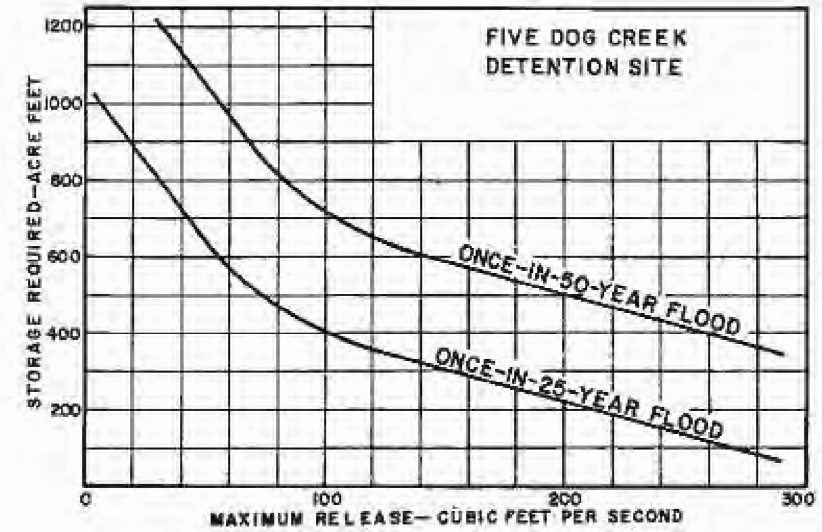
RAG GULCH (AREAS 49 AND 50)

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.

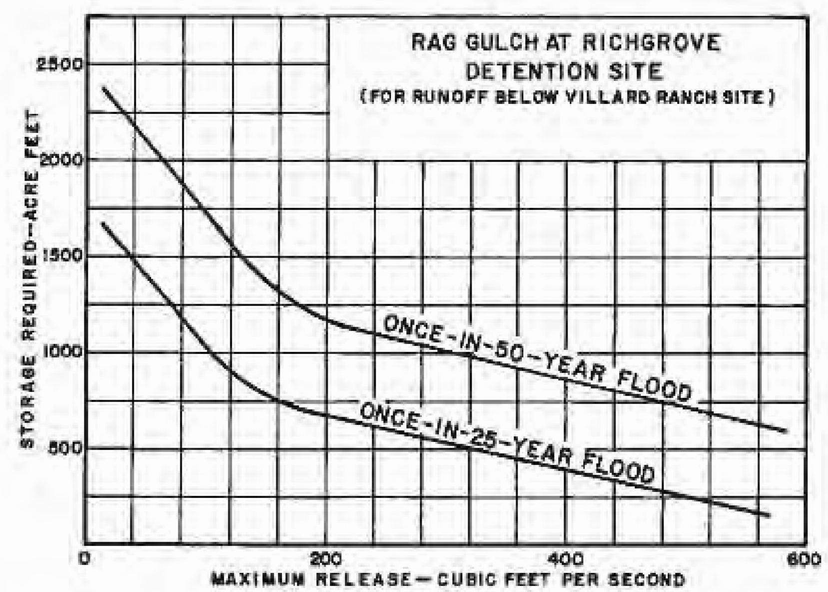
There are few detention storage sites on Rag Gulch and its principal tributary, Five Dog Creek. Two sites on the main Gulch and one on Five Dog Creek offer some potential and should be examined further in detailed studies; other sites on both streams also should be sought. The upper site on Rag Gulch, 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.

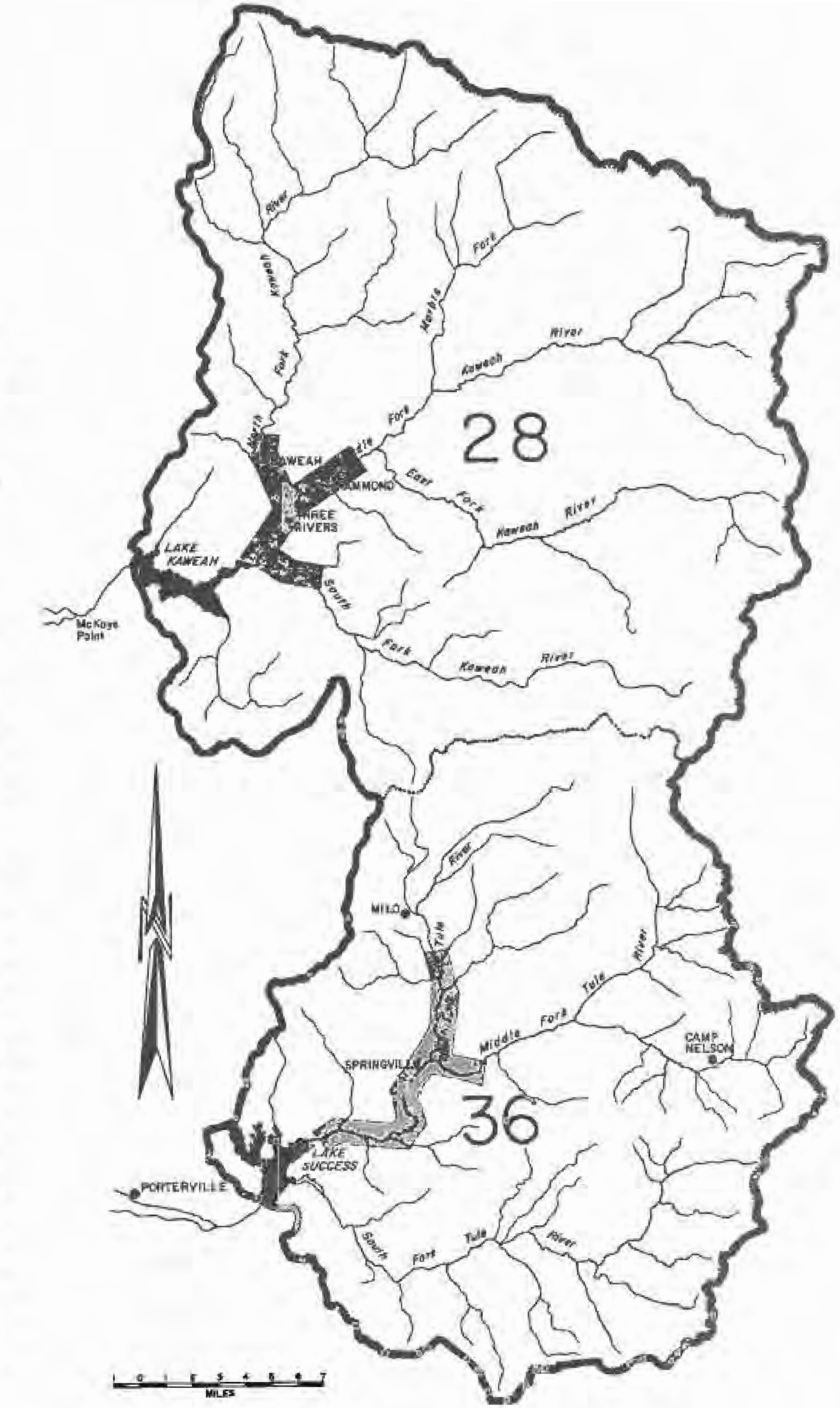
To the extent that flows from other Units which now terminate in the Tulare-Kings area can be controlled by upstream storage or diversion out of the area and by careful distribution in existing, improved or new channels to percolation ponds and to farm lands, flood damages in the Tulare-Kings Unit can 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

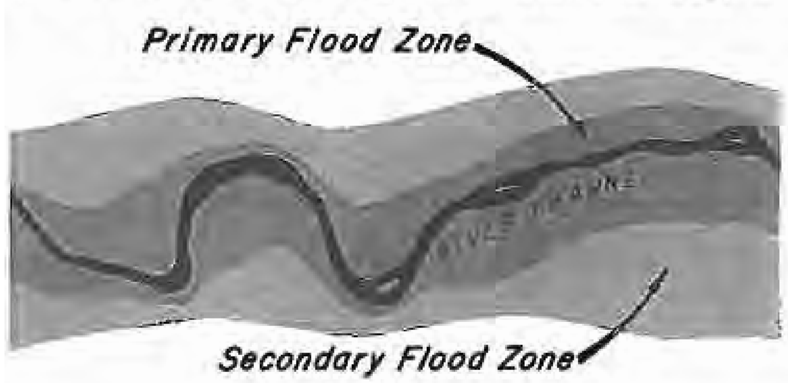
FLOOD PLAIN MANAGEMENT

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.

IV

FINANCING FLOOD CONTROL

FINANCING FLOOD CONTROL

IV

The studies leading to development of this Master Plan deal broadly with flooding throughout Tulare County Flood Control District and the immediately adjacent areas. It has necessarily been a broad study for the engineering purposes of developing detailed flood hydrology and flood control concepts. A substantial amount of additional study will be required to determine the economic justification and financial feasibility of specific projects and to identify the zones or areas benefitting from such projects. Following completion of such further studies, arrangements will have to be made for financing the two subsequent phases of each project, construction and operation and maintenance. Various alternative methods of financing implementation of the flood control concepts presented in Chapter 3, including programs of state and federal agencies dealing with flood control either separately or as a part of other programs, are described below.

THE DISTRICT ACT

Chapter 1149, Statutes of 1969, confers on Tulare County Flood Control District certain powers relating to control of flood waters originating within the District or originating outside the District and flowing through the District. The Act contains provisions relating to financing of flood control work as well as numerous other matters. Since the Act provides means of financing improvements which are largely independent of other agencies, it is appropriate to outline the principal elements of these financing powers of the District. Also, these financing provisions may be utilized to meet certain parts of total project costs (for example, operation and maintenance) where other agencies have planned or constructed the projects under the programs described in other sections of this chapter.

The Act establishes the Board of Supervisors of Tulare County ex officio as the governing Board of the District. Also, the Board appoints a commission of seven members to which may be delegated any or all of the Board's powers under the Act.

The Act permits an ad valorem tax not to exceed two cents on each $100 of assessed value to pay general administrative expenses and to carry out functions of common benefit. Such maximum assessment was levied in the current fiscal year and, based on a secured roll of about $470,000,000, yielded over $90,000 for these expenses of common benefit. Except for these funds, the District must rely on special assessments levied for activities of benefit to zones whose boundaries are fixed in accordance with procedures set out in the Act.

The District, through its Board of Supervisors (or the Commission) determines which projects or improvements are for the common benefit of the District, for the benefit of two or more zones (called participating zones), or for the benefit of a single zone. Once a zone or zones have been established, their boundaries may be amended by annexing property to them or by withdrawing property from them or a single zone may be divided into two or more zones. New or amended zones also may be superimposed on zones already in existence. However, no project may be undertaken without approval of a majority of the voters within a proposed zone or zones at an election, and once such approval has been indicated the boundaries of the zone or zones may not be changed without a further election.

Assessments may be levied against real and personal property within a zone or against real property only within such a zone. A bonding proposal may also be presented to the electorate within a zone as provided in general law.

OTHER AGENCIES OF LOCAL GOVERNMENT

Within Tulare County Flood Control District are many other agencies of local government. All are agencies organized under various special or general acts of the Legislature to carry out certain functions which may be either broad or limited depending on the type of district. Many are authorized, at least at the discretion of the governing board, to carry out flood control related activities. Many also incur higher costs of operation and maintenance due to structure damage and failures during floods and can act cooperatively with other agencies, including Tulare County Flood Control District, on joint developments which would reduce these higher costs. Others, such as those operating canal systems, have liability potentials derived from floodwaters flowing through their systems and have an interest in reducing such liabilities.

On another level, Fresno, Kings, Kern and Tulare Counties have common interests in varying degrees in solutions to flood problems in the general area. All have a broad common interest in developing better control of snowmelt runoff of the four large Tulare Basin streams to reduce damaging inflows to Tulare Lake and to conserve a maximum of such runoff. It is not within the scope of this report to present an analysis of the mechanics for two-, three- and four-county cooperation in these areas; suffice it to say such cooperation, including joint funding of planning, operation and maintenance, and possibly construction of specific projects should be explored.

STATE OF CALIFORNIA

There are a number of State programs of financial assistance to local agencies for water resources development, including flood control. Most of such programs, however, are for purposes other than flood control.

Under a 1945 Act of the Legislature (Water Code Section 12570, et seq.), the State provides funds, through the Department of Water Resources, to meet costs of lands, easements and rights-of-way for flood control projects constructed by the Corps of Engineers pursuant to federal law. Similarly, pursuant to Water Code Section 12850, et seq., the Department of Water Resources allocates funds to meet the same costs on projects constructed under the Federal Watershed Protection and Flood Prevention Act (familiarly known as Public Law 566).

Before the Department of Water Resources can expend funds for rights-of-way under these basic acts, the Legislature must authorize State participation in each specific project and thereafter must appropriate funds. Authorization of the Legislature is not required separately for State participation in so-called Small Flood Control Projects of the Corps, because Water Code Section 12750, et seq., authorizes such participation, in effect, when funds therefor are appropriated. Authorizations under these Acts were made regularly through the 1969 session of the Legislature, but no new projects have been authorized since that session. Bills looking toward modifications in present State-local agency cost-sharing arrangements were considered during recent sessions of the Legislature and several are under consideration in the current Legislature. These bills vary in detail but all, under certain circumstances, require local agencies to pay part of the costs of lands, easements and rights-of-way.

Closely parallel to the reimbursement procedures under the 1945 Act are the programs of the State Reclamation Board for acquisition of lands, easements and rights-of-way for levee and channel improvement projects constructed by the Corps of Engineers. The principal difference in the two programs is that under the reimbursement program of the Department of Water Resources, local agency personnel do the work associated with the acquisition, and rights-of-way are paid for with local funds. Then the agency is reimbursed for the costs upon approval by the Department. Under the Reclamation Board program, State personnel do the land acquisition work and landowners are paid directly with State funds, with rights-of-way being acquired in the name of the State. Only the Department is authorized to participate in the Corps small flood control program and the reimbursement procedure must be followed in such projects. Participation of the Reclamation Board in Corps projects is authorized in each case by the Legislature.

Under the Davis-Grunsky Act (Water Code Section 12800, et seq.), the Department of Water Resources can, with approval of the California Water Commission in all cases and with approval of the Legislature where grants of more than $400,000 are involved, grant funds to assist local agencies in constructing water projects, including those for the control of floods. Essentially, the amount of grants provided reflect project accomplishment in areas of recreation and fish and wildlife enhancement. Recreation benefits at reservoirs are dependent in part on availability of on-shore facilities such as picnic grounds, camp grounds, water supply and sanitation, and the capital costs of such facilities use a substantial part of the funds granted. It is unlikely that any of the foothill reservoirs can develop reliable minimum recreation pools or fish and wildlife benefits, and accordingly, financial assistance through the Davis-Grunsky Act is not promising.

Under a 1947 Legislative Act (Fish and Game Code Section 1300, et seq.), the Wildlife Conservation Board may construct or may provide funds for construction of on-shore facilities and small craft launching ramps along the rivers and at reservoirs managed by local agencies. Limited funds are available for this program and for the same reasons discussed in the previous paragraph, it is doubtful if they would be of assistance in construction of foothill reservoirs in Tulare County operated for flood control purposes.

Under Section 9063.1 of the Public Resources Code, the Division of Soil Conservation in the Department of Conservation makes grants to assist districts in carrying out projects, including small watershed flood control projects. Recipient districts must be Soil Conservation Districts organized in accordance with State law. Each grant must be approved by the State Soil Conservation Commission and an appropriation must be provided by the Legislature.

The California Water Commission is responsible for coordinating statewide programs relating to appropriations for surveys, investigations, and construction of projects by the Corps of Engineers and the Bureau of Reclamation. The Commission hears the recommendations of all local interests in regard to these appropriations, coordinates them, and represents the State of California in presentations to the appropriations committees of the Congress each year. These functions are exercised with respect to the funding of feasibility studies leading to requests for federal authorization as well as to the funding of actual construction of authorized projects. The functions are important because they aid in presenting to the Congress a unified California position rather than fragmented presentations by a large number of local interests.

FEDERAL AGENCIES

Corps of Engineers, Department of the Army

Under its civil works program, the Corps carries on two major programs involving construction of new flood control projects. One program, which has been in effect nationwide since 1936, is the program which led to completion of many flood control projects in California, including Pine Flat, Terminus, Success and Isabella Dams on the major Tulare Basin streams and many levee and channel projects. The other such major program was first authorized by the Congress in 1948 and involves what are called "Small Flood Control Projects"; that is, projects whose total federal cost does not exceed $1 million. In addition to these activities on new flood control projects (or modifications of existing projects which may involve further federal funding), the Corps performs important emergency work following floods. Also, under specific congressional authorizations, the Corps may disburse federal funds to local agencies building multiple-purpose reservoirs; the amounts of such funds reflect flood control benefits resulting from operation of the projects under regulations prescribed by the Secretary of the Army. Both the regular and Small Project programs of the Corps may be helpful in implementation of parts of this Master Plan.

Under the first (1936) program, a history of floods and requests of local interests will lead to a resolution by the Public Works Committee of either the House of Representatives or the United States Senate directing the Corps to make a survey of the area. Once funds for the survey are appropriated, the District Engineer directs preparation of a report which is in sufficient detail to determine economic justification of a project; specifically, average annual flood damages are estimated, the engineering soundness of a definite project plan is determined, estimates of capital and annual costs are made and the ratio of benefits to costs is defined. Also, opportunities for multiple-purpose development are explored, including recreation, fish and wildlife preservation and enhancement, irrigation, municipal water supply, and hydroelectric power, and the impact of the proposed project on the environment is appraised. After completion of such a report in draft form, the District Engineer holds public hearings, receives comments of local interests and local offices of affected state and federal agencies, completes his report, and forwards it through the Division Engineer to the Chief of Engineers, the Board of Engineers for Rivers and Harbors, and the Secretary of the Army for their reviews. Assuming approvals at these review levels, with or without modifications, the Secretary sends the report as his "Proposed Report" to the Governor of the affected State and designated federal agencies for their comments. Finally, after making any revisions he deems advisable in light of the formal comments received, the Secretary secures the views of the Director of the Office of Budget and Management, a part of the President's staff, and then transmits the report to the Congress for consideration. If the project is authorized for construction, funds for preparing designs and plans and specifications are subsequently sought in annual Public Works appropriations, as are funds for construction of the project. All these procedures are time consuming. While the time required between identification of need for a project and its completion varies from situation to situation, the whole process usually requires several years — ten or more years is not uncommon.

Under the second Corps of Engineers program, first authorized in 1948, small flood control project developments follow many of the above steps but omit others. Annual lump sum appropriations are made by the Congress, nationwide, for these projects and they are conducted by District Engineers under authorization of the Chief of Engineers. The same requirements of engineering feasibility and economic justification must be met and similar processes of coordination with local and state interests are followed. Procedurally, a small flood control project begins with a reconnaissance study to determine roughly that the project can be completed at a federal cost of less than $1 million and that its annual benefits will exceed its annual costs. This reconnaissance is followed with a detailed project report similar to the survey report described above. The latter report serves as a vehicle through which the Chief of Engineers can authorize preparation of final plans and specifications for the project and its construction. Availability of funds for planning and construction largely determines the time required to bring a small flood control project to completion but such projects, once their planning is initiated, require much less time than the normal Corps projects.

Over the years, project reports prepared under both of these Corps programs have given increased consideration to recreation and fish and wildlife preservation and enhancement. More recently, widespread concern with environmental and ecological effects of water resources developments have intensified study of these matters during report presentation and reviews. These evolving changes are identified here because they probably will extend the time required for completion of reports and projects of the Corps under either of the programs.

Except for certain projects so authorized by the Congress, both of the above programs place three responsibilities on non-federal interests apart from their initiatory and participatory functions in the planning stages. As a general rule, on channel improvement projects, non-federal interests must, prior to construction, furnish assurances that they will (1) furnish all lands, easements, and rights-of-way required for construction and operation of the project, (2) hold and save the United States free from damages due to the work and (3) maintain and operate the completed projects, but these requirements do not apply to reservoir projects. In some cases, additional requirements are placed on non-federal interests or one or more of these three requirements may be modified.

As referred to in the discussion of state programs, state funds have been used in most cases since 1945 to meet the costs of rights-of-way and road and utility relocations on both Corps programs. In recent years, local interests have furnished the other necessary assurances and have operated completed projects in accordance with regulations prescribed by the Secretary of the Army.

Presently, the District Engineer of the Sacramento District, which includes the San Joaquin Valley, is conducting studies in and adjacent to Tulare County under both its general and small projects authorizations. For example, studies of possible enlargement of Isabella Reservoir to expand recreational opportunities have been essentially completed and studies of enlargement of space for storage of water of Kings, Kaweah, and Tule Rivers and of connecting the Kern River to the California Aqueduct near Buena Vista Lake are under way.

Department of Agriculture

The Soil Conservation Service of the United States Department of Agriculture provides technical or financial assistance under three programs which may have some application to implementing this Flood Control Master Plan for Tulare County. The first of these comes under the Watershed Protection and Flood Prevention Act (Public Law 566) which has been referred to previously in describing state participation in that program. Under federal law, flood protection districts may participate; however, California law does not permit use of State funds for other than established soil conservation districts. Federal assistance includes conducting investigations and surveys, preparation of plans, cost estimates and cost allocations, and financial and other assistance. Where estimated federal costs exceed $250,000 or involve reservoirs storing more than 2,500 acre feet of water, the Committees on Agriculture of the House of Representatives and the Senate must approve. Where a reservoir having a capacity of more than 4,000 acre feet is involved, approvals of the House and Senate Public Works Committees are required. Both loans and grants may be made, but the total federal funds for a project are limited to $5 million. Except for projects involving recreation and fish and wildlife, federal funds meet construction and engineering costs related to flood control, while non-federal interests bear costs of lands, easements and rights-of-way and of operation and maintenance. Projects involving watershed and farm management and water conservation as well as flood control are common. Although individual steps vary, procedures from initiation of project planning through construction are similar to those for Corps of Engineers' projects in that other federal and state agencies are consulted and review proposals at various stages, including formal reviews by the Governor and Secretaries of major federal agencies, before definite proposals are transmitted to the Office of Budget and Management and the Congress. Federal appropriations are "lump sum" amounts made available to the Secretary of Agriculture with which to meet nationwide Public Law 566 requirements during each fiscal year.

Two other programs of the Department of Agriculture, both of which are loan programs, are administered by the Farmers' Home Administration of that Department. These programs appear to have limited application to a flood control program for Tulare County, but are mentioned because they might be of assistance in isolated cases. In one program, loans which may be repaid in up to 40 years may be made for

OTHER AGENCIES OF LOCAL GOVERNMENT

Within Tulare County Flood Control District are many other agencies of local government. All are agencies organized under various special or general acts of the Legislature to carry out certain functions which may be either broad or limited depending on the type of district. Many are authorized, at least at the discretion of the governing board, to carry out flood control related activities. Many also incur higher costs of operation and maintenance due to structure damage and failures during floods and can act cooperatively with other agencies, including Tulare County Flood Control District, on joint developments which would reduce these higher costs. Others, such as those operating canal systems, have liability potentials derived from floodwaters flowing through their systems and have an interest in reducing such liabilities.

On another level, Fresno, Kings, Kern and Tulare Counties have common interests in varying degrees in solutions to flood problems in the general area. All have a broad common interest in developing better control of snowmelt runoff of the four large Tulare Basin streams to reduce damaging inflows to Tulare Lake and to conserve a maximum of such runoff. It is not within the scope of this report to present an analysis of the mechanics for two-, three- and four-county cooperation in these areas; suffice it to say such cooperation, including joint funding of planning, operation and maintenance, and possibly construction of specific projects should be explored.

STATE OF CALIFORNIA

There are a number of State programs of financial assistance to local agencies for water resources development, including flood control. Most of such programs, however, are for purposes other than flood control.

Under a 1945 Act of the Legislature (Water Code Section 12570, et seq.), the State provides funds, through the Department of Water Resources, to meet costs of lands, easements and rights-of-way for flood control projects constructed by the Corps of Engineers pursuant to federal law. Similarly, pursuant to Water Code Section 12850, et seq., the Department of Water Resources allocates funds to meet the same costs on projects constructed under the Federal Watershed Protection and Flood Prevention Act (familiarly known as Public Law 566).

Before the Department of Water Resources can expend funds for rights-of-way under these basic acts, the Legislature must authorize State participation in each specific project and thereafter must appropriate funds. Authorization of the Legislature is not required separately for State participation in so-called Small Flood Control Projects of the Corps, because Water Code Section 12750, et seq., authorizes such participation, in effect, when funds therefor are appropriated. Authorizations under these Acts were made regularly through the 1969 session of the Legislature, but no new projects have been authorized since that session. Bills looking toward modifications in present State-local agency cost-sharing arrangements were considered during recent sessions of the Legislature and several are under consideration in the current Legislature. These bills vary in detail but all, under certain circumstances, require local agencies to pay part of the costs of lands, easements and rights-of-way.

Closely parallel to the reimbursement procedures under the 1945 Act are the programs of the State Reclamation Board for acquisition of lands, easements and rights-of-way for levee and channel improvement projects constructed by the Corps of Engineers. The principal difference in the two programs is that under the reimbursement program of the Department of Water Resources, local agency personnel do the work associated with the acquisition, and rights-of-way are paid for with local funds. Then the agency is reimbursed for the costs upon approval by the Department. Under the Reclamation Board program, State personnel do the land acquisition work and landowners are paid directly with State funds, with rights-of-way being acquired in the name of the State. Only the Department is authorized to participate in the Corps small flood control program and the reimbursement procedure must be followed in such projects. Participation of the Reclamation Board in Corps projects is authorized in each case by the Legislature.

Under the Davis-Grunsky Act (Water Code Section 12800, et seq.), the Department of Water Resources can, with approval of the California Water Commission in all cases and with approval of the Legislature where grants of more than $400,000 are involved, grant funds to assist local agencies in constructing water projects, including those for the control of floods. Essentially, the amount of grants provided reflect project accomplishment in areas of recreation and fish and wildlife enhancement. Recreation benefits at reservoirs are dependent in part on availability of on-shore facilities such as picnic grounds, camp grounds, water supply and sanitation, and the capital costs of such facilities use a substantial part of the funds granted. It is unlikely that any of the foothill reservoirs can develop reliable minimum recreation pools or fish and wildlife benefits, and accordingly, financial assistance through the Davis-Grunsky Act is not promising.

Under a 1947 Legislative Act (Fish and Game Code Section 1300, et seq.), the Wildlife Conservation Board may construct or may provide funds for construction of on-shore facilities and small craft launching ramps along the rivers and at reservoirs managed by local agencies. Limited funds are available for this program and for the same reasons discussed in the previous paragraph, it is doubtful if they would be of assistance in construction of foothill reservoirs in Tulare County operated for flood control purposes.

Under Section 9063.1 of the Public Resources Code, the Division of Soil Conservation in the Department of Conservation makes grants to assist districts in carrying out projects, including small watershed flood control projects. Recipient districts must be Soil Conservation Districts organized in accordance with State law. Each grant must be approved by the State Soil Conservation Commission and an appropriation must be provided by the Legislature.

The California Water Commission is responsible for coordinating statewide programs relating to appropriations for surveys, investigations, and construction of projects by the Corps of Engineers and the Bureau of Reclamation. The Commission hears the recommendations of all local interests in regard to these appropriations, coordinates them, and represents the State of California in presentations to the appropriations committees of the Congress each year. These functions are exercised with respect to the funding of feasibility studies leading to requests for federal authorization as well as to the funding of actual construction of authorized projects. The functions are important because they aid in presenting to the Congress a unified California position rather than fragmented presentations by a large number of local interests.

FEDERAL AGENCIES

Corps of Engineers, Department of the Army

Under its civil works program, the Corps carries on two major programs involving construction of new flood control projects. One program, which has been in effect nationwide since 1936, is the program which led to completion of many flood control projects in California, including Pine Flat, Terminus, Success and Isabella Dams on the major Tulare Basin streams and many levee and channel projects. The other such major program was first authorized by the Congress in 1948 and involves what are called "Small Flood Control Projects"; that is, projects whose total federal cost does not exceed $1 million. In addition to these activities on new flood control projects (or modifications of existing projects which may involve further federal funding), the Corps performs important emergency work following floods. Also, under specific congressional authorizations, the Corps may disburse federal funds to local agencies building multiple-purpose reservoirs; the amounts of such funds reflect flood control benefits resulting from operation of the projects under regulations

V

DEVELOPING SPECIFIC PROGRAMS

construction of drainage facilities in farming areas where sustained production is impaired because the land is too wet. The loan interest rate under this program is 5 percent on the unpaid balance of the principal amount loaned.

In another program of the Farmers' Home Administration, 5 percent loans may be made to soil and water conservation districts for special purpose equipment with which to do certain kinds of work including drainage. Loans may be repaid over the useful life of the equipment but not to exceed 40 years. There are other conditions involved in the loan which of themselves limit application of the program to the Tulare County Flood Control District and local districts within its boundaries.

Department of Housing and Urban Development

Under Public Law 83-560, the Community Resources Development Administration can make interest-free advances to public agencies to develop plans for public works to be placed under construction rapidly in the future. Advances may be used for feasibility studies, designs and preparation of plans and specifications for later construction of specific projects. The receiving agency must agree to contract to complete the plans promptly and to repay the advance. The advance is repayable when construction begins or a proportionate part is repayable when a portion of the public work is put under contract. Construction must conform to an overall state, local or regional plan.

Under this act, there are no provisions for assisting financially with construction, but the program could aid in completing feasibility studies, plans and specifications for some of the projects of this Master Plan. It would appear that those areas of the County where urban damages are suffered in floods, such as Woodlake, Tonyville, and Porterville, might be able to develop plans under the program preliminary to seeking alternative means of financing construction in a timely manner.

The same Administration, under the Housing and Urban Development Act of 1965 (Public Law 89-117), is authorized to make limited grants to state and local public bodies to assist in purchase of land and interest in land for future public uses. The amount of such grants is limited to the amount of reasonable interest paid on the locally borrowed funds used to finance acquisition of land only. The grant also is limited to the amount of interest accruing between the date funds are borrowed and the date construction begins on the acquired land, but not to exceed a 5-year period. Such a program appears of little assistance in implementing a master plan of flood control, but it is conceivable that in a specific circumstance, such as immediate availability of a particular land parcel for a project whose need is urgent, the approach offered in this program might be used.

Under Public Law 84-345, the Community Resources Development Administration can purchase securities of certain public agencies and private non-profit corporations, with priority given to towns of less than 10,000 population, which plan to construct basic public works including water and sewer systems. The securities involved must be first advertised for public sale and the Administration will purchase them only if private investors do not offer to purchase them at interest rates equal to or less than the rate governing the Housing and Urban Development Department. This program obviously is of little value in connection with this Master Plan; if the program is of any value at all, it would appear to be only in those areas where storm sewers are justified and are considered eligible under the program.

Under Title XIII of Public Law 90-448, the Federal Insurance Administration, Department of Housing and Urban Development, administers the National Flood Insurance Act of 1968. This program provides a means for residents of flood-prone areas to be reimbursed through private insurance companies for losses incurred from stream and coastal flooding. Those who reside in portions of the flood plain below a base flood level can obtain insurance at subsidized rates for losses incurred from flooding that is greater than the base flood. Future development below the base flood elevation must be regulated by State or local governments.

Through action of the County Board of Supervisors, Tulare County has been included in this program. Residents of recognized flood-prone areas in the County can purchase insurance at subsidized rates for single family residences, 2-4 family dwellings and small businesses. Final premium rates will be based on actuarial studies conducted for the Administration. Such actuarial studies are under way by the U.S. Corps of Engineers for the White River and Deer Creek areas upstream from Highway 99, the Springville and Three Rivers areas and the Woodlake and Porterville areas.

Economic Development Administration,
Department of Commerce

The Economic Development Administration makes grants and loans for public works and development of facilities which improve opportunities to establish or expand industrial and commercial plants. Essentially, the program is aimed in creating, through public works activities, long-term employment opportunities in an area primarily to benefit "hard core" unemployed and low-income families. The area involved must be one found economically depressed and must have an approved overall plan for economic development. Grants generally are limited to 50 percent of total project costs, although total grants up to 80 percent may be made in certain economically depressed areas. Loans are made only when funds for the project are not otherwise available, and if made, must be repaid in not more than 40 years. Some flood control projects in the Tulare County area may be eligible for grants or loans and further consideration should be given to this program of the Economic Development Administration; it appears, however, that the program will be of limited assistance in connection with this Flood Control Master Plan.

Bureau of Reclamation,
Department of the Interior

Under the Small Reclamation Projects Act of 1956 (Public Law 84-984), the Bureau of Reclamation can lend funds for primarily-irrigation projects costing not more than $10 million. While many of the reservoir concepts developed in Chapter 3 could augment irrigation uses of rain-flood runoff through control of releases, it is doubtful if any of these reservoirs would develop sizable irrigation benefits. More important, because of water right and other limitations described in Chapter 3, it is clear that development of firm irrigation yields at any of these reservoirs is not practical. Accordingly, it is considered that the Bureau's Small Reclamation Project Program cannot be used effectively in implementing this Flood Control Master Plan.

DEVELOPING SPECIFIC PROGRAMS

V

Historical flooding in Tulare County and its adjacent areas, flood hydrology, flood control concepts, and financing considerations which have been discussed in the previous chapters lead, as a whole, to the conclusion that solution of the flood problems in the seven flood control Units will involve continuing programs over a period of many years and perhaps of decades. Such programs may require that the Tulare County Flood Control District engage in activities which are largely independent of agencies outside Tulare County and participate in activities involving adjacent counties and State and Federal agencies. Action by County government also may be required to control development of flood plains for short or long periods of time, since the authority to establish such controls rests with the Board of Supervisors as the legislative body governing Tulare County rather than in the organic Act under which the Flood Control District functions.

Floods in the Tulare County area have only rarely resulted in loss of life, except perhaps indirectly through emotional stresses placed on individuals. It is probable that loss of life will not occur frequently in the future, but the potential will always be present. Flood damages principally reflect monetary losses, primarily in the expense of repair and replacement of the many different kinds of improvements affected by flood waters: inundated dwellings and commercial shops; overflowed or eroded farm land, or cropped areas laden with sand, gravel or other debris; destroyed farm roads, pumps and equipment; damaged County roads, bridges and culverts; eroded and broken levees; railroad failures; State highway damage; interrupted communication facilities; and broken canal systems belonging to individuals, private companies, local public agencies and the Federal Government. Monetary losses are also sustained by individuals and public agencies when travel and communications are disrupted by flooding. Social losses occur as well when homes are damaged and people are evacuated even temporarily.

All these factors are important to the individuals and agencies concerned and illustrate the impracticability of listing flood problems in any single order of severity. Urban and residential damage resulted from the 1966 and 1969 floods in many communities. Agricultural lands along most streams suffered varying degrees and kinds of damages. Irrigation systems were inundated and suffered extensive damage to structures and canal banks. Visalia and Tulare, the largest cities in the County, face potential hazards of inadequate controls of the combined flows of Dry Creek and Kaweah River.

Establishment of priorities for approaching solutions to flood problems on a stream by stream or area by area basis also is impractical. However, by pursuing flood problems in cooperation with other public agencies in Tulare County and on the inter-county, State and Federal levels, a properly organized effort can attack the County-wide flood problems on a broad basis enabling affected individuals, landowners and public officials within each area of the County to determine the priorities with which problems in their area may be resolved. Suggested steps and procedures at the intra-District level, the inter-county level and the State-Federal level are described below.

LOCAL PROGRAMS AND PROCEDURES

Flooding in Tulare County is partially caused by runoff originating in southern Fresno County and Kern County (Rag Gulch), as well as in the County itself. Control of such inter-county streams can benefit lands in all three counties and in Kings County as well. Thus, the six valley-floor flood control

Units discussed in Chapter 3 form an over-all hydrologic area having interrelated problems. No single governmental agency is authorized to resolve these problems effectively and in a manner equitable to all residents and property owners in the over-all area. If there were such a single agency, accomplishment of effective and equitable measures at the local level would be much easier.

Tulare County Flood Control District can act only for the benefit of residents and property owners within the District. The District may, for example, construct a detention basin on Hills Valley Creek to benefit lands and improvements within the District; however, if the District did construct such a basin, Fresno County landowners would benefit also and the District Act does not provide for participation by those landowners in the cost of the works. For purposes of suggesting procedures at the local level, this report ignores the fact that the Act applies only within the boundaries of Tulare County. In effect, the report assumes that the flood control Units described in Chapter 3 *are* within a single agency having the powers of the District.

As discussed below, it may be possible to reconcile the different hydrological and political areas through cooperative action and thus achieve the same result. If such a cooperative approach cannot be achieved, then the procedures outlined below will necessarily have to be reviewed and, possibly, limited in application to the District itself. Obviously such modified procedures may not achieve control of flooding in a fully beneficial way to all those affected by flows from all streams within the hydrological area.

Detailed planning and construction of many of the flood control projects in Tulare County and the adjacent areas will probably be the responsibility of agencies other than the District. However, there is little likelihood that these other agencies will solve all the flood control problems of the area except possibly over a period of many decades. The District itself, especially if cooperative arrangements can be established with other governmental agencies within its boundaries and in adjacent counties, may be able to carry out planning, construction and operating functions in parts of the area, thus supplementing efforts of others and aiding earlier completion of an over-all program. Accordingly, it is appropriate to consider possible procedures which might be employed in flood control activities in the District and its adjacent areas assuming provisions of the District Act are applicable throughout.

Two other factors — one practical and the other legal — also favor or require participation by local citizens in action flood control programs. Under present State and Federal policies, local agencies must agree to operate and maintain many completed flood control works to prescribed standards; such action involves continuing annual expenditures which equitably should be provided by those benefitting. Practically, also, the willingness of local agencies to expend their own funds on such programs encourages participation by higher governmental agencies.

Among the functions which the District might carry out are:

1. Liaison with cities and irrigation, soil conservation and other similar districts within Tulare County, with adjacent counties, and with local and State offices of appropriate Federal and State agencies.
2. Coordinating flood control activities on the individual streams and related stream systems.
3. Making recommendations as to boundaries of zones of benefit for planning purposes.
4. Reporting on the engineering and economic justification of specific projects.
5. Preparing final designs, plans and specifications of specific projects and directing their construction.
6. Operating and maintaining completed works.
7. Cooperating with local, State and Federal agencies in the collection of hydrologic data.
8. Conducting hydrologic and hydraulic studies for use of various departments of County government.

All these functions are required in an over-all flood control program. This does not mean they should or can be carried out only by County staff personnel. Time, availability of qualified personnel and funding limits will restrict the number and extent to which these functions can be performed by County staff. For specific projects, some of the functions will be carried out by others (for example, Corps of Engineers, local irrigation, water conservation, soil conservation districts, etc.). On specific studies and projects also, engagement of consultants may be appropriate for planning and zone of benefit studies and for design and construction of physical works.

Establishing Zones of Benefit

With this Master Plan at hand, implementing any of the concepts of Chapter 3 should follow three steps: (1) making detailed studies of the engineering feasibility and economic justification of specific projects and defining areas benefitting from their operation, (2) preparing final designs, plans and specifications, acquiring rights-of-way and constructing such projects, and (3) operating and maintaining them. In general, costs of the first and third steps are relatively small compared with the costs of the second step. Also, the first and second steps, though differing widely in cost, are "one-time" programs while the third—operation and maintenance of a specific project—represents a continuing annual cost. The distinction between the detailed engineering, economic and benefitted-area studies of Step 1 and the final design and construction work of Step 2 is important, for Step 1 determines the practical viability of a project.

Definition of a zone or zones benefitting from one or more projects requires thorough, detailed study of flooded areas, reservoirs and channel location and sizing. Normally the detailed study performed in Step 1 develops the zone or zones benefitting from a specific project or projects.

Any discussion of action programs by the District, either by itself or in cooperation with other local agencies, should consider the mechanics of financing such programs through Zones of Benefit as provided in the District Act. It is noted, however, that the District Act is not entirely clear as to whether all three of the normal procedural steps set forth above can be financed with funds raised under the District Act except over a period of many years. Without question, funding of Steps 2 and 3 can be accomplished through establishment of Zones of Benefit in accordance with the Act. It may be, however, that the Act does not provide specifically for Zones of Benefit for funding of the planning work of Step 1, which is necessary to establishing the justification for final design, acquisition of rights-of-way, construction, and eventual operation and maintenance. The Act may permit the Step 1 work to be accomplished with funds raised through District-wide assessment, but the relatively small amounts of such funds, apart from any other consideration, may restrict the rate at which these planning efforts can be carried out.

If it is desired to carry on a more extensive locally financed planning effort than can be accomplished through District-wide assessment, then a practical approach to raising more funds might be to develop Zones of Benefit for the purpose of making the determinations of engineering and economic viability called for in Step 1. If such a procedure is not permissible under the Act, amendments to the Act should be sought in the interests of establishing maximum flexibility in solution of the flood problems of Tulare County and adjacent areas. The discussion that follows is based on the assumption that establishment of Zones of Benefit for planning purposes is permissible under the Act or that the Act has been amended to permit zones to be established for that purpose. An example of application of the three-step procedure to flood control implementation is discussed below and illustrated schematically in Figures A, B, C and D.

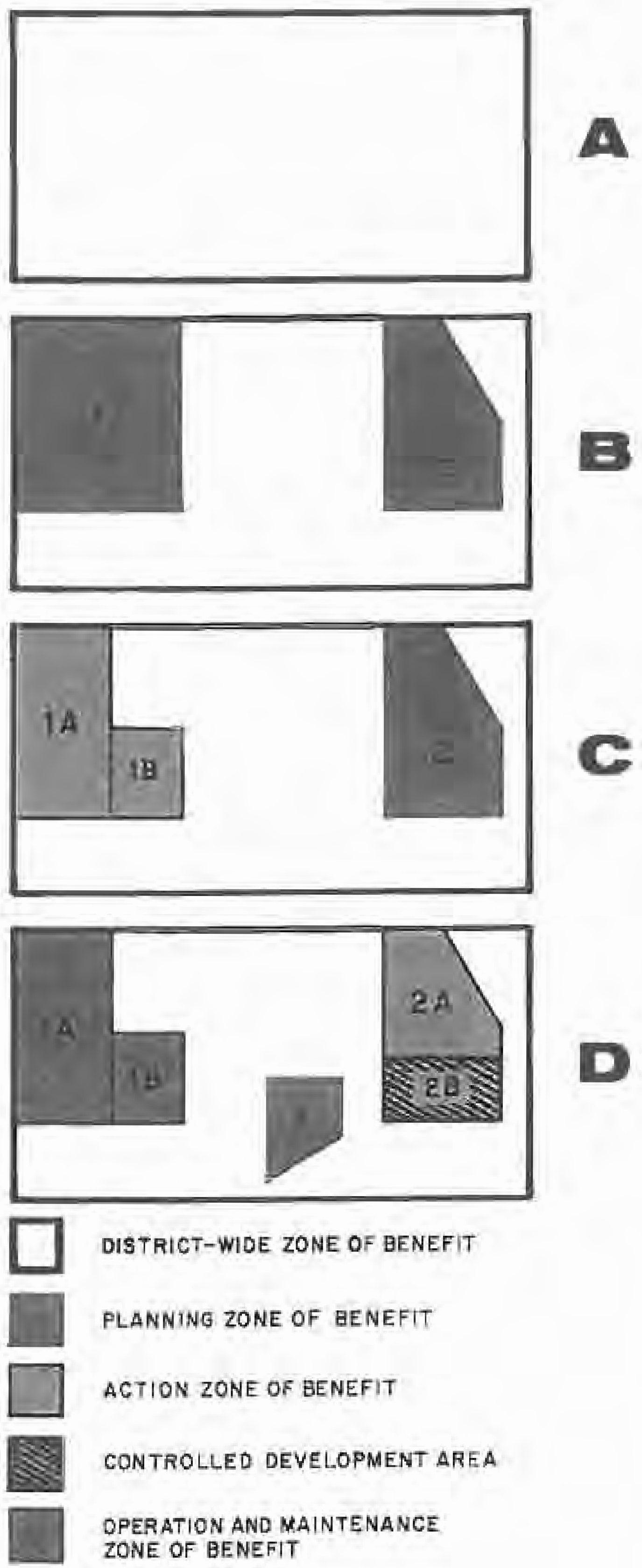


Figure A schematically represents the District-wide Zone of Benefit which was established, in effect, by the Act creating the District and implemented by the Board of Supervisors. This Master Plan, which quantifies the area-wide hydrology of flood problems and suggests concepts for flood control, was financed by funds raised District-wide as an essential first step in flood control planning for the entire District.

