10 ATTACHMENT 7 – TECHNICAL JUSTIFICATION OF PROJECTS

For the "AttachmentName" in the naming convention of BMS, use "TechJust" for this attachment.

Attachment 7 is mandatory. See Exhibit C for detailed guidance on the preparation of this attachment. There is no page limitation for Attachment 7; however, applicants are encouraged to be clear and concise.

Scoring for Attachment 7 will be based solely on the technical justification of project(s) with respect to the claimed physical benefits (i.e., technical basis of the project and capability of yielding the benefits). Documentation may include, but is not limited to: technical reports, feasibility studies, needs assessments, expert opinion or local knowledge, journals, etc. The magnitude of physical benefits will not be scored under this criterion. Please note that the magnitude of project benefits relative to costs will be evaluated based on the information provided in Attachment 8.

10.1 Technical Justification

Applicants should provide technical justification for the proposed project's claimed physical benefits. Regardless of the magnitude of benefits claimed, studies or documents used to support the projects must be clearly referenced. Estimates based on expert opinion or local knowledge (for example, from a District Engineer) should be documented with the individual's contact information. See Section V. for guidance on submitting studies, documents, or other reference materials.

10.1.1 Kaweah River Basin Description

The Kaweah River flows into Lake Kaweah, impounded by Terminus Dam, which is operated for flood control, conservation and other purposes. There are three major tributaries to the Kaweah River below Terminus Dam, Dry, Merthen and Yokohl Creeks. Dry Creek, having considerable flood potential but no storage facilities, enters the Kaweah River above McKays Point. Lake Kaweah is operated for an objective flow of 5,500 CFS at McKays Point. Greater flows cannot be controlled and may flood developed portions of Visalia. Lake Kaweah has not spilled uncontrollably since its completion in 1962. However, it filled in December of 1966 and nearly filled in 1969. As originally constructed, it is expected to spill substantially about once every 50 years.[3]

[3] 1990 Hydrology Report, Kaweah River Basin, CA, Section 1-02: Flood Problems, ACOE – Sacramento District

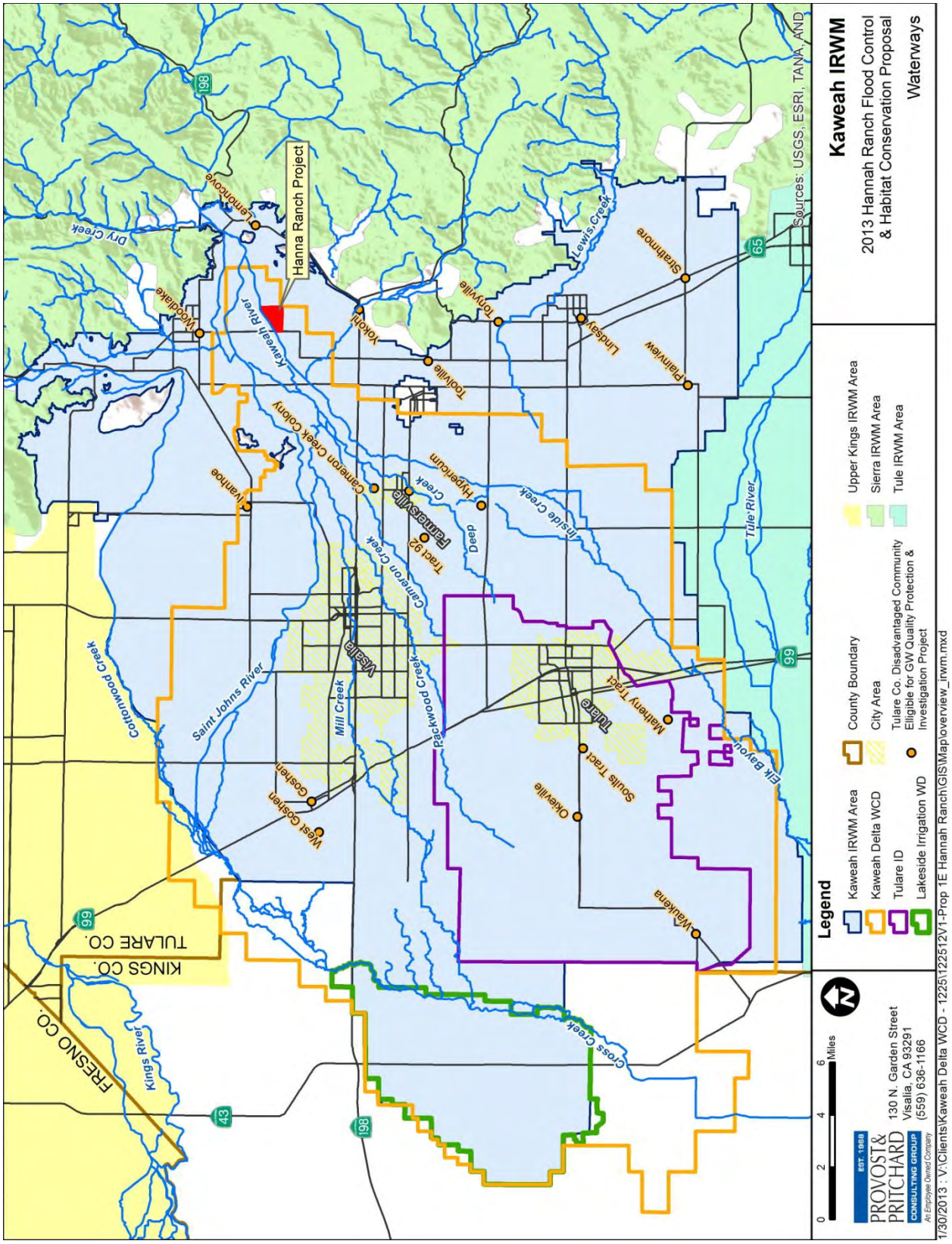


Figure 10-1 – Project Area Waterways

Modifications to Terminus Dam that were completed in 2004 have improved that protection to approximately 75 years.

Two types of floods may occur on the Kaweah River: winter rain and summer snowmelt. The winter rain floods are characterized by sharp peaks and most of the volume occurring within a few days. The snowmelt flows have a much larger volume, with the runoff occurring over a number of months. Peak snowmelt season flows rarely exceed channel capacity, but they may exceed irrigation and spreading capability for extended periods. Dry Creek basin does not extend into the higher elevations where snow accumulates, so floods on Dry Creek are a result of rain.[4]

10.1.1 Brief Project Description

The proposed 2013 Hannah Ranch Flood Control & Habitat Conservation Project is intended to layoff floodwaters downstream of McKays Point on the Lower Kaweah River in an effort to diminish the flood flows that make it along the system to the communities of Visalia and Farmersville (a disadvantaged community). The off-stream storage is intended to be reregulated so that the stored supply can be put to beneficial use later after flood events have passed and channel capacity and water demands return to a more normal state.

Kaweah Delta WCD currently owns approximately 380 acres on the south side of the Lower Kaweah River, just east of the Friant Kern Canal which is a portion of the property known as the Hannah Ranch. The District intends to develop the property into below ground earthen basins, develop a new more permanent Hannah Dam structure, develop a new turnout from the Friant-Kern Canal and develop a facility that would allow stored water in the new basins to be reregulated back to the Lower Kaweah River by gravity. This Project's primary benefits are flood damage reduction benefits, but secondary benefits also include the conservation of floodwater, the reduction of conflict over water resources in the area, environmental stewardship through the development of conserved habitat for endangered species, and expanding the Kaweah River Power Authority's ability to generate on-peak hydroelectric power at Terminus Dam.

[4] 1990 Hydrology Report, Kaweah River Basin, CA, Section 2-07: Runoff, ACOE – Sacramento District

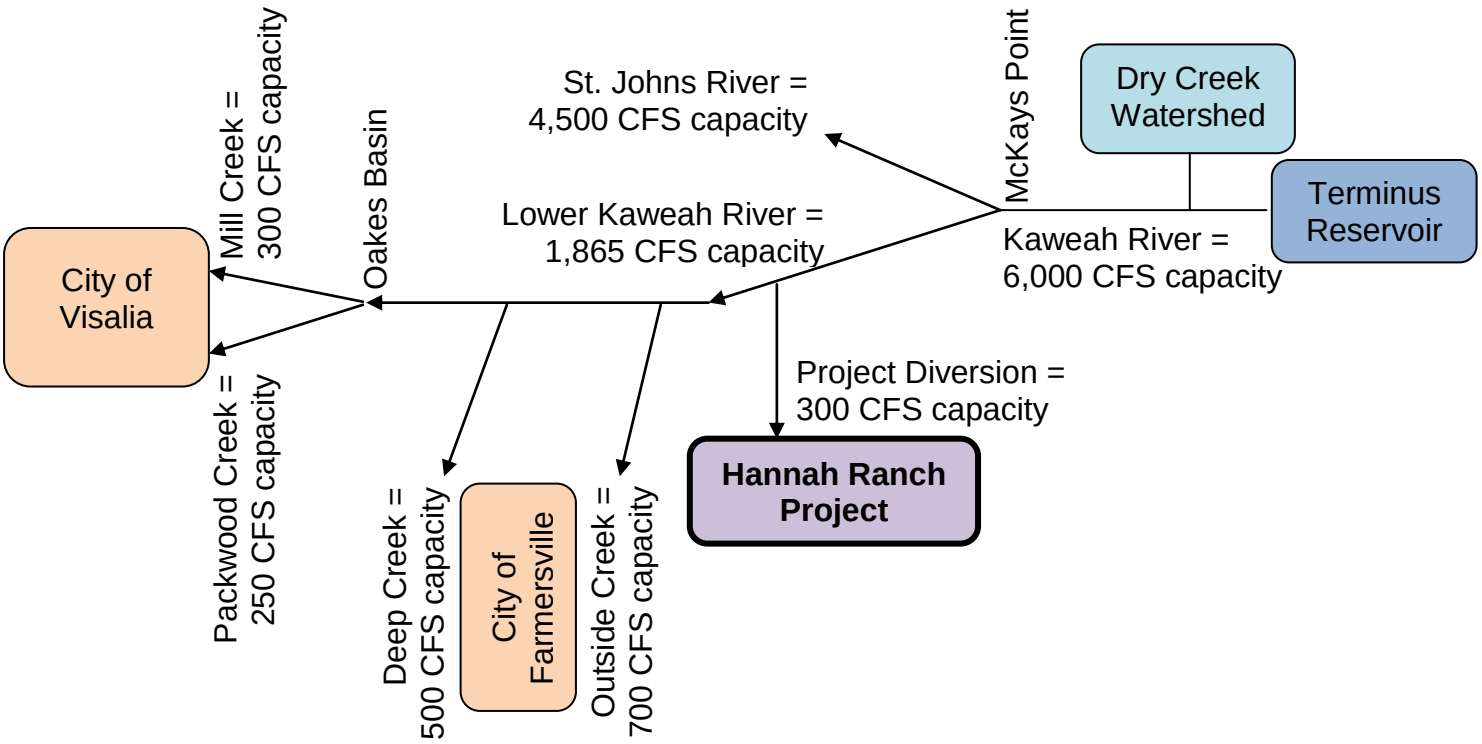


Figure 10-2 – Flood Channel Schematic

10.1.2 Flood Damage Benefit Analysis

10.1.2.1 Analysis Methods not Pursued

This application for grant funding was begun in January 2013 and therefore certain Project benefit analyses were not feasible given Project development at that point. Also, given the 11 mile distance between the City of Visalia and the Project site, and the four mile distance between the Project site and Terminus Dam a significant amount of topographic information would have been necessary to develop in order for a functional flow model to be used in the project benefit analysis. As this effort was evaluated in the initial stages of the grant application development it was viewed as potentially being very expensive and likely not feasible to complete within the available time given the likelihood of wet weather along these floodwater channels.

TR-20 would have been a suitable program to evaluate the flood runoff flows and volumes from the Dry Creek watershed and subsequent flooding in downstream areas. The watershed modeling could have been accomplished with USGS topographic contour mapping, but given the other studies that had already evaluated peak flows from this watershed it was not believed that the modeling analysis would further refine the published hydrograph information for the watershed. Also, the District had very little

topographic or cross-sectional information on the Kaweah River channel or other channels further downstream. In order to use these programs the structures at each diversion point and road crossing would be needed to be modeled and there was not readily available information to accomplish that. Given the lack of control structure information as well as topographic information on the channel and the overbank areas, HEC-RAS or HEC HMS models could have only been developed with major assumptions about conveyance geometry along the 15 mile alignment and given these assumptions were not viewed as more detailed efforts than the spreadsheet model that was ultimately developed.

10.1.2.2 Analysis Framework and Assumptions

Hydrograph information from ACOE's 1990 Hydrology Report for the Kaweah River Basin was used as the basis for irregular flood events generated by the Dry Creek watershed. Further, consistent with the December 1966 flooding event, it was assumed that Dry Creek was the generator of peak flood flows that cause flood damage in the City of Visalia. Using this information hydrographs were generated for 10, 25, 50 75 and 100 year Dry Creek events draining into the Kaweah River. The hourly flows associated with these hydrographs were compared with published channel capacities from the 1962 Terminus Dam and Lake Kaweah Reservoir Regulation Manual to develop a framework for flooding evaluations. Historic diversion records were used to estimate the flows past McKays Point in the Lower Kaweah that would eventually pass the Project site. Diversions from the Lower Kaweah were accounted for at Outside Creek (max. 700 CFS) and Deep Creek (max. 500 CFS).

Consistent with the opinion of the KDWCD District Engineer and other 100-year flood modeling for FEMA performed by Northwest Hydraulic Consultants in 2009 it was assumed that flood flows along the Lower Kaweah River caused significant overland flooding and therefore peak flows attenuated at Oakes Basin to roughly 1/3 the peak flow that passed the Project site (11 miles upstream). However although the peak flow is reduced due to attenuation it was also assumed that almost no volume was lost along the flood corridor and therefore the hydrograph near Oakes Basin had a long duration at or near the peak flow. At Oakes Basin, which is where the Lower Kaweah River bifurcates, it was assumed that the flows split evenly between Mill and Packwood Creeks.

Capacities in Packwood and Mill Creek were used from more recent studies in the City of Visalia for these conveyance systems. Packwood Creek was estimated to have a capacity of 250 CFS and Mill Creek 300 CFS. However for this analysis it was

assumed that the runoff from the City of Visalia required 50 CFS of channel capacity in each Creek and thereby reduced the available capacity.

10.1.3 Sources Used in Analysis Development

10.1.3.1 1990 Hydrology Report, Kaweah River Basin, CA (ACOE – Sacramento District)

The Sacramento District of the Army Corps of Engineers produced a Hydrology Report on the Kaweah River Basin in August of 1990 **(see Attachment 7, Appendix A)**. The report was prepared in support of a Kaweah River feasibility study and summarized hydrologic information for the Kaweah River and its major tributary, Dry Creek. The information was to be used to provide estimates of the probability of downstream peak flows and flow volumes resulting from various project configurations. In a 2009 FEMA publication on the 100-year Flood Zone along the Kaweah River by Northwest Hydraulic Consultants, this document was researched and verified as still describing current hydrology for the Region.

10.1.3.1.1 Dry Creek Standard Project Flood Hydrograph

This report contained two versions of standard project hydrographs for Dry Creek. One version was for a “specific” storm centered over the Dry Creek watershed, while the other was a “concurrent” storm that was more centered over the Kaweah River watershed. As noted in the 1990 ACOE Hydrology Report, “for the specific centering, total basin mean precipitation of 16.62 inches fell on the 81.9 square mile basin over 5 days.” “The resulting SPF peak inflow was 23,165 CFS and the total volume was 33,089 AF.” The specific storm hydrograph was selected for use in this evaluation because after reduction by flood series ratios it matched more closely with the Tulare County Flood Masterplan information on Dry Creek flows from the December 1966 storm.

10.1.3.1.2 Ratios for Flood Series

This report published a set of ratios that could be used with standard project events to estimate the hydrographs for different recurrence interval events. There were ratios for 10, 25, 50, 100, 200, and 500 year events. These ratios and the specific standard project event for Dry Creek were used to develop hydrographs for flood events upstream of McKays Point for 10, 25, 50 and 100 year events.

10.1.3.1.3 Regulated Rain Flow Frequency

This report also contained a chart (Chart 22) of regulated rainflow frequencies for existing conditions at McKays Point. The chart shows estimated peak flows at McKays Point for recurrence intervals from 5 to 1000 years.

10.1.3.2 1962 Terminus Dam & Lake Kaweah Reservoir Regulation Manual (ACOE – Sacramento District)

10.1.3.2.1 Channel Capacities (Chart 2)

This document **(see Attachment 7, Appendix B)** contains a map Titled Chart 2 that shows estimated channel capacities for most of the major creeks downstream of Terminus Dam on the Kaweah and St. Johns Rivers. In discussions with the District Engineer he felt that the estimated capacities from this figure matched with his experience in the area. Specifically capacities for the Kaweah River above McKays Point, the St. Johns River below McKays Point, the Lower Kaweah River below McKays point, Outside Creek, and Deep Creek were used from this document.

10.1.3.3 2005 Terminus Dam & Lake Kaweah Water Control Manual (ACOE)

10.1.3.3.1 Reservoir Design Flood Routing (Plate 8-2)

This report **(see Attachment 7, Appendix C)** contains a Plate that depicts the reservoir design flood routing given modifications that were completed at Terminus Dam in 2004. Plate 8-2 depicts the inflows to Terminus Dam, the releases from Terminus Dam, storage in Terminus Reservoir, and the flows from Dry Creek that were involved in the design for Terminus Dam modifications. Plate 8-2 shows a five day design flood routed through the reservoir where when Dry Creek flows begin to cause flooding releases from Terminus Dam are brought to a minimum to avoid additional flood damage. The plate shows that besides the period when Dry Creek peaks, Terminus Reservoir has sufficient storage to regulate flows downstream of the Dam to approximately 5,500 CFS.

10.1.3.3.2 Hypothetical December 1966 Flood Routing (Plate 8-5)

This Plate shows that with the modifications to Terminus Dam in 2004 that in a flood event like the one from December 1966 the reservoir could hold back the Kaweah River inflow while allowing Dry Creek to peak and then regulating flows into the Kaweah River to approximately 5,500 CFS. However the peak from Dry Creek would be

approximately 14,000 CFS and flows in excess of the 5,500 CFS target at McKays Point might last for approximately 22 hours.

10.1.3.4 Tulare County Flood Control Masterplan

After the December 1966 and 1969 floods, Tulare County studied the flood damage that occurred as a result of these two events, the rainfall that produced them and the protection that Terminus Dam (Kaweah River) and Success Dam (Tule River) provided the communities of Visalia and Porterville **(see Attachment 7, Appendix D)**.

10.1.3.4.1 Dry Creek Hydrograph for December 1966 (Hydrology Appendix – Figure 5)

In this document a gauging station on Dry Creek was used to produce a hydrograph for the December 1966 flood event. The peak for this storm was approximately 14,000 CFS. The flood event was estimated to be approximately a 67 year recurrence event. During the flood event, Kaweah River flows into Terminus Reservoir were not released from the reservoir while Dry Creek flows exceeded safe levels at McKays Point. After Dry Creek flows receded, then the reservoir began to make controlled releases again and was able to keep those releases near or below the 5,500 CFS target at McKays Point. The shape and magnitude of the Dry Creek hydrograph in this report was consistent with the information presented in the Army Corp's 1990 Hydrology Report for the Kaweah River Basin.

10.1.3.5 FEMA Flood Analyses in the Area

In 2009 Northwest Hydraulic Consultants (NWHC) published a Flood Insurance Study Report for FEMA on 100-year flood zones along the Kaweah and St. Johns Rivers between Terminus Dam and Highway 99 **(see Attachment 7, Appendix E)**. NWHC developed a two dimensional flood model for the area (composite MikeFLOOD, Mike 21 and Mike 11 models) and evaluated depths of flooding for the 100-year event. It was hoped that this modeling effort could support the flood damage reduction analysis for the proposed project, but after discussion with NWHC it was learned that extracting hydrographs or other basic model information would be a significant effort and wasn't feasible given the time available to prepare the grant application.

10.1.3.6 Discussions with District's Senior Engineer

10.1.3.6.1 System Management and Regional Flood Damage

10.1.3.6.1.1 Reasons for Flooding in Visalia

In discussions with the KDWCD's Senior Engineer, Larry Dotson, there appear to be two reasons for flooding in the City of Visalia. One would be from peak flows in excess of channel capacities, but the other is limited capacity in creek channels that have been incorporated into the City's storm drain system.

10.1.3.6.1.2 Historic Flow Records

KDWCD Senior Engineer provided daily average flow records for the Lower Kaweah River, Packwood Creek and Mill Creek for review. This information was not capable of showing short duration peak events, but did indicate that the events when channel capacity was exceeded in this area were very rare. Only three events could be identified and they were in 1966/67, 1969 and 1997.

10.1.3.6.1.3 Events when Damage was Experience

KDWCD's Senior Engineer described a few events since Terminus Dam was built where there was flood damage in the City of Visalia. These events were 1967, 1969, 1984, 1997, 2005, 2006 and 2010. However as described in the previous paragraph, the 1967, 1969 and 1997 events were the only events where flooding was caused by peak flood flows. As previously stated the 1967 event had a peak of 14,500 CFS on Dry Creek while in 1969 the second highest peak on record was 6,020 CFS and in 1997 the third highest peak on record was 4,300 CFS (below the 5,500 CFS target at McKays Point). The other events were longer rainfall events where several storms came through the area and high flows in the creeks caused localized flooding in Visalia because rainfall exceeded the storm drain systems ability to convey the precipitation away.

10.1.3.6.1.4 Management of Creek Systems

The distance from Terminus Dam to the City of Visalia is approximately 15 miles. Between Terminus Dam and the City of Visalia there are at least four significant locations were management decisions can be made to manage flows. These locations are at McKays Point, the Outside Creek diversion, the Deep Creek diversion and the bifurcation of the Lower Kaweah River to Packwood and Mill Creeks (at Oakes Basin). These channels and diversions are operated by local water managers to minimize flooding in the area and maximize regulated surface water supplies for conjunctive use after flood events have passed.

The District's Senior Engineer describes that when large flood events happen like the 1967 or 1969 flood that significant overland flooding occurs along the creeks due to the peak, but this also causes significant attenuation along the system and is one of the

reasons why peak flows near Oakes Basin are roughly 1/3 the magnitude that they are on the Lower Kaweah downstream of McKays Point. This point is supported by the two dimensional modeling that was done by NWHC for FEMA's 2009 revision of the 100-year Flood Zone in this area. Their modeling showed significant amounts of overland flow traveling much slower than the peak flows conveyed along the creeks.

10.1.4 Results of Spreadsheet Model Analysis

10.1.4.1 Pre-Project Flooding

A spreadsheet model was developed to track hourly flood flows from hydrographs for 10, 25, 50, 75 and 100 year storms through the different parts of the flood corridor and the flows beyond the channel capacity that would result in the City of Visalia **(see Attachment 7, Appendix F)**. The developed spreadsheet model roughly corresponds to the amount of flooding that has been experienced in different recurrence interval storms. For instance in smaller 10 year storms Visalia does not experience flood damage associated with peak flows overtopping creek banks and the spreadsheet model reflects that. However, the spreadsheet model indicates that in a 75 year storm channel capacity would be exceeded for a several hours and that is consistent with what happened in Visalia in December 1966.

The tables on the next page summarize the Flood Damage Reduction estimated due to the Project.

10.1.4.2 Post-Project Flooding

The incorporation of the 2013 Hannah Ranch Flood Control & Habitat Conservation Project into the spreadsheet model diverted 300 CFS from the flood flows on the Lower Kaweah below McKays Point and in the largest events was able to divert a maximum of 1,500 AF. This diversion was tracked hourly and the diverted volume was not allowed to proceed downstream toward Visalia. Because these are rainfall storms produced by a relatively small watershed this new diversion and storage had some significant impacts to flows beyond channel capacity in Visalia. Although the 300 CFS diversion capacity was not sufficient to avoid the peak flows exceeding channel capacity, the diversion capacity and storage was able to significantly reduce the duration of when flood flows exceeded channel capacity.

10.1.4.3 Area and Depth of Flooding

There was not sufficient time to do a detailed flood model that accounted for topographic variations in the City and use it to help estimate the details of where flood

waters would pool. In the time available for the preparation of the grant application several simplifying assumptions were made to help estimate the area impacted by flooding.

The topography in the area of the City of Visalia generally falls to the southwest toward the historic Tulare Lake bottom. Due to this the two creeks that flow through the City of Visalia flow generally perpendicular to contours. Therefore it was assumed that floodwaters from peak flows would rise to an average depth of 6-inches and then spread out to an area necessary to accommodate the flooding volume.

Packwood Creek is mostly an open channel along its alignment through the City and for that reason it was assumed that flooding would develop a corridor along the channel through the City. However Mill Creek transitions from a channel to an underground culvert that runs through most of the downtown business district. Consistent with the opinion of the City's previous City Engineer (John Dutton), it was assumed that the transition from channel to the underground culvert was the restriction and was the location around which flooding developed. Mill Creek flows then move southwest through downtown spreading out due to the general fall in the area.

10.1.4.4 Number of Buildings

After flooded areas were estimated, available GIS information was used to count the number of parcels impacted by flood waters in each storm. Given the somewhat crude method of determining the flooded areas, it was decided that all buildings identified would be evaluated as if they were residential (least valuable property) in order to be conservative on the estimates of Project benefits. Also consistent with this it was assumed that streets involved in damage estimate were included as the least costly paved roads.

Table 10-1: Hannah Ranch Project Summary Benefit Table

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

Note: Values in red designate flows in excess of channel capacity

10.1.4.5 Flood Damage Reduction Benefits

DWR's Flood-Rapid Assessment Model (F-RAM) was used to estimate the flood damage and the flood damage reduction benefits from the project for various recurrence interval storms.

10.2 Project Physical Benefits

10.2.1 Flood Protection

10.2.1.1 Land

Table 10-2: Hannah Ranch Project Summary Flood Flow Table

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

There are two areas that will be protected from flood damages in the City of Visalia. One area is along Packwood Creek in the southeast of the City and the other is in the City's downtown business district along Mill Creek. For 25, 50 and 75 year storms the benefit analysis indicated that many acres will be protected from flooding by the Project. Most of the land flooded by Packwood Creek is residential housing, while most of the land flooded by Mill Creek is commercial. The method of determining the flooded areas was based on an assumption of 6-inch flooding depth for all cases. This is a major simplifying assumption and was done because of limited time and a lack of information on developed water surface elevation from flood flows. In an attempt to be conservative in the analysis of benefits all lands were assumed to be residential, bringing down the value of lands flooded by Mill Creek, and thereby reducing the value of avoided flood damage.

The flooded area associated with Packwood Creek was viewed as having an average flood depth of 6-inches and an offset from the creek wide enough to develop the estimated flooded volume. The area surrounding the creek was viewed as not having any significant confining barriers and therefore allows floodwater to spread uniformly in width along the channel alignment. The flooded area produced by Mill Creek was

primarily focused on the area where the open channel creek transitions to a below ground culvert. The flooding scenario was envisioned to be when culvert reached capacity and began to develop backwater that eventually escaped the channel banks and began to flow overland. The below ground culvert through Visalia's downtown area was originally built in response to a large flood event that significantly damaged the City in the early part of the 1900s. Highway 198 to the south and Murray Avenue to the north were viewed as being confining barriers which then guided floodwater to the west in the direction of falling ground surface.

For the 100 year storm reduced flooded area was also calculated but will not be included in the benefits total. The reason for not including these benefits is because Terminus Dam has been estimated to provide protection up to approximately a 75 year event, but in a 100 year event it would not be able to regulate flows to the 5,500 CFS target at McKays Point. Instead the runoff from the Kaweah River would be much greater than the flow from Dry Creek (what is being evaluated in the other storms) and would likely make the layoff from the Project of minimal benefit.

Given the location of the Project's layoff basins it is anticipated that the City of Farmersville, a disadvantaged community, would also receive additional flood damage reduction benefits from the Project due to reduced peak flows along Deep Creek and Outside Creek. Currently there is not enough time to produce an analysis to estimate those benefits, but it is hoped that with additional time an estimate could be made for this community as well as for the City of Visalia.

10.2.1.2 Buildings

As was mentioned previously, the estimated flooded areas were used with GIS information on Tulare County parcels to estimate how many parcels were in each area. It was assumed that there was one building on each parcel in the areas, and since it was assumed that all lands were residential, it was further assumed that all buildings in the area were single story residences with no basement.

However it should be noted that the area flooded by Mill Creek is primarily Visalia's historic downtown business district. This area contains the City's convention center, three City Hall buildings, the City's Police Chief and Fire Chief offices, Redwood High school, Kaweah Delta Medical Center, several banks and many businesses that support the community of Visalia.

10.2.2 Public Safety

Kaweah Delta Medical Center is a regional hospital in the area and if it were flooded the impacts would delay emergency services to those needing emergency aid. As was mentioned in the previous paragraph there are also several government buildings in the flood areas as well as schools. Schools are often used as locations to gather in times of emergency, but in this case they would not likely be viable for this purpose. Also the flooding of government buildings will likely lengthen emergency response times in the area.

10.2.3 Floodwater Conserved

The Project's floodwater layoff basins will reregulate floodwater and conserve it so that it can hopefully be used for a beneficial use (recharge groundwater, irrigation supplies, etc.). The facilities are planned to have a maximum storage of 1,500 AF. The spreadsheet model that was used to evaluate flood flows was also used to account for floodwater diverted into the Project basins based on the maximum diversion rate of 300 CFS and an assumed start hour during each storm. The table below quantifies the estimated conserved floodwater from each recurrence interval storm.

Table 10-3: Hannah Ranch Project Conserved Floodwater Table

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

As can be seen it appears that in 50 – 100 year storms the basin will be filled to capacity, but in smaller storms the diversion rate won't be enough to fully fill the basins. Also it should be noted that while there was an estimate developed for the 100 year storm, these benefits are not being counted for the project because in this type of event the volume of available floodwater would be so great in the area that it is doubtful that the supply could be delivered to beneficial use.

The value of the conserved water is related to alternative sources of supply. In wet years these would be Friant Division CVP, other local river supplies and pumped groundwater. Friant Division CVP Class 2 supplies are roughly $35/AF, pumped

groundwater is roughly $40-60/AF in this area and local river supplies likely won't carry any cost. Due to this variety of possible costs the value of the conserved supplies was set at $20/AF.

10.2.4 Environmental Stewardship and Habitat Development

10.2.4.1 Acreage

The areas of the Project that will be developed for endangered species habitat are either along the south bank of the Kaweah River (a kind of habitat corridor along the river) or near the top of the levees that bound project basins. The width of the area along the Kaweah River is approximately 100 feet and its length is approximately 5,700 feet producing an area of 13.1 acres. The planted habitat area on the upper banks of basin levees will be approximately 20 feet wide on the 36,820 feet of levee producing and area of 16.9 acres. This habitat will be developed and maintained by KDWCD as part of the Habitat Conservation Plan.

10.2.4.2 Species

Following the initiation of Kaweah Delta WCD's 1993 Kaweah River Delta Corridor Enhancement Study that investigated the feasibility of managing surface and storm waters for the benefit of the region's groundwater and biological resources, Kaweah Delta WCD pursued the development of a Habitat Conservation Plan (HCP). A HCP comprehensively addresses the long-term habitat and species impacts beyond what would normally be handled on a project-by-project basis, allowing for comprehensive management of the water needs of the area. Currently, the Kaweah Delta WCD has received approval of the Plan of Study. The Plan of Study is divided into three phases: a) Project Development, b) HCP Development, and c) environmental analysis and review. The Project Development Phase includes those efforts needed to fully develop the scope and nature of the HCP, as well as integration of State of California, Endangered Species Act requirements. The HCP Development Phase will take elements from the Plan of Study and the Project Development Phase to form the content of the HCP document and the basis for a Section 10(a) Incidental Take Permit and associated State action. The final phase will develop appropriate environmental documentation in satisfaction of NEPA and CEQA guidelines for the covered actions within the proposed HCP.

The habitat area along the south bank of the Kaweah River would be planted with regionally significant phreatophytes such as willows, cottonwoods and potentially sycamores. The upper levees of the basin cells would be re-developed into Oak

Savannah habitat as this property located within the historic Kaweah River Delta. In the mid 1800's the Kaweah River Delta supported the largest stand of valley oak (*Quercus lobata*) riparian forest in the world (McClaron 1983). The vast majority of this habitat type has since been eliminated as a result of conversion to agriculture. The habitat development along the upper rim of the new basin levees includes the restoration of Valley Oak Savannah and wild rose. Also this project is consistent with the Tulare Lake Basin Plan through the implementation of watershed management activities by local agencies.

Anticipated endangered species that will benefit from the conserved habitat include brush rabbit, western pond turtle, and Swainsons hawk. Also the Project will support a nearby Heron rookery and several local raptor species.

10.2.5 Increased Peak Power Generation

Kaweah River Power Authority (KRPA) developed and operates a hydroelectric turbine at Terminus Dam that produces electricity to support the green energy needs of California. The additional offstream surface water storage developed through the Project creates the potential for KRPA to produce greater amounts of on-peak hydroelectric energy through Terminus Dam while reregulating surface water supplies through the Project basins so that water right holders are kept whole and do not loose available resources through the effort. Kaweah Delta WCD with Tulare ID are partners in KRPA.

ATTACHMENT 7 – TECHNICAL JUSTIFICATION

APPENDIX A

1990 Kaweah River Basin Hydrology Report

OFFICE REPORT AUGUST 1990

KAWEAH RIVER BASIN, CALIFORNIA

HYDROLOGY

US Army Corps
of Engineers
Sacramento District

CESPD-ED-W (CESPK-ED-D/17 May 89) 3rd End Mr. Markowitz/rvv/705-1434
SUBJECT: Hydrology Report, Kaweah River, California

DA, South Pacific Division, Corps of Engineers, 630 Sansome Street, Room 720, San Francisco, CA 94111-2206 JAN 30 1991

FOR Commander, Sacramento District, ATTN: CESPK-ED-D

Corrected copy of subject report is approved for use in the feasibility study.

FOR THE COMMANDER:

3 Encls
~~no~~ WD

JAY K. SOPER
Director, Engineering

HYDROLOGY OFFICE REPORT
KAWEAH RIVER, CALIFORNIA

TABLE OF CONTENTS

Paragraph	Subject	Page
	CHAPTER I - INTRODUCTION	
1-01	Purpose and Scope	1
1-02	Flood Problems	1
	CHAPTER II - DESCRIPTIVE HYDROLOGY	
2-01	Location, Kaweah River	2
2-02	Description, Kaweah River Area	2
2-03	Location, Dry Creek	3
2-04	Description, Dry Creek Area	3
2-05	Channel Capacities	4
2-06	Climate	4
2-07	Runoff	6
	CHAPTER III - UNIMPAIRED FLOW FREQUENCY ANALYSIS	
3-01	Unimpaired Rain Flow Frequency Curves, Kaweah River	9
3-02	Unimpaired Snowmelt Flow Frequency Curves	9
3-03	Unimpaired Rain Flow Frequency Curves, Dry Creek	10
3-04	Risk	10
	CHAPTER IV - STORM AND RUNOFF ANALYSIS	
4-01	Unit Hydrograph, Kaweah River	12
4-02	Unit Hydrograph, Dry Creek	12
4-03	Loss Rates and Base Flow, Kaweah River	12
	CHAPTER V - HYPOTHETICAL FLOODS	
5-01	Standard Project Flood, Kaweah River	13
5-02	Standard Project Flood, Local Streams	13
5-03	Probable Maximum Flood, Kaweah River	13
5-04	Probable Maximum Flood, Dry Creek	14
5-05	Flood Series	14

TABLE OF CONTENTS
(continued)

Paragraph	Subject	Page
	CHAPTER VI - REGULATED FLOW FREQUENCY ANALYSIS	
6-01	Regulated Peak Flow Frequency Curves	15
6-02	Regulated Volume Flow Frequency Curves	15
	CHAPTER VII - RESERVOIR DESIGN DATA	
7-01	Reservoir Sedimentation	17
7-02	Wave Runup	18
7-03	Storage Frequency	18

LIST OF TABLES

Table No.	Subject	Page
2-01	Percent of Area Above Given Elevations	2
2-02	Vegetal Cover on Kaweah River Basin above Lake Kaweah	3
2-03	Mean Monthly Temperatures	5
2-04	Mean Monthly Precipitation	6
2-05	Mean Monthly Runoff in Kaweah River and Dry Creek	7
2-06	Historical Maximum Inflow to Lake Kaweah During the Rain Season	7
2-07	Historical Maximum Inflow to Lake Kaweah During the Snowmelt Season	8
2-08	Historical Maximum Inflow to Dry Creek During the Snowmelt Season	8
3-01	Risk of being Flooded in a Given Period of Time	11
7-01	Estimated Past and Future Storage Capacities In Lake Kaweah	17
7-02	Lake Kaweah Wave Runup Data	18

LIST OF CHARTS

Chart No.	Subject
1	General Map
2	NAP Map
3	Unregulated Condition Flow Frequency Data, Kaweah River, General Rain Runoff
4	Rain Flow Frequency Curves, Kaweah River, Unimpaired Conditions

LIST OF CHARTS
(continued)

Chart No.	Subject
5	Unregulated Condition Flow Frequency Data, Kaweah River, Snowmelt Runoff
6	Snowmelt Flow Frequency Curves, Kaweah River, Unimpaired Conditions
7	Unregulated Flow Frequency Data, Dry Creek near emoncove, General Rain Runoff
8	Rain Flow Frequency Curves, Dry Creek Unimpaired Conditions
9	Unit Hydrograph, Kaweah River
10	Historical Flood Reproductions
11	Unit Hydrograph, Dry Creek
12	Standard Project Flood, Lake Kaweah
13	Standard Project Flood (Specific), Dry Creek
14	Standard Project Flood (Concurrent), Dry Creek
15	Standard Project Flood (Concurrent), Mehrten Creek
16	Standard Project Flood (Concurrent), Yokohl Creek
17	Probable Maximum Flood, Kaweah River
18	Probable Maximum Flood, Dry Creek
19	Ratios for Flood Series
20	1969 Daily Values and Ratios Used for Hypothetical Flood Routings
21	100-Year Flood Routed through Existing Lake Kaweah
22	Regulated Rain Flow Frequency, Existing Conditions
23	Assumed Maximum Daily Irrigation and Spreading Demand
24	Comparison of Simulated Flow to Tulare Lakebed to Actual Flow to Tulare Lakebed
25	Simulated Flow to Tulare Lakebed Under Existing 1988 Conditions
26	Annual Volume Frequency of Floodwaters to Tulare Lakebed under Existing Conditions
27	Seasonal Variation of Reservoir Storage

CHAPTER I - INTRODUCTION

1-01 Purpose and Scope.

This office report has been prepared to support the Kaweah River feasibility study. It summarizes hydrologic information developed for the Kaweah River and its major tributary, Dry Creek. This information will be used to provide estimates of the probability of downstream peak flows and flow volumes resulting from various project configurations. It will also be used to design the spillway and other hydraulic features and to determine freeboard and sediment requirements. Information in this report supercedes information contained in the documentation report for the Kaweah River Basin Investigation dated January 1987.

1-02 Flood Problems.

The Kaweah River flows into Lake Kaweah which is operated for flood control, conservation and other purposes. There are three major tributaries to the Kaweah River below Terminus Dam, Dry, Mehrten, and Yokohl Creeks. Dry Creek, having considerable flood potential but no storage facilities, enters the Kaweah River above McKays Point. McKays Point is a control point for objective flow releases from Terminus Dam, and is also where the river flows are divided between the St. Johns and Kaweah Rivers. Mehrten and Yokohl Creeks join the Kaweah River below this point, and are accounted for at the time releases are made from Terminus Dam. The main river channel of the Kaweah River forms numerous distributary channels east of Visalia. These distributaries transport water for irrigation and spreading, and most of the water is diverted or seeps into the sand beds. However, excess flow from these channels, as well as the Tule, Kings, and Kern Rivers and other sources enters Tulare Lakebed and floods valuable agricultural property.

Lake Kaweah is operated for an objective flow of 5,500 c.f.s. at McKays Point. Greater flows cannot be controlled and may flood developed portions of Visalia. McKays Point flows are split between the St. Johns and Kaweah Rivers. Further discussion of channel capacities may be found in section 2-05. Lake Kaweah has not spilled uncontrollably since its completion in 1962. However, it filled in December of 1966 and nearly filled in 1969. It is expected to spill substantially about once every 50 years on the average.

CHAPTER II - DESCRIPTIVE HYDROLOGY

2-01 Location - Kaweah River.

Headwaters of the Kaweah River are near Triple Divide Peak on the Great Western Divide, a secondary ridge parallel to the main crest of the Sierra Nevada above Visalia. Four tributaries form the main stream which flows southwesterly toward Visalia. Terminus Dam and associated reservoir, Lake Kaweah, are located on the Kaweah River about 21 miles east of Visalia. Chart 1 is a General Map of the Kaweah River area.

2-02 Description of the Kaweah River Basin Area.

The Kaweah River watershed is a fan-shaped area of about 561 square miles above Lake Kaweah. The North, Middle, East, and South Forks combine in the foothills to form the mainstem of the Kaweah River. The forks are fed by numerous steep streams with slopes from 400 to 1,000 feet per mile, transitioning to gentle slopes on the valley floor. Watershed elevations range from a maximum of about 12,600 feet in the headwater area to about 510 feet at Terminus Dam, 325 feet at Visalia and approximately 175 feet at the lowest point in Tulare Lakebed.

The percentages of total area above various elevations are listed below:

Table 2-01

Percent of Area Above Given Elevations

Elevation (feet)	Percent of Area Above Elevation
510	100
2,000	88
4,000	67
5,000	57
6,000	45
8,000	22
12,650	0

The portion of the basin above 9,000 feet elevation is characterized by mountain peaks and ridges having either a very thin mantle of soil or exposed rock. Remaining portions have soil cover that is moderate to deep and vegetal cover is described in the following table:

Table 2-02

Vegetal Cover on the Kaweah River Basin above Lake Kaweah

Description	Elevation (ft. m.s.l.)	Percent of Basin Area
Grass lands (with scattered brush)	1000 - 2,000	0.5
Brush lands (chaparral, etc.)	3,000 - 9,000	22.7
Deciduous forest (with brush, scattered conifers, and grass)	500 - 6,000	26.3
Light coniferous	5,000 - 12,000	30.1
Heavy coniferous	5,000 - 9,000	6.8
Sub-alpine forest	8,000 - 10,000	4.3
Bare rock, lakes, etc.	9,000 - 12,600	9.3

Source: Terminus Dam (Lake Kaweah) Reservoir Regulation Manual, June 1962; Sacramento District, Corps of Engineers.

Dry Creek joins the Kaweah River about one mile downstream of Lake Kaweah, and stream flows are split between the Kaweah and St. Johns Rivers approximately one mile further downstream at McKays Point Weir. The Kaweah River flows southwesterly toward Visalia through predominantly agricultural land. The main river channel of the Kaweah River forms numerous distributary channels east of the city, and irrigation diversions generally cause the river to dry up before reaching its terminus in Tulare Lake.

2-03 Location - Dry Creek.

Headwaters of Dry Creek are in Sequoia National Forest, located in the southern Sierra Nevada above Visalia. Dry Creek flows predominantly south to southwest through lower foothills and joins the Kaweah River about one mile below Lake Kaweah. The confluence of Dry Creek and the Kaweah River is approximately 20 miles east of Visalia.

2-04 Description of the Dry Creek Area.

The Dry Creek watershed above the proposed dam site is a narrow fan-shaped area of about 81.9 square miles on the western slope of the Sierra Nevada. It is separated from the Kaweah River basin by broad, hilly to steep lands adjacent to the streams.

Dry Creek flows through low foothills for about 25 miles before emerging on the valley floor and forming a junction with the Kaweah River. The basin area is predominantly rangeland, but trees and shrubs grow at higher elevations and along the

creek where water is readily available. Soil cover below 6,500 feet is moderately deep. Vegetal cover consists of Valley Oak, Blue Oak, conifer, and Sycamore woodlands, brushlands and large areas of grassland. Dry Creek seeps into the sandy creekbed and often dries up after the runoff season, as is typical of smaller streams that extend into the valley from the foothills.

Elevations of the watershed range from a maximum of about 6,500 feet in the headwater area to about 450 feet at the confluence with the Kaweah River. The higher areas are characterized by steep hills with rock outcrops transitioning to gentle slopes on the valley floor. Basin slopes range from 250 to 2,500 feet per mile.

2-05 Channel Capacities.

The objective flow on the Kaweah River at McKays Point is 5,500 c.f.s., above which control is lost and damage begins to occur. The flow is divided between the St. Johns and Kaweah Rivers. The St. Johns River carries flows northwest and the Kaweah River flows southwesterly from McKays Point. The Kaweah River and its distributaries ultimately terminate in Tulare Lakebed. Flooding of agricultural areas along the Kaweah River system channels has been observed at flows of 5,500 and less. The channel capacities within the system vary widely, and in many cases are unknown.

2-06 Climate.

Temperatures within the basin vary considerably. The valley floor is characterized by hot dry summers and moderate winters. Temperatures on the valley floor normally range between a high of 110 degrees Fahrenheit in the summer to about 30 degrees in the winter. Summers at the upper elevations are cool with temperatures averaging in the low to mid-sixties, and winters are severe with temperatures dropping below freezing. Actual monthly and mean annual temperatures at representative stations are shown in the following table.

Table 2-03

Mean Monthly Temperatures

Month	Terminus Dam Elev. 510	Grant Grove Elev. 6600 (degrees Fahrenheit)	Three Rivers Edison PH #1 Elev.1,140
Oct	65.4	49.3	64.9
Nov	57.1	40.6	53.1
Dec	49.3	36.1	47.1
Jan	46.6	33.9	46.9
Feb	51.3	34.7	51.3
Mar	54.8	34.9	54.0
Apr	59.5	38.9	58.7
May	68.0	46.2	68.2
Jun	75.2	55.2	76.0
Jul	81.3	62.9	82.1
Aug	79.9	61.4	80.9
Sep	74.7	57.1	75.8
Mean	63.6	46.0	63.3
Per of Rec'd	1965-1984	1941-1985	1971-1984

Normal annual precipitation (NAP) in the Kaweah River Basin varies from about 15 inches at the lower elevations to 55 inches at the headwaters. The NAP for the basin above Lake Kaweah is 36.6 inches. NAP isohyetals are shown on chart 2. Approximately 90 percent of the precipitation occurs from November through April and generally occurs as rain below 5,000 feet and as snow above that elevation. Occasionally warm winter storms produce rain up to 11,000 feet, and snow has occurred on the valley floor. Actual average monthly precipitation at representative stations is shown in table 2-04.

Table 2-04

Mean Monthly Precipitation

MONTH	Terminus Dam Elev. 510 Prec. (IN)	% of Tot.	Bear Trap Elev. 6800 Prec. (IN)	% of Tot.	Atwell Elev. 6480 Prec. (IN)	% of Tot.	Hockett Elev. 8500 Prec. (IN)	% of Tot.	Giant Forest Elev. 6650 Prec. (IN)	% of Tot.
Oct	0.72	4.8	1.85	3.6	1.62	3.7	1.65	3.9	1.62	3.8
Nov	1.91	12.6	5.63	10.9	4.57	10.6	3.54	8.3	4.44	10.3
Dec	2.51	16.6	8.72	16.8	6.72	15.5	6.75	15.8	7.22	16.8
Jan	2.71	17.9	8.48	16.4	7.89	18.2	7.06	16.5	7.35	17.1
Feb	2.34	15.5	8.83	17.0	6.73	15.6	8.23	19.3	7.61	17.7
Mar	2.55	16.8	7.79	15.1	6.74	15.6	6.34	14.8	6.70	15.6
Apr	1.42	9.4	4.44	8.6	3.81	8.8	3.63	8.5	4.65	10.8
May	0.29	1.9	2.10	4.1	1.68	3.9	1.36	3.2	1.74	4.0
Jun	0.18	1.2	0.56	1.1	0.61	1.4	0.68	1.6	0.54	1.3
Jul	0.02	0.1	0.67	1.3	0.59	1.4	0.85	2.0	0.19	0.4
Aug	0.03	0.2	0.39	0.8	0.63	1.5	0.66	1.5	0.16	0.4
Sep	0.45	3.0	2.22	4.3	1.62	3.8	1.98	4.6	0.76	1.8
Sum	15.13		51.68		43.21		42.73		42.98	
Per of Rec'd	1963-1986		1966-1986		1966-1986		1965-1986		1921-1986	

2-07 Runoff.

Two types of floods may occur on the Kaweah River: winter rain and summer snowmelt. The winter rain floods are characterized by sharp peaks and most of the volume occurring within a few days. The snowmelt floods have a much larger volume, with the runoff occurring over a number of months. Peak snowmelt season flows rarely exceed channel capacity, but they may exceed irrigation and spreading capability for extended periods.

Dry Creek basin does not extend into the higher elevations where snow accumulates, so floods on Dry Creek are a result of rain. Mean monthly runoff information for the Kaweah River and Dry Creek is listed in Table 2-05. Rain season historical maximum inflow data for Lake Kaweah and Dry Creek are included in Tables 2-06 and 2-07, respectively, and historical maximum inflows to Lake Kaweah during the snowmelt season are in Table 2-08.

Table 2-05

Mean Monthly Runoff in Lake Kaweah River and Dry Creek

Month	Kaweah R. Volume (acre-ft) 1904-1986	Percent of Annual	Dry Ck. Volume (acre-ft) 1960-1986	Percent of Annual
Oct	5,200	1.18	46	0.2
Nov	8,900	2.01	298	1.6
Dec	18,700	4.23	1,537	8.1
Jan	26,600	6.02	3,197	16.8
Feb	32,900	7.44	4,221	22.1
Mar	46,100	10.43	4,427	23.2
Apr	66,800	15.11	3,451	18.1
May	106,900	24.17	1,291	6.8
Jun	85,200	19.27	434	2.3
Jul	31,500	7.12	111	0.6
Aug	8,700	1.97	22	0.1
Sep	4,700	1.06	24	0.1
Total	442,200	100.0	19,059	100.0

Table 2-06

Historical Maximum Inflow to Lake Kaweah During the Rain Season 1904-1986

Date of Peak	Peak Flow	Max 1-Day	Max 3-Day	Max 7-Day	Max 15-Day	Max 30- Day
	(cfs)	(Average Flow in cfs)				
6 Dec 1966	105,000	53,300	25,700	12,500	6,450	3,570
23 Dec 1955	84,300*	44,700*	23,000*	12,300*	6,550*	3,710*
19 Nov 1950	54,300*	16,700*	9,790*	5,150*	2,780*	2,400*
25 Jan 1969	40,000	22,400	13,400	8,520	6,060	3,770
11 Dec 1937	34,800*	11,300*	7,750*	3,980*	2,850*	2,270*
13 Jan 1980	34,000	16,900	13,900	7,640	4,280	2,760
11 Apr 1982	28,800	18,500	10,740	6,470	3,860	2,310

* Kaweah River near Three Rivers adjusted to Lake Kaweah inflow.

Table 2-07

Historical Maximum Dry Creek Flows During the Rain Season
1960-1986

Date of Peak	Peak Flow	Max 1-Day	Max 3-Day	Max 7-Day	Max 15-Day	Max 30-Day
	(cfs)	(Average Flow in cfs)				
6 Dec 1966	14,500	6,300	2,530	1,120	534	272
25 Jan 1969	6,020	3,150	1,850	1,290	808	58
11 Apr 1982	3,895	1,920	1,020	574	385	265

Table 2-08

Historical Maximum Inflow to Lake Kaweah
During the Snowmelt Season
1904-1986

Water Year	Max 1-Day	Max 15-Day	Max 30-Day	Max 60-Day	Max 90-Day	Max 120-Day
	(Average Flow in cfs)					
1906	7,260*	5,880*	5,340*	4,550*	3,910*	3,500*
1969	6,820	5,990	5,400	4,350	3,570	3,340
1983	6,670	5,390	5,240	4,460	3,610	3,120
1967	5,230	4,320	3,530	3,440	2,900	2,550
1952	5,170*	4,630*	4,240*	3,410*	2,850*	2,460*
1938	5,130*	4,210*	3,940*	3,260*	2,780*	2,350*
1978	4,630	4,040	3,550	3,040	2,590	2,270

* Kaweah River near Three Rivers gage adjusted to Lake Kaweah inflow.

CHAPTER III - UNIMPAIRED FLOW FREQUENCY ANALYSIS

3-01 Unimpaired Rain Flow Frequency Curves - Kaweah River.

Flow records on the Kaweah River near Three Rivers begin in water year 1904. The drainage area above the Three Rivers gage was 514 square miles. In February 1936, the gage was moved and the drainage area increased to 520 square miles. October 1961 marked the start of Kaweah River flow measurements into Lake Kaweah, and the Three Rivers gage was discontinued. Total drainage area above Terminus Dam is 561 square miles. The NAP above the Three Rivers gage site is 38.1 inches and above Terminus Dam it is 36.6 inches. In order to use the longest period possible for the frequency analysis, flow data at Three Rivers gage, from 1904 through 1961, were increased by 4 percent and combined with the inflow data to Lake Kaweah producing 85 years of continuous inflow record to the reservoir.

The computer program FRQPLT was used to compute the statistics and plot the data points and curves. FRQPLT computes and plots flow frequency curves in accordance with the procedures recommended by the Water Resources Council's Bulletin No. 17B, "Guidelines for Determining Flood Flow Frequency." The mean, standard deviations and skews for the maximum annual flows of various durations were computed from the 85 years of record. The computed standard deviations and skews were adjusted for consistency between the different flow durations. The skews were further adjusted to make them compatible with the historic record. The expected probability correction was applied. Median plotting positions were used.

From chapter II it can be seen that the maximum short term flows are due to rain and generally occur during the winter months. Large flow volumes for long periods are due to snowmelt and generally occur during the spring and summer. Occasionally significant short term flows may occur in March or April, and in those cases, the flow records were compared to precipitation records to determine which group to apply the flow to.

The unregulated flow data used to prepare the curves is shown on chart 3 and the curves are shown on chart 4.

3-02 Unimpaired Snowmelt Flow Frequency Curves.

It was assumed that all snowmelt flow originated above the Three Rivers gage. No correction to the gage flows was necessary when combined with Lake Kaweah inflows to form an equivalent snowmelt flow record for water year 1904 through 1988.

The mean, standard deviations and skews for the maximum annual flows of various durations were computed from the 85 years of record. Four low outliers were assumed for each duration and

the conditional probability correction was applied in accordance with appendix 5 of the WRC guidelines. The computer program FRQPLT was used to compute the statistics and plot the data points and curves. The computed standard deviations and skews were adjusted for consistency between the different flow durations, and the expected probability correction was applied. Median plotting positions were used.

Data for the unregulated snowmelt flow conditions is tabulated in chart 5 and plotted in chart 6.

3-03 Unimpaired Rain Flow Frequency Curves - Dry Creek.

Flow records on Dry Creek are available from October 1959 through the present. Development of the rain flow frequency curves was based on a comparison of the Dry Creek flow statistics with the longer record on the Kaweah River, in accordance with appendix 7 of the WRC guidelines. The plotting positions of the flows were based on the assumption that the 1967 flood was historic, the largest in 85 years. The computed standard deviations and skews were adjusted for consistency between different flow durations, and expected probability was applied. The computer program, FRQPLT, was used to plot the data points and curves.

The unregulated flow data used to prepare the curves is shown on chart 7 and the curves are shown on chart 8.

3-04 Risk.

Flow frequency curves indicate the probability that a flow will be equalled or exceeded in any given year. For example, the 100-year flow is expected to be equalled or exceeded on the average once every 100 years, or has a one percent chance of being equalled or exceeded in any given year. However, it is often of more interest to know the probability that a flow with a given annual probability will be equalled or exceeded at least once within a given number of consecutive years. Table 3-01 provides this information. For example, a flow with a probability of 0.01 of being equalled or exceeded in 1 year has a 0.26 probability of being equalled or exceeded one or more times in 30 years.

Table 3-01
Risk of Being Flooded in a Given Period of Time

Annual Probability	Given Period of Time in Years				
	10	25	30	50	100
	Percent Chance of Flood Occurring in Given Period of Time (Values in %)				
.1	65	93	96	99	99.997
.04	34	64	71	87	98
.02	18	40	45	64	87
.01	10	22	26	39	63
.005	5	12	14	22	39

CHAPTER IV - STORM AND RUNOFF ANALYSIS

4-01 Unit Hydrograph - Kaweah River.

Unit hydrographs are used to estimate the rainfall/runoff response of a river basin, and the Kaweah River Basin's 1-hour unit hydrograph is shown on chart 9. The Snyder method of unit hydrograph representation was used, and optimal Snyder parameters were determined by the optimization routine in the stream routing program HEC-1, and applied in reproduction of the December 1966 and January 1969 floods. Reproductions of these historical floods are shown on chart 10.

4-02 Unit Hydrograph - Dry Creek.

A 1-hour unit hydrograph for the entire Dry Creek basin, 81.9 square miles was developed from data in our 1971 hydrologic study of this area. Snyder parameters were used also used. The unit hydrograph for Dry Creek is shown on chart 11.

4-03 Loss Rates and Base Flow - Kaweah River.

During the December 1966 flood, an average of 18.64 inches of precipitation fell on the Kaweah River basin in three days. The constant loss rates for this flood were quite high probably because it occurred early in the season. However there was approximately 6 inches of precipitation on the basin 2 days before the flood. Flood reproductions used an initial loss of zero inches and a constant loss rate of 0.38 inches per hour. The initial base flow was assumed to be 400 c.f.s. and the recession flow was started at 10,000 c.f.s.

An average of 10.56 inches of precipitation fell on the Kaweah River basin in 4 days during the January 1969 flood. The 1969 flood reproduction, used an initial loss of 1.0 inch and a constant loss rate of 0.285 inches per hour. The initial base flow was assumed to be 4,000 c.f.s. and the recession was started at 10,000 c.f.s..

Loss rates for the SPF are discussed in Chapter V.

CHAPTER V - HYPOTHETICAL FLOODS

5-01 Standard Project Flood - Kaweah River.

The Standard Project Flood (SPF), used in design studies for Terminus Dam to define standard project runoff at the dam site, was based on analysis of the largest recorded event at that time, the December 1955 flood. A reevaluation of the SPF conducted in 1971, based on criteria developed by the Sacramento District, for the Sacramento-San Joaquin Valley, indicated a greater potential runoff from the Kaweah River basin above the dam and a much larger coincident accretion between the dam and downstream damage areas, principally from the Dry Creek basin. The storm shown in this report was centered over the Kaweah River basin above Terminus Dam with a total basin mean precipitation, including snowmelt, of 23.42 inches over 5 days.

HEC-1 was used to calculate the SPF hydrograph. The initial loss was assumed to be 0.0, and 0.22 inches was used as the constant loss. The SPF volume is 245,500 acre-feet and the peak flow is 117,700 c.f.s.. The SPF at Terminus Dam is shown on chart 12.

5-02 Standard Project Flood - Local Streams.

A Standard Project Flood was computed for the Dry Creek basin based on criteria developed by the Sacramento District for the Sacramento-San Joaquin Valley. For the specific centering, total basin mean precipitation of 16.62 inches fell on the 81.9 square mile basin over 5 days. An initial loss of zero and a constant loss rate of 0.2 inches per hour were assumed. The resulting SPF peak inflow was 23,165 c.f.s. and the total volume was 33,089 acre-feet. Chart 13 shows the specific Dry Creek SPF.

The major sources of local inflow to the Kaweah River below Terminus Dam are Dry, Mehrten, and Yokohl Creeks. The concurrent SPF hydrographs for these streams are shown on charts 14, 15, and 16.

5-03 Probable Maximum Flood - Kaweah River.

The Probable Maximum Flood (PMF) will be used to design the spillways of reservoir projects considered during the Kaweah River feasibility study. The PMF at Terminus Dam is shown on chart 17. It was developed in accordance with procedures shown in Hydrometeorological Report #36. The PMF unit graph was based on the SPF unit graph with a decrease in lag time of 15%.

HEC-1 was used to calculate the PMF hydrograph. The total basin mean precipitation, including snowmelt, was 42.1 inches over 5 days. The exponential rainfall loss rate method was used in HEC-1 to develop the PMF. Major variables of this method, STRKR, RTIOL, and ERAIN, had values of 0.65, 2.0, and 0.75,

respectively. The resulting flood volume is 713,000 acre-feet and the peak flow is approximately 330,000 c.f.s.

5-04 Probable Maximum Flood - Dry Creek.

A Probable Maximum Flood, PMF, for Dry Creek was recomputed in 1988. The previous PMF, developed in 1971, was a concurrent storm, complementing the PMF at Terminus Dam, and was for the 81.9 square mile basin above Limekiln dam site. The 1988 PMF revision includes only the area above the most recent Dry Creek Dam site, a total of 78.2 square miles.

The PMF unit graph was based on the SPF unit graph with the lag time decreased by 15% and a constant 0.20 inches per hour loss rate. No initial loss was applied since the basin was assumed to be saturated at the onset of the storm.

HEC-1 was used to calculate the PMF hydrograph. A total of 29.35 inches of precipitation fell over the Dry Creek basin for 3.5 days. The peak flow was 45,000 c.f.s. and the PMF volume was 64,600 acre-feet.

The specific Dry Creek PMF flood is shown on chart 18.

5-05 Flood Series.

Hypothetical floods were used to develop the infrequent portions of the flow frequency curves under project conditions, because the flow data record on the Kaweah River is not long enough for graphical analysis.

The flood series for peak flows under project conditions are 30 days long and are balanced so that all volumes between one and 30 days agree with the unimpaired rain flow frequency curves. Each 5-day wave of the flood series was developed by multiplying the SPF times a ratio. The ratios shape the six sequential 5-day waves of the 30-day series so that the largest wave is in the middle. This storm pattern is typical for this area of the U.S.. Chart 19 contains the ratios for the various flood frequencies.

Frequency curves of annual flow to Tulare Lake were developed, and annual flood series information was used to describe the portion of the frequency curves involving unusual events. The annual series were developed by multiplying the separate ratios times the 1969 October through March and April through September flows. The ratios were based on the 90-day rain flow frequency curves and the 90-day snowmelt flow frequency curves respectively. The 1969 flood year was used because of its typical volume distribution for large runoff years. The 1969 daily flows and ratios used to simulate different frequencies are shown on chart 20.

CHAPTER VI - REGULATED FLOW FREQUENCY CURVES

6-01 Regulated Peak Flow Frequency Curves.

Peak flows are important to the area between Terminus Dam and Tulare Lakebed, because they determine the size of the flood plain adjacent to the river channel. Peak snowmelt flows in the Kaweah River are relatively low, particularly when compared to rain floods. Therefore, only rain floods were considered for the peak flow analysis below Terminus Dam.

Hypothetical floods are used to estimate the peak flows that may occur during unusual events. The flood series described in Chapter V were routed through the project using a computer program called HYCOMP which simulates reservoir operation in conformance with the rules applicable to Lake Kaweah and other reservoirs in the Sacramento District. The resulting peak flows were plotted in accordance with the frequency assigned to the flood series used for the routing. The reservoir storage at the start of the flood simulation was 8,000 acre-feet, and the project was operated as prescribed in the flood control diagram in the manual currently being revised, except releases were not allowed to exceed 80 percent of channel capacity to account for operational contingencies. The starting storage of 8,000 acre-feet includes the present 1,000 acre-feet of sediment space available plus 7,000 acre-feet of permissible carry over.

Local flow below Lake Kaweah from Mehrten and Yokohl Creeks is significant. Although the two creeks join the Kaweah River a short distance below McKays Point, their flow was considered part of the local flow at McKays Point for the routings. The sedimentation and topography assumed for the routings and frequency curves in this report are based on the most current survey which was completed in 1977.

A routing of the 100-year flood, developed as described in paragraph 5-05, is shown on chart 21. Resulting reservoir outflow under operating conditions described in the preceeding paragraph was 36,400 c.f.s.. The regulated rain flow frequency curve for existing conditions is shown on chart 22.

6-02 Regulated Volume Flow Frequency Curves.

Regulated flow volume frequency curves are important to Tulare Lakebed because Tulare Lakebed has no outlet to the sea, and the inflow volume determines the size of the flood plain there.

A volume frequency curve for flow to Tulare Lake was developed by simulating Lake Kaweah daily operation over the 85 year period of available flow information. HYCOMP was used to determine daily storages and releases over the 85-year period of record. Lake Kaweah starting storage was 8,000 acre-feet, and flow to Tulare Lake was estimated by subtracting an assumed

maximum schedule of irrigation and spreading demand, shown on chart 23, from the project releases on a daily basis.

The simulation model was calibrated by comparing the simulated flow to Tulare Lakebed to the flow what actually occurred in 1978, 1980, 1982 and 1983, shown on chart 24. The difference between simulated and actual conditions for smaller floods may be attributed to options available to the operator that cannot be accounted for in our model. However, the model is believed to be reasonably representative of how the project will be operated in the future. When used for economic purposes, the same assumptions will be used for present and project conditions so that any bias that may be inherent in the model will be applied to both conditions.

The infrequent portion of the curve was estimated by routing the annual flood series, discussed in Chapter V, through Lake Kaweah. As above, the current flood control diagram and 1977 lake bottom topography were used.

The total flow to Tulare Lakebed was summed for each year, shown on chart 25, and plotted on probability grid along with the hypothetical annual flood series routing results. The frequency curve of annual flow to Tulare Lake is shown on chart 26.

Daily storages resulting from the simulated 85 year operation where used to prepare the Seasonal Variation of Reservoir Storage curves shown on chart 27.

CHAPTER VII - RESERVOIR DESIGN DATA

7-01 Reservoir Sedimentation.

When Lake Kaweah construction was completed in 1962, it was believed to have a capacity of 150,000 acre-feet. A 1977 survey showed that Lake Kaweah had a capacity of 143,200 acre-feet. This indicates a high rate of sediment accumulation. However, in December 1966 a peak inflow occurred that is estimated to have been greater than a 100-year event. It is believed that much of the present sediment in the reservoir is due to that flood, and as a result, the sedimentation estimates are distorted since the period between surveys was short.

Recent studies on the Kaweah River indicate that the 1966 flood has distorted sedimentation rates and that the normal rate of sediment accumulation in the reservoir should be about 0.18 acre-feet per square mile per year. The Kaweah River basin above Lake Kaweah is approximately 561 square miles, so this amounts to about 100 acre-feet per year. It is believed that at this rate of sediment accumulation, the capacity of Lake Kaweah would be 141,900 acre-feet at the end of 1988, and about 140,700 acre-feet by the year 2000.

The year 2000 is assumed to be the base year for the current Kaweah River study. The economic life of a project investigated is generally assumed to be 100 years, so in order to make allowance for an unusual event, such as the December 1966 flood, within the 100 year economic life, the sedimentation rate was increased to 0.2 acre-feet per square mile per year. The table below shows the estimated storage capacity available up to the current spillway elevation at various points in history through the year 2100:

Table 7-01

Estimated Past and Future Storage Capacities in Lake Kaweah

Water Year	Lake Kaweah Storage Below Elevation 694 Ft (acre-feet)
1977	143,000
1988	141,900
2000	140,700
2050	134,700
2100	128,700

7-02 Wave Runup.

Elevation 747.6 is the flood pool elevation for the current PMF routed through the existing project. Wave height and runup has been computed for this elevation in as specified in the following references:

ETL 1110-2-305, dated 17 February 1984, for wave height,
ETL 1110-2-221, dated 29 November 1976, for wave runup,
"SHORE PROTECTION MANUAL," US Army Coastal Engineering Research Center, 1977, for wave runup.

No local wind speed data was available, so wind speeds were estimated from data at Fresno Airport. The longest fetch at Lake Kaweah is from the east-southeast. Fetches from other directions either did not affect the dam, or were too short to produce a significant wave runup. Overland wind velocities of 50 m.p.h. for 1 minute and 35 m.p.h. for 60 minutes were adopted for Lake Kaweah. Wave runup data follows:

Table 7-02

Lake Kaweah Wave Runup Data

Wind Direction: East-southeast
Average Fetch: 2.46 miles
Average Water Depth over Fetch: 150 feet
Water/Land Wind Speed Ratio: 1.1

	1-Minute	60-Minute
Overland Wind Speed:	50 mph	35 mph
Overwater Wind Speed:	55 mph	39 mph

Design Wind Speed: 39 mph

Deep Water Wave Conditions Used

Embankment Slope: 1:2.0
Embankment Type: Riprap
Design Wind Duration: 51 minutes
Design Wave Period: 2.8 seconds
Design Wave Height: 2.5 feet
Wave Runup: 2.78 feet
Wind Setup: 0.03 feet
Wave Runup Plus Wind Setup: 2.81 feet

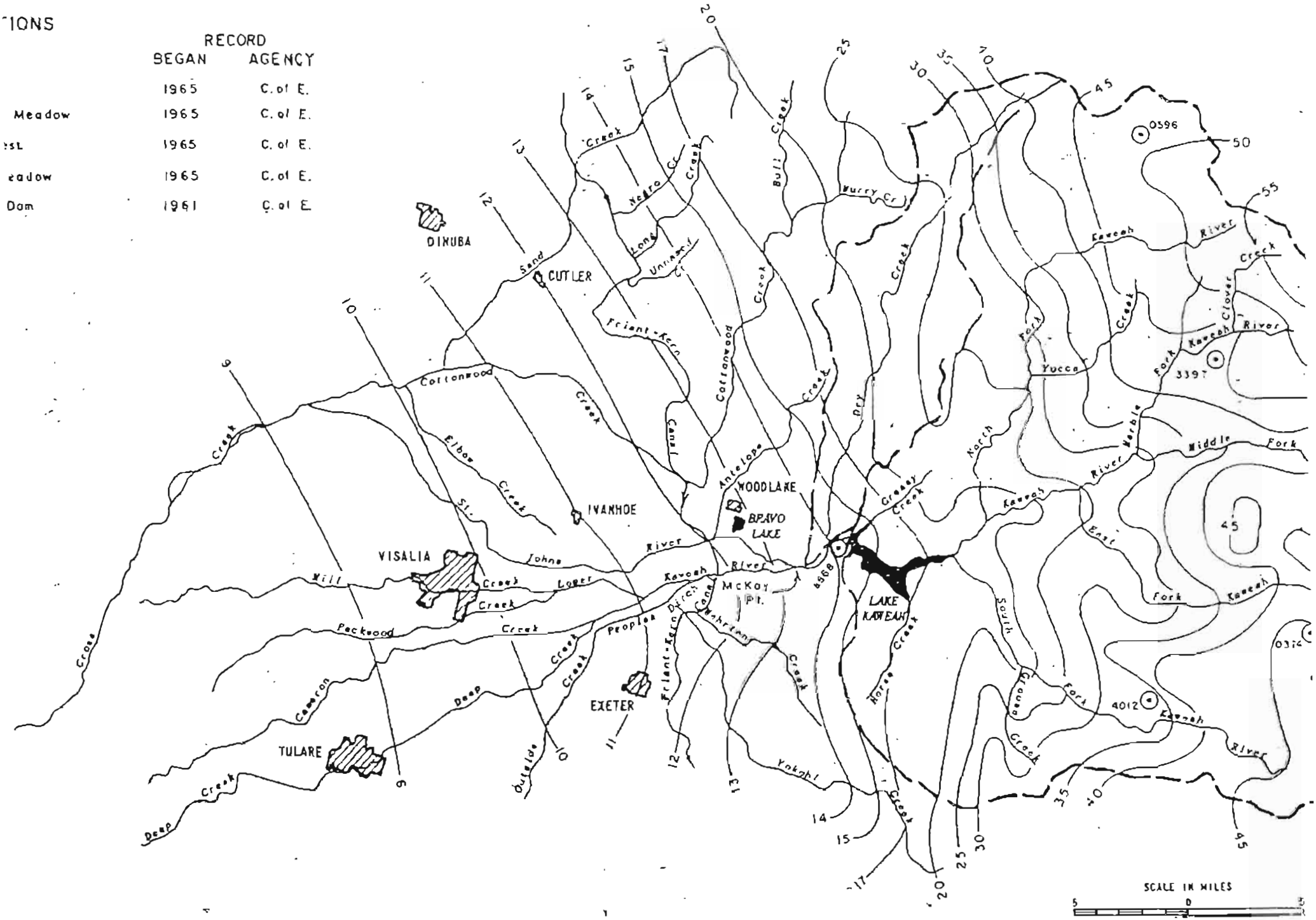
7-03 Storage Frequency.

The likelihood of particular reservoir storages resulting from the simulated operations using the 85 years of data was analyzed and presented as a family of curves in chart 27. The curves were developed using daily storages from the reservoir simulation operations described in paragraph 6-02. Three computer programs STFREQ, WCCOMP, and DSPLAY were used to prepare the curves. STFREQ was used to analyze the 85 years of

daily storages, the data was smoothed using WCCOMP, and plots were drawn with DSPLAY.

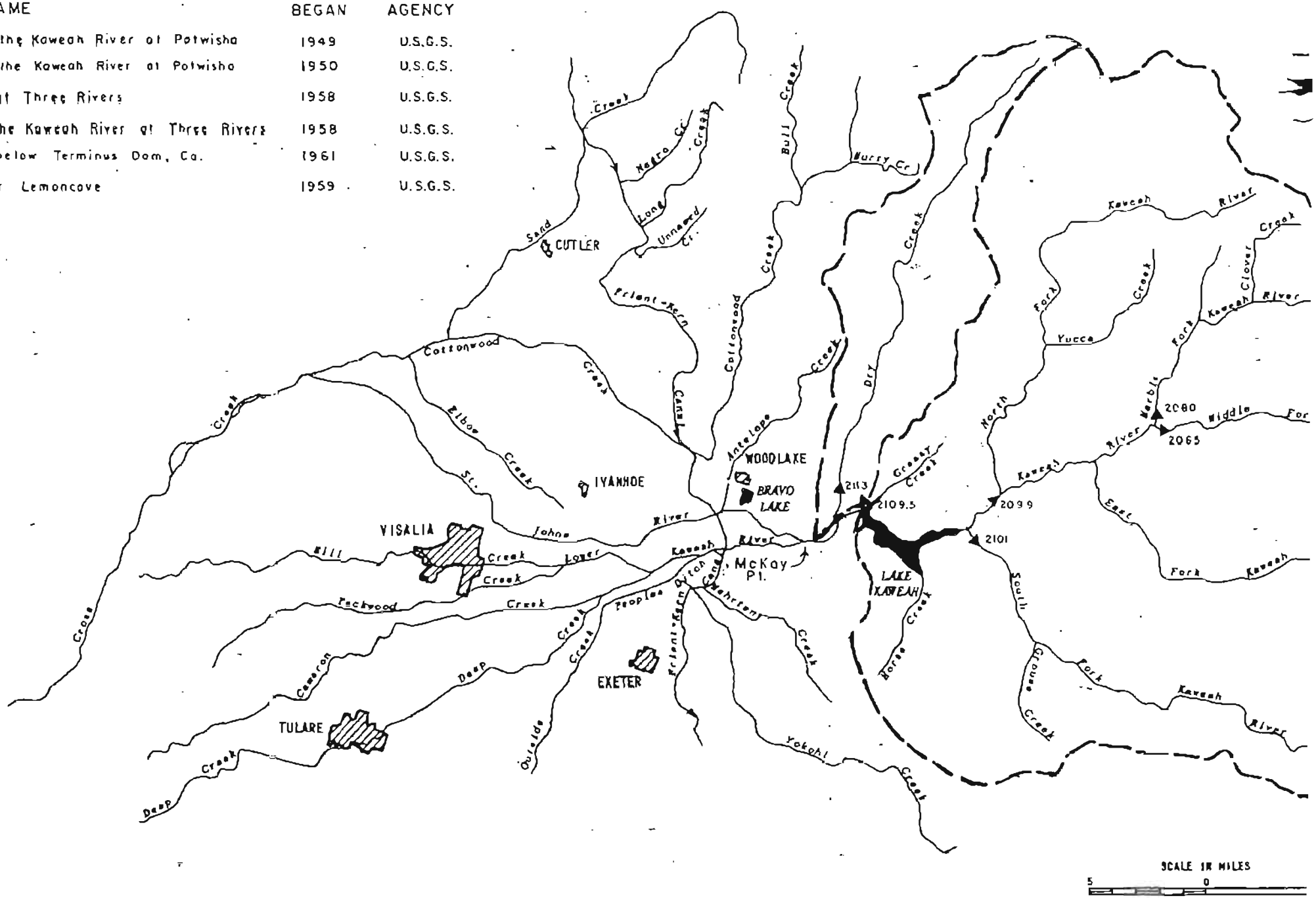
TIONS

	RECORD BEGAN	AGENCY
	1965	C. of E.
Meadow	1965	C. of E.
:SL	1965	C. of E.
eadow	1965	C. of E.
Dam	1961	C. of E.



STATIONS

NAME	RECORD BEGAN	AGENCY
gf the Kaweah River at Potwisha	1949	U.S.G.S.
of the Kaweah River at Potwisha	1950	U.S.G.S.
ir at Three Rivers	1958	U.S.G.S.
of the Kaweah River at Three Rivers	1958	U.S.G.S.
er below Terminus Dam, Ca.	1961	U.S.G.S.
near Lemoncove	1959	U.S.G.S.



UNREGULATED CONDITION FLOW FREQUENCY DATA
KAWEAH RIVER
(Flow in c.f.s.)

GENERAL RAIN RUNOFF

WATER YEAR	1-DAY	3-DAY	7-DAY	15-DAY	30-DAY	60-DAY	90-DAY
1904	4080	2120	1447	1031	794	526	372
1905	3219	2602	1526	913	594	427	323
1906	8903	7430	5141	3846	2664	1706	1431
1907	3219	2351	1860	1654	1258	963	802
1908	982	941	917	835	646	495	403
1909	9624	6019	3062	2842	2038	1646	1307
1910	8266	3710	1986	1160	1076	853	750
1911	6907	5957	3354	2048	1306	1076	763
1912	287	264	255	233	210	160	142
1913	371	353	331	271	213	165	129
1914	10325	6897	3751	2174	1359	939	662
1915	852	826	742	649	459	410	319
1916	10555	5810	3145	2759	1933	1662	1542
1917	3428	2508	1850	1191	851	654	533
1918	1463	1170	874	770	584	365	263
1919	1460	1080	742	545	500	363	281
1920	2810	2490	1835	1159	1040	613	449
1921	1790	1787	1493	1163	938	695	556
1922	2560	1348	920	654	534	395	366
1923	4608	2445	1840	920	635	356	319
1924	251	200	165	132	126	113	100
1925	1254	843	576	460	434	361	307
1926	789	588	408	295	225	151	137
1927	6218	3699	2539	1839	1327	941	708
1928	2539	2205	1578	930	573	385	306
1929	852	603	484	415	334	240	203
1930	1118	858	549	423	340	230	176
1931	409	222	165	151	136	116	95
1932	4619	2842	2090	1348	966	857	655
1933	805	550	482	438	370	284	232
1934	1588	774	452	302	291	203	201
1935	4608	2686	1777	1130	773	508	416
1936	5392	3825	2466	1735	1223	995	712
1937	13585	7200	3867	3125	2080	1070	800
1938	11286	7754	3981	2853	2268	1662	1227
1939	1285	1108	898	783	534	396	318
1940	4504	2811	2450	1839	1327	1165	1034
1941	3323	2445	1933	1390	1233	978	818
1942	1662	1290	1027	802	603	594	509
1943	9760	7054	4473	3699	2633	1674	1454
1944	1181	838	640	577	438	329	268
1945	9938	6458	3449	1965	1212	1066	757

UNREGULATED CONDITION FLOW FREQUENCY DATA
KAWEAH RIVER
(Flow in c.f.s.)

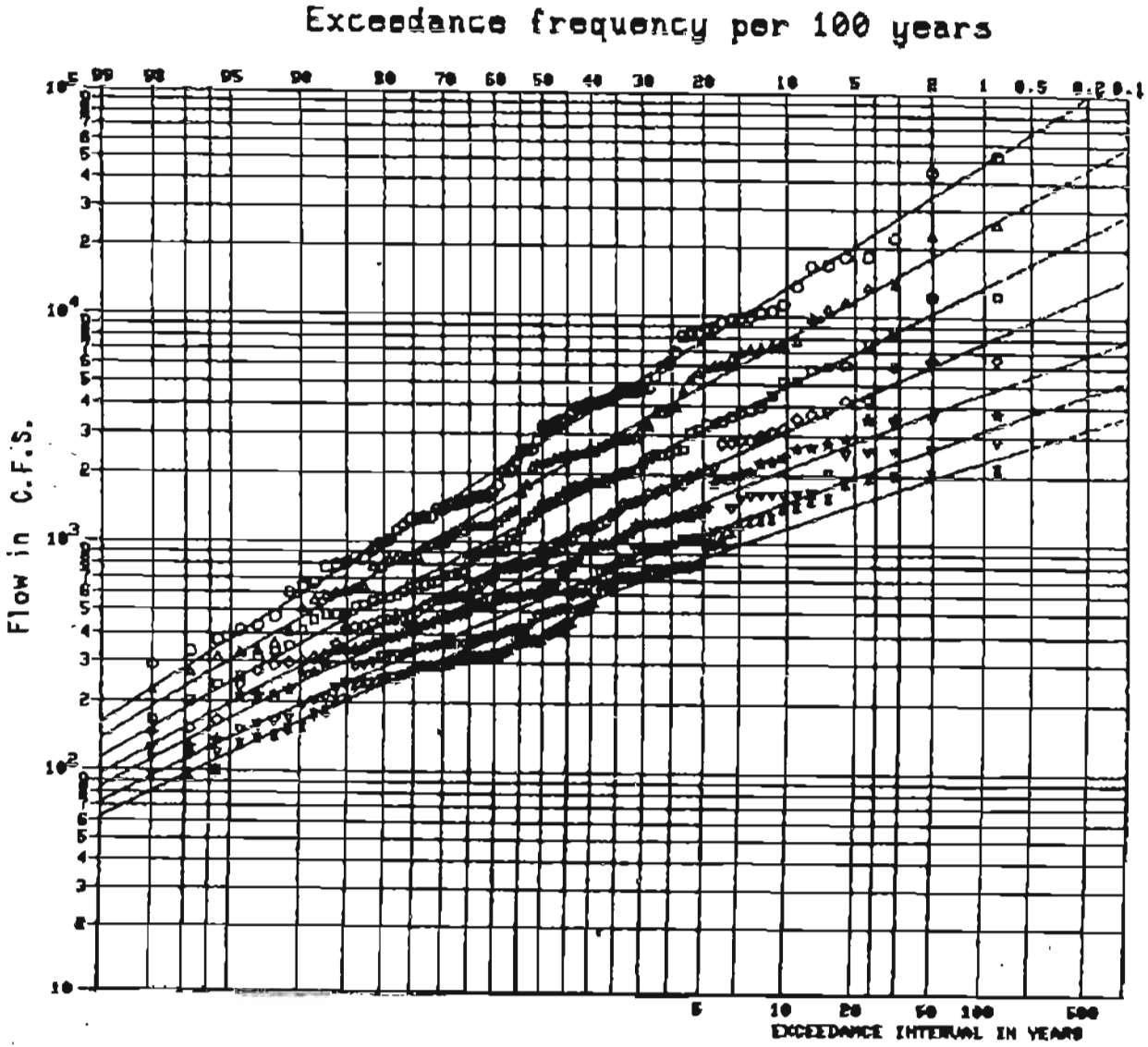
GENERAL RAIN RUNOFF

WATER YEAR	1-DAY	3-DAY	7-DAY	15-DAY	30-DAY	60-DAY	90-DAY
1946	2080	1379	1150	816	599	450	445
1947	4692	2309	1379	858	656	502	424
1948	4087	2238	1310	796	531	318	241
1949	426	330	312	288	268	193	155
1950	2518	1651	1034	694	573	481	373
1951	16720	9792	5152	2780	2404	1453	1137
1952	5946	3271	2027	1557	1244	1009	1005
1953	3439	2392	1790	563	461	368	364
1954	1515	990	676	568	523	420	339
1955	4274	2205	1244	772	565	391	322
1956	44726	23032	12310	6552	3710	2644	1955
1957	774	571	524	467	395	325	255
1958	4107	2905	2383	1660	1453	967	746
1959	1505	1160	715	492	489	366	286
1960	1285	773	664	523	387	334	247
1961	601	323	201	145	126	120	94
1962	3707	3236	2045	1498	991	517	375
1963	18400	11540	5830	3200	1860	1150	788
1964	470	399	350	310	264	209	181
1965	3920	2750	2250	1490	1110	821	698
1966	1260	973	649	460	365	326	293
1967	53280	25736	12460	6450	3570	2070	1606
1968	659	506	481	456	421	350	255
1969	22440	13430	8520	6060	3770	2882	2009
1970	8790	4600	2460	1540	994	762	671
1971	914	630	521	427	377	350	311
1972	633	623	607	568	482	350	290
1973	4200	2800	1680	1026	931	790	724
1974	3890	2400	1727	1240	984	759	710
1975	1570	1210	897	689	576	424	330
1976	2040	1090	568	320	212	170	152
1977	329	310	236	164	112	85	76
1978	8140	5540	3370	2100	1940	1595	1259
1979	1400	1170	917	792	752	610	506
1980	16930	13890	7640	4280	2760	2580	2040
1981	1015	841	718	581	418	360	287
1982	18500	10740	6061	3559	2324	1683	1273
1983	8330	5173	3600	2990	2910	2580	2167
1984	4802	3919	2581	1737	1222	1074	931
1985	1395	1169	826	576	471	425	380
1986	9428	7427	6150	4259	3554	2523	1845
1987	1584	967	566	356	339	293	239
1988	2282	1185	653	455	342	299	288
1989	890	758	654	593	546	382	285

UNREGULATED CONDITION FLOW FREQUENCY DATA
KAWEAH RIVER
(Flow in c.f.s.)

GENERAL RAIN RUNOFF

	1-DAY	3-DAY	7-DAY	15-DAY	30-DAY	60-DAY	90-DAY
			COMPUTED STATISTICS				
MEAN	3.448	3.285	3.124	2.978	2.864	2.744	2.655
ST DEV	0.510	0.475	0.427	0.395	0.367	0.355	0.346
SKEW	0.121	0.116	0.063	0.066	0.013	0.053	0.054
			ADOPTED STATISTICS				
MEAN	3.448	3.285	3.124	2.978	2.864	2.744	2.655
ST DEV	0.520	0.475	0.438	0.395	0.365	0.345	0.330
SKEW	0.000	-0.050	-0.100	-0.150	-0.200	-0.250	-0.300



LEGEND:

- ○ 1-Day
- △ 3-Day
- □ 7-Day
- ◇ 15-Day
- ★ 30-Day
- ▽ 60-Day
- ▪ 90-Day

ADOPTED STATISTICS

Curve	Mean	Std Dev	Skew	Eq Years
1-Day	3.448	0.520	0.000	85
3-Day	3.285	0.475	-0.050	85
7-Day	3.124	0.438	-0.100	85
15-Day	2.978	0.395	-0.150	85
30-Day	2.864	0.365	-0.200	85
60-Day	2.744	0.345	-0.250	85
90-Day	2.655	0.330	-0.300	85

NOTES:

1. Curves based on expected probability.
2. Period of Record: 1904-1988.
3. Drainage Area: 561.0 sq. mi.

KAWEAH RIVER, CALIFORNIA

RAIN FLOW FREQUENCY CURVES UNIMPAIRED CONDITIONS

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: WLJ
Drawn: WLJ

Date: OCTOBER, 1988

UNREGULATED CONDITION FLOW FREQUENCY DATA
KAWEAH RIVER
(Flow in c.f.s.)

SNOWMELT RUNOFF

WATER YEAR	1-DAY	7-DAY	15-DAY	30-DAY	60-DAY	90-DAY	120-DAY
1904	3280	3110	2850	2490	1850	1550	1210
1905	2190	2020	1860	1740	1450	1220	1000
1906	7260	6220	5880	5340	4550	3910	3500
1907	3480	2930	2530	2300	2140	2030	1790
1908	1630	1360	1140	1010	888	779	633
1909	6000	5190	4530	3700	3150	2700	2260
1910	1990	1770	1650	1560	1390	1120	890
1911	3030	2770	2510	2080	1900	1690	1490
1912	2360	2280	1860	1540	1080	844	678
1913	1470	1360	1270	1180	981	827	690
1914	2420	2150	1990	1940	1630	1470	1260
1915	3280	2630	2430	2120	1750	1480	1230
1916	3440	3070	2950	2650	2440	2240	1940
1917	2830	2500	2410	2080	1890	1640	1350
1919	2040	1817	1671	1614	1381	1086	845
1920	2980	2753	2549	2217	1763	1559	1249
1921	2450	2250	1840	1650	1490	1240	1020
1922	3520	3260	3140	2740	2310	1820	1490
1923	2450	2230	2100	1830	1450	1300	1050
1924	940	906	804	682	525	381	292
1925	1990	1850	1590	1530	1330	1180	977
1926	1990	1550	1460	1340	1152	883	680
1927	2900	2520	2160	2100	1870	1610	1330
1928	1160	1030	931	878	764	624	487
1929	3780	1530	1470	1300	1070	886	712
1930	1720	1610	1380	1290	1040	890	700
1931	1120	982	851	707	541	429	332
1932	3200	2800	2660	2380	2140	1850	1550
1933	2750	2540	2160	2030	1385	1160	960
1934	748	655	622	541	444	367	289
1935	2480	2290	2100	1900	1720	1420	1120
1936	2840	2660	2480	2290	2030	1780	1440
1937	4760	4270	3620	3190	2640	2300	1900
1938	5130	4630	4210	3940	3260	2780	2350
1939	1410	1310	1210	1140	1050	847	665
1940	2840	2730	2550	2310	2000	1720	1350
1941	3810	3330	3090	3000	2650	2190	1870
1942	3220	3020	2650	2600	2090	1820	1520
1943	3260	3020	2710	2480	2250	1960	1630
1944	2170	2040	1880	1780	1470	1200	987
1945	2990	2810	2690	2430	2190	1920	1600

UNREGULATED CONDITION FLOW FREQUENCY DATA
KAWEAH RIVER
(Flow in c.f.s.)

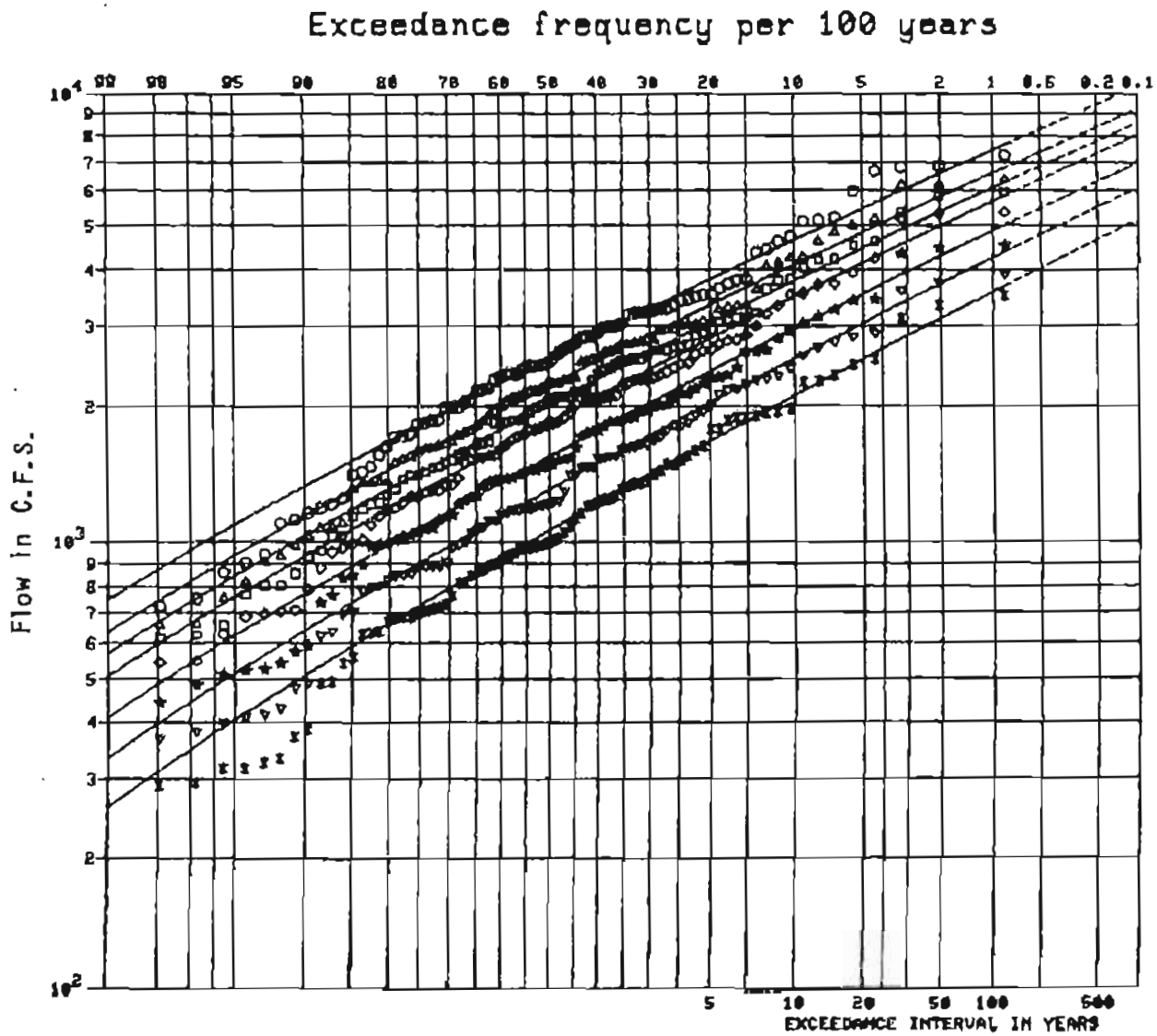
SNOWMELT RUNOFF

WATER YEAR	1-DAY	7-DAY	15-DAY	30-DAY	60-DAY	90-DAY	120-DAY
1946	2310	2120	2100	1840	1480	1190	940
1947	1830	1730	1310	1220	997	798	622
1948	2610	2150	1930	1690	1380	1120	871
1949	1860	1640	1500	1390	1270	991	760
1950	2060	1910	1840	1540	1410	1190	930
1951	1870	1590	1430	1190	1030	890	719
1952	5170	5020	4630	4240	3410	2850	2460
1953	3340	1750	1570	1340	1210	1050	893
1954	2350	2110	2060	1800	1520	1230	970
1955	2160	1950	1660	1560	1240	1010	813
1956	3420	2940	2650	2300	1950	1660	1410
1957	6840	2620	2180	2090	1540	1210	971
1958	4370	4130	3780	3330	2820	2440	1980
1959	857	751	653	626	574	476	371
1960	1560	1350	1180	972	843	693	540
1961	692	658	614	545	485	416	324
1962	2460	2250	1850	1780	1530	1410	1160
1963	2660	2550	2360	2080	1850	1620	1360
1964	1740	1620	1520	1300	988	854	684
1965	2700	2320	2280	2100	1780	1560	1310
1966	1430	1350	1220	1090	1010	805	627
1967	5230	4850	4230	3530	3440	2900	2550
1968	1250	1100	1030	952	834	703	553
1969	6820	6410	5990	5400	4350	3750	3340
1970	2290	2090	2010	1720	1260	1070	861
1971	1710	1500	1410	1260	1130	979	815
1972	900	819	766	693	590	488	384
1973	4430	4080	3820	3720	2920	2340	1890
1974	2990	2730	2590	2340	1960	1660	1080
1975	3630	3320	3130	2790	2010	1540	1250
1976	1100	932	804	702	519	400	315
1977	721	635	578	483	395	330	259
1978	4630	4250	4040	3550	3040	2590	2270
1979	3210	2950	2720	2250	1820	1480	1200
1980	3170	3020	2890	2660	2340	2180	1950
1981	2360	1650	1410	1260	1120	908	726
1982	3524	3296	3076	2797	2662	2309	1908
1983	6671	6207	5393	5236	4474	3606	3120
1984	2538	2181	2069	1852	1432	1186	1006
1985	1845	1673	1589	1496	1365	1162	914
1986	3712	3616	3215	2869	2310	2134	1790
1987	1188	1083	1035	990	735	635	490
1988	1212	1069	958	785	509	410	314
1989	1416	1359	1299	1061	828	609	469

UNREGULATED CONDITION FLOW FREQUENCY DATA
KAWEAH RIVER
(Flow in c.f.s.)