In Figure B, it is assumed that two "Planning Zones of Benefit", No. 1 and No. 2, have been established for the necessary detailed planning. These zones are in areas of past and potential flooding where prospects of developing a definite project either by action programs of the District or of other agencies appear promising. In establishing boundaries of the zones, recent flooding patterns and consequent tangible and intangible damages were considered. The number of such zones in existence at any one time will depend on the intensity of planning efforts by the District and other agencies.

Next, it is assumed that the engineering and economic feasibility of a definite project in Planning Zone No. 1 has been established as a result of detailed planning. The project would be advantageous to land and improvements in part of the zone and would protect a portion of Planning Zone of Benefit No. 1, identified as 1A in Figure C, against more frequent or damaging flooding than the portion marked 1B. It was also established that part of Planning Zone of Benefit No. 1 would receive negligible benefits from the construction and operation of the project; this part should be separated from the other two areas. Thus, as a result of the detailed planning effort, the areas designated as 1A and 1B are proposed as Action Zones of Benefit.

In Figure C it is assumed that the areas designated 1A and 1B have been approved as Action Zones of Benefit for implementation of the selected project. Figure C also shows schematically the continuation of detailed planning work in Planning Zone of Benefit No. 2.

It is emphasized that limited work would be done with funds raised in the Planning Zones of Benefit. The engineering and economic feasibilities of projects would be examined and the specific areas which would benefit by operation of the projects would be determined. This planning, in almost all cases, will cost a small fraction of actual construction cost of the project and will establish engineering and economic facts on which action programs can be presented for decision to the Supervisors and the residents of a proposed Action Zone of Benefit. The actions taken and the means of financing them may vary widely. Small inexpensive projects might be financed by annual assessments within the Action Zones of Benefit, with portions of the work being executed each year and without exceeding reasonable assessments. Larger projects might require bonding. Definite plans and the demonstration of economic merit might support grants or loans from other agencies under programs discussed in Chapter 4. Action programs might consist simply of turning to other agencies with requests for review and concurrence in the merits of the project and consequent direction of final design, construction and participation in costs of lands, easements and rights-of-way. Appropriately, under the District Act residents within a proposed Action Zone of Benefit will determine the program to be undertaken through their approval of establishment of such a zone.

Figure D shows further development of flood control within the District. A new Planning Zone of Benefit, No. 3, has been established for development of detailed plans and the boundaries of another possible Action Zone of Benefit. The project for Action Zones of Benefit Nos. 1A and 1B has been constructed and those zones have been converted to Operation and Maintenance Zones of Benefit Nos. 1A and 1B, with assessments which cover continuing costs of operation and maintenance of the work reflecting the different degrees of flood protection provided by the project. Also, a portion of Planning Zone of Benefit No. 2, marked 2A, was found to be a viable Action Zone of Benefit, while the remainder, marked 2B, although subject to serious flooding, was found to be so costly to protect as to make it an impractical part of an Action Zone of Benefit. The Board of Supervisors might consider designating the latter area as an area where development would be controlled under ordinance, as indicated in Figure D; establishment of such controls could make affected property owners in area No. 2B eligible for flood insurance under Public Law 90-448.

Other examples could be developed to illustrate the application of these procedures. An apparently viable project proposed as a result of detailed studies in Planning Zone of Benefit No. 3, for instance, might prove to be impossible to finance and might subsequently be abandoned altogether.

The procedure for establishing separate Zones of Benefit described above has the advantage of permitting the electorate affected to become informed at each stage as to costs and benefits. However, the procedure may be cumbersome and overly time-consuming, inasmuch as at least two elections are required and each election must be preceded by hearings. When one considers the number of potential Zones of Benefit in the District, and in related areas outside the District, it is apparent that the sheer mechanics of these procedures may make them difficult and expensive to apply.

Since areas upstream of Success and Terminus Dams are not, at least at present, economically susceptible of protection, there is justification for treating the Mountain Unit portion of the District differently from the remainder of the District and adjacent areas. Also, the potential unwieldiness of the procedures outlined previously tends to justify consideration of forming a single valley-floor Planning Zone of Benefit, including all of the District except the Mountain Unit; in such a zone, detailed planning could be accomplished within an over-all program to solve progressively the valley-floor flood problems.

Thus, it is suggested that consideration be given to three approaches to defining Planning Zones of Benefit. In one, a valley-floor Planning Zone of Benefit would be established and would include all the District except the Mountain Unit. In a second approach, separate Planning Zones of Benefit would be established. In a third approach, a valley-floor Planning Zone of Benefit might be established as in the first approach, and separate Planning Zones of Benefit might be superimposed thereon. If separate Planning Zones of Benefit were established, or were superimposed on a larger Planning Zone of Benefit, the separate zones might encompass the areas suggested below, although more detailed analysis will be required to support their specific metes and bounds descriptions.

Tulare-Fresno Unit

Consideration of the widespread flooding during the 1966 and 1969 storms and the concepts presented in this Master Plan clearly indicate that this entire Unit is influenced by the canal system of Alta Irrigation District and that system is important to solution of flood problems throughout the Unit. Wide areas within the Unit are flooded from combined sources. Most residents of the areas not actually flooded are inconvenienced to some extent by disruption of communications. Drainage of urban areas is interrupted during periods of flooding, and damage to county roads, bridges and culverts requires expenditure of county funds which otherwise could be devoted to other purposes.

If a Planning Zone of Benefit covering the whole Tulare-Fresno Unit were established and the concepts presented in Chapter 3 were used, detailed planning of a coordinated development to control flooding in that Unit could be initiated. As a part of such detailed planning, and consistent with the procedures recommended above, the difference, if any, in benefits of operating the planned works to the various parts of the Unit should be determined because even if the works are constructed by other agencies the local area may have to finance their operation and maintenance. Also, such information will be required if the residents of the Unit are called upon to decide the desirability of constructing the work in stages through annual assessments, or in a continuing program based on bond financing.

As suggested, portions of the Tulare-Fresno Unit lying outside the boundaries of the District, from a standpoint of equity and self-interest, should participate financially and otherwise in development of detailed plans for flood control on many of the streams in the Unit. In Fresno County, areas east of Kings River and Wahtoke Creek and in the vicinity of Friant-Kern Canal can benefit from a coordinated plan of flood control.

Kaweah Unit

The entire Kaweah Unit could also be designated as a single Planning Zone of Benefit. Almost all of the residents within the Unit have an interest in the successful conclusion of current studies by the Corps of Engineers on augmentation of storage on Kaweah River and control of Dry Creek and of possible modifications of the control structure at McKays Point. These interests are either direct, because landowners are flooded by combined flows of Kaweah River and Dry Creek, or indirect in that they are threatened by such flooding or are inconvenienced in many ways when floods occur. Other landowners, including those in the vicinities of Woodlake, Lindsay and Exeter and those flooded by waters of Antelope, Mehrten, Yokohl and Lewis Creeks, have an interest in common with those actually or potentially flooded from Kaweah River and Dry Creek flows because the ultimate solutions to flooding in their areas depend on the availability of sufficient capacity in Kaweah River distributaries to convey controlled flows of all these creeks.

Terminus Dam is a Federally-owned structure; its modification is appropriately a function of the Corps of Engineers. The Corps is presently studying the feasibility of controlling Kaweah Basin snowmelt by providing additional storage in Lake Kaweah and a reservoir on Dry Creek. Any detailed planning for the control of rain-floods originating on the other smaller watersheds within Kaweah Unit should be coordinated with studies of Kaweah River flood control being conducted by the Corps. Equally important, detailed planning for protection against rain-floods in the smaller watersheds of Kaweah Unit should be conducted in close consultation with management and operating officials of agencies owning Kaweah Delta canal systems.

Tule Unit

After the December 1966 flood, in which extensive areas adjacent to Tule River were inundated by the high flows passing Success Dam, considerable channel work west of Porterville was done; as a result, runoff from the smaller flood of February 1969 was carried with only minor channel overflow. Most of the area in the Unit has a substantial interest in possible augmentation of storage space at Success Reservoir. Other portions of the Unit, including specifically those affected by the flows of Frazier Creek and those in the vicinity of Porterville, warrant detailed planning study. The entire Unit can benefit through improved communications and otherwise if floods are reduced. Thus, the entire Tule Unit might form a Planning Zone of Benefit.

Deer Unit

Study of areas flooded by the flows of Deer Creek during the flood of 1969 indicates that this Unit could well be included in a single Planning Zone of Benefit. Direct benefits from flood control measures would, of course, accrue to owners of land and improvements in areas such as were flooded in 1969. Indirect benefits from improved communication during flood times would accrue to all the area within the Deer Unit from control of flows of Deer Creek, Fountain Springs Gulch and Terra Bella—Ducor and Ducor East drainages.

White Unit

As in the case of the Deer Unit, flooding patterns resulting from the storms of February 1969 suggest that the entire Unit form a single Planning Zone of Benefit through which detailed planning could be conducted for control of floods on White River, Rag Gulch and intervening drainages. More study might reveal that indirect benefits such as non-interruption of communications during high flows of White River and Rag Gulch are not sufficiently interrelated as to warrant establishment of such a single Planning Zone of Benefit. If not, then consideration might be given to establishing two Planning Zones of Benefit in White Unit, one of which would examine detailed plans for control of White River and adjacent drainages, and the other, detailed plans for control of Rag Gulch. The localized nature of flows from Rag Gulch, the concepts for such control discussed in Chapter 3, and the fact that lands in both Tulare and Kern Counties are involved might also support a conclusion that such separate Planning Zones of Benefit would be appropriate.

Tulare-Kings Unit

Districts in Kings County currently are participating with Tulare County districts in flood control activities. However, the entire Tulare-Kings Unit is involved in control of flooding from streams originating in the other five valley-floor Units and in the Mountain Unit. It is clear also that some of the streams flooding the other Units do not produce significant damage in the whole of Tulare-Kings Unit. At least as evidenced by flood patterns during the 1969 flood, one stream, Rag Gulch, does not convey water to Tulare-Kings Unit at all. Obviously the largest part of Tulare-Kings Unit is outside Tulare County Flood Control District.

It appears equitable and in the self-interest of landowners in Tulare-Kings Unit that they participate actively in financing detailed planning studies in the other valley-floor Units and in guiding such planning. Landowners in various parts of the Unit also could profitably coordinate their efforts in studying plans of flood control through channel modifications within the Unit.

Consideration might be given (if appropriate multi-county coordination is secured) to establishing a Unit-wide Planning Zone of Benefit. It is possible also, that Tulare-Kings Unit might be divided into two or more Planning Zones of Benefit to recognize the different sources of damaging waters. If two such Planning Zones of Benefit were established in the Unit, one might include the portion of Tulare-Kings Unit north of Tule River and the other a portion of the Unit south of Tule River. Also, a Unit-wide Planning Zone of Benefit might be established with two separate zones — one north and one south of Tule River — superimposed thereon.

INTER-COUNTY ACTION

Flooding of land in the District is related in part to flooding in portions of Fresno, Kings and Kern Counties. No single political subdivision of the State encompasses the entire area involved. Equitable solutions to the interrelated problems of the area perhaps could best be accomplished if such a single entity existed; in its absence all possible forms of effective, cooperative action should be explored among the four county governments concerned, with full participation of all local water and soil conservation districts and agencies.

Exploration in depth of ways and means to secure this effective and coordinated action must be based on understanding the flooding problems in the area. It is believed that this Master Plan can make possible such understanding. Beyond this, and without essential agreement by property owners in the areas affected that common problems do exist, it is possible only to suggest a few mechanics for achieving results.

Inasmuch as Tulare County Flood Control District is an important and centrally located portion of the total area, it might initiate proposals for joint action on the various flood problems involving land and flood sources in two or more of the four counties. Preliminary to such proposals, copies of this Master Plan should be provided to officials in Fresno, Kings and Kern Counties and to the many local districts in the four county area. Assuming agreement that common problems do exist in one part of the general area or another and should be attacked by coordinated effort of the many political agencies involved, legal advice could be sought to determine their powers to enter into formal cooperative agreements or to otherwise undertake appropriate action.

PROGRAMS INVOLVING STATE AND FEDERAL AGENCIES

State and Federal agencies may accomplish a substantial part of the over-all flood control program in the District and adjacent areas. Locally, the District should monitor the programs of State and Federal agencies and should encourage existing and suggest new programs. Moreover, the District actually can help State and Federal agencies accomplish their programs by direct action in gathering data and in performing detailed planning studies. Any arrangements made to implement inter-county actions discussed above should involve all three of these activities — monitoring, encouraging or suggesting programs, and direct action.

Monitoring is simply maintaining current knowledge of the programs of Federal and State agencies and of their status. Frequent contacts with local and State offices of these agencies can provide the knowledge upon which suggestions can be based and which can assure coordination with the District's program. At the same time, District officials should be aware of legislative proposals affecting the area. Participation in associations with broader interests may also be of help.

Encouraging Corps studies of enlarging snowmelt storage capability on Kings, Kaweah, Tule and Kern Rivers obviously is of great importance to developmental planning on many of the foothill streams of Tulare County and adjacent areas. Similarly, local action should encourage further planning, authorization and construction of the proposed East Side Project, since that project can provide facilities significant to an over-all flood control program. New Small Flood Control Projects can be suggested to the Corps and planning trends on other projects may be influenced in ways to assist the flood control program.

Where individual projects clearly will cost less than $1,000,000, and consultation with the District Engineer of the Corps of Engineers indicates the action to be appropriate, such individual projects might be planned in conformance with Corps standards as to engineering, cost estimates and benefits. It appears reasonable, as a minimum, that preparation of feasibility reports by the District in such cases could accelerate construction of some projects which the Corps otherwise would necessarily have to schedule at later times.

SELECTED BIBLIOGRAPHY

FLOODS

California High Water, 1966-1967, Bulletin No. 69-67, June 1968
California High Water, 1968-1969, Bulletin No. 66-69, June 1970
—Department of Water Resources, The Resources Agency, State of California

Floods of January and February 1969 in Central and Southern California, Open-file report, 1969
—Geological Survey, U.S. Department of the Interior

Report on Floods, Central Valley of California, 1966-67 Flood Season, December 1967
Report on Floods, Central Valley of California, 1968-69 Flood Season, August 1970
—Sacramento District, Corps of Engineers, Department of the Army

FLOOD HYDROLOGY

Flood Control Master Plan: Hydrology Appendix, Tulare County Flood Control District, April 1971
—Murray, Burns and Kienlen, Consulting Civil Engineers and The Spink Corporation, Sacramento, California

FLOOD PLAIN MANAGEMENT

Flood Plain Management Study, Tulare County, California, March 1970
—Tulare County Planning Department

Flood Plain Information, Kaweah River, Three Rivers, California, October 1967
Flood Plain Information, Tule River, Springville, California, July 1968
—Sacramento District, Corps of Engineers, Department of the Army

GENERAL PLANNING

An Area General Plan, Tulare County, California, Report No. 1: Basic Determinates for Plan Preparation, April 1962
Report No. 2: Proposals and Tools for Achievement, April 1963
—Robert Grunwald and Associates, City and Regional Planning Consultants, Hanford, Calif.

General Plan, City of Porterville, California: Public Services and Facilities, October 1965
—Koebig and Koebig, Inc., Hahn, Wise and Associates, Inc., Los Angeles and San Carlos, Calif.

A Comprehensive Master Plan for the Development of the Soil and Water Resources of the Upper Kaweah River Watershed: A Report for the Three Rivers Soil Conservation District, c. 1962
—Blair-Westfall Associates, Consulting Engineers, San Jose-Fresno, California

PROJECT PLANNING AND OPERATION

Preliminary Report and Plans and Specifications, Curtis Mountain Drain, Navelencia Soil Conservation District, Tulare County, April 1970
—Soil Conservation Service, U.S. Department of Agriculture

Stone Corral Watershed Work Plan, May 1970;
Hydrologic Appendix, May 1968
—Stone Corral Soil Conservation District, Stone Corral Irrigation District and Tulare County Board of Supervisors with Division of Soil Conservation, State of California and Soil Conservation Service, U.S. Department of Agriculture

Review Report for Flood Control on Poso Creek Stream Group, California, November 1967
—Sacramento District, Corps of Engineers, Department of the Army

East Side Division, Initial Phase, Central Valley Project: A Report on the Feasibility of Water Supply Development, December 1965, rev. June 1966
—Region 2, Bureau of Reclamation, U.S. Department of the Interior

East Side Division, Initial Phase: Proposed Report of the Secretary of the Interior, September 1968
Comments of the State of California, August 1970

Conceptual Study for the Long Range Development of the Water Resources of the Kaweah River and Adjacent Streams, for the Southern San Joaquin Valley Flood Control and Water Conservation Association, June 1970
—Amalio Gomez, Consulting Civil Engineer

Success Project, Tule River, Reservoir Regulation Manual, June 1961, rev. August 1966
Terminus Project, Kaweah River, Reservoir Regulation Manual, June 1962, rev. February 1963
—Sacramento District, Corps of Engineers, Department of the Army

OTHER

Handbook of Federal and State Programs of Financial Assistance for Water Development, 1969
—California Legislature, Assembly Committee on Water, Carley V. Porter, Chairman

Report and General Soil Map, Tulare County, California, Unpublished report, October 1967
—Soil Conservation Service, U.S. Department of Agriculture

The Possibilities of the Permanent Reclamation of Tulare Lake Basin, California, January 10, 1907
—Engineering News Record

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GEOGRAPHY

Tulare County encompasses an area of approximately 5,000 square miles. The eastern two-thirds of the County consists of part of the Sierra Nevada and adjacent foothills; the western one-third is valley-floor land. The County contains some of the loftiest peaks of the Sierra Nevada, including Mount Whitney, which has an elevation of 14,496 feet. West of the Sierra Nevada are dissected uplands which extend to the foothill line at an elevation of approximately 500 feet. Low alluvial plains and fans extend westward to the bottom lands of Tulare Lakebed. The western border of the County is at an elevation of approximately 200 feet.

Geology

The Sierra Nevada were formed primarily from a single gigantic block of crystalline rock which has been uplifted on the eastern edge along a fault zone, forming a steep eastern escarpment. The westward tilting of the top of the block resulted in gentler slopes toward the west. Major rivers have incised deep canyons into this western slope. Soils are typically shallow throughout the area.

The dissected uplands east and south of Porterville and between Orange Cove and Woodlake include deeply weathered, eroded and uplifted alluvial deposits. Weathering has produced dark reddish-brown soils; erosion has resulted in gullies as much as 50 feet deep.

West of the foothill line the valley proper is a broad plain of low relief. The plain consists of the three large coalescing alluvial fans of the Kings, Kaweah and Tule Rivers. The Kings River alluvial fan, the largest, is separated in the upper portion from the Kaweah River alluvial fan by the Cottonwood Creek interfan and Cross Creek. The Kaweah River alluvial fan is separated in the upper portion from the Tule River alluvial fan by Lewis Creek interfan area and Elk-Bayou. South of the Tule River fan are smaller fans created by Deer Creek and White River with intervening fans from smaller stream channels. The soils of the fans are generally sandy, permeable and fertile, although hardpan is present in some areas. In the interfan areas the soils are somewhat alkaline and less fertile. The plains and fans form the largest part of the valley floor, presently a highly developed agricultural area.

Overflow lands and lake bottoms -- which are flat, nearly featureless areas -- are located in the western part of the County. These lands were formerly inundated during flood stages of Tulare Lake and supported growth of marsh and tule vegetation. The soils generally have limited permeability, but are fertile and mostly free from alkaline.

Drainage Areas

The eastern one-third of the County is drained by the Kern River system, which flows in a southerly direction to a point east of the City of Bakersfield, thence westerly through Kern County to Bakersfield where it discharges onto the floor of the San Joaquin Valley. Buena Vista Lake and Tulare Lake are the terminal points for Kern River water. Almost all of the lands drained by the Kern River stream system within Tulare County are located within the Sequoia National Forest.

The northeastern portion of the County is located within the drainage area of the Kings River. All of the tributary streams in this area flow in a generally northerly direction through Kings Canyon National Park. The Kings River flows onto the valley floor in a southerly direction and enters Tulare County to the west of Dinuba. It flows through Tulare County for approximately six miles and continues westward to a bifurcation from which the waters flow either southward into Tulare Lake or northward to the San Joaquin River.

The remaining portion of the County is drained by stream systems which flow to the west and discharge onto the floor of the San Joaquin Valley. The two largest stream systems which drain these western slopes are the Kaweah and Tule Rivers. In addition to these two major river systems, approximately 34 smaller drainage areas discharge water onto the valley floor within Tulare County. Another six drainage areas discharge water onto the valley floor outside the Tulare County boundaries; however, resulting flood flows may enter the County. All 40 drainage areas are identified on Plate I and are listed in Table 1, which also gives the area in square miles for each drainage. Also shown on Plate I and listed in Table 1 are those drainage areas in Kings and Kern Counties whose runoff has some effect on Tulare County. Brief descriptions of some of the watersheds which discharge onto the valley floor are contained in the following paragraphs.

Citrus Cove Drainage (Drainage Area 3). Citrus Cove drainage encompasses the area between Wahtoke Creek and Granite Hill. The maximum elevation in the drainage area is 1,500 feet and the elevation at the Friant-Kern Canal crossing is about 440 feet. Between Friant-Kern Canal and the Alta East Branch Canal the channel is known as Navelencia Creek. Water from Navelencia Creek is distributed by Alta East Canal into the canal system of the Alta Irrigation District. The drainage area above Friant-Kern Canal is 8.3 square miles.

Hills Valley Creek (Drainage Area 6). Hills Valley Creek heads on Bear Mountain at elevation 3,355 feet and flows southerly about six miles to Friant-Kern Canal. The elevation at the Friant-Kern Canal crossing is approximately 440 feet. In the lower reaches the stream channel has been realigned by recent land development. The drainage area of Hills Valley Creek at Friant-Kern Canal is 10.7 miles.

Wooten Creek (Drainage Area 7). Wooten Creek rises in Fresno County immediately north of the Tulare County line. It flows in a generally southwesterly direction into Tulare County in the vicinity of Orange Cove. East of Friant-Kern Canal, Wooten Creek has been realigned during land development and west of Friant-Kern Canal it is channelized from the Canal to the Alta East Branch Canal about one and one-half miles west of Orange Cove. The drainage area at Friant-Kern Canal is 11.3 square miles and ranges in elevation from 1,945 feet to 440 feet in the vicinity of Orange Cove.

Sand Creek (Drainage Areas 9 and 10). Sand Creek rises on the northern slopes of Goldstein Peak (elevation 2,814 feet). From its origin Sand Creek flows in a northwesterly direction about five miles, then turns and flows southwest about eight miles to discharge onto the floor of the valley between Primero and Curtis Mountains at an elevation of approximately 430 feet. From this point Sand Creek is channelized between Orosi and Cutler to the vicinity of Cottonwood Creek about six miles southeast of Dinuba. The drainage area at Friant-Kern Canal is 38.8 square miles. The Soil Conservation Service classifies runoff from the drainage basin as rapid.

Long Creek (Drainage Area 14). Long Creek drainage to Friant-Kern Canal is a relatively narrow 11.2 square mile area draining Long Valley, which is located between Tucker Mountain and Sawyer Peak. Elevations at these two locations are 2,603 feet and 2,403 feet, respectively. Story Creek, a principal tributary, joins Long Creek about one mile east of the Friant-Kern Canal at an elevation of approximately 450 feet. Long Creek channel west of the Friant-Kern Canal has been obliterated by land development. Runoff from the drainage area is classified as medium to rapid.

Cottonwood Creek (Drainage Areas 22, 23 and 24). Cottonwood Creek drainage is bounded on the north by a ridge containing Mitchell Peak (elevation 3,574 feet). Several tributaries flow south from this ridge and join in the vicinity of Cottonwood School to form Cottonwood Creek. Below this point Cottonwood Creek flows in a generally southerly direction about 14 miles to the south end of Colvin Mountain. It then turns west and flows across the floor of the San Joaquin Valley to its confluence with St. Johns River near U. S. Highway 99. The waters of Cottonwood Creek and St. Johns River are conveyed by the Cross Creek system southerly to Tulare Lake. The area drained by Cottonwood Creek ranges from a maximum elevation of 4,124 feet at Bear Mountain to about 430 feet at the south end of Colvin Mountain. The total area drained by Cottonwood Creek above Friant-Kern Canal is 88.1 Square miles. Runoff from the northerly half of the drainage area above Friant-Kern Canal is classified as rapid and from the southerly half as medium to rapid.

Antelope Creek (Drainage Area 25). Antelope Creek rises on the western slopes of Long Mountain and flows southerly about five miles to the vicinity of Woodlake. The watershed ranges in elevation from 2,516 feet to approximately 430 feet. The drainage area above Woodlake is 20.7 square miles. The natural terminal point for Antelope Creek water is the St. Johns River near the Friant-Kern Canal. Runoff from the drainage area is classified as medium to rapid.

Dry Creek (Drainage Area 27). Dry Creek, also known as Limekiln Creek, rises on the southern slopes of Park Ridge about one mile south of the Fresno-Tulare County Line. It flows in a generally southerly direction about 24 miles, discharging into the Kaweah River approximately one mile below Terminus Dam. The total drainage area at its mouth is approximately 82 square miles. The basin varies in elevation from a maximum of 7,540 feet to about 490 feet at the Kaweah River. Runoff from the drainage area is classified as rapid.

Kaweah River (Drainage Area 28). The source of the Kaweah River is a group of glacial lakes near Triple Divide Peak. The main stream is formed by the confluence of the middle and East Forks approximately five miles northeast of Three Rivers. Between this point and Terminus Dam the North and South Forks discharge into the main stream. The total watershed above Terminus Dam is 561 square miles. Elevations in the watershed range from a maximum of 12,634 feet to about 500 feet at the foothill line. Those portions of the watershed above 10,000 feet in elevation are characterized by mountain peaks and ridges having either a very thin mantle of soil or exposed brush.

Mehrten Creek (Drainage Area 29). Mehrten Creek flows generally in a northwesterly direction. The drainage area at its crossing with Foothill Ditch and Highway 198 is 19 square miles. From the Foothill Ditch crossing, Mehrten Creek water flows in a relatively undefined channel to Yokohl Creek near the latter's confluence with Consolidated Peoples Ditch. The maximum elevation in the watershed is 2,432 feet and the elevation at Foothill Ditch is approximately 460 feet. Runoff from the drainage area is classified as medium to rapid.

Yokohl Creek (Drainage Area 30). Yokohl Creek rises on the western slope of Blue Ridge and flows in a generally northwesterly direction about 16 miles to where it discharges onto the valley floor at a point about four miles northeast of Exeter. Yokohl Creek continues in a northwesterly direction approximately 3.5 miles to its confluence with Consolidated Peoples Ditch. The watershed contains approximately 71 square miles and ranges in elevation from 5,733 feet to approximately 460 feet at the foothill line. Runoff from the drainage area is classified as medium to rapid.

Lewis Creek (Drainage Areas 31 and 32). Lewis Creek rises on the southern slopes of Blue Ridge and flows through the foothills in a generally westerly direction for about eight miles. It then flows for about four miles along the foothill line to the Friant-Kern Canal immediately east of Lindsay. From this point Lewis Creek flows northerly around Lindsay then westerly to the vicinity of Outside Creek. Round Valley runoff enters Lewis Creek about one mile east of the Friant-Kern Canal. The Lewis Creek drainage area, including Round Valley, is approximately 32 square miles and ranges in elevation from a maximum of 2,901 feet to about 420 feet. Runoff from the eastern portion of the drainage area is classified as rapid and in the Round Valley area as medium to rapid.

Frazier Creek (Drainage Area 33). Frazier Creek rises at an elevation of approximately 1,500 feet in the foothills northeast of Porterville. It flows in a generally westerly direction about five miles to discharge onto the floor of the valley.

The watershed above a location one-half mile east of Road 256 contains 18.1 square miles and ranges in elevation from 2,308 feet to approximately 480 feet. West of Road 256 agricultural development has obliterated the Frazier Creek channel. Runoff from the watershed is classified as slow to medium.

Tule River (Drainage Area 36). The main stream of the Tule River is formed by the junction of the North and Middle Forks at a point about one mile northeast of Springville. Below this junction the Tule flows in a generally southwesterly direction about seven miles to Success Dam. Tule River channels continue westerly and terminate in Tulare Lake about four miles south of Corcoran in Kings County. The watershed above the dam contains 393 square miles and ranges in elevation from a maximum of 10,042 feet to approximately 500 feet at the dam.

Deer Creek (Drainage Areas 37 and 38). Deer Creek rises on the western slopes of Greenhorn Mountains and flows in a generally northwesterly direction about 27 miles to where it discharges onto the valley floor. Deer Creek channel terminates at the Homeland Canal about 10 miles west of Pixley. The watershed above Hungry Hollow Damsite contains approximately 124 square miles and ranges in elevation from a maximum of 8,284 feet to about 500 feet. Runoff from the basin is classified as medium to rapid.

Fountain Springs Gulch (Drainage Area 39). Fountain Springs Gulch rises on Galley Mountain at elevation 2,852 feet and flows westerly about eight miles. It then flows northwesterly in an entrenched channel past Terra Bella to its confluence with Deer Creek at an elevation of approximately 450 feet. The drainage area contains 35 square miles. Runoff from the drainage area to the north of the community of Fountain Springs is classified as medium to rapid, and to the east as rapid.

White River (Drainage Areas 43 and 44). White River rises on the western slopes of Bull Run Peak in the Greenhorn Mountains and flows in a generally westerly direction about 29 miles before discharging onto the valley floor. White River channel essentially disappears about five miles west of Earlimart. The watershed above State Highway 65 near Vestal contains approximately 120 square miles and ranges in elevation from 8,284 feet to approximately 500 feet. Runoff east of the White River near Ducor stream gaging station is classified as rapid and to the west as slow to medium.

Rag Gulch (Drainage Areas 49 and 50). Rag Gulch heads in Kern County on Blue Mountain (elevation 4,356). It flows westerly for about 20 miles at an elevation of about 500 feet to the Tulare-Kern County Line at Richgrove. Five Dog Creek, a major tributary, joins Rag Gulch about five miles southeast of Richgrove. From Richgrove westward to the Friant-Kern Canal, the Rag Gulch channel has been almost obliterated by land development. Rag Gulch drainage area contains 138 square miles at the SPRR tracks at Richgrove.

Between the major watersheds described above are smaller tributary areas which contribute significant stormflow to lands on the valley floor. These areas are also identified on Plate I and listed in Table 1. Runoff characteristics for these smaller tributaries can be generalized as follows: north of Kaweah River - medium to rapid; Porterville area (Drainage Areas 34 and 35) - rapid on the steep upper slopes and slow to medium on the moderate slopes; foothill areas between Terra Bella and Richgrove - slow to medium.

NORMAL ANNUAL PRECIPITATION

Normal annual precipitation within Tulare County ranges from about seven inches in the southwest corner of the County to over 50 inches in the northeast. Precipitation generally falls in the form of rain below the 5,000-foot elevation and as snow above this elevation. However, infrequent warm storms can produce rainfall at higher elevations near the crest of the Sierra with consequent high rates of runoff from the upper basins.

Precipitation stations in Tulare County and in immediately adjacent areas are listed in Table 2 and located on Plate II. Table 2 lists the station number assigned by the California Department of Water Resources, source of record, period of record, station elevation and normal annual precipitation for the periods 1911-60 and 1911-70 for those stations for which the normals have been computed. The normal annual precipitation values for the 1911-60 period have been developed by the California Department of Water Resources as described in "Precipitation in the Central Valley, Office Report, Coordinated Statewide Planning Program, Sacramento District, August 1966".

For purposes of this study, the 1911-60 normal annual precipitation amounts for 21 long-record stations in Tulare County and adjacent areas were updated to 1970. The additional 10 years of record changed the normal annual precipitation amounts for these stations by less than one percent on the average. For all practical purposes, precipitation amounts for Tulare County stations for the 1911-70 period are the same as the precipitation amounts for the 1911-60 period.

Precipitation, whether in the form of rain or snow, is measured as depth in inches of water that falls at a given location. At higher elevations where much of the precipitation is in the form of snow, it is difficult -- if not impossible -- to "catch" the true amounts of precipitation in rain gages. Therefore, rain gage data in these areas are supplemented with snow course measurements of water content in the snowpack. Snow courses and aerial markers in Tulare County and in immediately adjacent areas are listed in Table 3 and their locations depicted on Plate II.

Distribution of precipitation over an area is depicted by an isohyetal map -- a map showing lines of equal precipitation amounts. The isohyets are developed from point precipitation amounts and knowledge of the orographic effects on precipitation distribution. The normal annual isohyetal map of Tulare County for the base period 1911-70 is shown on Plates II and III. In addition to the isohyetal lines, drainage area boundaries are shown on Plate III. Isohyetal maps and data from the Sacramento District, U. S. Corps of Engineers, and the California Department of Water Resources were utilized in developing the isohyetal map for Tulare County.

STORM SYSTEMS

The storm systems that produce flood runoff in Tulare County are significant to an understanding of the flood hydrology of the area. Fall rains usually begin in November in the San Joaquin Valley. However, in some seasons the fall rains begin in September or October; in some years they are delayed until December. Large storms are most likely to occur in the months from November to April, although the predominant flood-producing period is the two-month period December and January. Recently major storms resulting in severe floods were experienced in 1966-67 and 1969.

The onset of fall and winter precipitation occurs with the southward migration of the polar jet stream, which is the maximum westerly wind in the upper levels of the atmosphere. In September the wind maximum is located near Latitude 50 degrees North (about the latitude of Vancouver, B. C.), but by mid-November it reaches Latitude 42 degrees North (about the latitude of the California-Oregon border). This southward swing of the westerlies causes the storm track to also move southward, bringing weather fronts into the San Joaquin Valley. The stronger fronts produce precipitation, the weaker ones only cloudiness.

Pacific storm systems usually involve classic cold and warm fronts and occlusions. Occluded fronts result when a cold front overtakes a warm front in a wave cyclone. Stronger fronts bring period of precipitation which can be as brief as six hours for a fast-moving front or as long as 24 hours for a slow-moving front. Periods of prolonged precipitation usually occur when cold fronts become quasi-stationary in a region. A stationary front lying parallel to a strong upper-level wind flow will frequently develop waves (undulations) which move along the front producing intense bursts of rain. This wave mechanism, in combination with orographic lifting of moist air, is the optimum condition for producing substantial precipitation amounts. (Frontal lifting is a mechanism of the storm itself; orographic lifting is caused by the flow of air over topographic barriers.) In all major flood-producing storms affecting Tulare County in the past, orographic precipitation has been quite significant.

<u>December 1966 Storm</u>

In the early part of December 1966 the polar jet stream shifted southward over the eastern Pacific Ocean. The storm track also moved southward along with the southward shift of the jet stream. In California the series of storms began on December 1 with the movement of a cold front into the State. This front reached Tulare County on December 2, producing generally light precipitation.

On December 4 a stronger front moved into the State; precipitation began in Tulare County on the afternoon of the same day. On December 5 the front became stationary in the southern San Joaquin Valley; on the 6th the front surged northward as shown by the weather maps in Figure 1. During the three-day period from midday December 4 to the afternoon of the 6th, heavy rain fell in the southern San Joaquin Valley. In the Kaweah River Basin on the night of December 4-5, snowfall was reported at Grant Grove (elevation 6,600 feet), and the snow level (elevation where precipitation changes from rain to snow) was at approximately 6,000 feet. With the northward movement of the front on December 6, the snow level lifted to 9,000 feet, a relatively high snow level.

The time distribution of precipitation for December 2 through December 6 is illustrated in Figure 2 by the hyetograph (plot of hourly precipitation) for the Exeter Fauver Ranch station, which is at an elevation of 439 feet. Precipitation amounts at other representative stations for the period December 2-7, 1966, are given in Table 4. It should be noted that the observation time is not the same for all stations listed in Table 4.

Precipitation totals for the period December 2-7 ranged from about three inches in the Tulare Lake area and six inches at the foothill line to 30 inches in the headwaters of the Kaweah and Tule River Basins. Heavy precipitation at high elevations, combined with the wet antecedent ground conditions resulting from the rain of December 2, produced very heavy runoff; severe flood conditions in Tulare County resulted.

Snow Accumulation 1967

The December 1966 storm was followed by another unusual event -- the rest of the winter season and the spring were characterized by a record accumulation of snow in the southern Sierra Nevada. Heavy deposition of snow came in March and April 1967 when a series of cold storms brought heavy precipitation to the higher elevations. Because of relatively cold spring temperatures, snowmelt did not begin until the middle of May.

To illustrate the magnitude of the snow accumulation, the April-July 1967 volume of runoff on the Kings River Basin was

194 percent of normal, Kaweah River Basin 231 percent of normal, Tule River Basin 291 percent of normal and Kern River Basin 214 percent of normal.

January 1969 Storm

The airflow pattern over the Pacific Ocean during January 1969 is typical of many which have resulted in severe storms. The flow of cold air coming fron Alaska curves out over the Pacific in a cyclonic arc to meet an extended current of warm, moist air originating in the region of the Hawaiian Islands. This flow enters California as a strong southwest or west-southwest current and is heavily laden with moisture. As the air currents sweep up over the Coast Ranges and the Sierra Nevada copious precipitation can be produced. The areas crossed by this strong air current receive the highest precipitation. In the December 1955 and December 1964 storms the main current entered Northern California; in the January 1969 storm it crossed Southern California. Satellite pictures of the January 1969 storm clearly show a band of clouds stretching out over the Pacific for a distance of 2,000 miles.

In 1969 this typical confluent flow pattern began on January 15. Precipitation came in two waves or concentrations separated by one day; the first covered the period January 18-22 and the second January 24-28. The total 10-day precipitation in Tulare County ranged from about five inches in the Corcoran area and 10 inches in the foothills to 45 inches in the High Sierra. The weather map (Figure 1) shows streamlines of airflow for the northern hemisphere at approximately 10,000 feet for the period January 15-31, 1969. The time distribution of precipitation for January 18-28, 1969, is illustrated by the hyetograph (Figure 2) for Exeter Fauver Ranch station. Amounts of precipitation at other representative stations, both recording and non-recording, are given in Table 5.

February 1969 Storm

During the period February 21-28, 1969, the flow pattern consisted of a series of fronts moving over California from the northwest. These storms were colder than the storms in January, with snow levels about 4,500 feet in the Kaweah and Tule River basins. The cold front of February 24 was the most intense, bringing 2.33 inches of precipitation at Exeter Fauver Ranch in the 24-hour period ending at midnight February 24. Rainfall was not confined to the passage of the front, but lingered after the front because of the primary low pressure center remaining off the northern California coast. The four-day precipitation totals for the February 23-26 period varied from about two inches in the Corcoran area and five inches in the foothills to 20 inches in the high Sierra.

The time distribution of precipitation for February 22-26, 1969, is presented for the Exeter Fauver Ranch station in the hyetograph on Figure 2. Amounts of precipitation at other representative stations are given in Table 6.

Snow Accumulation 1969

The snow level varied during the period January 18-28, 1969, but remained at fairly high elevations during the times of heavy precipitation. In the Kaweah River Basin the snow level was about 6,000 feet during January 18-22. The station at Grant Grove reported the heaviest accumulation of snow from 8 a.m. on the 21st to 8 a.m. on the 22nd -- about 13 inches. Then a cold front moving through the State in the early morning of January 22 brought a cold air mass in its wake, temporarily ending precipitation. A significant renewal of the confluent flow pattern occurred on January 24 and the resulting warm air flow over the southern Sierra Nevada once again brought the snow level in the Kaweah River Basin to 7,000 feet during January 24-28.

More snow accumulated in the Kings, Kaweah, Tule and Kern Basins during February and, to a lesser extent, March and the first half of April, bringing the snowpack to record depths, exceeding even those recorded in 1967. For example, the station at Farewell Gap (elevation 9,000 feet) in the Kaweah River Basin reported a snow water content of 67.7 inches on February 4, 102 inches on March 4, 99.3 inches on April 7, 88.9 inches on April 26, and 67.6 inches on May 28. The April 7 reading of 99.3 inches is over three times the April 1 normal of 31.7 inches.

In the snowmelt period, the month of April 1969 differed from April 1967 in that the former had nearly normal temperatures, allowing the 1969 snowpack to ripen earlier and start an earlier melt. The volume of runoff for the April-July 1969 period on the Kings River was 277 percent of normal, Kaweah River Basin 309 percent of normal, Tule River Basin 399 percent of normal, and Kern River Basin 415 percent of normal.

FLOOD RUNOFF

A thorough search was made to obtain all streamflow data in the Tulare County area for flood periods. Federal, State and local agencies were canvassed and engineers active in the area were contacted to be sure all available data were obtained. Particular emphasis was placed on obtaining flood data for the smaller drainage areas located between the Kings, Kaweah, Tule and Kern River watersheds. Table 7 is a summary of stream gaging stations in the area that are pertinent to this study. The location of these stations is shown on Plate I. Station histories for the foothill gaging stations are presented on page 39.

The specific data required for development of rain-flood hydrology for an area are principally instantaneous peak flows during flood periods and records of runoff at sufficiently short intervals of time during flood periods to define the time distribution of runoff. The time distribution of runoff may be plotted as a continuous curve of discharge versus time, producing a "hydrograph", which pictorially describes the flood event.

Every effort was made to obtain sufficient detail to delineate hydrographs of runoff for each major rain-flood event. For a variety of reasons, these efforts produced a limited amount of usable data. While many years of streamflow records were available for some streams, the data consisted of mean daily or mean monthly flows suitable for water supply analysis; detailed data for flood periods frequently were not available.

In some instances, extreme floods of December 1966 and January-February 1969 washed out or badly damaged stream gaging station equipment. Other stations which had been operated by the U.S. Bureau of Reclamation were discontinued in 1967 and thus no record was obtained during the 1969 flood events. However, immediately following the January-February 1969 floods, the staff of the U. S. Geological Survey, Water Resources Division, developed -- by accepted indirect methods -- estimates of peak flows for many foothill drainage areas in Tulare County. Table 8 contains a summary of available peak flow data for Tulare County and adjacent streams for December 1966, January-February 1969 and for the maximum previously recorded. Note that the peak discharge sites are identified on Plate I.

The only hydrographs available for foothill streams for the December 1966 flood are Sand Creek near Orange Cove (Figure 3), Cottonwood Creek above Highway 65 (69) (Figure 4), Dry (Limekiln) Creek near Lemoncove (Figure 5); and for the January-February 1969 floods, Sand Creek near Orange Cove (Figure 3), Deer Creek near Fountain Springs (Figure 6) and White River near Ducor (Figure 7).

Snowmelt floods are characterized by an increase in runoff over a period of days or weeks rather than hours as in a rain-flood and by relatively low peak flows and large volumes of runoff. The many years of stream flow records collected on the larger streams in Tulare County for water supply purposes provide an adequate record for hydrologic analysis of snow-flood runoff.

HYDROLOGIC ANALYSES

The development of the flood control concepts presented in the Flood Control Master Plan required that runoff amounts, both peak flow and volume, be developed for each foothill drainage area. In addition, precipitation intensity-duration-frequency analysis and procedures were developed for use in studying small drainage areas in the foothills and on the valley floor.

Peak Flow and Volume Analysis

Estimates of maximum flood peak discharge and volume to be expected for given frequencies or "return periods" are essential for hydrologic design purposes and economic analyses. "Return period" is defined as the average interval of time within which a flood of a given magnitude will be equalled or exceeded once. Because of the short period of available record, caution should be exercised in using frequency or return periods to describe a given historical flood or storm event.

The basic flood hydrology data available were inadequate for a rigorous solution of discharge frequencies at each required location by standard methods. Very few of the stations had continuous records for long-term frequency analysis. Most records consisted only of peak flows and stages for one or two major floods. In order to estimate flood peaks and 1-day, 2-day, 3-day and 5-day flood volumes for the many drainage areas affecting Tulare County, a regional flood frequency analysis technique, based upon procedures described in USGS Water Supply Papers 1543-A and 1687, Vol. 2, was utilized. The objective of a regional flood frequency analysis is to establish the relationship between normal annual precipitation and physical characteristics of drainage areas, so that estimates of flood runoff -- both peak and volume for given return periods for any watershed in the study area -- can be made.