SNOWMELT RUNOFF

	1-DAY	7-DAY	15-DAY	30-DAY	60-DAY	90-DAY	120-DAY
				COMPUTED STATISTICS			
MEAN	3.389	3.332	3.291	3.245	3.169	3.094	3.004
ST DEV	0.231	0.228	0.230	0.233	0.239	0.247	0.260
SKEW	-0.299	-0.252	-0.246	-0.280	-0.327	-0.356	-0.292
				ADOPTED STATISTICS			
MEAN	3.400	3.340	3.300	3.260	3.180	3.110	3.020
ST DEV	0.209	0.213	0.216	0.220	0.225	0.231	0.238
SKEW	-0.170	-0.180	-0.180	-0.180	-0.190	-0.190	-0.200



LEGEND:
- ○ 1-Day
- △ 15-Day
- □ 30-Day
- ◇ 60-Day
- ★ 90-Day
- ▽ 120-Day

ADOPTED STATISTICS

Curve	Mean	Std Dev	Skew	Eq Years
1-Day	3.400	0.209	-.170	85
7-Day	3.340	0.213	-.180	85
15-Day	3.300	0.216	-.180	85
30-Day	3.260	0.220	-.180	85
60-Day	3.180	0.225	-.190	85
90-Day	3.110	0.231	-.190	85
120-Day	3.020	0.238	-.200	85

NOTES:
1. Curves based on expected probability.
2. Period of Record: 1904-1988.
3. Drainage Area: 561.0 sq. mi.

KAWEAH RIVER, CALIFORNIA

SNOWMELT FLOW FREQUENCY CURVES UNIMPAIRED CONDITIONS

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: WLJ Date: OCTOBER, 1988

UNREGULATED CONDITION FLOW FREQUENCY DATA
DRY CREEK NEAR LEMONCOVE
(Flow in c.f.s.)

GENERAL RAIN RUNOFF

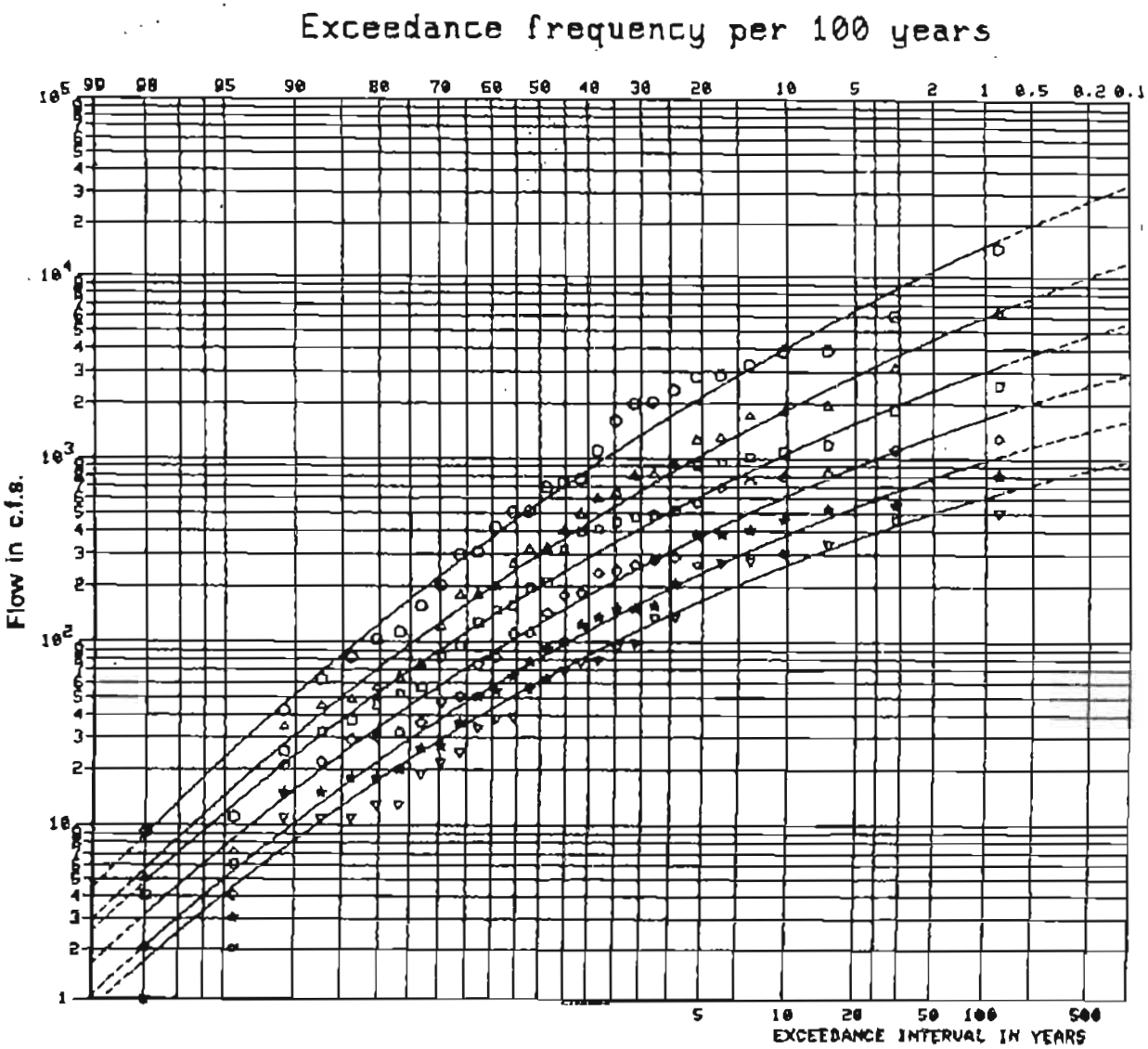
WATER YEAR	PEAK	1-DAY	3-DAY	7-DAY	15-DAY	30-DAY
1960	156	63	52	29	20	13
1961	11	7	6	4	3	2
1962	732	604	492	291	208	136
1963	1600	647	397	179	102	56
1964	202	120	83	50	36	25
1965	770	402	321	185	124	80
1966	112	75	56	32	18	11
1967	14500	6370	2530	1120	534	272
1968	42	34	25	21	15	13
1969	6070	3150	1850	1290	808	511
1970	1990	928	480	245	135	78
1971	102	56	45	36	27	22
1972	81	48	37	30	18	11
1973	2350	817	520	281	158	137
1974	2030	800	412	238	152	99
1975	420	199	148	112	78	63
1976	62	44	32	22	15	11
1977	9	5	4	2	1	1
1978	2860	1800	1190	738	384	308
1979	507	322	212	143	93	70
1980	2800	1290	919	693	409	278
1981	307	178	127	75	54	38
1982	3895	1920	1020	574	385	265
1983	3870	1710	1081	826	562	468
1984	1100	491	448	263	152	94
1985	691	264	196	111	65	39
1986	3270	1260	957	801	467	345
1987	297	180	94	47	26	19
1988	512	316	157	82	50	34

COMPUTED STATISTICS

MEAN	2.732	2.451	2.281	2.071	1.865	1.707
ST DEV	0.804	0.755	0.709	0.704	0.694	0.677
SKEW	-0.503	-0.534	-0.603	-0.617	-0.723	-0.607

ADOPTED STATISTICS

MEAN	2.699	2.420	2.244	2.039	1.845	1.716
ST DEV	0.733	0.689	0.640	0.625	0.615	0.591
SKEW	-0.500	-0.550	-0.600	-0.650	-0.700	-0.750



LEGEND:

- ○ Peak
- △ 1-Day
- □ 3-Day
- ◇ 7-Day
- ★ 15-Day
- ▽ 30-Day

ADOPTED STATISTICS

Curve	Mean	Std Dev	Skew	Eq Years
Peak	2.699	0.733	-.500	60
1-Day	2.420	0.689	-.550	60
3-Day	2.244	0.640	-.600	60
7-Day	2.039	0.625	-.650	60
15-Day	1.845	0.615	-.700	60
30-Day	1.716	0.591	-.750	60

NOTES:

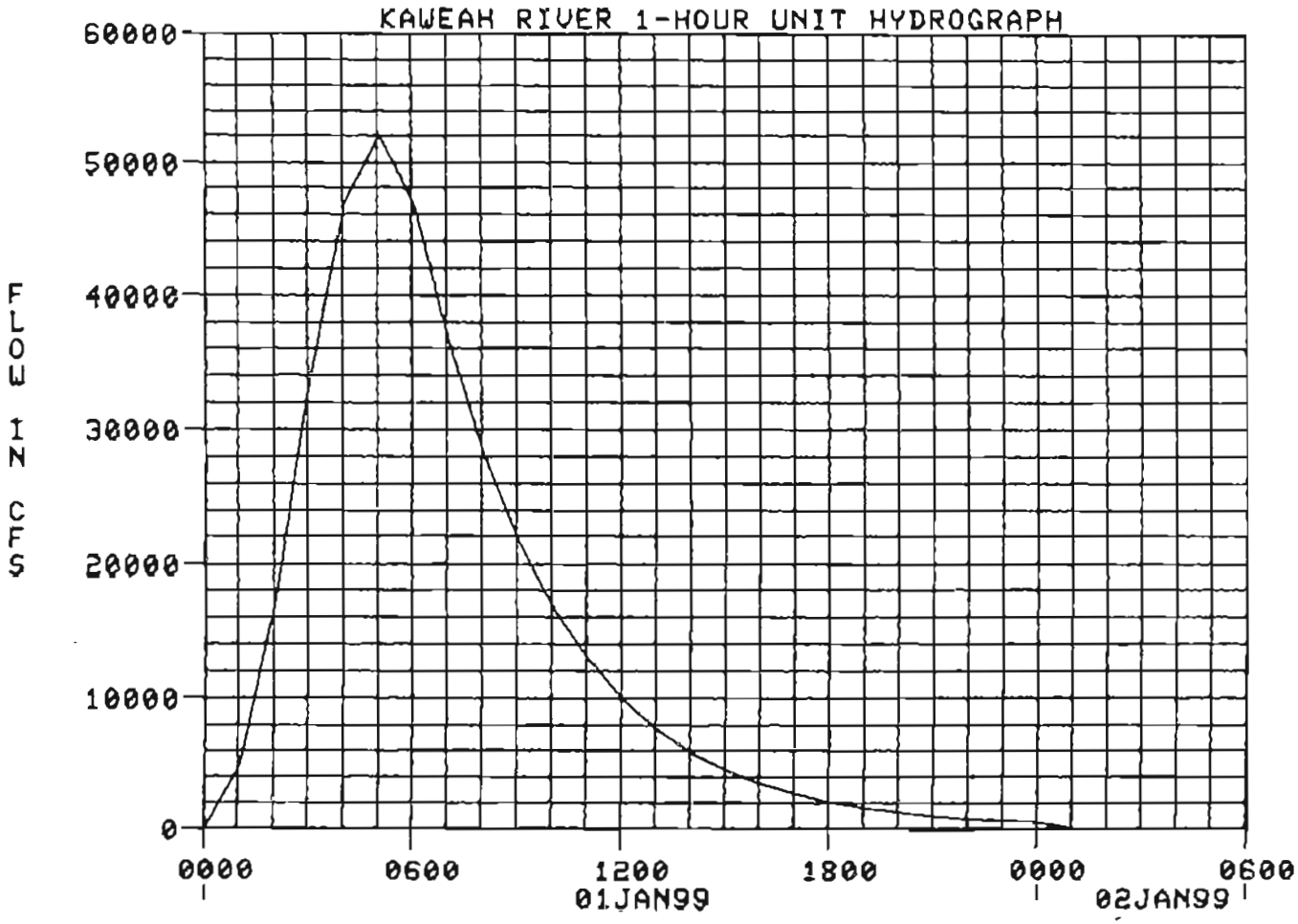
1. Curves based on expected probability.
2. Flows assuming largest flow of record was the largest in 85 years.
3. Period of Record: 1960-1988.
4. Drainage Area: 80.0 sq. mi.

DRY CREEK, CALIFORNIA

RAIN FLOW FREQUENCY CURVES UNIMPAIRED CONDITIONS

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: WLJ
Drawn: WLJ
Date: OCTOBER, 1988



L	=	33.90
LCA	=	15.80
LLCA**.3	=	6.69
Tp	=	4.45
Cp	=	0.646
Ct	=	0.676
Volume	=	29,750 A.F.

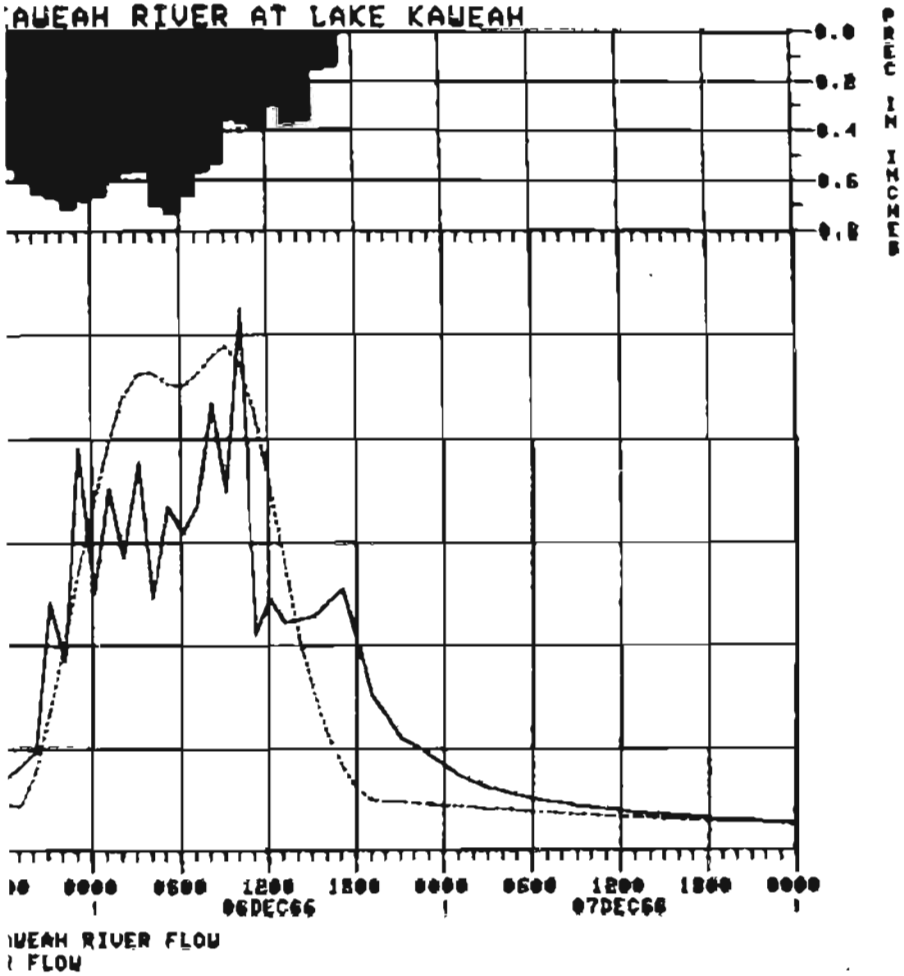
KAWEAH RIVER, CALIFORNIA

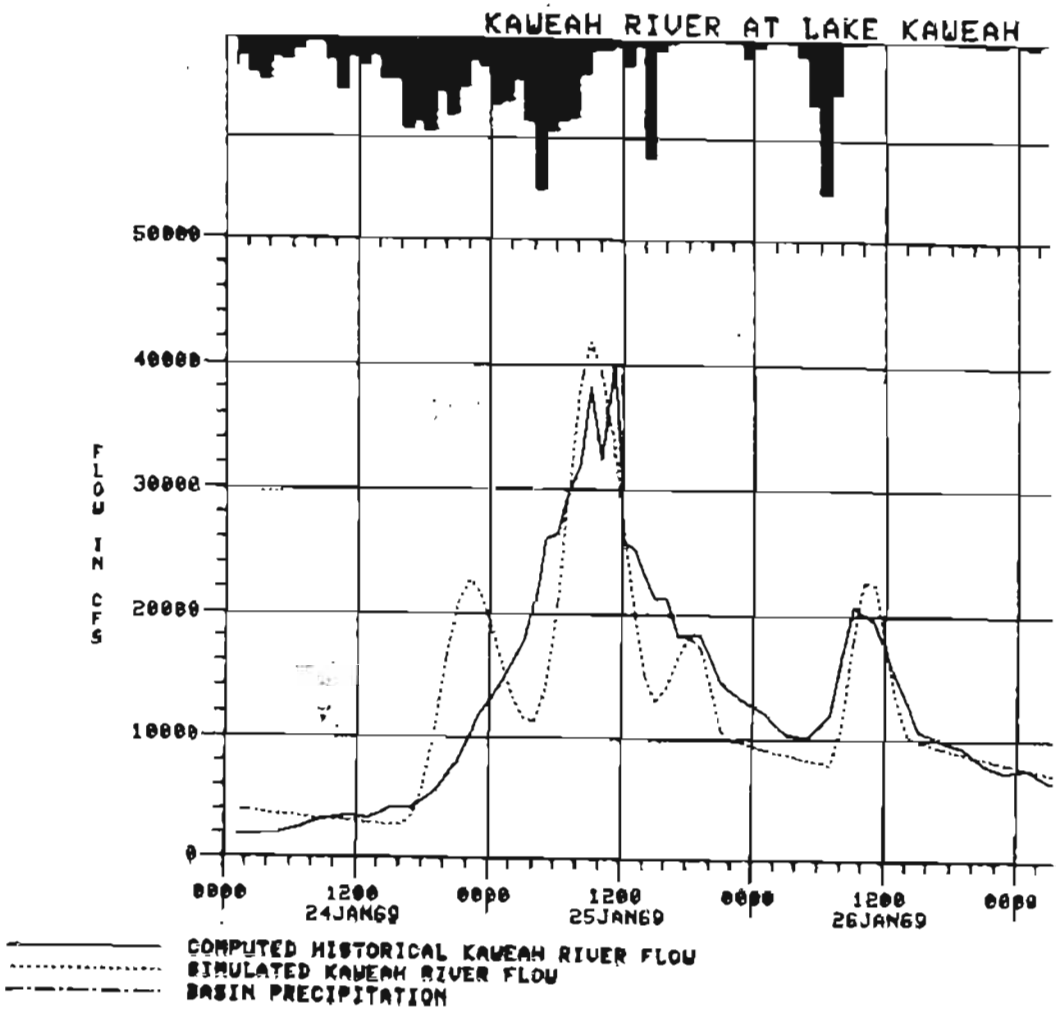
UNIT HYDROGRAPH

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: WLJ

Date: OCTOBER, 1988

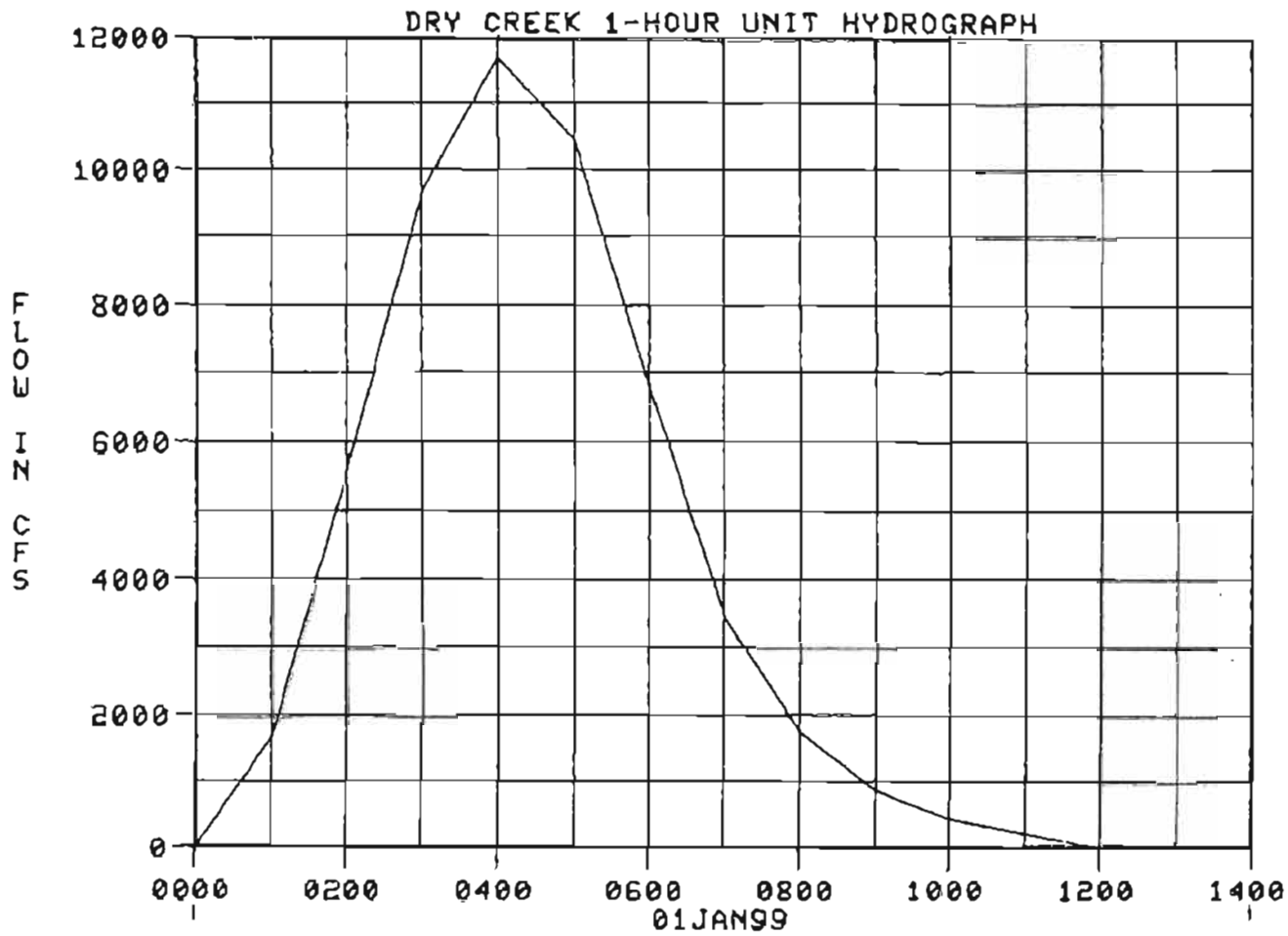




Drainage Area: 561 sq. mi.

KAV

H



DRAINAGE AREA - 81.9 SQ MILES

L	=	27.80
LCA	=	11.70
LLCA**.3	=	5.67
Tp	=	3.60
Cp	=	0.81
Ct	=	0.619
Volume	=	4,370 A.F.

DRY CREEK, CALIFORNIA

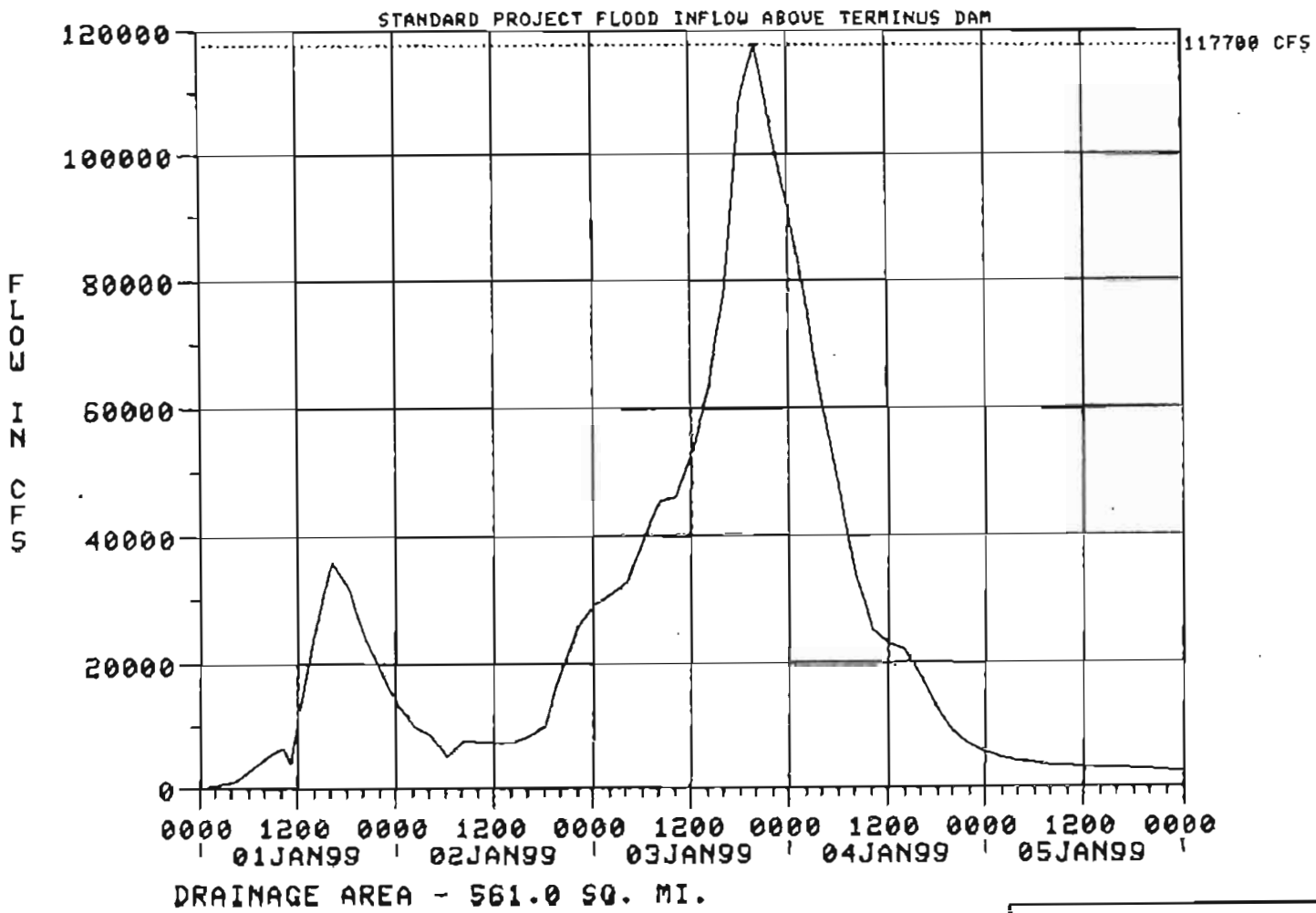
UNIT HYDROGRAPH

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: WLJ

Date: APRIL, 1989

PLATE 11



KAWEAH RIVER, CALIFORNIA

STANDARD PROJECT FLOOD

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: WLJ

Date: NOV. 1988

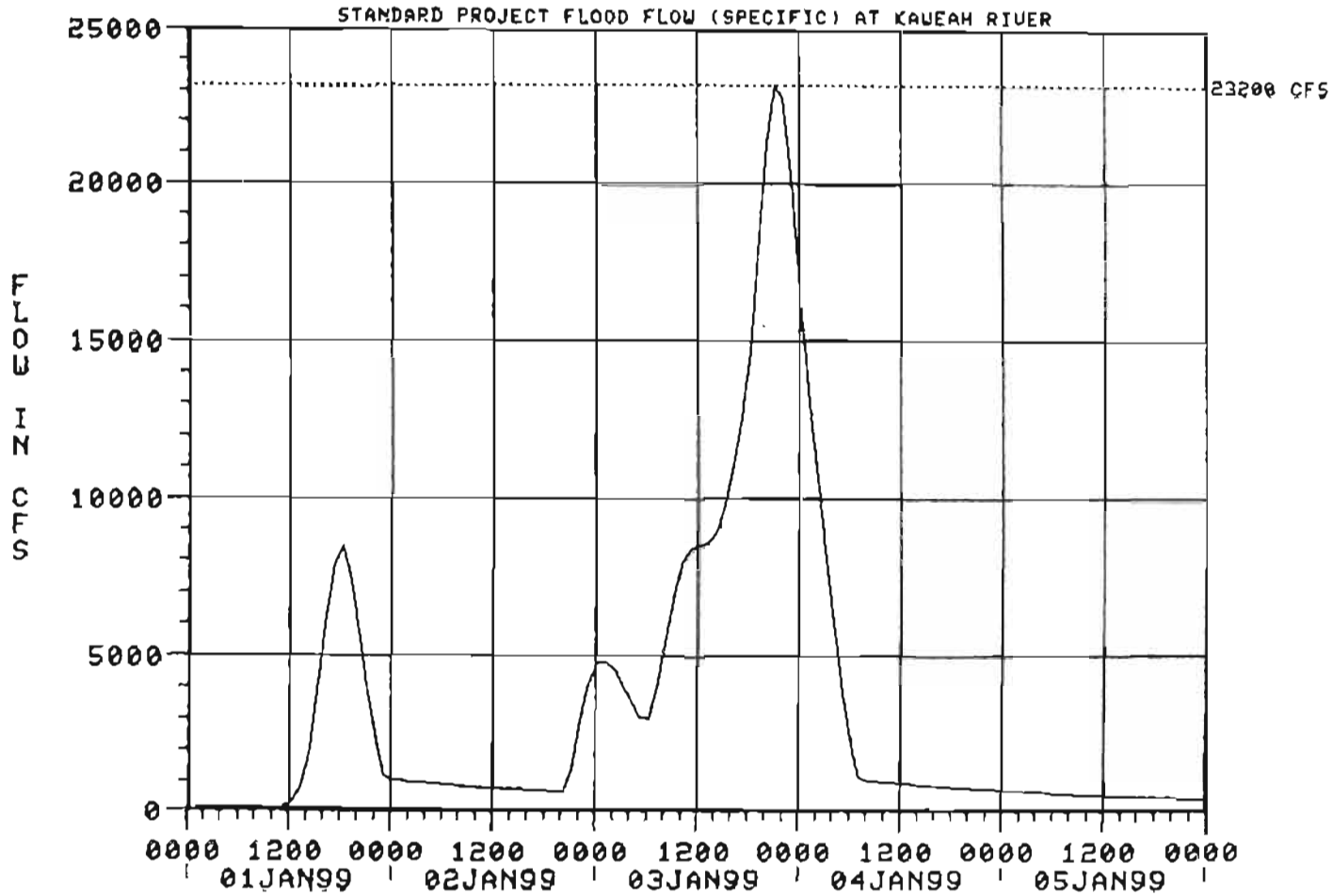
STANDARD PROJECT FLOOD INFLOW (SPECIFIC)
TO LAKE KAWEAH
(HOURLY FLOW IN C.F.S.)

01JAN99, 0100;	400.	500.	650.	800.	1805.	2810.
01JAN99, 0700;	3860.	4910.	5710.	6510.	3930.	12270.
01JAN99, 1300;	19055.	25840.	30830.	35820.	33850.	31880.
01JAN99, 1900;	28060.	24240.	21370.	18500.	16075.	13650.
02JAN99, 0100;	11885.	10120.	9385.	8650.	6865.	5080.
02JAN99, 0700;	6355.	7630.	7525.	7420.	7390.	7360.
02JAN99, 1300;	7405.	7450.	7855.	8260.	9120.	9980.
02JAN99, 1900;	14525.	19070.	22350.	25630.	27345.	29060.
03JAN99, 0100;	29870.	30680.	31535.	32390.	35750.	39110.
03JAN99, 0700;	42210.	45310.	45600.	45890.	49555.	53220.
03JAN99, 1300;	58340.	63460.	70685.	77910.	93330.	108750.
03JAN99, 1900;	113225.	117700.	110675.	103650.	96900.	90150.
04JAN99, 0100;	82725.	75300.	67530.	59760.	52955.	46150.
04JAN99, 0700;	39765.	33380.	29270.	25160.	23990.	22820.
04JAN99, 1300;	22435.	22050.	19725.	17400.	14765.	12130.
04JAN99, 1900;	10505.	8880.	7905.	6930.	6280.	5630.
05JAN99, 0100;	5190.	4750.	4445.	4140.	3930.	3720.
05JAN99, 0700;	3580.	3440.	3350.	3270.	3190.	3120.
05JAN99, 1300;	3060.	3000.	2950.	2900.	2800.	2700.
05JAN99, 1900;	2650.	2600.	2550.	2500.	2450.	2400.

STANDARD PROJECT FLOOD HOURLY PRECIPITATION
LAKE KAWEAH
(IN INCHES)

01JAN99, 0100;	0.00	0.00	0.01	0.01	0.08	0.08
01JAN99, 0700;	0.21	0.21	0.16	0.16	0.44	0.45
01JAN99, 1300;	0.72	0.72	0.53	0.52	0.25	0.25
01JAN99, 1900;	0.07	0.07	0.06	0.06	0.00	0.00
02JAN99, 0100;	0.01	0.01	0.02	0.02	0.00	0.00
02JAN99, 0700;	0.00	0.00	0.00	0.00	0.00	0.00
02JAN99, 1300;	0.00	0.00	0.13	0.13	0.05	0.05
02JAN99, 1900;	0.57	0.57	0.37	0.37	0.45	0.45
03JAN99, 0100;	0.29	0.29	0.37	0.38	0.55	0.56
03JAN99, 0700;	0.50	0.51	0.51	0.52	0.53	0.53
03JAN99, 1300;	0.68	0.69	0.71	0.71	1.08	1.09
03JAN99, 1900;	0.65	0.65	0.53	0.53	0.51	0.50
04JAN99, 0100;	0.29	0.29	0.21	0.20	0.10	0.90
04JAN99, 0700;	0.00	0.00	0.02	0.02	0.15	0.16
04JAN99, 1300;	0.13	0.13	0.00	0.00	0.00	0.00
04JAN99, 1900;	0.00	0.00	0.00	0.00	0.00	0.00
05JAN99, 0100;	0.00	0.00	0.00	0.00	0.00	0.00
05JAN99, 0700;	0.00	0.00	0.00	0.00	0.00	0.00
05JAN99, 1300;	0.00	0.00	0.00	0.00	0.00	0.00
05JAN99, 1900;	0.00	0.00	0.00	0.00	0.00	0.00

NOTE:
Dates are hypothetical
Kaweah River centering



DRAINAGE AREA - 81.9 SQ. MI.

DRY CREEK, CALIFORNIA

STANDARD PROJECT FLOOD

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: WLJ
Drawn: WLJ

Date: NOV. 1988

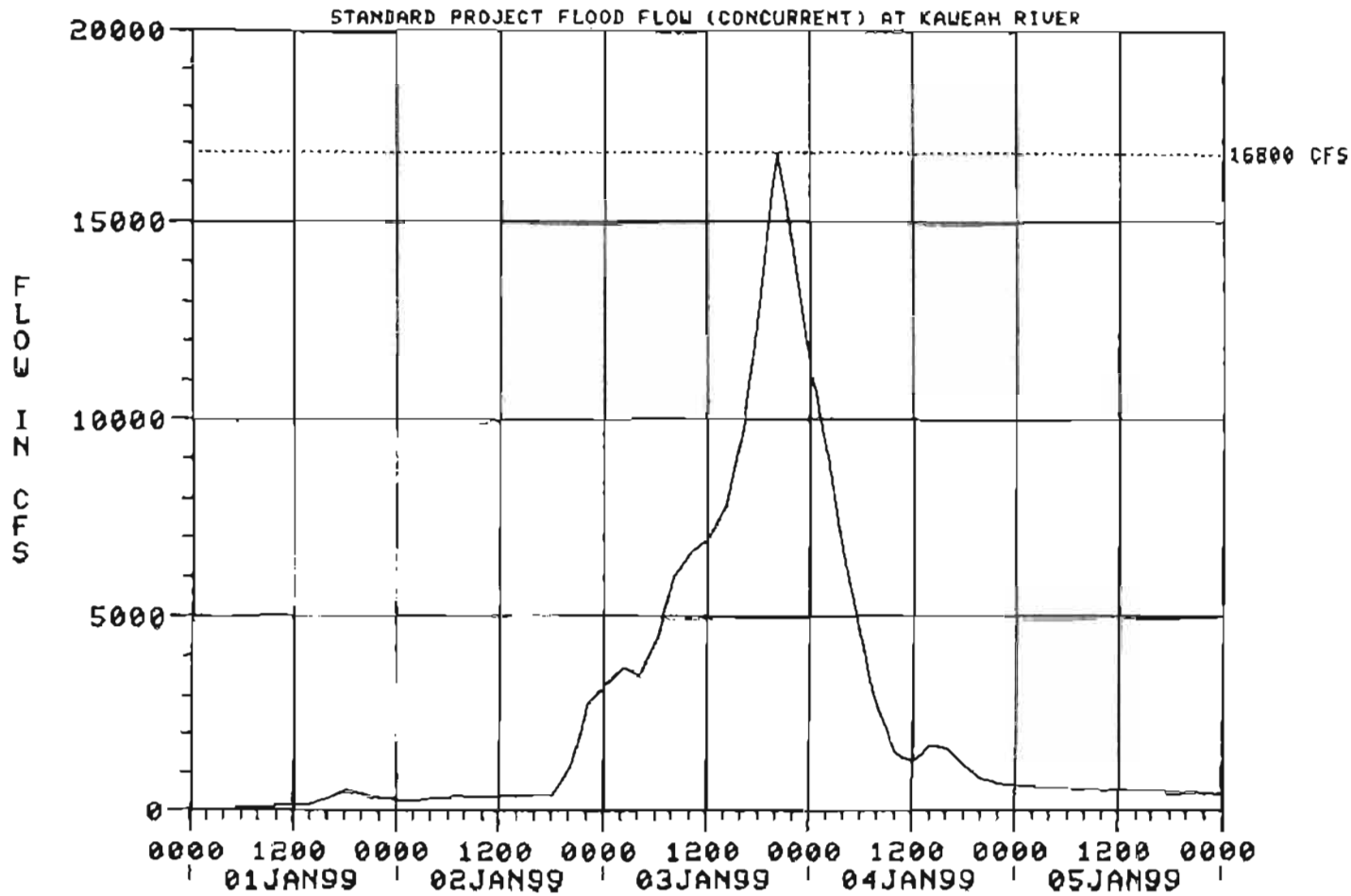
STANDARD PROJECT FLOOD INFLOW (SPECIFIC)
DRY CREEK NEAR LEMONCOVE
(HOURLY FLOW IN C.F.S.)

01JAN99, 0100;	100.	98.	95.	93.	91.	88.
01JAN99, 0700;	86.	84.	82.	80.	78.	225.
01JAN99, 1300;	720.	1843.	3767.	6025.	7818.	8421.
01JAN99, 1900;	7562.	5738.	3768.	2183.	1175.	983.
02JAN99, 0100;	959.	936.	913.	891.	869.	848.
02JAN99, 0700;	827.	807.	787.	768.	750.	731.
02JAN99, 1300;	713.	696.	679.	662.	646.	631.
02JAN99, 1900;	615.	600.	1326.	2817.	4123.	4768.
03JAN99, 0100;	4790.	4516.	4127.	3593.	3032.	2990.
03JAN99, 0700;	3902.	5438.	6934.	7940.	8365.	8462.
03JAN99, 1300;	8532.	8839.	9596.	10851.	12473.	14643.
03JAN99, 1900;	17742.	21076.	23165.	22809.	20006.	16205.
04JAN99, 0100;	12981.	10517.	8294.	6077.	3956.	2225.
04JAN99, 0700;	1128.	981.	957.	934.	911.	889.
04JAN99, 1300;	867.	846.	826.	805.	786.	767.
04JAN99, 1900;	748.	730.	712.	694.	678.	661.
05JAN99, 0100;	645.	629.	614.	599.	584.	570.
05JAN99, 0700;	556.	543.	529.	516.	504.	491.
05JAN99, 1300;	480.	468.	456.	445.	434.	424.
05JAN99, 1900;	413.	403.	394.	384.	375.	365.

STANDARD PROJECT FLOOD HOURLY PRECIPITATION
DRY CREEK NEAR LEMONCOVE
(IN INCHES)

01JAN99, 0100;	0.00	0.00	0.01	0.01	0.06	0.06
01JAN99, 0700;	0.13	0.14	0.11	0.11	0.29	0.29
01JAN99, 1300;	0.45	0.45	0.33	0.33	0.16	0.16
01JAN99, 1900;	0.05	0.05	0.04	0.03	0.00	0.00
02JAN99, 0100;	0.01	0.01	0.01	0.02	0.00	0.00
02JAN99, 0700;	0.00	0.00	0.00	0.00	0.00	0.00
02JAN99, 1300;	0.00	0.00	0.09	0.09	0.03	0.04
02JAN99, 1900;	0.38	0.38	0.24	0.24	0.32	0.31
03JAN99, 0100;	0.20	0.20	0.28	0.28	0.40	0.40
03JAN99, 0700;	0.36	0.35	0.36	0.37	0.37	0.36
03JAN99, 1300;	0.49	0.49	0.52	0.53	0.86	0.85
03JAN99, 1900;	0.46	0.45	0.36	0.37	0.34	0.34
04JAN99, 0100;	0.20	0.20	0.14	0.13	0.07	0.06
04JAN99, 0700;	0.00	0.00	0.02	0.01	0.10	0.10
04JAN99, 1300;	0.09	0.08	0.00	0.00	0.00	0.00
04JAN99, 1900;	0.00	0.00	0.00	0.00	0.00	0.00
05JAN99, 0100;	0.00	0.00	0.00	0.00	0.00	0.00
05JAN99, 0700;	0.00	0.00	0.00	0.00	0.00	0.00
05JAN99, 1300;	0.00	0.00	0.00	0.00	0.00	0.00
05JAN99, 1900;	0.00	0.00	0.00	0.00	0.00	0.00

NOTE:
Dates are hypothetical
Dry Creek Centering



DRAINAGE AREA - 81.9 SQ. MI.

DRY CREEK, CALIFORNIA

STANDARD PROJECT FLOOD

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

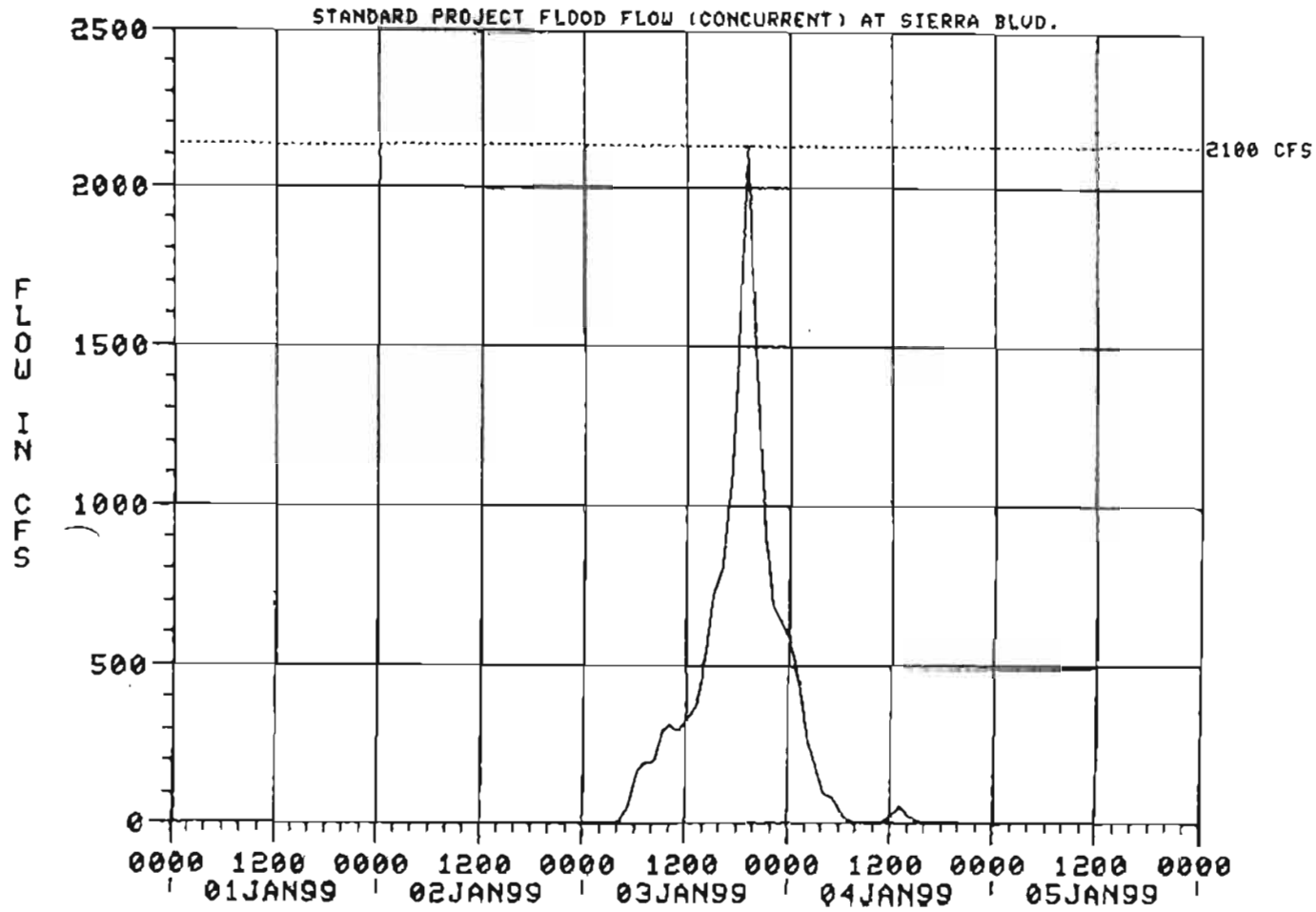
Prepared: WLJ

Date: NOV. 1988

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

01JAN99, 0100;	10.	20.	30.	40.	50.	60.
01JAN99, 0700;	70.	80.	90.	100.	110.	120.
01JAN99, 1300;	130.	140.	210.	281.	401.	522.
01JAN99, 1900;	464.	405.	353.	302.	283.	265.
02JAN99, 0100;	267.	269.	278.	287.	294.	300.
02JAN99, 0700;	362.	320.	330.	340.	350.	360.
02JAN99, 1300;	370.	380.	390.	400.	410.	420.
02JAN99, 1900;	733.	1126.	1923.	2720.	2961.	3202.
03JAN99, 0100;	3430.	3658.	3576.	3494.	3967.	4440.
03JAN99, 0700;	5224.	6008.	6300.	6601.	6794.	6988.
03JAN99, 1300;	7387.	7786.	8748.	9711.	11423.	13135.
03JAN99, 1900;	14952.	16768.	15478.	14189.	12665.	11141.
04JAN99, 0100;	10018.	8894.	7606.	6318.	5304.	4289.
04JAN99, 0700;	3334.	2578.	2044.	1510.	1391.	1272.
04JAN99, 1300;	1471.	1670.	1644.	1617.	1381.	1145.
04JAN99, 1900;	992.	839.	775.	711.	688.	666.
05JAN99, 0100;	648.	630.	613.	600.	590.	580.
05JAN99, 0700;	570.	560.	550.	540.	530.	520.
05JAN99, 1300;	510.	500.	490.	480.	470.	460.
05JAN99, 1900;	450.	440.	430.	420.	410.	400.

NOTE:
Dates are hypothetical
Kaweah River centering



DRAINAGE AREA - 18.5 SQ. MI.