The drainage areas for which some runoff records were available and which were used in this regional analysis are:

Station No. Shown on Plate I	Stream Flow Station
1	Kings River above North Fork nr. Trimmer
2	Kings River at Piedra
3	Mill Creek near Piedra
4	Sand Creek near Orange Cove
6	Dry Creek near Lemoncove
7	Dry (Limekiln) Creek near Mouth
9	Middle Fork Kaweah River nr. Potwisha Camp
10	Marble Fork Kaweah River nr. Potwisha Camp
17	North Fork of Middle Fork Tule River nr. Springville
20	Tule River near Porterville
22	South Fork Tule River near Success
24	Deer Creek nr. Fountain Springs (Kilbreth)
26	White River near Ducor
27	Kern River near Kernville

Review of the records for these stream flow stations indicate that the period 1943-69 could be used as a base for frequency evaluation. The period of record includes 1943, 1950, 1955, 1966 and 1969, all of which were years of major flooding. The frequency evaluation was based on the maximum annual peak discharge for each year of record. Many of the stream gaging stations did not have continuous records during the base period. As a result, it was necessary to establish an order of magnitude, since specific values could not be obtained. Data for individual stations were ranked by size of flood and plotted on semi-log paper against "return period". Return period (T_p) was computed as follows:

$$T_p = \frac{(\text{years of record } +1)}{\text{rank}}$$

Individual magnitude-frequency relationships for the stream flow stations were then used to develop a regional frequency relationship. First, non-dimensional curves for each drainage area relating the 25- and 50-year floods to an index flood were developed. These non-dimensional plots were compared and an average relationship between the index flood event and the 25- and 50-year flood event was established for the region. Index floods were also used to establish the relationship between flood events and the physical characteristics of the drainage areas.

Many factors enter into the relationship between flood peaks, volumes, and physical characteristics of the basin; however, with limited data it is only possible to utilize a few factors. After studies of basin characteristics it was determined that flood peaks could be most effectively related to drainage area, elevation, basin orientation and normal annual precipitation; flood volumes (maximum daily volume) could be most effectively related to drainage area and normal annual precipitation. The physical characteristics of the basins (area, elevation and orientation) were taken from 1:250,000 topographical maps and USGS quadrangle sheets. Normal annual precipitation was taken from the isohyetal map shown in Plates II and III. In the development of the relationships it was assumed that the peak flows would be channelized to the locations for which flow estimates were required.

The runoff relationships presented here were adjusted to conform to the long-term frequency characteristics of the area. As previously noted, the 1943-69 period contained five major flood events, which is an exceptionally high number of flood events compared to runoff records in the area dating back to 1897. A study was made to determine the relationship between the 1943-69 period and longer periods of record. A frequency plot for the period 1911-69 was made for the South Fork Tule River near Success. The 25- and 50-year floods for the long-term period appeared to be about 70 percent of the flood estimates developed from the 1943-69 data. Similar but smaller differences were noted on other drainage areas for which long-term records were available. Therefore, the ratios of the 25- and 50-year floods to the index flood were adjusted to 85 percent of the plotted values in order to make allowance for length of record in the study period.

Peak Flow and Flood Volume Relationships

The charts expressing the relationship for peak index flood discharges are shown in Figures 8 and 9. The nomograph in Figure 8 is used to obtain the peak index flood discharge for (a) areas greater than 10 square miles, regardless of normal annual precipitation amount and (b) for areas less than 10 square miles with normal annual precipitation amounts greater than 16 inches. The relationships in Figure 9 are used to obtain the peak index flood discharge for areas under 10 square miles with normal annual precipitation 16 inches or less.

Nomographs and curves providing estimates of 1-day, 2-day, 3-day and 5-day flood volume indexes are shown on Figures 10 and 11. Figure 10 is used to obtain the maximum 1-day index flood for (a) areas greater than 10 square miles, regardless of normal annual precipitation amounts and (b) for areas less than 10 square miles with normal annual precipitation amounts greater than 16 inches. Figure 11 is used to obtain the 2-day, 3-day and 5-day index floods.

The maximum 1-day flood volume for areas under 10 square miles with normal annual precipitation of 16 inches for less is obtained by multiplying the peak flows derived from Figure 9 by the following percentages:

Drainage Area Normal Annual Precipitation	Percentage of Peak Flow for 1:25 year	1:50 year
12" - 16"	18%	19%
10" - 12"	16%	17%
Less than 10"	13%	14%

Procedures for the application of the peak flow and flood volume relationships and examples are presented below.

Procedure to Estimate Peak Flows for:

(a) Drainage areas greater than 10 square miles, regardless of normal annual precipitation amount.

(b) Drainage areas less than 10 square miles with normal annual precipitation amounts greater than 16 inches.

1. Determine drainage area parameters:
   a. Drainage area in square miles.
   b. Orientation of the principal axis of drainage basin from headwaters to outlet (for basin orientation factor see Figure 8).
   c. Elevation index, computed as the mean elevation of two points, one at 10% and the other at 85% of the channel length measured from the outflow point of the basin.
   d. Normal annual precipitation from isohyetal map (Plates II and III).

2. Using the parameters developed in 1, determine the peak index flood factor from the nomograph in Figure 8.

3. Multiply this peak index flood factor by the factor selected from the basin orientation diagram on Figure 8 to obtain the peak index flood discharge value.

4. Multiply the peak index flood discharge value by the following values to estimate the magnitude of the 25-, 50- or 100-year occurrences:

Index Flood	25-year	50-year	100-year
Peak Flow	4.2	6.0	8.0

EXAMPLE

Determine peak flows at Sand Creek near Orange Cove for return periods of 25, 50 and 100 years.

1. Drainage area parameters:
   a. Drainage area = 31.6 sq. mi. (Table 1).
   b. Basin orientation factor = 1.2 (Figure 8).
   c. Elevation index = 1,050 feet
   d. Normal annual precipitation = 18.2 inches (Plates II and III - Table 1).

2. Peak index flood factor = 530 cfs. (Figure 8).

3. Peak index flood discharge:
   530 cfs x 1.2 = 636 cfs.

4. Sand Creek near Orange Cove peak flows:
   1:25 yr. peak flow = 636 cfs x 4.2 = 2,671 cfs.
   1:50 yr. peak flow = 636 cfs x 6.0 = 3,816 cfs.
   1:100 yr. peak flow = 636 cfs x 8.0 = 5,088 cfs.

Procedure to Estimate Peak Flows For Drainage Areas Less than 10 Square Miles with Normal Annual Precipitation 16 Inches or Less

1. Determine drainage area parameters:
   - a. Drainage area in square miles.
   - b. Normal annual precipitation, from isohyetal map (Plates II and III.

2. Using the parameters developed in 1, determine the peak index flood discharge from Figure 9.

3. Multiply the peak index flood discharge value by the following values to estimate the magnitude of the 25-and 50-year peak flood occurrence:

Index Flood	25-year	50-year
Peak Flow	4.2	6.0

EXAMPLE

Determine peak flows for Granite Hill Drainage at Friant-Kern Canal (Area 4) for return periods of 25 and 50 years.

1. Drainage area parameters:

   a. Drainage area = 3.6 sq. mi. (Table 1)

   b. Normal annual precipitation = 13.8 inches (Plates II and III - Table 1).

2. Peak index flood discharge = 90 cfs. (Figure 9)

3. Granite Hill Drainage at Friant-Kern Canal peak flows:

   1:25 yr. peak flow = 90 cfs x 4.2 = 378 cfs.

   1:50 yr. peak flow = 90 cfs x 6.0 = 540 cfs.

Procedure to Estimate 1-, 2-, 3-, and 5-Day Flood Volumes for:

(a) Drainage areas greater than 10 square miles, regardless of normal annual precipitation amounts, and

(b) Drainage areas less than 10 square miles with normal annual precipitation amounts greater 16 inches.

1. Determine drainage area parameters:
   a. Drainage area in square miles.
   b. Normal annual precipitation, from isohyetal map (Plates II and III).

2. Using the parameters developed in 1, determine the maximum 1-day index flood from the nomograph in Figure 10.

3. Using the maximum 1-day index flood value from 2, determine the 2-day index flood value, 3-day index flood value, and 5-day index flood value from Figure 11.

4. Multiply the 1-day and multiple-day index flood values by the following figures to estimate the magnitude of the 25-year and 50-year occurrence.

Index Flood	25-year	50-year
1-day	3.5	5.2
2-day	3.4	4.8
3-day	3.3	4.6
5-day	3.3	4.6

5. The 1-day and multiple-day flood values are total volumes expressed in second-foot days. To obtain the volumes in acre feet, multiply the second-foot day values by 1.98.

EXAMPLE

Determine 1-day, 2-day, 3-day and 5-day flood volumes for Sand Creek near Orange Cove for 25- and 50-year return periods.

1. Drainage area parameters:

   a. Drainage area = 31.6 sq. mi. (Table 1)
   b. Normal annual precipitation = 18.2 inches (Plates II and III - Table 1)

2. Maximum 1-day index flood = 205 second-foot days (sfd)(Figure 10).

3. Multiple-day index flood values (Figure 11)

   2-day index flood = 270 sfd
   3-day index flood = 330 sfd
   5-day index flood = 400 sfd

4. Sand Creek near Orange Cove flood volumes (second-foot days):

   1:25 Year Flood Volume

   1-day flood volume (205 sfd) (3.5) = 718 sfd
   2-day flood volume (270 sfd) (3.4) = 918 sfd
   3-day flood volume (330 sfd) (3.3) = 1089 sfd
   5-day flood volume (400 sfd) (3.3) = 1320 sfd

   1:50 Year Flood Volume

   1-day flood volume (205 sfd) (5.2) = 1066 sfd
   2-day flood volume (270 sfd) (4.8) = 1296 sfd
   3-day flood volume (330 sfd) (4.6) = 1518 sfd
   5-day flood volume (400 sfd) (4.6) = 1840 sfd

5. Sand Creek near Orange Cove flood volumes (acre feet):

Flood Volume

	1:25 year	1:50 year
1-day	1,420 af	2,110 af
2-day	1,820 af	2,560 af
3-day	2,160 af	3,000 af
5-day	2,620 af	3,640 af

Procedure to Estimate Flood Volumes for Areas Less than 10 Square Miles with Normal Annual Precipitation 16 Inches or Less

1. Determine peak flow for the required return periods by following procedure on page 28.
2. Multiply the peak flows by the following percentages to obtain the maximum 1-day flood volume:

Drainage Area Normal Annual Precipitation	Percentage of Peak Flow For 1:25 year	1:50 year
12"-16"	18%	19%
10"-12"	16%	17%
Less than 10"	13%	14%

3. Maximum 1-day flood volumes from 2 are expressed in second-foot days. To obtain the volumes in acre feet, multiply the second-foot day values by 1.98.

EXAMPLE

Determine the 1-day flood volumes for Granite Hill Drainage at Friant-Kern Canal for 25- and 50-year return periods.

1. Peak flows (page 29)

   1:25 year = 378 cfs

   1:50 year = 540 cfs

2. Granite Hill Drainage at Friant-Kern Canal maximum 1-day flood volumes (second foot days)
   (Normal annual precipitation = 13.8")

   1:25 year = (378 cfs)(0.18) = 68 sfd

   1:50 year = (540 cfs)(0.19) =102 sfd

3. Granite Hill Drainage at Friant-Kern Canal maximum 1-day flood volumes (acre feet).

   1:25 year = (68 sfd)(1.98) = 135 af

   1:50 year = (102 sfd)(1.98)= 202 af

Precipitation Intensity - Duration - Frequency Relationship

Relationships for estimating precipitation intensities (Figures 12 and 13) for return periods of 2 to 100 years and duration of ten minutes to six hours in areas of Tulare County below elevation 2,000 feet were developed from hydrologic analysis of available data and studies of the U. S. Weather Bureau and the California Department of Water Resources.

Precipitation amounts derived from the intensity-duration-frequency relationship represent maximum hour amounts (as distinguished from clock-hour amounts) and a partial duration series (as distinguished from an annual series). The maximum hour is the maximum 60-minute period, rather than the single maximum clock hour of the 24-hour day. A partial duration series represents all events during the period of record; an annual series represents only the maximum event of each year. Although the relationships were developed from clock-hour and annual series data, they were adjusted to maximum hour and partial duration series through procedures described in U. S. Weather Bureau Technical Bulletins 24, 25 and 28.

Although the intensity - duration - frequency relationship presented here can be applied to larger drainage areas, its primary function is in the determination of flood runoff from drainage areas less than one square mile in size.

Procedure to Estimate Precipitation Intensities at Any Location for Return Period of 2 to 100 Years and Durations of 10 Minutes to 6 Hours

1. Determine normal annual precipitation at the site from isohyetal map (Plates II or III).

2. Using Figure 12 and the normal annual precipitation from 1, determine the one-hour precipitation intensity for the desired return period.

3. Using Figure 13, determine the intensity factor for the desired duration using the normal annual precipitation amount from 1.

4. Multiply the one-hour precipitation intensity value by the intensity factor from 3. The product is the precipitation rate in inches per hour for the desired frequency and duration.

5. To obtain total precipitation in inches, multiply the precipitation rate (from 4) by the duration in hours.

EXAMPLE

Determine for a location adjacent to McKays Point control structure the total rainfall that would be expected to occur for a duration of 30 minutes (1/2 hour) on the average of once in 25 years.

1. Normal annual precipitation = 13.1 inches (Plates II or III).

2. One-hour precipitation intensity for return period of once in 25 years = 0.96 inches per hour (Figure 12).

3. Intensity factor for 30 minutes (1/2 hour) = 1.55 (Figure 13)

4. Precipitation rate that is expected to occur for 30 minutes on the average of once in 25 years = 0.96" x 1.55 = 1.49 inches per hour.

5. Total precipitation expected to occur in 30 minutes on the average of once in 25 years = 1.49 in./hr. x 1/2 hr. = 0.75 inches.

STREAM GAGING STATION HISTORIES

The following are station histories for foothill gaging stations in Tulare County shown on Plate I. The stream gaging station numbers are those listed in Table 7.

Sand Creek nr. Orange Cove (Stream Gaging Station No. 4)

Location: NW¼ Section 15, T15S, R25E, MDB&M, on right bank 3.8 miles east of Orange Cove.

Drainage area: 31.6 square miles

Record: Station was installed by USBR in 1943. USGS operated station and published record 1944-1954. USBR operated 1954-1967; unpublished records available in USBR files. From 1968 to 1971 recorder operated by Kaweah Delta Water Conservation District (KDWCD); however, no analysis made of record. USGS reactivated station in February 1971 under a cooperative agreement with Tulare County.

Cottonwood Creek above Highway 65 (69)(Stream Gaging Station No. 5)

Location: NE¼ Section 14, T16S, R26E, MDB&M, on right bank about one mile upstream from bridge on Highway 69 (formerly 65) over Cottonwood Creek.

Drainage area: 52.2 square miles.

Record: Station installed in 1956 by USBR. Unpublished 1956-1967 records available in USBR files. From 1968-1971 recorder operated by KDWCD; however, no analysis made of record. USGS relocated station to Highway 69 bridge over Cottonwood Creek in February 1971 under a cooperative program with Tulare County.

Dry Creek nr. Lemoncove (Stream Gaging Station No. 6a)

Location: SE¼ Section 15, T17S, R27E, MDB&M, on right bank 0.5 mile downstream from Bequette Canyon and 4.4 miles north of Lemoncove.

Drainage area: 75.6 square miles.

Record: Station installed at present location in 1969. Gage previously installed in 1959 in NW¼ Section 26, T17S, R27E (Station No. 6); drainage area 80.4 square miles. USGS operates station and publishes record.

Dry (Limekiln) Creek nr. Mouth (Stream Gaging Station No. 7)

Location: SW¼ Section 26, T17S, R27E, MDB&M, on right bank approximately 4,500 feet upstream from confluence with Kaweah River.

Drainage area: 82 square miles.

Record: Station installed in 1943 by USBR. Unpublished records are available in USBR files for 1943-1954.

Yokohl Creek East of Exeter (Stream Gaging Station No. 8)

Location: NW¼ Section 23, T19S, R27E, MDB&M, on left bank approximately 8 miles east of Exeter at a point 200 feet upstream from County bridge.

Drainage area: 75 square miles.

Record: Station installed in 1962 by USBR. Unpublished records available in USBR files. Station destroyed by flood runoff on December 6, 1966.

Deer Creek nr. Fountain Springs (Kilbreth) (Stream Gaging Station No. 24)

Location: NE¼ Section 10, T23S, R29E, MDB&M, on left bank 1.0 mile upstream from Pothole Creek, 6.3 miles northeast of Fountain Springs.

Drainage area: 83.3 square miles.1/

Record: Station installed in 1919 for Terra Bella Irrigation District. Operated and record maintained for water supply purposes by Althouse-Strauss Engineering Services (and predecessors) until 1966. Peak flow data not available during period 1919-1966; however, maximum 1943 peak estimated by Althouse. USGS reactivated station in 1968.

Deer Creek at Hungry Hollow (Stream Gaging Station No. 25)

Location: NW¼ Section 22, T22S, R28E, MDB&M, on left bank 5 miles east and 2 miles north of Terra Bella.

Drainage area: 124 square miles

Record: Station installed in 1962 by USBR. Unpublished records 1962-1967 available in USBR files.

White River nr. Ducor (Stream Gaging Station No. 26)

Location: NE¼ Section 27, T24S, R28E, MDB&M, on right bank 500 feet downstream from bridge at Gilliam Ranch, 3 miles downstream from Coho Creek and 8 miles southeast of Ducor.

Drainage area: 92.9 square miles.

Record: Station established by USGS in 1942. USGS operated station and published record 1942-1953. Station operated during 1954 by USBR; unpublished record available in USBR files. Operated by Delano-Earlimart Irrigation District 1954-1958; recorder charts available in District's files; however, no analysis made of record by District. Operated by USBR 1959-1967; unpublished records available in USBR files. USGS reactivated station in February 1971 under a cooperative agreement with Tulare County. New station located approximately 300 feet upstream from old station.

1/ 67.0 square miles published by USGS in 1967-68 -- corrected in 1968-69 WSP.

ABBREVIATIONS USED IN APPENDIX

DEID	Delano Earlimart Irrigation District
DWR	California Department of Water Resources
JGB	J. G. Boswell Co.
KDWCD	Kaweah Delta Water Conservation District
KRWA	Kings River Water Association
PC	Private Cooperators
SCE	Southern California Edison Company
SDF	State Division of Forestry
UCF	University of California Forestry, Berkeley
USBR	U. S. Bureau of Reclamation
USCE	U. S. Corps of Engineers
USFS	U. S. Forest Service
USGS	U. S. Geological Survey
USWB	U. S. Weather Bureau

TABLE NO. 1

DRAINAGE AREAS and NORMAL ANNUAL PRECIPITATION AMOUNTS

No. Shown on Plate No. I	Drainage Area Designation	Drainage Area (Sq.Mi.)	Normal Annual Precipitation (Inches)
1	Mill Creek nr. Piedra	127	24.7
2	Wahtoke Creek at Friant-Kern Canal (FK)	21.5	15.4
3	Citrus Cove Drainage at FK	8.3	14.3
4	Granite Hill Drainage at FK	3.6	13.8
5	Surprise Creek at FK	2.3	13.8
6	Hills Valley Creek at FK	10.7	15.6
7	Wooten Creek at FK	11.3	15.2
8	Orange Cove Drainage at FK	3.7	13.7
9	Sand Creek at FK	38.8	17.4
10	Sand Creek nr. Orange Cove	31.6	18.2
11	Curtis Mtn. Drainage at FK	1.0	13.2
12	Negro Creek at FK	5.3	14.1
13	Avenue 424 Drainage at FK	0.7	13.3
14	Long Creek at FK	11.2	15.4
15	Avenue 416 Drainage at FK	8.4	13.5
16	Stokes Mountain-West Drainage at FK	1.3	12.4
17	Stokes Mountain-South Drainage into FK	1.8	12.6
18	Stone Corral Canyon Drainage at FK	2.7	13.4
19	Road 180 Drainage at FK	1.0	13.4
20	Avenue 384 Drainage at FK	2.3	13.2
21	Colvin Mountain Drainage into FK	2.4	12.4
22	Cottonwood Creek at FK	88.1	18.4
23	Cottonwood Creek at Elderwood	83.4	18.8
24	Cottonwood Creek above Highway 65 (69)	52.2	20.9
25	Antelope Creek at Woodlake	20.7	14.3
26	Antelope Mountain-Woodlake Drainage at Bravo Lake	3.0	13.2
27	Dry Creek nr. Lemoncove	80.4 1/	23.4
28	Kaweah River at Terminus Dam	561	36.7
29	Mehrten Creek at Foothill Ditch	19.0	13.8
30	Yokohl Creek at Hamilton Ranch	70.6	17.5

1/ Station moved upstream 1969, drainage area 75.6 sq. mi.

TABLE NO. 1 (Continued)

DRAINAGE AREAS
and
NORMAL ANNUAL PRECIPITATION AMOUNTS

No. Shown on Plate No. I	Drainage Area Designation	Drain-age Area (Sq.Mi.)	Normal Annual Precip-itation (Inches)
31	Lewis Creek nr. Strathmore	18.3	15.9
32	Lewis Creek at Road 236	32.1	14.7
33	Frazier Creek 1/2 mile East of Road 256	18.1	12.9
34	Lewis Hill Drainage at Porterville	3.6	10.8
35	Rocky Hill Drainage at Porter Slough	7.9	11.6
36	Tule River at Success Dam	391	28.4
37	Deer Creek at Hungry Hollow	124	22.2
38	Deer Creek nr. Fountain Springs (Kilbreth)	83.3	25.7
39	Fountain Springs North Drainage at Deer Creek	19.3	11.1
40	Fountain Springs Gulch at Deer Creek	35.0	11.8
41	Terra Bella-Ducor Drainage at FK	16.9	9.4
42	Ducor East Drainage at SPRR	13.9	9.9
43	White River nr. Vestal	120	15.1
44	White River nr. Ducor	92.9	16.5
45	Orris East Drainage at SPRR	1.8	8.9
46	Vestal East Drainage at SPRR	7.8	8.8
47	Vestal Southeast Drainage at SPRR	2.6	8.3
48	Richgrove East Drainage at SPRR	28.4	9.0
49	Rag Gulch at SPRR	138	11.4
50	Rag Gulch nr. Villard Ranch	71.2	12.4

TABLE NO. 2

PRECIPITATION STATIONS

No. Shown on Plate No. II	Station Name	DWR Station No.	Source of Record	Period of Record	Elevation (Feet)	Normal Annual Precipitation 1911-60 (Inches)	Normal Annual Precipitation 1911-70 (Inches)
		TULARE COUNTY					
1	Angiola	C0204	USWB	1899-	205	7.17	7.36
2	Ash Mountain	C0343	USWB	1925-	1708	25.2	25.4
3	Atwell	C0374	USWB	1948-	6400	38.0	
4	Badger	C0422	USWB	1940-	3030	25.5	
5	Beartrap Meadow	C0596	USWB	1959-	6800	47.7	
6	California Hot Springs R.S.	C1300	USWB	1907-1965	2950	23.5	
7	Camp Nelson	C1425	PC	1959-	4825	25.9	
8	Camp Wishon	C1470	USWB	1940-1961	3800	33.6	
9	Chagoopa	C1647	USCE	1964-	10390	-	
10	Crabtree Meadow	C2114	USWB	1948-	720	21.7	
11	Deer Creek Ranch	C2335	PC	1968-1969	950	-	
12	Dinuba	C2440	USWB	1893-1945	330	11.1	
13	Dinuba Alta I.D.	C2440	PC	1944-	334	10.7	
14	Doublebunk Meadow	C2492	USWB	1955-	6200	35.8	
15	Eagle Creek	C2591	USCE	1964-	6650	36.0	
16	East Vidette Meadow	C2653	USWB	1955-1964	400	20.8	
17	Exeter	C2921	USWB	1897-1929	391	-	
18	Exeter Fauver Ranch	C2922	USWB	1938-	439	11.2	
19	Fountain Springs F.S.	C3207	SDF	1965-	800	-	
20	Giant Forest	C3397	USWB	1921-	6412	42.4	

TABLE NO. 2 (Continued)

PRECIPITATION STATIONS

No. Shown on Plate No. II	Station Name	DWR Station No.	Source of Record	Period of Record	Elevation (Feet)	Normal Annual Precipitation 1911-60 (Inches)	Normal Annual Precipitation 1911-70 (Inches)
21	Goshen SPRR	C3514	USWB	1897-1918	286	-	
22	Grant Grove	C3551	USWB	1924-	6580	41.9	42.3
23	Hills Orchard	C3979	PC	1924-1948	700	-	
24	Hockett Meadows	C4012	USWB	1959-	8500	-	
25	Hossack	C4120	USWB	1959-	7100	40.1	
26	Ivanhoe I.D.	C4312	PC	1954-	370	-	
27	Johnsondale	C4389	USWB	1954-	4680	23.5	
28	Kaweah PH 3	C4452	SCE	1913-	1370	24.9	
29	Kern River Intake #3	C4518	USWB	1952-1966	3650	18.2	
30	Kern River Intake #3 SCE	C4519	SCE	1921-	3642	17.3	
31	Lemoncove	C4890	USWB	1899-	513	13.68	13.72
32	Lindsay	C4957	USWB	1913-	395	10.9	11.0
33	Lindsay Gov't. Camp	C4957	USBR	1952-1954	-	-	
34	Lodgepole	C5026	USWB	1968-	6735	-	
35	Lodgepole R.S.	C5028	USWB	1951-1956	6695	38.8	
36	Milo	C5668	USWB	1898-1922	1600	-	
37	Milo 5 NE	C5669	USWB	1957-	3400	28.7	
38	Mineral King	C5680	USWB	1956-1969	7975	32.6	
39	Monache Meadows	C5770	USWB	1940-	8000	14.5	
40	Moraine Creek	C5832	USBR	1964-	8840	24.3	
41	Mountain Home	C5883	USWB	1897-1911	6680	-	
42	Mountain Home 2	C5887	USCE	1962-	5360	-	
43	Old Porter Ranch	C6413	USWB	1947-1955	6470	8.3	
44	Pear Lake	C6767	USWB	1956-1969	9700	40.0	
45	Porterville R.S.	C7076	SDF	1945-1952	455	-	

TABLE NO. 2 (Continued)

PRECIPITATION STATIONS

No. Shown on Plate No. II	Station Name	DWR Station No.	Source of Record	Period of Record	Elevation (Feet)	Normal Annual Precipitation 1911-60 (Inches)	Normal Annual Precipitation 1911-70 (Inches)
46	Porterville	C7077	USWB	1893-	393	10.39	10.52
47	Porterville F.S.	C7078	SDF	1945-1952	455	-	
48	Porterville 3W	C7079	PC	1958-	413	8.3	
49	Portuguese Meadow	C7093	USWB	1953-	7000	44.2	
50	Portuguese Pass	C7094	USWB	1948-1953	7300	29.4	
51	Posey 4 ENE	C7095	USWB	1960-1962	5490	-	
52	Posey 3E	C7096	USWB	1954-	4920	29.0	
53	Quaking Aspen	C7179	USWB	1955-	7200	38.4	
54	Quinn R.S.	C7205	USWB	1948-1959	8300	35.0	
55	Rector	C7288	SCE	1888-	344	9.88	
56	Rogers Camp	C7529	USCE	1964-	6240	-	
57	Round Meadow	C7579	USWB	1947-	9000	36.5	
58	Sierra Vista Ranch	C8220	PC	1926-1948	404	-	
59	Springville	C8451	PC	1924-1944	4050	16.5	
60	Springville 3 ENE	C8453	USWB	1951-1953	1460	16.1	
61	Springville 7 ENE	C8455	USWB	1953-	2470	27.6	27.9
62	Springville R.S.	C8460	USWB	1924-	1050	18.2	
63	Springville Tule HDW	C8463	USWB	1907-	4070	35.79	
64	Stevenson Dist.Sec. 33	C8520	JGB	1951-1969	212	7.5	
65	Success Dam	C8620	USCE	1959-	590	14.0	
66	Success	C8622	USWB	1923-1928	600	-	
67	Taylor Meadow	C8790	USWB	1948-1955	7000	19.6	
68	Terminus Dam	C8868	USCE	1959-	965	-	
69	Terra Bella	C8876	PC	1924-1947	490	9.6	
70	Terra Bella 1E	C8876	PC	1919-1958	-	9.3	

TABLE NO. 2 (Continued)

PRECIPITATION STATIONS

No. Shown on Plate No. II	Station Name	DWR Station No.	Source of Record	Period of Record	Elevation (Feet)	Normal Annual Precipitation 1911-60 (Inches)	Normal Annual Precipitation 1911-70 (Inches)
71	Terra Bella 5E	C8876	PC	1955-1958	-	12.3	
72	Three Rivers 6SE	C8912	USWB	1940-	2200	18.6	
73	Three Rivers PH #2	C8914	USWB	1909-	950	19.71	
74	Three Rivers PH #1	C8917	USWB	1940-	1140	19.9	
75	Traver SPRR	C9011	USWB	1885-1909	291	-	
76	Traver 4 ESE	C9011	DWR	1962-1965	283	-	
77	Trout Meadows	C9038	USWB	1948-1955	6250	18.8	
78	Tulare	C9051	SCE	1919-	293	9.1	
79	Tulare Tuohy	C9051	USWB	1874-1914	285	-	
80	Tulare Near	C9051	USWB	1893-1909	274	-	
81	Tulare SP Co	C9051	USWB	1906-1918	285	-	
82	Tulare Evap	C9051	USBR	1903-1905	287	-	
83	Tule River Intake	C9059	SCE	1910-	2450	26.0	
84	Tule River PH	C9060	SCE	1910-	1240	19.86	
85	Tunnel R.S.	C9061	USWB	1945-	8950	18.4	
86	Uhl R.S.	C9120	USWB	1965-	3680	-	
87	Vandalia I.D.	C9257	PC	1925-1959	-	11.2	
88	Vestal	C9304	SCE	1920-	500	8.1	
89	Visalia	C9367	USWB	1903-	354	9.40	9.46
90	Visalia 4E	C9369	PC	1959-	357	-	
91	Wet Meadow	C9602	USWB	1959-	8950	36.6	
92	Whitaker Forest	C9629	UCF	1966-	5360	-	
93	Windy Springs	C9731	PC	1929-1934	6500	10.4	

TABLE NO. 2 (Continued)

PRECIPITATION STATIONS

No. Shown on Plate No. II	Station Name	DWR Station No.	Source of Record	Period of Record	Elevation (Feet)	Normal Annual Precipitation 1911-60 (Inches)	Normal Annual Precipitation 1911-70 (Inches)
		FRESNO COUNTY					
94	Balch Powerhouse	C0449	USWB	1921-	1720	29.8	30.1
95	Benner Ranch	C0676	PC	1967-	3525	-	
96	Dunlap	C2557	USWB	1937-1955	1940	21.6	
97	Dunlap near	C2558	USWB	1911-1917	2800	26.0	
98	Five Points 5 SSW	C3083	USWB	1942-	276	6.4	6.5
99	Fresno WB AP	C3257	USWB	1899-	331	10.9	10.9
100	Kingsburg	C4564	USWB	1879-1918	301	-	
101	Miramonte Honor Camp	C5708	USWB	1958-	3005	23.4	
102	Orange Cove	C6476	USWB	1931-	431	12.9	12.9
103	Pine Flat Dam	C6896	USCE	1949-	615	18.7	18.7
104	Pinehurst	C6902	USFS	1954-	4050	31.9	
105	Reedley MVFD	C7354	PC	1962-	345	-	
106	Reedley SJVRR	C7355	USWB	1899-1923	347	11.5	
107	Sanger SPRR	C7800	USWB	1889-1918	371	10.6	
108	Sanger 1 NE	C7800	PC	1959-	375	-	
109	Sanger R.S.	C7800	SDF	1958-	375	-	
110	Schafer Ranch	C8036	PC	1959-1961	365	10.1	
111	Selma	C8086	USWB	1886-1918	311	9.2	
112	Westhaven	C9560	USWB	1925-	285	6.6	6.6

TABLE NO. 2 (Continued)

PRECIPITATION STATIONS

No. Shown on Plate No. II	Station Name	DWR Station No.	Source of Record	Period of Record	Elevation (Feet)	Normal Annual Precipitation 1911-60 (Inches)	Normal Annual Precipitation 1911-70 (Inches)
	KINGS COUNTY						
113	Corcoran	C2009	USWB	1940-1956	200	6.8	
114	Corcoran I.D.	C2012	USWB	1912-	200	6.8	6.8
115	Hanford	C3747	USWB	1899-	242	8.01	8.04
116	Hanford Refinery	C3749	PC	1964-	245	-	
117	Homeland Dist. Sec. 9	C4061	JGB	1952-	190	7.6	
118	Homeland Dist. Sec. 17	C4061	JGB	1952-1964	206	7.1	
119	Homeland Dist. Sec. 34	C4061	JGB	1951-1969	196	6.6	
120	Kingsburg 5S No. 1	C4564	DWR	1957-1958	276	-	
121	Kingsburg 5S No. 2	C4564	DWR	1958-1962	277	8.6	
122	Kingsburg near	C4564	USWB	1928-1932	309	8.6	
123	South Lake Farms Hdqtrs.	C8407	PC	1959	190	7.2	
	KERN COUNTY						
124	Delano	C2346	USWB	1876-	323	7.8	7.7
125	Glennville	C3463	USWB	1951-	3140	17.2	17.3
126	Kern River PH No. 3	C4523	USWB	1946-	2703	12.4	12.7
127	Wasco	C9452	USWB	1899-	333	6.32	6.43
128	Wofford Heights	C9754	USWB	1894-	2700	10.7	10.9

TABLE NO. 3

SNOW COURSES AND AERIAL MARKERS

No. Shown on Plate No. II	Station Name	Calif. No.	Period of Record	Elevation (Feet)	Average April 1 Water Content (Inches)
	KINGS RIVER DRAINAGE				
1	Charlotte Ridge	299 1/	1955-	10,700	35.1
2	Bullfrog Lake	307	1932-	10,650	33.5
3	State Lakes 2/	545 1/	1956-	10,300	
4	Copper Creek Summit	001	1931-1936	10,200	
5	Granite Basin	546	1953-	10,000	
6	Mitchell Meadow 2/	511 1/	1956-	9,900	
7	Scenic Meadow	512	1953-	9,650	
8	Vidette Meadow	309	1956-	9,500	21.8
9	Rowell Meadow	226 1/	1930-	8,850	27.5
10	Moraine Meadows	002	1929-1942	8,400	
11	Junction Meadow	231	1930-1963	8,250	17.8
12	Kennedy Meadow	003	1929-1942	7,600	
13	Big Meadows	236	1930-	7,600	25.9
14	Horse Corral Meadow	237 1/	1930-	7,600	17.6
15	Grant Grove	240	1930-	6,600	14.6

1/ Aerial snow depth marker located on or near course.

2/ Radio reporting gage.

TABLE NO. 3 (Continued)

SNOW COURSES AND AERIAL MARKERS

No. Shown on Plate No.II	Station Name	Calif. No.	Period of Record	Elevation (Feet)	Average April 1 Water Content (Inches)
	KAWEAH RIVER DRAINAGE				
16	White Chief	374	1970-	9,200	
17	Farewell Gap	292	1952-	9,000	35.9
18	Panther Meadow	243	1925-	8,600	36.8
19	Hockett Meadows	244	1930-	8,500	29.0
20	Mineral King	245	1948-	8,000	21.3
21	Giant Forest	568 1/	1970-	6,650	
22	Giant Forest 2/	246	1930-	6,400	16.6
	TULE RIVER DRAINAGE				
23	Quaking Aspen	247	1937-	7,000	13.3
24	Old Enterprise Mill	248	1937-	6,600	16.4
	DEER CREEK DRAINAGE				
25	Dead Horse Meadow	249	1937-	7,300	12.6
	KERN RIVER DRAINAGE				
26	Upper Tyndall Creek 2/	516 1/	1957-	11,450	
27	Bighorn Plateau	250 1/	1949-	11,350	23.4
28	Cottonwood Pass	251 1/	1948-	11,050	14.1
29	Siberian Pass	252 1/	1948-	10,900	18.9
30	Crabtree Meadow	253 1/	1949-	10,700	19.8

TABLE NO. 3 (Continued)

SNOW COURSES AND AERIAL MARKERS

No. Shown on Plate No.	Station Name	Calif. No.	Period of Record	Elevation (Feet)	Average April 1 Water Content (Inches)
	KERN RIVER (Continued)				
31	Guyot Flat	254 1/	1949-	10,650	21.0
32	Sandy Meadows	275 1/	1949-	10,650	19.0
33	Tyndall Creek	255 1/	1949-	10,650	18.9
34	Shotgun Pass	517	1959-	10,400	
35	Chagoopa Plateau	514	1953-	10,300	
36	Big Whitney Meadow	257 1/	1948-	9,750	17.6
37	Rock Creek	256 1/	1949-	9,600	17.7
38	Round Meadow 2/	258 1/	1930-	9,000	25.6
39	Wet Meadow 2/	518 1/	1957-	8,950	
40	Ramshaw Meadows	259 1/	1930-	8,700	11.5
41	Little Whitney Meadow	260 1/	1930-	8,500	14.0
42	Casa Vieja Meadows	262 1/	1930-	8,400	19.7
43	Quinn Ranger Station	264 1/	1930-	8,350	20.4
44	Bonita Meadows	261 1/	1930-	8,300	14.3
45	Monache Meadows	263 1/	1931-	8,000	7.9
46	Beach Meadows	265 1/	1930-	7,650	9.5
47	Cannel Meadows	004	1929-1944	7,500	
	OWENS RIVER DRAINAGE				
48	Kearsarge Pass	539	1954-	11,300	
49	Cottonwood Lakes	541	1954-	11,200	
50	Cottonwood Lakes 2	220	1926-	11,100	12.5

TABLE NO. 4

DAILY PRECIPITATION AMOUNTS
(Inches)

December 1966 Storm

No. Shown on Plate No.II	Station Name	Elevation (Feet)	Observation Time	Date 2	3	4	5	6	7	Storm Total
114	Corcoran I. D.	200	8 AM	.01	.70		.24	1.20	.80	2.95
89	Visalia	354	8 AM							1/
46	Porterville	393	8 AM	.03	.73		.50	2.34	1.95	5.55
32	Lindsay	395	7 PM	.13	.68	.13	1.00	3.57		5.51
102	Orange Cove	431	10 AM	.18	.99		1.25	2.62	.33	5.37
18	Exeter Fauver Ranch	439	Mid	.72		.24	2.09	1.90		4.95
31	Lemoncove	513	5 PM	.24	.51	.06	2.20	3.14		6.15
73	Three Rivers PH #2	950	2 PM	.34	1.41		2.03	7.90	.17	11.85
62	Springville R.S.	1050	Mid	1.66	.02	.21	5.04	3.85		10.78
74	Three Rivers PH #1	1140	Mid	1.65	.17	.59	5.69	4.06		12.16
72	Three Rivers 6SE	2200	Mid	1.46	.01	.35	5.84	5.05		12.71
4	Badger	3030	Mid	2.63	.18	.62	5.27	3.78	.05	12.53
63	Springville Tule HDW	4070	Mid	3.11	.38	1.38	1/	1/	1/	1/
52	Posey 3E	4920	7 AM	.21	1.60	3.22	6.89	3.53		15.45

1/ Missing record.

TABLE NO. 5

DAILY PRECIPITATION AMOUNTS
(Inches)
January 1969 Storm

No. Shown on Plate No.II	Station Name	Elevation (Feet)	Observation Time	Date 18	19	20	21	22	23	24	25	26	27	28	29	Storm Total
114	Corcoran I.D.	200	8 AM		.36	1.93	.63	.05		.26	1.02	.22	.08			4.55
89	Visalia	354	8 AM		.84	2.16	.72	.69		.10	1.42	.12	.02		.20	6.27
46	Porterville	393	8 AM		.97	1.82	1.02	.18	T	.18	1.55	.27	.16	.02	.64	6.81
32	Lindsay	395	7 PM	.40	2.47	.24	.94	.07	.05	.37	1.20	.26	.18	.20	.21	6.59
102	Orange Cove	431	10 AM		1.65	1.73	1.16	.91	.01	.28	1.75	.38	.04	.14	.16	8.21
18	Exeter Fauver Ranch	439	Mid	.99	2.40	.34	1.36		.03	.65	1.66	.35		.33		8.11
31	Lemoncove	513	5 PM	.54	2.90	.40	1.15	.65		.40	1.74	.47	.05	.28	.06	8.64
73	Three Rivers PH #2	950	2 PM	.05	4.93	1.42	1.49	1.05		.56	3.23	1.19	.04	.51	.25	14.72
62	Springville R.S.	1050	Mid	1.42	2.22	.34	1.08	.02	.07	.98	1.37	.53	.03	.70		8.76
74	Three Rivers PH #1	1140	Mid	2.73	3.44	.46	1.65	.38	.10	1.75	2.15	1.04	.07	.68		14.45
72	Three Rivers 6SE	2200	Mid	1.53	2.92	.39	2.16	.26	1/	1/	3.55	1.21	.06	.49	.03	12.60
4	Badger	3030	Mid	3.10	5.47	1.01	3.44	.76	.10	2.26	2.73	.89	.03	.93	.03	20.75
63	Springville Tule HDW	4070	Mid	3.03	4.71	1/	1/	1/	1/	1/	5.28	.90	.35	1.31		15.58
52	Posey 3E	4920	7 AM		2.62	2.00	.83	1.02	.16	.90	3.00	1.35	.72	.20	1.20	14.00

1/ Amount included in following measurement.

TABLE NO. 6

DAILY PRECIPITATION AMOUNTS
(Inches)
February 1969 Storm

No. Shown on Plate No.II	Station Name	Elevation (Feet)	Observation Time	Date 23	24	25	26	Storm Total
114	Corcoran I.D.	200	8 AM	.30	.04	1.50	.27	2.11
89	Visalia	354	8 AM	.19	.27	2.08	.11	2.65
46	Porterville	393	8 AM	.27	.19	2.72	.11	3.29
32	Lindsay	395	7 PM	.31	1.03	1.66	.09	3.09
102	Orange Cove	431	10 AM	.29	.59	2.43	.12	3.43
18	Exeter Fauver Ranch	439	Mid	.34	2.33	.40	.07	3.14
31	Lemoncove	513	5 PM	.39	1.33	1.85	.14	3.71
73	Three Rivers PH #2	950	2 PM	.44	.88	3.30	.38	5.00
62	Springville R.S.	1050	Mid	.65	2.62	.80	.31	4.38
74	Three Rivers PH #1	1140	Mid	.51	3.49	.61	.33	4.94
72	Three Rivers 6SE	2200	Mid	.46	3.54	.65	.27	4.92
4	Badger	3030	Mid	.77	1/	4.96	.26	5.99
63	Springville Tule HDW	4070	Mid	2/	4.00	.95	.44	5.39
52	Posey 3E	4920	7 AM	.22	1.25	3.63	.47	5.57

1/ Amount included in following measurement.
2/ Missing record.

TABLE NO. 7

STREAM GAGING STATIONS

No. Shown on Plate No. I	Station Name	Station No.	Source of Record	Period of Record	Drainage Area (Sq.Mi.)
1	Kings River above North Fork nr. Trimmer	11-2135	USGS	1931	952
2	Kings River at Piedra 1/	11-2220	USGS	1895-1959	1687
3	Mill Creek near Piedra		KRWA	1938-1960	127
		11-2217	USGS	1957-	
4	Sand Creek near Orange Cove	11-2120	USGS	1944-1954	31.6
			USBR 2/	1954-1967	
			KDWCD 2/	1968-1971	
		11-2120	USGS	1971-	
5	Cottonwood Creek above Hwy 65 (69)	-	USBR 2/	1956-1967	52.2
			KDWCD 2/	1968-1971	
5a	Cottonwood Creek nr. Elderwood	11-2117.9	USGS	1971-	60.4
6	Dry Creek nr. Lemoncove	11-2113	USGS	1959-1969	80.4
6a	Dry Creek nr. Lemoncove	11-2113	USGS	1969-	75.6
7	Dry (Limekiln) Creek nr. mouth	-	USBR 2/	1943-1954	82
8	Yokohl Creek east of Exeter	-	USBR 2/	1963-1966	75
9	Middle Fork Kaweah River nr. Potwisha Camp	11-2065	USGS	1949-	102
10	Marble Fork Kaweah River nr. Potwisha Camp	11-2080	USGS	1950-	51.4
11	East Fork Kaweah River nr. Three Rivers	11-2087.3	USGS	1952-	85.8
12	North Fork Kaweah River at Kaweah	11-2095	USGS	1910-1960 3/	128
13	Kaweah River at Three Rivers	11-2099	USGS	1958-	418
14	South Fork Kaweah River at Three Rivers	11-2101	USGS	1958-	86.7
15	Kaweah River nr. Three Rivers	11-2105	USGS	1903-1961	520

1/ Prior to Oct. 1, 1924, published as "near Sanger."

2/ Unpublished - records available in agency office.

3/ Operated as Crest gage 1966-67

TABLE NO. 7 (Continued)

STREAM GAGING STATIONS

No. Shown on Plate No. I	Station Name	Station No.	Source of Record	Period of Record	Drainage Area (Sq.Mi.)
16	Kaweah River Below Terminus Dam	11-2109.5	USGS	1961-	561
17	North Fork of Middle Fork Tule River nr. Springville	11-2020	USGS	1939-	39.5
18	North Fork Tule River at Springville	11-2031	USGS	1957-1966	97.9
19	Tule River nr. Springville	11-2032	USGS	1957-	229
20	Tule River nr. Porterville	11-2035	USGS	1901-1960	261
21	Tule River below Porterville	CO3169	DWR	1957-	-
22	South Fork Tule River nr. Success	11-2045	USGS	1930-	109
23	Tule River below Success Dam 4/	11-2049	USGS	1953-	393
24	Deer Creek nr. Fountain Springs (Kilbreth)		TBID	1919-1966	83.3
		11-2008	USGS	1968-	83.3
25	Deer Creek at Hungry Hollow	-	USBR 2/	1962-1967	124
26	White River nr. Ducor	11-1995	USGS	1942-1953	92.9
			USBR 2/	1954	
			DEID 2/	1955-1958	
			USBR 2/	1959-1967	
			DEID 2/	1968-1969	
		11-1995	USGS	1971	
27	Kern River nr. Kernville	11-1860	USGS	1912-	846
28	Poso Creek nr. Oildale	11-1978	USGS	1959-	230
29	Cross Creek below Lakeland Canal No. 2	CO2602	DWR	1921-	-
30	Tulare Lake	CO3110	DWR	1937-	-

4/ Prior to Oct. 1960, published as "at Worth Bridge nr. Porterville."

TABLE NO. 8

PEAK DISCHARGE

No. Shown on Plate No. I	Location	Station No.	Dec. 1966 Date	Dec. 1966 cfs.	Jan.-Feb. 1969 Date	Jan.-Feb. 1969 cfs.	Max. Previous Date	Max. Previous cfs.
3	Mill Creek nr. Piedra	11-2217	6	11,000	1/25	9,860	12/23/55	6,000
					2/24	9,030		
31	Wahtoke Creek nr. Centerville				2/24	1,760		
32	Travers Creek nr. Reedley				2/24	1,130		
33	Wooten Creek nr. Orange Cove				2/24	264		
4	Sand Creek nr. Orange Cove	11-2120	6	2,100	1/25	2,900	12/23/55	1,320
					2/24	3,520		
34	Cottonwood Creek at Elderwood		6	4,650	2/24	4,670		
5	Cottonwood Creek above Hwy.65 (69)		6	5,700			3/ 3/58	2,460
35	Antelope Creek at Woodlake				2/24	1,050		
6	Dry Creek nr. Lemoncove	11-2113	6	14,500	1/25	5,710	12/23/55	6,070
					2/24	5,120		
9	Middle Fork Kaweah River nr. Potwisha Camp	11-2065	6	23,300	1/25	6,580	12/23/55	46,800
					2/24	1,270		
10	Marble Fork Kaweah River at Potwisha Camp	11-2080	6	6,400	1/25	2,610	12/23/55	12,500
					2/24	200		
11	East Fork Kaweah River nr. Three Rivers	11-2087.3	6	13,000	1/25	4,700	2/ 1/63	2,850
					2/24	1,590		
12	North Fork Kaweah River at Kaweah	11-2095	6	23,900			12/23/55	21,500
13	Kaweah River at Three Rivers	11-2099	5	73,000	1/25	24,200	12/23/55	71,000
					2/24	11,900		
14	South Fork Kaweah River at Three Rivers	11-2101	6	11,600	1/25	5,960	12/23/55	10,000
					2/24	6,360		
15	Kaweah River nr. Three Rivers	11-2105					12/23/55	80,700

Rev. 12/9/71

TABLE NO. 8 (Continued)

PEAK DISCHARGE

No. Shown on Plate No. I	Location	Station No.	Date and Peak Discharge Dec. 1966 Date	cfs.	Jan.-Feb. 1969 Date	cfs.	Max. Previous Date	cfs.
16	Kaweah River below Terminus Dam	11-2109.5	8	5,740	1/30	4,250	1/31/63	5,080
36	Yokohl Creek nr. Exeter		5	3,400				
37	Lewis Creek nr. Strathmore				2/24	1,480		
38	Lewis Creek nr. Lindsay		6	1,900				
17	North Fork of Middle Fork Tule River nr. Springville	11-2020	6	16,900	1/25	5,080	12/23/55	12,400
18	North Fork Tule River at Springville	11-2031	5	24,200			1/31/63	4,600
19	Tule River nr. Springville	11-2032	6	49,600 1/	1/25	17,300	4/ 3/58	3,400
20	Tule River nr. Porterville	11-2035					11/19/50	25,500
22	South Fork Tule River nr. Success	11-2045	6	14,300	1/25	5,280	11/19/50	7,100
					2/24	4,720		
23	Tule River below Success Dam	11-2049	6	9,050	1/29	2,540	12/23/55	27,000 2/
					2/27	3,210	11/19/50	32,000 2/ 3/
21	Tule River below Porterville	CO 3169	7	8,850	1/27	2,034 4/	5/19/57	5,170
					2/27	2,904 4/		
24	Deer Creek nr. Fountain Springs (Kilbreth)	11-2008	6	5,330	1/25	2,510	3/ 9/43	8,000
					2/24	3,340		
25	Deer Creek at Hungry Hollow		6	6,050				
39	Deer Creek at Trenton Weir		6	3,500				
40	Coho Creek nr. White River		6	221	1/25	155		
					2/24	564		

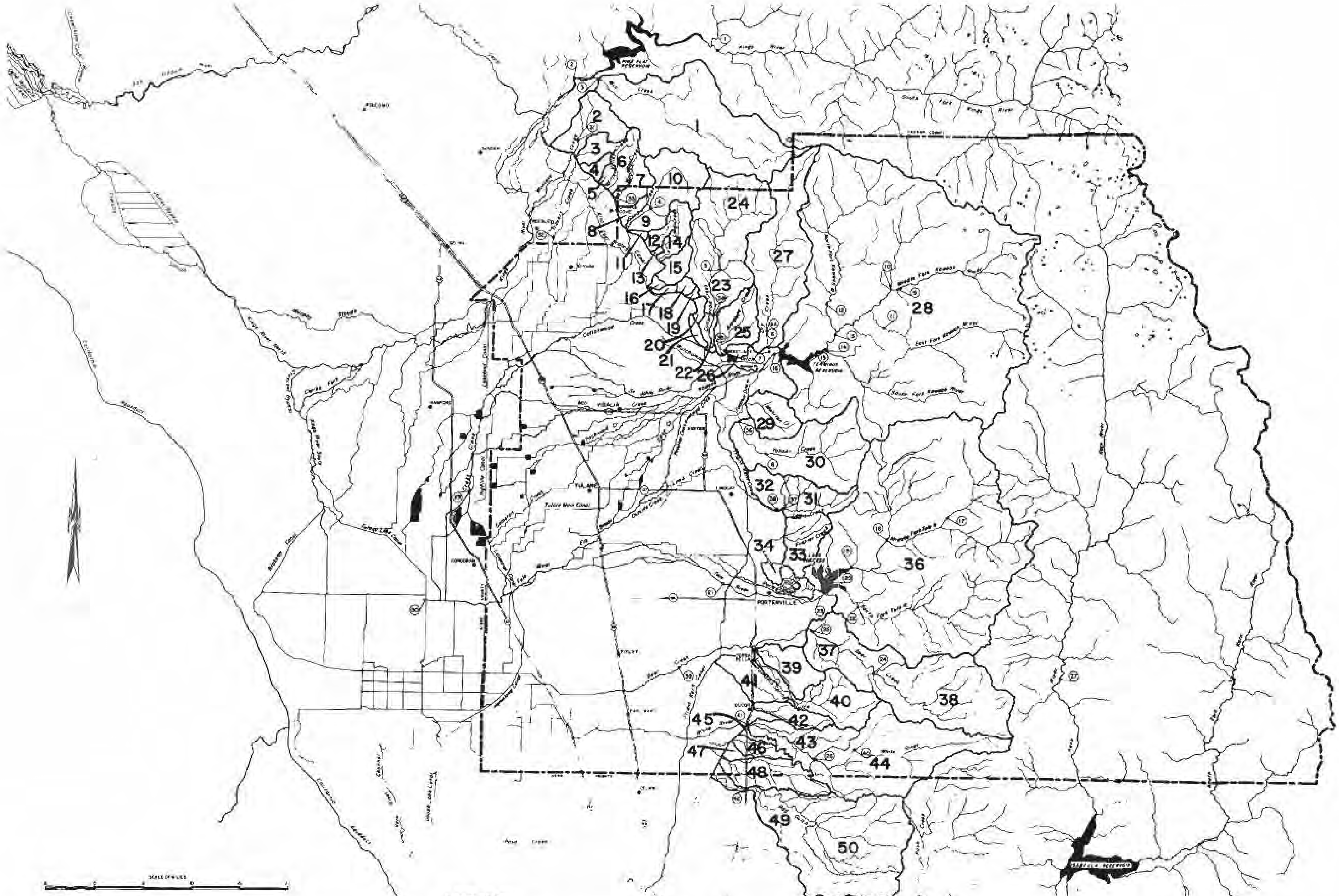
1/ At site 1.9 miles upstream.
2/ Prior to regulation by Lake Success
3/ At previous site.
4/ Mean Daily Discharge.

TABLE NO. 8 (Continued)

PEAK DISCHARGE

No. Shown on Plate No. I	Location	Station No.	Dec. 1966 Date	Dec. 1966 cfs.	Jan. - Feb. 1969 Date	Jan. - Feb. 1969 cfs.	Max. Previous Date	Max. Previous cfs.
26	White River nr. Ducor	11-1995	6	1,204			3/ 9/43	2,300
41	White River nr. Vestal				2/24	4,560		
42	Rag Gulch nr. Richgrove				2/24	2,240		
28	Poso Creek nr. Oildale	11-1978	6	4,300	1/25	3,020	4/ 4/58	2,750
					2/25	6,700		
29	Cross Creek below Lakeland Canal No. 2	CO 2602	14	1,250 4/	1/29	2,625 4/	12/27/55	2,070 4/
					2/27	4,030 4/		

			Maximum Daily Gage Height 1966-67		1968-69		1940-41	
30	Tulare Lake	CO 3110	5/22	183.58	6/24	192.50	6/28	196.8



LEGEND:

- (29) → NO. 1 - 30, STREAM GAGING STATIONS (TABLE NO. 7)
- (42) → NO. 31-42, PEAK DISCHARGE SITES (TABLE NO. 8)
- (35) DRAINAGE AREAS (TABLE NO. 1)

MURRAY, BURNS AND KIENLEN — CONSULTING CIVIL ENGINEERS

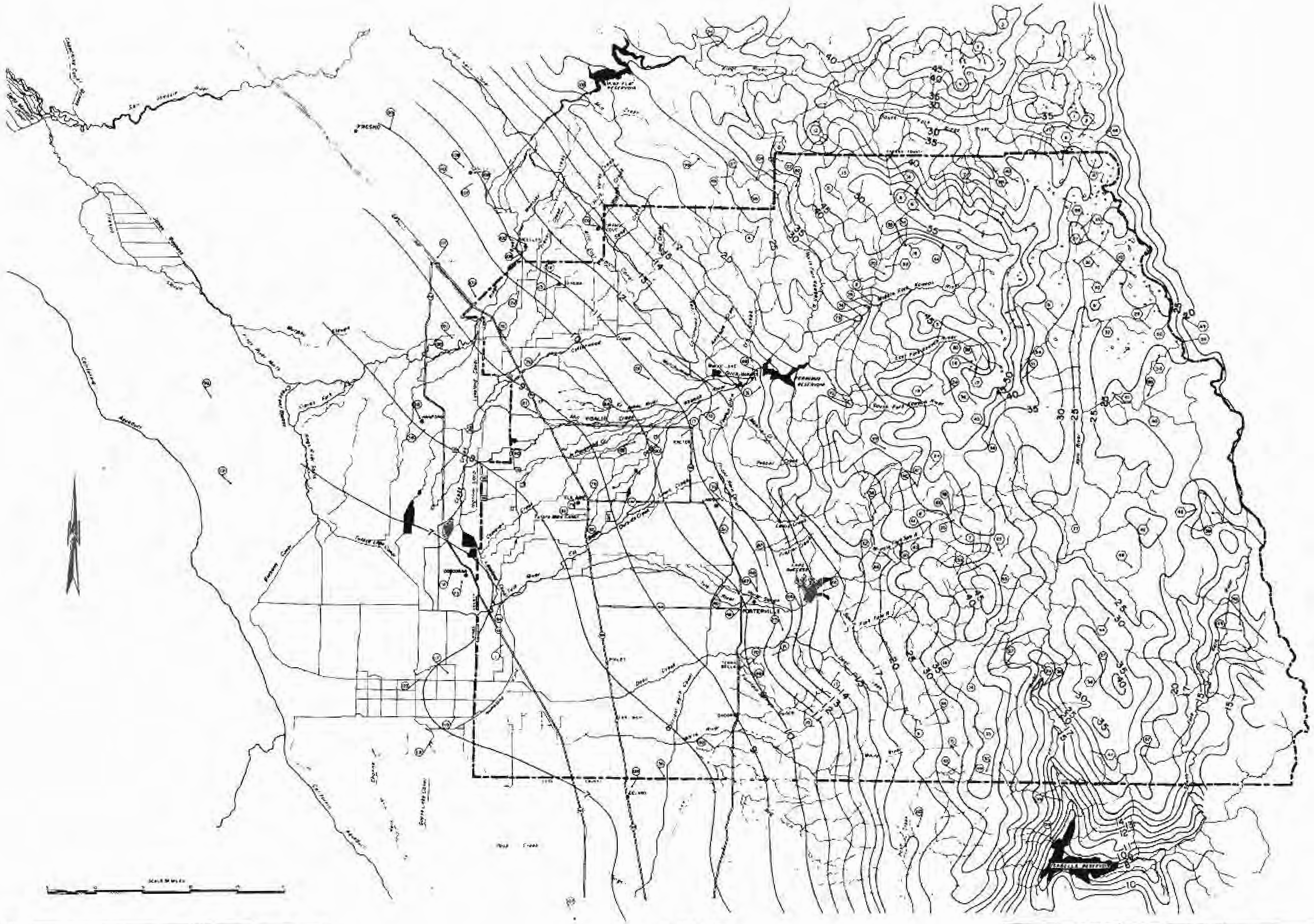
THE SPINK CORPORATION

TULARE COUNTY FLOOD CONTROL DISTRICT

FLOOD CONTROL MASTER PLAN HYDROLOGY APPENDIX

DRAINAGE AREAS, STREAM GAGING STATIONS AND PEAK DISCHARGE SITES

APRIL, 1971 — PLATE 1



MURRAY, BURNS AND KIENLEN CONSULTING CIVIL ENGINEERS

THE SPINK CORPORATION

LEGEND:

—12— NORMAL ANNUAL PRECIPITATION - INCHES

(13) PRECIPITATION STATIONS (TABLE NO. 2)

(31) SNOW COURSES AND AERIAL MARKERS (TABLE NO. 3)

TULARE COUNTY FLOOD CONTROL DISTRICT

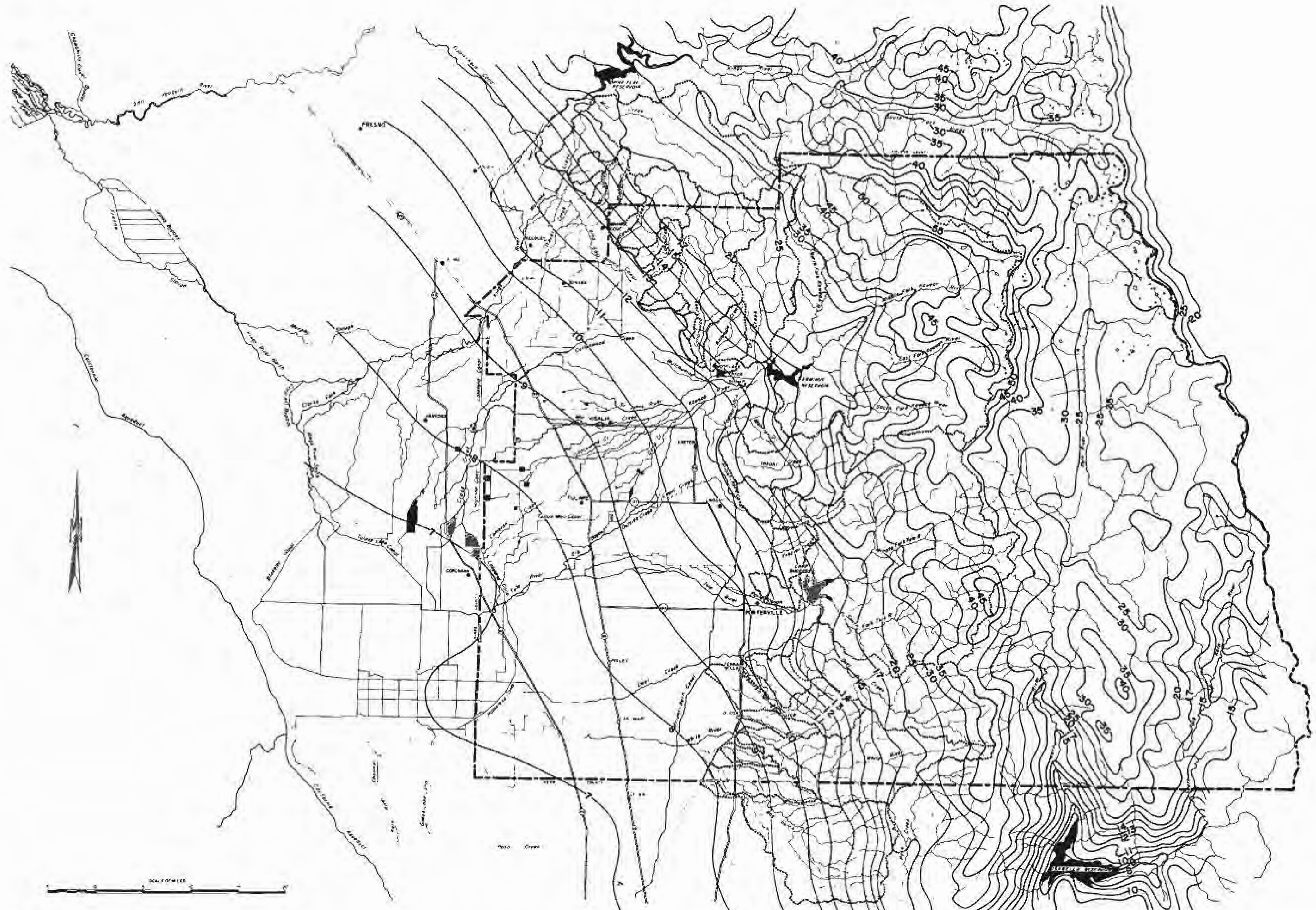
FLOOD CONTROL MASTER PLAN HYDROLOGY APPENDIX

NORMAL ANNUAL PRECIPITATION (1911-1970)

PRECIPITATION STATIONS AND SNOW COURSES

APRIL, 1971

PLATE II



MURRAY, BURNS AND KIENLEN — CONSULTING CIVIL ENGINEERS

THE SPINK CORPORATION

LEGEND:

—12— NORMAL ANNUAL PRECIPITATION - INCHES

DRAINAGE AREAS (SEE PLATE II)

TULARE COUNTY FLOOD CONTROL DISTRICT

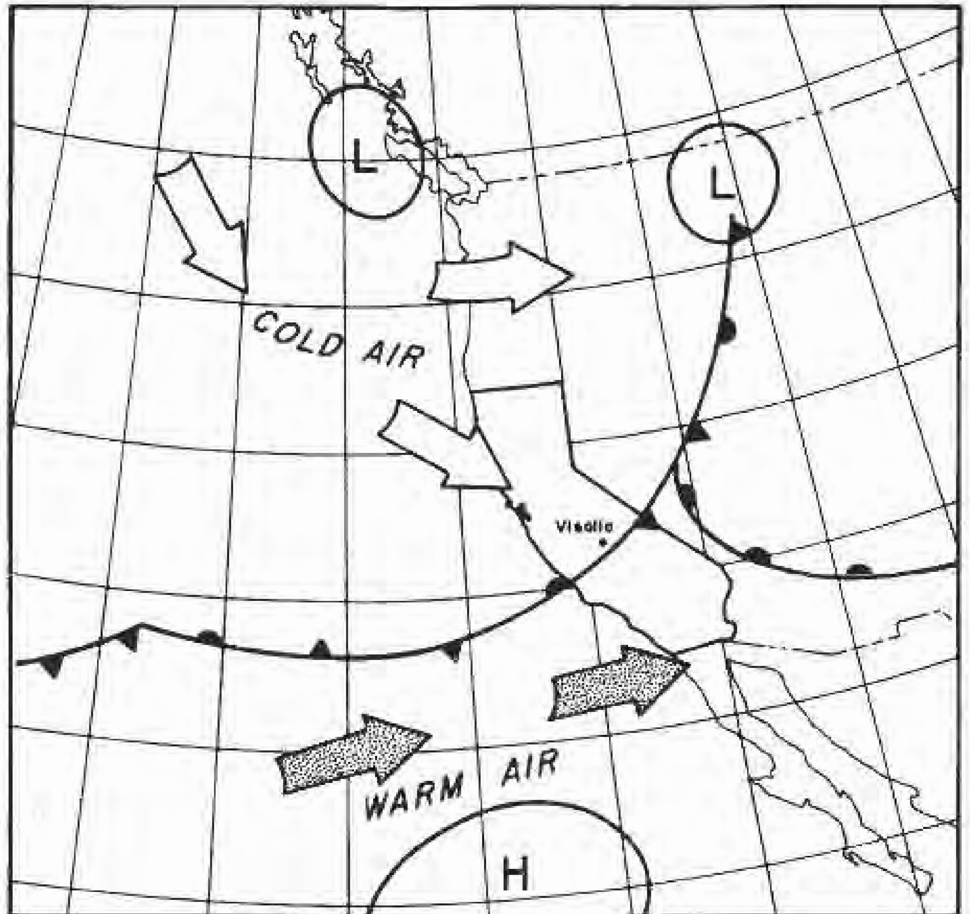
FLOOD CONTROL MASTER PLAN HYDROLOGY APPENDIX

DRAINAGE AREAS AND NORMAL ANNUAL PRECIPITATION

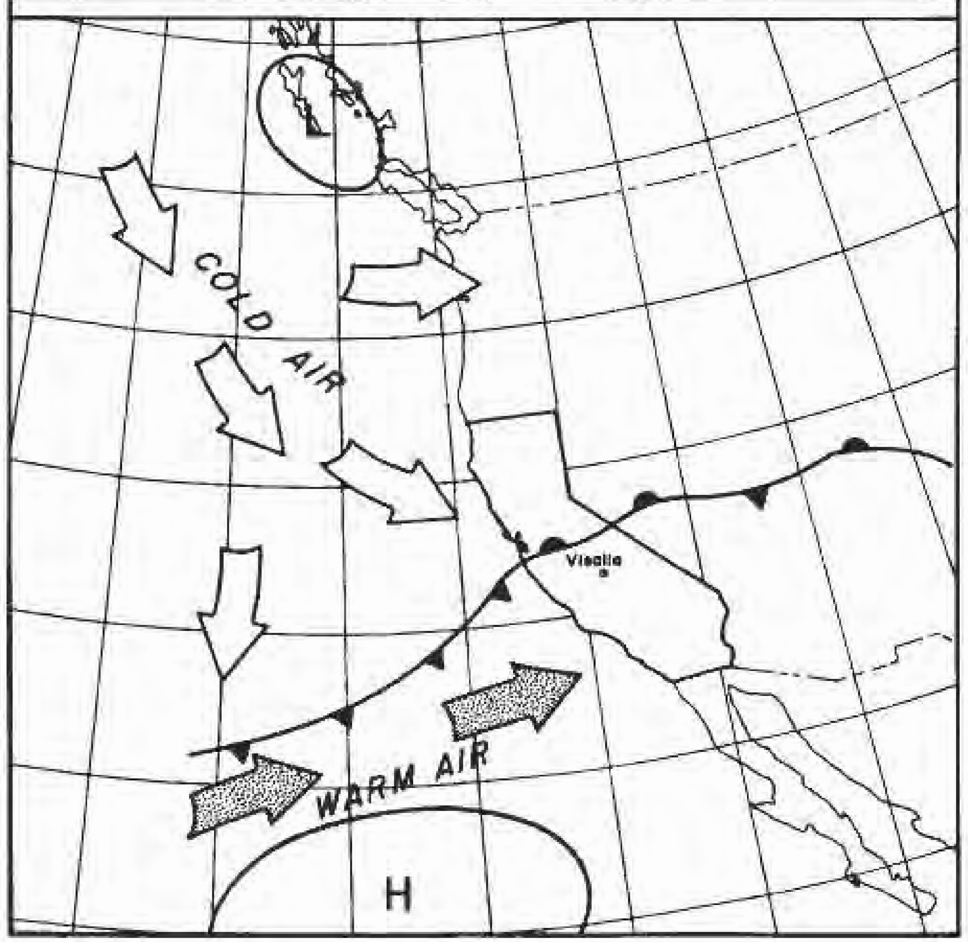
APRIL 1971

PLATE II

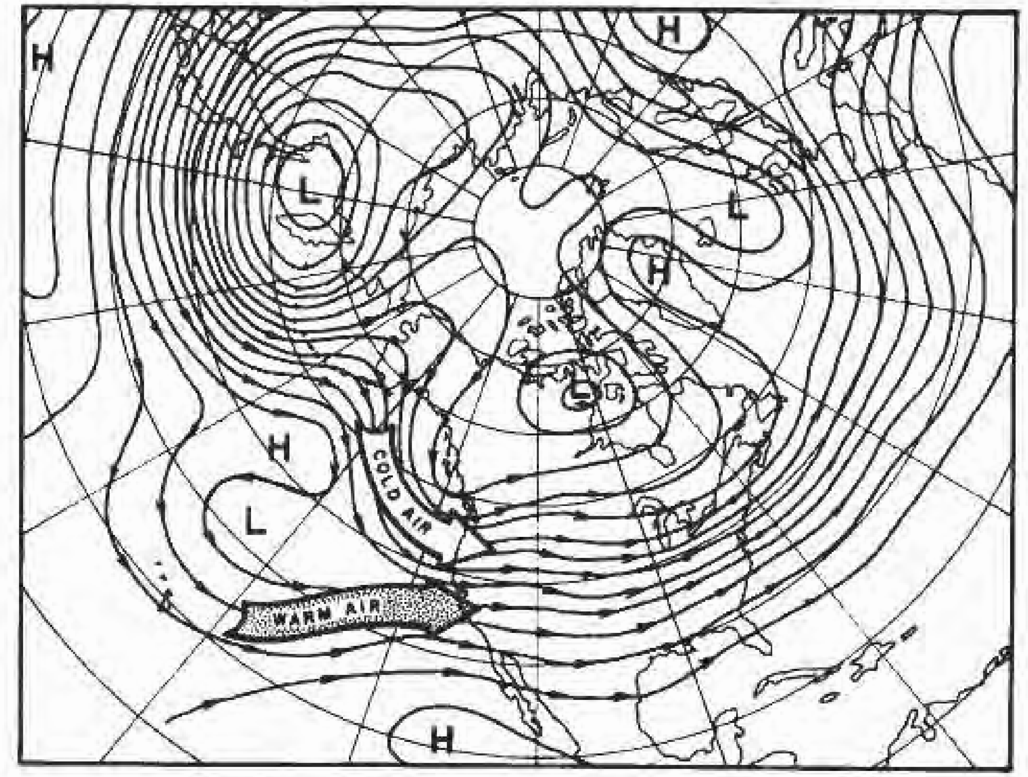
FIGURE 1



WEATHER MAP
AT 1000 PST
DECEMBER 5, 1966



WEATHER MAP
AT 1000 PST
DECEMBER 6, 1966



STREAMLINES OF FLOW
AT APPROXIMATELY 10,000 FEET
JANUARY 15-31, 1969

LEGEND

- OCCLUSION
- COLD FRONT
- WARM FRONT
- STATIONARY FRONT

TULARE COUNTY FLOOD CONTROL DISTRICT

FLOOD CONTROL MASTER PLAN—HYDROLOGY APPENDIX

WEATHER MAPS DECEMBER 1966 AND JANUARY 1969

Murray, Burns and Kienlen—Consulting Civil Engineers

The Spink Corporation

FIGURE 2

TULARE COUNTY FLOOD CONTROL DISTRICT

FLOOD CONTROL MASTER PLAN—HYDROLOGY APPENDIX

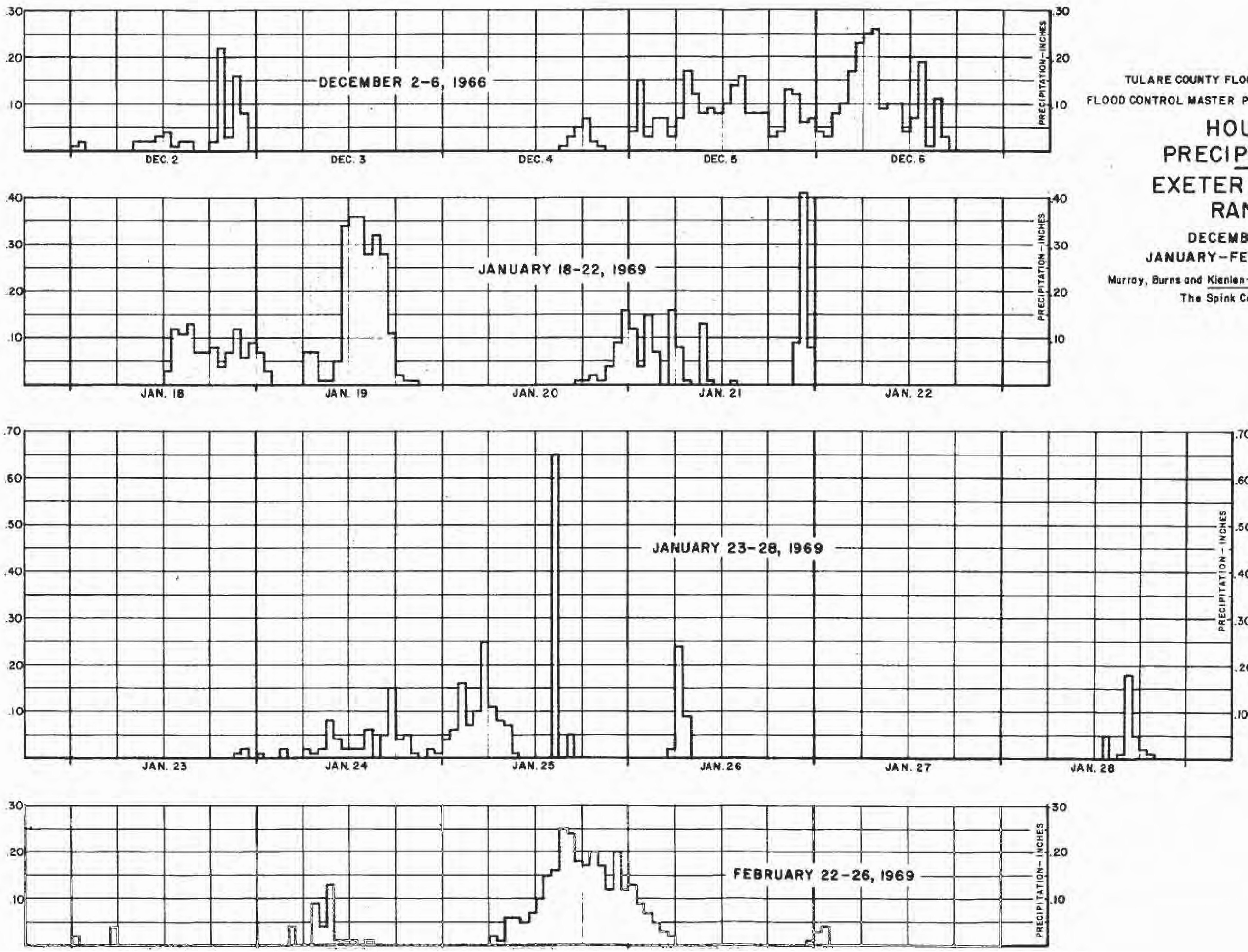
HOURLY PRECIPITATION EXETER FAUVER RANCH

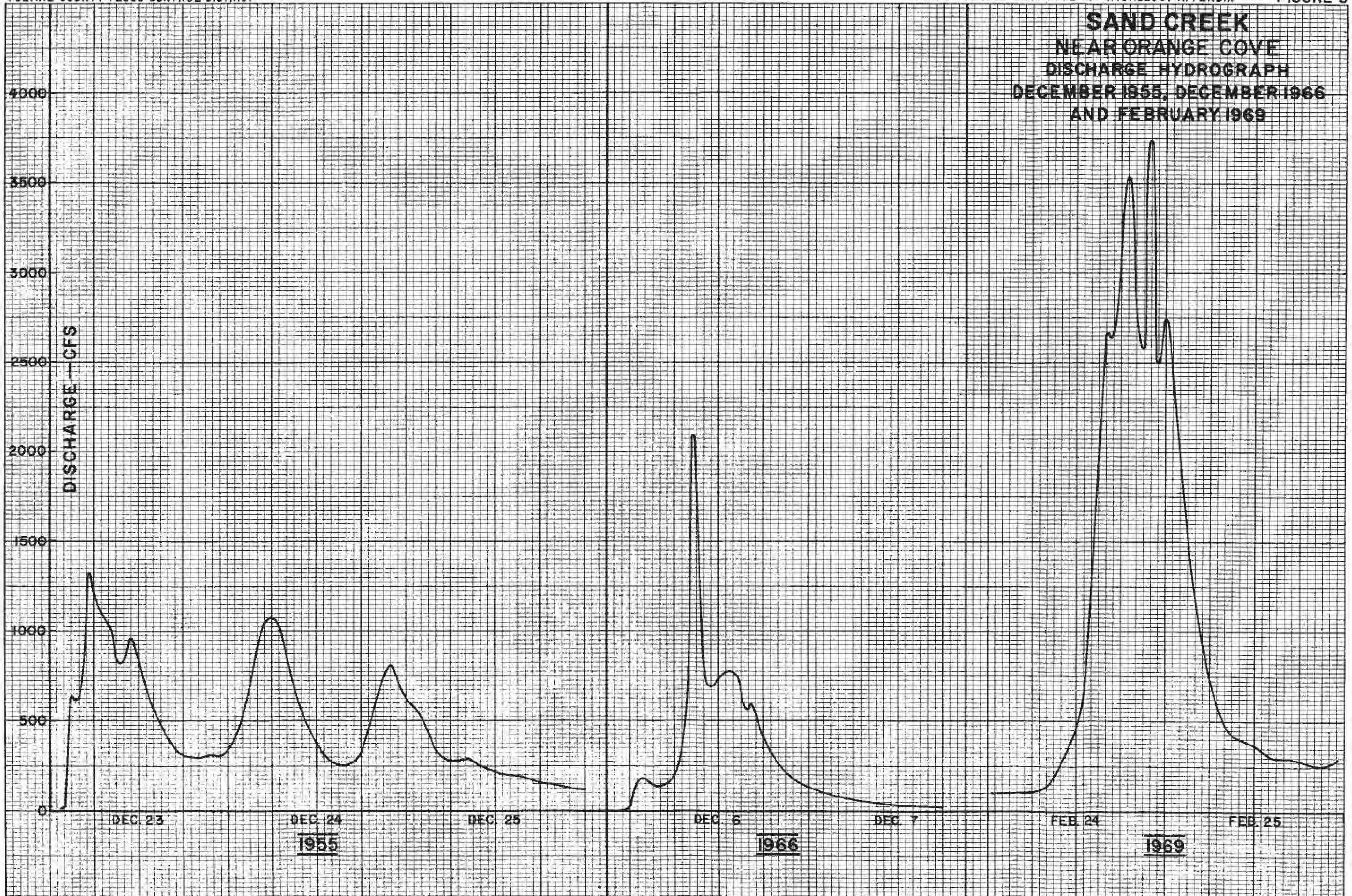
DECEMBER 1966

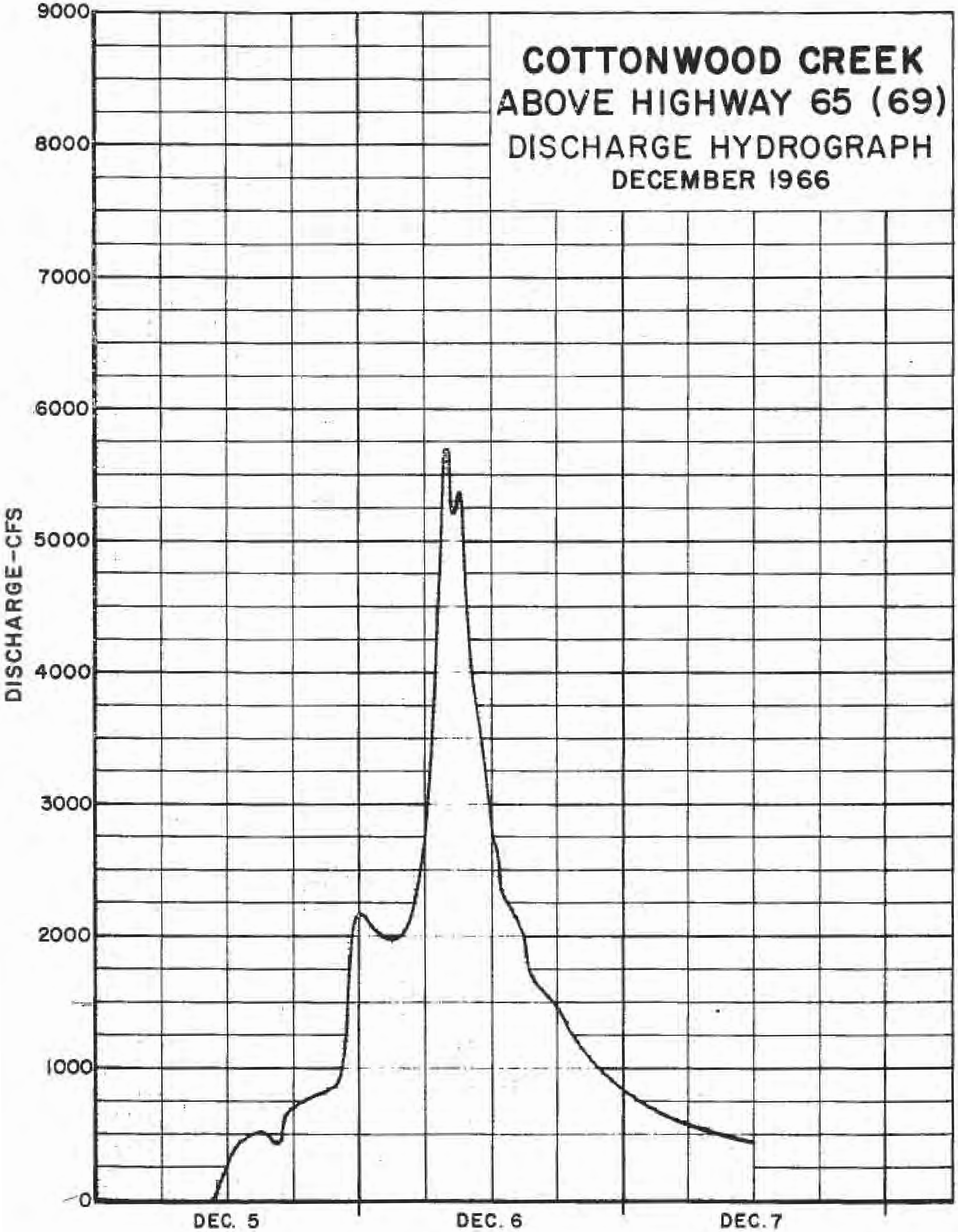
JANUARY–FEBRUARY 1969

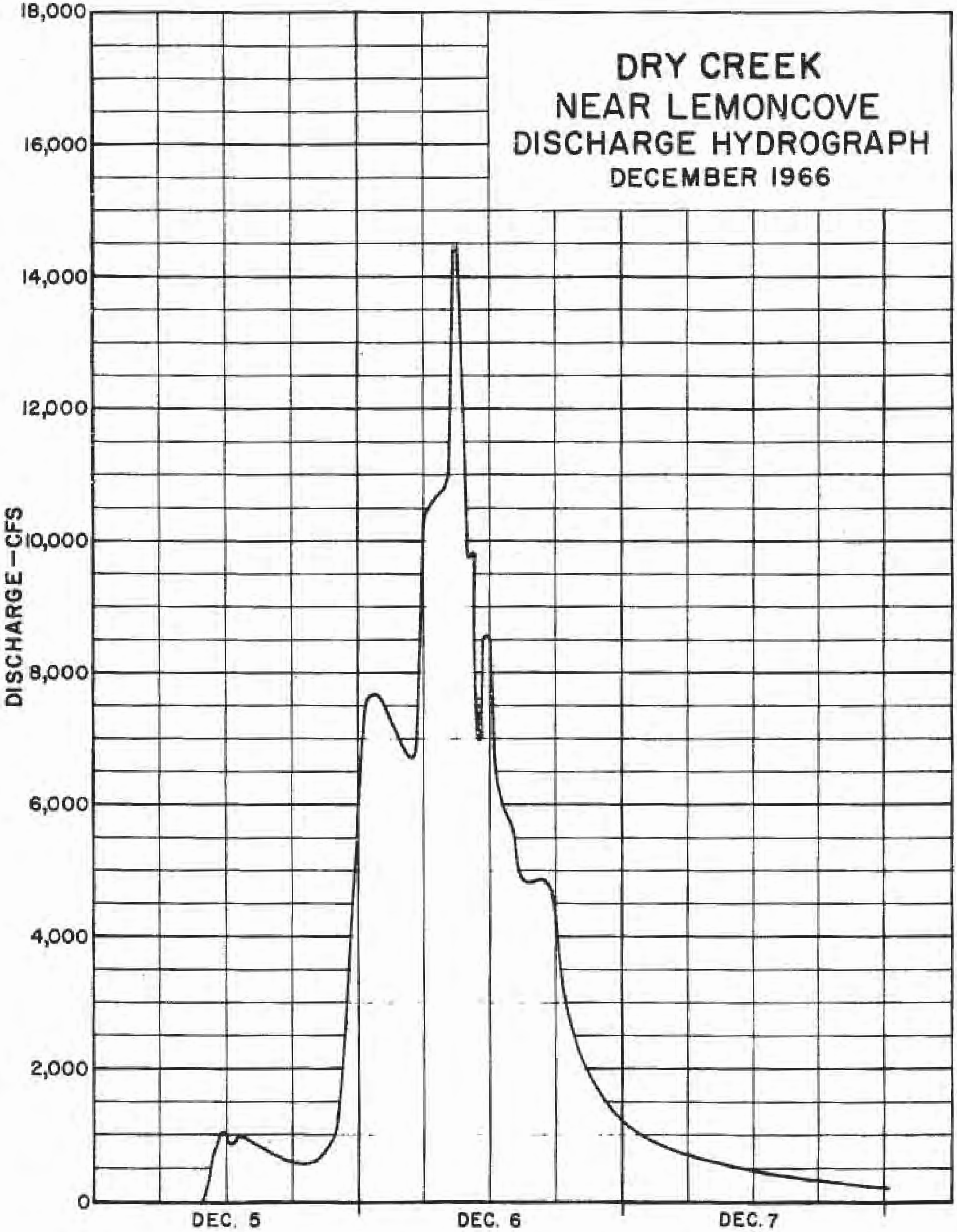
Murray, Burns and Kienlen – Consulting Civil Engineers

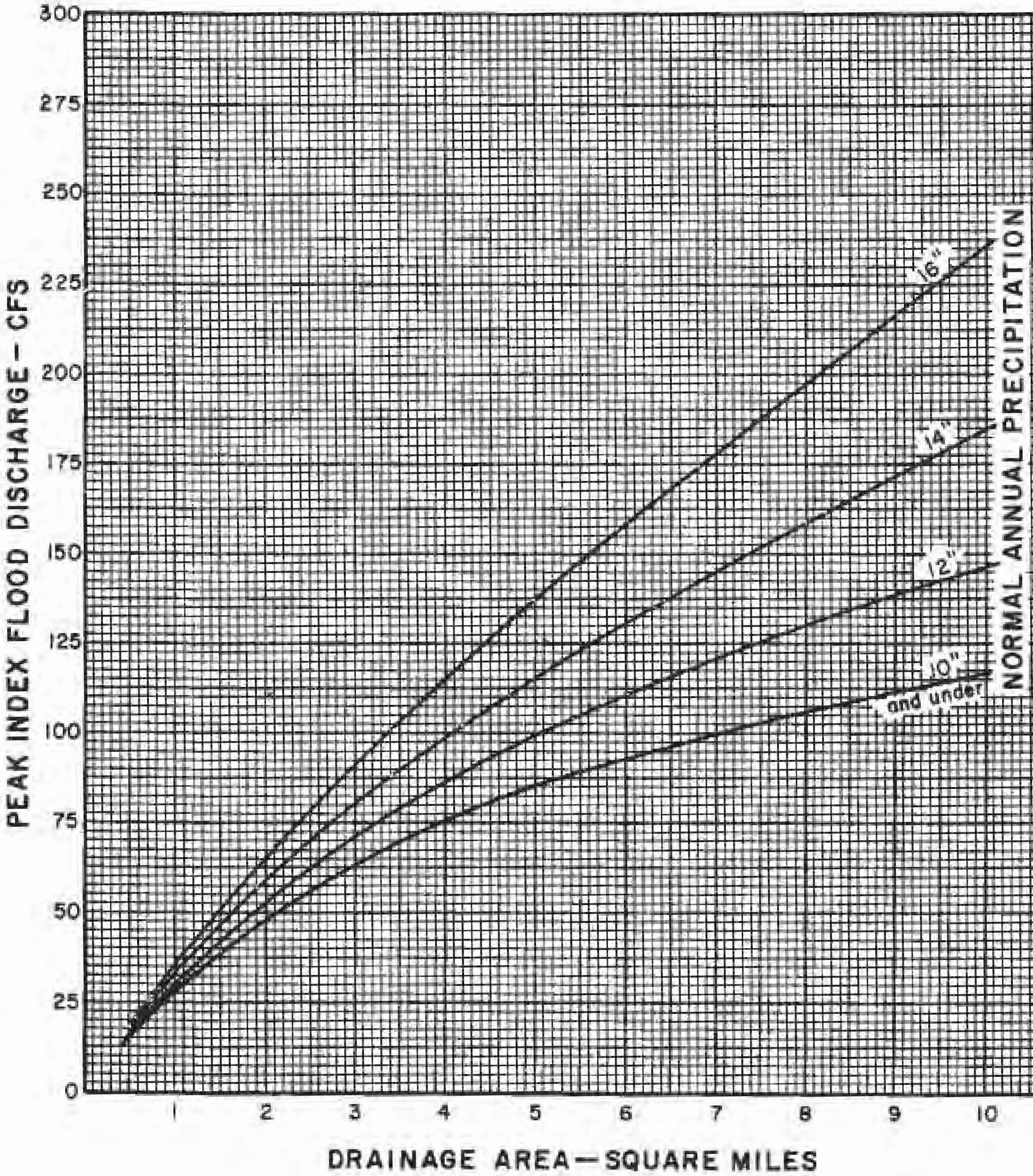
The Spink Corporation




SAND CREEK
NEAR ORANGE COVE
DISCHARGE HYDROGRAPH
DECEMBER 1955, DECEMBER 1966
AND FEBRUARY 1969
DISCHARGE — CFS
4000
3500
3000
2500
2000
1500
1000
500
0
DEC. 23
DEC. 24
DEC. 25
1955
DEC. 6
DEC. 7
1966
FEB. 24
FEB. 25
1969

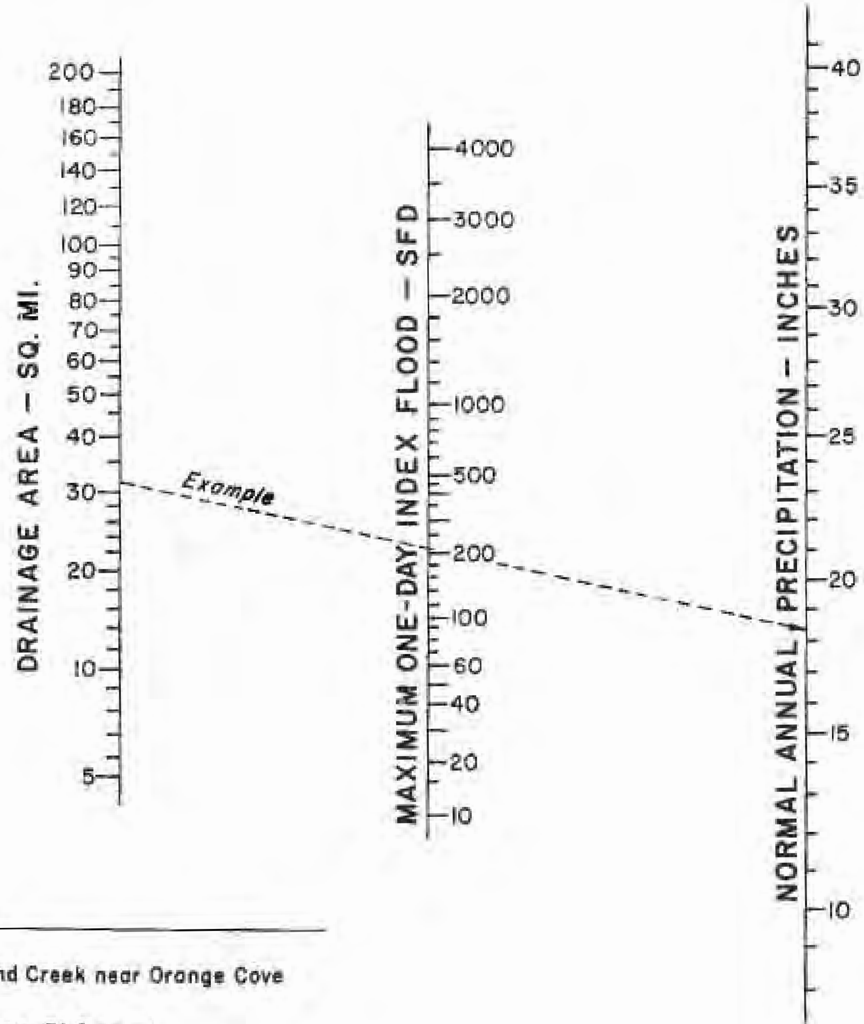

COTTONWOOD CREEK
ABOVE HIGHWAY 65 (69)
DISCHARGE HYDROGRAPH
DECEMBER 1966
DISCHARGE-CFS
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
DEC. 5
DEC. 6
DEC. 7


DRY CREEK
NEAR LEMONCOVE
DISCHARGE HYDROGRAPH
DECEMBER 1966
DISCHARGE—CFS
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
DEC. 5
DEC. 6
DEC. 7



PEAK INDEX FLOOD DISCHARGE
SMALL FOOTHILL DRAINAGE AREAS

Normal Annual Precipitation of 16 Inches or Less



EXAMPLE

Station: Sand Creek near Orange Cove

Drainage Area: 31.6 sq. mi.
Normal Annual Precipitation: 18.2 in.