MEHRTEN CREEK, CALIFORNIA

STANDARD PROJECT FLOOD

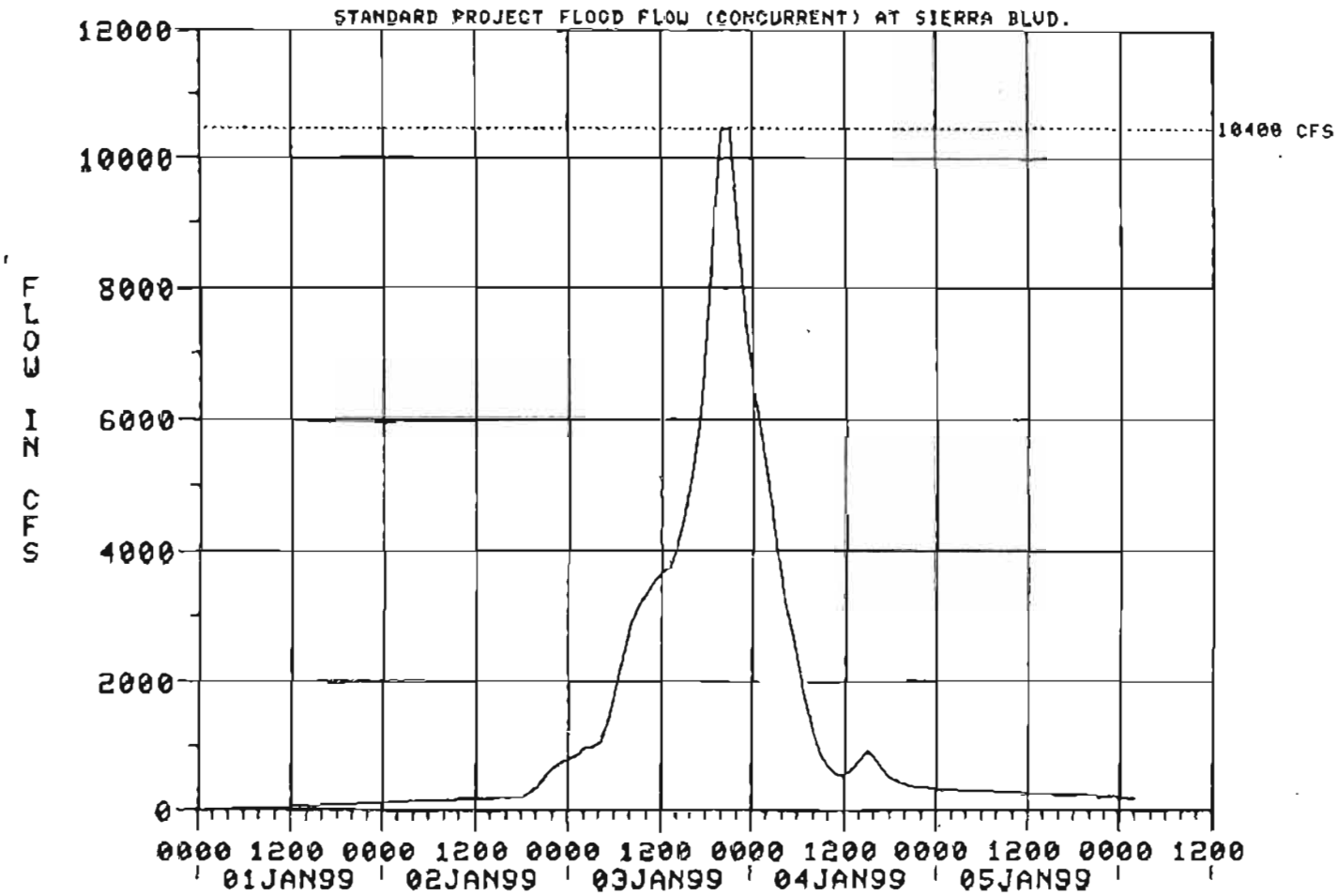
CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: WLJ
Drawn: WLJ
Date: NOV. 1988

STANDARD PROJECT FLOOD FLOW (CONCURRENT)
MEHRTEN CREEK NEAR VISALIA
(HOURLY FLOW IN C.F.S.)

01JAN99, 0100;	0.	0.	0.	0.	0.	0.
01JAN99, 0700;	0.	0.	0.	0.	0.	0.
01JAN99, 1300;	0.	0.	0.	0.	0.	0.
01JAN99, 1900;	0.	0.	0.	0.	0.	0.
02JAN99, 0100;	0.	0.	0.	0.	0.	0.
02JAN99, 0700;	0.	0.	0.	0.	0.	0.
02JAN99, 1300;	0.	0.	0.	0.	0.	0.
02JAN99, 1900;	0.	0.	0.	0.	0.	0.
03JAN99, 0100;	0.	0.	0.	0.	47.	163.
03JAN99, 0700;	191.	197.	292.	313.	294.	329.
03JAN99, 1300;	372.	532.	719.	799.	1107.	1622.
03JAN99, 1900;	2130.	1361.	912.	688.	639.	577.
04JAN99, 0100;	444.	267.	192.	98.	83.	31.
04JAN99, 0700;	11.	2.	1.	0.	0.	24.
04JAN99, 1300;	58.	26.	9.	2.	1.	0.
04JAN99, 1900;	0.	0.	0.	0.	0.	0.
05JAN99, 0100;	0.	0.	0.	0.	0.	0.
05JAN99, 0700;	0.	0.	0.	0.	0.	0.
05JAN99, 1300;	0.	0.	0.	0.	0.	0.
05JAN99, 1900;	0.	0.	0.	0.	0.	0.

NOTE:
Dates are hypothetical
Kaweah River centering



DRAINAGE AREA - 73.8 SQ. MI.

YOKOHL CREEK, CALIFORNIA

STANDARD PROJECT FLOOD

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

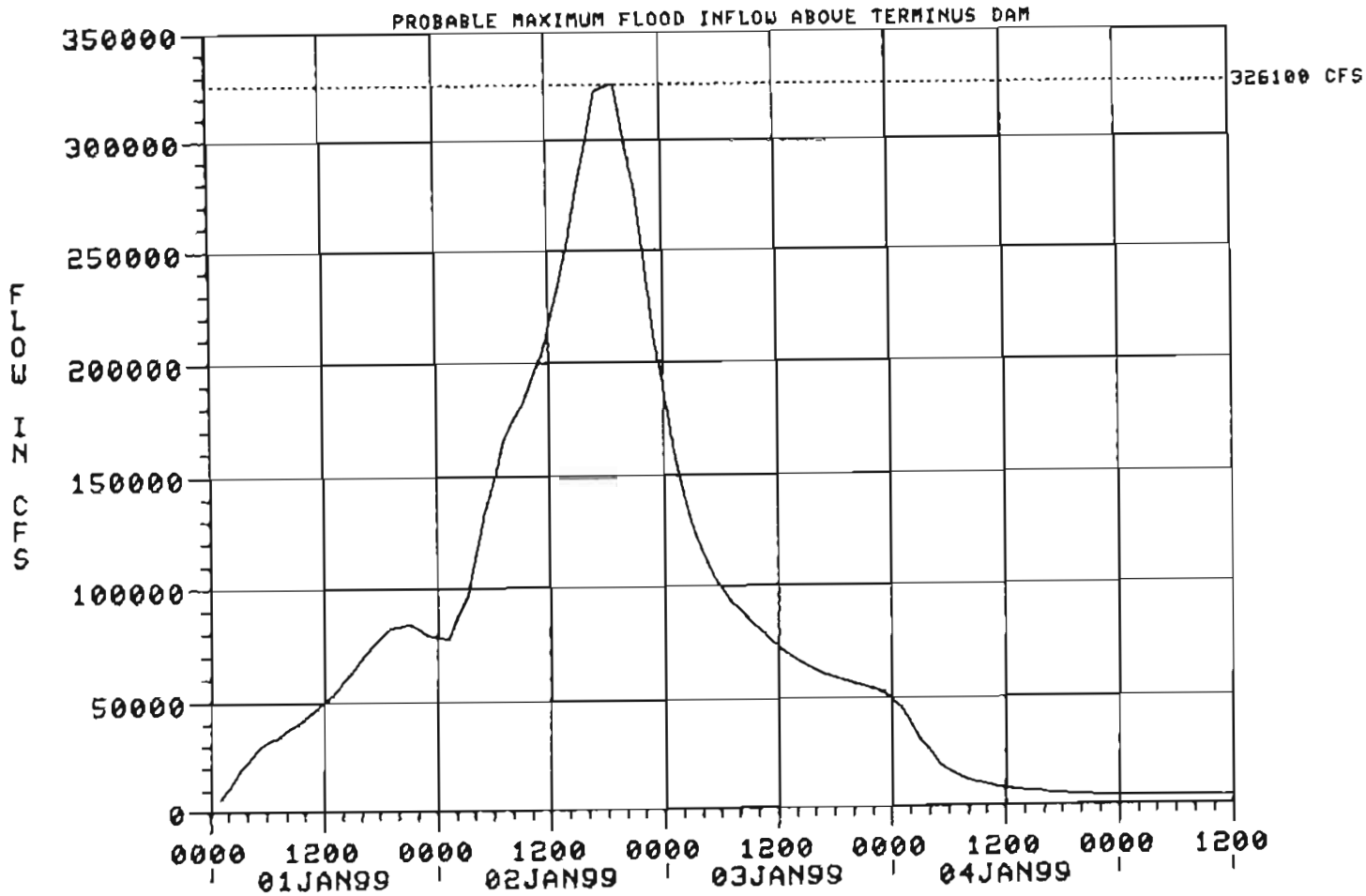
Prepared: WLJ
Drawn: WLJ

Date: NOV. 1988

STANDARD PROJECT FLOOD FLOW (CONCURRENT)
YOKOHL CREEK NEAR VISALIA
(HOURLY FLOW IN C.F.S.)

01JAN99, 0100;	5.	10.	15.	20.	25.	30.
01JAN99, 0700;	35.	40.	45.	50.	55.	60.
01JAN99, 1300;	65.	70.	75.	80.	85.	90.
01JAN99, 1900;	95.	100.	105.	110.	115.	120.
02JAN99, 0100;	125.	130.	135.	140.	145.	150.
02JAN99, 0700;	155.	160.	165.	170.	175.	180.
02JAN99, 1300;	185.	190.	195.	200.	205.	210.
02JAN99, 1900;	259.	349.	516.	659.	736.	805.
03JAN99, 0100;	851.	967.	991.	1044.	1353.	1851.
03JAN99, 0700;	2448.	2907.	3154.	3331.	3518.	3652.
03JAN99, 1300;	3739.	4028.	4454.	5186.	6038.	7476.
03JAN99, 1900;	9111.	10443.	10448.	8870.	7496.	6531.
04JAN99, 0100;	5755.	5019.	4130.	3309.	2666.	2101.
04JAN99, 0700;	1648.	1200.	875.	674.	552.	540.
04JAN99, 1300;	625.	788.	907.	814.	640.	522.
04JAN99, 1900;	453.	403.	366.	345.	333.	324.
05JAN99, 0100;	315.	306.	300.	295.	290.	285.
05JAN99, 0700;	280.	275.	270.	265.	260.	255.
05JAN99, 1300;	250.	245.	240.	235.	230.	225.
05JAN99, 1900;	220.	215.	210.	205.	200.	195.
06JAN99, 0100;	190.	185.				

NOTE:
Dates are hypothetical
Kaweah River Centering



DRAINAGE AREA - 561.0 SQ. MI.

KAWEAH RIVER, CALIFORNIA

PROBABLE MAXIMUM FLOOD

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

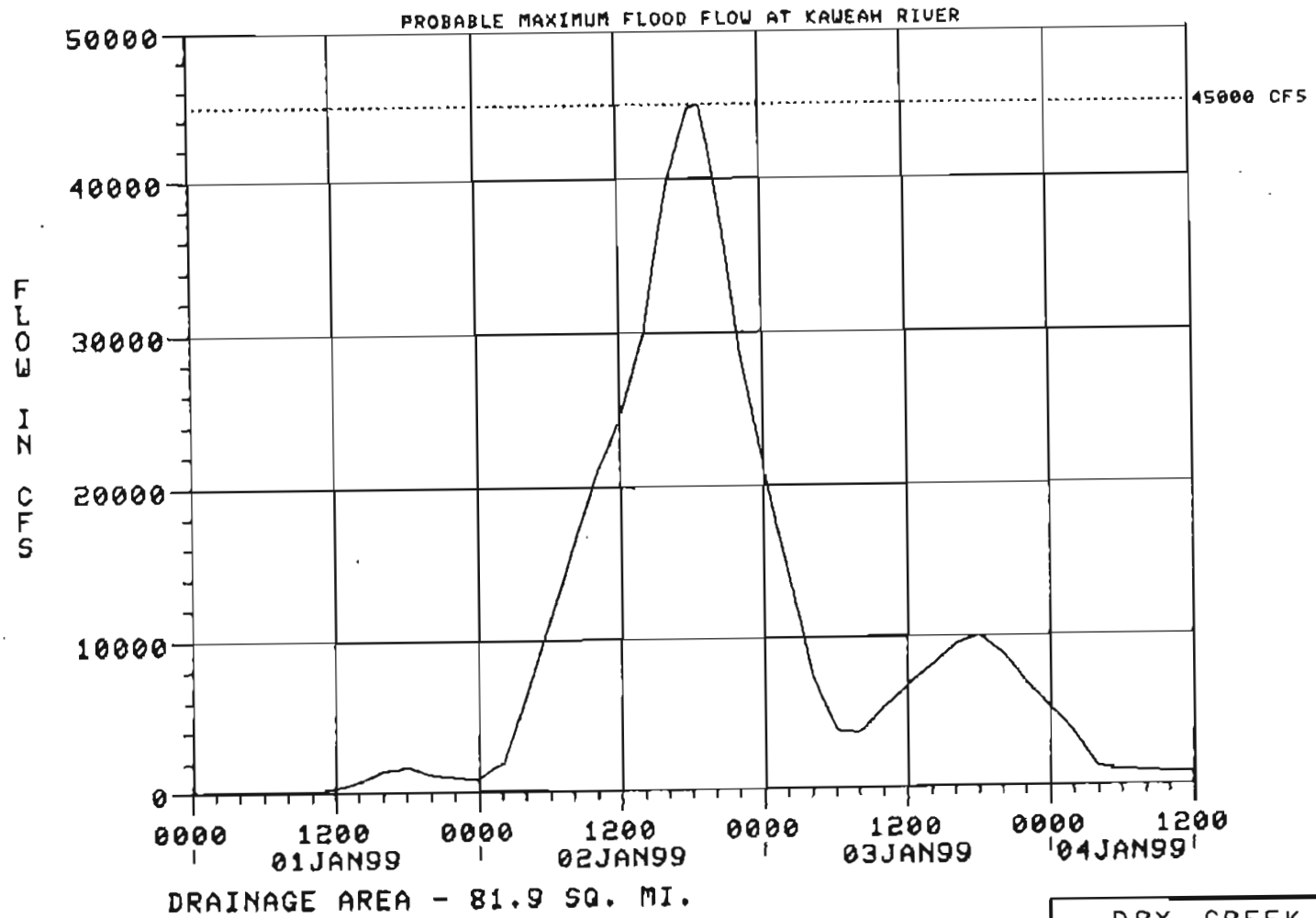
Prepared: WLJ

Date: NOV. 1988

PROBABLE MAXIMUM FLOOD INFLOW INTO LAKE KAWEAH
(HOURLY FLOW IN C.F.S.)

01JAN99, 0100;	5225.0	12015.5	18806.0	24046.5
01JAN99, 0500;	29287.0	31700.0	34113.0	36975.5
01JAN99, 0900;	39838.0	43186.0	46534.0	50084.0
01JAN99, 1300;	53634.0	58747.5	63861.0	69120.0
01JAN99, 1700;	74379.0	78204.0	82029.0	82969.5
01JAN99, 2100;	83910.0	81547.5	79185.0	78240.0
02JAN99, 0100;	77295.0	86734.5	96174.0	114617.0
02JAN99, 0500;	133060.0	149085.0	165110.0	173408.5
02JAN99, 0900;	181707.0	192230.0	202753.0	218532.5
02JAN99, 1300;	234312.0	256098.5	277885.0	300208.0
02JAN99, 1700;	322531.0	324324.5	326118.0	301106.0
02JAN99, 2100;	276094.0	242810.5	209527.0	184058.0
03JAN99, 0100;	158589.0	141793.5	124998.0	114695.0
03JAN99, 0500;	104392.0	98505.5	92619.0	88577.5
03JAN99, 0900;	84536.0	80477.0	76418.0	72742.5
03JAN99, 1300;	69067.0	66386.5	63706.0	61897.5
03JAN99, 1700;	60089.0	58752.5	57416.0	56109.0
03JAN99, 2100;	54802.0	53443.0	52084.0	48407.5
04JAN99, 0100;	44731.0	37384.0	30037.0	24541.0
04JAN99, 0500;	19045.0	16340.0	13635.0	12060.0
04JAN99, 0900;	10485.0	9497.5	8510.0	7847.5
04JAN99, 1300;	7185.0	6712.0	6239.0	5849.5
04JAN99, 1700;	5460.0	5153.0	4846.0	4609.0
04JAN99, 2100;	4372.0	4213.5	4055.0	3968.5
05JAN99, 0100;	3882.0	3832.0	3782.0	3753.0
05JAN99, 0500;	3724.0	3695.0	3666.0	3637.0
05JAN99, 0900;	3608.0	3579.0	3550.0	3525.0

NOTE:
Dates are hypothetical



DRY CREEK, CALIFORNIA

PROBABLE MAXIMUM FLOOD

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: WLJ

Date: NOV. 1988

PROBABLE MAXIMUM FLOOD FLOW
DRY CREEK NEAR LEMONCOVE
(HOURLY FLOW IN C.F.S.)

01JAN99, 0100;	90.0	90.0	85.0	80.0
01JAN99, 0500;	80.0	80.0	75.0	70.0
01JAN99, 0900;	96.0	122.0	218.5	315.0
01JAN99, 1300;	510.5	706.0	1043.5	1381.0
01JAN99, 1700;	1513.5	1646.0	1372.0	1098.0
01JAN99, 2100;	1009.0	920.0	877.0	834.0
02JAN99, 0100;	1404.5	1975.0	4259.5	6544.0
02JAN99, 0500;	8916.0	11288.0	13812.0	16336.0
02JAN99, 0900;	18597.5	20859.0	22796.5	24734.0
02JAN99, 1300;	27316.0	29898.0	34624.0	39350.0
02JAN99, 1700;	42037.5	44725.0	45000.0	40725.0
02JAN99, 2100;	34857.5	28941.0	25091.0	21241.0
03JAN99, 0100;	17652.5	14064.0	10786.5	7509.0
03JAN99, 0500;	5644.5	3780.0	3732.5	3685.0
03JAN99, 0900;	4523.0	5361.0	6099.0	6837.0
03JAN99, 1300;	7451.0	8065.0	8763.5	9462.0
03JAN99, 1700;	9738.5	10015.0	9400.5	8786.0
03JAN99, 2100;	7806.5	6827.0	6047.0	5267.0
04JAN99, 0100;	4352.0	3437.0	2345.0	1253.0
04JAN99, 0500;	1093.0	933.0	889.5	846.0
04JAN99, 0900;	807.0	768.0	732.0	696.0

NOTES:
Dates are hypothetical

RATIOS FOR FLOOD SERIES

RATIOS TO MULTIPLY THE KAWEAH RIVER SPF TO SIMULATE THE INDICATED FLOOD SERIES

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

1969 DAILY VALUES AND RATIOS
USED FOR HYPOTHETICAL FLOOD ROUTINGS

1969 INFLOW TO LAKE KAWEAH
(Flow in c.f.s.)

01OCT68, 2400;	31.	30.	31.	29.	29.	31.
07OCT68, 2400;	31.	32.	29.	34.	28.	31.
13OCT68, 2400;	43.	214.	237.	141.	111.	106.
19OCT68, 2400;	101.	92.	59.	58.	51.	46.
25OCT68, 2400;	39.	38.	32.	62.	63.	77.
31OCT68, 2400;	105.	74.	80.	104.	182.	147.
06NOV68, 2400;	112.	96.	84.	87.	88.	96.
12NOV68, 2400;	111.	174.	136.	251.	247.	178.
18NOV68, 2400;	165.	167.	163.	146.	133.	130.
24NOV68, 2400;	127.	131.	113.	111.	109.	82.
30NOV68, 2400;	85.	92.	93.	86.	96.	91.
06DEC68, 2400;	85.	94.	84.	82.	85.	150.
12DEC68, 2400;	132.	97.	143.	464.	445.	229.
18DEC68, 2400;	161.	170.	144.	125.	117.	143.
24DEC68, 2400;	156.	396.	439.	240.	254.	290.
30DEC68, 2400;	226.	208.	197.	201.	197.	204.
05JAN69, 2400;	231.	249.	257.	250.	234.	222.
11JAN69, 2400;	197.	184.	224.	733.	437.	328.
17JAN69, 2400;	294.	422.	13077.	4320.	7976.	5437.
23JAN69, 2400;	2140.	3804.	22437.	12327.	5511.	3775.
29JAN69, 2400;	2744.	2216.	1894.	1664.	1532.	1313.
04FEB69, 2400;	1219.	1264.	2540.	1729.	1434.	1309.
10FEB69, 2400;	1251.	1223.	1360.	1275.	1130.	1916.
16FEB69, 2400;	1896.	1474.	1699.	1897.	1578.	1535.
22FEB69, 2400;	1640.	1751.	7349.	8292.	3765.	2664.
28FEB69, 2400;	2901.	2628.	2194.	2215.	1922.	1702.
06MAR69, 2400;	1575.	1495.	1332.	1264.	1324.	1173.
12MAR69, 2400;	1175.	1118.	1047.	1007.	1011.	1161.
18MAR69, 2400;	1331.	1320.	1367.	1449.	1307.	1336.
24MAR69, 2400;	1432.	1553.	1681.	1809.	1994.	2217.
30MAR69, 2400;	2418.	2582.	2520.	2477.	2714.	2179.
05APR69, 2400;	3365.	3193.	2393.	2217.	2121.	2036.
11APR69, 2400;	2121.	2356.	2421.	2389.	2071.	1956.
17APR69, 2400;	2082.	2337.	2253.	2580.	3032.	3262.
23APR69, 2400;	3103.	2600.	2281.	2189.	2300.	2528.
29APR69, 2400;	2745.	2922.	3044.	3088.	2727.	2546.
05MAY69, 2400;	2397.	2747.	3111.	3680.	4232.	4567.
11MAY69, 2400;	4530.	4402.	4525.	4413.	4337.	4581.
17MAY69, 2400;	5052.	5204.	5035.	5024.	5256.	5401.
23MAY69, 2400;	5019.	5630.	5820.	5702.	5687.	5591.
29MAY69, 2400;	6021.	6420.	6785.	6824.	6660.	6267.
04JUN69, 2400;	5911.	5630.	5545.	5283.	4813.	4299.
10JUN69, 2400;	3385.	2878.	2774.	2991.	3418.	3638.
16JUN69, 2400;	3850.	3705.	3210.	3348.	3530.	3455.
22JUN69, 2400;	3667.	3742.	3587.	3310.	3061.	3036.
28JUN69, 2400;	2915.	2809.	2944.	2994.	2916.	2864.
04JUL69, 2400;	2762.	2693.	2604.	2537.	2489.	2396.
10JUL69, 2400;	2390.	2341.	2273.	2574.	2351.	2162.

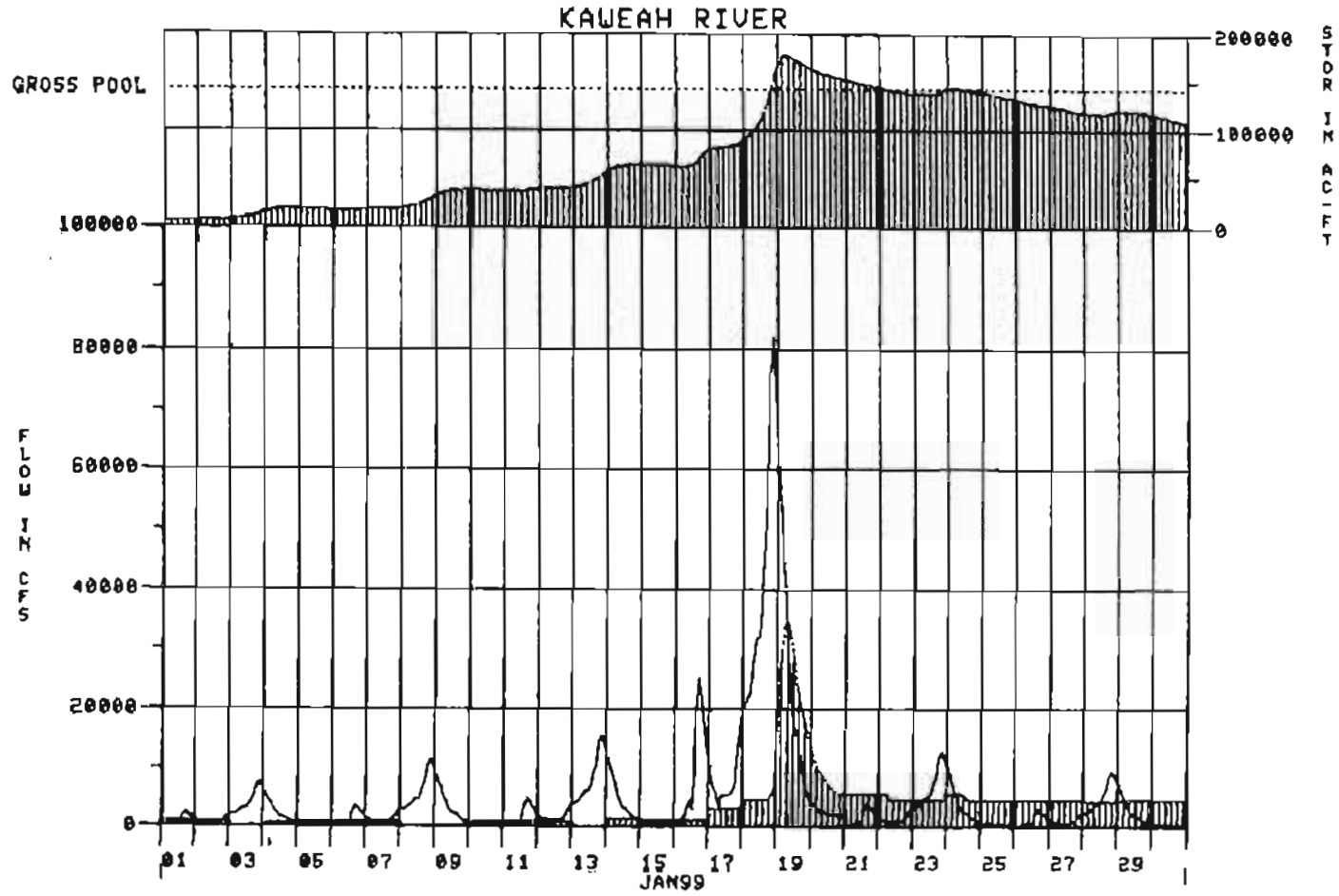
1969 DAILY VALUES AND RATIOS USED FOR HYPOTHETICAL FLOOD ROUTINGS

1969 INFLOW TO LAKE KAWEAH
(Flow in c.f.s.)

16JUL69, 2400;	2137.	2078.	2014.	1968.	2037.	1960.
22JUL69, 2400;	1914.	1777.	1662.	1485.	1436.	1367.
28JUL69, 2400;	1382.	1290.	1271.	1248.	1215.	1110.
03AUG69, 2400;	1047.	1005.	932.	782.	709.	687.
09AUG69, 2400;	635.	711.	964.	730.	660.	616.
15AUG69, 2400;	576.	562.	532.	493.	439.	418.
21AUG69, 2400;	397.	413.	346.	353.	354.	323.
27AUG69, 2400;	309.	378.	213.	277.	240.	228.
02SEP69, 2400;	246.	254.	219.	189.	207.	261.
08SEP69, 2400;	218.	233.	204.	221.	198.	168.
14SEP69, 2400;	131.	162.	159.	161.	163.	143.
20SEP69, 2400;	145.	153.	151.	155.	164.	136.
26SEP69, 2400;	153.	129.	130.	140.	106.	

RATIOS TO MULTIPLY TIMES 1969 INFLOW TO LAKE KAWEAH TO SIMULATE INDICATED FLOOD

RAIN FLOOD SEASON				SNOWMELT FLOOD SEASON			
100-YR	200-YR	500-YR	1000-YR	100-YR	200-YR	500-YR	1000-YR
1.14	1.37	1.59	1.87	1.13	1.31	1.49	1.63



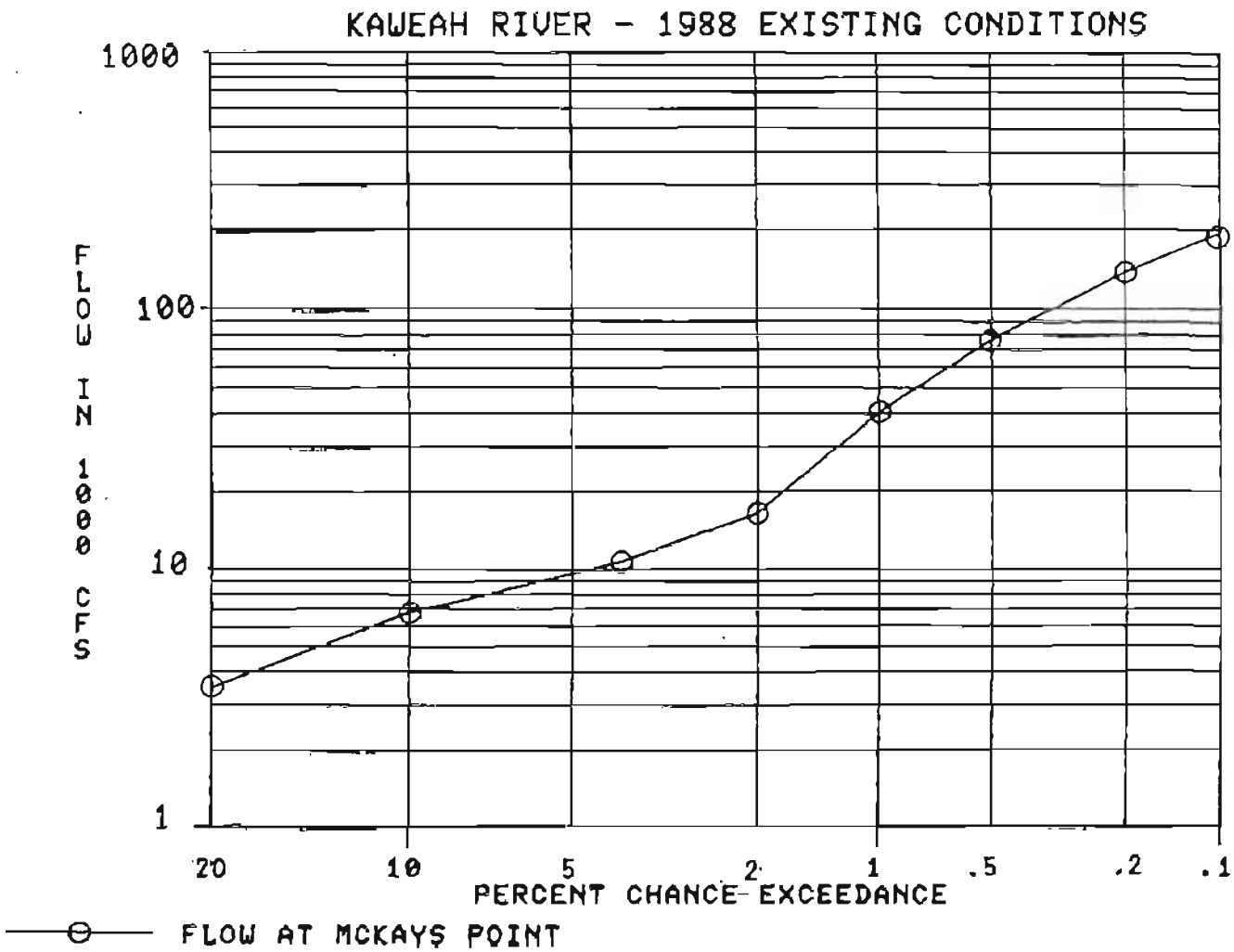
100 YEAR LAKE KAWEAH INFLOW
100 YEAR LAKE KAWEAH OUTFLOW
100 YEAR LAKE KAWEAH STORAGE

KAWEAH RIVER, CALIFORNIA

100 YEAR FLOOD ROUTED THROUGH EXISTING LAKE KAWEAH

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: WLJ
Drawn: WLJ
Date: DEC. 1988



KAWEAH RIVER, CALIFORNIA

REGULATED RAIN FLOW FREQUENCY EXISTING CONDITIONS

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: WLJ

Drawn: WLJ

Date: DEC. 1988

ASSUMED MAXIMUM DAILY IRRIGATION AND SPREADING DEMAND
(Flow in c.f.s.)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
2	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
3	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
4	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
5	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
6	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
7	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
8	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
9	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
10	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
11	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
12	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
13	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
14	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
15	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
16	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
17	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
18	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
19	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
20	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
21	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
22	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
23	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
24	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
25	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
26	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
27	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
28	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
29	1000	1000	1200	1200	1200	1200	1500	2100	2600	2600	2300	1500
30	1000	1000	1200	1200		1200	1500	2100	2600	2600	2300	1500
31	1000		1200	1200		1200		2100		2600	2300	
TOTAL (1000 AF)	61	60	74	74	69	74	89	129	155	160	141	89

CHART 23

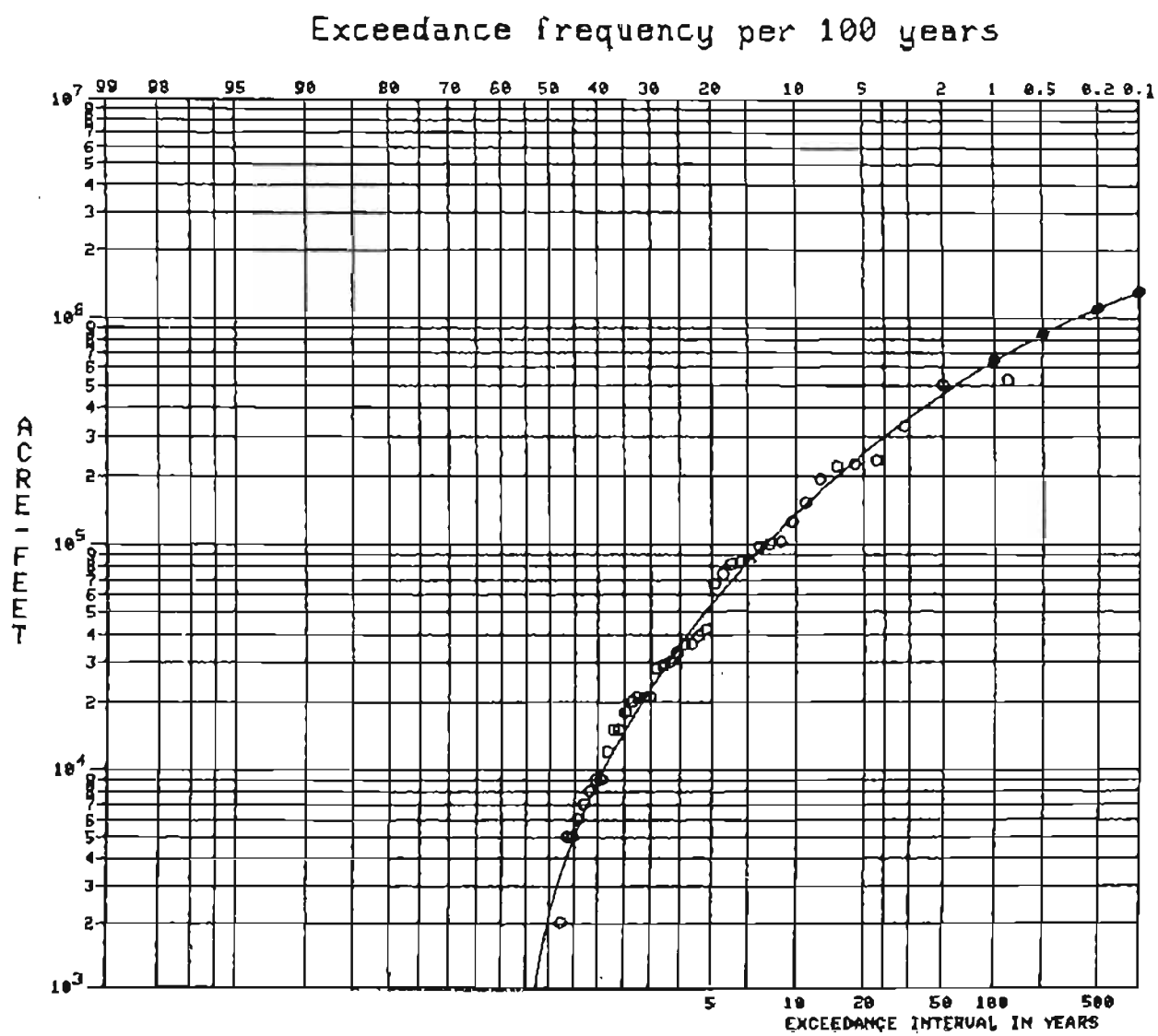
COMPARISON OF SIMULATED FLOW TO TULARE LAKEBED
TO ACTUAL FLOW TO TULARE LAKEBED

WATER YEAR	ACTUAL FLOW TO TULARE LAKEBED PLUS WATER PUMPED INTO THE FRIANT-KERN CANAL (1,000 ACRE-FEET)	COMPUTED FLOW ABOVE ASSUMED MAXIMUM IRRIGATION AND SPREADING DEMAND (1,000 ACRE-FEET)
1978	26	84
1980	36	221
1982	61	36
1983	595	531

CHART 24

SIMULATED FLOW TO TULARE LAKEBED
UNDER EXISTING 1988 CONDITIONS
(Flow in Acre-Feet)

1904	7000	1946	0
1905	0	1947	0
1906	332000	1948	0
1907	12000	1949	0
1908	0	1950	1000
1909	103000	1951	98000
1910	28000	1952	84000
1911	42000	1953	0
1912	0	1954	1000
1913	0	1955	5000
1914	39000	1956	235000
1915	0	1957	0
1916	101000	1958	15000
1917	9000	1959	0
1918	0	1960	0
1919	0	1961	0
1920	2000	1962	15000
1921	0	1963	67000
1922	0	1964	6000
1923	0	1965	21000
1924	0	1966	0
1925	0	1967	227000
1926	0	1968	9000
1927	33000	1969	506000
1928	0	1970	20000
1929	0	1971	0
1930	0	1972	0
1931	0	1973	21000
1932	21000	1974	5000
1933	0	1975	1000
1934	0	1976	0
1935	1000	1977	0
1936	30000	1978	84000
1937	82000	1979	8000
1938	154000	1980	221000
1939	0	1981	0
1940	36000	1982	36000
1941	18000	1983	531000
1942	0	1984	74000
1943	127000	1985	0
1944	0	1986	194000
1945	29000	1987	0
		1988	0



○ RECORDED INFLOW HYDROGRAPH

● HYPOTHETICAL INFLOW HYDROGRAPH

KAWEAH RIVER, CALIFORNIA

ANNUAL VOLUME FREQUENCY OF FLOODWATERS TO TULARE LAKE

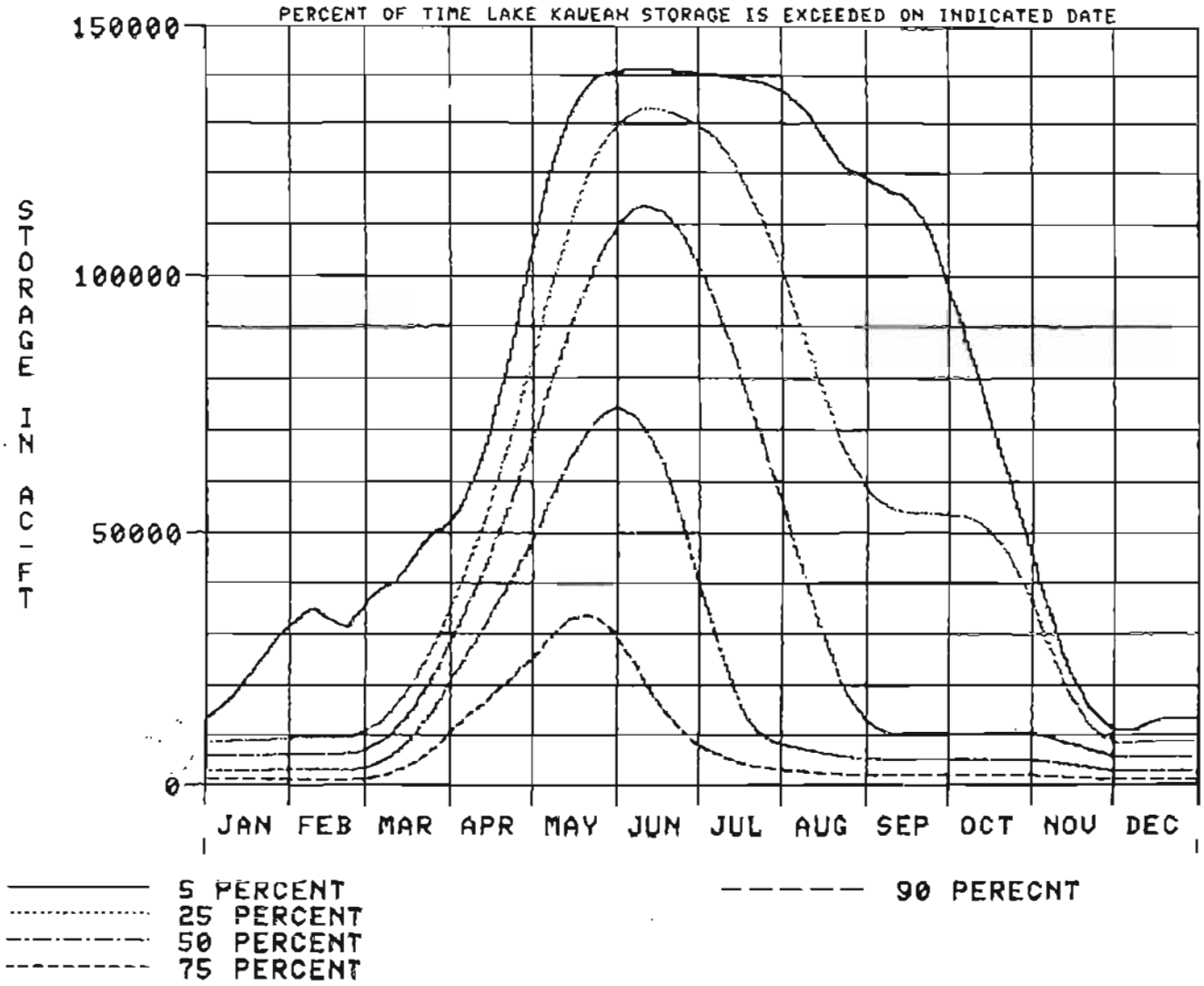
EXISTING CONDITIONS

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: WLJ
Drawn: WLJ

Date: DEC 1988

CHART 26



KAWEAH RIVER, CALIFORNIA

SEASONAL VARIATION OF RESERVOIR STORAGE

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: WLJ

Drawn: WLJ

Date: DEC. 1988

ATTACHMENT 7 – TECHNICAL JUSTIFICATION

APPENDIX B

1962 Terminus Dam Reservoir Regulation Manual

TERMINUS DAM (LAKE KAWEAH)
Kaweah River, California

RESERVOIR REGULATION MANUAL

JUNE 1962

Revised November 1971

DEPARTMENT OF THE ARMY

SACRAMENTO DISTRICT, CORPS OF ENGINEERS

SACRAMENTO, CALIFORNIA

TERMINUS DAM (LAKE KAWEAH)
KAWEAH RIVER, CALIFORNIA

RESERVOIR REGULATION

PERTINENT DATA

General

Drainage areas
- Kaweah River at McKay Point . . . . . 647 sq miles
- Kaweah River at Terminus Dam site . . . . . 561 sq miles
- Kaweah River at Three Rivers . . . . . 418 sq miles
- South Fork Kaweah River at Three Rivers . . . 87 sq miles
- North Fork Kaweah River at Kaweah . . . . . 129 sq miles
- Marble Fork Kaweah River at Potwisha Camp . . 32 sq miles
- Middle Fork Kaweah River near Potwisha Camp . 102 sq miles
- Dry Creek near Lemoncove . . . . . 80 sq miles

Flows at dam site (estimated)
- Mean annual (1904-1970) . . . . . 422,000 ac-ft
- Average depth on basin . . . . . 14.1 inches
- Average flow . . . . . 58.3 cfs
- Maximum flow (6 Dec 1966) . . . . . 105,000 cfs
- Minimum flow . . . . . 8 cfs
- Standard project peak inflow 119,000
- Standard project peak outflow 45,000
- Spillway design peak inflow . . . . . 290,000 cfs
- Spillway design peak outflow . . . . . 274,000 cfs

Reservoir

Elevation
- Inactive pool . . . . . 570.0 ft
- Conditional winter pool . . . . . 586.5 ft
- Gross pool . . . . . 694.0 ft
- Taking line . . . . . 704 ft
- Spillway design flood pool . . . . . 745.1 ft

Area
- Inactive pool . . . . . 344 acres
- Conditional winter pool . . . . . 500 acres
- Gross pool . . . . . 1,945 acres
- Taking line . . . . . 2,059 acres
- Spillway design flood pool . . . . . 2,630 acres

Storage capacity
- Inactive pool . . . . . 8,000 ac-ft
- Conditional winter pool . . . . . 15,000 ac-ft
- Gross pool . . . . . 150,000 ac-ft
- Taking line . . . . . 170,000 ac-ft
- Spillway design flood pool . . . . . 266,000 ac-ft

Reservoir length at gross pool elevation . . . 5 miles

Spillway (uncontrolled broad-crested) (combination service and auxiliary)

- Crest length (service). . . . . 135 ft
  - (auxiliary). . . . . 172 ft
- Crest elevation (service) . . . . . 694.0 ft
  - (auxiliary) . . . . . 708.4 ft
- Reservoir design flood head (service) . . . . None
  - (auxiliary) . . . None
- Standard project flood head (service) . . . . 14.4 ft
  - (auxiliary) . . . None
- Spillway design flood head (service) . . . . 51.1 ft
  - (auxiliary). . . . 36.7 ft

Main dam (earth fill)

- Elevation, top of dam . . . . . 750.0 ft
- Freeboard above spillway design flood pool. . 4.9 ft
- Maximum height . . . . . 250 ft
- Length of crest . . . . . 2,375 ft
- Width of crest . . . . . 25.0 ft
- Width of roadway. . . . . 16.0 ft
- Upstream slope . . . . . 1 on 2.25 and 1 on 2
- Downstream slope . . . . . 1 on 2
- Total excavation . . . . . 300,000 cu-yds
- Total volume of embankment. . . . . 6,450,000 cu-yds

Auxiliary dam (earth fill)

- Elevation, top of dam . . . . . 750 ft
- Freeboard, above spillway design flood pool. . . . . 4.9 ft
- Maximum height. . . . . 130 ft
- Length of crest . . . . . 870 ft
- Width of crest . . . . . 20 ft
- Width of roadway. . . . . 16 ft
- Upstream slope. . . . . 1 on 2.75 and 1 on 2
- Downstream slope. . . . . 1 on 2
- Total excavation. . . . . 40,000 cu-yds
- Total volume of embankment. . . . . 445,000 cu-yds

Main outlet

Tunnel (concrete lined)
- No. and size . . . . . 1 - 12'9" ID
- Intake elevation, invert. . . . . 520 ft
- Length . . . . . 1,080 ft
- Gross head. . . . . 174 ft

Gates (hydraulic slide)
- Service gates, no. and size . . . . . 3 - 5' x 9'
- Emergency gates, no. and size . . . . . 3 - 5' x 9'

Total capacity of outlets with water surface
- At elevation 570 ft. (inactive pool). . . . 4,500 cfs
- At elevation 694 ft. (gross pool) . . . . . 8,400 cfs

Lemon Cove Irrigation Ditch Outlet

Steel pipe (concrete enclosed)
- Diameter . . . . . 36 inches
- Intake elevation, invert. . . . . 522 feet
- Length . . . . . 1,250 feet
- Gross head. . . . . 145.5 feet

Gates (number and size)
- Service (double disc type valve). . . . . 1 - 36"
- Emergency (double disc type valve). . . . . 1 - 36"

Flume capacity. . . . . 15 cfs
- At pool elevation 551 and above . . . . . 15 cfs by gravity
- At pool elevation less than 551 . . . . . 10 cfs by pumping

Emergency pump
- 50 hp vertical turbine . . . . . 4450 g.p.m.