From Nomograph:

Maximum One-Day Index Flood = 205 SFD

ONE-DAY INDEX FLOOD NOMOGRAPH

FIGURE 6

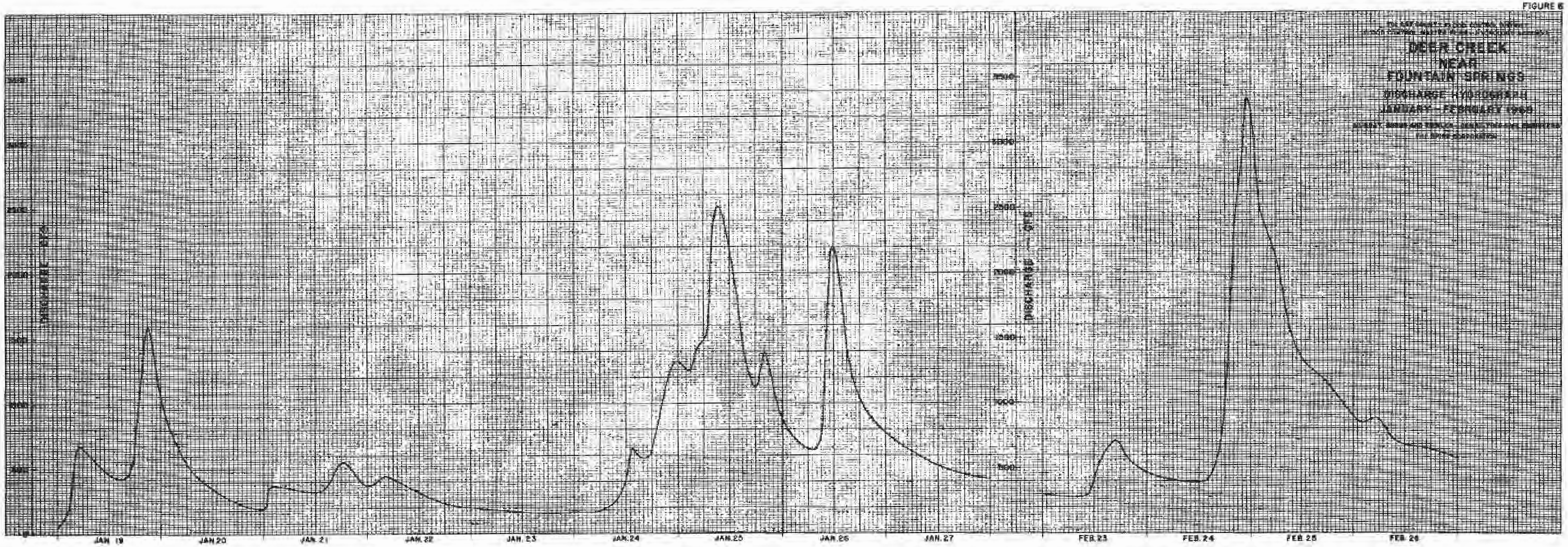
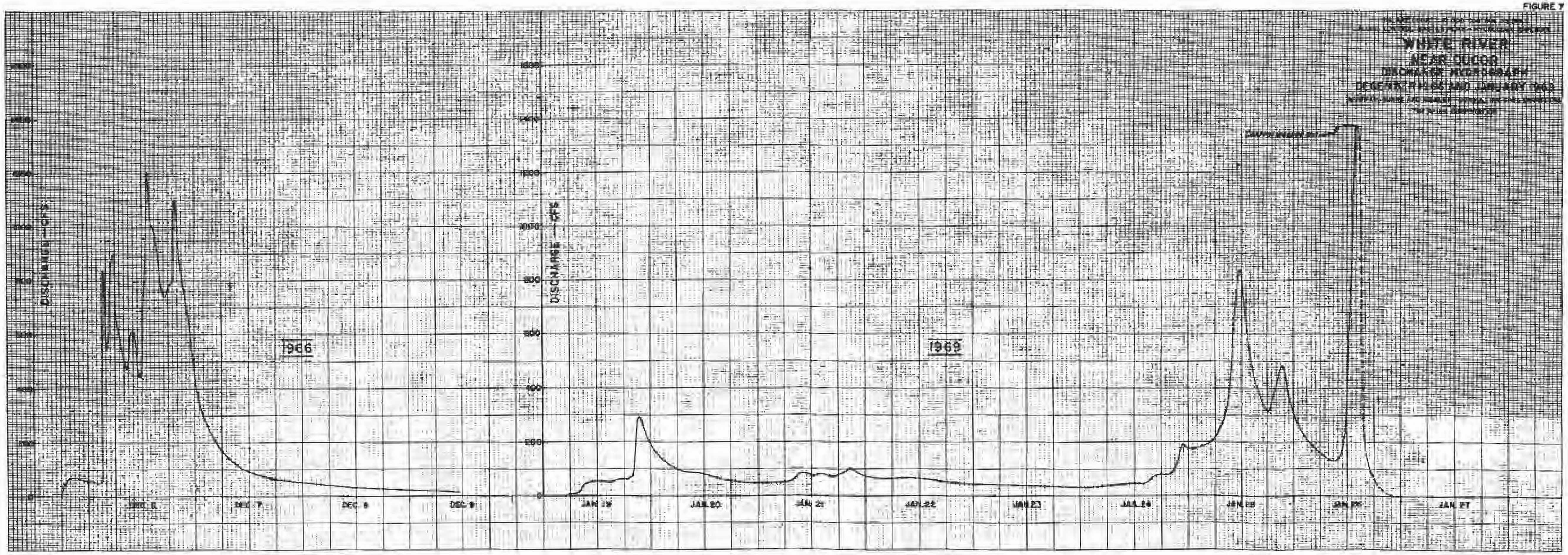
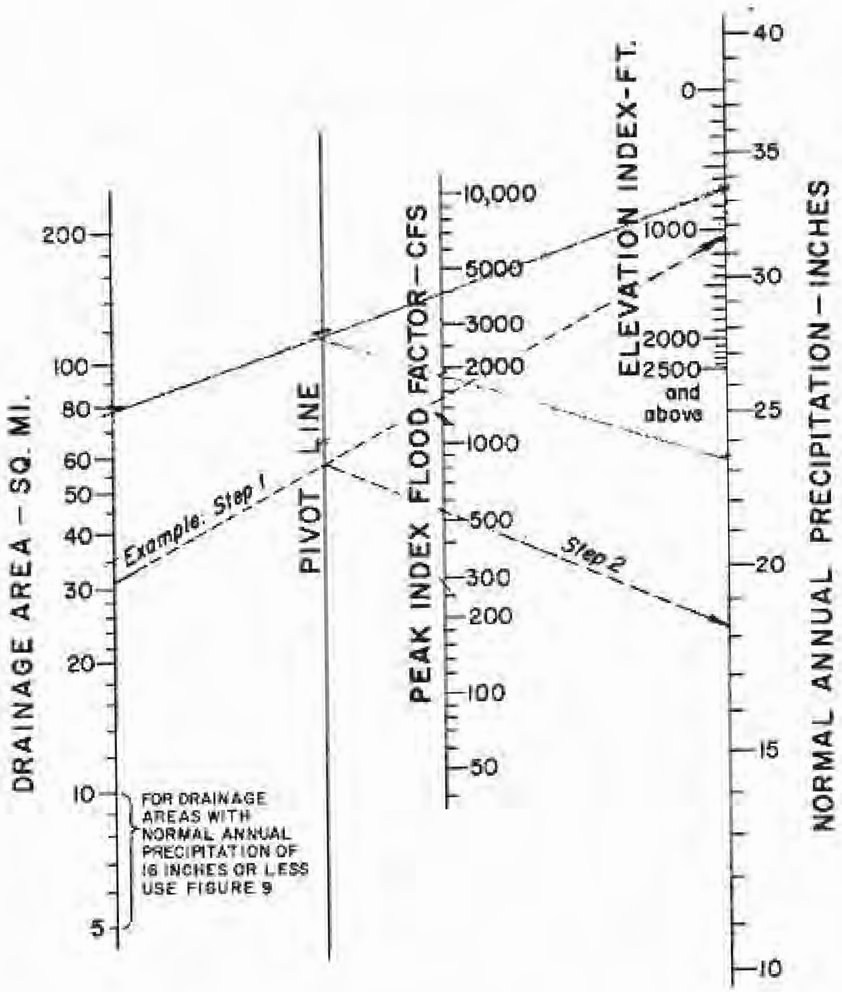
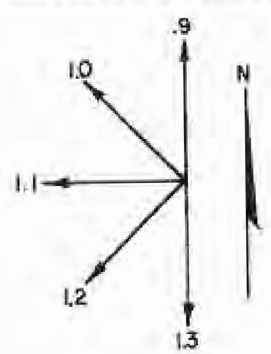


FIGURE 7





BASIN ORIENTATION DIAGRAM



Step 3

PEAK INDEX FLOOD DISCHARGE =

BASIN ORIENTATION FACTOR x PEAK INDEX FLOOD FACTOR
From diagram at left *From nomograph*

Step 4

Multiply PEAK INDEX FLOOD DISCHARGE *by the following values to estimate* 1:25 YEAR and 1:50 YEAR FLOOD PEAKS:

1:25 Year	4.2
1:50 Year	6.0
1:100 Year	8.0

EXAMPLE

STATION: SAND CREEK NEAR ORANGE COVE

DRAINAGE AREA = 31.6 SQ. MI.
ELEVATION INDEX = 1050 FT.
NORMAL ANNUAL PRECIPITATION = 18.2 IN.

Steps 1 & 2 (Nomograph)

PEAK INDEX FLOOD FACTOR = 530 CFS

Step 3

BASIN ORIENTATION FACTOR = 1.2

PEAK INDEX FLOOD DISCHARGE =
BASIN ORIENTATION FACTOR x PEAK INDEX FLOOD FACTOR =
(530 cfs) x (1.2) = 636 cfs

Step 4

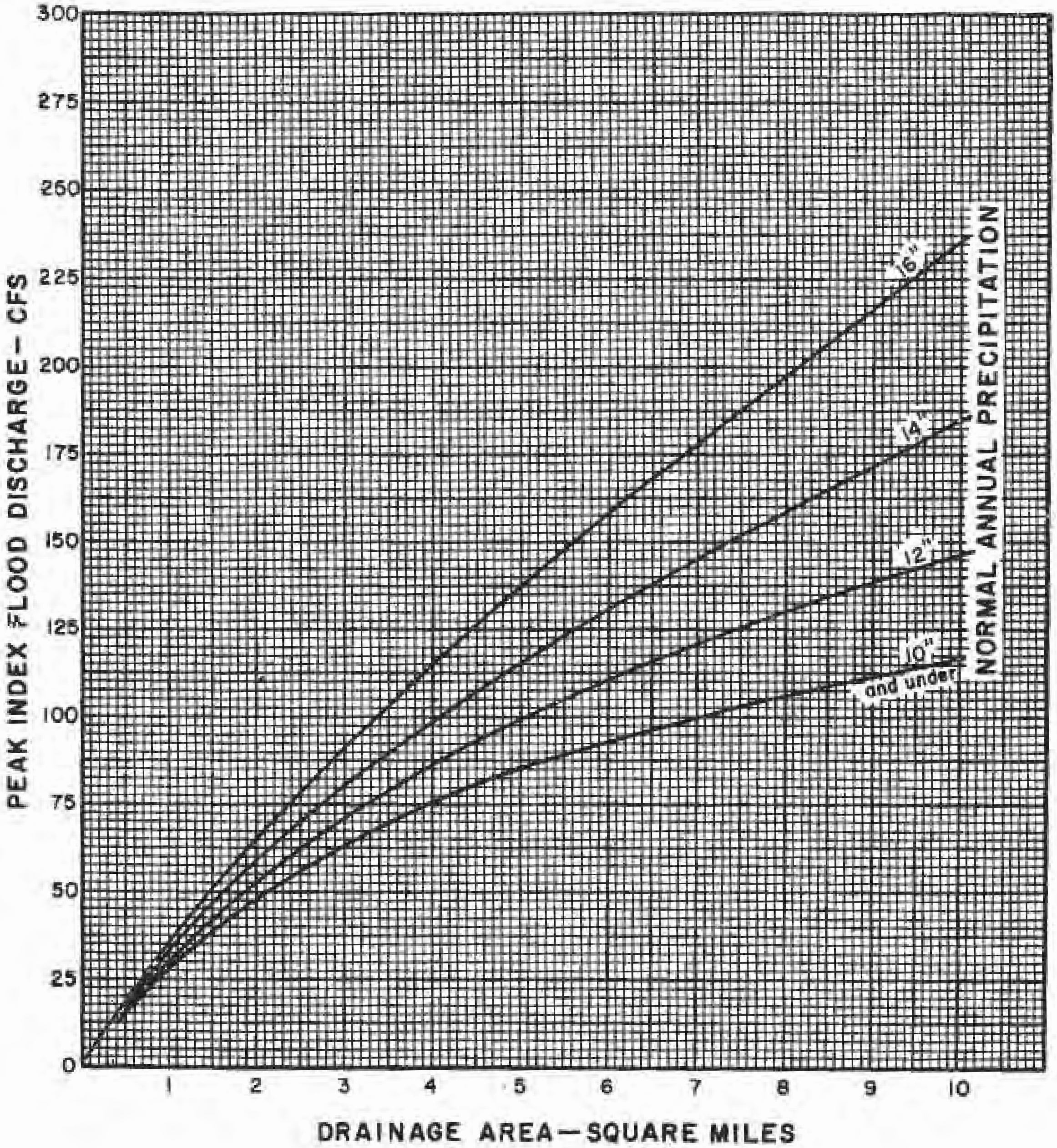
PEAK INDEX FLOOD DISCHARGE x 1:25 YEAR VALUE =
1:25 YEAR PEAK FLOW
(636 cfs) x (4.2) = 2671 cfs

TULARE COUNTY FLOOD CONTROL DISTRICT

FLOOD CONTROL MASTER PLAN–HYDROLOGY APPENDIX

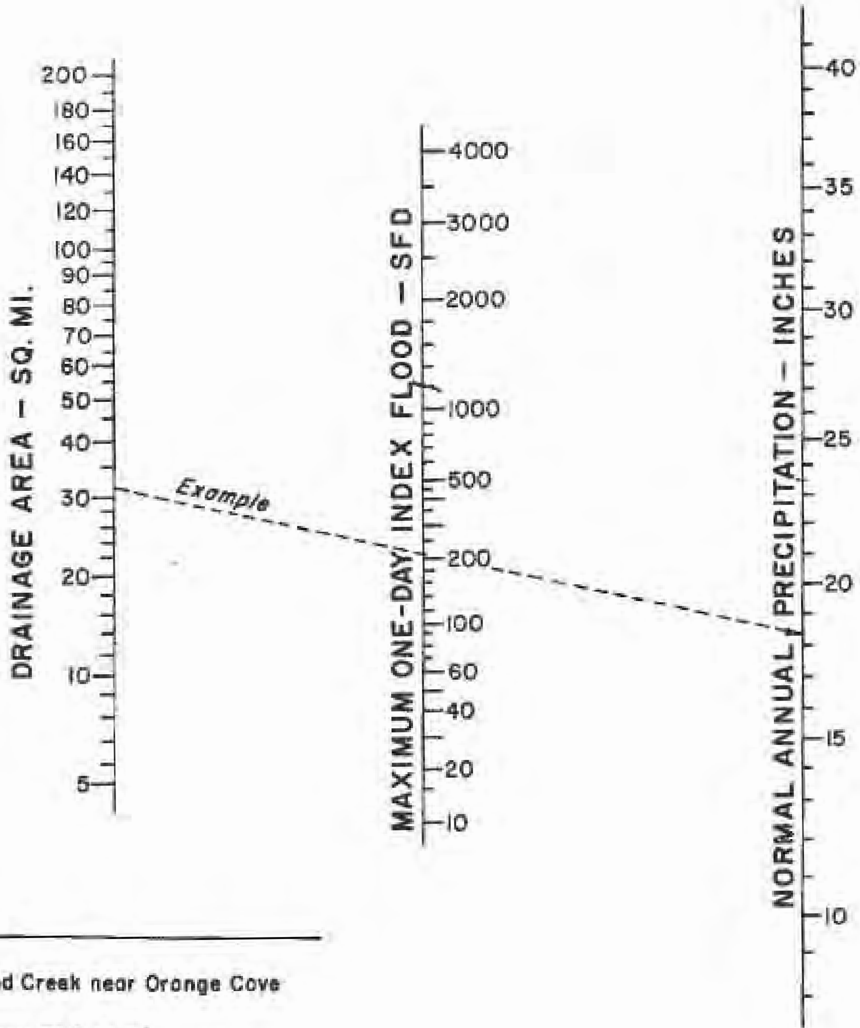
PEAK INDEX FLOOD DISCHARGE NOMOGRAPH

Murray, Burns and Kienlen—Consulting Civil Engineers
The Spink Corporation



PEAK INDEX FLOOD DISCHARGE
SMALL FOOTHILL DRAINAGE AREAS

Normal Annual Precipitation of 16 Inches or Less



EXAMPLE

Station: Sand Creek near Orange Cove

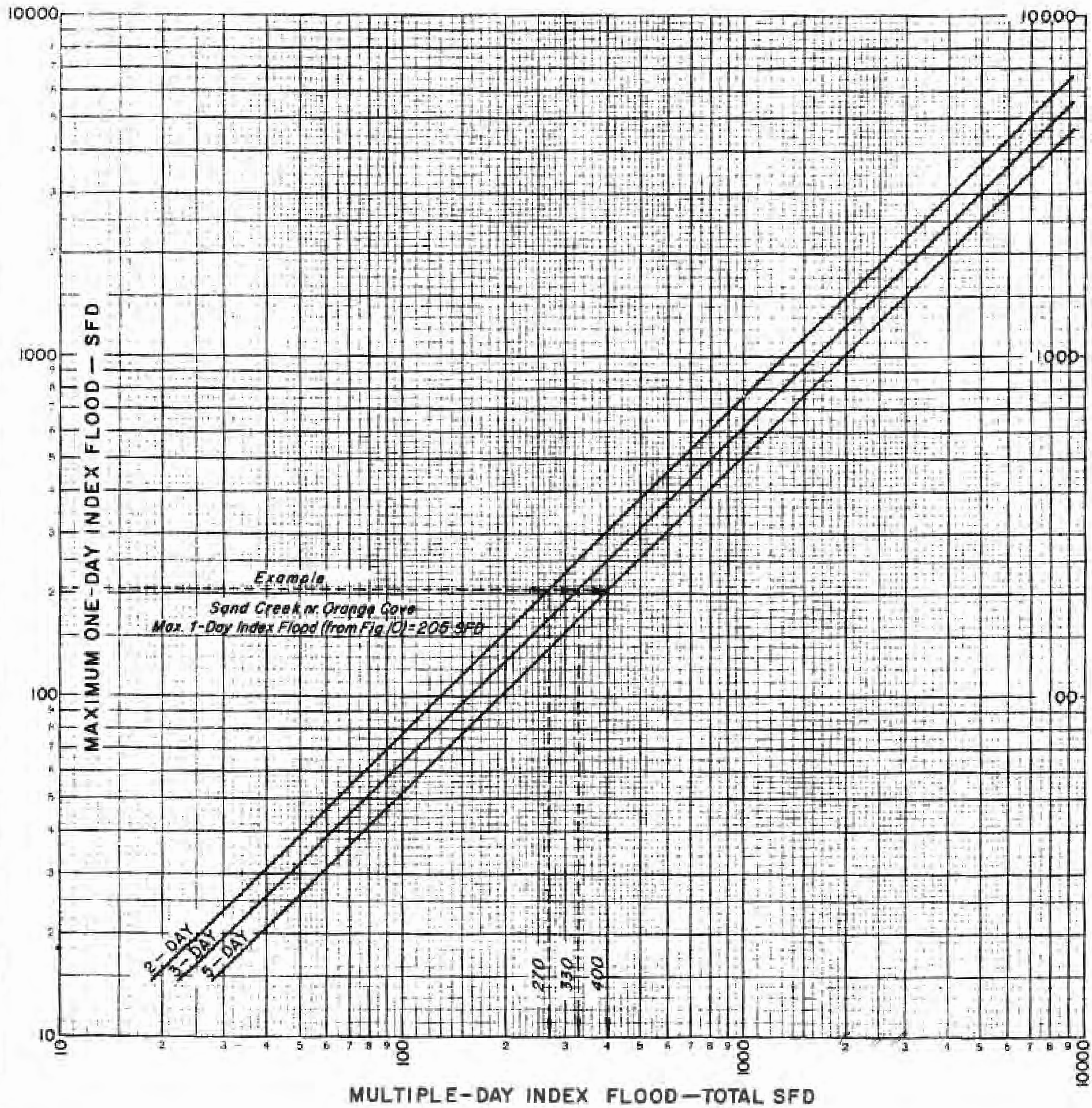
Drainage Area: 31.6 sq. mi.
Normal Annual Precipitation: 18.2 in.

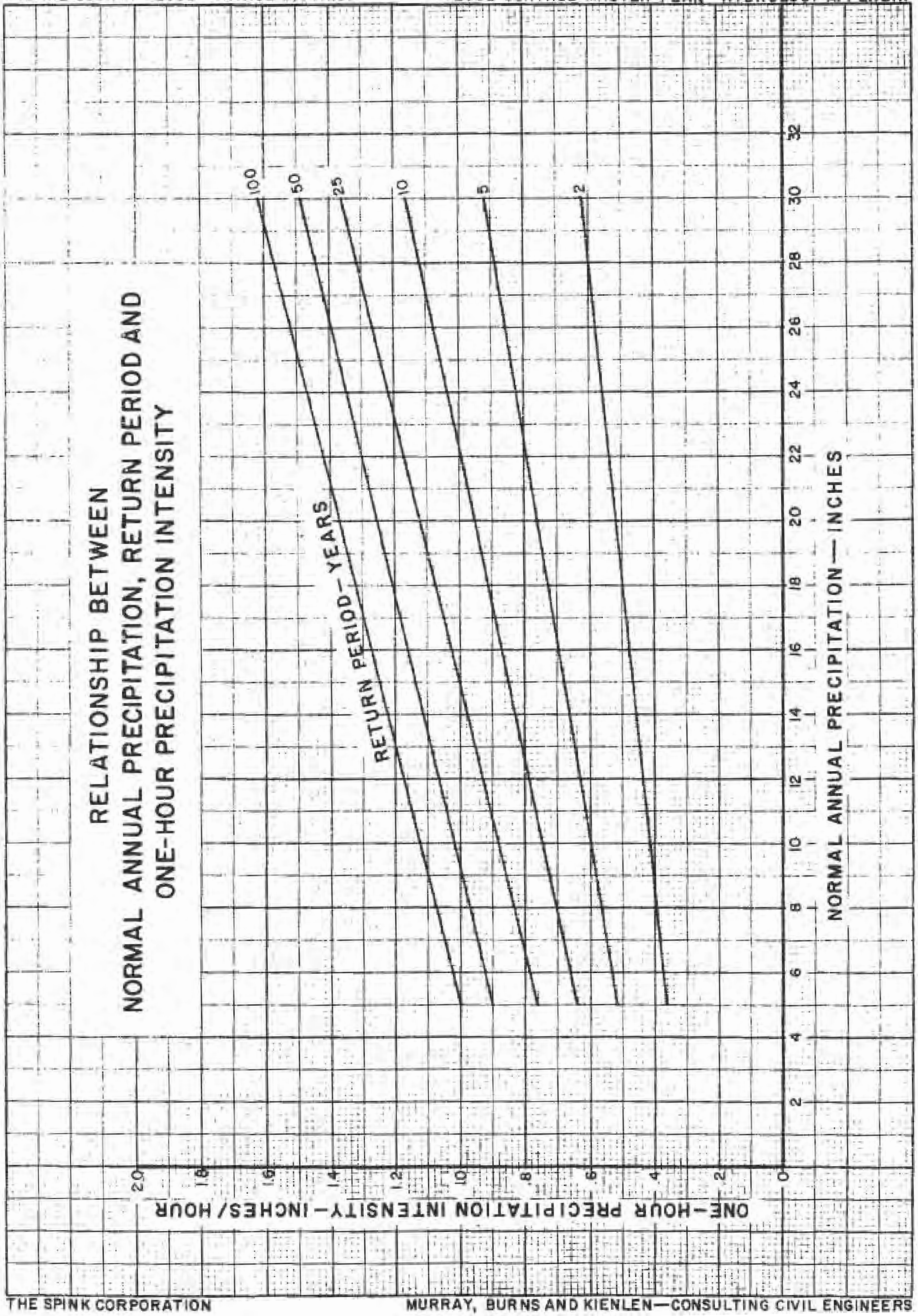
From Nomograph:

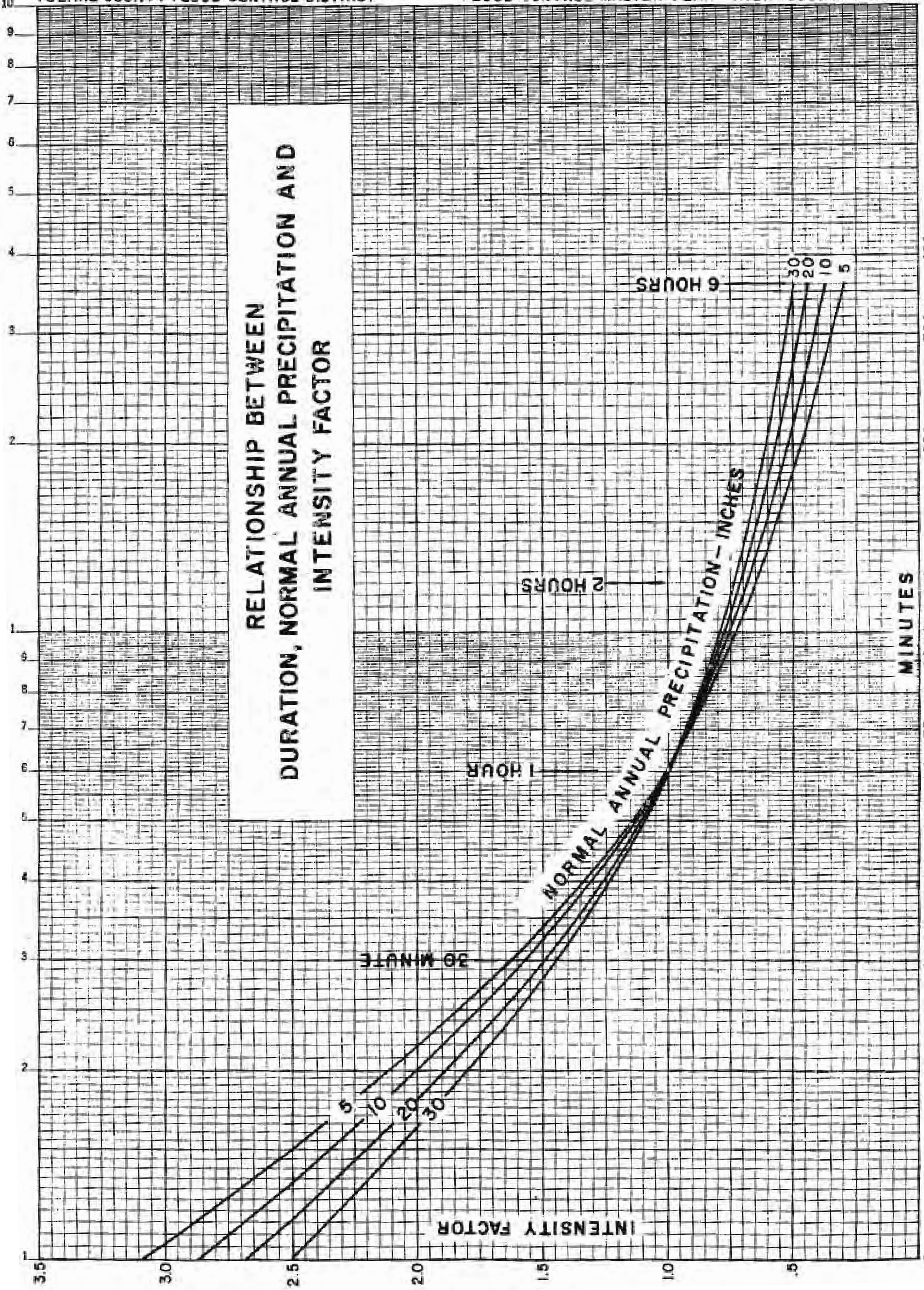
Maximum One-Day Index Flood = 205 SFD

ONE-DAY INDEX FLOOD NOMOGRAPH

ONE-DAY VS MULTIPLE-DAY INDEX FLOODS




RELATIONSHIP BETWEEN
NORMAL ANNUAL PRECIPITATION, RETURN PERIOD AND
ONE-HOUR PRECIPITATION INTENSITY
RETURN PERIOD—YEARS
100
50
25
10
5
2
NORMAL ANNUAL PRECIPITATION—INCHES
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
ONE-HOUR PRECIPITATION INTENSITY-INCHES/HOUR
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0


RELATIONSHIP BETWEEN
DURATION, NORMAL ANNUAL PRECIPITATION AND
INTENSITY FACTOR
NORMAL ANNUAL PRECIPITATION—INCHES
6 HOURS
2 HOURS
1 HOUR
30 MINUTE
5
10
20
30
MINUTES
INTENSITY FACTOR
10
20
30
40
50
60
70
80
90
100
120
200
300
400
3.5
3.0
2.5
2.0
1.5
1.0
.5

ATTACHMENT 7 – TECHNICAL JUSTIFICATION

APPENDIX E

2005 City of Visalia Flood Insurance Study Hydrology Report

City of Visalia Flood Insurance Study Hydrology Report

March 28, 2005

Prepared for:
FEMA

Prepared by:
northwest hydraulic consultants

nhc

Table of Contents

1. Background

The City of Visalia has a population of about 90,000 and is located in Tulare County in the southern portion of California's Central Valley, approximately 200 miles north of Los Angeles and 220 miles south of Sacramento (see Figure 1). The climate in this region is Mediterranean, with the majority of precipitation occurring between November and April. Average annual rainfall totals range from 10 inches at the valley floor to 55 inches near the crest of the Sierra Nevada Mountains, with much of the precipitation falling as snow at higher elevations. Major flooding is typically generated by rain and rain-on-snow events, with lesser flood flows resulting from snowmelt runoff.

Visalia lies on the lower portion of a large alluvial fan formed by the Kaweah and St. Johns Rivers and their distributaries at the foot of the Sierra Nevada Range along the eastern border of the valley. The fan has been largely stabilized by agriculture and development since the early 1900s. The distributary channels are utilized for transport and delivery of irrigation water, and many of the diversions are controlled by turnout structures. This network of channels is undersized for very large flood events, and excess flows result in shallow flooding across large portions of the alluvial fan. Visalia has experienced several such damaging flood events over the last 100 years. The most significant flooding occurred in December 1955 when downtown Visalia was inundated by several feet of water. Terminus Dam was constructed upstream of the apex of the alluvial fan in 1962, providing considerable flood protection via the Lake Kaweah reservoir. The largest flood on the Kaweah River since construction of the dam occurred in December 1966: reservoir operations reduced a peak inflow of about 73,000 cfs to a peak outflow of less than 5,500 cfs.

2. Corps of Engineers Hydrologic Analyses

The Sacramento District of the Corps of Engineers initiated a feasibility study for increasing flood and water supply storage at Lake Kaweah in the late 1980s. The alternative selected for implementation was a 21-foot raise of the Terminus Dam spillway, with construction finalized in 2004. The dam raise was completed by installing fusegates across the spillway; these have a design return period of greater than 10,000 years. The Corps of Engineers performed hydrologic analyses in support of this modification, determining revised reservoir outflows for a range of return periods.

Wayne Johnson of the Water Management Section of the Corps of Engineers Sacramento District provided hydrographs for the flood events of interest on the Kaweah River below the dam and its downstream tributaries. A meeting was held with Mr. Johnson to discuss the Kaweah River hydrology, as he was the primary hydrologist on the Lake Kaweah project. **nhc** also reviewed the report "Kaweah River Basin, California – Hydrology" (Corps of Engineers, 1990); this report is provided in Appendix A. The Kaweah River hydrology report summarizes the analyses performed for the feasibility study and is currently the only written documentation available describing the hydrology of the reservoir with the raised spillway. The Terminus Dam Water Control Manual will contain a description of the final hydrology developed for the spillway raise, but will not be available until late spring 2005. Mr. Johnson noted that the hydrologic analyses have not changed substantially from those documented in the 1990 report.

Lake Kaweah is operated to provide flood control storage from November through March, and is allowed to fill starting in late spring for water supply storage. The objective flow is 5,500 cfs at McKays Point, approximately two miles downstream of the reservoir. The objective flow includes estimated contributions from three local tributaries which enter the Kaweah River system below Terminus Dam: Dry, Mehrten and Yokohl Creeks. Figure 2 shows the inflow locations of these tributaries as well as the general distributary nature of the system. The Corps of Engineers developed a series of 30-day hydrographs for the Kaweah River and each tributary using standard design flood methodology, as described below. This information is available in greater detail in the Corps' hydrology report for the Kaweah River Basin (Corps of Engineers, 1990).

Unimpaired rainflood and snowmelt frequency analyses were performed using an 85-year flow record for the Kaweah River and a 29-year flow record for Dry Creek. The Kaweah River gage is located just upstream of the reservoir, and the Dry Creek gage is located just upstream of its confluence with the Kaweah River. Frequency curves were developed for the peak, 1-, 3-, 7-, 15- and 30-day flows for return periods of 10, 20, 50, 100, 200, 500 and 1000 years. The largest floods occur during rain and rain-on-snow events; snowmelt alone does not normally generate the largest peak annual flows.

An HEC-1 rainfall-runoff model was developed for the Kaweah River and Dry Creek watersheds using the Snyder unit hydrograph method to generate one-hour unit hydrographs for each basin. The HEC-1 model was then calibrated to the historical December 1966 and January 1969 flood hydrographs by adjusting loss rates and base flows. The resultant HEC-1 model was used to develop the Standard Project Flood (SPF) at the dam site and on the downstream tributaries (Dry, Yokohl and Merhten Creeks).

A hypothetical flood series representative of the region was then developed from the SPF and the unimpaired rainflood frequency analysis results for return periods of 10 through 1000 years. Each 30-day flood series consists of six 5-day waves, and incorporates the 1- through 30-day volumes determined from the frequency analysis. Each wave was generated by applying a ratio to the SPF, and the largest wave was set as the fourth wave, addressing possible antecedent storm conditions. Reservoir routing was performed using the hypothetical flood series on the Kaweah River and tributaries downstream of the dam, a starting reservoir volume of 12,000 acre-feet and current reservoir operating rules. The resultant concurrent Terminus Dam, Dry Creek and Merhten/Yokohl Creek hourly hydrographs are available for the Federal Emergency Management Agency (FEMA) regulatory flows of 10-, 50-, 100- and 500-year return periods. The Corps of Engineers provided several spreadsheets that documented these flows as well as the reservoir routing process; these are included as electronic files with this report.

3. Application of Flows to the City of Visalia Flood Insurance Study

Review of the Corps of Engineers hydrologic analysis in support of the Terminus Dam raise indicates that development of the design hydrographs follows standard Corps practices. Several elements of the analysis were reviewed in detail to assess the validity of utilizing these flows for FEMA's Flood Insurance Study for the City of Visalia.

The first element is the Corps of Engineers' standard practice of using expected probability when performing frequency analyses for design projects. This generally results in higher flows than computed probability, which FEMA prefers for flood insurance studies. The magnitude of the difference between computed and expected probability decreases as the number of years in the record increases, however. Given that an 85-year record was used for the frequency analyses on the Kaweah River, the 10-, 50-, 100- and 500-year flows determined with expected probability are not likely to be significantly different than those determined with computed probability.

The second element of the hydrologic analysis looked at in detail was the initial reservoir volume assumed for the reservoir routing. Mr. Johnson noted in our interview that a volume of 12,000 acre-feet was assumed at the start of the 30-day inflow hydrograph; this volume corresponds to the target flood season storage volume on the reservoir operating curve. It should be noted that this volume differs from the initial reservoir volume of 8,000 acre-feet originally reported in the Corps' 1990 Kaweah River Hydrology Report. Lake Kaweah daily reservoir volumes were downloaded from a Corps of Engineers website for Water Years 1995 through 2004. A duration analysis of these reservoir volumes indicates that the volume of 12,000 acre-feet was exceeded 47% of the time during the flood control season (November through March) over the last 10 years. While a portion of this time can be attributed to periods immediately following large storms, the fact that the reservoir is fuller than the assumption used in the Corps analysis almost 50% of the time is a potential issue. The effect of assuming a greater initial reservoir volume was therefore investigated using the Corps of Engineers reservoir routing spreadsheets. A less frequently exceeded initial reservoir volume of 24,000 acre-feet, which is exceeded about 20% of the time during flood control season, was tested. The corresponding peak outflow was about 25,000 cfs, which is almost 40% larger than the currently defined 100-year flow of 18,000 cfs. This reflects the fact that the 100-year peak discharge occurs while the reservoir is spilling and a relatively small change in storage volume causes a large increase in outflow.

Finally, the 30-day design inflow hydrograph was compared to several of the largest recorded flow events on the Kaweah River to assess how well the synthetic hydrograph matched actual flood patterns. Average daily flows during the December 1955 and December 1966 were used for the comparison. The results shown in Figure 3 indicate that the design inflow hydrograph is fairly representative of large flood events on the Kaweah River. The primary difference in the synthetic hydrograph is the series of smaller events preceding the largest flow. This suggests that the design inflow hydrograph is somewhat conservative, and may offset uncertainty in the initial reservoir volume.

4. Conclusions and Recommendations

nhc reviewed the Corps of Engineers hydrology developed in support of the 21-foot spillway raise at Terminus Dam for application to the City of Visalia Flood Insurance Study. Three main elements of the hydrology study were examined: 1) the use of expected probability in the frequency analyses; 2) the initial reservoir volume; and 3) comparison of the design inflow hydrograph to actual flood event patterns.

The Corps of Engineers standard application of expected probably was determined to not have any significant implications for the City of Visalia Flood Insurance Study. While FEMA prefers computed probability in determining the 100-year discharge, the 85-year flow record is long enough to suggest that the computed probability flows are likely not much different than the expected probability flows.