Hawkeye Ditch Company Outlet

Steel pipe (from Lemon Cove Ditch stilling well)
- Diameter. . . . . 12 inches
- Discharge at pool elev 551. . . . . 3 cfs

Foothill Ditch Diversion and Control Weir

- Location . . . . . Approx 2,500' downstream from dam
- Type . . . . . Concrete Ogee Weir
- Crest Length . . . . . 99 feet
- Crest elevation - (varies). . . . . 496 to 501 feet
- Maximum capacity. . . . . 10,000 cfs
- Foothill ditch diversion. . . . . 42" pipe in left abutment of weir
- Gates . . . . . 1 - 42" head gate
- Discharge at elev 496 feet. . . . . 40 cfs
- Required discharge. . . . . 40 cfs

RESERVOIR REGULATION MANUAL
TERMINUS DAM (LAKE KAWEAH)
KAWEAH RIVER, CALIFORNIA

TABLE OF CONTENTS

Paragraph	Subject	Page
	Pertinent data	Inside cover
	Photo - Terminus Dam and Lake Kaweah	
	Personnel	Frontispiece
	CHAPTER 1 - GENERAL INFORMATION	
1	Authority and scope	1
2	Project authorization	1
3	Changes to authorized plan	1
	CHAPTER 2 - BASIN DESCRIPTION	
4	Description of project area	3
5	Climate	5
6	Runoff characteristics	7
7	Flood characteristics	9
8	Upstream regulation	11
	CHAPTER 3 - PROJECT FEATURES	
9	Description of project	12
10	Power development	13
11	Recreation facilities	13
12	Hydrologic bases for design	14
13	Construction history	15
	CHAPTER 4 - GENERAL PROJECT OPERATION	
14	Responsibility for operation	16
15	Irrigation and spreading uses	16
16	Downstream channel capacities	16
17	Flood damages under project conditions	16
18	Sediment and water quality measurement	17
19	Relation to other projects	17
	CHAPTER 5 - OPERATION	
20	Operation requirements	18
21	Project document operation plan	18
22	Changes in operation plan	19

TABLE OF CONTENTS (cont'd)

Paragraph	Subject	Page
	CHAPTER 5 - OPERATION (Cont'd)	
23	Limitations on storage	20
24	Limitations on releases	20
25	Flood control operation	20
26	Conservation operation	22
27	Outlet gate operation	22
	CHAPTER 6 - OPERATIONAL CONTROLS	
28	Division of responsibility for operation	23
29	Standing instructions	24
30	Modification of instructions	24
31	Hydrologic facilities	24
32	Communication facilities	25
33	Forecasts of inflow	25
	CHAPTER 7 - PROJECT ACCOMPLISHMENTS	
34	Examples of operation	28
35	Operation record	28

LIST OF CHARTS

1. Kaweah River drainage basin and service area
2. Topography and stream gaging stations
3. Normal annual precipitation, precipitation stations, and snow courses
4. Hydrologic and operating characteristics
5. Plan and profiles, main dam and auxiliary dam
6. Typical embankment sections, main dam and auxiliary dam
7. Spillway, plan, profile, and sections
8. Spillway rating curve
9. Outlet works, plan, profile, and sections
10. Outlet works, outlet structure and miscellaneous details
11. River outlet rating curve
12. Area and capacity curves
13. Area and capacity tables
14. Recreation facilities map
15. Normal anticipated irrigation and spreading demands
16. Percolation basins, Kaweah Delta Water Conservation District
17. Spreading basins and spreading demands, Kaweah Delta
18. Flow - Damage Curves

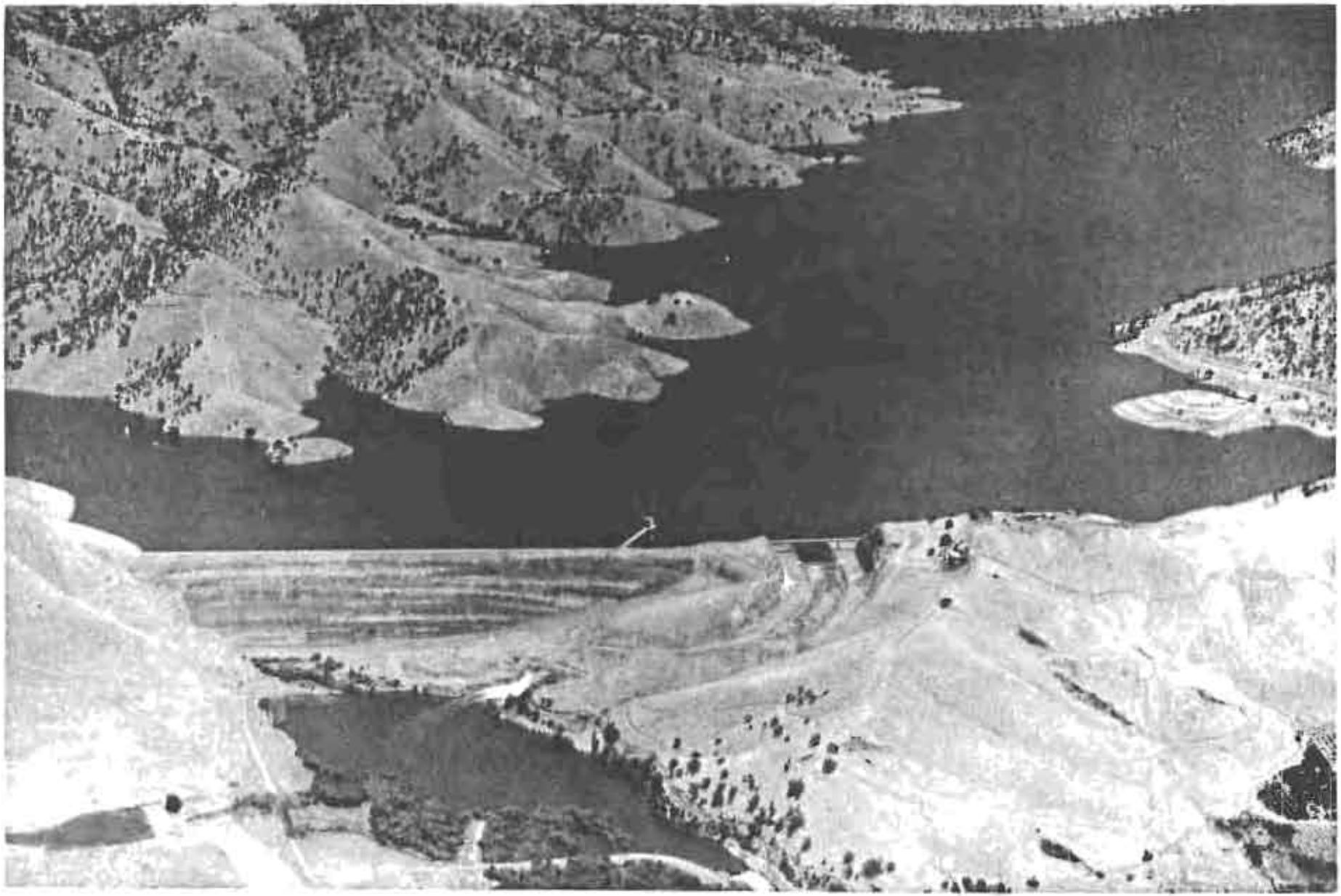
PERSONNEL CONCERNED IN THE OPERATION OF TERMINUS RESERVOIR

	UNIT	OFFICE PHONE	RADIO	NAME	HOME PHONE
PROJECT OFFICE VISALIA, CALIFORNIA	TERMINUS RESERVOIR	209-597-2301 (Lemon Cove)	WUK 372 (Terminus)	RALPH BUTTS PROJECT MANAGER	209-597-2493 (Lemon Cove)
DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	DISTRICT ENGINEER	916-449-2232*		COL. JAMES C. DONOVAN DISTRICT ENGINEER	
	RESERVOIR REGULATION	916-449-2378* 916-449-3167* 916-449-3168*	WUK-3 (Res Reg)	R. P. LEATHAM CHIEF, RES. REG. SECTION	916-483-2010
				J. D. COUNTRYMAN	916-421-9728
	HYDROLOGIC FACILITIES	916-449-3475*	WUK-3 (Hydrology)	B. D. MINTER	916-371-4468
	OPERATIONS BRANCH MAINTENANCE	916-449-2327*	WUK-3 (C-O Div)	LYNN E. HENSON CHIEF, OPERATIONS BRANCH	916-967-2007
		916-449-2326*		W. J. HOLTON CHIEF, PROJ OPERATIONS SECTION	916-489-4211
IRRIGATION INTERESTS	KAWEAH DELTA WATER CONSERVATION DISTRICT 1110 NORTH CAIN STREET P.O. BOX 1247 VISALIA, CALIFORNIA 93277	209-732-0111 (Visalia)		L. J. CHRISMAN WATERMASTER	209-686-7737 (Tulare)
				MAX GARVER ASST. WATERMASTER	209-592-2720 (Exeter)

FTS: Sacramento 916-449-2000

*NOTE: Between 4:30 p.m. and 7:45 a.m., or on Saturday, Sunday, or Holidays use 916-452-1535 (Flood Season Only)

TERMINUS RESERVOIR, KAWEAH RIVER, CALIFORNIA REV. NOVEMBER 1971



TERMINUS DAM AND LAKE KAWEAH

PERSONNEL CONCERNED IN THE OPERATION OF TERMINUS RESERVOIR

	UNIT	OFFICE PHONE	RADIO	NAME	HOME PHONE
PROJECT OFFICE VISALIA, CALIFORNIA	TERMINUS RESERVOIR	209-597-2301 (Lemon Cove)	WUX 372 (Terminus)	RALPH BUTTS PROJECT MANAGER	209-597-2493 (Lemon Cove)
DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	DISTRICT ENGINEER	916-449-2232*		COL. JAMES C. DONOVAN DISTRICT ENGINEER	
	RESERVOIR REGULATION	916-449-2378* 916-449-3167* 916-449-3168*	WUK-3 (Res Reg)	R. P. LEATHAM CHIEF, RES. REG. SECTION	916-483-2010
				J. D. COUNTRYMAN	916-421-9728
	HYDROLOGIC FACILITIES	916-449-3475*	WUK-3 (Hydrology)	B. D. MINTER	916-371-4468
	OPERATIONS BRANCH MAINTENANCE	916-449-2327*	WUK-3 (C-O Div)	LYNN E. HENSON CHIEF, OPERATIONS BRANCH	916-967-2007
		916-449-2326*		W. J. HOLTON CHIEF, PROJ OPERATIONS SECTION	916-489-4211
IRRIGATION INTERESTS	KAWEAH DELTA WATER CONSERVATION DISTRICT 1110 NORTH CAIN STREET P.O. BOX 1247 VISALIA, CALIFORNIA 93277	209-732-0111 (Visalia)		L. J. CHRISMAN WATERMASTER	209-686-7737 (Tulare)
				MAX GARVER ASST. WATERMASTER	209-592-2720 (Exeter)

FTS: Sacramento 916-449-2000

*NOTE: Between 4:30 p.m. and 7:45 a.m., or on Saturday, Sunday, or Holidays use 916-452-1535 (Flood Season Only)

RESERVOIR REGULATION MANUAL
TERMINUS DAM (LAKE KAWEAH)
KAWEAH RIVER, CALIFORNIA

APPENDIX III
TO
MASTER MANUAL OF RESERVOIR REGULATION
TULARE LAKE BASIN, CALIFORNIA

JUNE 1962

REVISED NOVEMBER 1971

U. S. Army Engineer District
Corps of Engineers
Sacramento, California

RESERVOIR REGULATION MANUAL
TERMINUS DAM (LAKE KAWEAH)
KAWEAH RIVER, CALIFORNIA

TABLE OF CONTENTS

Paragraph	Subject	Page
	Pertinent data	Inside cover
	Photo - Terminus Dam and Lake Kaweah	
	Personnel	Frontispiece
	CHAPTER 1 - GENERAL INFORMATION	
1	Authority and scope	1
2	Project authorization	1
3	Changes to authorized plan	1
	CHAPTER 2 - BASIN DESCRIPTION	
4	Description of project area	3
5	Climate	5
6	Runoff characteristics	7
7	Flood characteristics	9
8	Upstream regulation	11
	CHAPTER 3 - PROJECT FEATURES	
9	Description of project	12
10	Power development	13
11	Recreation facilities	13
12	Hydrologic bases for design	14
13	Construction history	15
	CHAPTER 4 - GENERAL PROJECT OPERATION	
14	Responsibility for operation	16
15	Irrigation and spreading uses	16
16	Downstream channel capacities	16
17	Flood damages under project conditions	16
18	Sediment and water quality measurement	17
19	Relation to other projects	17
	CHAPTER 5 - OPERATION	
20	Operation requirements	18
21	Project document operation plan	18
22	Changes in operation plan	19

TABLE OF CONTENTS (cont'd)

Paragraph	Subject	Page
	CHAPTER 5 - OPERATION (Cont'd)	
23	Limitations on storage	20
24	Limitations on releases	20
25	Flood control operation	20
26	Conservation operation	22
27	Outlet gate operation	22
	CHAPTER 6 - OPERATIONAL CONTROLS	
28	Division of responsibility for operation	23
29	Standing instructions	24
30	Modification of instructions	24
31	Hydrologic facilities	24
32	Communication facilities	25
33	Forecasts of inflow	25
	CHAPTER 7 - PROJECT ACCOMPLISHMENTS	
34	Examples of operation	28
35	Operation record	28

LIST OF CHARTS

1. Kaweah River drainage basin and service area
2. Topography and stream gaging stations
3. Normal annual precipitation, precipitation stations, and snow courses
4. Hydrologic and operating characteristics
5. Plan and profiles, main dam and auxiliary dam
6. Typical embankment sections, main dam and auxiliary dam
7. Spillway, plan, profile, and sections
8. Spillway rating curve
9. Outlet works, plan, profile, and sections
10. Outlet works, outlet structure and miscellaneous details
11. River outlet rating curve
12. Area and capacity curves
13. Area and capacity tables
14. Recreation facilities map
15. Normal anticipated irrigation and spreading demands
16. Percolation basins, Kaweah Delta Water Conservation District
17. Spreading basins and spreading demands, Kaweah Delta
18. Flow - Damage Curves

LIST OF CHARTS (Cont'd)

19. Sedimentation ranges
20. Forecast verification data
21. Snowmelt forecast criteria
22. Supplementary snowmelt forecast criteria
23. Rain-flood forecast criteria
24. Hypothetical reservoir operation and observed hydrograph (6 sheets)
25. Hypothetical reservoir operation (summary)
26. Flood routings
27. Seasonal variation of reservoir storage frequency
28. Stage - duration curve
29. Stage - frequency curve
30. Rain - flood frequency curve
31. Operation record

APPENDIX A - STANDING OPERATING INSTRUCTIONS

Paragraph		Page
1.	Operating requirements	A-1
2.	Operating reports	A-2
3.	Special weather and flood reports	A-3
4.	Computation of hydrologic data	A-3
5.	Emergency flood operation	A-6

LIST OF CHARTS

A-1	SPK form 333, radio reporting gages
A-2	SPK form 115, record of evaporation and climatological observations
A-3	SPK form 351, bi-hourly and mean daily flow
A-4	SPK form 153-4, daily reservoir computations
A-5	SPK form 441-c, flood control parameter computation (2 sheets)
A-6	SPK form 121, short-period reservoir inflow computations
A-71	SPK form 147, log of gate operations
A-8	SPK form 122, log of messages and instructions
A-9	Stage-discharge curves
A-10	Tentative evaporation coefficients
A-11	Flood control diagram
A-12	Operation of outlet gates for flood control

CHAPTER 1 - GENERAL INFORMATION

1. AUTHORITY AND SCOPE

This reservoir regulation manual is an appendix to the Master Manual of Reservoir Regulation, Tulare Lake Basin, California, and is prepared in accordance with instructions in ER 1110-2-240 and EM 1110-2-3600. It contains descriptive information and operating rules for Terminus Dam (Lake Kaweah), Kaweah River, and assigns responsibilities for the operation of the project. A description of the general plan of reservoir operation for the Tulare Lake Basin, of which Lake Kaweah is a unit, is given in the Master Manual.

2. PROJECT AUTHORIZATION

Terminus Dam (Lake Kaweah) was authorized by the Flood Control Act of 1944, approved 22 December 1944, the pertinent portion of which follows:

> "The plan for Terminus and Success Reservoirs on the Kaweah and Tule Rivers for flood control and other purposes in the San Joaquin Valley, California, in accordance with the recommendations of the Chief of Engineers in Flood Control Committee Document Number 1, Seventh-eighth Congress, Second Session, is approved, and there is hereby authorized $4,600,000 for initial and partial accomplishment of the plan."

In that document, the Chief of Engineers recommended a capacity of 100,000 acre-feet for Terminus Reservoir.

3. CHANGES TO AUTHORIZED PLAN

The Comprehensive Report on Sacramento-San Joaquin Basin Streams and Supplement thereto, published as House Document 367, 81st Congress, 1st Session, recommended a capacity of 145,000 acre-feet. No specific reservation for sediment accumulation was defined. The reservoir capacity was increased from 100,000 acre-feet to the recommended 145,000 acre-feet by letter from Sacramento District to South Pacific Division dated 28 September 1951, subject: "Supplement No. 2, Preliminary Definite Project Report, Terminus Project, Kaweah River, California." By 6th Indorsement, dated 3 December 1952, the Chief of Engineers stated that the capacity of 145,000 acre-feet would be approved for design purposes if the State of California would not actively oppose the increased capacity. Subsequent to that date, the State appeared before the Bureau of the Budget and Appropriations Committees in support of the project as modified for the 145,000 acre-feet capacity. On 9 May 1956, at a conference attended by representatives of OCE, SPD and the Sacramento District, decision was made to consider the total reservoir capacity as 150,000 acre-feet including reservation of 8,000 acre-feet of that

amount for future sedimentation and for other project uses. The inactive storage space could be used for a recreation pool by local interests if they provided the necessary water supply. All storage space was required to be evacuated to minimum pool level (8,000 acre-feet) from 1 November through 31 March and the entire capacity of 150,000 acre-feet was reserved when needed for control of forecasted snowmelt runoff. Storage of irrigation water from 1 April through 31 July was made conditional depending on amount of snowmelt runoff predicted to occur between any given date and 31 July. The latest flood control diagram approved 2 July 1971 permits conditional carryover storage of water up to 7000 acre-feet above minimum pool level (total storage 15,000 acre-feet) during the November-March period of dry years, based on watershed precipitation. By joint resolution of the Senate and House of Representatives, Public Law 87-568, 87th Congress, H.J. Res. 417, August 6, 1962, the reservoir formed by the Terminus Dam was designated as "Lake Kaweah." All references in this manual to Terminus Reservoir refer to the reservoir formed by Terminus Dam and designated as "Lake Kaweah" in H.J. Res. 417.

CHAPTER 2 - BASIN DESCRIPTION

4. DESCRIPTION OF PROJECT AREA

a. The project area, shown on Chart 1, comprises the watershed of Kaweah River, its valley alluvial fan, and the reclaimed Tulare Lakebed area which is the common terminus of the Kings, Kaweah, Tule and Kern Rivers. This area lies on the westerly slope of the western ridge of the Sierra Nevada, southeast of Fresno and north of Bakersfield, and is situated between Kings River Basin on the north, Kern River Basin on the east, and Tule River Basin on the south. The source of the Kaweah River is a group of glacial lakes near Triple Divide Peak on the Great Western Divide, a secondary ridge parallel to the main crest of the Sierra Nevada and separated from it by the upper basin of Kern River.

b. The watershed above the foothill line consists of a fanshaped mountainous area of about 630 square miles, 560 square miles of which is tributary to Lake Kaweah. Elevations in the watershed area range from a maximum of about 12,600 feet in the headwater area to about 510 feet at Terminus Dam. The portion of the area above 10,000 feet elevation (about 7 percent of the area above the dam) is characterized by mountain peaks and ridges having either a very thin mantle of soil or exposed rock. The remainder of the basin has moderate to deep soil. The vegetative cover is distributed approximately as follows:

Description	Range of elevation (feet)	Percent of basin area
Bare rock, lakes, etc.	9,000 - 12,600	9.3
Grass lands	1,000 - 2,000	0.5
Brush lands (Chaparral, etc.)	3,000 - 9,000	22.7
Deciduous forest (with brush, scattered conifers and grass)	500 - 6,000	26.3
Light coniferous	5,000 - 12,000	30.1
Heavy coniferous	5,000 - 9,000	6.8
Sub-Alpine	8,000 - 10,000	4.3
Total		100.0

The main stream is formed by the confluence of the North, Middle, and South Forks near the foothill line. These main forks have an overall slope of about 350 feet per mile. They are fed by numerous short, steep streams with slopes ranging from 400 feet per mile to almost 1,000 feet per mile. Topography of the basin is shown on Chart 2. More than half of the basin is within Sequoia National Park, and the upper half of the East Fork is within Sequoia National Game Refuge. Three small hydroelectric plants on Middle Fork of Kaweah River operate on the unregulated flow of that stream.

Sect 1

c. Below Terminus Dam, Kaweah River flows a few miles through low foothills and emerges on the valley floor near the town of Lemoncove. Nearby at McKays Point, the flow of the river is divided into two channels. The northerly channel, known as St. Johns River, flows westerly about 23 miles, passes the city of Visalia on the north, and unites with Cottonwood Creek to form Cross Creek, which flows southwesterly about 35 miles to the Tulare Lakebed area. The southerly channel, which retains the name of Kaweah River, flows southwesterly about 4 miles and then divides into numerous distributaries. One of these distributaries, Mill Creek, is carried through the city of Visalia in a closed conduit. Others pass the City on the south. Flows in these distributaries not diverted for irrigation or lost by seepage in the delta region unite with flows from Tule River to enter the Tulare Lakebed area. The flow division at McKays Point is accomplished by means of a fixed broad crested weir consisting of two sections, each 113.6 feet in length with the same crest elevations, one section crossing the head of each channel. Flows are divided equally between the Kaweah and St. Johns channels, with the exception that once the flow has receded to 80 c.f.s. in the late summer months, the entire flow is diverted into the Kaweah channel by means of flashboards until the first time that flows exceed 80 c.f.s. after 1 October.

d. The urban area at Visalia, which is bordered by St. Johns River, is subject to damage from rainfloods. It is estimated that a flood having a peak flow greater than 22,000 c.f.s. above the division works at McKays
* Point (a once in 60 years event on the average) would overtop or breach the existing south levee of St. Johns River and flood Visalia. A continuous flow at McKays Point in excess of 15,000 c.f.s. would probably cause some damage in Visalia.

e. The Tulare Lakebed is a large (about 300 square miles), shallow, closed depression in the trough of the Sacramento-San Joaquin Valley, which occasionally receives flood waters from Kings, Kaweah, Tule, and Kern Rivers and other smaller streams. The area is thus subject to extended periods of inundation, has only minor development other than agricultural and is essentially uninhabited. The lakebed has been extensively reclaimed for agricultural development by means of an intricate grid-like system of levees dividing the area into numerous irrigable tracts, and usually is entirely available for cultivation during dry years. Irrigation in Tulare Lakebed has been made possible by diversion from streams, storage of floodwaters in selected tracts, and by pumping from groundwater. Rights to diversion of Kaweah River water for irrigation use in Tulare Lakebed have been transferred to Kaweah Delta Water Conservation District for use in the upstream service area by terms of agreement dated 4 January 1965. The reduction in water supply to Tulare Lake area as a result of this agreement is estimated at 26,920 acre-feet per year, on the average. A map of the lake area and storage-capacity curves of the individual cells are given in the Master Manual of Reservoir Regulation, Tulare Lake Basin, California. The average annual total income produced in non-flood years in the Tulare Lakebed area is in excess of $25,000,000.

* Revised April 1972

f. The economy of the Kaweah River service area is dominated by agriculture and the processing of agricultural products. The principal limitation on agriculture is the deficiency in water supply during series of dry years. Extensive irrigation systems for the diversion and distribution of water have been developed, and general use is made of underground sources of water, as precipitation is not sufficient to support normal farm crops. The mountainous portion of the basin is limited by rugged terrain and climatic conditions to livestock production, lumbering, mining, recreation, and hydroelectric power production. The area is served by a main highway, two major railroads, and a major airline, supplemented by an extensive network of secondary state and county paved highways and branch line railroad and airline systems.

5. CLIMATE

a. Annual precipitation averages 39 inches in the area tributary to Terminus Dam, distributed as illustrated on Chart 3. About 89 percent of the runoff producing precipitation occurs during the winter months of November through April. The normal monthly distribution at representative stations is shown in the following tabulation:

Average Monthly Precipitation

Month	Visalia Elev. 325		Three Rivers Edison P.H.2: Elev. 950		Giant Forest Elev. 6650	
	Inches	% of Annual	Inches	% of Annual	Inches	% of Annual
July	0.02	0.2	0.04	0.2	0.13	0.3
Aug	0.01	0.1	0.04	0.2	0.15	0.4
Sept	0.16	1.6	0.18	0.9	0.45	1.0
Oct	0.44	4.5	0.81	4.0	1.53	3.5
Nov	0.87	9.0	1.96	9.5	4.28	9.8
Dec	1.56	16.0	3.48	17.0	7.77	17.8
Jan	1.92	19.8	3.87	18.9	7.81	17.9
Feb	1.70	17.5	3.70	18.0	7.92	18.2
Mar	1.59	16.4	3.11	15.2	6.36	14.6
Apr	1.00	10.3	2.27	11.1	4.89	11.2
May	0.38	3.9	0.83	4.0	1.72	3.9
June	0.07	0.7	0.21	1.0	0.62	1.4
Total	9.72	100.0	20.50	100.0	43.63	100.0
Period of Record	1878-1970		1909-1970		1920-1970	

b. On the valley floor, practically all the precipitation occurs as rain, while in the mountains, it occurs as rain during the summer and rain or snow during other seasons. Winter storms occasionally produce rain up to 11,000 feet in elevation. However, above the 5,000-foot level such storms usually produce snow, which accumulates until about March before the snowmelt usually begins. Snowpack data typical of wet years are illustrated by those of 1952, and snowpack data for normal years are illustrated by those of 1954 in the following tabulation:

Snow course	April snow survey data							
	Elev in feet	Depth in inches		Water equivalent Inches			% Normal	
		1952	1954	1952	1954	Normal	1952	1954
Panther Meadow	8650	185	98.8	74.5	35.6	37.3	200	95
Hocket Meadow	8600	118	95.6	56.2	32.0	31.3	179	102
Quinn Ranger St	8000	104	58.3	48.4	21.5	22.5	215	95
Giant Forest	6360	110	57.1	50.2	19.0	17.3	290	110

c. Temperatures on the valley floor normally range from a winter low of about 30° F. to a summer high of 110° F. At high elevations the summers are cool and the winters severe. The monthly distribution of mean temperatures at representative stations is given in the following tabulation:

Month	Monthly Mean Temperature (F°) Visalia Elev. 325	Three Rivers Edison P.H.2 Elev. 950	Giant Forest Elev. 6650
Jan	46.0	45.7	32.8
Feb	51.3	50.0	34.1
Mar	55.1	53.7	37.1
Apr	60.8	59.1	41.2
May	67.5	65.7	48.1
Jun	74.5	73.1	56.0
Jul	80.9	80.0	64.5
Aug	79.1	78.3	63.4
Sep	73.4	72.6	61.0
Oct	64.7	63.7	49.6
Nov	54.4	53.5	41.0
Dec	46.7	46.7	34.7
Period of Record	1889-1970	1913-1970	1920-1970

d. Evaporation and transpiration rates for Lake Kaweah area are estimated to be approximately as follows:

Average Monthly Evaporation for Lake Kaweah			
Month	Preproject Evap-transp inches	Water-surface evap inches	Net change* inches
January	1.0	1.0	- 3.2
February	1.4	1.4	- 3.4
March	2.3	2.5	0.5
April	2.5	3.9	2.7
May	2.6	6.6	7.6
June	1.7	9.0	8.4
July	1.0	11.5	11.0
August	0.7	10.3	11.1
September	0.8	7.3	7.6
October	1.2	4.5	4.0
November	1.7	2.6	0.3
December	1.2	1.4	- 2.7
Annual	18.1	62.0	43.9

* Adjusted for underground storage effects.

6. RUNOFF CHARACTERISTICS

The seasonal distribution of the flow of Kaweah River is similar to that of other major streams flowing from the Sierra Nevada into the Tulare Lake Basin and San Joaquin Valley. Runoff during the months of November through March is mostly from rainfall, and runoff during the months April through July results principally from melting of the accumulated snowpack. The runoff hydrograph near Three Rivers for the period 1904-1960 is shown in conjunction with the hypothetical project operation study for that period on Chart 24. The runoff hydrograph since operations began in 1962 is shown as inflow to Lake Kaweah on Chart 31. Locations of stream gaging stations are shown on Chart 2. Recorded runoff data for the Kaweah River near Three Rivers and at gaging stations established to replace the "near Three Rivers" measurements when that station became affected by Lake Kaweah are given in the following tabulation:

Recorded Runoff Data

	Kaweah River at Three Rivers	South Fork Kaweah River at Three Rivers	Combined Kaweah & So. Fork at Three Rivers	Kaweah River near Three Rivers
Period of record included	1958-70	1958-70	1958-70	1903-61
Drainage area, sq. mi.	418	86.7	504.7	520
Instantaneous flow, c.f.s.				
Maximum	73,000 (5Dec66)	11,600 (6Dec66)	-	80,700 (23Dec55)
Minimum	14 (9,10Sep59, 16Oct61)	0 (at times 1960-62)	-	8.5 (19Sep34)
Mean Daily	525	69	594	554
Instantaneous flow, c.f.s./sq. mi.				
Maximum	174.64	133.79	-	155.19
Minimum	0.03	0.00	-	0.02
Mean Daily	1.26	0.80	1.18	1.07
Annual flow, acre-feet				
Maximum	1,092,200 (1968-69)	158,000 (1968-69)	1,250,200 (1968-69)	1,104,000 (1905-06)
Minimum	102,600 (1960-61)	10,900 (1960-61)	113,500 (1960-61)	102,000 (1923-24)
Mean	380,200	49,800	430,000	401,100
Annual flow, inches				
Maximum	48.99	34.17	46.45	39.81
Minimum	4.60	2.36	4.22	3.68
Mean	17.05	10.77	15.97	14.46
March-June flow, acre-feet				
Maximum	674,700 (1969)	95,300 (1969)	770,000 (1969)	750,000 (1906)
Minimum	74,300 (1961)	9,100 (1961)	83,400 (1961)	75,500 (1924)
Mean	241,800	33,500	275,300	287,500
March-June flow, inches				
Maximum	30.26	20.61	28.61	27.04
Minimum	3.33	1.97	3.10	2.72
Mean	10.85	7.24	10.23	10.37

About 68 percent of the runoff of the Kaweah River above Lake Kaweah occurs during the months of April through July. The monthly runoff at the preceding stations is given in the following table and its percentage distribution is shown graphically on Chart 4. Distribution of snowmelt season runoff at Terminus Dam for selected large years is shown graphically on Chart 22.

Average Monthly Runoff Data

Month	Kaweah River at Three Rivers (DA 418 sq.mi.)		South Fork Kaweah River at Three Rivers (DA 86.7 sq.mi.)		Combined Kaweah & So. Fork at Three Rivers (DA 504.7 sq.mi.)		Kaweah River near Three Rivers (DA 520 sq.mi.)	
	acre-feet	%	acre-feet	%	acre-feet	%	acre-feet	%
Oct	3,650	1.0	240	0.5	3,890	0.9	4,810	1.2
Nov	6,710	1.8	670	1.3	7,380	1.7	7,580	1.9
Dec	23,360	6.2	3,420	6.9	26,780	6.2	15,580	3.9
Jan	28,880	7.6	4,060	8.1	32,940	7.7	21,080	5.2
Feb	29,730	7.8	4,330	8.7	34,060	7.9	26,830	6.7
Mar	29,850	7.8	3,910	7.9	33,760	7.8	41,340	10.3
Apr	54,950	14.4	7,550	15.2	62,500	14.6	64,650	16.1
May	88,040	23.2	12,630	25.4	100,670	23.4	101,540	25.4
Jun	68,960	18.1	9,410	18.9	78,370	18.2	79,990	20.0
Jul	32,310	8.5	2,990	6.0	35,300	8.2	27,140	6.8
Aug	9,600	2.5	430	0.8	10,030	2.4	7,000	1.7
Sep	4,160	1.1	160	0.3	4,320	1.0	3,560	0.8
Total	380,200	100.0	49,800	100.0	430,000	100.0	401,100	100.0

7. FLOOD CHARACTERISTICS

a. Flood flows on the Kaweah River are of two types, winter rainfloods and spring snowmelt floods. The winter-type floods are characterized by sharp high peaks and small volumes and are usually of short duration, seldom lasting longer than four days. These floods normally occur during November through March and are caused by relatively intense rains, sometimes augmented by the melting of snow at lower elevations. The largest rainflood of record on Kaweah River near the Terminus Dam was that of 6 December 1966 which had an estimated peak inflow to Terminus Reservoir of 105,000 c.f.s. A comparison of maximum experienced flows at the near Three Rivers gaging station and at replacement stations is as follows:

Date	Kaweah River at Three Rivers		South Fork Kaweah River at Three Rivers		Kaweah River near Three Rivers (Discont'd 30Sep61)	
	Peak Discharge (c.f.s.)	4-Day Volume (ac-ft)	Peak Discharge (c.f.s.)	4-Day Volume (ac-ft)	Peak Discharge (c.f.s.)	4-Day Volume (ac-ft)
23 Dec 1955	-	-	-	-	80,700	143,000
19 Nov 1950	-	-	-	-	52,000	60,700
11 Dec 1937	-	-	-	-	33,300	48,000
6 Feb 1937	-	-	-	-	18,900	45,000
5 Dec 1966	73,000	125,900	-	-	-	-
6 Dec 1966	-	-	11,600	22,700	-	-
1 Feb 1963	30,900	71,400	2,440	6,300	-	-
25 Jan 1969	24,200	69,800	5,960	12,300	-	-
19 Jan 1969	16,900	46,300	5,820	8,100	-	-
24 Feb 1969	11,900	28,900	6,400	9,800	-	-

The peak flows of the historical floods of January 1862 and December 1867 had been previously estimated as 40,000 and 50,000 c.f.s., respectively. In view of data obtained during the December 1955 flood, it is now indicated that the historical flood of December 1867 was probably equal to or somewhat larger than the December 1955 flood, while the flood of January 1862 had a probable magnitude somewhere between those observed in the floods of November 1950 and December 1955.

b. During the December 1955 and January 1956 storms, before Terminus Dam was built, the Kaweah River flooded about 126,000 acres of land. The flooded area extended from Terminus Damsite on the east to Cross Creek on the west, and from Cottonwood Creek on the north to Elk Bayou on the south. Kaweah River flood water and flood water from other streams entered Tulare Lakebed and caused damage in that area. Most of the flood area was along the river and its principal distributaries: St. Johns River, Mill Creek, Cameron Creek, Packwood Creek, Cross Creek, and Elk Bayou. The December 1955 flood inundated portions of the city of Visalia and portions of the communities of Farmersville and Three Rivers, as well as residences in the southern part of the community of Woodlake, and a large agricultural area. In January 1956, much of the same agricultural area and part of the city of Visalia were reflooded. Damage in Visalia was heavy in the business district, and in a residential section where water in some homes was about 30 inches deep for 6 days. Most of the irrigation diversion structures

on the river were washed out. Water and debris piled up against the Friant-Kern Canal, causing over-topping, which washed away large sections of canal embankment. Large quantities of debris accumulated against bridges and canal crossings, causing severe damage to most of these structures. Stream bank erosion was severe in many places, and great quantities of sand were deposited on farmlands adjacent to the streams. Nearly all roads in the flooded area were damaged. Primary damages estimated at $11,845,000 occurred below the dam site, and above Tulare Lakebed. About 85 percent of the damage was attributed to the December flood and 15 percent attributed to the January flood. In contrast, the larger December 1966 rainflood was controlled in Lake Kaweah with downstream flows contained in existing channels. The 1966 rainflood produced 3-day volume runoff of 154,000 acre-feet, approximately equivalent to that of the reservoir design flood. The peak inflow, estimated from reservoir storage, probably exceeded that of the reservoir design flood, and has been estimated at 105,000 cubic feet per second. Downstream accretions were substantial in this flood. A peak flow of 14,500 c.f.s. and a 3-day volume of 15,000 acre-feet occurred on Dry Creek. Extensive flooding in Visalia and other valley floor communities from this flood was prevented, and protection was afforded to thousands of acres of crop and orchard land in the Kaweah River delta and Tulare Lakebed.

c. Snowmelt floods, while not producing as high peak flows as winter-type floods, have a much larger runoff volume. These floods occur during the months of April through July. The largest snowmelt flood of record on Kaweah River near Terminus Dam site was that of 1906, which had a maximum mean daily discharge of 7,260 c.f.s. and a runoff volume during the period April through July of 814,000 acre-feet. The snowmelt flood of 1969 approached that of 1906 in total April-July volume (799,000 acre-feet) and in maximum daily flow (6,800 c.f.s.). The effects of this flood were greatly reduced by storage in Lake Kaweah. Flow rates were reduced to a maximum outflow of 5,600 c.f.s. which was generally contained in existing channels of Kaweah and St. Johns Rivers. Of the total April-July inflow to Lake Kaweah, plus downstream accretions, about 172,000 acre-feet reached Tulare Lakebed and about 640,000 acre-feet were diverted and absorbed within the Kaweah Delta service area. With regulation provided by Lake Kaweah, only in years of exceptionally high snow accumulation will snowmelt runoff cause damage downstream along Kaweah River and distributaries, but serious flooding in the Tulare Lakebed may occur whenever the total annual runoff is in excess of about 120 percent of normal, or in excess of about 500,000 acre-feet.

8. UPSTREAM REGULATION

Regulation of flows for power production at three small hydroelectric plants in the upper reaches of Kaweah River Basin has no significant effect on stream flow at the dam site.

CHAPTER 3 - PROJECT FEATURES

9. DESCRIPTION OF PROJECT

a. The Terminus Project consists of a dam and storage reservoir for flood control and irrigation on Kaweah River about two miles northeast of Lemoncove, California.

b. The dam is an earthfill structure with a height of approximately 250 feet and length of 2,375 feet. There is a rolled earthfill auxiliary dam with a maximum height of about 130 feet and a crest length of 870 feet. Plans, profiles, and sections of main and auxiliary dams are shown on Charts 5 and 6.

c. The spillway is located in the left abutment of the main dam and is essentially a broad crested notch weir. The total crest length is 307 feet. The unlined spillway channel has a notch 135 feet wide and 14.4 feet deep which extends the full length of the channel and forms the service portion of the spillway. The control section consists of a concrete sill at elevation 694 feet for the notch, at elevation 708.4 for the remaining portion, extending up the sides of the excavated channel to elevation 745 feet. The notch is designed to pass outflow up to 22,000 c.f.s. which results in the maximum flow that can be passed at the city of Visalia without extensive damages. Plan, profile and sections of the spillway are shown on Chart 7. The spillway rating curve is shown on Chart 8.

d. The outlet works are located in the left abutment of the main dam and consist of an intake with trash racks, control tower, control house, circular concrete lined tunnel, outlet portal, and facilities for Lemon Cove Ditch. The control section of the outlet works consists of three 5 ft. x 9 ft. rectangular conduits with appropriate transitions at the upstream end to the intake and at the downstream end to the 12-foot 9-inch diameter tunnel. The irrigation and flood control releases are controlled by three service gates. These are 5 ft. x 9 ft. hydraulically operated slide gates. Three identical emergency gates are installed in tandem with the service gates. Also housed in the gate chamber are the regulating valves and appurtenances for Lemon Cove Ditch irrigation facilities. The outlet for the ditch consists of an inlet, control valves, 36-inch diameter concrete encased steel pipe, by-pass, stilling well and outlet, wasteway, Parshall measuring flume, flume over the spillway discharge channel and open channel connecting to the existing ditch. A rating curve for Lemon Cove Ditch is shown on Chart A-9. From the tower to the downstream portal, the 36-inch pipe is located under the invert of the tunnel. Provisions for servicing Hawkeye Ditch from the Lemon Cove stilling well consist of a 12-inch pipe connection and Dall flow tube. A 12-inch pipeline which conveys Hawkeye Ditch Company water (maximum 3 c.f.s.) across government property is maintained by Hawkeye Ditch Company. Should the water surface drop below elevation 547.6 feet m.s.l., (2,528 acre-feet storage) gravity delivery from

Lemon Cove stilling well will become impossible and pumping will be necessary to effect delivery of water to Lemon Cove and Hawkeye Ditches. Plan, profile, and sections of the outlet works are shown on Chart 9 and miscellaneous details are shown on Chart 10. An outlet rating curve is shown on Chart 11.

e. A low concrete ogee type weir with a stepped crest and a guide wing levee is located downstream from the dam to act as a control section for the outflow gaging station and to serve as a diversion dam for the Foothill irrigation ditch. The right end of the wing levee has a crest elevation two feet lower than the abutments of the control structure so that for flows greater than about 15,000 c.f.s. the levee will be washed out leaving the main control structure undamaged. Water is conveyed to the existing Foothill Ditch by a steel pipe which discharges into a small stilling well. A Parshall flume measures flows into Foothill Ditch. Rating curves for the outflow gaging station and for Foothill Ditch are shown on Chart A-9.

f. The reservoir is about five miles long at gross pool elevation. The main pool extends upstream in a southeasterly direction for about two miles. The gross capacity is 150,000 acre-feet and the area covered at gross pool is 1,945 acres. Area and capacity curves and tables are shown on Charts 12 and 13. Development of the reservoir area for recreational purposes is discussed in paragraph 11 below, and a map of the reservoir area showing recreational facilities is shown on Chart 14.

10. POWER DEVELOPMENT

On Kaweah River there are three small hydroelectric powerplants, all located in the upper reaches of the river as shown on Chart 1, and owned by the Southern California Edison Company. The total installed capacity is 6,700 kilowatts and the average annual output is approximately 40,000,000 kilowatt hours. These plants are small and their regulatory storage is insignificant. Since they are all upstream from Terminus Dam, they are not affected by the operation of Terminus Dam.

11. RECREATION FACILITIES

Terminus Dam and Lake Kaweah attract a large number of sightseers and many other visitors who come to utilize the recreation resources created by the lake and the surrounding environmental resources. In 1970 the annual visitation to the lake was over 344,000 recreation days. In the interest of public welfare, safety, and sanitation, recreation facilities have been and will be provided around the lake area. Recreational pursuits engaged in at Lake Kaweah include picnicking, camping, boating, swimming, and fishing.

Established recreation areas which contain facilities are Lemon Hill, Kaweah, Horse Creek, and Area 6. These and other areas for development are shown on Chart 14. Picnic and camp sites, boat launching ramps, parking areas, access roads, water supplies, sanitation facilities, and swimming facilities have been provided. A marina concession is in operation on the lake. By means of a license agreement, Tulare County has provided valuable assistance in the recreational development, management, operation, and maintenance of the recreation facilities. The County also provides law enforcement for recreation areas and the lake surface.

12. HYDROLOGIC BASES FOR DESIGN

a. 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 *reasonably probable floods, including the standard project flood. Re-*evaluated flood frequency analysis and increased standard project flood *potential developed subsequent to the December 1966 flood event (see para-*graph 12b below and chart 30) indicate that actual protection available *to the city of Visalia (flows not exceeding 22,000 c.f.s.) is in the order *of 59 out of 60 years on the average.

(2) Protection of the agricultural lands in the Kaweah River flood plain against all floods of record.

(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 of space for sedimentation reserve, which reservation can also be used for other project purposes including storage of recreation water if local interests provide the necessary water supply.

b. The standard project rainflood used in design studies for Terminus Dam defined standard project runoff at the damsite, based on analysis of the largest recorded event at that time, the December 1955 storm. A re-evaluation 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 downstream damage areas, principally from the Dry Creek drainage area. The recomputed standard project flood (shown on Chart 26) 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

*Revised April 1972

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 per hour during the standard project storm. The resulting Kaweah River standard project flood hydrograph has a peak flow of 119,000 c.f.s. and a four-day volume of 248,000 acre-feet, or 8.3 inches over the drainage area. The standard project flood runoff from Dry Creek has a peak flow of 20,500 c.f.s. and a four-day volume of *32,000 acre-feet (7.3 inches). Routing of the revised standard project *flood through Lake Kaweah demonstrates the effect of larger local flows *entering the river between Terminus Dam and McKays Point on Terminus re-*leases. Impairment of release capability during periods when the coinci-*dent local flows pre-empt all or an appreciable portion of available chan-*nel capacity results in earlier loss of control during the standard project *flood passage and a maximum surcharge of 41,000 acre-feet with corresponding *increase in maximum outflow to 45,000 c.f.s. as shown on chart 26.

c. The spillway design flood was derived from the 66-hour maximum probable storm as developed by the Hydrometeorological Section of the U. S. Weather Bureau. Infiltration rates used in the derivation were varied from a maximum rate of 2.4 inches per six hours to a minimum rate of 0.5 inches per six hours, depending upon the total accumulated infiltration in inches. The resulting flood hydrograph has a peak of 290,000 c.f.s., and a volume of 740,000 acre-feet or 24.8 inches over the drainage area. The flood was routed through the reservoir (see Chart 26) using an initial storage of 107,000 acre-feet and 5,500 c.f.s. release through the outlets which was progressively reduced to zero as the spillway discharge reached 5,500 c.f.s. The initial storage of 107,000 acre-feet was based on the reservoir being full seven days prior to the beginning of the spillway design flood, and subsequent releases being made in accordance with the flood control diagram.

13. CONSTRUCTION HISTORY

Construction funds were initially appropriated in fiscal year 1957 but relatively little was accomplished until fiscal year 1959 due to lack of adequate monetary authorization for the Kaweah-Tule River Basin. Construction on the main dam and appurtenances was begun during February 1959 and the project was placed in operational status on 1 June 1962. Closure of the dam was completed in November 1961. The latest estimate of Federal expenditures is about $19,826,000, including preauthorization studies and recreational facilities.

* Revised April 1972

CHAPTER 4 - GENERAL PROJECT OPERATION

14. RESPONSIBILITY FOR OPERATION

*Lake Kaweah is operated by the U. S. Army, Corps of Engineers, and is under the jurisdiction of the District Engineer, Sacramento, California.

15. IRRIGATION AND SPREADING USES

The irrigation requirements and infiltration capability of the Kaweah River service area play an important role in flood control operation of Lake Kaweah. Since the Kaweah River has no outlet to the ocean, all floodflows not stored in Lake Kaweah must be utilized or disposed of within the service area, otherwise they enter Tulare Lakebed as damaging floodwaters. When flood control releases must be made from Lake Kaweah, all possible diversions to irrigation uses are made. The normal anticipated irrigation requirements of the service area are shown on Chart 15 and on the flood control diagram, Chart A-11. In addition, extensive areas of permeable soils have been reserved by the local interests for disposal of flood waters, by ponding and spreading, with the two-fold purpose of recharging the heavily pumped ground water storage (thus storing the surplus waters within the service area for later beneficial use) while simultaneously preventing inundation of valuable agricultural cropland in Tulare Lakebed. A map showing the location and capacity of spreading areas operated by the Kaweah Delta Water Conservation District is shown on Chart 16, and a tabulation of pertinent statistics on these spreading areas is shown on Chart 17.

16. DOWNSTREAM CHANNEL CAPACITIES

Kaweah River from Terminus Dam to McKays Point, a distance of about three miles, flows in a single channel having a one-day capacity of 15,000 c.f.s. *and a sustained capacity for 90 days of 6,000 c.f.s. The estimated non-*damage capacities of the various distributary streams and channels through *the Kaweah River service area between Terminus Dam and Tulare Lakebed *are shown on chart 2. The controlling total capacity of distributary *channels below McKays Point, for reservoir operation purposes, corresponds to a flow at McKays Point of 5,500 c.f.s. for short periods (up to a week) and 5,000 c.f.s. for long periods (up to 90 days). Such flows would be reduced by channel losses, irrigation and spreading to a flow which, although larger than some within-bank capacities, would not cause significant damage within the service area. In most instances it is expected that the critical reach would be in the channels of Cross Creek southwest of Highway 99.

17. FLOOD DAMAGES UNDER PROJECT CONDITIONS

*A comparison of the effect of Terminus Project on flows downstream is *demonstrated by the frequency of flow curves shown on chart 30. Terminus

*Revised April 1972

*Dam releases will not exceed 5500 c.f.s. in 44 out of 45 years on the
*average, and thus a moderate degree of protection is provided to
*agricultural areas between the dam and the Tulare Lake bed from flows
*originating in the watershed above the dam. As the curve of regulated
*flows below Dry Creek indicates, however, uncontrolled flows from Dry
*Creek can exceed the controlling downstream channel capacity about once
*in ten years on the average. The area protected above Tulare Lakebed consists of about 125,000 acres of agricultural and suburban lands along the Kaweah River and its distributaries, and the Visalia urban
*and suburban area, which has a population of about 39,000. During years of extremely large runoff, this area will receive some agricultural damage from snowmelt floods. Also, significant damage in Tulare Lakebed
*area will occur in years of large runoff volume. Pertinent flow damage curves are shown on Chart 18.

18. SEDIMENT AND WATER QUALITY MEASUREMENT

a. It is estimated that in a 50-year period sediment accumulation in Lake Kaweah will amount to 7,700 acre-feet. An accumulation of 2,500 acre-feet of sediment in Lake Kaweah was measured by reconnaissance methods in November 1967. Most of that deposition occurred during the December 1966 flood. Since the 1966 flood is a rare event, the estimate of 7,700 acre-feet of sediment in 50 years is still considered valid. The system of 27 sediment ranges, shown on Chart 19, has been adopted to measure the sediment deposit. Each range is straight with permanent concrete markers at both ends located about 10 feet above gross pool, and with secondary markers of capped galvanized iron pipe set above the inactive pool level at the edge of the anticipated zone of heavy sediment deposits.

b. Reconnaissance-type surveys are made after major floods or at about five-year intervals. Instrument or hydrographic resurveys are made at about 10-year intervals or oftener if a need for such is indicated by a reconnaissance survey.

c. Samples of the outflow are taken periodically to evaluate the sediment outflow from the dam and the quality of the water released from the reservoir.

19. RELATION TO OTHER PROJECTS

The operation of Lake Kaweah will be related to the operation of Pine Flat Lake on Kings River, Success Lake on Tule River, and Isabella Lake on Kern River only in their common objective to minimize undesired flows into the Tulare Lakebed area. Under existing conditions, undesired Kaweah River flows will reach Tulare Lakebed occasionally. In such cases, some degree of coordination with Pine Flat, Success, and Isabella operations may be found desirable under the conditions then prevailing. The Friant-Kern

* Revised April 1972

Canal, a unit of the U. S. Bureau of Reclamation's Central Valley Project, crosses Kaweah River about 5.5 miles below Terminus Dam and provides the physical means for importing supplemental irrigation water to the Kaweah River service area. Supplemental water available to the area from this source averages about 100,000 acre-feet per year.

CHAPTER 5 - OPERATION

20. OPERATION REQUIREMENTS

a. Lake Kaweah will be operated for flood control and conservation on the basis of the following objectives:

(1) To restrict flows in downstream channels of Kaweah River and its distributaries to non-damaging rates, insofar as possible.

(2) To minimize damaging flows from Kaweah River into the Tulare Lakebed area.

(3) To provide the maximum practicable amount of storage space for conservation of irrigation water without impairment of the flood-control functions.

(4) To maintain a recreation pool using water supplied by local interests, except when release is required for control of forecasted snowmelt runoff.

(5) To permit temporary storage of conservation water, up to a total reservoir storage of 15,000 acre-feet, during the winter months of dry years when this does not interfere with flood control requirements.

b. In achieving the above objectives, forecasting of snowmelt flows will be of primary importance. When it is anticipated that large quantities of undesired snowmelt water might be discharged into Tulare Lakebed area, all possible use of water should be made by irrigation and spreading. As the rate at which water can be used for irrigation and spreading is relatively small, releases for such purposes should be initiated as soon as possible in order to obtain the maximum empty space for the storage of subsequent floodwaters. Furthermore, large releases to Tulare Lakebed area should be delayed as long as is practicable in order to guard against making unnecessary releases because of errors in forecast. Forecasting of rainfloods will also be important, particularly when storage within the primary flood-control reservation, defined on Chart A-11, is anticipated. A daily analysis and summary of watershed precipitation must be kept and water temporarily stored in the conditional winter carryover zone must be evacuated promptly whenever precipitation parameters indicate the need for full flood control space.

21. PROJECT DOCUMENT OPERATION PLAN

Previous operation plans. - The pertinent portion of the operation plan proposed in the project document (Kaweah and Tule Rivers, California) is quoted from that document as follows:

" . . . The plans contemplate operation to the best interests of both flood control and irrigation. During the winter flood season prior to March 1, the runoff would be stored up to 50 percent of the reservoir capacity in order to provide substantial carry-over storage, for irrigation use during the following season, in the event the snow pack were light. During the winter flood season, 50 percent of the reservoir capacity would be reserved to regulate the runoff from rainfloods, for which purpose it would be ample. On or before March 1, in order to preclude flood damage from prospective snowmelt runoff, carry-over storage would be released or reduced to provide sufficient space to store snowmelt runoff in excess of irrigation demand and spreading capacity. Carry-over storage releases would be limited to insure a full reservoir by the end of the snowmelt period, no carry-over being released if prospective snowmelt runoff were inadequate to fill the reservoir. During years when the entire storage capacity of the reservoir would be inadequate to store snowmelt runoff in excess of irrigation requirements and spreading capacity, excess inflow would have to be released and would reach Tulare Lake Basin. . . ."

22. CHANGES IN OPERATION PLAN

The project document operation plan has been presented in more detail in the Preliminary Definite Project Report for Terminus Dam, Kaweah River, dated 20 June 1949, and in Supplement No. 1 to that report, dated 5 September 1950. Both reports provided for use of the total reservoir capacity (100,000 acre-feet at that time) for control of snowmelt floods, when required, and a maximum of 80,000 acre-feet for the control of rainfloods between 1 December and 15 March. The 1949 report provided for releasing 1,100 c.f.s. to Tulare Lake when storage was within the top 70,000 acre-feet of rainflood space and 5,500 c.f.s. release when storage was within the top 50,000 acre-feet of rainflood space. The 1950 report eliminated the intermediate release to Tulare Lake and provided for releasing 5,500 c.f.s. only when storage was within the top 25,000 acre-feet of space. The operating plan presented in Design Memorandum No. 6 on Reservoir Regulation, dated October 1957, is based on the 150,000 acre-feet reservoir capacity as built, and provides for releasing 5,500 c.f.s. throughout the top 70,000 acre-feet of space. The first nine years of project operation followed this plan. A modification to the operating criteria approved 2 July 1971 permits conditional conservation use of 7,000 acre-feet of space above minimum pool during the period when the flood control requirement would otherwise be at minimum pool level, except that this water must be promptly

evacuated by transfer to downstream percolation areas whenever watershed wetness parameters indicate a need for the full flood control space.

23. LIMITATIONS ON STORAGE

Operational limitations on storage in Lake Kaweah are specified on the flood control diagram, Chart A-11. [redacted] no legal limitations on [redacted], as the taking-line elevation is above any normal operation level. The taking-line elevation of 704 feet is based on 10 feet of freeboard above the gross pool elevation 694 feet.

24. LIMITATIONS ON RELEASES

Releases should be restricted insofar as practicable to irrigation and spreading demands and channel losses in downstream reaches. Any necessary releases in excess of irrigation and spreading demands must be restricted as long as possible to channel capacities as listed on Chart 2 or as otherwise determined by the Corps of Engineers. Releases of large quantities of water to Tulare Lakebed area will be delayed as long as possible in order to guard against making unnecessary releases because of errors in forecast. When transfer of water from conditional winter storage to the downstream spreading areas is required, releases will be made at full channel capacity rates for the spreading basin inlet channels as scheduled on the flood control diagram, Chart A-11.

25. FLOOD CONTROL OPERATION

a. The criteria for flood-control operation of Lake Kaweah are given on Chart A-11. This diagram is designed to reserve only as much space for flood control as is necessary to control the reservoir design rainflood and, insofar as possible, the forecasted snowmelt runoff. Flood releases over and above direct irrigation uses are disposed of in two ways: (1) percolation into the ground by spreading and (2) storage in the Tulare Lakebed area, which is usually damaging. Releases greater than irrigation and spreading demands are unavoidable during years of heavy runoff; however, it is desirable to defer such releases as long as practicable in order to minimize the chance of unnecessarily making releases (because of large errors in early forecasts) and in order to provide the maximum time for the harvesting of crops in the Tulare Lakebed area.

b. During the rainflood season, flood protection is accomplished by reservation of 142,000 acre-feet of storage space. This reservation is divided into three bands designed (1) to allow conditional carryover of up to 7,000 acre-feet of water within the basic 142,000 acre-feet of space whenever dry watershed conditions are indicated, (2) to provide flood protection to the Tulare Lakebed area at low reservoir stages, and (3) to assure protection to areas along Kaweah River at high reservoir stages.

During the period 1 November to 1 April, water stored in the 7,000 acre-feet conditional winter storage band (available flood control space 135,000-142,000 acre-feet) must be evacuated as indicated by precipitation parameters defined on the flood control diagram, Chart A-11, for transfer to downstream percolation areas at specified rates up to 5,400 acre-feet per day. Precipitation index parameters will be computed using total precipitation measured during the preceeding 30 days at Atwell, Bear Trap Meadow, Giant Forest, Hockett Meadow, and Terminus Dam, to compute the 30-day accumulated basin mean precipitation. The basin mean will be computed from the 30-day accumulated precipitation records at these stations by multiplying the total of such records by the ratio of the basin average normal annual precipitation to the total of the individual stations normal annual precipitation, i.e.:

30-day basin mean precipitation =

$$\frac{(\text{Basin average NAP})(\Sigma\,\text{30-day station precip.})}{\Sigma\,\text{station NAP}}$$

Pertinent NAP values are:

K = 21/26.5

2.3	- Atwell	39.6	inches
2.9	- Bear Trap Meadow	45.9	"
7.9	Giant Forest	43.0	"
1.2	- Hockett Meadow	40.9	"
1.15	- Terminus Dam	14.0	"
12.45			
2.65	Total	183.4	"

Basin average 39.0 inches

When the available flood control space is between 70,000 acre-feet and the space corresponding to the top of the permitted conditional winter storage, releases equal to full irrigation and spreading capabilities are made. When the available flood control space is less than 70,000 acre-feet, channel capacity releases corresponding to flow at McKays Point of 5,500 c.f.s. are made. Such operation permits control of the reservoir design flood and the maximum rainflood of record (December 1966) to channel capacity release.

c. Snowmelt parameters shown on Chart A-11 were derived using procedures described in Office Report "Reservoir Operation Criteria for Flood Control, Sacramento-San Joaquin Valley, California," October 1959. Parameters are based on computed relationships between remaining runoff and required flood control space, with an allowance of one standard error of forecast. This allowance results in a risk calculated such that unavoidable forecast errors

will result in some spreading that might not have been required 5 times for each time that they result in damaging water into Tulare Lakebed area that might have been avoided with a perfect forecast. Based on a study of observed runoff of Kaweah River Basin, each year of record which would have required use of flood control space was back-routed to determine the relationships of required space to remaining runoff at the beginning of each month, for an outflow required for full irrigation and spreading. The positions of parameters shown on Chart A-11 were determined from these relationships, after adding error allowance which included both the standard error of forecast and standard errors of the derived relationships of required space to remaining runoff.

26. CONSERVATION OPERATION

A contract, No. 14-06-200-1729A dated 11 January 1965 was entered into between the United States of America and the Kaweah Delta Water Conservation District providing for the operation and maintenance, and for the repayment of the cost of Terminus Dam and Reservoir allocated to irrigation. Operation of Lake Kaweah by the Corps of Engineers will be in accordance with the following:

a. All inflow in excess of the releases requested by the Kaweah River irrigation interests will be stored to the extent that conservation space is available.

b. Release of water stored for irrigation will be in accordance with the requests of the Kaweah River watermaster, conforming with mutual agreements and stipulations of the water users, unless prior release is required for flood control purposes.

c. Releases through the Lemon Cove outlet will equal the sum of Lemon Cove Ditch and Hawkeye Water Company demands.

d. Water stored in the conditional winter storage space will be released in accordance with requests of the Kaweah River watermaster or his designated agent except when watershed precipitation parameters indicate required evacuation of this space for flood control purposes.

27. OUTLET GATE OPERATION

When the reservoir water surface rises above the spillway crest elevation (694.0) the outlets will normally be closed gradually as the spillway releases increase, in order to limit the maximum flow at McKays Point as long as possible to 5,500 c.f.s. Operation criteria for outlet gates when the reservoir level is above spillway crest are specified on Chart A-12. Maintenance of the downstream channel system to accomodate flows to 5,500 c.f.s. at McKays Point is basic to project design and is the responsibility of local interests.

CHAPTER 6 - OPERATIONAL CONTROLS

28. DIVISION OF RESPONSIBILITY FOR OPERATION

a. The primary responsibilities for operating Lake Kaweah are assigned to units of the Engineering Division and Construction-Operations Division as outlined herein. Names and telephone numbers for those individuals whose duties are outlined in the following paragraphs are given on the personnel chart at the front of this manual.

b. The Reservoir Regulation Section (Engineering Division) is responsible for:

(1) Analyzing current reservoir and hydrologic data, determining the schedule under which the reservoir shall be operated, and issuing appropriate instructions (except for routine daily operations for conservation only) to the reservoir operator.

(2) Preparing monthly operation and other special reports concerning the operation of the reservoir, as required by the Office, Chief of Engineers.

(3) Advising the District Engineer whenever there has been an unavoidable departure from these operating rules, or when there is a need for making a temporary modification of these operating rules.

(4) Keeping advised at all times of channel and seepage conditions in downstream channels and spreading areas. This will require periodic inspections during years of high runoff.

(5) Arranging for the collection of requests for water for downstream irrigation and spreading, and maintaining a record of instructions issued, data transmitted and requests received from other agencies.

c. The Hydrology Section (Engineering Division) is responsible for:

(1) Obtaining current hydrometeorological data and weather forecasts as required for use by the Reservoir Regulation Section.

(2) Maintaining hydrologic equipment and supervising its operation.

(3) Supervising a program of water quality and sediment measurement.

d. The Operations Branch (Construction-Operations Division) is responsible for supervising the physical operation of the reservoir facilities and for operation and maintenance of communication facilities connected with the project.

e. The responsibilities of the reservoir operator (under the supervision of the Operations Branch, Construction-Operations Division, with functional flood control operation directed by the Reservoir Regulation Section, Engineering Division) are outlined in Appendix A.

29. STANDING INSTRUCTIONS

Standing instructions for operation of Terminus Dam (Lake Kaweah) are contained in Appendix A of this manual.

30. MODIFICATION OF INSTRUCTIONS

The operating rules contained herein are subject to temporary modification during flood or other emergencies by the District Engineer. Major changes in the operating rules are subject to prior approval by the Chief of Engineers.

31. HYDROLOGIC FACILITIES

Hydrologic facilities for operating Terminus Project consist of.

a. Reporting precipitation gage at Bear Trap Meadow.

b. Reporting precipitation gage at Atwell.

c. Reporting precipitation gage at Hockett Meadow.

d. Reporting precipitation, temperature, and snow water depth equivalent gages at Giant Forest.

These four precipitation gages report on demand the total amount of precipitation since the beginning of the season. The Giant Forest gage also reports current ambient air temperature and the water equivalent in the snowpack at that point.

e. Recording stream gaging station on Kaweah River at Three Rivers.

f. Recording stream gaging station on South Fork Kaweah River near Three Rivers.

g. Recording pool gage at Terminus Dam.

h. Recording stream gaging station on Kaweah River at the concrete control weir below Terminus Dam.

i. Recording stream gaging station on the Parshall Flume at the head of Lemon Cove Ditch.

j. Non-recording Dall flow meter on Hawkeye Ditch outflow below Lemon Cove Ditch stilling well.

k. Recording stream gaging station at the Parshall Flume at the head of Foothill Ditch.

l. Recording stream gaging station on Dry Creek near Lemon Cove.

m. Weather station at the dam near Lemon Cove Ditch stilling well consisting of:

(1) Recording precipitation gage.

(2) Non-recording precipitation gage.

(3) Weather Bureau type class A land evaporation pan with anemometer and sixes thermometer.

(4) "Cotton Belt" type shelter containing hygrothermograph, maximum thermometer, minimum thermometer, and fan aspirated psychrometer.

32. COMMUNICATION FACILITIES

Communication facilities for the operation of the project consist of:

a. Commercial telephone service.

b. Direct radio backup service between the District Office in Sacramento and the project office.

c. Continuous wire transmission from the stream gaging stations on Kaweah River below the dam, Foothill Ditch, and Lemon Cove Ditch to the control tower.

d. Telemark type wire transmission from the stream gaging stations on Kaweah River at Three Rivers and on Dry Creek to the control tower and administration building.

e. On call radio transmission from the reporting precipitation gages at Bear Trap, Atwell, Hockett Meadow and Giant Forest, and from the temperature gage and the snow gage at Giant Forest.

33. FORECASTS OF INFLOW

a. Of primary concern in the functional operation of Lake Kaweah are forecasts of the volume of snowmelt inflow which occurs each year during

the months of April through July, and of the approximate time distribution of the seasonal snowmelt. Also, forecasts of rainflood runoff may be important during the November-April period, particularly when rainflood space is occupied.

b. Forecasts of snowmelt runoff made by the Department of Water Resources of the State of California are used as the basis for flood control operation of Lake Kaweah during the spring runoff season. The Department prepares and publishes forecasts of April through July runoff for "Kaweah River, total inflow to Terminus Reservoir" as of 1 February, 1 March, 1 April, 1 May, and in critical years 1 June of each year. Forecasts are published in the report titled "Water Conditions in California". Kaweah River Basin snow survey data for 1 April and 1 May have been collected and published by the State since 1932, and forecasts of snowmelt runoff for Kaweah River have been made continuously on these dates since 1936. Since February 1953, the State has also been making and publishing forecasts of seasonal Kaweah River snowmelt runoff based on snow survey data for 1 February and 1 March. A summary of available published forecasts compared to observed runoff for the April-July period of each year through 1971 is shown on Chart 20. The State of California forecasting procedure for Kaweah River, total inflow to Terminus Reservoir is illustrated on Chart 21. Figure 1 is the diagram used to solve the forecast equation. Figure 2 shows forms used to compute indexes required in the forecast equation, and Figure 3 shows the forecast summary and forecast range diagram. Forecasts are based on conditions as of the date of forecast, with median precipitation and snowpack increments assumed after the date of forecast. The forecast range diagram of Figure 3 is used to determine the probable range of forecast departure for any forecast date during the season. As an example, suppose that a forecast of 300,000 acre-feet April-July runoff is made on 1 March, assuming median conditions after 1 March. Referring to point "A" on the forecast range diagram, there is a 10 percent probability that the actual runoff will exceed 300,000 plus 105,000 or 405,000 acre-feet. Referring to point "B", there is a 90 percent probability that the runoff will exceed (or a 10 percent probability that the runoff will be less than) 300,000 minus 77,000 or 223,000 acre-feet.

c. Because of the importance of the actual distribution of snowmelt runoff in the flood control operation of Lake Kaweah, and because changing hydrologic conditions may affect the total volume of seasonal snowmelt, forecasts made by the State may be modified or supplemented as the snowmelt season progresses. Data obtained from the radio reporting snow pillow station established at Giant Forest in 1969, and from radio reporting snow pillows at Mitchell Meadows and Wet Meadows in adjacent drainage basins, supplemented by aerial reconnaissance flights, will be used for this purpose. Also, after peak rates of flow have occurred and runoff rates are

receding, the normal rate of runoff recession provides an excellent guide to remaining snowmelt flows. Recession rates for typical large years are given on Chart 22. Also, on Chart 22 are curves indicating the distribution of April-July seasonal runoff for selected years and daily temperature accumulation at Giant Forest during the snowmelt season. These curves are useful in anticipating the level to which the reservoir will rise by a given date.

d. When necessary, the Reservoir Regulation Section will prepare forecasts of rainflood inflow. For this purpose, criteria contained on Chart 23 have been developed. The runoff volume to be expected from a forecasted rainfall can be estimated approximately by use of Figure E of Chart 23. After a major storm has begun and a detailed evaluation of expected inflow on a current basis is required, an inflow hydrograph will be computed using unit hydrograph data and procedures illustrated on Chart 23. Loss rates for this computation must be evaluated largely by judgement until more consistent loss rate data are available. Surface runoff is computed by tabulating ordinates of the unit hydrograph in reverse order on a strip of paper, which is then placed beside the column of water excess values as illustrated on Chart 23. The surface runoff at the time opposite the lowest figure on the strip (excluding zero) equals the sum of the cross-products of the water excess values and the corresponding values on the unit hydrograph strip. The strip is then lowered to the next position and the process is repeated.

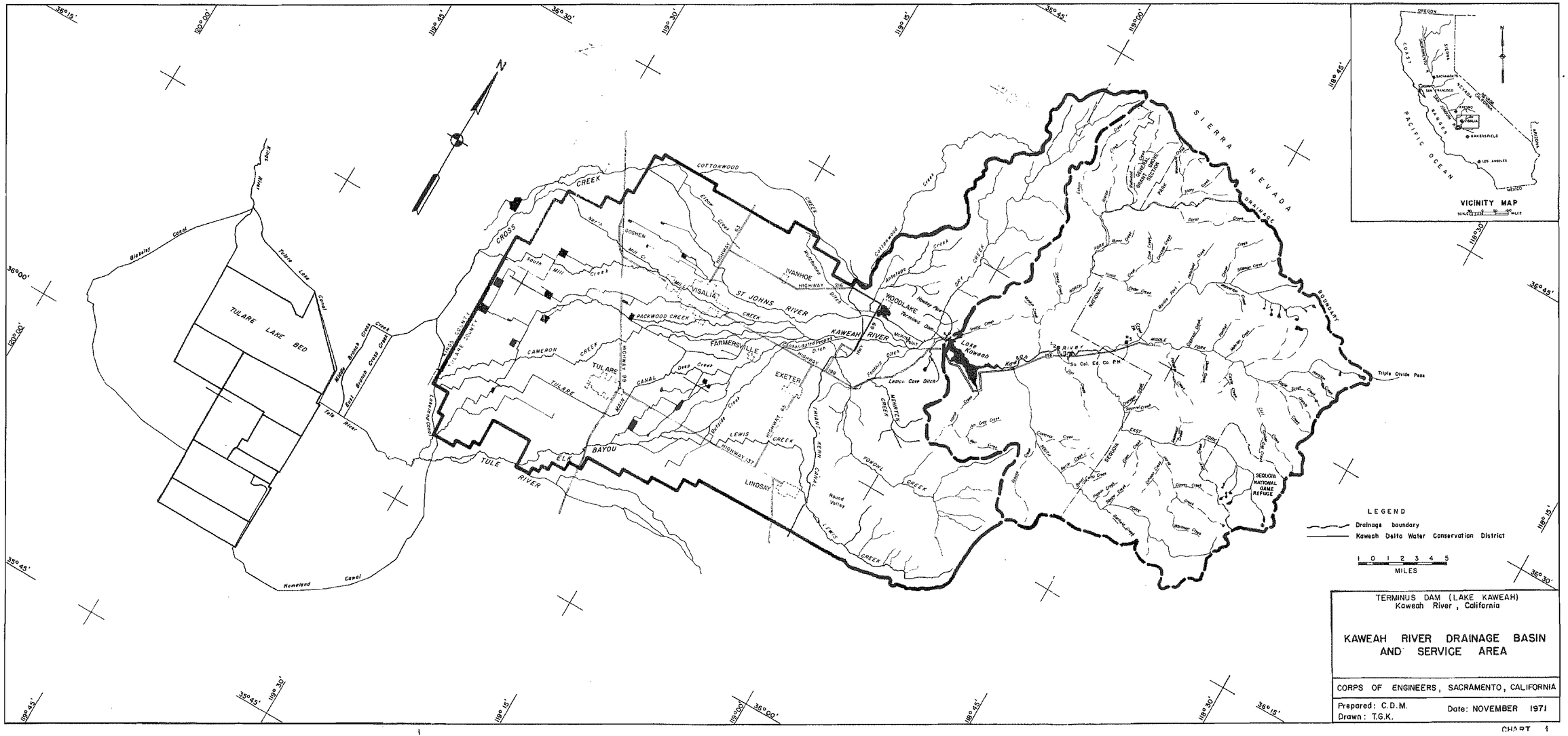
CHAPTER 7 - PROJECT ACCOMPLISHMENTS

34. EXAMPLES OF OPERATION

Hypothetical operation of Lake Kaweah during the 1903-1960 period in accordance with the procedures outlined in this manual and the flood control diagram, and based on reasonable random forecast error, is illustrated on Chart 24 and summarized on Chart 25. Actual operation from 1 April 1962 through 30 September 1971 is shown on Chart 31. Routing of the spillway design flood, the standard project flood and the December 1966 (approximate equivalent to reservoir design) flood are shown on Chart 26. Reservoir storage frequency data are summarized on Chart 27. A stage duration curve is shown on Chart 28 and stage frequency on Chart 29. Project and preproject rainflood frequency curves are shown on Chart 30.

35. OPERATION RECORD

The official operation record of Lake Kaweah is included in a monthly report of operation submitted to the Chief of Engineers. A summary of operations to date is shown on Chart 31. Daily storage and daily flows at the inflow and outflow stations are published annually in the U. S. Geological Survey Water Supply Papers.



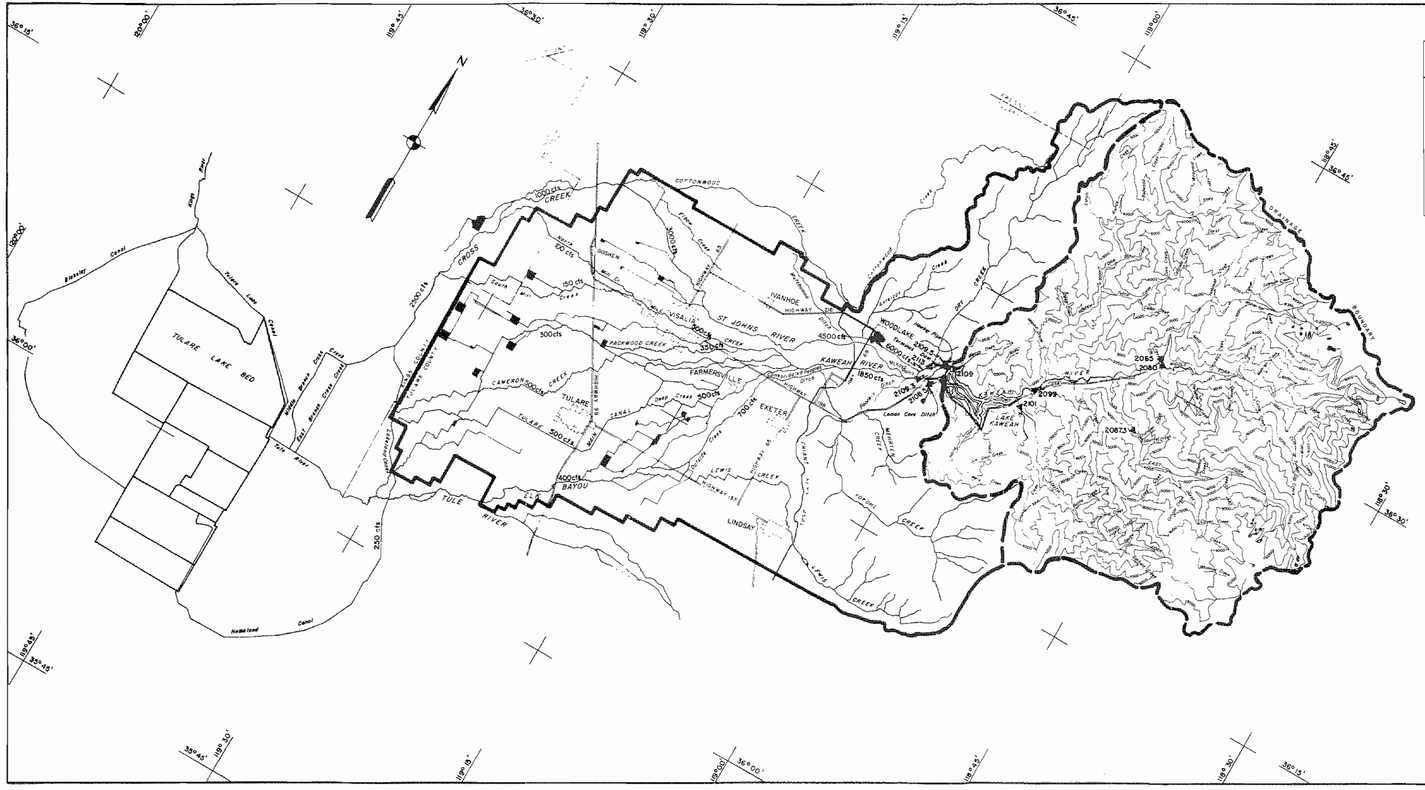
TERMINUS DAM (LAKE KAWEAH)
Kaweah River, California

KAWEAH RIVER DRAINAGE BASIN AND SERVICE AREA

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: C.D.M.
Drawn: T.G.K.
Date: NOVEMBER 1971

CHART 1



STREAM GAGING STATIONS

CALIF. INDEX NUMBER	GAGING STATIONS	TYPE OF GAGE	LOCATION LATITUDE Deg. Min.	LOCATION LONGITUDE Deg. Min.	ELEVATION (Feet)	ELEVATION Datum	DRAINAGE AREA (sq. mi.)	RECORDS Began In	RECORDS Agency Or Charge***	MAXIMUM FLOW Date	MAXIMUM FLOW (cfs)
*2065	Middle Fork Kaweah River nr Potwisha Camp Calif	▲	36 30.8	118 47.4	2100	TM	102	1949	SCE	23 Dec 55	45 800
*2080	Marble Fork Kaweah River at Potwisha Camp Calif	▲	36 31.1	118 49.0	2150	TM	51.4	1950	SCE	23 Dec 55	12 500
*2087 3	East Fork Kaweah River nr Three River Calif	▲	36 27.0	118 47.2	2509	TM	85.8	1952	SCE	6 Dec 55	13 000
*2099	Kaweah River at Three Rivers Calif	◢	36 26.6	118 54.2	809.52	MSL	418	1958	USGS	5 Dec 56	73 000
*2101	South Fork Kaweah River at Three Rivers Calif	◢	36 25.0	118 54.8	907.22	MSL	86.7	1958	USGS	6 Dec 66	11 600
2108 5	Lemon Cove Ditch below Terminus Dam Calif	◢	36 24.9	119 00.4	546.3	MSL	-	1962	USCE	1963 64 65 66	8.4
*2109	Lake Kaweah near Lemon Cove, Calif	◘	36 24.9	119 00.1	-	-	560	1961	USCE	-	-
2109 1	Foothill Ditch below Terminus Dam Calif	◢	36 24.8	119 00.8	492.6	MSL	-	1961	USCE	10 Feb 62	50
2109 5	Kaweah River below Terminus Dam Calif	◢	36 24.8	119 00.7	485.9	MSL	561	1961	USGS	8 Dec 66	5 370
*2113	Dry Creek near Lemon Cove Calif	◢	36 26.6	119 01.4	570.0	TM	75.6	1959	USGS	6 Dec 66	18 500

* 2065 - Monthly discharge only for water years 1958 1967 published in WSP 1735. Prior to October 1954 records for river and conduit published separately; combined only October 1954 to September 1967

2080 - Monthly discharge only for March 1950 published in WSP 1315-E Prior to October 1954 records for river and conduit published separately; combined only October 1954 to September 1967

2087 3 - Period of Record: May 1952 to September 1955 October 1957 to current year Prior to October 1957 combined only

2099 & 2101 - These gaging stations replace station: 2105 - Kaweah River nr Three Rivers Calif period of record. April 1961 to September 1961

2105 - Fragmentary prior to March 1967 Prior to October 1962 published as Terminus Reservoir near Lemon Cove

** TM - Topographic Map

MSL - Mean Sea Level

*** SCE - Southern California Edison

USGS - U S Geological Survey

USCE - U S Army Corps of Engineers

▲ Recording Stream Gage

◢ Recording Stream Gage w/telemark

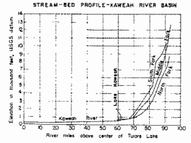
◘ Recording Reservoir Gage

Used in combination with other symbols as ◢ to indicate telephonic or remote wired transfer

GAGE TRANSMISSION MEDIA (ALPHETTES)

Lemon Cove Ditch	TP
Foothill Ditch	J1
Whitestone Ditch	Jw1
Dry Creek Ditch	J2
Unpublished Peoples Ditch	TO1
Deep Creek	VO
Deep Creek Cut	XW
Cutler Gate	TO2
Tulare Irrigation Co. Canal	OO2
Fleming Ditch	JJ
Paramount Creek	TO3
Deep Creek	TO
Owens Ditch	TO
Watson Ditch	WO
Persian Ditch	XO
Longs Creek	XO
Cottonwood POND and pipe	XO
Dewberry Ditch	JJ
Lewis Slough	LOO
Lewis Creek	LOO
Paramount Canal	XO
Tulare Irrigation Dist. Canal	OO2
Mathews Ditch	WO
Mathews Ditch	XO
Jackson Ditch	JO
Quail Ditch	WO
Mosher Ditch	LOO
Cross Creek Ditch	JJ
Graham Ditch	LOO
Dadmoor Ditch	WO

STREAM-BED PROFILE-KAWEAH RIVER BASIN



LEGEND

2000 Contour line

Drainage boundary

3000cfs Channel capacity (90 day)

Kaweah Delta Water Conservation District

1 0 1 2 3 4 5
MILES

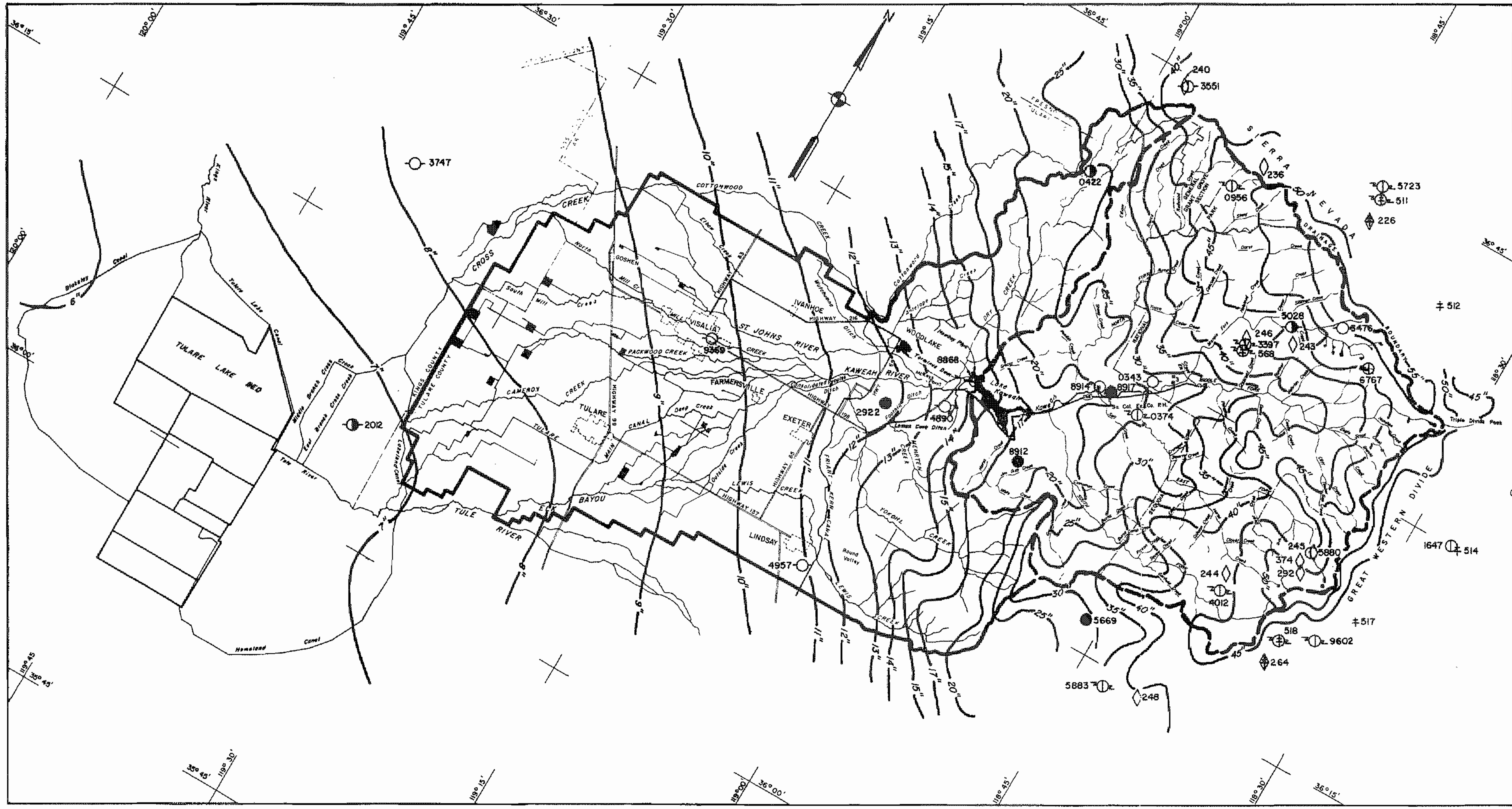
TERMINUS DAM (LAKE KAWEAH)
Kaweah River, California

TOPOGRAPHY
AND STREAM GAGING STATIONS

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: C.D.M.
Drawn: T.G.K.
Date: NOVEMBER 1971

CHART 2



CLIMATOLOGICAL STATIONS

CALIF INDEX NUMBER	STATION	TYPE OF GAGE	RIVER BASIN	ELEV (feet)	LOCATION LATITUDE Deg Min	LOCATION LONGITUDE Deg Min	RECORD BEGAN	RECORD PUBLISHED BY*
0343	Ash Mountain		Kaweah	1708	36 29 5	118 49 6	1925	NOAA
0374	Atwell CC Camp		Kaweah	6480	36 28 0	118 40 0	1948	USCE
0422	Badger		Kaweah	3030	36 37 9	119 00.8	1940	NOAA
0956	Bear Trap Meadow		Kaweah	6800	36 41 0	118 52 0	1959	USCE
1647	Chagoopa		Kern	10390	36 30 0	118 27 0	1964	USCE
2012	Corcoran Irrigation District		Kaweah	200	36 05 9	119 34 8	1912	NOAA
2922	Exeter Fauver Ranch		Kaweah	439	36 21 5	119 04 8	1938	NOAA
3397	Grant Forest		Kaweah	6650	36 34 0	118 46 0	1921	USCE
3551	Grant Grove		Kings	6580	36 44 5	118 57 7	1924	NOAA
3747	Hanford		Kaweah	242	36 19 7	119 39 [illegible]	1899	NOAA
4012	Hockett Meadow		Kaweah	8520	36 22 0	118 39 0	1959	USCE
4890	Lemon Cove		Kaweah	513	36 23 0	119 01 5	1899	NOAA
4957	Lindsay		Kaweah	395	36 11 4	119 04 3	1913	NOAA
5028	Lodge Pole R S		Kaweah	6695	36 36.0	118 44 0	1951	NOAA
5669	Milo 5NE		Tule	3400	36 16 7	118 46 2	1957	NOAA
5680	Mineral King		Kaweah	7975	36 26 0	118 35 0	1956	NOAA
5723	Mitchell Meadow		Kings	9700	36 45 0	118 43 0	1957	NOAA
5883	Mountain Home		Tule	5360	36 14 0	118 43 0	1957	USCE
6476	Orange Cove		Kaweah	431	36 37 3	118 40 7	1931	NOAA
6767	Pear Lake (Closed 9/12/69)		Kaweah	9700	36 35 0	118 40 0	1956	-
8868	Terminus Dam		Kaweah	965	36 24 6	119 00 3	1959	USCE
8912	Three Rivers 6SE		Kaweah	2200	36 22 0	118 51 0	1940	DWR
8914	Three Rivers Edison P H #2		Kaweah	950	36 27 7	118 52 7	1909	NOAA
8917	Three Rivers Edison P H. #1		Kaweah	1140	36 28 0	118 51 7	1940	DWR
9369	Visalia		Kaweah	354	36 19 8	119 17 3	1903	NOAA
9602	Wet Meadow		Kern	9200	36 22 0	118 32.0	1959	NOAA

NOAA - National Oceanic and Atmospheric Administration
USCE - U S Army Corps of Engineers
DWR - Department of Water Resources - State of California

Precipitation only
Precipitation and Temperature
Precipitation Temperature and Evaporation
Precipitation Storage Gage
Radio Equipped Precip Storage Gage

Type of Gage: Non recording
Recording
Both Types

SNOW COURSES AND AERIAL SNOW DEPTH MARKERS*

CALIF INDEX NUMBER	STATION	TYPE OF GAGE	ELEVATION (feet)	LOCATION LATITUDE Deg Min	LOCATION LONGITUDE Deg Min	RECORD BEGAN	MEASUREMENT DATES **	MEASURED BY ***	AVG 1 APRIL WATER CONTENT (Inches)
226	Rowell Meadow		8 850	36 43 0	118 44 2	1930	4, 5	KRWA	27.5
236	Big Meadows		7 600	36 42 9	118 50 5	1930	2, 3, 4, 5	KRWA	25.9
237	Horse Corral Meadow		7,600	36 45 1	118 45 0	1930	4, 5	KRWA	17.6
240	Grant Grove		6,500	36 44 5	118 57 8	1930	2, 3, 4, 5	SKCP	14.6
243	Panther Meadow		8,600	36 35 3	118 43 0	1925	2, 3, 4, 5	SKCP	36.8
244	Hockett Meadows		8 500	36 22 9	118 39 3	1930	3, 4	SKCP	29.0
245	Mineral King		8,000	36 26 2	118 35 2	1948	2, 3, 4	TRRD	21.3
246	Giant Forest		6,400	36 34 2	118 46 1	1930	2, 3, 4, 5	SKCP	15.6
248	Old Enterprise Mill		6,600	36 14 6	118 40 7	1957	3, 4	TRRD	16.4
264	Quinn Ranger Station		8 350	36 19 7	118 34.4	1930	3, 4	SKCP	20 4
292	Farewell Gap		9,000	36 24 7	118 35.0	1952	2, 3, 4	TRRD	35.9
374	White Chief		9 200	36 25.3	118 35 5	1970	2, 3, 4	TRRD	-
511	Mitchell Meadow		9,900	36 44 2	118 42 7	1956	2, 3, 4, 5	USCE	-
512	Scenic Meadow		9,650	36 41.1	118 35 8	1953	2, 3, 4, 5	USCE	-
514	Chagoopa Plateau		10,300	36 29 8	118 26 5	1953	2, 3, 4, 5	USCE	-
517	Shotgun Pass		10,400	36 23 8	118 30 3	1959	2, 3, 4, 5	USCE	-
518	Wet Meadow		8,950	36 20 9	118 34 3	1957	2, 3, 4, 5	USCE	-
568	Grant Forest		6,650	36 33.8	118 46 2	1970	2, 3, 4, 5	USCE	-

* Snow Course information obtained from "California Snow Survey Measurement Schedule" California Cooperative Snow Surveys, 1971, DWR, State of California

** Numbers indicate dates of scheduled observations: 2 - on or about 1 February. 3 - on or about 1 March etc.

*** KRWA - Kings River Water Association Fresno
SKCP - Sequoia and Kings Canyon National Parks, Ash Mountain
TRRD - Tule River Ranger District Springville
USCE - U.S. Army Corps of Engineers, Sacramento

Existing Snow Course
Aerial Snow Depth Marker
Aerial Snow Depth Marker Located on or near Snow Course
Radio Equipped Snow Pillow

LEGEND

40" Isohyetal line
Drainage boundary
Kaweah Delta Water Conservation District

1 0 1 2 3 4 5
MILES

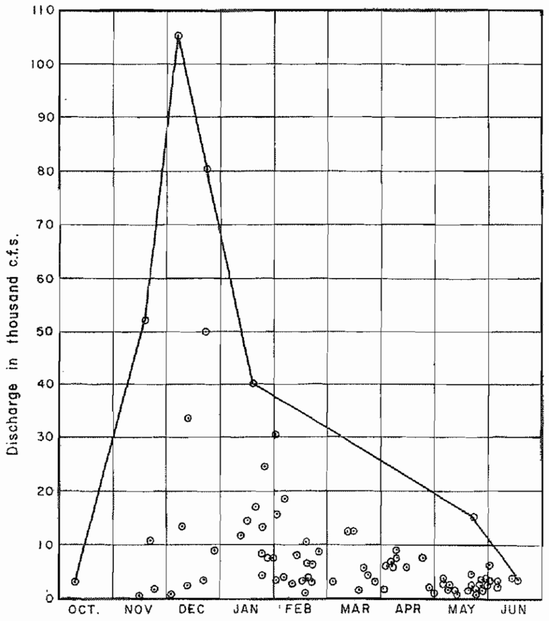
TERMINUS DAM (LAKE KAWEAH)
Kaweah River, California

NORMAL ANNUAL PRECIPITATION, PRECIPITATION STATIONS, AND SNOW COURSES

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

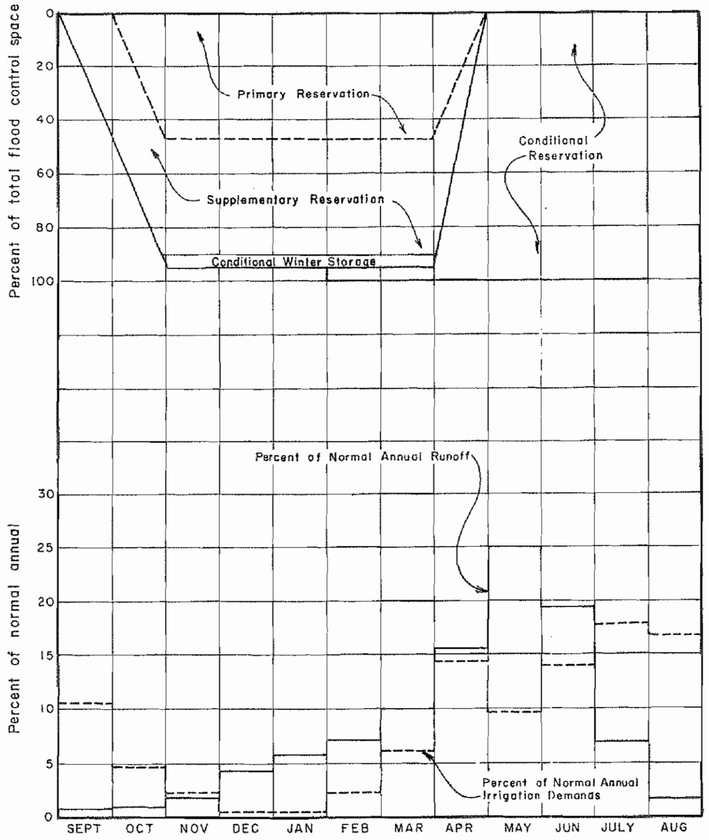
Prepared: C.D.M.
Drawn: T.G.K.
Date: NOVEMBER 1971

CHART 3



SEASONAL DISTRIBUTION OF OBSERVED PEAK FLOWS

NOTES:
1. Peak flows are for period of record ending 30 Sept. 1969
2. Floods occurring Oct.–Feb. are rain floods
3. Floods occurring Mar.–Jun. are caused by snowmelt or a combination of rain and snowmelt



FUNCTIONAL OPERATING DETERMINANTS

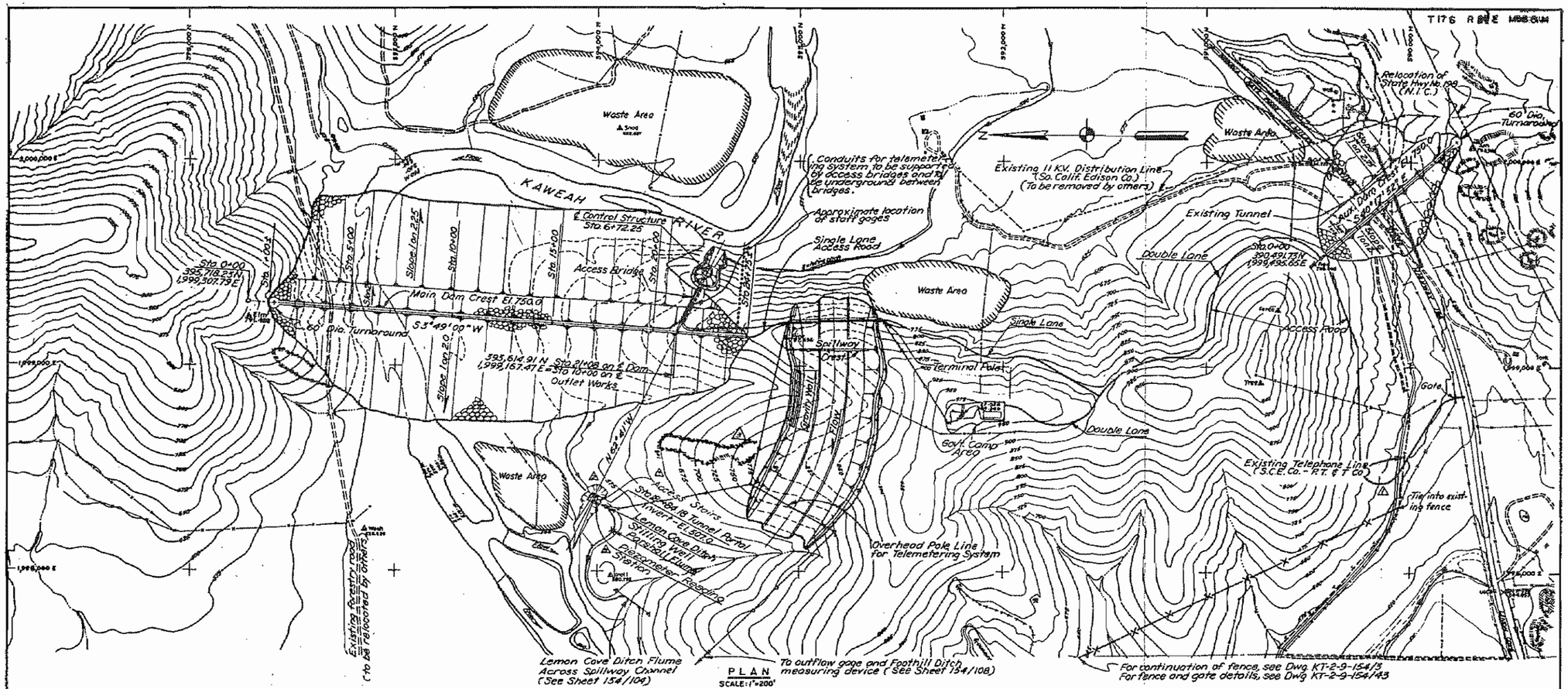
TERMINUS DAM (LAKE KAWEAH)
Kaweah River, California

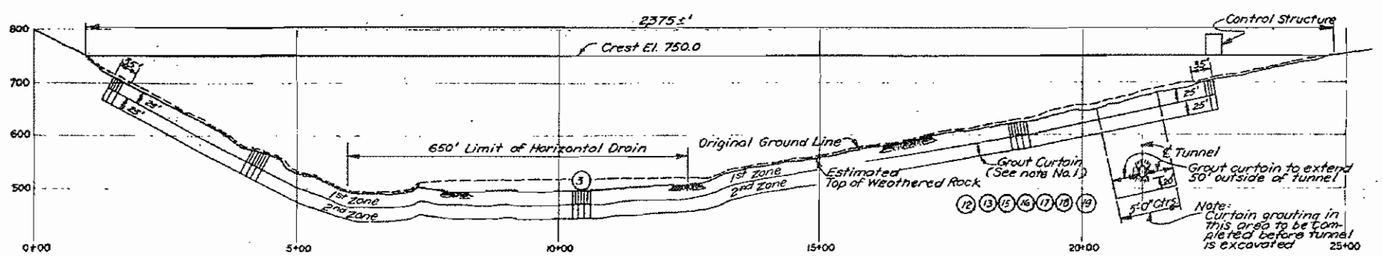
HYDROLOGIC
AND OPERATING CHARACTERISTICS

CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA

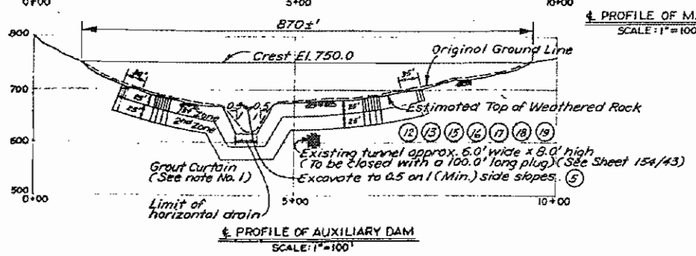
Prepared: H.A.Z.
Drawn: R.E.Y.
Date: Sept. 1971

CHART 4

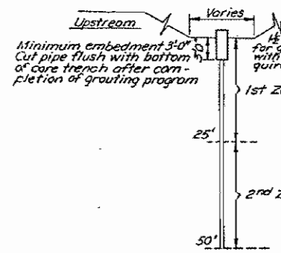




℄ PROFILE OF MAIN DAM
SCALE: 1" = 100'



℄ PROFILE OF AUXILIARY DAM
SCALE: 1" = 100'



DETAIL A

GENERAL NOTES:

1. Grout Curtain: 1½" dia. grout holes (Ex.), 2 zones each 25', grout holes on 5' centers. Mtholes measured as normal to slope. 2nd zone on 10' centers, cut to 5' centers if required by permeabilities encountered.
2. Figures in circles, thus, ⑬ indicate items under which payment will be made
3. Topography shown is Mean Sea Level Datum of 1929. Contour interval, 5 ft. Third order triangulation, 1927 North American datum, California State coordinate system, zone 4. Topography by Fairchild Aerial Surveys, Inc. and Army Corps of Engineers.
4. Payment for cement in grout will be made at contract price item. ⑫

GRAPHIC SCALE

SCALE: 1" = 200' 200 100 0 200 400 600 800 1,000

1" = 100' 100 50 0 100 200 300 400 500

References

154/2 General Plan, Reservoir Area
154/3 " " Contractors Working and Borrow Areas
154/5 Embankment Section, Main Dam and Auxiliary Dam
154/43 Main Dam and Auxiliary Dam, Roadway Details and Tunnel Plug.