Unlike the use of expected probability, the initial reservoir volume assumption does appear to have a significant impact on the 100-year discharge. The Corps of Engineers used 12,000 acre-feet for their analysis, which corresponds to the operational target during much of the flood control season. Since this volume has been exceeded 47% of the time during the winter months over the last 10 years, the Corps' flow routing analyses were re-run assuming a larger initial volume of 24,000 acre-feet. The resultant 100-year discharge of these analyses (25,000 cfs) is almost 40% larger than the Corps' estimated 100-year discharge of 18,000 cfs. While the sensitivity of the 100-year discharge to the starting reservoir water level is of some concern in defining the City of Visalia Flood Insurance Study flows, it is impossible to say with any reliability what level the reservoir would be at the onset of the 30-day Corps storm progression. Furthermore, the pattern of the design inflow hydrograph, which includes several small events antecedent to the large event, is somewhat conservative when compared to the patterns of actual flood events. This conservatism may offset some of the concern with using the lower starting reservoir volume.

Review of the hydrologic analyses performed by the Corps of Engineers in support of the Terminus Dam spillway raise indicates that these analyses are generally applicable for use in the City of Visalia Flood Insurance Study. There is some concern that the Corps' estimated 100-year discharge of 18,000 cfs may be low if the event were to occur coincident with a fuller reservoir starting condition. However, considering that the Corps of Engineers are expected to certify the flows developed in their evaluation the Lake Kaweah Project, there does not appear to be a compelling reason to use alternative flows. **nhc** therefore recommends that the Corps of Engineers design hydrographs be used for the 10-, 50-, 100- and 500-year FEMA flood events.

5. References

Corps of Engineers, Sacramento District, 1990. Office Report. Kaweah River Basin, California - Hydrology.

Corps of Engineers, 1997. Engineering Manual 1110-2-1420. Hydrologic Engineering Requirements for Reservoirs.

Johnson, Wayne. Personal interviews. 20 January 2005 and 16 March 2005.

FIGURES

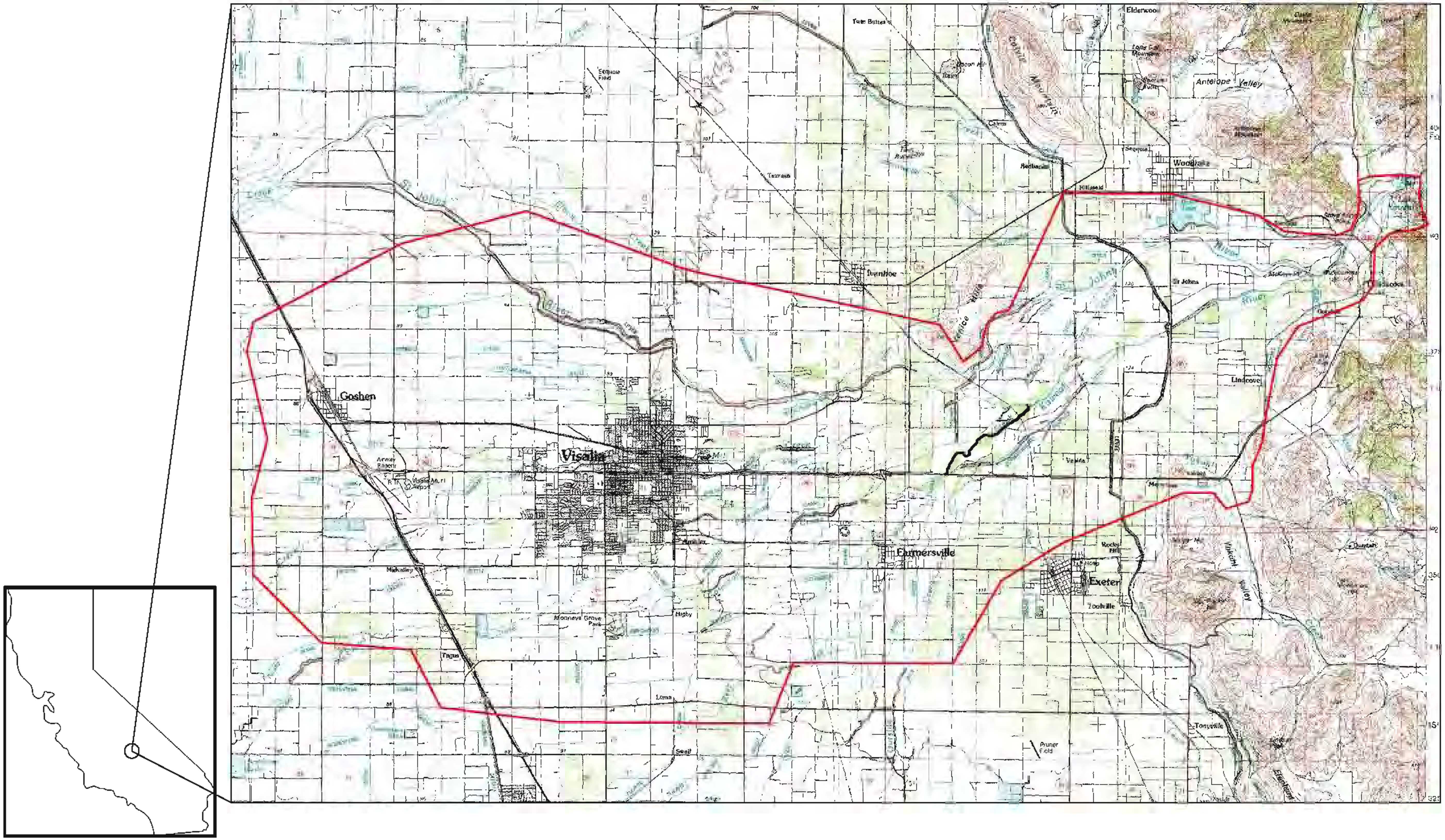


Figure 1. Location Map

nhc
City of Visalia
Flood Insurance Study

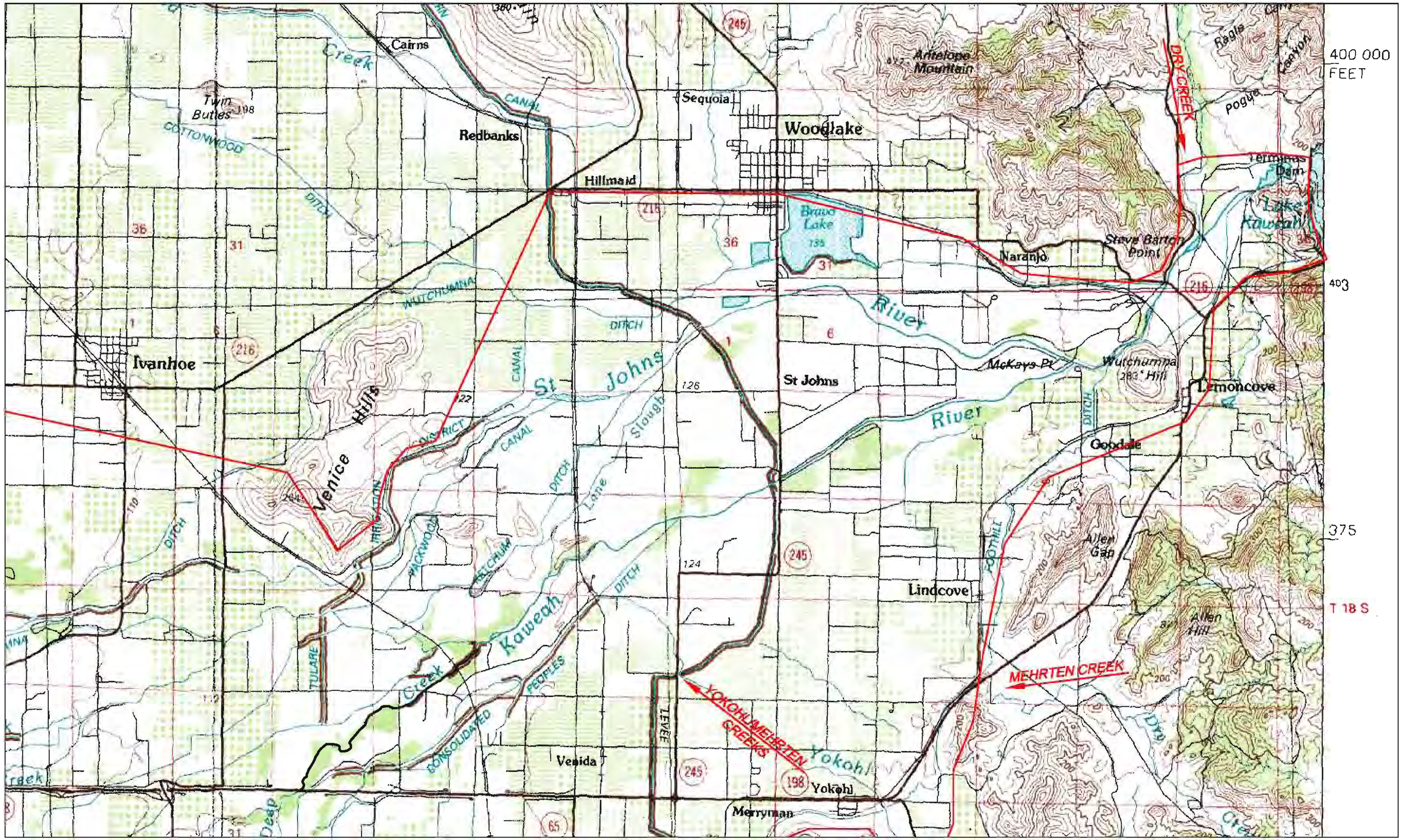


Figure 2. Local Inflows

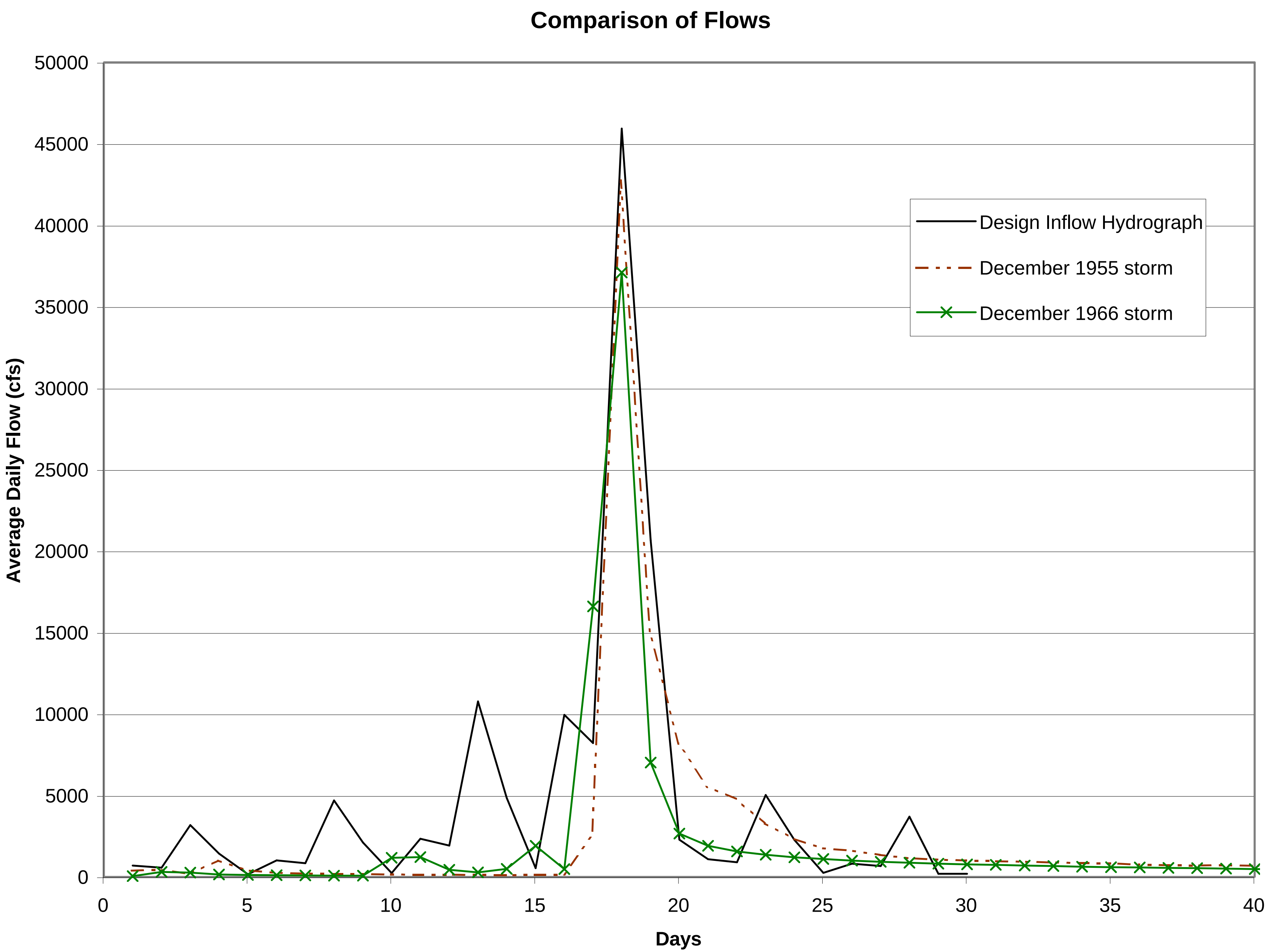


Figure 3 Comparison of Flows

APPENDIX A

ATTACHMENT 7 – TECHNICAL JUSTIFICATION

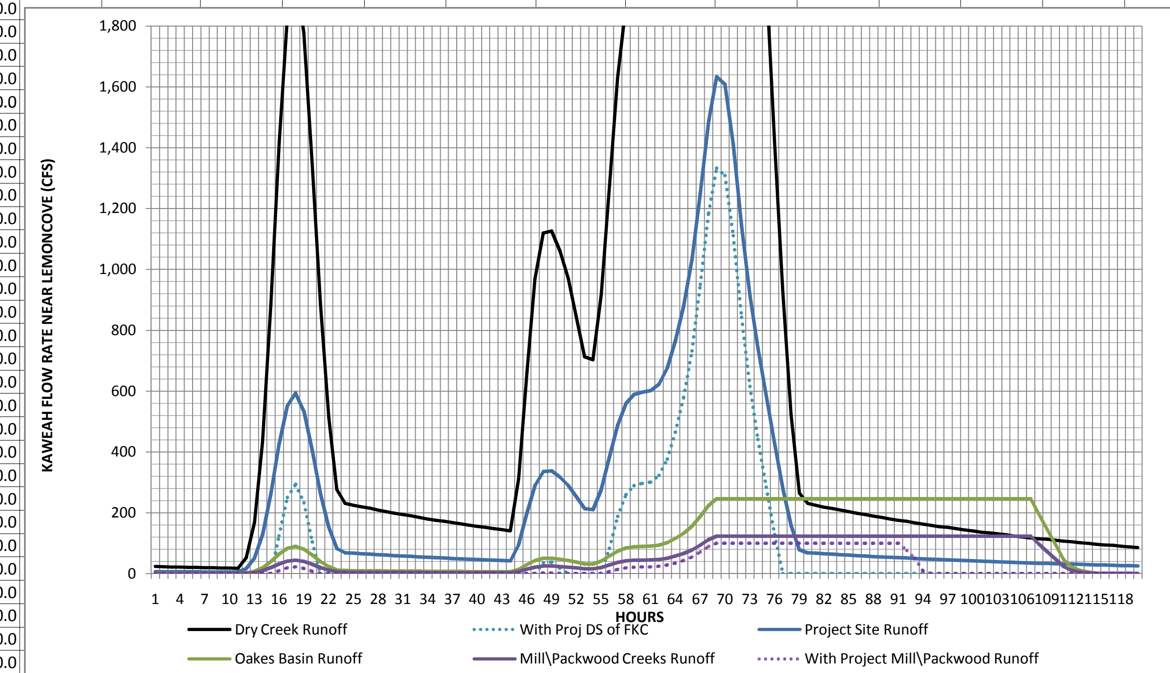
APPENDIX F

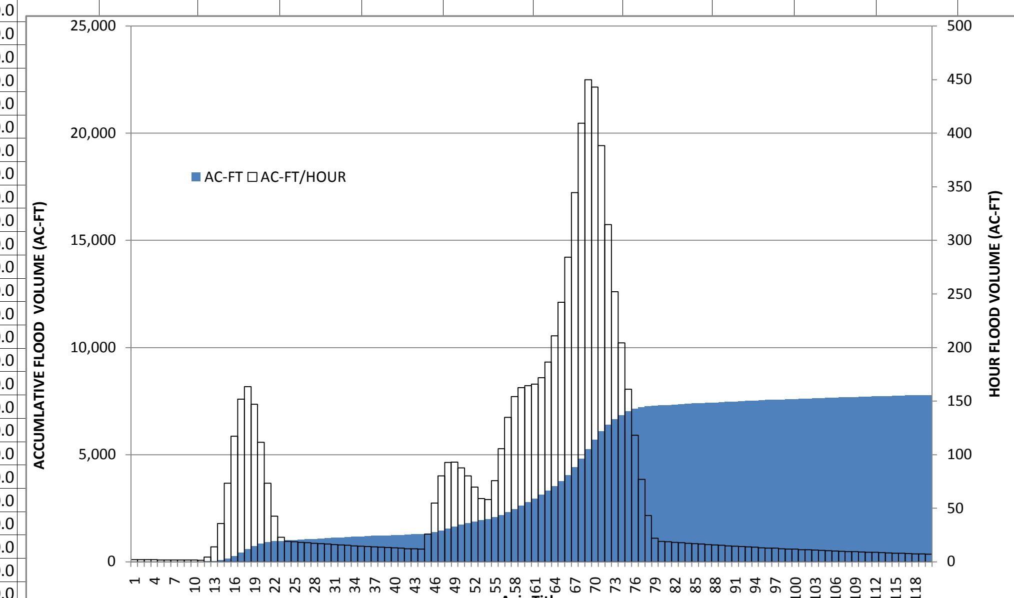
Provost & Pritchard Spreadsheet Model

Hannah Ranch Project Flooding Model / 10 Year Storm - Dry Creek Hydrograph

STANDARD PROJECT FLOOD FLOW (SPECIFIC) DRY CREEK NEAR LEMONCOVE (HOURLY FLOW IN C.F.S.)

				Key Factors:		0.3	300	700		500		33.33%		50.00%				50.00%			
				PROB. FLOOD YEAR 10	RATIO RANK 1	Project Site	With Project DS of FKC	DS of Outside Creek	With Project DS of Outside Creek	DS of Deep Creek	With Project DS of Deep Creek	Oakes Basin	With Project Oakes Basin	Mill Creek	Mill Creek Flooded Volume	With Project Mill Creek	With Proj Mill Creek Flooded Volume	Pack Creek	Pack Creek Flooded Volume	With Project Pack Creek	With Proj Pack Creek Volume
DAY	HOUR	HOURS	CFS	AC-FT /HOUR	TOTAL AC-FT	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	AF	CFS	AF	CFS	AF	CFS	AF
DAY 1	1	1	24	2	2	7	0	4	0	3	0	1	0	1	0.0	0	0.0	1	0.0	0	0.0
DAY 1	2	2	23	2	4	7	0	4	0	3	0	1	0	1	0.0	0	0.0	1	0.0	0	0.0
DAY 1	3	3	22	2	6	7	0	4	0	3	0	1	0	0	0.0	0	0.0	0	0.0	0	0.0
DAY 1	4	4	22	2	8	7	0	4	0	3	0	1	0	0	0.0	0	0.0	0	0.0	0	0.0
DAY 1	5	5	21	2	9	6	0	4	0	3	0	1	0	0	0.0	0	0.0	0	0.0	0	0.0
DAY 1	6	6	21	2	11	6	0	4	0	3	0	1	0	0	0.0	0	0.0	0	0.0	0	0.0
DAY 1	7	7	20	2	13	6	0	4	0	3	0	1	0	0	0.0	0	0.0	0	0.0	0	0.0
DAY 1	8	8	20	2	14	6	0	4	0	3	0	1	0	0	0.0	0	0.0	0	0.0	0	0.0
DAY 1	9	9	19	2	16	6	0	4	0	3	0	1	0	0	0.0	0	0.0	0	0.0	0	0.0
DAY 1	10	10	19	2	17	6	0	4	0	3	0	1	0	0	0.0	0	0.0	0	0.0	0	0.0
DAY 1	11	11	18	1	19	5	0	3	0	2	0	1	0	0	0.0	0	0.0	0	0.0	0	0.0
DAY 1	12	12	53	4	23	16	0	10	0	7	0	2	0	1	0.0	0	0.0	1	0.0	0	0.0
DAY 1	13	13	169	14	37	51	0	32	0	23	0	8	0	4	0.0	0	0.0	4	0.0	0	0.0
DAY 1	14	14	433	36	73	130	0	81	0	59	0	20	0	10	0.0	0	0.0	10	0.0	0	0.0
DAY 1	15	15	885	73	146	266	0	165	0	120	0	40	0	20	0.0	0	0.0	20	0.0	0	0.0
DAY 1	16	16	1,416	117	263	425	125	264	78	193	57	64	19	32	0.0	9	0.0	32	0.0	9	0.0
DAY 1	17	17	1,837	152	415	551	251	343	156	250	114	83	38	42	0.0	19	0.0	42	0.0	19	0.0
DAY 1	18	18	1,979	164	579	594	294	369	183	269	133	90	44	45	0.0	22	0.0	45	0.0	22	0.0
DAY 1	19	19	1,777	147	725	533	233	331	145	242	106	81	35	40	0.0	18	0.0	40	0.0	18	0.0
DAY 1	20	20	1,348	111	837	404	104	251	65	183	47	61	16	31	0.0	8	0.0	31	0.0	8	0.0
DAY 1	21	21	885	73	910	266	0	165	0	120	0	40	0	20	0.0	0	0.0	20	0.0	0	0.0
DAY 1	22	22	513	42	952	154	0	96	0	70	0	23	0	12	0.0	0	0.0	12	0.0	0	0.0
DAY 1	23	23	276	23	975	83	0	51	0	38	0	13	0	6	0.0	0	0.0	6	0.0	0	0.0
DAY 1	24	24	231	19	994	69	0	43	0	31	0	10	0	5	0.0	0	0.0	5	0.0	0	0.0
DAY 2	1	25	225	19	1,013	68	0	42	0	31	0	10	0	5	0.0	0	0.0	5	0.0	0	0.0
DAY 2	2	26	220	18	1,031	66	0	41	0	30	0	10	0	5	0.0	0	0.0	5	0.0	0	0.0
DAY 2	3	27	215	18	1,049	65	0	40	0	29	0	10	0	5	0.0	0	0.0	5	0.0	0	0.0
DAY 2	4	28	209	17	1,066	63	0	39	0	28	0	9	0	5	0.0	0	0.0	5	0.0	0	0.0
DAY 2	5	29	204	17	1,083	61	0	38	0	28	0	9	0	5	0.0	0	0.0	5	0.0	0	0.0
DAY 2	6	30	199	16	1,099	60	0	37	0	27	0	9	0	5	0.0	0	0.0	5	0.0	0	0.0
DAY 2	7	31	194	16	1,115	58	0	36	0	26	0	9	0	4	0.0	0	0.0	4	0.0	0	0.0
DAY 2	8	32	190	16	1,131	57	0	35	0	26	0	9	0	4	0.0	0	0.0	4	0.0	0	0.0
DAY 2	9	33	185	15	1,146	56	0	35	0	25	0	8	0	4	0.0	0	0.0	4	0.0	0	0.0
DAY 2	10	34	180	15	1,161	54	0	34	0	24	0	8	0	4	0.0	0	0.0	4	0.0	0	0.0
DAY 2	11	35	176	15	1,176	53	0	33	0	24	0	8	0	4	0.0	0	0.0	4	0.0	0	0.0
DAY 2	12	36	172	14	1,190	52	0	32	0	23	0	8	0	4	0.0	0	0.0	4	0.0	0	0.0
DAY 2	13	37	168	14	1,204	50	0	31	0	23	0	8	0	4	0.0	0	0.0	4	0.0	0	0.0
DAY 2	14	38	164	14	1,218	49	0	31	0	22	0	7	0	4	0.0	0	0.0	4	0.0	0	0.0
DAY 2	15	39	160	13	1,231	48	0	30	0	22	0	7	0	4	0.0	0	0.0	4	0.0	0	0.0
DAY 2	16	40	156	13	1,244	47	0	29	0	21	0	7	0	4	0.0	0	0.0	4	0.0	0	0.0
DAY 2	17	41	152	13	1,256	46	0	28	0	21	0	7	0	3	0.0	0	0.0	3	0.0	0	0.0
DAY 2	18	42	148	12	1,268	44	0	28	0	20	0	7	0	3	0.0	0	0.0	3	0.0	0	0.0
DAY 2	19	43	145	12	1,280	44	0	27	0	20	0	7	0	3	0.0	0	0.0	3	0.0	0	0.0
DAY 2	20	44	141	12	1,292	42	0	26	0	19	0	6	0	3	0.0	0	0.0	3	0.0	0	0.0
DAY 2	21	45	312	26	1,318	94	0	58	0	42	0	14	0	7	0.0	0	0.0	7	0.0	0	0.0
DAY 2	22	46	662	55	1,373	199	0	123	0	90	0	30	0	15	0.0	0	0.0	15	0.0	0	0.0
DAY 2	23	47	969	80	1,453	291	0	181	0	132	0	44	0	22	0.0	0	0.0	22	0.0	0	0.0
DAY 2	24	48	1,120	93	1,545	336	36	209	22	152	16	51	5	25	0.0	3	0.0	25	0.0	3	0.0
DAY 3	1	49	1,126	93	1,638	338	38	210	23	153	17	51	6	26	0.0	3	0.0	26	0.0	3	0.0
DAY 3	2	50	1,061	88	1,726	318	18	198	11	144	8	48	3	24	0.0	1	0.0	24	0.0	1	0.0
DAY 3	3	51	970	80	1,806	291	0	181	0	132	0	44	0	22	0.0	0	0.0	22	0.0	0	0.0
DAY 3	4	52	844	70	1,876	253	0	157	0	115	0	38	0	19	0.0	0	0.0	19	0.0	0	0.0
DAY 3	5	53	713	59	1,935	214	0	133	0	97	0	32	0	16	0.0	0	0.0	16	0.0	0	0.0
DAY 3	6	54	703	58	1,993	211	0	131	0	96	0	32	0	16	0.0	0	0.0	16	0.0	0	0.0
DAY 3	7	55	917	76	2,069	275	0	171	0	125	0	42	0	21	0.0	0	0.0	21	0.0	0	0.0
DAY 3	8	56	1,278	106	2,174	383	83	238	52	174	38	58	13	29	0.0	6	0.0	29	0.0	6	0.0
DAY 3	9	57	1,629	135	2,309	489	189	304	117	222	86	74	29	37	0.0	14	0.0	37	0.0	14	0.0
DAY 3	10	58	1,866	154	2,463	560	260	348	161	254	118	85	39	42	0.0	20	0.0	42	0.0	20	0.0
DAY 3	11	59	1,966	162	2,626	590	290	367	180	268	131	89	44	45	0.0	22	0.0	45	0.0	22	0.0
DAY 3	12	60	1,989	164	2,790	597	297	371	184	271	135	90	45	45	0.0	22	0.0	45	0.0	22	0.0
DAY 3	13	61	2,005	166	2,956	602	302	374	187	273	137	91	46	45	0.0	23	0.0	45	0.0	23	0.0
DAY 3	14	62	2,077	172	3,127	623	323	387	201	283	147	94	49	47	0.0	24	0.0	47	0.0	24	0.0
DAY 3	15	63	2,255	186	3,314	677	377	421	234	307	171	102	57	51	0.0	28	0.0	51	0.0	28	0.0
DAY 3	16	64	2,550	211	3,524	765	465	476	289	347	211	116	70	58	0.0	35	0.0	58	0.0	35	0.0
DAY 3	17	65	2,931	242	3,767	879	579	547	360	399	263	133	88	66	0.0	44	0.0	66	0.0	44	0.0
DAY 3	18	66	3,441	284	4,051	1,032	732	642	455	468	332	156	111	78	0.0	55	0.0	78	0.0	55	0.0
DAY 3	19	67	4,169	345	4,396	1,251	951	777	591	567	431	189	144	95	0.0	72	0.0	95	0.0	72	0.0
DAY 3	20	68	4,953	409	4,805	1,486	1,186	924	737	674	538	225	179	112	0.0	90	0.0	112	0.0	90	0.0
DAY 3	21	69	***5,444***	450	5,255	1,633	1,333	1,015	829	741	605	247	202	123	0.0	101	0.0	123	0.0	101	0.0





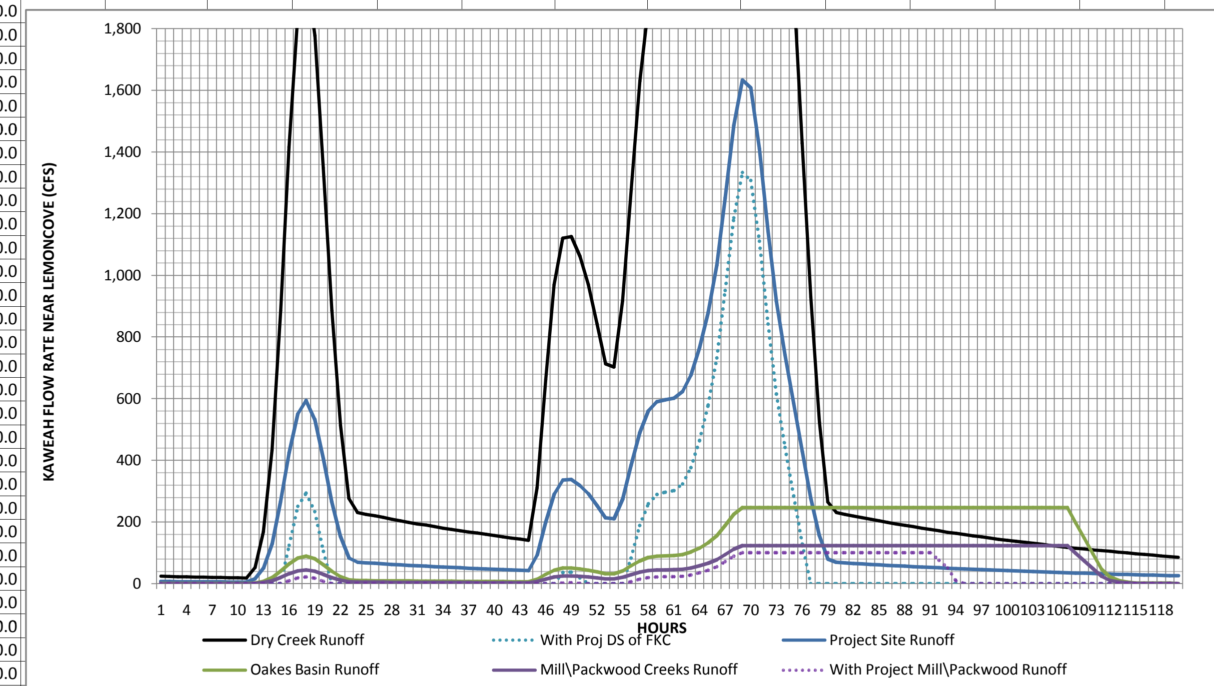
Hannah Ranch Project Flooding Model / 10 Year Storm - Dry Creek Hydrograph

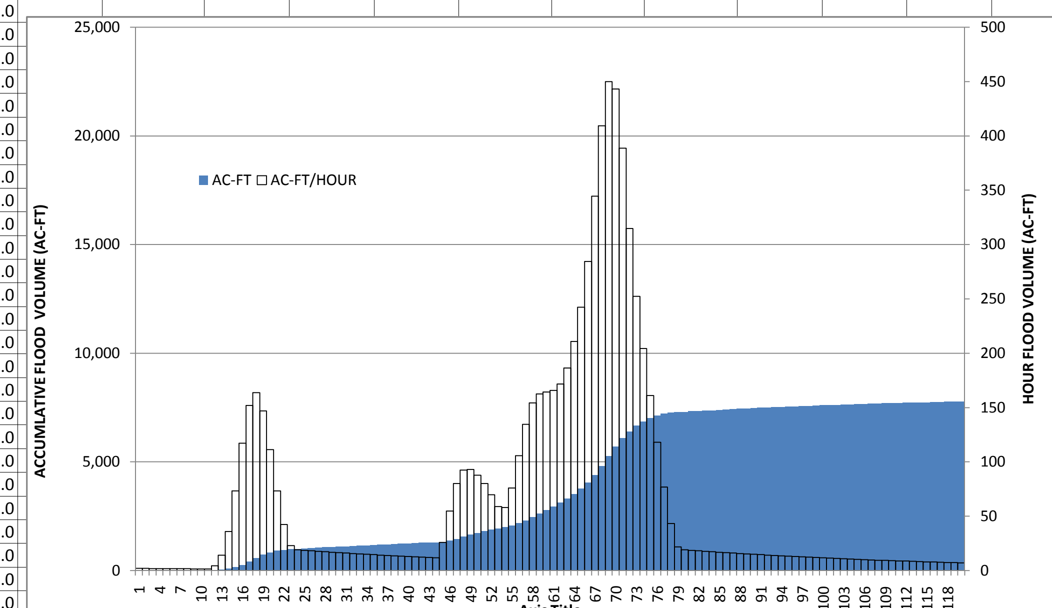
STANDARD PROJECT FLOOD FLOW (SPECIFIC) DRY CREEK NEAR LEMONCOVE (HOURLY FLOW IN C.F.S.)				***Key Factors:***		0.3	300	700		500		33.33%		50.00%				50.00%			
				PROB. FLOOD YEAR	RATIO RANK	Project Site	With Project DS of FKC	DS of Outside Creek	With Project DS of Outside Creek	DS of Deep Creek	With Project DS of Deep Creek	Oakes Basin	With Project Oakes Basin	Mill Creek	Mill Creek Flooded Volume	With Project Mill Creek	With Proj Mill Creek Flooded Volume	Pack Creek	Pack Creek Flooded Volume	With Project Pack Creek	With Proj Pack Creek Volume
				10	1																
DAY	HOUR	HOURS	CFS	AC-FT /HOUR	TOTAL AC-FT	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	AF	CFS	AF	CFS	AF	CFS	AF
DAY 3	22	70	5,360	443	5,698	1,608	1,308	1,000	813	729	593	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 3	23	71	4,701	389	6,086	1,410	1,110	877	690	640	504	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 3	24	72	3,808	315	6,401	1,142	842	710	524	518	382	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	1	73	3,051	252	6,653	915	615	569	382	415	279	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	2	74	2,471	204	6,857	741	441	461	274	336	200	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	3	75	1,949	161	7,019	585	285	363	177	265	129	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	4	76	1,428	118	7,137	428	128	266	80	194	58	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	5	77	930	77	7,213	279	0	173	0	127	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	6	78	523	43	7,257	157	0	98	0	71	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	7	79	265	22	7,279	80	0	49	0	36	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	8	80	231	19	7,298	69	0	43	0	31	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	9	81	225	19	7,316	68	0	42	0	31	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	10	82	219	18	7,334	66	0	41	0	30	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	11	83	214	18	7,352	64	0	40	0	29	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	12	84	209	17	7,369	63	0	39	0	28	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	13	85	204	17	7,386	61	0	38	0	28	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	14	86	199	16	7,403	60	0	37	0	27	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	15	87	194	16	7,419	58	0	36	0	26	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	16	88	189	16	7,434	57	0	35	0	26	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	17	89	185	15	7,450	56	0	35	0	25	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	18	90	180	15	7,464	54	0	34	0	24	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	19	91	176	15	7,479	53	0	33	0	24	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	20	92	172	14	7,493	52	0	32	0	23	0	247	152	123	0.0	76	0.0	123	0.0	76	0.0
DAY 4	21	93	167	14	7,507	50	0	31	0	23	0	247	102	123	0.0	51	0.0	123	0.0	51	0.0
DAY 4	22	94	163	13	7,520	49	0	30	0	22	0	247	18	123	0.0	9	0.0	123	0.0	9	0.0
DAY 4	23	95	159	13	7,534	48	0	30	0	22	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 4	24	96	155	13	7,546	47	0	29	0	21	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	1	97	152	13	7,559	46	0	28	0	21	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	2	98	148	12	7,571	44	0	28	0	20	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	3	99	144	12	7,583	43	0	27	0	20	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	4	100	141	12	7,595	42	0	26	0	19	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	5	101	137	11	7,606	41	0	26	0	19	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	6	102	134	11	7,617	40	0	25	0	18	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	7	103	131	11	7,628	39	0	24	0	18	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	8	104	128	11	7,639	38	0	24	0	17	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	9	105	124	10	7,649	37	0	23	0	17	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	10	106	121	10	7,659	36	0	23	0	16	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	11	107	118	10	7,669	35	0	22	0	16	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	12	108	115	10	7,678	35	0	21	0	16	0	197	0	98	0.0	0	0.0	98	0.0	0	0.0
DAY 5	13	109	113	9	7,687	34	0	21	0	15	0	147	0	73	0.0	0	0.0	73	0.0	0	0.0
DAY 5	14	110	110	9	7,696	33	0	21	0	15	0	97	0	48	0.0	0	0.0	48	0.0	0	0.0
DAY 5	15	111	107	9	7,705	32	0	20	0	15	0	47	0	23	0.0	0	0.0	23	0.0	0	0.0
DAY 5	16	112	105	9	7,714	32	0	20	0	14	0	22	0	11	0.0	0	0.0	11	0.0	0	0.0
DAY 5	17	113	102	8	7,722	31	0	19	0	14	0	11	0	5	0.0	0	0.0	5	0.0	0	0.0
DAY 5	18	114	100	8	7,731	30	0	19	0	14	0	5	0	3	0.0	0	0.0	3	0.0	0	0.0
DAY 5	19	115	97	8	7,739	29	0	18	0	13	0	2	0	1	0.0	0	0.0	1	0.0	0	0.0
DAY 5	20	116	95	8	7,747	29	0	18	0	13	0	2	0	1	0.0	0	0.0	1	0.0	0	0.0
DAY 5	21	117	93	8	7,754	28	0	17	0	13	0	2	0	1	0.0	0	0.0	1	0.0	0	0.0
DAY 5	22	118	90	7	7,762	27	0	17	0	12	0	2	0	1	0.0	0	0.0	1	0.0	0	0.0
DAY 5	23	119	88	7	7,769	26	0	16	0	12	0	2	0	1	0.0	0	0.0	1	0.0	0	0.0
DAY 5	24	120	86	7	7,776	26	0	16	0	12	0	0	0	0	0.0	0	0.0	0	0.0	0	0.0
						28,227	13,196	17,547	8,203	12,804	5,986	12,805	5,986	6,402	0	2,993	0	6,402	0	2,993	0
							15,032	CFS-HRS	9,344	CFS-HRS	6,819	CFS-HRS						12,805			
							1,242	AF	772	AF	564	AF									
						Total layoff into Outside and Deep Creeks =					***1,336***	AF									

Hannah Ranch Project Flooding Model / 25 Year Storm - Dry Creek Hydrograph

STANDARD PROJECT FLOOD FLOW (SPECIFIC) DRY CREEK NEAR LEMONCOVE (HOURLY FLOW IN C.F.S.)

DAY	HOUR	HOURS	CFS	PROB. FLOOD YEAR 10 / AC-FT /HOUR	RATIO RANK 1 / TOTAL AC-FT	Project Site CFS	With Project DS of FKC CFS	DS of Outside Creek CFS	With Project DS of Outside Creek CFS	DS of Deep Creek CFS	With Project DS of Deep Creek CFS	Oakes Basin CFS	With Project Oakes Basin CFS	Mill Creek CFS	Mill Creek Flooded Volume AF	With Project Mill Creek CFS	With Proj Mill Creek Flooded Volume AF	Pack Creek CFS	Pack Creek Flooded Volume AF	With Project Pack Creek CFS	With Proj Pack Creek Volume AF
					Key Factors:	0.3	300	700		500		33.33%		50.00%				50.00%			
DAY 1	1	1	24	2	2	7	0	4	0	3	0	1	0	1	0.0	0	0.0	1	0.0	0	0.0
DAY 1	2	2	23	2	4	7	0	4	0	3	0	1	0	1	0.0	0	0.0	1	0.0	0	0.0
DAY 1	3	3	22	2	6	7	0	4	0	3	0	1	0	0	0.0	0	0.0	0	0.0	0	0.0
DAY 1	4	4	22	2	8	7	0	4	0	3	0	1	0	0	0.0	0	0.0	0	0.0	0	0.0
DAY 1	5	5	21	2	9	6	0	4	0	3	0	1	0	0	0.0	0	0.0	0	0.0	0	0.0
DAY 1	6	6	21	2	11	6	0	4	0	3	0	1	0	0	0.0	0	0.0	0	0.0	0	0.0
DAY 1	7	7	20	2	13	6	0	4	0	3	0	1	0	0	0.0	0	0.0	0	0.0	0	0.0
DAY 1	8	8	20	2	14	6	0	4	0	3	0	1	0	0	0.0	0	0.0	0	0.0	0	0.0
DAY 1	9	9	19	2	16	6	0	4	0	3	0	1	0	0	0.0	0	0.0	0	0.0	0	0.0
DAY 1	10	10	19	2	17	6	0	4	0	3	0	1	0	0	0.0	0	0.0	0	0.0	0	0.0
DAY 1	11	11	18	1	19	5	0	3	0	2	0	1	0	0	0.0	0	0.0	0	0.0	0	0.0
DAY 1	12	12	53	4	23	16	0	10	0	7	0	2	0	1	0.0	0	0.0	1	0.0	0	0.0
DAY 1	13	13	169	14	37	51	0	32	0	23	0	8	0	4	0.0	0	0.0	4	0.0	0	0.0
DAY 1	14	14	433	36	73	130	0	81	0	59	0	20	0	10	0.0	0	0.0	10	0.0	0	0.0
DAY 1	15	15	885	73	146	266	0	165	0	120	0	40	0	20	0.0	0	0.0	20	0.0	0	0.0
DAY 1	16	16	1,416	117	263	425	125	264	78	193	57	64	19	32	0.0	9	0.0	32	0.0	9	0.0
DAY 1	17	17	1,837	152	415	551	251	343	156	250	114	83	38	42	0.0	19	0.0	42	0.0	19	0.0
DAY 1	18	18	1,979	164	579	594	294	369	183	269	133	90	44	45	0.0	22	0.0	45	0.0	22	0.0
DAY 1	19	19	1,777	147	725	533	233	331	145	242	106	81	35	40	0.0	18	0.0	40	0.0	18	0.0
DAY 1	20	20	1,348	111	837	404	104	251	65	183	47	61	16	31	0.0	8	0.0	31	0.0	8	0.0
DAY 1	21	21	885	73	910	266	0	165	0	120	0	40	0	20	0.0	0	0.0	20	0.0	0	0.0
DAY 1	22	22	513	42	952	154	0	96	0	70	0	23	0	12	0.0	0	0.0	12	0.0	0	0.0
DAY 1	23	23	276	23	975	83	0	51	0	38	0	13	0	6	0.0	0	0.0	6	0.0	0	0.0
DAY 1	24	24	231	19	994	69	0	43	0	31	0	10	0	5	0.0	0	0.0	5	0.0	0	0.0
DAY 2	1	25	225	19	1,013	68	0	42	0	31	0	10	0	5	0.0	0	0.0	5	0.0	0	0.0
DAY 2	2	26	220	18	1,031	66	0	41	0	30	0	10	0	5	0.0	0	0.0	5	0.0	0	0.0
DAY 2	3	27	215	18	1,049	65	0	40	0	29	0	10	0	5	0.0	0	0.0	5	0.0	0	0.0
DAY 2	4	28	209	17	1,066	63	0	39	0	28	0	9	0	5	0.0	0	0.0	5	0.0	0	0.0
DAY 2	5	29	204	17	1,083	61	0	38	0	28	0	9	0	5	0.0	0	0.0	5	0.0	0	0.0
DAY 2	6	30	199	16	1,099	60	0	37	0	27	0	9	0	5	0.0	0	0.0	5	0.0	0	0.0
DAY 2	7	31	194	16	1,115	58	0	36	0	26	0	9	0	4	0.0	0	0.0	4	0.0	0	0.0
DAY 2	8	32	190	16	1,131	57	0	35	0	26	0	9	0	4	0.0	0	0.0	4	0.0	0	0.0
DAY 2	9	33	185	15	1,146	56	0	35	0	25	0	8	0	4	0.0	0	0.0	4	0.0	0	0.0
DAY 2	10	34	180	15	1,161	54	0	34	0	24	0	8	0	4	0.0	0	0.0	4	0.0	0	0.0
DAY 2	11	35	176	15	1,176	53	0	33	0	24	0	8	0	4	0.0	0	0.0	4	0.0	0	0.0
DAY 2	12	36	172	14	1,190	52	0	32	0	23	0	8	0	4	0.0	0	0.0	4	0.0	0	0.0
DAY 2	13	37	168	14	1,204	50	0	31	0	23	0	8	0	4	0.0	0	0.0	4	0.0	0	0.0
DAY 2	14	38	164	14	1,218	49	0	31	0	22	0	7	0	4	0.0	0	0.0	4	0.0	0	0.0
DAY 2	15	39	160	13	1,231	48	0	30	0	22	0	7	0	4	0.0	0	0.0	4	0.0	0	0.0
DAY 2	16	40	156	13	1,244	47	0	29	0	21	0	7	0	4	0.0	0	0.0	4	0.0	0	0.0
DAY 2	17	41	152	13	1,256	46	0	28	0	21	0	7	0	3	0.0	0	0.0	3	0.0	0	0.0
DAY 2	18	42	148	12	1,268	44	0	28	0	20	0	7	0	3	0.0	0	0.0	3	0.0	0	0.0
DAY 2	19	43	145	12	1,280	44	0	27	0	20	0	7	0	3	0.0	0	0.0	3	0.0	0	0.0
DAY 2	20	44	141	12	1,292	42	0	26	0	19	0	6	0	3	0.0	0	0.0	3	0.0	0	0.0
DAY 2	21	45	312	26	1,318	94	0	58	0	42	0	14	0	7	0.0	0	0.0	7	0.0	0	0.0
DAY 2	22	46	662	55	1,373	199	0	123	0	90	0	30	0	15	0.0	0	0.0	15	0.0	0	0.0
DAY 2	23	47	969	80	1,453	291	0	181	0	132	0	44	0	22	0.0	0	0.0	22	0.0	0	0.0
DAY 2	24	48	1,120	93	1,545	336	36	209	22	152	16	51	5	25	0.0	3	0.0	25	0.0	3	0.0
DAY 3	1	49	1,126	93	1,638	338	38	210	23	153	17	51	6	26	0.0	3	0.0	26	0.0	3	0.0
DAY 3	2	50	1,061	88	1,726	318	18	198	11	144	8	48	3	24	0.0	1	0.0	24	0.0	1	0.0
DAY 3	3	51	970	80	1,806	291	0	181	0	132	0	44	0	22	0.0	0	0.0	22	0.0	0	0.0
DAY 3	4	52	844	70	1,876	253	0	157	0	115	0	38	0	19	0.0	0	0.0	19	0.0	0	0.0
DAY 3	5	53	713	59	1,935	214	0	133	0	97	0	32	0	16	0.0	0	0.0	16	0.0	0	0.0
DAY 3	6	54	703	58	1,993	211	0	131	0	96	0	32	0	16	0.0	0	0.0	16	0.0	0	0.0
DAY 3	7	55	917	76	2,069	275	0	171	0	125	0	42	0	21	0.0	0	0.0	21	0.0	0	0.0
DAY 3	8	56	1,278	106	2,174	383	83	238	52	174	38	58	13	29	0.0	6	0.0	29	0.0	6	0.0
DAY 3	9	57	1,629	135	2,309	489	189	304	117	222	86	74	29	37	0.0	14	0.0	37	0.0	14	0.0
DAY 3	10	58	1,866	154	2,463	560	260	348	161	254	118	85	39	42	0.0	20	0.0	42	0.0	20	0.0
DAY 3	11	59	1,966	162	2,626	590	290	367	180	268	131	89	44	45	0.0	22	0.0	45	0.0	22	0.0
DAY 3	12	60	1,989	164	2,790	597	297	371	184	271	135	90	45	45	0.0	22	0.0	45	0.0	22	0.0
DAY 3	13	61	2,005	166	2,956	602	302	374	187	273	137	91	46	45	0.0	23	0.0	45	0.0	23	0.0
DAY 3	14	62	2,077	172	3,127	623	323	387	201	283	147	94	49	47	0.0	24	0.0	47	0.0	24	0.0
DAY 3	15	63	2,255	186	3,314	677	377	421	234	307	171	102	57	51	0.0	28	0.0	51	0.0	28	0.0
DAY 3	16	64	2,550	211	3,524	765	465	476	289	347	211	116	70	58	0.0	35	0.0	58	0.0	35	0.0
DAY 3	17	65	2,931	242	3,767	879	579	547	360	399	263	133	88	66	0.0	44	0.0	66	0.0	44	0.0
DAY 3	18	66	3,441	284	4,051	1,032	732	642	455	468	332	156	111	78	0.0	55	0.0	78	0.0	55	0.0
DAY 3	19	67	4,169	345	4,396	1,251	951	777	591	567	431	189	144	95	0.0	72	0.0	95	0.0	72	0.0
DAY 3	20	68	4,953	409	4,805	1,486	1,186	924	737	674	538	225	179	112	0.0	90	0.0	112	0.0	90	0.0
DAY 3	21	69	***5,444***	450	5,255	1,633	1,333	1,015	829	741	605	247	202	123	0.0	101	0.0	123	0.0	101	0.0



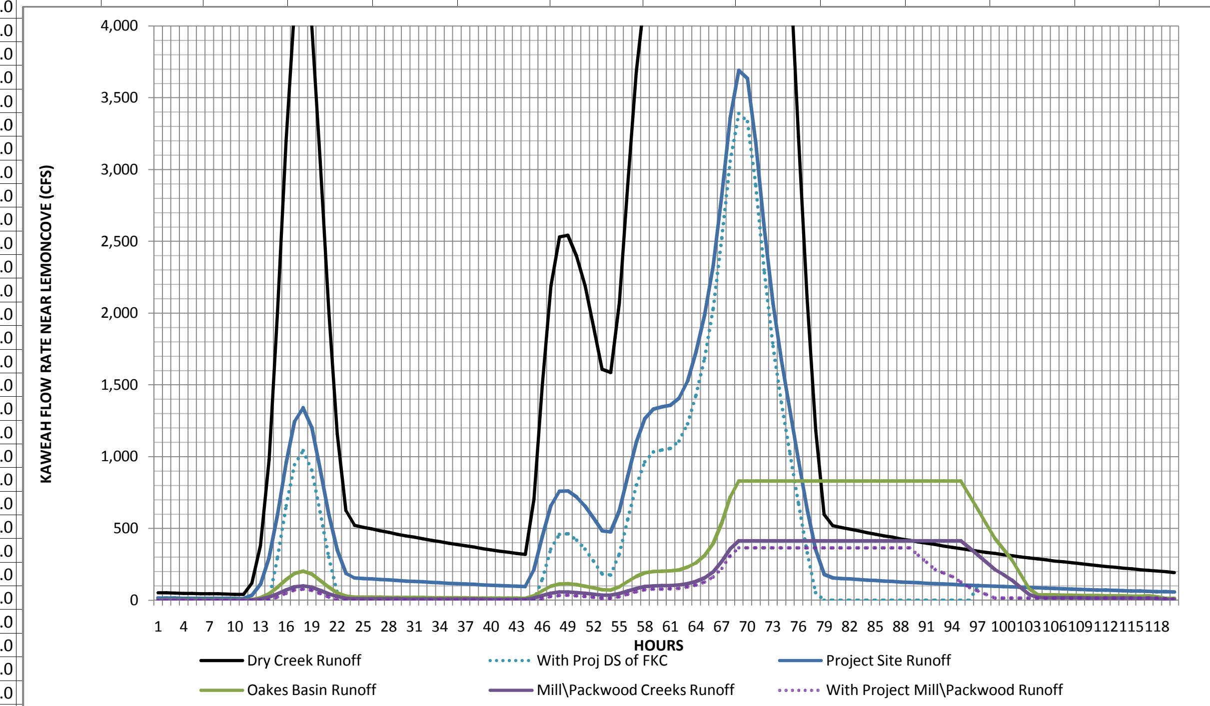


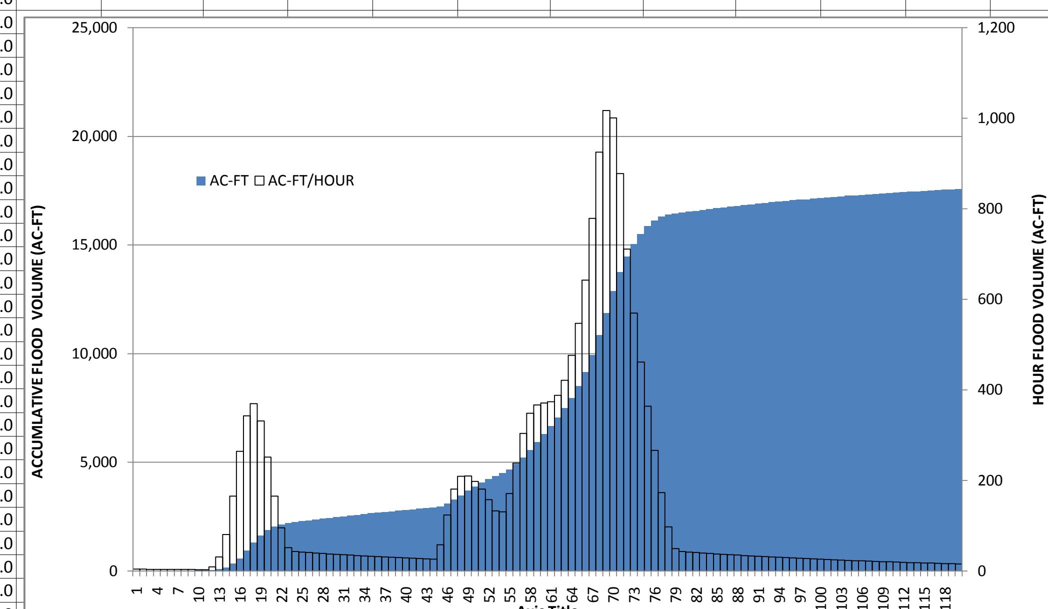
Hannah Ranch Project Flooding Model / 25 Year Storm - Dry Creek Hydrograph

STANDARD PROJECT FLOOD FLOW (SPECIFIC) DRY CREEK NEAR LEMONCOVE (HOURLY FLOW IN C.F.S.)				PROB. FLOOD YEAR	RATIO RANK	Project Site	With Project DS of FKC	DS of Outside Creek	With Project DS of Outside Creek	DS of Deep Creek	With Project DS of Deep Creek	Oakes Basin	With Project Oakes Basin	Mill Creek	Mill Creek Flooded Volume	With Project Mill Creek	With Proj Mill Creek Flooded Volume	Pack Creek	Pack Creek Flooded Volume	With Project Pack Creek	With Proj Pack Creek Volume
				Key Factors:		0.3	300	700		500		33.33%		50.00%				50.00%			
				10	1																
DAY	HOUR	HOURS	CFS	AC-FT /HOUR	TOTAL AC-FT	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	AF	CFS	AF	CFS	AF	CFS	AF
DAY 3	22	70	5,360	443	5,698	1,608	1,308	1,000	813	729	593	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 3	23	71	4,701	389	6,086	1,410	1,110	877	690	640	504	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 3	24	72	3,808	315	6,401	1,142	842	710	524	518	382	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	1	73	3,051	252	6,653	915	615	569	382	415	279	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	2	74	2,471	204	6,857	741	441	461	274	336	200	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	3	75	1,949	161	7,019	585	285	363	177	265	129	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	4	76	1,428	118	7,137	428	128	266	80	194	58	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	5	77	930	77	7,213	279	0	173	0	127	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	6	78	523	43	7,257	157	0	98	0	71	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	7	79	265	22	7,279	80	0	49	0	36	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	8	80	231	19	7,298	69	0	43	0	31	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	9	81	225	19	7,316	68	0	42	0	31	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	10	82	219	18	7,334	66	0	41	0	30	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	11	83	214	18	7,352	64	0	40	0	29	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	12	84	209	17	7,369	63	0	39	0	28	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	13	85	204	17	7,386	61	0	38	0	28	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	14	86	199	16	7,403	60	0	37	0	27	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	15	87	194	16	7,419	58	0	36	0	26	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	16	88	189	16	7,434	57	0	35	0	26	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	17	89	185	15	7,450	56	0	35	0	25	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	18	90	180	15	7,464	54	0	34	0	24	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	19	91	176	15	7,479	53	0	33	0	24	0	247	202	123	0.0	101	0.0	123	0.0	101	0.0
DAY 4	20	92	172	14	7,493	52	0	32	0	23	0	247	152	123	0.0	76	0.0	123	0.0	76	0.0
DAY 4	21	93	167	14	7,507	50	0	31	0	23	0	247	102	123	0.0	51	0.0	123	0.0	51	0.0
DAY 4	22	94	163	13	7,520	49	0	30	0	22	0	247	18	123	0.0	9	0.0	123	0.0	9	0.0
DAY 4	23	95	159	13	7,534	48	0	30	0	22	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 4	24	96	155	13	7,546	47	0	29	0	21	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	1	97	152	13	7,559	46	0	28	0	21	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	2	98	148	12	7,571	44	0	28	0	20	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	3	99	144	12	7,583	43	0	27	0	20	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	4	100	141	12	7,595	42	0	26	0	19	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	5	101	137	11	7,606	41	0	26	0	19	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	6	102	134	11	7,617	40	0	25	0	18	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	7	103	131	11	7,628	39	0	24	0	18	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	8	104	128	11	7,639	38	0	24	0	17	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	9	105	124	10	7,649	37	0	23	0	17	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	10	106	121	10	7,659	36	0	23	0	16	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	11	107	118	10	7,669	35	0	22	0	16	0	247	0	123	0.0	0	0.0	123	0.0	0	0.0
DAY 5	12	108	115	10	7,678	35	0	21	0	16	0	197	0	98	0.0	0	0.0	98	0.0	0	0.0
DAY 5	13	109	113	9	7,687	34	0	21	0	15	0	147	0	73	0.0	0	0.0	73	0.0	0	0.0
DAY 5	14	110	110	9	7,696	33	0	21	0	15	0	97	0	48	0.0	0	0.0	48	0.0	0	0.0
DAY 5	15	111	107	9	7,705	32	0	20	0	15	0	47	0	23	0.0	0	0.0	23	0.0	0	0.0
DAY 5	16	112	105	9	7,714	32	0	20	0	14	0	22	0	11	0.0	0	0.0	11	0.0	0	0.0
DAY 5	17	113	102	8	7,722	31	0	19	0	14	0	11	0	5	0.0	0	0.0	5	0.0	0	0.0
DAY 5	18	114	100	8	7,731	30	0	19	0	14	0	5	0	3	0.0	0	0.0	3	0.0	0	0.0
DAY 5	19	115	97	8	7,739	29	0	18	0	13	0	2	0	1	0.0	0	0.0	1	0.0	0	0.0
DAY 5	20	116	95	8	7,747	29	0	18	0	13	0	2	0	1	0.0	0	0.0	1	0.0	0	0.0
DAY 5	21	117	93	8	7,754	28	0	17	0	13	0	2	0	1	0.0	0	0.0	1	0.0	0	0.0
DAY 5	22	118	90	7	7,762	27	0	17	0	12	0	2	0	1	0.0	0	0.0	1	0.0	0	0.0
DAY 5	23	119	88	7	7,769	26	0	16	0	12	0	2	0	1	0.0	0	0.0	1	0.0	0	0.0
DAY 5	24	120	86	7	7,776	26	0	16	0	12	0	0	0	0	0.0	0	0.0	0	0.0	0	0.0
						28,227	13,196	17,547	8,203	12,804	5,986	12,805	5,986	6,402	0	2,993	0	6,402	0	2,993	0
							15,032	CFS-HRS	9,344	CFS-HRS	6,819	CFS-HRS						12,805			
							1,242	AF	772	AF	564	AF									
						Total layoff into Outside and Deep Creeks =					***1,336***	AF									

Hannah Ranch Project Flooding Model / 50 Year Storm - Dry Creek Hydrograph

STANDARD PROJECT FLOOD FLOW (SPECIFIC) DRY CREEK NEAR LEMONCOVE (HOURLY FLOW IN C.F.S.)				***Key Factors:***		0.3	300	700		500		33.33%		50.00%				50.00%			
				PROB. FLOOD YEAR 50	RATIO RANK 1	Project Site	With Project DS of FKC	DS of Outside Creek	With Project DS of Outside Creek	DS of Deep Creek	With Project DS of Deep Creek	Oakes Basin	With Project Oakes Basin	Mill Creek	Mill Creek Flooded Volume	With Project Mill Creek	With Proj Mill Creek Flooded Volume	Pack Creek	Packwood Creek Flooded Volume	With Project Packwood Creek	With Proj Packwood Volume
DAY	HOUR	HOURS	CFS	AC-FT /HOUR	TOTAL AC-FT	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	AF	CFS	AF	CFS	AF	CFS	AF
DAY 1	1	1	53	4	4	16	16	10	10	7	7	2	2	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	2	2	52	4	9	16	16	10	10	7	7	2	2	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	3	3	50	4	13	15	15	9	9	7	7	2	2	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	4	4	49	4	17	15	15	9	9	7	7	2	2	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	5	5	48	4	21	14	14	9	9	7	7	2	2	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	6	6	47	4	25	14	14	9	9	6	6	2	2	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	7	7	46	4	29	14	14	9	9	6	6	2	2	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	8	8	45	4	32	14	14	8	8	6	6	2	2	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	9	9	44	4	36	13	13	8	8	6	6	2	2	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	10	10	42	3	39	13	13	8	8	6	6	2	2	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	11	11	41	3	43	12	12	8	8	6	6	2	2	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	12	12	119	10	53	36	0	22	0	16	0	5	0	3	0.0	0	0.0	3	0.0	0	0.0
DAY 1	13	13	382	32	84	115	0	71	0	52	0	17	0	9	0.0	0	0.0	9	0.0	0	0.0
DAY 1	14	14	979	81	165	294	0	183	0	133	0	44	0	22	0.0	0	0.0	22	0.0	0	0.0
DAY 1	15	15	2,000	165	330	600	300	373	186	272	136	91	45	45	0.0	23	0.0	45	0.0	23	0.0
DAY 1	16	16	3,199	264	595	960	660	597	410	435	299	145	100	73	0.0	50	0.0	73	0.0	50	0.0
DAY 1	17	17	4,151	343	938	1,245	945	774	588	565	429	188	143	94	0.0	71	0.0	94	0.0	71	0.0
DAY 1	18	18	4,472	370	1,307	1,342	1,042	834	647	609	472	203	157	101	0.0	79	0.0	101	0.0	79	0.0
DAY 1	19	19	4,015	332	1,639	1,205	905	749	562	546	410	182	137	91	0.0	68	0.0	91	0.0	68	0.0
DAY 1	20	20	3,047	252	1,891	914	614	568	382	415	279	138	93	69	0.0	46	0.0	69	0.0	46	0.0
DAY 1	21	21	2,001	165	2,056	600	300	373	187	272	136	91	45	45	0.0	23	0.0	45	0.0	23	0.0
DAY 1	22	22	1,159	96	2,152	348	48	216	30	158	22	53	7	26	0.0	4	0.0	26	0.0	4	0.0
DAY 1	23	23	624	52	2,204	187	0	116	0	85	0	28	0	14	0.0	0	0.0	14	0.0	0	0.0
DAY 1	24	24	522	43	2,247	157	0	97	0	71	0	24	0	12	0.0	0	0.0	12	0.0	0	0.0
DAY 2	1	25	509	42	2,289	153	0	95	0	69	0	23	0	12	0.0	0	0.0	12	0.0	0	0.0
DAY 2	2	26	497	41	2,330	149	0	93	0	68	0	23	0	11	0.0	0	0.0	11	0.0	0	0.0
DAY 2	3	27	485	40	2,370	146	0	90	0	66	0	22	0	11	0.0	0	0.0	11	0.0	0	0.0
DAY 2	4	28	473	39	2,409	142	0	88	0	64	0	21	0	11	0.0	0	0.0	11	0.0	0	0.0
DAY 2	5	29	461	38	2,447	138	0	86	0	63	0	21	0	10	0.0	0	0.0	10	0.0	0	0.0
DAY 2	6	30	450	37	2,484	135	0	84	0	61	0	20	0	10	0.0	0	0.0	10	0.0	0	0.0
DAY 2	7	31	439	36	2,521	132	0	82	0	60	0	20	0	10	0.0	0	0.0	10	0.0	0	0.0
DAY 2	8	32	429	35	2,556	129	0	80	0	58	0	19	0	10	0.0	0	0.0	10	0.0	0	0.0
DAY 2	9	33	418	35	2,591	125	0	78	0	57	0	19	0	9	0.0	0	0.0	9	0.0	0	0.0
DAY 2	10	34	408	34	2,624	122	0	76	0	56	0	19	0	9	0.0	0	0.0	9	0.0	0	0.0
DAY 2	11	35	398	33	2,657	119	0	74	0	54	0	18	0	9	0.0	0	0.0	9	0.0	0	0.0
DAY 2	12	36	388	32	2,689	116	0	72	0	53	0	18	0	9	0.0	0	0.0	9	0.0	0	0.0
DAY 2	13	37	379	31	2,721	114	0	71	0	52	0	17	0	9	0.0	0	0.0	9	0.0	0	0.0
DAY 2	14	38	370	31	2,751	111	0	69	0	50	0	17	0	8	0.0	0	0.0	8	0.0	0	0.0
DAY 2	15	39	361	30	2,781	108	0	67	0	49	0	16	0	8	0.0	0	0.0	8	0.0	0	0.0
DAY 2	16	40	352	29	2,810	106	0	66	0	48	0	16	0	8	0.0	0	0.0	8	0.0	0	0.0
DAY 2	17	41	343	28	2,839	103	0	64	0	47	0	16	0	8	0.0	0	0.0	8	0.0	0	0.0
DAY 2	18	42	335	28	2,866	101	0	62	0	46	0	15	0	8	0.0	0	0.0	8	0.0	0	0.0
DAY 2	19	43	327	27	2,893	98	0	61	0	44	0	15	0	7	0.0	0	0.0	7	0.0	0	0.0
DAY 2	20	44	319	26	2,920	96	0	59	0	43	0	14	0	7	0.0	0	0.0	7	0.0	0	0.0
DAY 2	21	45	704	58	2,978	211	0	131	0	96	0	32	0	16	0.0	0	0.0	16	0.0	0	0.0
DAY 2	22	46	1,496	124	3,101	449	149	279	92	204	67	68	22	34	0.0	11	0.0	34	0.0	11	0.0
DAY 2	23	47	2,189	181	3,282	657	357	408	222	298	162	99	54	50	0.0	27	0.0	50	0.0	27	0.0
DAY 2	24	48	2,532	209	3,492	760	460	472	286	345	208	115	69	57	0.0	35	0.0	57	0.0	35	0.0
DAY 3	1	49	2,543	210	3,702	763	463	474	288	346	210	115	70	58	0.0	35	0.0	58	0.0	35	0.0
DAY 3	2	50	2,398	198	3,900	719	419	447	261	326	190	109	63	54	0.0	32	0.0	54	0.0	32	0.0
DAY 3	3	51	2,191	181	4,081	657	357	409	222	298	162	99	54	50	0.0	27	0.0	50	0.0	27	0.0
DAY 3	4	52	1,908	158	4,239	572	272	356	169	260	124	87	41	43	0.0	21	0.0	43	0.0	21	0.0
DAY 3	5	53	1,610	133	4,372	483	183	300	114	219	83	73	28	37	0.0	14	0.0	37	0.0	14	0.0
DAY 3	6	54	1,588	131	4,503	476	176	296	110	216	80	72	27	36	0.0	13	0.0	36	0.0	13	0.0
DAY 3	7	55	2,072	171	4,674	622	322	386	200	282	146	94	49	47	0.0	24	0.0	47	0.0	24	0.0
DAY 3	8	56	2,888	239	4,913	866	566	539	352	393	257	131	86	66	0.0	43	0.0	66	0.0	43	0.0
DAY 3	9	57	3,682	304	5,217	1,105	805	687	500	501	365	167	122	84	0.0	61	0.0	84	0.0	61	0.0
DAY 3	10	58	4,216	348	5,566	1,265	965	786	600	574	438	191	146	96	0.0	73	0.0	96	0.0	73	0.0
DAY 3	11	59	4,442	367	5,933	1,333	1,033	828	642	604	468	201	156	101	0.0	78	0.0	101	0.0	78	0.0
DAY 3	12	60	4,493	371	6,304	1,348	1,048	838	651	611	475	204	158	102	0.0	79	0.0	102	0.0	79	0.0
DAY 3	13	61	4,530	374	6,679	1,359	1,059	845	658	616	480	205	160	103	0.0	80	0.0	103	0.0	80	0.0
DAY 3	14	62	4,694	388	7,066	1,408	1,108	875	689	639	503	213	168	106	0.0	84	0.0	106	0.0	84	0.0
DAY 3	15	63	5,095	421	7,488	1,529	1,229	950	764	693	557	231	186	116	0.0	93	0.0	116	0.0	93	0.0
DAY 3	16	64	5,762	476	7,964	1,729	1,429	1,075	888	784	648	261	216	131	0.0	108	0.0	131	0.0	108	0.0
DAY 3	17	65	6,623	547	8,511	1,987	1,687	1,287	1,049	939	765	313	255	157	0.0	128	0.0	157	0.0	128	0.0
DAY 3	18	66	7,775	643	9,154	2,333	2,033	1,633	1,333	1,191	972	397	324	199	0.0	162	0.0	199	0.0	162	0.0
DAY 3	19	67	9,421	779	9,932	2,826	2,526	2,126	1,826	1,626	1,333	542	444	271	1.7	222	0.0	271	5.9	222	1.8
DAY 3	20	68	11,191	925	10,857	3,357	3,057	2,657	2,357	2,157	1,857	719	619	360	9.1	310	4.9	360	13.2	310	9.1
DAY 3	21	69	***12,301***	1,017	11,874	3,690	3,390	2,990	2,690	2,490	2,190	830	730	415	13.6	365	9.5	415	17.8	365	13.6



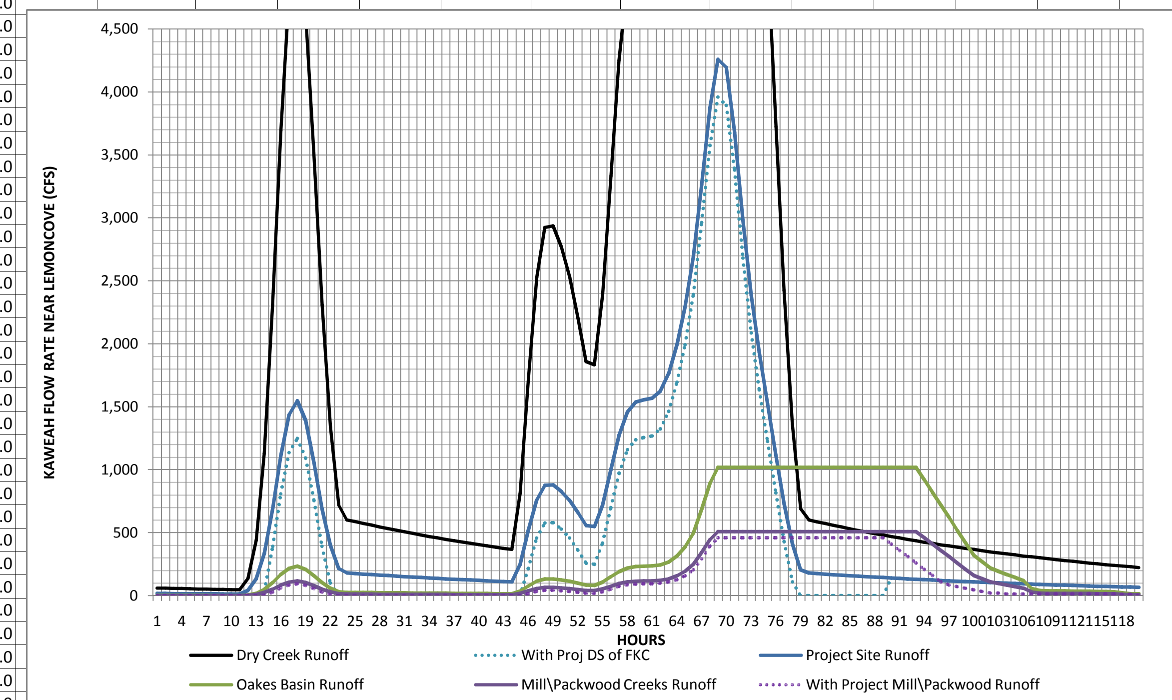


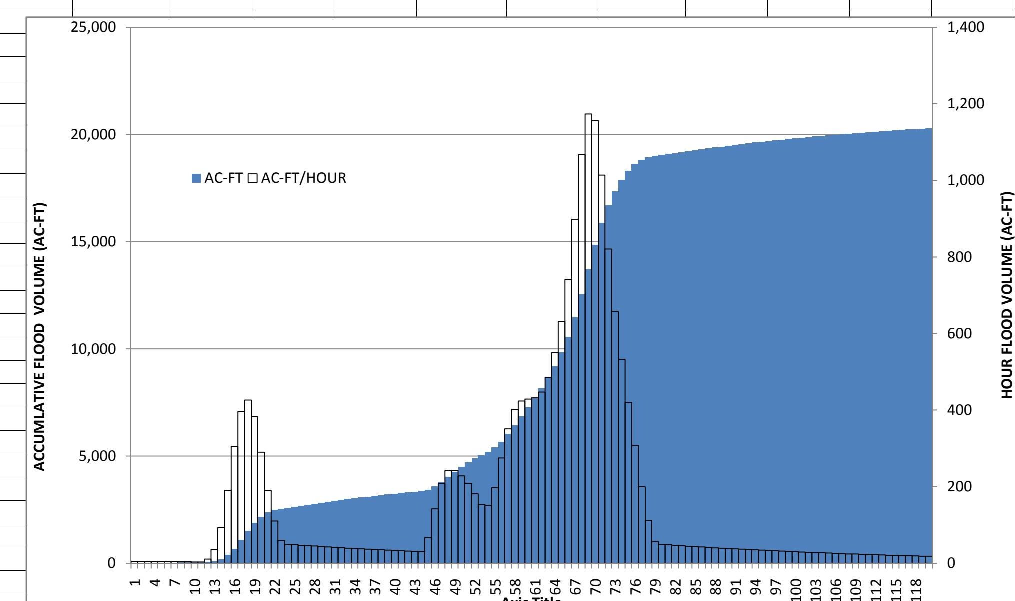
Hannah Ranch Project Flooding Model / 50 Year Storm - Dry Creek Hydrograph

STANDARD PROJECT FLOOD FLOW (SPECIFIC) DRY CREEK NEAR LEMONCOVE (HOURLY FLOW IN C.F.S.)				***Key Factors:***		0.3	300	700		500		33.33%		50.00%				50.00%			
				PROB. FLOOD YEAR	RATIO RANK	Project Site	With Project DS of FKC	DS of Outside Creek	With Project DS of Outside Creek	DS of Deep Creek	With Project DS of Deep Creek	Oakes Basin	With Project Oakes Basin	Mill Creek	Mill Creek Flooded Volume	With Project Mill Creek	With Proj Mill Creek Flooded Volume	Pack Creek	Packwood Creek Flooded Volume	With Project Packwood Creek	With Proj Packwood Volume
				50	1																
DAY	HOUR	HOURS	CFS	AC-FT /HOUR	TOTAL AC-FT	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	AF	CFS	AF	CFS	AF	CFS	AF
DAY 3	22	70	12,112	1,001	12,875	3,634	3,334	2,934	2,634	2,434	2,134	830	730	415	13.6	365	9.5	415	17.8	365	13.6
DAY 3	23	71	10,623	878	13,753	3,187	2,887	2,487	2,187	1,987	1,687	830	730	415	13.6	365	9.5	415	17.8	365	13.6
DAY 3	24	72	8,605	711	14,464	2,582	2,282	1,882	1,582	1,382	1,154	830	730	415	13.6	365	9.5	415	17.8	365	13.6
DAY 4	1	73	6,893	570	15,033	2,068	1,768	1,368	1,099	998	802	830	730	415	13.6	365	9.5	415	17.8	365	13.6
DAY 4	2	74	5,585	462	15,495	1,676	1,376	1,042	855	760	624	830	730	415	13.6	365	9.5	415	17.8	365	13.6
DAY 4	3	75	4,404	364	15,859	1,321	1,021	821	635	599	463	830	730	415	13.6	365	9.5	415	17.8	365	13.6
DAY 4	4	76	3,227	267	16,126	968	668	602	415	439	303	830	730	415	13.6	365	9.5	415	17.8	365	13.6
DAY 4	5	77	2,101	174	16,299	630	330	392	205	286	150	830	730	415	13.6	365	9.5	415	17.8	365	13.6
DAY 4	6	78	1,181	98	16,397	354	54	220	34	161	25	830	730	415	13.6	365	9.5	415	17.8	365	13.6
DAY 4	7	79	599	50	16,446	180	0	112	0	82	0	830	730	415	13.6	365	9.5	415	17.8	365	13.6
DAY 4	8	80	521	43	16,490	156	0	97	0	71	0	830	730	415	13.6	365	9.5	415	17.8	365	13.6
DAY 4	9	81	508	42	16,531	152	0	95	0	69	0	830	730	415	13.6	365	9.5	415	17.8	365	13.6
DAY 4	10	82	496	41	16,572	149	0	92	0	67	0	830	730	415	13.6	365	9.5	415	17.8	365	13.6
DAY 4	11	83	484	40	16,612	145	0	90	0	66	0	830	730	415	13.6	365	9.5	415	17.8	365	13.6
DAY 4	12	84	472	39	16,651	142	0	88	0	64	0	830	730	415	13.6	365	9.5	415	17.8	365	13.6
DAY 4	13	85	460	38	16,690	138	0	86	0	63	0	830	730	415	13.6	365	9.5	415	17.8	365	13.6
DAY 4	14	86	449	37	16,727	135	0	84	0	61	0	830	730	415	13.6	365	9.5	415	17.8	365	13.6
DAY 4	15	87	439	36	16,763	132	0	82	0	60	0	830	730	415	13.6	365	9.5	415	17.8	365	13.6
DAY 4	16	88	427	35	16,798	128	0	80	0	58	0	830	730	415	13.6	365	9.5	415	17.8	365	13.6
DAY 4	17	89	417	34	16,833	125	0	78	0	57	0	830	730	415	13.6	365	9.5	415	17.8	365	13.6
DAY 4	18	90	407	34	16,866	122	0	76	0	55	0	830	630	415	13.6	315	5.4	415	17.8	315	9.5
DAY 4	19	91	397	33	16,899	119	0	74	0	54	0	830	530	415	13.6	265	1.2	415	17.8	265	5.4
DAY 4	20	92	388	32	16,931	116	0	72	0	53	0	830	430	415	13.6	215	0.0	415	17.8	215	1.2
DAY 4	21	93	378	31	16,962	113	0	70	0	51	0	830	380	415	13.6	190	0.0	415	17.8	190	0.0
DAY 4	22	94	369	30	16,993	111	0	69	0	50	0	830	330	415	13.6	165	0.0	415	17.8	165	0.0
DAY 4	23	95	360	30	17,023	108	0	67	0	49	0	830	255	415	13.6	128	0.0	415	17.8	128	0.0
DAY 4	24	96	351	29	17,052	105	0	65	0	48	0	730	180	365	9.5	90	0.0	365	13.6	90	0.0
DAY 5	1	97	342	28	17,080	103	103	64	64	47	47	630	130	315	5.4	65	0.0	315	9.5	65	0.0
DAY 5	2	98	334	28	17,108	100	100	62	62	45	45	530	80	265	1.2	40	0.0	265	5.4	40	0.0
DAY 5	3	99	326	27	17,134	98	98	61	61	44	44	430	30	215	0.0	15	0.0	215	1.2	15	0.0
DAY 5	4	100	318	26	17,161	95	95	59	59	43	43	355	30	178	0.0	15	0.0	178	0.0	15	0.0
DAY 5	5	101	310	26	17,186	93	93	58	58	42	42	280	30	140	0.0	15	0.0	140	0.0	15	0.0
DAY 5	6	102	303	25	17,211	91	91	57	57	41	41	180	30	90	0.0	15	0.0	90	0.0	15	0.0
DAY 5	7	103	295	24	17,236	89	89	55	55	40	40	80	30	40	0.0	15	0.0	40	0.0	15	0.0
DAY 5	8	104	288	24	17,260	86	86	54	54	39	39	39	30	20	0.0	15	0.0	20	0.0	15	0.0
DAY 5	9	105	281	23	17,283	84	84	52	52	38	38	38	30	19	0.0	15	0.0	19	0.0	15	0.0
DAY 5	10	106	274	23	17,305	82	82	51	51	37	37	37	30	19	0.0	15	0.0	19	0.0	15	0.0
DAY 5	11	107	268	22	17,328	80	80	50	50	36	36	36	30	18	0.0	15	0.0	18	0.0	15	0.0
DAY 5	12	108	261	22	17,349	78	78	49	49	36	36	36	30	18	0.0	15	0.0	18	0.0	15	0.0
DAY 5	13	109	255	21	17,370	77	77	48	48	35	35	35	30	17	0.0	15	0.0	17	0.0	15	0.0
DAY 5	14	110	249	21	17,391	75	75	46	46	34	34	34	30	17	0.0	15	0.0	17	0.0	15	0.0
DAY 5	15	111	242	20	17,411	73	73	45	45	33	33	33	30	16	0.0	15	0.0	16	0.0	15	0.0
DAY 5	16	112	236	20	17,430	71	71	44	44	32	32	32	30	16	0.0	15	0.0	16	0.0	15	0.0
DAY 5	17	113	230	19	17,449	69	69	43	43	31	31	31	30	16	0.0	15	0.0	16	0.0	15	0.0
DAY 5	18	114	225	19	17,468	68	68	42	42	31	31	31	30	15	0.0	15	0.0	15	0.0	15	0.0
DAY 5	19	115	219	18	17,486	66	66	41	41	30	30	30	30	15	0.0	15	0.0	15	0.0	15	0.0
DAY 5	20	116	214	18	17,504	64	64	40	40	29	29	29	30	15	0.0	15	0.0	15	0.0	15	0.0
DAY 5	21	117	209	17	17,521	63	63	39	39	28	28	32	30	16	0.0	15	0.0	16	0.0	15	0.0
DAY 5	22	118	204	17	17,538	61	61	38	38	28	28	24	30	12	0.0	15	0.0	12	0.0	15	0.0
DAY 5	23	119	199	16	17,554	60	60	37	37	27	27	14	25	7	0.0	13	0.0	7	0.0	13	0.0
DAY 5	24	120	194	16	17,570	58	58	36	36	26	26	13	20	7	0.0	10	0.0	7	0.0	10	0.0
						63,780	45,662	43,058	30,866	32,495	23,191	32,495	23,192	16,247	395	11,596	211	16,247	529	11,596	313
							18,118	CFS-HRS	12,191	CFS-HRS	9,304	CFS-HRS						32,495			
							1,497	AF	1,008	AF	769	AF									
						Total layoff into Outside and Deep Creeks =					***1,776***	AF									

Hannah Ranch Project Flooding Model / 75 Year Storm - Dry Creek Hydrograph

STANDARD PROJECT FLOOD FLOW (SPECIFIC) DRY CREEK NEAR LEMONCOVE (HOURLY FLOW IN C.F.S.)				***Key Factors:***		0.3	300	700		500		33.33%		50.00%				50.00%			
				PROB. FLOOD YEAR	RATIO RANK	Project Site	With Project DS of FKC	DS of Outside Creek	With Project DS of Outside Creek	DS of Deep Creek	With Project DS of Deep Creek	Oakes Basin	With Project Oakes Basin	Mill Creek	Mill Creek Flooded Volume	With Project Mill Creek	With Proj Mill Creek Flooded Volume	Pack Creek	Pack Creek Flooded Volume	With Project Pack Creek	With Proj Pack Creek Flooded Volume
				75	1																
DAY	HOUR	HOURS	CFS	AC-FT /HOUR	TOTAL AC-FT	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	AF	CFS	AF	CFS	AF	CFS	AF
DAY 1	1	1	61	5	5	18	18	11	11	8	8	3	3	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	2	2	60	5	10	18	18	11	11	8	8	3	3	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	3	3	58	5	15	17	17	11	11	8	8	3	3	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	4	4	57	5	20	17	17	11	11	8	8	3	3	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	5	5	56	5	24	17	17	10	10	8	8	3	3	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	6	6	54	4	29	16	16	10	10	7	7	2	2	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	7	7	53	4	33	16	16	10	10	7	7	2	2	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	8	8	51	4	37	15	15	10	10	7	7	2	2	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	9	9	50	4	41	15	15	9	9	7	7	2	2	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	10	10	49	4	45	15	15	9	9	7	7	2	2	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	11	11	48	4	49	14	14	9	9	7	7	2	2	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	12	12	138	11	61	41	41	26	26	19	19	6	6	3	0.0	3	0.0	3	0.0	3	0.0
DAY 1	13	13	441	36	97	132	0	82	0	60	0	20	0	10	0.0	0	0.0	10	0.0	0	0.0
DAY 1	14	14	1,130	93	191	339	39	211	24	154	18	51	6	26	0.0	3	0.0	26	0.0	3	0.0
DAY 1	15	15	2,309	191	381	693	393	431	244	314	178	105	59	52	0.0	30	0.0	52	0.0	30	0.0
DAY 1	16	16	3,693	305	687	1,108	808	689	502	503	366	168	122	84	0.0	61	0.0	84	0.0	61	0.0
DAY 1	17	17	4,792	396	1,083	1,438	1,138	894	707	652	516	217	172	109	0.0	86	0.0	109	0.0	86	0.0
DAY 1	18	18	5,162	427	1,509	1,549	1,249	963	776	702	566	234	189	117	0.0	94	0.0	117	0.0	94	0.0
DAY 1	19	19	4,636	383	1,892	1,391	1,091	865	678	631	495	210	165	105	0.0	82	0.0	105	0.0	82	0.0
DAY 1	20	20	3,517	291	2,183	1,055	755	656	469	479	343	160	114	80	0.0	57	0.0	80	0.0	57	0.0
DAY 1	21	21	2,310	191	2,374	693	393	431	244	314	178	105	59	52	0.0	30	0.0	52	0.0	30	0.0
DAY 1	22	22	1,338	111	2,485	401	101	250	63	182	46	61	15	30	0.0	8	0.0	30	0.0	8	0.0
DAY 1	23	23	720	60	2,544	216	0	134	0	98	0	33	0	16	0.0	0	0.0	16	0.0	0	0.0
DAY 1	24	24	603	50	2,594	181	0	112	0	82	0	27	0	14	0.0	0	0.0	14	0.0	0	0.0
DAY 2	1	25	588	49	2,642	176	0	110	0	80	0	27	0	13	0.0	0	0.0	13	0.0	0	0.0
DAY 2	2	26	574	47	2,690	172	0	107	0	78	0	26	0	13	0.0	0	0.0	13	0.0	0	0.0
DAY 2	3	27	560	46	2,736	168	0	104	0	76	0	25	0	13	0.0	0	0.0	13	0.0	0	0.0
DAY 2	4	28	546	45	2,781	164	0	102	0	74	0	25	0	12	0.0	0	0.0	12	0.0	0	0.0
DAY 2	5	29	533	44	2,825	160	0	99	0	73	0	24	0	12	0.0	0	0.0	12	0.0	0	0.0
DAY 2	6	30	520	43	2,868	156	0	97	0	71	0	24	0	12	0.0	0	0.0	12	0.0	0	0.0
DAY 2	7	31	507	42	2,910	152	0	95	0	69	0	23	0	11	0.0	0	0.0	11	0.0	0	0.0
DAY 2	8	32	495	41	2,951	149	0	92	0	67	0	22	0	11	0.0	0	0.0	11	0.0	0	0.0
DAY 2	9	33	482	40	2,991	145	0	90	0	66	0	22	0	11	0.0	0	0.0	11	0.0	0	0.0
DAY 2	10	34	471	39	3,030	141	0	88	0	64	0	21	0	11	0.0	0	0.0	11	0.0	0	0.0
DAY 2	11	35	460	38	3,068	138	0	86	0	63	0	21	0	10	0.0	0	0.0	10	0.0	0	0.0
DAY 2	12	36	448	37	3,105	134	0	84	0	61	0	20	0	10	0.0	0	0.0	10	0.0	0	0.0
DAY 2	13	37	437	36	3,141	131	0	81	0	59	0	20	0	10	0.0	0	0.0	10	0.0	0	0.0
DAY 2	14	38	427	35	3,176	128	0	80	0	58	0	19	0	10	0.0	0	0.0	10	0.0	0	0.0
DAY 2	15	39	416	34	3,211	125	0	78	0	57	0	19	0	9	0.0	0	0.0	9	0.0	0	0.0
DAY 2	16	40	406	34	3,244	122	0	76	0	55	0	18	0	9	0.0	0	0.0	9	0.0	0	0.0
DAY 2	17	41	396	33	3,277	119	0	74	0	54	0	18	0	9	0.0	0	0.0	9	0.0	0	0.0
DAY 2	18	42	387	32	3,309	116	0	72	0	53	0	18	0	9	0.0	0	0.0	9	0.0	0	0.0
DAY 2	19	43	377	31	3,340	113	0	70	0	51	0	17	0	9	0.0	0	0.0	9	0.0	0	0.0
DAY 2	20	44	368	30	3,371	110	0	69	0	50	0	17	0	8	0.0	0	0.0	8	0.0	0	0.0
DAY 2	21	45	813	67	3,438	244	0	152	0	111	0	37	0	18	0.0	0	0.0	18	0.0	0	0.0
DAY 2	22	46	1,727	143	3,580	518	218	322	136	235	99	78	33	39	0.0	16	0.0	39	0.0	16	0.0
DAY 2	23	47	2,527	209	3,789	758	458	471	285	344	208	115	69	57	0.0	35	0.0	57	0.0	35	0.0
DAY 2	24	48	2,923	242	4,031	877	577	545	359	398	262	133	87	66	0.0	44	0.0	66	0.0	44	0.0
DAY 3	1	49	2,936	243	4,274	881	581	548	361	400	263	133	88	67	0.0	44	0.0	67	0.0	44	0.0
DAY 3	2	50	2,768	229	4,502	830	530	516	330	377	241	126	80	63	0.0	40	0.0	63	0.0	40	0.0
DAY 3	3	51	2,530	209	4,711	759	459	472	285	344	208	115	69	57	0.0	35	0.0	57	0.0	35	0.0
DAY 3	4	52	2,203	182	4,893	661	361	411	224	300	164	100	55	50	0.0	27	0.0	50	0.0	27	0.0
DAY 3	5	53	1,859	154	5,047	558	258	347	160	253	117	84	39	42	0.0	19	0.0	42	0.0	19	0.0
DAY 3	6	54	1,833	151	5,199	550	250	342	155	249	113	83	38	42	0.0	19	0.0	42	0.0	19	0.0
DAY 3	7	55	2,392	198	5,396	718	418	446	260	326	189	109	63	54	0.0	32	0.0	54	0.0	32	0.0
DAY 3	8	56	3,333	275	5,672	1,000	700	622	435	454	317	151	106	76	0.0	53	0.0	76	0.0	53	0.0
DAY 3	9	57	4,251	351	6,023	1,275	975	793	606	578	442	193	147	96	0.0	74	0.0	96	0.0	74	0.0
DAY 3	10	58	4,867	402	6,425	1,460	1,160	908	721	662	526	221	175	110	0.0	88	0.0	110	0.0	88	0.0
DAY 3	11	59	5,128	424	6,849	1,538	1,238	956	770	698	562	233	187	116	0.0	94	0.0	116	0.0	94	0.0
DAY 3	12	60	5,187	429	7,278	1,556	1,256	967	781	706	570	235	190	118	0.0	95	0.0	118	0.0	95	0.0
DAY 3	13	61	5,230	432	7,710	1,569	1,269	975	789	712	576	237	192	119	0.0	96	0.0	119	0.0	96	0.0
DAY 3	14	62	5,418	448	8,158	1,625	1,325	1,010	824	737	601	246	200	123	0.0	100	0.0	123	0.0	100	0.0
DAY 3	15	63	5,882	486	8,644	1,765	1,465	1,097	910	800	664	267	221	133	0.0	111	0.0	133	0.0	111	0.0
DAY 3	16	64	6,652	550	9,194	1,996	1,696	1,296	1,054	945	769	315	256	158	0.0	128	0.0	158	0.0	128	0.0
DAY 3	17	65	7,646	632	9,826	2,294	1,994	1,594	1,294	1,163	944	388	315	194	0.0	157	0.0	194	0.0	157	0.0
DAY 3	18	66	8,976	742	10,567	2,693	2,393	1,993	1,693	1,493	1,235	498	412	249	0.0	206	0.0	249	4.0	206	0.5
DAY 3	19	67	10,876	899	11,466	3,263	2,963	2,563	2,263	2,063	1,763	688	588	344	7.8	294	3.6	344	11.9	294	7.8
DAY 3	20	68	12,920	1,068	12,534	3,876	3,576	3,176	2,876	2,676	2,376	892	792	446	16.2	396	12.1	446	20.3	396	16.2
DAY 3	21	69	***14,200***	1,174	13,708	4,260	3,960	3,560	3,260	3,060	2,760	1,020	920	510	21.5	460	17.4	510	25.6	460	21.5