REVISION	DATE	DESCRIPTION	BY	BY
3	10 Aug. 59	Sta. adjusted for Parshall Flume & Piezometer Reading Station		
2	30 July 59	Revised outlet portal to fit exist. excav.	C.S.	
1	25 Feb. 58	Sheet redrawn. Access Rd Alignment Revised		

U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DRAWN BY: P.D.
CHECKED BY: K.E.M.
THIS PLAN: Approved
CHIEF, HYD. STRUCTURES
SUBMITTED: Brach
CHIEF, CIV. DESIGN BRANCH

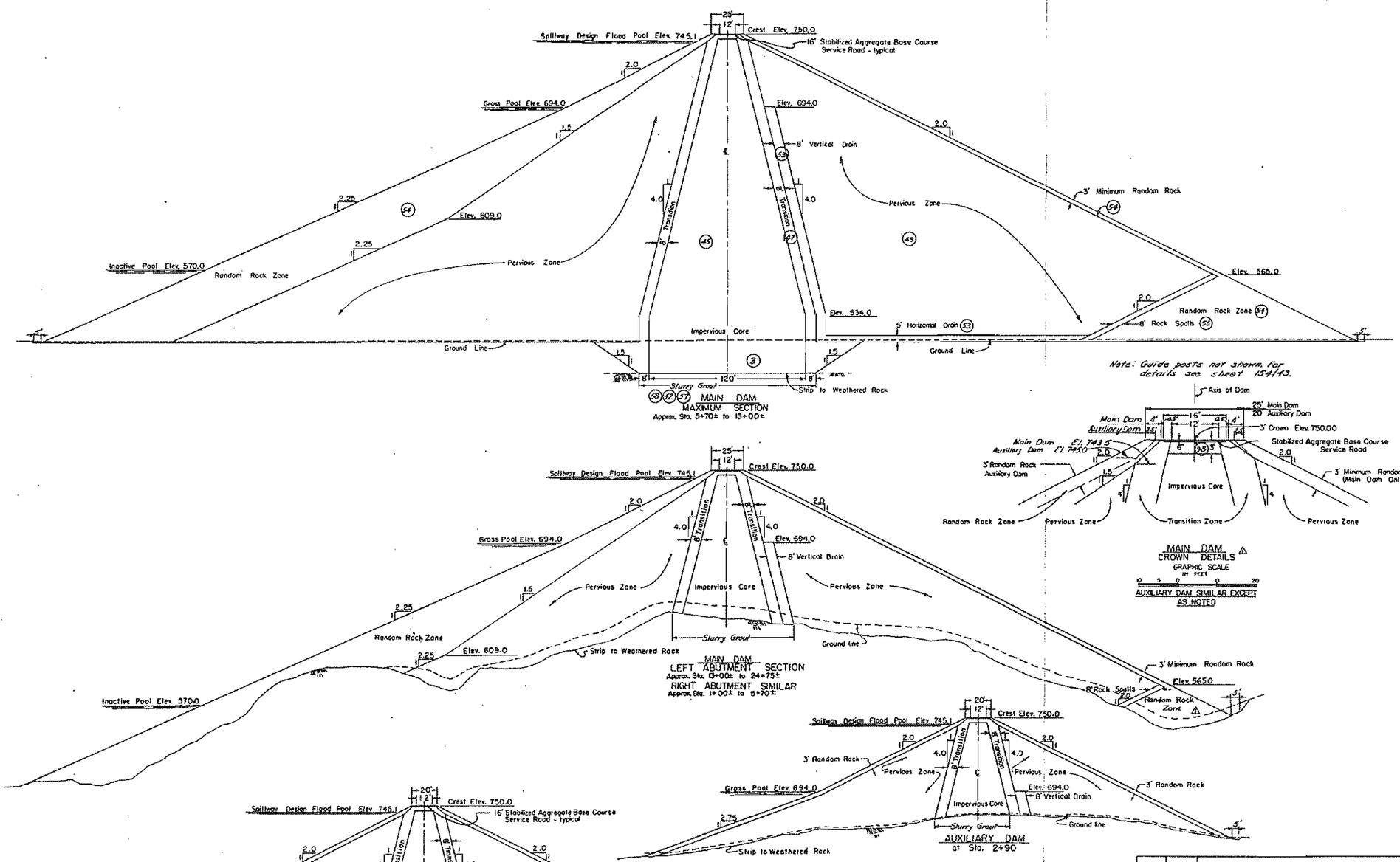
KAWEAH & TULE RIVER, CALIFORNIA
TERMINUS PROJECT
KAWEAH RIVER
PLAN & PROFILES
MAIN DAM & AUXILIARY DAM

APPROVED: Harry A. Dillman
CHIEF, DESIGN BRANCH
CHIEF, ENGINEERING DIVISION

APPROVED: Paul A. Snap
LT. COL., C.E., DISTRICT ENGINEER
FOR THE DISTRICT ENGINEER
DATE: DEC. 19, 1957

SCALE: AS SHOWN
DWG. NO. 2382
FILE NO. KT-2-9-154
SHEETS 154/1 TO 154/111
SHEET NO. 154/43

CHART 5



GENERAL NOTES

1. Figures in circles, thus, ◯ indicate item numbers under which payment will be made.
2. Payment for slurry grouting will be made at contract price item (58).
3. Payment for cement for slurry grouting will be made at contract price item (42).
4. Payment for additional rolling for compaction will be made at contract price item (56).

References

154/2 General Plan, Reservoir and Borrow Areas
154/4 Plan and Profiles, Main Dam and Auxiliary
154/43 Main Dam and Auxiliary Dam, Roadway Details and Tunnel Plug.

REVISION	DATE	DESCRIPTION	BY	BY
1	10 Oct 58	Added Random Rock Zone and revised Crown Details		

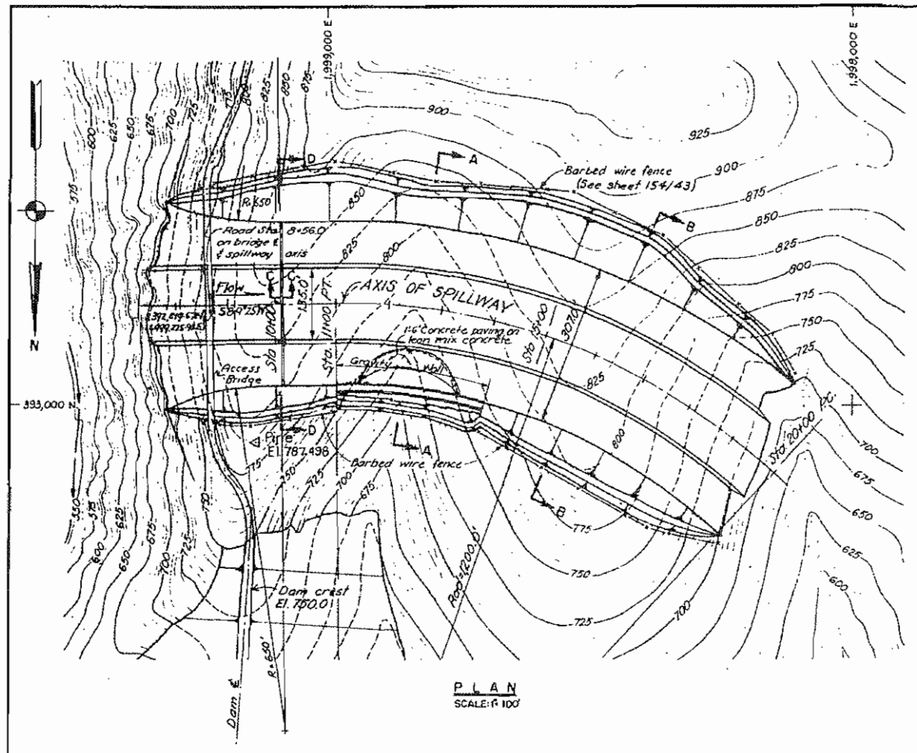
CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
SACRAMENTO DISTRICT
SACRAMENTO, CALIFORNIA

KAWEAH AND TULE RIVERS, CALIFORNIA
TERMINUS PROJECT
KAWEAH RIVER

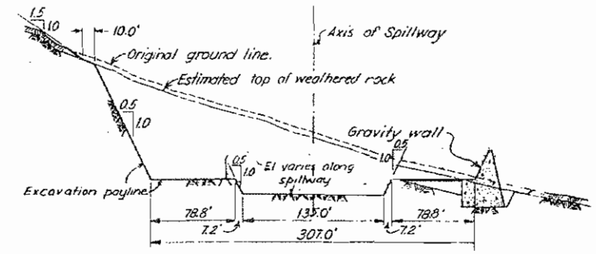
TYPICAL EMBANKMENT SECTIONS
MAIN DAM AND AUXILIARY DAM

DRAWN BY: W.L.H. & RES.
CHECKED BY: W.L.G.
SCALE: AS SHOWN
SPEC. NO. 2362
FILE NO. KT-2-9-154
SHEETS 154/1 TO 154/111
SHEET NO. 154/5.1
DATE: DEC 19 1957

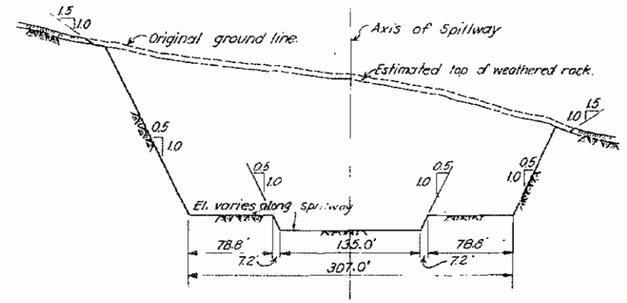
CHART 6



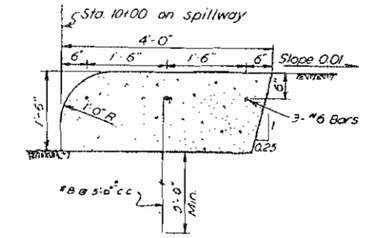
PLAN
SCALE: 1" = 100'



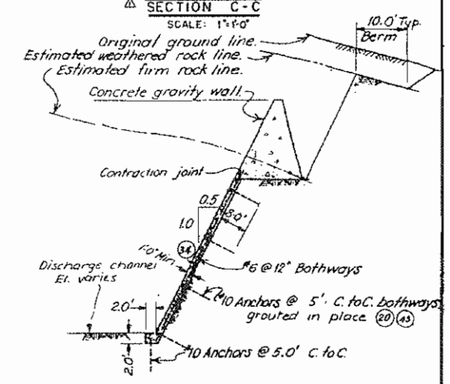
SECTION A-A
SCALE: 1" = 50'



SECTION B-B
SCALE: 1" = 50'



△ CONCRETE SILL
SECTION C-C
SCALE: 1" = 1'-0"



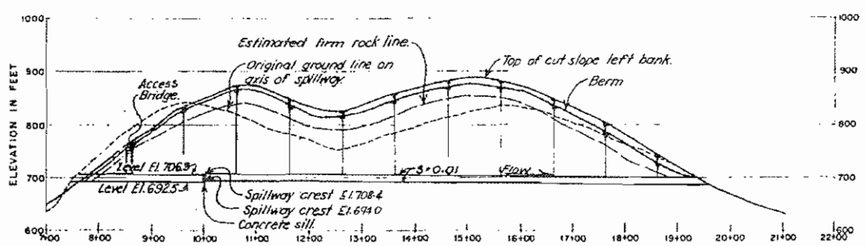
SECTION F-F
SCALE: 1" = 10'

GENERAL NOTES

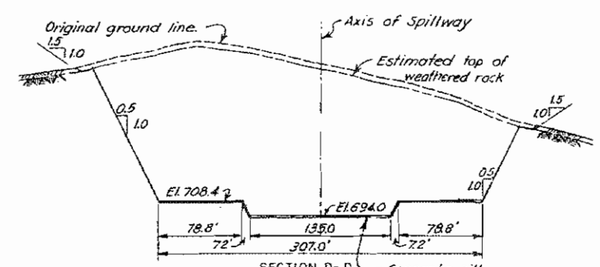
1. Figures in circles, thus, ○ indicate item numbers under which payment will be made.
2. Payment for spillway excavation will be made at contract price item (4)
3. Payment for cement in gravity wall, paving, & spillway crest will be made at contract price item (40)
4. Chamfer exposed edges of concrete ¾"
5. Payment for reinforcement steel will be made at contract price item (43)
6. Concrete Finishes: Formed Surfaces - Class B Finish; Unformed " - Wood Float Finish

References

154/4 Plan and Profiles, Main Dam and Auxiliary
154/45 Spillway Bridge, General Plan and Elevation

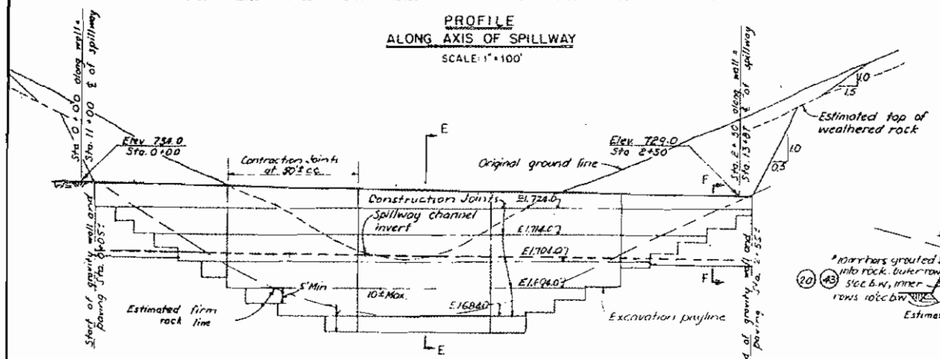


PROFILE
ALONG AXIS OF SPILLWAY
SCALE: 1" = 100'

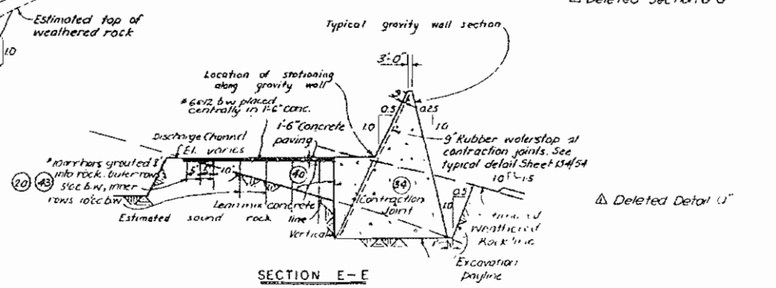


SECTION D-D
SCALE 1" = 50'

△ Deleted Section G-G



GRAVITY WALL PROFILE
SCALE 1" = 20'



SECTION E-E

△ Deleted Detail "J"

△	21 July 59	Revised Conc. Spillway Sill. Deleted Sec. G-G & Detail "J"	
REVISION	DATE	DESCRIPTION	BY

COPY OF ENGINEERS, U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
SACRAMENTO DISTRICT
SACRAMENTO, CALIFORNIA

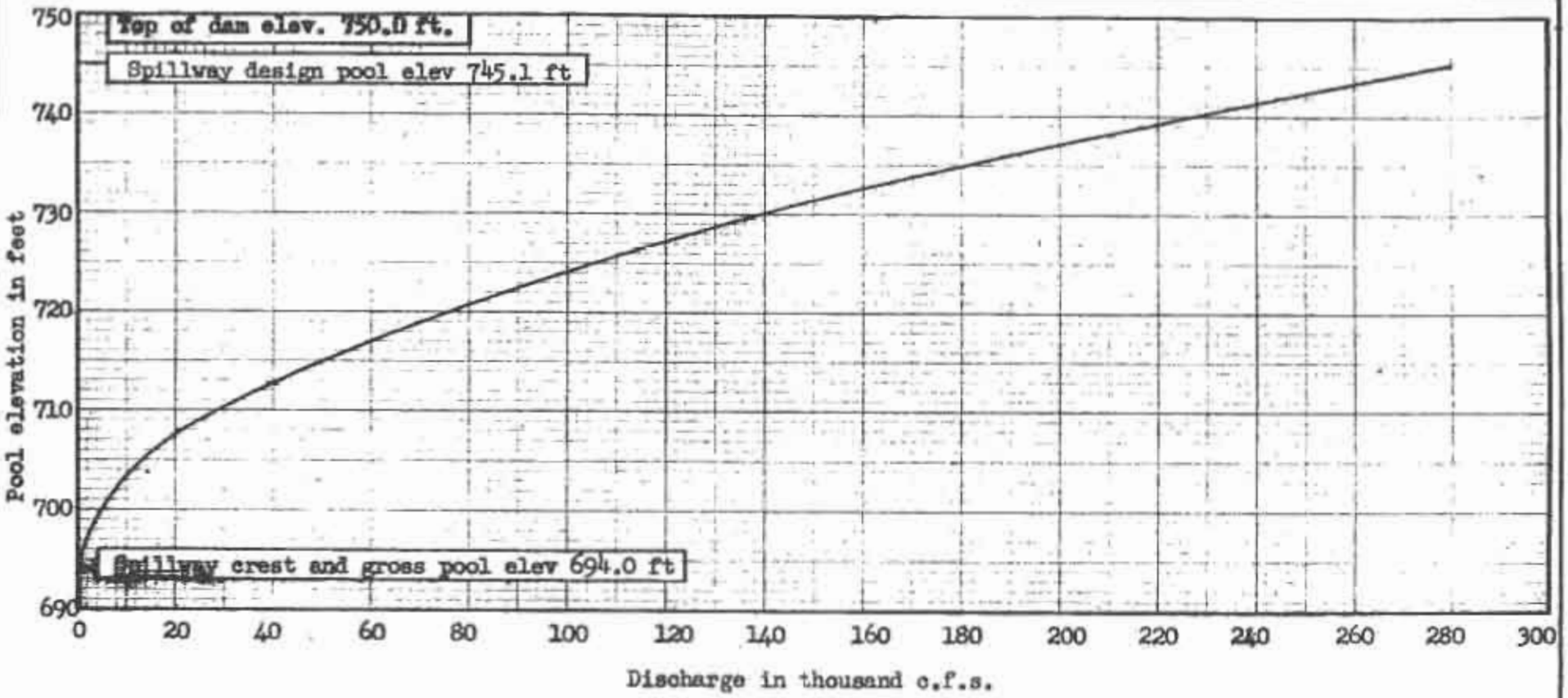
DRAWN BY: W.E.L.
CHECKED BY: F.L.T.

KAWEAH & TULE RIVERS, CALIFORNIA
TERMINUS PROJECT
KAWEAH RIVER

SPILLWAY
PLAN, PROFILE & SECTIONS

SCALE: AS SHOWN
DWG. NO. 2382
FILE NO. KT-2-9-154
SERIES NO. 154/1 TO 154/111
SHEET NO. 154/4.1
DATE DEC 19 1957

CHART 7

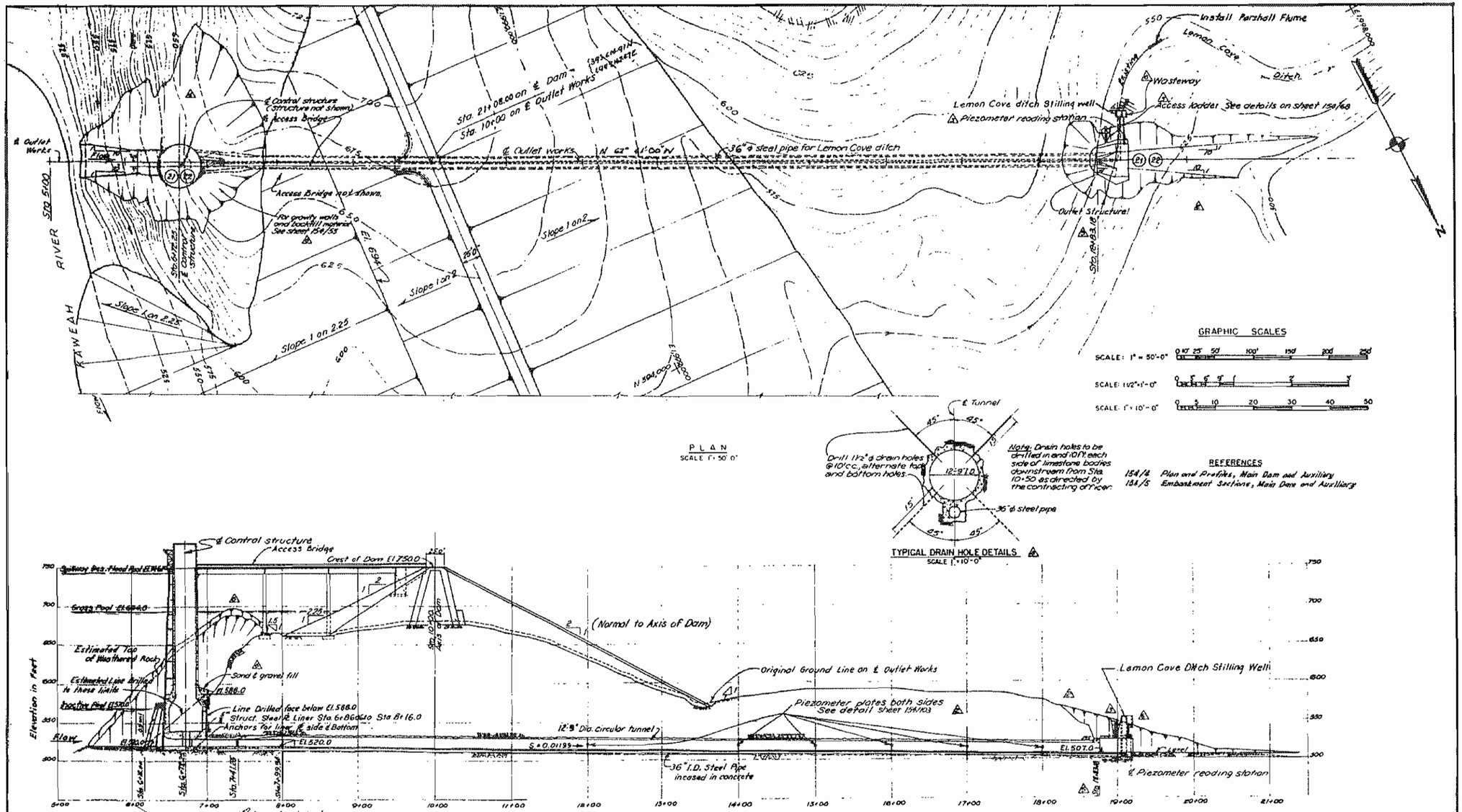


TERMINUS PROJECT
Kaweah River, California

SPILLWAY RATING CURVE

Corps of Engineers	Sacramento, Calif.
R. J. K. Oct. 1957	File: KT-2-26-179

CHART 8



GENERAL NOTES

1. Consolidation Grouting Tunnel: Type "A" - 1 1/2" Dia. - 10' into rock or to greater depth (20') if required by geologic conditions. Sta. 7+96 to Sta. 19+50 on 10 centers.
2. Contact Grouting Tunnel: Type "B" - Pipe as shown for entire length of the tunnel - 10' centers.
3. Stationing on Type "A", Type "B" is on 5' alternate stationing
4. Figures in circles, thus, ○ indicate item numbers under which payment will be made.
5. Payment for excavation in tunnel will be made at contract price item (23)
6. Payment for cement in grout will be made at contract price item (42)
7. Payment for excavation for Control Structure and Outlet Portal will be made at contract price item (21). Line drilling (22)

DIVISION	DATE	DESCRIPTION	BY	BY
4	20 Jan 65	Revised excavation lines at toe and added small gravel fill. Rev. Wasteway	JL	LD
3	15 Apr 60	Revised outlet portal	JL K	
2	18 Nov 59	Added typical drain hole details	JL K	
1	7 Aug 59	Piezometer reading station & access ladder added	A.C.	
0	30 July 58	Revised outlet portal to fit exist. excav.	A.C.	
1	10 Mar 58	Clarified grout hole spacing	K.E.M.	L.D.

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
SACRAMENTO DISTRICT
SACRAMENTO, CALIFORNIA

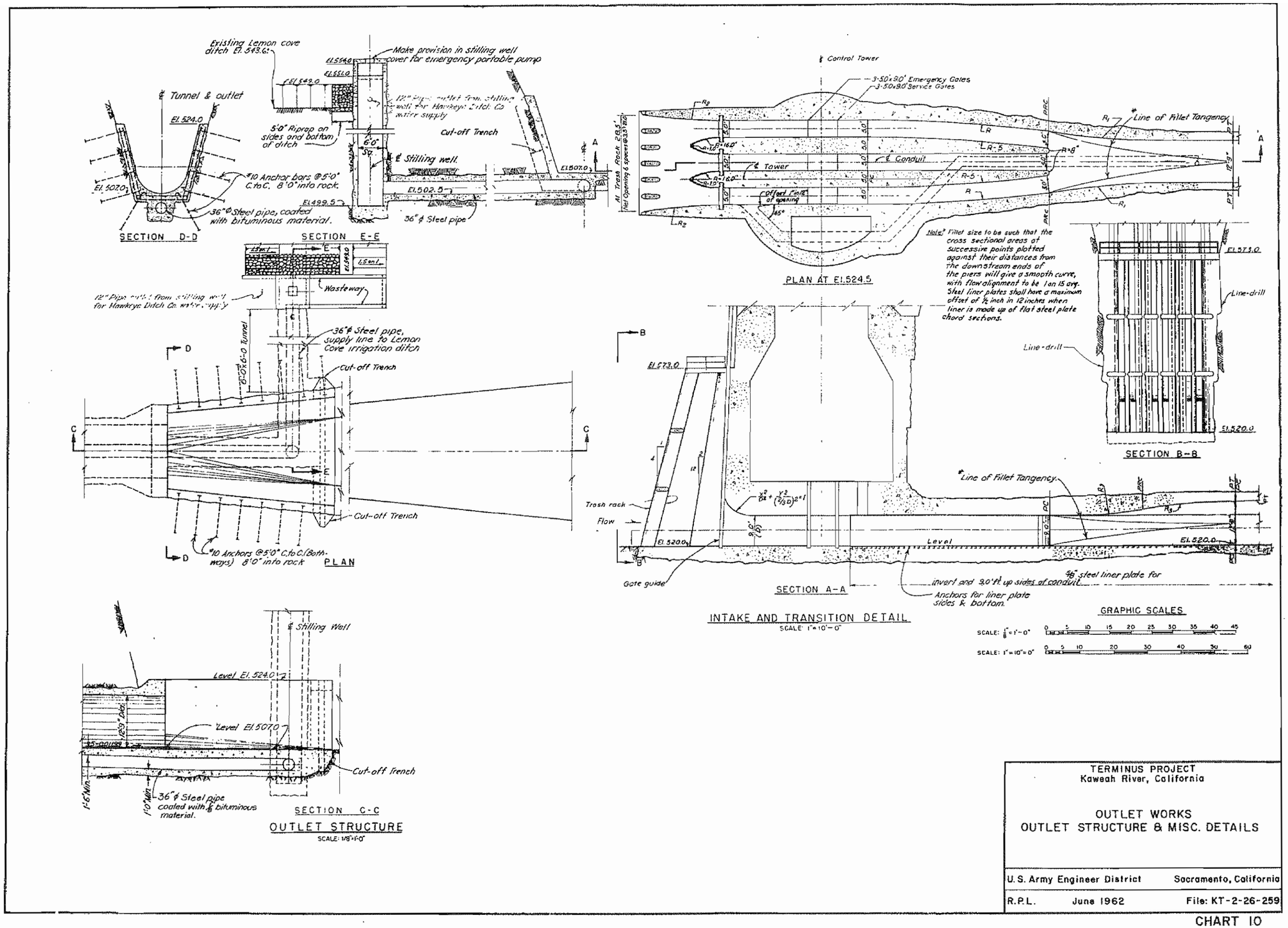
DRAWN BY: R.D. & L.H.
CHECKED BY: K.E.M.

KAWEAH AND TULE RIVERS, CALIFORNIA
TERMINUS RESERVOIR
KAWEAH RIVER

OUTLET WORKS
PLAN PROFILE AND SECTIONS

SCALE: AS SHOWN
SPEC. NO. 2382
FILE NO. KT-2-9-154
SHEETS 154/1 TO 154/11, 154/6-6
DATE: DEC 1 9 1957

CHART 9

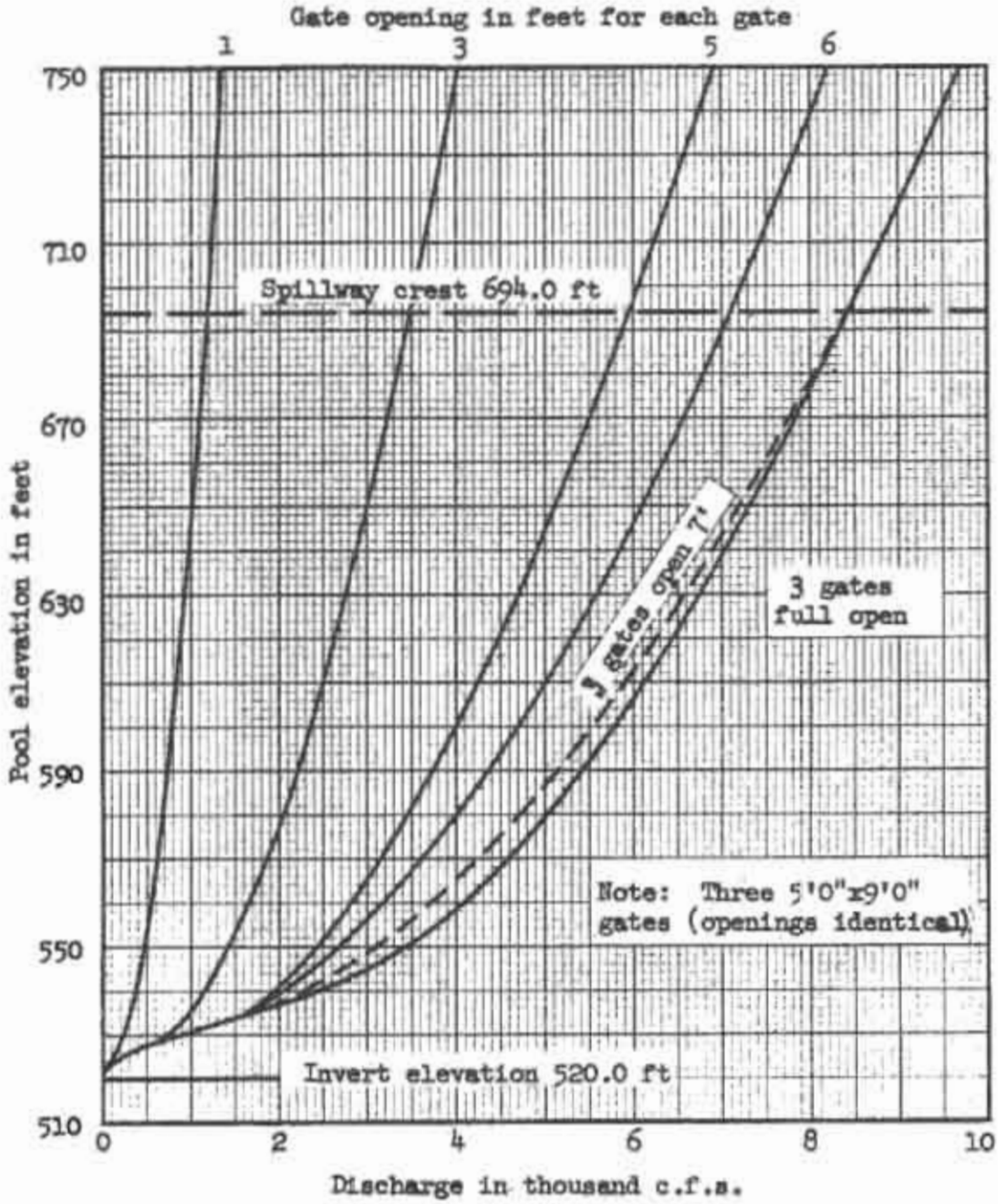


TERMINUS PROJECT
Kaweah River, California

OUTLET WORKS
OUTLET STRUCTURE & MISC. DETAILS

U.S. Army Engineer District		Sacramento, California
R.P.L.	June 1962	File: KT-2-26-259

CHART 10

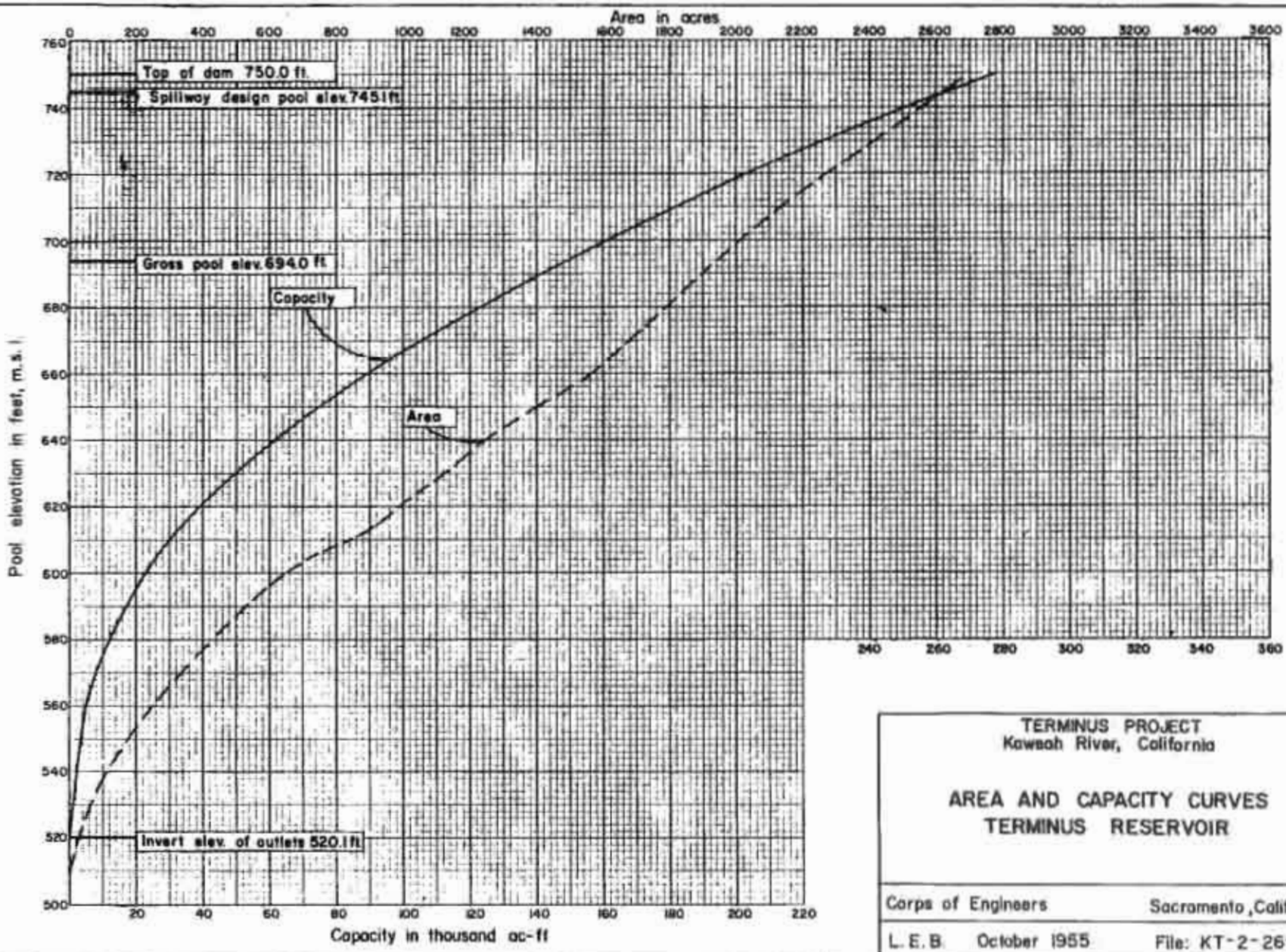


TERMINUS PROJECT
Kaweah River, California

RIVER OUTLET RATING CURVE

U S Army Engineer District
Sacramento California
H.F.R. June 1962 File: KT-2-26-253

CHART 11



TERMINUS PROJECT
Kaweah River, California

AREA AND CAPACITY CURVES
TERMINUS RESERVOIR

Corps of Engineers	Sacramento, California
L. E. B. October 1955	File: KT-2-26-182

CHART 12

TERMINUS RESERVOIR, KAWEAH RIVER, CALIFORNIA - AREA AND CAPACITY TABLE

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
520.0	166	169	172	175	177	180	183	186	189	192
	28	28	29	29	29	29	30	30	30	31
521.0	195	199	202	205	208	211	215	218	221	225
	31	31	32	32	32	32	33	33	33	34
522.0	228	231	235	238	242	245	249	252	256	260
	34	34	35	35	35	35	36	36	36	37
523.0	263	267	271	275	278	282	286	290	294	298
	37	37	38	38	38	38	39	39	39	40
524.0	302	306	310	314	318	322	326	331	335	339
	40	40	41	41	41	42	42	42	42	43
525.0	343	348	352	356	361	365	370	374	379	383
	43	43	44	44	44	45	45	45	46	46
526.0	388	393	397	402	407	411	416	421	426	431
	46	47	47	47	47	48	48	48	49	49
527.0	436	441	446	451	456	461	466	471	476	481
	49	50	50	50	51	51	51	52	52	52
528.0	487	492	497	503	508	513	519	524	530	535
	53	53	53	54	54	54	54	55	55	55
529.0	541	546	552	558	563	569	575	581	586	592
	56	56	56	57	57	57	58	58	58	59

TERMINUS RESERVOIR, KAWEAH RIVER, CALIFORNIA - AREA AND CAPACITY TABLE

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
530.0	598	604	610	616	622	628	634	641	647	653
	59	59	60	60	61	61	62	62	63	63
531.0	660	666	672	679	685	692	699	705	712	719
	64	64	65	65	66	66	67	67	68	68
532.0	726	733	739	746	753	761	768	775	782	789
	69	69	70	70	70	71	71	72	72	73
533.0	797	804	811	819	826	834	841	849	857	865
	73	74	74	75	75	76	76	77	77	78
534.0	872	880	888	896	904	912	920	929	937	945
	78	79	79	80	81	81	82	82	83	84
535.0	954	962	971	979	988	997	1005	1014	1023	1032
	84	85	86	86	87	87	88	89	89	90
536.0	1041	1050	1059	1069	1078	1087	1097	1106	1116	1126
	91	91	92	93	94	94	95	96	97	97
537.0	1135	1145	1155	1165	1175	1185	1196	1206	1216	1227
	98	99	100	100	101	102	103	103	104	105
538.0	1237	1248	1259	1269	1280	1291	1302	1313	1324	1335
	106	107	107	108	109	110	110	111	112	113
539.0	1347	1358	1370	1381	1393	1404	1416	1428	1440	1452
	113	114	115	116	116	117	118	119	119	120

TERMINUS RESERVOIR, KAWEAH RIVER, CALIFORNIA - AREA AND CAPACITY TABLE

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
540.0	1464	1476	1488	1500	1513	1525	1537	1550	1562	1575
	121	121	122	122	123	123	124	124	125	125
541.0	1587	1600	1612	1625	1638	1651	1664	1676	1689	1702
	126	126	127	127	128	128	129	129	130	130
542.0	1715	1728	1742	1755	1768	1781	1795	1808	1821	1835
	131	131	132	132	132	133	133	134	134	135
543.0	1848	1862	1876	1889	1903	1917	1930	1944	1958	1972
	135	136	136	137	137	138	138	139	139	140
544.0	1986	2000	2014	2028	2043	2057	2071	2086	2100	2115
	140	141	141	142	142	143	144	144	145	145
545.0	2129	2144	2158	2173	2188	2203	2218	2233	2248	2263
	146	146	147	148	148	149	149	150	150	151
546.0	2278	2293	2308	2324	2339	2354	2370	2386	2401	2417
	152	152	153	154	154	155	156	156	157	157
547.0	2433	2449	2464	2480	2497	2513	2529	2545	2561	2578
	158	159	159	160	161	161	162	163	163	164
548.0	2594	2611	2627	2644	2661	2677	2694	2711	2728	2745
	165	165	166	167	167	168	169	169	170	171
549.0	2762	2779	2797	2814	2831	2849	2866	2884	2901	2919
	171	172	173	173	174	175	175	176	177	177

TERMINUS RESERVOIR, KAWEAH RIVER, CALIFORNIA - AREA AND CAPACITY TABLE

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
550.0	2937	2955	2973	2991	3009	3027	3045	3063	3082	3100
	178	179	179	180	181	182	182	183	184	184
551.0	3118	3137	3156	3174	3193	3212	3231	3250	3269	3288
	185	186	187	187	188	189	189	190	191	192
552.0	3307	3326	3346	3365	3385	3404	3424	3444	3463	3483
	192	193	194	195	195	196	197	197	198	199
553.0	3503	3523	3543	3563	3584	3604	3624	3645	3665	3686
	200	200	201	202	202	203	204	205	205	206
554.0	3706	3727	3748	3769	3790	3811	3832	3853	3874	3896
	207	208	208	209	210	211	211	212	213	214
555.0	3917	3939	3960	3982	4003	4025	4047	4069	4091	4113
	215	215	216	217	218	219	219	220	221	222
556.0	4136	4158	4180	4203	4225	4248	4271	4294	4316	4339
	223	223	224	225	226	227	228	229	229	230
557.0	4362	4386	4409	4432	4456	4479	4503	4526	4550	4574
	231	232	233	234	235	235	236	237	238	239
558.0	4598	4622	4646	4670	4695	4719	4743	4768	4792	4817
	240	241	241	242	243	244	245	246	247	247
559.0	4842	4867	4892	4917	4942	4967	4993	5018	5043	5069
	248	249	250	251	252	253	254	254	255	256

June 1966

TERMINUS RESERVOIR, KAWEAH RIVER, CALIFORNIA - AREA AND CAPACITY TABLE

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
560.0	5093	5119	5145	5170	5196	5223	5249	5275	5301	5328
	257	258	259	260	261	261	262	263	264	265
561.0	5354	5381	5408	5435	5462	5489	5516	5543	5570	5597
	266	267	268	269	270	270	271	272	273	274
562.0	5625	5652	5680	5708	5736	5763	5791	5820	5848	5876
	275	276	277	278	279	279	280	281	282	283
563.0	5904	5933	5961	5990	6019	6047	6076	6105	6134	6164
	284	285	286	287	288	288	289	290	291	292
564.0	6193	6222	6252	6281	6311	6340	6370	6400	6430	6460
	293	294	295	296	296	297	298	299	300	301
565.0	6490	6520	6551	6581	6611	6642	6673	6703	6734	6765
	302	303	303	304	305	306	307	308	309	310
566.0	6796	6827	6858	6890	6921	6952	6984	7015	7047	7079
	310	311	312	313	314	315	315	316	317	318
567.0	7111	7143	7175	7207	7239	7271	7303	7336	7368	7401
	319	320	320	321	322	323	324	325	326	326
568.0	7434	7466	7499	7532	7565	7598	7631	7665	7698	7731
	327	328	329	330	331	331	332	333	334	335
569.0	7765	7799	7832	7866	7900	7934	7968	8002	8036	8070
	336	336	337	338	339	340	341	341	342	343

TERMINUS RESERVOIR, KAWEAH RIVER, CALIFORNIA - AREA AND CAPACITY TABLE

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
570.0	8105	8139	8174	8208	8243	8278	8313	8348	8383	8418
	344	345	346	347	347	348	349	350	351	352
571.0	8453	8488	8524	8559	8595	8631	8666	8702	8738	8774
	353	354	354	355	356	357	358	359	360	361
572.0	8810	8846	8883	8919	8956	8992	9029	9065	9102	9139
	362	362	363	364	365	366	367	368	369	370
573.0	9176	9213	9250	9288	9325	9363	9400	9438	9475	9513
	370	371	372	373	374	375	376	377	378	379
574.0	9551	9589	9627	9665	9704	9742	9780	9819	9858	9896
	379	380	381	382	383	384	385	386	387	388
575.0	9935	9974	10013	10052	10091	10131	10170	10210	10249	10289
	389	390	390	391	392	393	394	395	396	397
576.0	10328	10368	10408	10448	10488	10529	10569	10609	10650	10690
	398	399	400	401	402	403	403	404	405	406
577.0	10731	10772	10813	10854	10895	10936	10977	11018	11060	11101
	407	408	409	410	411	412	413	414	415	416
578.0	11143	11185	11227	11268	11310	11353	11395	11437	11479	11522
	417	418	419	420	421	422	422	423	424	425
579.0	11565	11607	11650	11693	11736	11779	11822	11865	11909	11952
	426	427	428	429	430	431	432	433	434	435