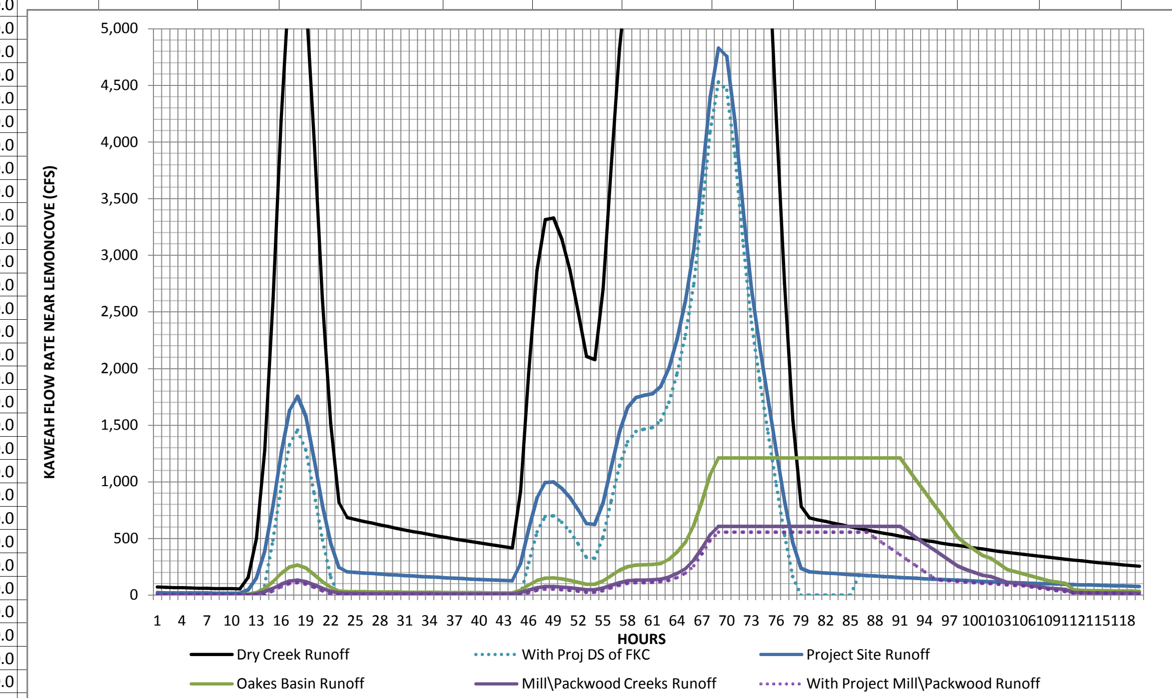
Hannah Ranch Project Flooding Model / 75 Year Storm - Dry Creek Hydrograph

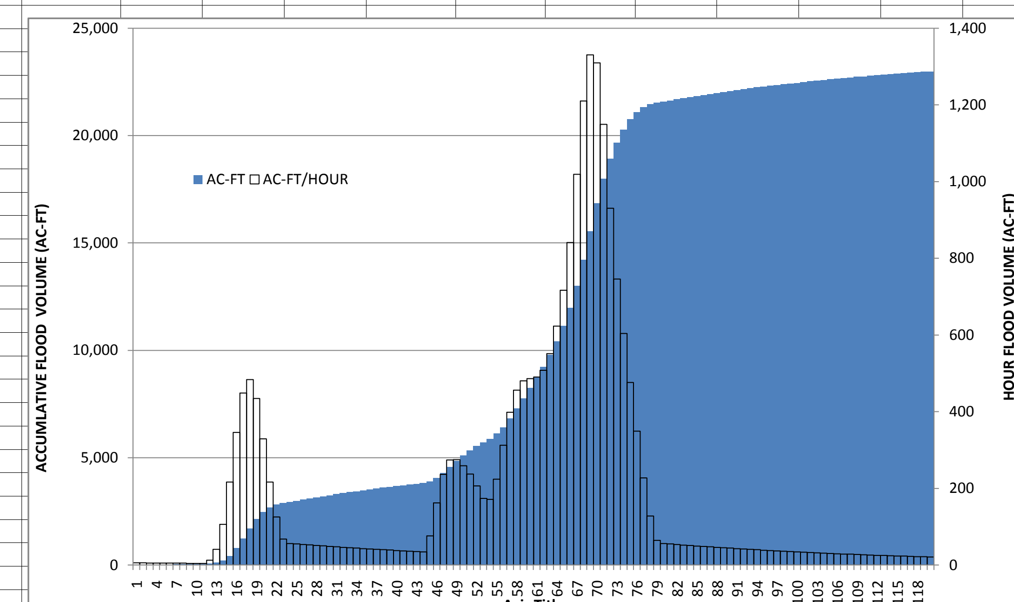
STANDARD PROJECT FLOOD FLOW (SPECIFIC) DRY CREEK NEAR LEMONCOVE (HOURLY FLOW IN C.F.S.)				***Key Factors:***		0.3	300	700		500		33.33%		50.00%				50.00%			
				PROB. FLOOD YEAR	RATIO RANK	Project Site	With Project DS of FKC	DS of Outside Creek	With Project DS of Outside Creek	DS of Deep Creek	With Project DS of Deep Creek	Oakes Basin	With Project Oakes Basin	Mill Creek	Mill Creek Flooded Volume	With Project Mill Creek	With Proj Mill Creek Flooded Volume	Pack Creek	Pack Creek Flooded Volume	With Project Pack Creek	With Proj Pack Creek Flooded Volume
				75	1																
DAY	HOUR	HOURS	CFS	AC-FT /HOUR	TOTAL AC-FT	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	AF	CFS	AF	CFS	AF	CFS	AF
DAY 3	22	70	13,982	1,156	14,863	4,195	3,895	3,495	3,195	2,995	2,695	1,020	920	510	21.5	460	17.4	510	25.6	460	21.5
DAY 3	23	71	12,264	1,014	15,877	3,679	3,379	2,979	2,679	2,479	2,179	1,020	920	510	21.5	460	17.4	510	25.6	460	21.5
DAY 3	24	72	9,934	821	16,698	2,980	2,680	2,280	1,980	1,780	1,480	1,020	920	510	21.5	460	17.4	510	25.6	460	21.5
DAY 4	1	73	7,957	658	17,355	2,387	2,087	1,687	1,387	1,231	1,012	1,020	920	510	21.5	460	17.4	510	25.6	460	21.5
DAY 4	2	74	6,447	533	17,888	1,934	1,634	1,234	1,016	901	741	1,020	920	510	21.5	460	17.4	510	25.6	460	21.5
DAY 4	3	75	5,084	420	18,308	1,525	1,225	948	762	692	556	1,020	920	510	21.5	460	17.4	510	25.6	460	21.5
DAY 4	4	76	3,725	308	18,616	1,118	818	695	508	507	371	1,020	920	510	21.5	460	17.4	510	25.6	460	21.5
DAY 4	5	77	2,425	200	18,816	728	428	452	266	330	194	1,020	920	510	21.5	460	17.4	510	25.6	460	21.5
DAY 4	6	78	1,364	113	18,929	409	109	254	68	186	50	1,020	920	510	21.5	460	17.4	510	25.6	460	21.5
DAY 4	7	79	691	57	18,986	207	0	129	0	94	0	1,020	920	510	21.5	460	17.4	510	25.6	460	21.5
DAY 4	8	80	601	50	19,036	180	0	112	0	82	0	1,020	920	510	21.5	460	17.4	510	25.6	460	21.5
DAY 4	9	81	587	49	19,084	176	0	109	0	80	0	1,020	920	510	21.5	460	17.4	510	25.6	460	21.5
DAY 4	10	82	573	47	19,132	172	0	107	0	78	0	1,020	920	510	21.5	460	17.4	510	25.6	460	21.5
DAY 4	11	83	558	46	19,178	167	0	104	0	76	0	1,020	920	510	21.5	460	17.4	510	25.6	460	21.5
DAY 4	12	84	545	45	19,223	164	0	102	0	74	0	1,020	920	510	21.5	460	17.4	510	25.6	460	21.5
DAY 4	13	85	531	44	19,267	159	0	99	0	72	0	1,020	920	510	21.5	460	17.4	510	25.6	460	21.5
DAY 4	14	86	519	43	19,310	156	0	97	0	71	0	1,020	920	510	21.5	460	17.4	510	25.6	460	21.5
DAY 4	15	87	506	42	19,352	152	0	94	0	69	0	1,020	920	510	21.5	460	17.4	510	25.6	460	21.5
DAY 4	16	88	493	41	19,392	148	0	92	0	67	0	1,020	920	510	21.5	460	17.4	510	25.6	460	21.5
DAY 4	17	89	482	40	19,432	145	0	90	0	66	0	1,020	920	510	21.5	460	17.4	510	25.6	460	21.5
DAY 4	18	90	470	39	19,471	141	141	88	88	64	64	1,020	820	510	21.5	410	13.2	510	25.6	410	17.4
DAY 4	19	91	459	38	19,509	138	138	86	86	62	62	1,020	720	510	21.5	360	9.1	510	25.6	360	13.2
DAY 4	20	92	447	37	19,546	134	134	83	83	61	61	1,020	620	510	21.5	310	5.0	510	25.6	310	9.1
DAY 4	21	93	436	36	19,582	131	131	81	81	59	59	1,020	520	510	21.5	260	0.8	510	25.6	260	5.0
DAY 4	22	94	425	35	19,617	128	128	79	79	58	58	920	420	460	17.4	210	0.0	460	21.5	210	0.8
DAY 4	23	95	416	34	19,651	125	125	78	78	57	57	820	320	410	13.2	160	0.0	410	17.4	160	0.0
DAY 4	24	96	405	33	19,685	122	122	76	76	55	55	720	220	360	9.1	110	0.0	360	13.2	110	0.0
DAY 5	1	97	395	33	19,718	119	119	74	74	54	54	620	170	310	5.0	85	0.0	310	9.1	85	0.0
DAY 5	2	98	386	32	19,749	116	116	72	72	53	53	520	145	260	0.8	73	0.0	260	5.0	73	0.0
DAY 5	3	99	376	31	19,780	113	113	70	70	51	51	420	120	210	0.0	60	0.0	210	0.8	60	0.0
DAY 5	4	100	367	30	19,811	110	110	68	68	50	50	320	95	160	0.0	48	0.0	160	0.0	48	0.0
DAY 5	5	101	358	30	19,840	107	107	67	67	49	49	270	70	135	0.0	35	0.0	135	0.0	35	0.0
DAY 5	6	102	349	29	19,869	105	105	65	65	47	47	220	45	110	0.0	23	0.0	110	0.0	23	0.0
DAY 5	7	103	341	28	19,897	102	102	64	64	46	46	195	45	98	0.0	23	0.0	98	0.0	23	0.0
DAY 5	8	104	333	28	19,925	100	100	62	62	45	45	170	30	85	0.0	15	0.0	85	0.0	15	0.0
DAY 5	9	105	324	27	19,952	97	97	60	60	44	44	145	30	73	0.0	15	0.0	73	0.0	15	0.0
DAY 5	10	106	316	26	19,978	95	95	59	59	43	43	120	30	60	0.0	15	0.0	60	0.0	15	0.0
DAY 5	11	107	309	26	20,003	93	93	58	58	42	42	58	30	29	0.0	15	0.0	29	0.0	15	0.0
DAY 5	12	108	301	25	20,028	90	90	56	56	41	41	41	30	20	0.0	15	0.0	20	0.0	15	0.0
DAY 5	13	109	294	24	20,053	88	88	55	55	40	40	40	30	20	0.0	15	0.0	20	0.0	15	0.0
DAY 5	14	110	287	24	20,076	86	86	54	54	39	39	39	30	20	0.0	15	0.0	20	0.0	15	0.0
DAY 5	15	111	280	23	20,099	84	84	52	52	38	38	38	30	19	0.0	15	0.0	19	0.0	15	0.0
DAY 5	16	112	273	23	20,122	82	82	51	51	37	37	37	30	19	0.0	15	0.0	19	0.0	15	0.0
DAY 5	17	113	266	22	20,144	80	80	50	50	36	36	36	30	18	0.0	15	0.0	18	0.0	15	0.0
DAY 5	18	114	260	21	20,165	78	78	48	48	35	35	35	30	18	0.0	15	0.0	18	0.0	15	0.0
DAY 5	19	115	253	21	20,186	76	76	47	47	34	34	34	30	17	0.0	15	0.0	17	0.0	15	0.0
DAY 5	20	116	247	20	20,207	74	74	46	46	34	34	34	30	17	0.0	15	0.0	17	0.0	15	0.0
DAY 5	21	117	242	20	20,227	73	73	45	45	33	33	32	30	16	0.0	15	0.0	16	0.0	15	0.0
DAY 5	22	118	235	19	20,246	71	71	44	44	32	32	24	20	12	0.0	10	0.0	12	0.0	10	0.0
DAY 5	23	119	230	19	20,265	69	69	43	43	31	31	16	20	8	0.0	10	0.0	8	0.0	10	0.0
DAY 5	24	120	224	19	20,284	67	67	42	42	30	30	15	8	8	0.0	4	0.0	8	0.0	4	0.0
						73,630	55,612	50,767	38,458	38,964	29,456	38,964	29,457	19,482	607	14,728	408	19,482	744	14,728	521
							18,018	CFS-HRS	12,309	CFS-HRS	9,507	CFS-HRS						38,964			
							1,489	AF	1,017	AF	786	AF									
						Total layoff into Outside and Deep Creeks =					***1,803***	AF									
												0	0								

Hannah Ranch Project Flooding Model / 100 Year Storm - Dry Creek Hydrograph

STANDARD PROJECT FLOOD FLOW (SPECIFIC) DRY CREEK NEAR LEMONCOVE (HOURLY FLOW IN C.F.S.)

DAY	HOUR	HOURS	CFS	PROB. FLOOD YEAR	RATIO RANK	Project Site	With Project DS of FKC	DS of Outside Creek	With Project DS of Outside Creek	DS of Deep Creek	With Project DS of Deep Creek	Oakes Basin	With Project Oakes Basin	Mill Creek	Mill Creek Flooded Volume	With Project Mill Creek	With Proj Mill Creek Flooded Volume	Pack Creek	Pack Creek Flooded Volume	With Project Pack Creek	With Proj Pack Creek Flooded Volume
				Key Factors:		0.3	300	700		500		33.33%		50.00%				50.00%			
				100	1																
DAY	HOUR	HOURS	CFS	AC-FT /HOUR	TOTAL AC-FT	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	AF	CFS	AF	CFS	AF	CFS	AF
DAY 1	1	1	70	6	6	21	21	13	13	10	10	3	3	2	0.0	2	0.0	2	0.0	2	0.0
DAY 1	2	2	68	6	11	20	20	13	13	9	9	3	3	2	0.0	2	0.0	2	0.0	2	0.0
DAY 1	3	3	66	5	17	20	20	12	12	9	9	3	3	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	4	4	65	5	22	20	20	12	12	9	9	3	3	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	5	5	63	5	27	19	19	12	12	9	9	3	3	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	6	6	61	5	32	18	18	11	11	8	8	3	3	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	7	7	60	5	37	18	18	11	11	8	8	3	3	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	8	8	58	5	42	17	17	11	11	8	8	3	3	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	9	9	57	5	47	17	17	11	11	8	8	3	3	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	10	10	56	5	52	17	17	10	10	8	8	3	3	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	11	11	54	4	56	16	16	10	10	7	7	2	2	1	0.0	1	0.0	1	0.0	1	0.0
DAY 1	12	12	156	13	69	47	47	29	29	21	21	7	7	4	0.0	4	0.0	4	0.0	4	0.0
DAY 1	13	13	500	41	110	150	0	93	0	68	0	23	0	11	0.0	0	0.0	11	0.0	0	0.0
DAY 1	14	14	1,281	106	216	384	84	239	52	174	38	58	13	29	0.0	6	0.0	29	0.0	6	0.0
DAY 1	15	15	2,618	216	432	785	485	488	302	356	220	119	73	59	0.0	37	0.0	59	0.0	37	0.0
DAY 1	16	16	4,187	346	779	1,256	956	781	594	570	434	190	145	95	0.0	72	0.0	95	0.0	72	0.0
DAY 1	17	17	5,434	449	1,228	1,630	1,330	1,013	827	739	603	246	201	123	0.0	101	0.0	123	0.0	101	0.0
DAY 1	18	18	5,853	484	1,711	1,756	1,456	1,092	905	797	660	266	220	133	0.0	110	0.0	133	0.0	110	0.0
DAY 1	19	19	5,256	434	2,146	1,577	1,277	980	794	715	579	238	193	119	0.0	97	0.0	119	0.0	97	0.0
DAY 1	20	20	3,988	330	2,475	1,196	896	744	557	543	407	181	136	90	0.0	68	0.0	90	0.0	68	0.0
DAY 1	21	21	2,619	216	2,692	786	486	488	302	356	220	119	73	59	0.0	37	0.0	59	0.0	37	0.0
DAY 1	22	22	1,517	125	2,817	455	155	283	96	206	70	69	23	34	0.0	12	0.0	34	0.0	12	0.0
DAY 1	23	23	817	68	2,885	245	0	152	0	111	0	37	0	19	0.0	0	0.0	19	0.0	0	0.0
DAY 1	24	24	683	56	2,941	205	0	127	0	93	0	31	0	15	0.0	0	0.0	15	0.0	0	0.0
DAY 2	1	25	667	55	2,996	200	0	124	0	91	0	30	0	15	0.0	0	0.0	15	0.0	0	0.0
DAY 2	2	26	651	54	3,050	195	0	121	0	89	0	30	0	15	0.0	0	0.0	15	0.0	0	0.0
DAY 2	3	27	635	52	3,102	191	0	118	0	86	0	29	0	14	0.0	0	0.0	14	0.0	0	0.0
DAY 2	4	28	619	51	3,154	186	0	115	0	84	0	28	0	14	0.0	0	0.0	14	0.0	0	0.0
DAY 2	5	29	604	50	3,204	181	0	113	0	82	0	27	0	14	0.0	0	0.0	14	0.0	0	0.0
DAY 2	6	30	589	49	3,252	177	0	110	0	80	0	27	0	13	0.0	0	0.0	13	0.0	0	0.0
DAY 2	7	31	575	48	3,300	173	0	107	0	78	0	26	0	13	0.0	0	0.0	13	0.0	0	0.0
DAY 2	8	32	561	46	3,346	168	0	105	0	76	0	25	0	13	0.0	0	0.0	13	0.0	0	0.0
DAY 2	9	33	547	45	3,391	164	0	102	0	74	0	25	0	12	0.0	0	0.0	12	0.0	0	0.0
DAY 2	10	34	534	44	3,435	160	0	100	0	73	0	24	0	12	0.0	0	0.0	12	0.0	0	0.0
DAY 2	11	35	521	43	3,479	156	0	97	0	71	0	24	0	12	0.0	0	0.0	12	0.0	0	0.0
DAY 2	12	36	508	42	3,520	152	0	95	0	69	0	23	0	12	0.0	0	0.0	12	0.0	0	0.0
DAY 2	13	37	496	41	3,561	149	0	92	0	67	0	22	0	11	0.0	0	0.0	11	0.0	0	0.0
DAY 2	14	38	484	40	3,601	145	0	90	0	66	0	22	0	11	0.0	0	0.0	11	0.0	0	0.0
DAY 2	15	39	472	39	3,640	142	0	88	0	64	0	21	0	11	0.0	0	0.0	11	0.0	0	0.0
DAY 2	16	40	460	38	3,679	138	0	86	0	63	0	21	0	10	0.0	0	0.0	10	0.0	0	0.0
DAY 2	17	41	449	37	3,716	135	0	84	0	61	0	20	0	10	0.0	0	0.0	10	0.0	0	0.0
DAY 2	18	42	439	36	3,752	132	0	82	0	60	0	20	0	10	0.0	0	0.0	10	0.0	0	0.0
DAY 2	19	43	427	35	3,787	128	0	80	0	58	0	19	0	10	0.0	0	0.0	10	0.0	0	0.0
DAY 2	20	44	417	34	3,822	125	0	78	0	57	0	19	0	9	0.0	0	0.0	9	0.0	0	0.0
DAY 2	21	45	922	76	3,898	277	0	172	0	125	0	42	0	21	0.0	0	0.0	21	0.0	0	0.0
DAY 2	22	46	1,958	162	4,060	587	287	365	179	266	130	89	43	44	0.0	22	0.0	44	0.0	22	0.0
DAY 2	23	47	2,865	237	4,296	860	560	534	348	390	254	130	85	65	0.0	42	0.0	65	0.0	42	0.0
DAY 2	24	48	3,314	274	4,570	994	694	618	432	451	315	150	105	75	0.0	52	0.0	75	0.0	52	0.0
DAY 3	1	49	3,329	275	4,845	999	699	621	434	453	317	151	106	76	0.0	53	0.0	76	0.0	53	0.0
DAY 3	2	50	3,139	259	5,105	942	642	585	399	427	291	142	97	71	0.0	49	0.0	71	0.0	49	0.0
DAY 3	3	51	2,868	237	5,342	860	560	535	348	390	254	130	85	65	0.0	42	0.0	65	0.0	42	0.0
DAY 3	4	52	2,497	206	5,548	749	449	466	279	340	204	113	68	57	0.0	34	0.0	57	0.0	34	0.0
DAY 3	5	53	2,107	174	5,722	632	332	393	206	287	151	96	50	48	0.0	25	0.0	48	0.0	25	0.0
DAY 3	6	54	2,078	172	5,894	623	323	388	201	283	147	94	49	47	0.0	24	0.0	47	0.0	24	0.0
DAY 3	7	55	2,712	224	6,118	814	514	506	319	369	233	123	78	62	0.0	39	0.0	62	0.0	39	0.0
DAY 3	8	56	3,779	312	6,431	1,134	834	705	518	514	378	171	126	86	0.0	63	0.0	86	0.0	63	0.0
DAY 3	9	57	4,819	398	6,829	1,446	1,146	899	712	656	520	219	173	109	0.0	87	0.0	109	0.0	87	0.0
DAY 3	10	58	5,518	456	7,285	1,655	1,355	1,029	843	751	615	250	205	125	0.0	102	0.0	125	0.0	102	0.0
DAY 3	11	59	5,814	480	7,765	1,744	1,444	1,084	898	791	655	264	218	132	0.0	109	0.0	132	0.0	109	0.0
DAY 3	12	60	5,881	486	8,251	1,764	1,464	1,097	910	800	664	267	221	133	0.0	111	0.0	133	0.0	111	0.0
DAY 3	13	61	5,930	490	8,741	1,779	1,479	1,106	919	807	671	269	224	134	0.0	112	0.0	134	0.0	112	0.0
DAY 3	14	62	6,143	508	9,249	1,843	1,543	1,146	959	836	700	279	233	139	0.0	117	0.0	139	0.0	117	0.0
DAY 3	15	63	6,669	551	9,800	2,001	1,701	1,301	1,057	949	771	316	257	158	0.0	129	0.0	158	0.0	129	0.0
DAY 3	16	64	7,541	623	10,424	2,262	1,962	1,562	1,262	1,140	921	380	307	190	0.0	154	0.0	190	0.0	154	0.0
DAY 3	17	65	8,669	716	11,140	2,601	2,301	1,901	1,601	1,401	1,168	467	389	233	0.0	195	0.0	233	2.8	195	0.0
DAY 3	18	66	10,177	841	11,981	3,053	2,753	2,353	2,053	1,853	1,553	618	518	309	4.9	259	0.7	309	9.0	259	4.9
DAY 3	19	67	12,331	1,019	13,000	3,699	3,399	2,999	2,699	2,499	2,199	833	733	417	13.8	367	9.6	417	17.9	367	13.8
DAY 3	20	68	14,648	1,211	14,211	4,394	4,094	3,694	3,394	3,194	2,894	1,065	965	532	23.3	482	19.2	532	27.5	482	23.3





Hannah Ranch Project Flooding Model / 100 Year Storm - Dry Creek Hydrograph

STANDARD PROJECT FLOOD FLOW (SPECIFIC) DRY CREEK NEAR LEMONCOVE (HOURLY FLOW IN C.F.S.)				***Key Factors:***		0.3	300	700		500		33.33%		50.00%				50.00%			
				PROB. FLOOD YEAR	RATIO RANK	Project Site	With Project DS of FKC	DS of Outside Creek	With Project DS of Outside Creek	DS of Deep Creek	With Project DS of Deep Creek	Oakes Basin	With Project Oakes Basin	Mill Creek	Mill Creek Flooded Volume	With Project Mill Creek	With Proj Mill Creek Flooded Volume	Pack Creek	Pack Creek Flooded Volume	With Project Pack Creek	With Proj Pack Creek Flooded Volume
				100	1																
DAY	HOUR	HOURS	CFS	AC-FT /HOUR	TOTAL AC-FT	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	AF	CFS	AF	CFS	AF	CFS	AF
DAY 3	21	69	***16,100***	1,331	15,541	4,830	4,530	4,130	3,830	3,630	3,330	1,210	1,110	605	29.3	555	25.2	605	33.5	555	29.3
DAY 3	22	70	15,852	1,310	16,851	4,756	4,456	4,056	3,756	3,556	3,256	1,210	1,110	605	29.3	555	25.2	605	33.5	555	29.3
DAY 3	23	71	13,904	1,149	18,000	4,171	3,871	3,471	3,171	2,971	2,671	1,210	1,110	605	29.3	555	25.2	605	33.5	555	29.3
DAY 3	24	72	11,262	931	18,931	3,379	3,079	2,679	2,379	2,179	1,879	1,210	1,110	605	29.3	555	25.2	605	33.5	555	29.3
DAY 4	1	73	9,022	746	19,677	2,707	2,407	2,007	1,707	1,507	1,245	1,210	1,110	605	29.3	555	25.2	605	33.5	555	29.3
DAY 4	2	74	7,309	604	20,281	2,193	1,893	1,493	1,193	1,089	870	1,210	1,110	605	29.3	555	25.2	605	33.5	555	29.3
DAY 4	3	75	5,764	476	20,757	1,729	1,429	1,075	888	784	648	1,210	1,110	605	29.3	555	25.2	605	33.5	555	29.3
DAY 4	4	76	4,224	349	21,106	1,267	967	788	601	575	439	1,210	1,110	605	29.3	555	25.2	605	33.5	555	29.3
DAY 4	5	77	2,749	227	21,334	825	525	513	326	374	238	1,210	1,110	605	29.3	555	25.2	605	33.5	555	29.3
DAY 4	6	78	1,546	128	21,461	464	164	288	102	210	74	1,210	1,110	605	29.3	555	25.2	605	33.5	555	29.3
DAY 4	7	79	784	65	21,526	235	0	146	0	107	0	1,210	1,110	605	29.3	555	25.2	605	33.5	555	29.3
DAY 4	8	80	682	56	21,582	205	0	127	0	93	0	1,210	1,110	605	29.3	555	25.2	605	33.5	555	29.3
DAY 4	9	81	665	55	21,637	200	0	124	0	90	0	1,210	1,110	605	29.3	555	25.2	605	33.5	555	29.3
DAY 4	10	82	649	54	21,691	195	0	121	0	88	0	1,210	1,110	605	29.3	555	25.2	605	33.5	555	29.3
DAY 4	11	83	633	52	21,743	190	0	118	0	86	0	1,210	1,110	605	29.3	555	25.2	605	33.5	555	29.3
DAY 4	12	84	618	51	21,794	185	0	115	0	84	0	1,210	1,110	605	29.3	555	25.2	605	33.5	555	29.3
DAY 4	13	85	603	50	21,844	181	0	112	0	82	0	1,210	1,110	605	29.3	555	25.2	605	33.5	555	29.3
DAY 4	14	86	588	49	21,893	176	176	110	110	80	80	1,210	1,110	605	29.3	555	25.2	605	33.5	555	29.3
DAY 4	15	87	574	47	21,940	172	172	107	107	78	78	1,210	1,110	605	29.3	555	25.2	605	33.5	555	29.3
DAY 4	16	88	559	46	21,987	168	168	104	104	76	76	1,210	1,010	605	29.3	505	21.1	605	33.5	505	25.2
DAY 4	17	89	546	45	22,032	164	164	102	102	74	74	1,210	910	605	29.3	455	16.9	605	33.5	455	21.1
DAY 4	18	90	533	44	22,076	160	160	99	99	73	73	1,210	810	605	29.3	405	12.8	605	33.5	405	16.9
DAY 4	19	91	520	43	22,119	156	156	97	97	71	71	1,210	710	605	29.3	355	8.7	605	33.5	355	12.8
DAY 4	20	92	507	42	22,161	152	152	95	95	69	69	1,110	610	555	25.2	305	4.5	555	29.3	305	8.7
DAY 4	21	93	495	41	22,201	149	149	92	92	67	67	1,010	510	505	21.1	255	0.4	505	25.2	255	4.5
DAY 4	22	94	482	40	22,241	145	145	90	90	66	66	910	410	455	16.9	205	0.0	455	21.1	205	0.4
DAY 4	23	95	471	39	22,280	141	141	88	88	64	64	810	310	405	12.8	155	0.0	405	16.9	155	0.0
DAY 4	24	96	459	38	22,318	138	138	86	86	62	62	710	260	355	8.7	130	0.0	355	12.8	130	0.0
DAY 5	1	97	448	37	22,355	134	134	84	84	61	61	610	250	305	4.5	125	0.0	305	8.7	125	0.0
DAY 5	2	98	437	36	22,391	131	131	81	81	59	59	510	240	255	0.4	120	0.0	255	4.5	120	0.0
DAY 5	3	99	427	35	22,427	128	128	80	80	58	58	450	230	225	0.0	115	0.0	225	2.1	115	0.0
DAY 5	4	100	416	34	22,461	125	125	78	78	57	57	400	220	200	0.0	110	0.0	200	0.0	110	0.0
DAY 5	5	101	406	34	22,495	122	122	76	76	55	55	350	210	175	0.0	105	0.0	175	0.0	105	0.0
DAY 5	6	102	396	33	22,527	119	119	74	74	54	54	325	200	163	0.0	100	0.0	163	0.0	100	0.0
DAY 5	7	103	386	32	22,559	116	116	72	72	53	53	275	190	138	0.0	95	0.0	138	0.0	95	0.0
DAY 5	8	104	377	31	22,590	113	113	70	70	51	51	225	180	113	0.0	90	0.0	113	0.0	90	0.0
DAY 5	9	105	368	30	22,621	110	110	69	69	50	50	205	170	103	0.0	85	0.0	103	0.0	85	0.0
DAY 5	10	106	359	30	22,650	108	108	67	67	49	49	185	160	93	0.0	80	0.0	93	0.0	80	0.0
DAY 5	11	107	350	29	22,679	105	105	65	65	48	48	165	140	83	0.0	70	0.0	83	0.0	70	0.0
DAY 5	12	108	341	28	22,708	102	102	64	64	46	46	145	120	73	0.0	60	0.0	73	0.0	60	0.0
DAY 5	13	109	334	28	22,735	100	100	62	62	45	45	125	100	63	0.0	50	0.0	63	0.0	50	0.0
DAY 5	14	110	325	27	22,762	98	98	61	61	44	44	114	80	57	0.0	40	0.0	57	0.0	40	0.0
DAY 5	15	111	317	26	22,788	95	95	59	59	43	43	103	60	52	0.0	30	0.0	52	0.0	30	0.0
DAY 5	16	112	309	26	22,814	93	93	58	58	42	42	46	40	23	0.0	20	0.0	23	0.0	20	0.0
DAY 5	17	113	302	25	22,839	91	91	56	56	41	41	41	40	21	0.0	20	0.0	21	0.0	20	0.0
DAY 5	18	114	295	24	22,863	89	89	55	55	40	40	40	40	20	0.0	20	0.0	20	0.0	20	0.0
DAY 5	19	115	287	24	22,887	86	86	54	54	39	39	39	40	20	0.0	20	0.0	20	0.0	20	0.0
DAY 5	20	116	280	23	22,910	84	84	52	52	38	38	38	30	19	0.0	15	0.0	19	0.0	15	0.0
DAY 5	21	117	274	23	22,933	82	82	51	51	37	37	37	30	19	0.0	15	0.0	19	0.0	15	0.0
DAY 5	22	118	267	22	22,955	80	80	50	50	36	36	36	20	18	0.0	10	0.0	18	0.0	10	0.0
DAY 5	23	119	261	22	22,976	78	78	49	49	36	36	36	20	18	0.0	10	0.0	18	0.0	10	0.0
DAY 5	24	120	254	21	22,997	76	76	47	47	35	35	35	10	17	0.0	5	0.0	17	0.0	5	0.0
						83,480	65,417	58,645	46,111	45,671	35,900	45,671	35,901	22,835	806	17,950	573	22,835	948	17,950	689
							18,063	CFS-HRS	12,534	CFS-HRS	9,770	CFS-HRS						45,671			

Hannar Ranch Project Flooding Model / Sotrm Series Ratios and Summary Tables

RATIOS TO MULTIPLY SPF TO SIMULATE INDICATED FLOOD SERIES

5-DAY CYCLE		YEAR	YEAR	YEAR	YEAR	YEAR	YEAR	YEAR	YEAR
WAVE ORDER	RATIO RANK	10	25	50	75	100	200	500	1000
4	1	0.235	0.371	0.531	0.613	0.695	0.914	1.226	1.621
3	2	0.069	0.096	0.108	0.136	0.163	0.155	0.196	0.104
5	3	0.056	0.084	0.084	0.080	0.076	0.104	0.148	0.071
2	4	0.055	0.072	0.080	0.076	0.071	0.064	0.040	0.063
6	5	0.048	0.065	0.072	0.064	0.056	0.040	0.032	0.055
1	6	0.040	0.044	0.064	0.056	0.048	0.016	0.024	0.052

Original Version

Pre-Project

Recurrence Interval (Year)	Dry Crk Peak (CFS)	StJR 70% (CFS)	LKR 30% (CFS)	Oakes Basin (CFS)	Mill Crk Peak (CFS)	Packwood Crk Peak (CFS)
100	16,100	11,270	4,830	1,210	605	605
75	14,200	9,940	4,260	1,420	710	710
50	12,300	8,610	3,690	1,230	615	615
25	8,600	6,020	2,578	859	430	430
10	5,450	3,815	1,633	544	272	272

Pre-Project

Recurrence Interval (Year)	Dry Crk Peak (CFS)	Mill Crk Peak (CFS)	Beyond Capacity (HRS)	Mill Crk Flood (AF)	Packwood Crk Peak (CFS)	Beyond Capacity (HRS)	Packwood Crk Flood (AF)	Total Flood (AF)	Flooded Area (Acres)
100	16,100	805	58	806	805	62	948	1,754	3,508
75	14,200	710	54	1,547	710	59	1,784	3,330	6,660
50	12,300	615	48	1,213	615	57	1,426	2,639	5,277
25	8,600	430	44	596	430	47	783	1,379	2,757
10	5,450	272	38	70	272	41	233	303	605

Post-Project

Recurrence Interval (Year)	Dry Crk Peak (CFS)	Mill Crk Peak (CFS)	Beyond Capacity (HRS)	Mill Crk Flood (AF)	Packwood Crk Peak (CFS)	Beyond Capacity (HRS)	Packwood Crk Flood (AF)	Total Flood (AF)	Flooded Area (Acres)
100	16,100	555	13	573	555	21	689	1,262	2,524
75	14,200	660	11	189	660	17	244	433	866
50	12,300	565	9	130	565	12	173	304	608
25	8,600	380	6	37	380	7	63	100	200
10	5,450	222	0	0	222	2	3	3	7

Flood Damage Reduction Benefits

Recurrence Interval (Year)	Mill Crk Pre Proj (AF)	Mill Crk Post proj (AF)	Mill Crk Benefits (AF)	Beyond Capacity (HRS)	Packwood Pre Proj (AF)	Packwood Post proj (AF)	Packwood Benefits (AF)	Beyond Capacity (HRS)	Total Volume (AF)	Total Area (Acres)
100	806	573	233	-45	948	689	923	-41	1,156	2,312
75	1,547	189	1,357	-43	1,784	244	1,601	-42	2,958	5,916
50	1,213	130	1,083	-39	1,426	173	1,256	-45	2,338	4,677
25	596	37	559	-38	783	63	622	-40	1,181	2,363
10	70	0	70	-38	233	3	73	-39	143	286

Modified Version

Pre-Project

Recurrence Interval (Year)	Dry Crk Peak (CFS)	StJR 70% (CFS)	LKR 30% (CFS)	Oakes Basin (CFS)	Mill Crk Peak (CFS)	Packwood Crk Peak (CFS)
~~100~~	~~16,100~~	~~11,270~~	~~4,830~~	~~1,210~~	~~605~~	~~605~~
75	14,200	9,940	4,260	1,020	510	510
50	12,301	8,611	3,690	830	415	415
25	8,594	6,016	2,578	459	230	230
10	5,444	3,811	1,633	247	123	123

Pre-Project

Recurrence Interval (Year)	Dry Crk Peak (CFS)	Mill Crk Peak (CFS)	Beyond Capacity (HRS)	Mill Crk Flood (AF)	Packwood Crk Peak (CFS)	Beyond Capacity (HRS)	Packwood Crk Flood (AF)	Total Flood (AF)	Flooded Area (Acres)
~~100~~	~~16,100~~	~~605~~	~~29~~	~~806~~	~~605~~	~~31~~	~~948~~	~~1,754~~	~~3,508~~
75	14,200	510	27	607	510	29	744	1,350	2,701
50	12,301	415	25	395	415	26	529	924	1,848
25	8,594	230	0	0	230	26	79	79	158
10	5,444	123	0	0	123	0	0	0	0

Post-Project

Recurrence Interval (Year)	Dry Crk Peak (CFS)	Mill Crk Peak (CFS)	Beyond Capacity (HRS)	Mill Crk Flood (AF)	Packwood Crk Peak (CFS)	Beyond Capacity (HRS)	Packwood Crk Flood (AF)	Total Flood (AF)	Percent Reduction	Flooded Area (Acres)
~~100~~	~~16,100~~	~~555~~	~~28~~	~~573~~	~~555~~	~~29~~	~~689~~	~~1,262~~	~~28.1%~~	~~2,524~~
75	14,200	460	27	408	460	29	521	929	31.2%	1,859
50	12,301	365	24	211	365	26	313	525	43.2%	1,049
25	8,594	192	0	0	230	0	0	0	100.0%	0
10	5,444	101	0	0	101	0	0	0	--	0

Flood Damage Reduction Benefits

Recurrence Interval (Year)	Mill Crk Pre Proj (AF)	Mill Crk Post Proj (AF)	Mill Crk Benefits (AF)	Beyond Capacity (HRS)	Packwood Pre Proj (AF)	Packwood Post proj (AF)	Packwood Benefits (AF)	Beyond Capacity (HRS)	Total Volume (AF)	Total Area (Acres)
~~100~~	~~806~~	~~573~~	~~233~~	~~-1~~	~~948~~	~~689~~	~~259~~	~~-2~~	~~492~~	~~984~~
75	607	408	198	0	744	521	223	0	421	842
50	395	211	184	-1	529	313	215	0	399	798
25	0	0	0	0	79	0	79	-26	79	158
10	0	0	0	0	0	0	0	0	0	0

Recurrence Interval (Year)	Mill Crk Pre Proj Flooding (Acres)	Mill Crk Post Proj Flooding (Acres)	Mill Creek Flood Protection (Acres)	Packwood Pre Proj Flooding (Acres)	Packwood Post Proj Flooding (Acres)	Packwood Flood Protection (Acres)	Total Flood Protection (Acres)
~~100~~	~~1,613~~	~~1,146~~	~~467~~	~~1,895~~	~~1,378~~	~~517~~	~~984~~
75	1,213	816	397	1,487	1,042	445	842
50	790	422	368	1,057	627	430	798
25	0	0	0	158	0	158	158
10	0	0	0	0	0	0	0

Recurrence Interval (Year)	Conserved Flood Water (AF)
~~100~~	~~1,500~~
75	1,500
50	1,500
25	1,470
10	1,250