TERMINUS RESERVOIR, KAWEAH RIVER, CALIFORNIA - AREA AND CAPACITY TABLE

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
580.0	11996	12039	12083	12127	12171	12215	12259	12303	12347	12392
	436	437	438	439	440	440	441	442	443	444
581.0	12436	12481	12525	12570	12615	12660	12705	12750	12795	12840
	445	446	447	448	449	450	450	451	452	453
582.0	12886	12931	12977	13022	13068	13114	13160	13206	13252	13298
	454	455	456	457	458	459	460	461	461	462
583.0	13344	13391	13437	13484	13531	13577	13624	13671	13718	13765
	463	464	465	466	467	468	469	470	471	472
584.0	13812	13860	13907	13955	14002	14050	14098	14146	14194	14242
	473	474	474	475	476	477	478	479	480	481
585.0	14290	14338	14386	14435	14483	14532	14581	14630	14679	14728
	482	483	484	485	487	488	489	490	491	492
586.0	14777	14827	14876	14926	14976	15025	15075	15126	15176	15226
	493	494	496	497	498	499	500	501	502	504
587.0	15276	15327	15378	15428	15479	15530	15581	15633	15684	15735
	505	506	507	508	509	510	512	513	514	515
588.0	15787	15839	15890	15942	15994	16046	16099	16151	16203	16256
	516	517	518	519	521	522	523	524	525	526
589.0	16309	16361	16414	16467	16521	16574	16627	16681	16734	16788
	527	529	530	531	532	533	534	536	537	538

TERMINUS RESERVOIR, KAWEAH RIVER, CALIFORNIA - AREA AND CAPACITY TABLE

ELEV FEET	CAP AREA *0	CAP AREA *1	CAP AREA *2	CAP AREA *3	CAP AREA *4	CAP AREA *5	CAP AREA *6	CAP AREA *7	CAP AREA *8	CAP AREA *9
590.0	16842	16896	16950	17004	17058	17113	17167	17222	17276	17331
	539	540	541	542	543	544	545	546	547	548
591.0	17386	17441	17496	17551	17606	17661	17717	17772	17828	17884
	549	550	551	552	553	554	555	556	557	558
592.0	17940	17995	18051	18108	18164	18220	18277	18333	18390	18446
	559	560	561	562	563	564	565	566	567	568
593.0	18503	18560	18617	18674	18732	18789	18846	18904	18961	19019
	569	570	571	572	573	574	575	576	577	578
594.0	19077	19135	19193	19251	19309	19368	19426	19485	19543	19602
	579	580	581	582	583	584	585	586	587	588
595.0	19661	19720	19779	19838	19898	19957	20017	20076	20136	20196
	589	590	592	593	594	595	597	598	599	600
596.0	20256	20317	20377	20437	20498	20559	20620	20681	20742	20803
	602	603	604	606	607	608	609	611	612	613
597.0	20864	20926	20988	21049	21111	21173	21236	21298	21360	21423
	615	616	617	618	620	621	622	624	625	626
598.0	21486	21548	21611	21674	21738	21801	21864	21928	21992	22056
	628	629	630	632	633	634	635	637	638	639
599.0	22120	22184	22248	22312	22377	22442	22506	22571	22636	22702
	641	642	643	645	646	647	649	650	651	653

TERMINUS RESERVOIR, KAWEAH RIVER, CALIFORNIA - AREA AND CAPACITY TABLE

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
600.0	22767	22832	22898	22964	23030	23096	23162	23229	23295	23362
	654	656	657	659	660	662	663	665	666	668
601.0	23429	23496	23563	23630	23698	23766	23833	23901	23969	24038
	670	671	673	674	676	677	679	681	682	684
602.0	24106	24175	24244	24312	24381	24451	24520	24590	24659	24729
	685	687	688	690	691	693	694	696	698	699
603.0	24799	24869	24940	25010	25081	25151	25222	25293	25365	25436
	701	702	704	705	707	709	710	712	713	715
604.0	25508	25579	25651	25723	25796	25868	25941	26014	26087	26160
	716	718	720	722	724	726	727	729	731	733
605.0	26233	26307	26381	26455	26529	26603	26677	26752	26827	26902
	735	737	738	740	742	744	746	748	750	752
606.0	26977	27053	27128	27204	27280	27357	27433	27510	27587	27664
	753	756	758	760	762	764	766	768	770	773
607.0	27741	27819	27897	27975	28053	28131	28210	28289	28368	28447
	775	777	779	781	783	785	788	790	792	794
608.0	28527	28606	28686	28767	28847	28927	29008	29089	29170	29252
	796	798	800	803	805	807	809	811	813	815
609.0	29334	29415	29497	29580	29662	29745	29828	29911	29994	30078
	817	820	822	824	826	828	830	833	835	837

TERMINUS RESERVOIR, KAWEAH RIVER, CALIFORNIA - AREA AND CAPACITY TABLE

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
610.0	30162	30246	30330	30414	30499	30583	30668	30753	30839	30924
	839	841	842	844	846	848	849	851	853	855
611.0	31009	31095	31181	31267	31353	31440	31527	31613	31700	31787
	857	858	860	862	864	865	867	869	871	872
612.0	31875	31962	32050	32138	32226	32314	32402	32491	32580	32669
	874	876	878	879	881	883	885	886	888	890
613.0	32758	32847	32936	33026	33116	33206	33296	33386	33477	33567
	892	893	895	897	899	901	902	904	906	908
614.0	33658	33749	33841	33932	34023	34115	34207	34299	34391	34484
	909	911	913	915	916	918	920	922	923	925
615.0	34576	34669	34762	34855	34948	35041	35135	35228	35322	35415
	927	928	929	930	932	933	934	935	936	937
616.0	35509	35603	35697	35791	35885	35980	36074	36169	36264	36358
	938	940	941	942	943	944	945	946	947	949
617.0	36453	36548	36643	36739	36834	36930	37025	37121	37217	37313
	950	951	952	953	954	955	957	958	959	960
618.0	37409	37505	37601	37698	37794	37891	37987	38084	38181	38278
	961	962	963	965	966	967	968	969	970	971
619.0	38376	38473	38570	38668	38766	38863	38961	39059	39157	39256
	973	974	975	976	977	978	979	981	982	983

TERMINUS RESERVOIR, KAWEAH RIVER, CALIFORNIA - AREA AND CAPACITY TABLE

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
620.0	39354	39452	39551	39650	39749	39848	39947	40046	40145	40245
	984	985	987	988	989	991	992	993	995	996
621.0	40344	40444	40544	40644	40744	40845	40945	41046	41146	41247
	997	998	1000	1001	1002	1004	1005	1006	1008	1009
622.0	41348	41449	41551	41652	41753	41855	41957	42059	42161	42263
	1010	1012	1013	1014	1016	1017	1018	1020	1021	1022
623.0	42365	42468	42570	42673	42776	42879	42982	43085	43188	43292
	1024	1025	1026	1028	1029	1030	1031	1033	1034	1035
624.0	43395	43499	43603	43707	43811	43916	44020	44125	44229	44334
	1037	1038	1040	1041	1042	1044	1045	1046	1048	1049
625.0	44439	44544	44649	44755	44860	44966	45072	45178	45284	45390
	1051	1052	1053	1055	1056	1057	1059	1060	1062	1063
626.0	45497	45603	45710	45816	45923	46031	46138	46245	46353	46460
	1064	1066	1067	1069	1070	1072	1073	1074	1076	1077
627.0	46568	46676	46784	46892	47001	47109	47218	47327	47436	47545
	1079	1080	1082	1083	1085	1086	1087	1089	1090	1092
628.0	47654	47763	47873	47983	48092	48202	48313	48423	48533	48644
	1093	1095	1096	1097	1099	1100	1102	1103	1105	1106
629.0	48754	48865	48976	49087	49199	49310	49422	49533	49645	49757
	1108	1109	1110	1112	1113	1115	1116	1118	1119	1121

TERMINUS RESERVOIR, KAWEAH RIVER, CALIFORNIA - AREA AND CAPACITY TABLE

ELEV FEET	CAP AREA *0	CAP AREA *1	CAP AREA *2	CAP AREA *3	CAP AREA *4	CAP AREA *5	CAP AREA *6	CAP AREA *7	CAP AREA *8	CAP AREA *9
630.0	49869	49981	50094	50206	50319	50432	50544	50657	50771	50884
	1122	1123	1124	1125	1127	1128	1129	1130	1131	1132
631.0	50997	51110	51224	51338	51451	51565	51679	51793	51908	52022
	1134	1135	1136	1137	1139	1139	1141	1142	1143	1144
632.0	52136	52251	52366	52480	52595	52710	52826	52941	53056	53172
	1145	1146	1148	1149	1150	1151	1152	1153	1154	1156
633.0	53287	53403	53519	53635	53751	53867	53984	54100	54217	54333
	1157	1158	1159	1160	1161	1163	1164	1165	1166	1167
634.0	54450	54567	54684	54801	54918	55036	55153	55271	55389	55507
	1168	1170	1171	1172	1173	1175	1176	1177	1178	1180
635.0	55625	55743	55861	55979	56098	56217	56335	56454	56573	56693
	1181	1182	1183	1185	1186	1187	1189	1190	1191	1192
636.0	56812	56931	57051	57171	57290	57410	57531	57651	57771	57892
	1194	1195	1196	1198	1199	1200	1202	1203	1204	1206
637.0	58012	58133	58254	58375	58496	58618	58739	58861	58982	59104
	1207	1209	1210	1211	1213	1214	1215	1217	1218	1219
638.0	59226	59348	59471	59593	59716	59838	59961	60084	60207	60330
	1221	1222	1224	1225	1226	1228	1229	1230	1232	1233
639.0	60454	60577	60701	60825	60949	61073	61197	61321	61446	61570
	1234	1236	1237	1238	1240	1241	1243	1244	1245	1247

CHART 13

TERMINUS RESERVOIR, KAWEAH RIVER, CALIFORNIA - AREA AND CAPACITY TABLE

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
640.0	61695	61820	61945	62070	62195	62321	62446	62572	62698	62824
	1248	1249	1251	1252	1254	1255	1257	1258	1260	1261
641.0	62950	63077	63203	63330	63457	63584	63711	63838	63966	64093
	1263	1264	1266	1267	1269	1270	1272	1273	1275	1276
642.0	64221	64349	64477	64605	64733	64862	64990	65119	65248	65377
	1278	1279	1281	1282	1284	1285	1287	1288	1290	1291
643.0	65506	65636	65765	65895	66025	66155	66285	66415	66546	66676
	1293	1294	1296	1297	1299	1300	1302	1303	1305	1306
644.0	66807	66938	67069	67200	67331	67463	67595	67726	67858	67990
	1308	1310	1311	1313	1314	1316	1317	1319	1321	1322
645.0	68123	68255	68388	68521	68653	68787	68920	69053	69187	69320
	1324	1325	1327	1328	1330	1332	1333	1335	1336	1338
646.0	69454	69588	69722	69857	69991	70126	70261	70396	70531	70666
	1339	1341	1343	1344	1346	1348	1349	1351	1352	1354
647.0	70802	70937	71073	71209	71345	71482	71618	71755	71892	72029
	1356	1357	1359	1361	1362	1364	1366	1367	1369	1371
648.0	72166	72303	72441	72578	72716	72854	72992	73130	73269	73407
	1372	1374	1375	1377	1379	1380	1382	1384	1385	1387
649.0	73546	73685	73824	73963	74103	74242	74382	74522	74662	74802
	1389	1390	1392	1393	1395	1397	1398	1400	1402	1403

TERMINUS RESERVOIR, KAWEAH RIVER, CALIFORNIA - AREA AND CAPACITY TABLE

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
650.0	74943	75083	75224	75365	75506	75648	75789	75931	76073	76215
	1405	1407	1409	1410	1412	1414	1416	1417	1419	1421
651.0	76357	76499	76642	76784	76927	77070	77213	77357	77500	77644
	1423	1424	1426	1428	1430	1431	1433	1435	1437	1438
652.0	77788	77932	78076	78221	78366	78510	78655	78801	78946	79091
	1440	1442	1444	1445	1447	1449	1451	1452	1454	1456
653.0	79237	79383	79529	79675	79822	79968	80115	80262	80409	80556
	1458	1460	1461	1463	1465	1467	1468	1470	1472	1474
654.0	80704	80851	80999	81147	81295	81444	81592	81741	81890	82039
	1475	1477	1479	1481	1482	1484	1486	1488	1489	1491
655.0	82188	82337	82487	82636	82786	82936	83086	83236	83386	83537
	1493	1494	1496	1497	1498	1500	1501	1502	1504	1505
656.0	83687	83838	83989	84140	84291	84442	84593	84745	84897	85048
	1506	1508	1509	1510	1511	1513	1514	1515	1517	1518
657.0	85200	85352	85504	85657	85809	85962	86114	86267	86420	86573
	1519	1521	1522	1523	1525	1526	1527	1529	1530	1531
658.0	86726	86879	87033	87187	87340	87494	87648	87802	87956	88111
	1533	1534	1535	1537	1538	1539	1541	1542	1543	1545
659.0	88265	88420	88575	88730	88885	89040	89195	89351	89506	89662
	1546	1547	1549	1550	1551	1552	1554	1555	1556	1558

TERMINUS RESERVOIR, KAWEAH RIVER, CALIFORNIA - AREA AND CAPACITY TABLE

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
660.0	89818	89974	90130	90286	90442	90599	90755	90912	91069	91226
	1559	1560	1561	1563	1564	1565	1566	1568	1569	1570
661.0	91383	91540	91697	91855	92012	92170	92328	92486	92644	92802
	1571	1572	1574	1575	1576	1577	1579	1580	1581	1582
662.0	92960	93119	93277	93436	93595	93753	93912	94072	94231	94390
	1583	1585	1586	1587	1588	1589	1591	1592	1593	1594
663.0	94550	94709	94869	95029	95189	95349	95509	95670	95830	95991
	1596	1597	1598	1599	1600	1602	1603	1604	1605	1607
664.0	96151	96312	96473	96634	96795	96957	97118	97280	97442	97603
	1608	1609	1610	1611	1613	1614	1615	1616	1617	1619
665.0	97765	97927	98089	98252	98414	98577	98739	98902	99065	99228
	1620	1621	1622	1624	1625	1626	1627	1628	1630	1631
666.0	99391	99554	99718	99881	100045	100209	100373	100537	100701	100865
	1632	1633	1634	1636	1637	1638	1639	1640	1642	1643
667.0	101029	101194	101358	101523	101688	101853	102018	102183	102348	102514
	1644	1645	1646	1648	1649	1650	1651	1652	1654	1655
668.0	102679	102845	103011	103176	103343	103509	103675	103841	104008	104174
	1656	1657	1658	1660	1661	1662	1663	1664	1666	1667
669.0	104341	104508	104675	104842	105009	105177	105344	105512	105679	105847
	1668	1669	1670	1672	1673	1674	1675	1676	1678	1679

TERMINUS RESERVOIR, KAWEAH RIVER, CALIFORNIA - AREA AND CAPACITY TABLE

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
670.0	106015	106183	106351	106520	106688	106857	107025	107194	107363	107532
	1680	1681	1683	1684	1685	1686	1688	1689	1690	1691
671.0	107702	107871	108040	108210	108380	108549	108719	108890	109060	109230
	1693	1694	1695	1697	1698	1699	1700	1702	1703	1704
672.0	109401	109571	109742	109913	110084	110255	110426	110598	110769	110941
	1706	1707	1708	1709	1711	1712	1713	1715	1716	1717
673.0	111113	111285	111457	111629	111801	111973	112146	112319	112491	112664
	1718	1720	1721	1722	1723	1725	1726	1727	1729	1730
674.0	112837	113011	113184	113357	113531	113705	113878	114052	114227	114401
	1731	1732	1734	1735	1736	1738	1739	1740	1741	1743
675.0	114575	114750	114924	115099	115273	115448	115623	115798	115974	116149
	1744	1745	1746	1747	1748	1749	1750	1751	1752	1753
676.0	116324	116500	116675	116851	117027	117203	117379	117555	117731	117907
	1754	1755	1756	1757	1758	1759	1760	1761	1762	1763
677.0	118083	118260	118437	118613	118790	118967	119144	119321	119498	119676
	1764	1765	1766	1767	1768	1769	1771	1772	1773	1774
678.0	119853	120030	120208	120386	120564	120742	120920	121098	121276	121454
	1775	1776	1777	1778	1779	1780	1781	1782	1783	1784
679.0	121633	121811	121990	122169	122347	122526	122705	122884	123064	123243
	1785	1786	1787	1788	1789	1790	1791	1792	1793	1794

TERMINUS RESERVOIR, KAWEAH RIVER, CALIFORNIA - AREA AND CAPACITY TABLE

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
680.0	123423	123602	123782	123962	124141	124321	124501	124682	124862	125042
	1795	1796	1797	1798	1799	1800	1802	1803	1804	1805
681.0	125223	125404	125584	125765	125946	126127	126309	126490	126671	126853
	1806	1807	1808	1809	1810	1811	1813	1814	1815	1816
682.0	127034	127216	127398	127580	127762	127944	128127	128309	128491	128674
	1817	1818	1819	1820	1821	1822	1823	1825	1826	1827
683.0	128857	129040	129223	129406	129589	129772	129956	130139	130323	130506
	1828	1829	1830	1831	1832	1833	1835	1836	1837	1838
684.0	130690	130874	131058	131242	131427	131611	131796	131980	132165	132350
	1839	1840	1841	1842	1843	1844	1846	1847	1848	1849
685.0	132535	132720	132905	133090	133275	133461	133646	133832	134018	134204
	1850	1851	1852	1853	1854	1855	1856	1857	1858	1859
686.0	134390	134576	134762	134948	135134	135321	135507	135694	135881	136068
	1860	1861	1862	1863	1864	1865	1866	1867	1868	1869
687.0	136255	136442	136629	136816	137003	137191	137378	137566	137754	137942
	1870	1871	1872	1873	1874	1875	1876	1877	1878	1879
688.0	138129	138318	138506	138694	138882	139071	139259	139448	139637	139825
	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889
689.0	140014	140203	140393	140582	140771	140961	141150	141340	141530	141719
	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899

TERMINUS RESERVOIR, KAWEAH RIVER, CALIFORNIA - AREA AND CAPACITY TABLE

ELEV FEET	CAP AREA •0	CAP AREA •1	CAP AREA •2	CAP AREA •3	CAP AREA •4	CAP AREA •5	CAP AREA •6	CAP AREA •7	CAP AREA •8	CAP AREA •9
690.0	141909	142099	142290	142480	142670	142861	143051	143242	143433	143624
	1900	1901	1902	1903	1904	1906	1907	1908	1909	1910
691.0	143815	144006	144197	144389	144580	144772	144964	145155	145347	145539
	1911	1912	1913	1914	1916	1917	1918	1919	1920	1921
692.0	145732	145924	146116	146309	146501	146694	146887	147080	147273	147466
	1922	1923	1925	1926	1927	1928	1929	1930	1931	1932
693.0	147660	147853	148046	148240	148434	148628	148822	149016	149210	149404
	1934	1935	1936	1937	1938	1939	1940	1941	1942	1944
694.0	149599	149793	149988	150183	150377	150572	150768	150963	151158	151354
	1945	1946	1947	1948	1949	1950	1951	1953	1954	1955
695.0	151549	151745	151940	152136	152332	152529	152725	152921	153118	153314
	1956	1957	1958	1960	1961	1962	1963	1964	1965	1967
696.0	153511	153708	153905	154102	154299	154496	154694	154891	155089	155287
	1968	1969	1970	1971	1972	1974	1975	1976	1977	1978
697.0	155485	155683	155881	156079	156277	156476	156674	156873	157072	157271
	1979	1981	1982	1983	1984	1985	1987	1988	1989	1990
698.0	157470	157669	157868	158068	158267	158467	158667	158867	159067	159267
	1991	1992	1994	1995	1996	1997	1998	2000	2001	2002
699.0	159467	159667	159868	160069	160269	160470	160671	160872	161073	161275
	2003	2004	2006	2007	2008	2009	2010	2011	2013	2014

TERMINUS RESERVOIR, KAWEAH RIVER, CALIFORNIA - AREA AND CAPACITY TABLE

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
700.0	161476	161678	161879	162081	162283	162485	162687	162889	163092	163294
	2015	2016	2017	2018	2019	2020	2022	2023	2024	2025
701.0	163497	163699	163902	164105	164308	164511	164714	164917	165121	165324
	2026	2027	2028	2029	2030	2031	2033	2034	2035	2036
702.0	165528	165732	165936	166140	166344	166548	166752	166957	167161	167366
	2037	2038	2039	2040	2041	2042	2044	2045	2046	2047
703.0	167570	167775	167980	168185	168391	168596	168801	169007	169212	169418
	2048	2049	2050	2051	2052	2053	2055	2056	2057	2058
704.0	169624	169830	170036	170242	170448	170655	170861	171068	171275	171481
	2059	2060	2061	2062	2063	2064	2066	2067	2068	2069
705.0	171688	171895	172103	172310	172517	172725	172933	173141	173349	173557
	2070	2071	2073	2074	2076	2077	2078	2080	2081	2083
706.0	173765	173974	174182	174391	174600	174809	175018	175228	175437	175647
	2084	2085	2087	2088	2090	2091	2092	2094	2095	2097
707.0	175856	176066	176276	176486	176697	176907	177118	177328	177539	177750
	2098	2099	2101	2102	2104	2105	2106	2108	2109	2111
708.0	177961	178173	178384	178596	178807	179019	179231	179443	179655	179868
	2112	2113	2115	2116	2118	2119	2120	2122	2123	2125
709.0	180080	180293	180506	180719	180932	181145	181358	181572	181786	181999
	2126	2127	2129	2130	2132	2133	2134	2136	2137	2139

TERMINUS RESERVOIR, KAWEAH RIVER,CALIFORNIA - AREA AND CAPACITY TABLE

ELEV FEET	CAP AREA *0	CAP AREA *1	CAP AREA *2	CAP AREA *3	CAP AREA *4	CAP AREA *5	CAP AREA *6	CAP AREA *7	CAP AREA *8	CAP AREA *9
710.0	182213	182427	182642	182856	183070	183285	183500	183715	183930	184145
	2140	2141	2143	2144	2146	2147	2148	2150	2151	2153
711.0	184360	184576	184791	185007	185223	185439	185655	185872	186088	186305
	2154	2156	2157	2158	2160	2161	2163	2164	2165	2167
712.0	186521	186738	186955	187173	187390	187607	187825	188043	188261	188479
	2168	2170	2171	2173	2174	2175	2177	2178	2180	2181
713.0	188697	188915	189134	189352	189571	189790	190009	190228	190447	190667
	2182	2184	2185	2187	2188	2190	2191	2192	2194	2195
714.0	190886	191106	191326	191546	191766	191987	192207	192428	192648	192869
	2197	2198	2200	2201	2202	2204	2205	2207	2208	2210
715.0	193090	193311	193533	193754	193976	194198	194419	194642	194864	195086
	2211	2212	2214	2215	2217	2218	2220	2221	2223	2224
716.0	195309	195531	195754	195977	196200	196423	196646	196870	197094	197317
	2226	2227	2228	2230	2231	2233	2234	2236	2237	2239
717.0	197541	197765	197990	198214	198438	198663	198888	199113	199338	199563
	2240	2242	2243	2244	2246	2247	2249	2250	2252	2253
718.0	199789	200014	200240	200466	200692	200918	201144	201370	201597	201824
	2255	2256	2258	2259	2261	2262	2263	2265	2266	2268
719.0	202051	202278	202505	202732	202960	203187	203415	203643	203871	204099
	2269	2271	2272	2274	2275	2277	2278	2280	2281	2283

TERMINUS RESERVOIR, KAWEAH RIVER, CALIFORNIA - AREA AND CAPACITY TABLE

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
720.0	204327	204556	204784	205013	205242	205471	205700	205929	206159	206388
	2284	2285	2287	2288	2289	2291	2292	2294	2295	2296
721.0	206618	206848	207078	207308	207538	207769	207999	208230	208461	208692
	2298	2299	2300	2302	2303	2305	2306	2307	2309	2310
722.0	208923	209154	209385	209617	209848	210080	210312	210544	210776	211009
	2311	2313	2314	2316	2317	2318	2320	2321	2323	2324
723.0	211241	211474	211706	211939	212172	212405	212639	212872	213106	213339
	2325	2327	2328	2329	2331	2332	2334	2335	2336	2338
724.0	213573	213807	214041	214276	214510	214745	214979	215214	215449	215684
	2339	2341	2342	2343	2345	2346	2347	2349	2350	2352
725.0	215919	216155	216390	216626	216862	217098	217334	217570	217806	218043
	2353	2354	2356	2357	2358	2360	2361	2363	2364	2365
726.0	218279	218516	218753	218990	219227	219464	219702	219939	220177	220415
	2367	2368	2369	2371	2372	2374	2375	2376	2378	2379
727.0	220653	220891	221129	221368	221606	221845	222084	222323	222562	222801
	2380	2382	2383	2385	2386	2387	2389	2390	2392	2393
728.0	223040	223280	223519	223759	223999	224239	224479	224720	224960	225201
	2394	2396	2397	2398	2400	2401	2403	2404	2405	2407
729.0	225441	225682	225923	226164	226406	226647	226889	227130	227372	227614
	2408	2410	2411	2412	2414	2415	2416	2418	2419	2421

TERMINUS RESERVOIR, KAWEAH RIVER,CALIFORNIA - AREA AND CAPACITY TABLE

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
730.0	227856	228099	228341	228584	228826	229069	229312	229555	229798	230042
	2422	2423	2425	2426	2428	2429	2430	2432	2433	2434
731.0	230285	230529	230773	231017	231261	231505	231749	231994	232238	232483
	2436	2437	2439	2440	2441	2443	2444	2445	2447	2448
732.0	232728	232973	233218	233463	233709	233955	234200	234446	234692	234938
	2450	2451	2452	2454	2455	2456	2458	2459	2461	2462
733.0	235184	235431	235677	235924	236171	236418	236665	236912	237160	237407
	2463	2465	2466	2467	2469	2470	2472	2473	2474	2476
734.0	237655	237903	238150	238399	238647	238895	239144	239392	239641	239890
	2477	2479	2480	2481	2483	2484	2485	2487	2488	2490
735.0	240139	240388	240637	240887	241136	241386	241636	241886	242136	242386
	2491	2492	2494	2495	2496	2498	2499	2501	2502	2503
736.0	242637	242887	243138	243389	243640	243891	244142	244393	244645	244896
	2505	2506	2507	2509	2510	2512	2513	2514	2516	2517
737.0	245148	245400	245652	245904	246157	246409	246662	246915	247167	247420
	2518	2520	2521	2523	2524	2525	2527	2528	2530	2531
738.0	247674	247927	248180	248434	248688	248942	249196	249450	249704	249958
	2532	2534	2535	2536	2538	2539	2541	2542	2543	2545
739.0	250213	250468	250722	250977	251232	251488	251743	251999	252254	252510
	2546	2548	2549	2550	2552	2553	2554	2556	2557	2559

TERMINUS RESERVOIR, KAWEAH RIVER, CALIFORNIA - AREA AND CAPACITY TABLE

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
740.0	252766	253022	253278	253535	253791	254048	254304	254561	254818	255075
	2560	2561	2563	2564	2566	2567	2568	2570	2571	2572
741.0	255333	255590	255848	256106	256363	256621	256880	257138	257396	257655
	2574	2575	2577	2578	2579	2581	2582	2583	2585	2586
742.0	257913	258172	258431	258690	258950	259209	259469	259728	259988	260248
	2588	2589	2590	2592	2593	2594	2596	2597	2599	2600
743.0	260508	260768	261029	261289	261550	261810	262071	262332	262593	262855
	2601	2603	2604	2605	2607	2608	2610	2611	2612	2614
744.0	263116	263378	263640	263901	264163	264426	264688	264950	265213	265475
	2615	2617	2618	2619	2621	2622	2623	2625	2626	2628

Notes:

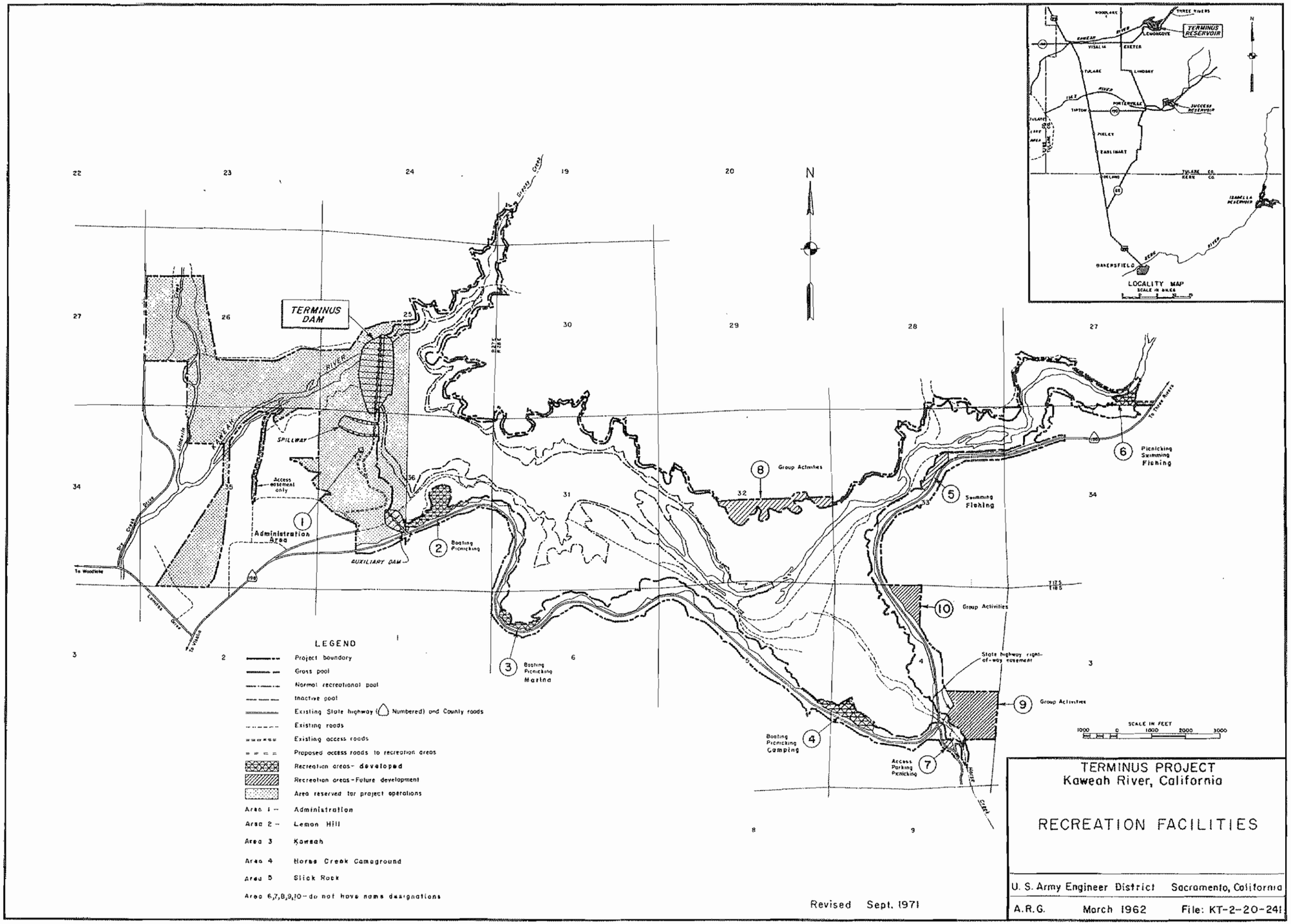
1. This area-capacity table is a recomputation by electronic computer, of the area-capacity table, dated October 1955. It is based on data from Fairchild Aerial Survey Topography, Terminus Reservoir Site, 1945 U.S.E.D. maps KT-2-13-39 and KT-2-13-40, scale 1:10,000, contour interval 5 feet. Elevations given are U.S.G.S. datum.

2. Inactive storage 8,000 acre-feet at elevation 570.0 feet.

3. Gross pool elevation 694.0 feet.

4. Top of dam elevation 750.0 feet.

5. Areas are in acres; capacities are acre-feet.



TERMINUS PROJECT
Kaweah River, California

RECREATION FACILITIES

U. S. Army Engineer District Sacramento, California

A.R.G. March 1962 File: KT-2-20-241

CHART 14

TERMINUS PROJECT
Kaweah River, California

NORMAL ANTICIPATED IRRIGATION AND SPREADING DEMANDS

Thousand acre-feet

October 1957

Month	Irrigation				Spreading	Total
	(1)	(2)	(3)	Total	* *	Irrig and Spread.
October	31.4	0	2.6	34.0	42.6	76.6
November	18.0	13.2	0.2	31.4	42.6	74.0
December	0	16.2*	0	16.2	42.6	58.8
January	0	16.2*	0	16.2	42.6	58.8
February	16.0	13.2	0.2	29.4	42.6	72.0
March	43.6	0	1.1	44.7	42.6	87.3
April	99.8	0	5.4	105.2	42.6	147.8
May	68.2	0	2.8	71.0	42.6	113.6
June	96.2	0	5.6	101.8	42.6	144.4
July	121.5	0	9.1	130.6	42.6	173.2
August	113.8	0	9.6	123.4	42.6	166.0
September	70.4	0	6.0	76.4	42.6	119.0

(1) General crop irrigation demand

(2) Cotton crop irrigation demand

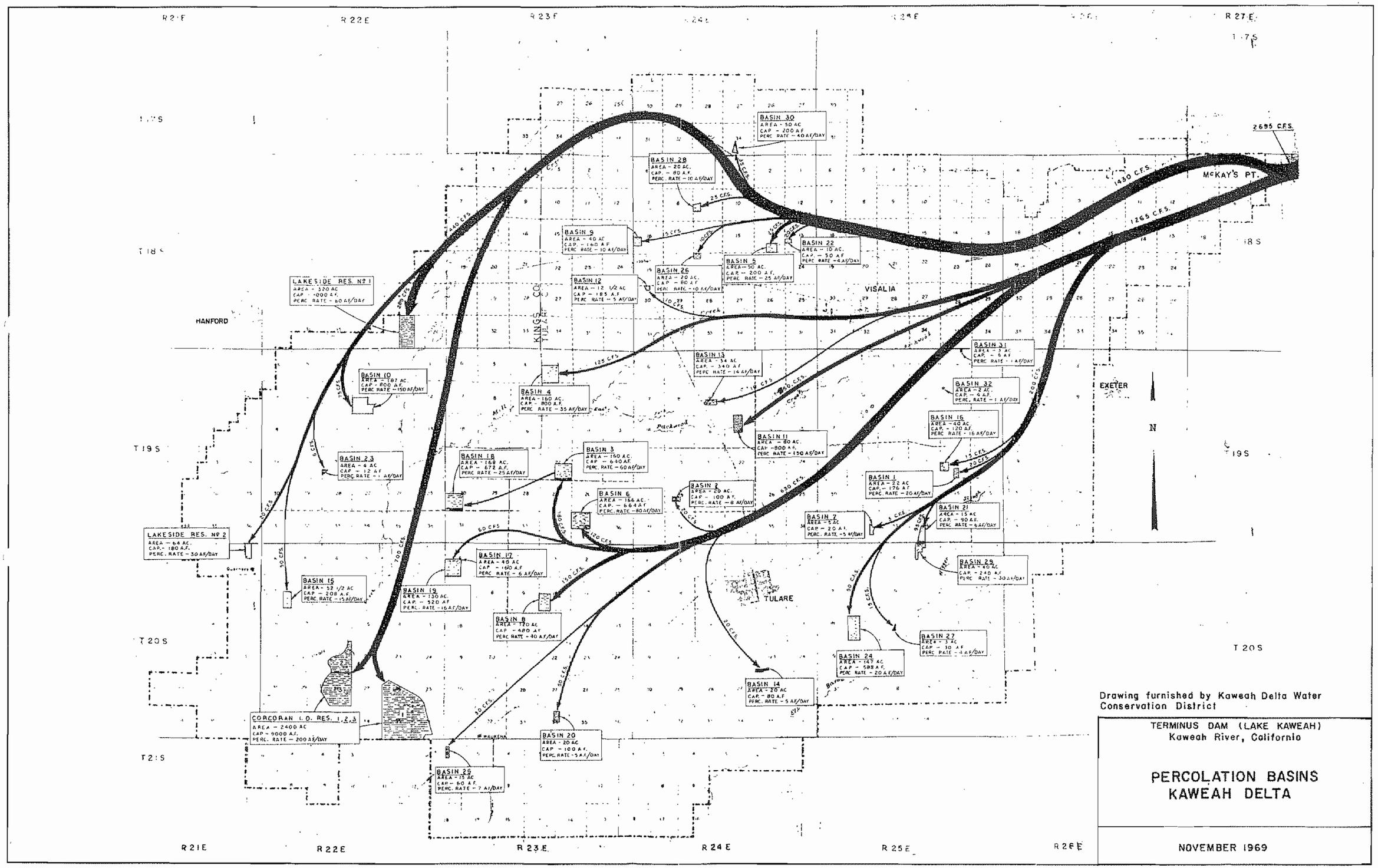
(3) Corcoran irrigation district demand

* Irrigation demands increased by 22.5% for canal losses

** Average values for long durations.

File: KT-2-26-187

CHART 15



Drawing furnished by Kaweah Delta Water Conservation District

TERMINUS DAM (LAKE KAWEAH)
Kaweah River, California

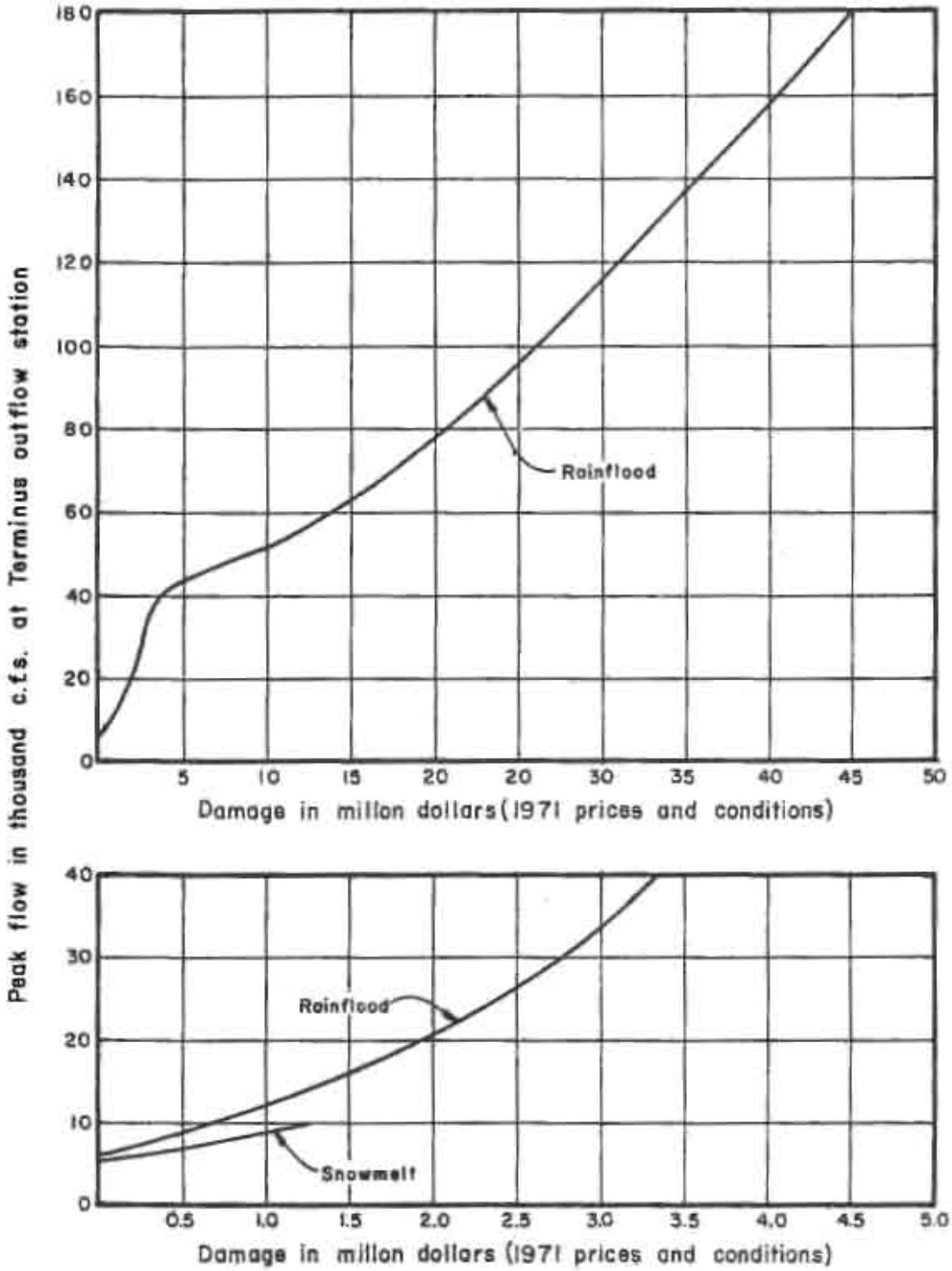
PERCOLATION BASINS KAWEAH DELTA

NOVEMBER 1969

CHART 16

KAWEAH DELTA WATER CONSERVATION DISTRICT
SPREADING BASINS
AND SPREADING DEMAND USED IN ROUTING STUDIES

NAME	BASIN No.	ACREAGE	CAPACITY AF	INFLOW CAP CSF	DAYS TO FILL	SINKING AF/D	SINKING CSF/D	SUPPLY
Eda Shannon	1	22	176	20	4.4	20	10	Farmers
Enterprise	2	20	100	20	2.5	8	4	Tulare I D
Colpein	3	160	640	180	1.8	60	30	Tulare I D
Packwood	4	160	800	125	3.2	35	18	South Mill
Willow School	5	50	200	25	4.0	25	13	Modoc
Cartmill	6	166	664	120	2.8	80	40	Tulare I D
Gary Shannon	7	5	20	5	2.0	5	3	Farmers
Corcoran Highway	8	120	480	150	9.2	40	20	Tulare I D
Doe	9	40	160	15	5.3	10	5	Modoc
Lakeside	10	187	800	75	5.3	150	75	Lakeside
Tagus	11	80	800	250	1.6	150	75	Tulare I D
Goshen Pit	12	12	185	10	9.3	5	3	North Mill Creek
Nelson Pit	13	34	340	10	17.0	14	7	Evans
Abercrombie	14	20	80	20	2.0	5	3	Tulare I D
Howe	15	52 1/2	208	50	2.1	15	8	Lakeside
Parr	16	40	120	15	4.0	16	8	Farmers
Anderson	17	40	160			6	3	Tulare I D
Franks	19	130	520	60	5.7	16	8	Tulare I D
Guinn	18	168	672	70	4.8	25	13	Tulare I D
Wilbur	20	20	100	50	1.0	5	3	Tulare I D
Shannon	21	15	90	45	1.0	6	3	Farmers
Shannon-Modoc	22	10	50	20	1.3	4	2	Modoc
Green	23	4	12	6	1.0	1	1	Lakeside
Consolidated	24	147	588	50	5.9	20	10	Farmers
Doris	25	15	60	30	1.0	7	4	Tulare I D
Doe-Ritchie	26	20	80	10	4.0	10	5	Modoc
Ellis	27	3	30	15	1.0	4	2	Farmers
Doe-Goshen	28	20	80	25	1.6	10	5	Goshen
Nunes	29	40	240	50	2.4	30	15	Farmers
Harrell	30	50	200	35	2.9	40	20	St Johns River
Hammer	31	3	6	3	1.0	1	1	Peoples
Clark	32	2	4	2	1.0	1	1	Peoples
Lakeside Res. #1		320	1000	289	3.5	60	30	Lakeside
Lakeside Res. #2		64	180	20	4.5	30	15	Lakeside
Corcoran I.D. Res1,2,3		2400	9000	700	6.4	200	100	Corcoran I D
Totals		4640	18845	2695		1114	563	



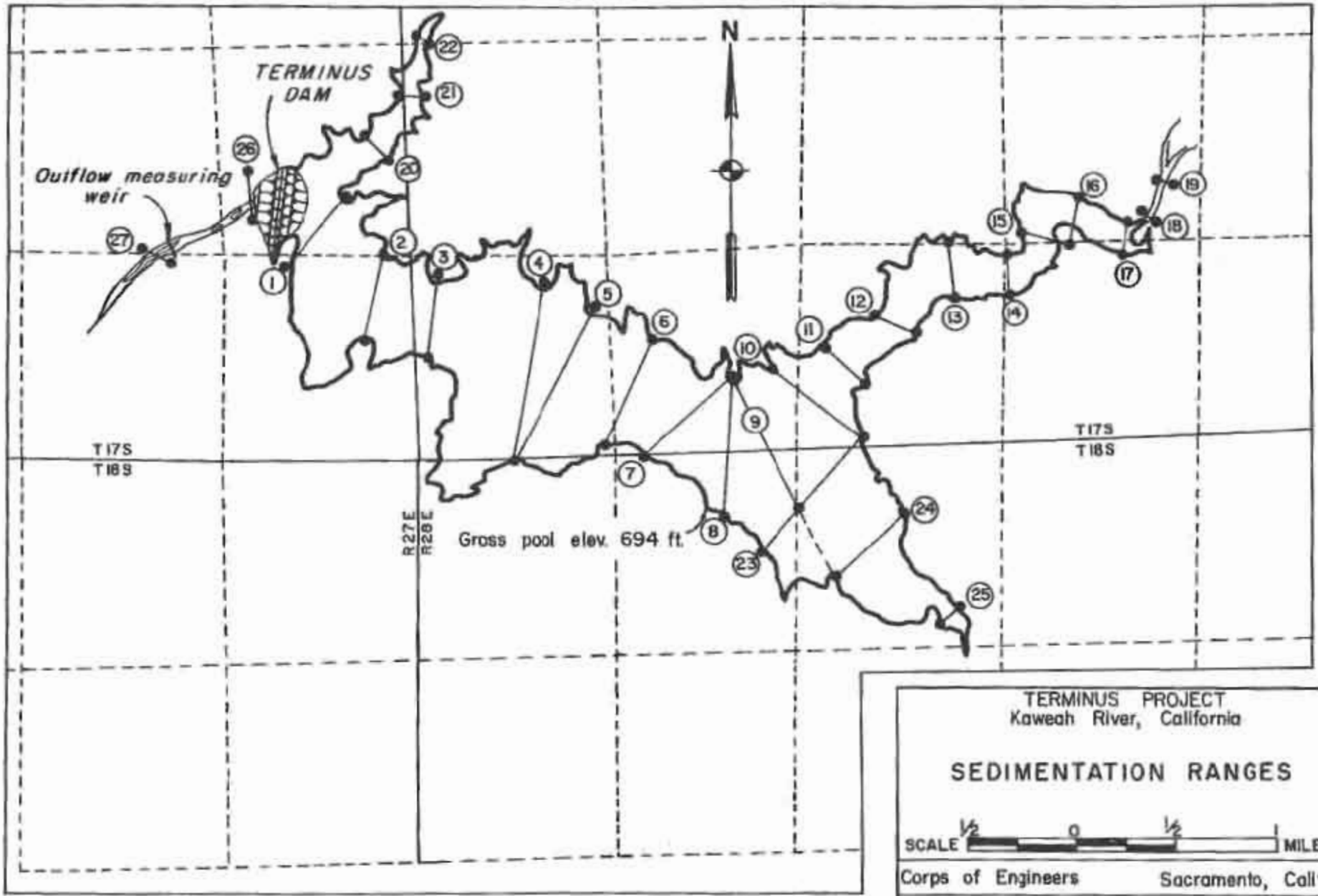
TERMINUS DAM (LAKE KAWEAH)
Kaweah River, California

DAMAGE FLOW CURVE

CORPS OF ENGINEERS SACRAMENTO, CALIF.

Prepared: J.E.M.R.
Drawn: R.E.Y.
Date: Sept. 1971

CHART 18



TERMINUS PROJECT
Kaweah River, California

SEDIMENTATION RANGES

SCALE ½ 0 ½ 1 MILES

Corps of Engineers Sacramento, Calif.

R.E.B. Oct. 1957 File: KT-2-26-184

Rev. Nov. 1971

CHART 19

TERMINUS PROJECT, Kaweah River, California

FORECAST VERIFICATION DATA
KAWEAH RIVER NEAR THREE RIVERS*
NATURAL APRIL - JULY FLOWS

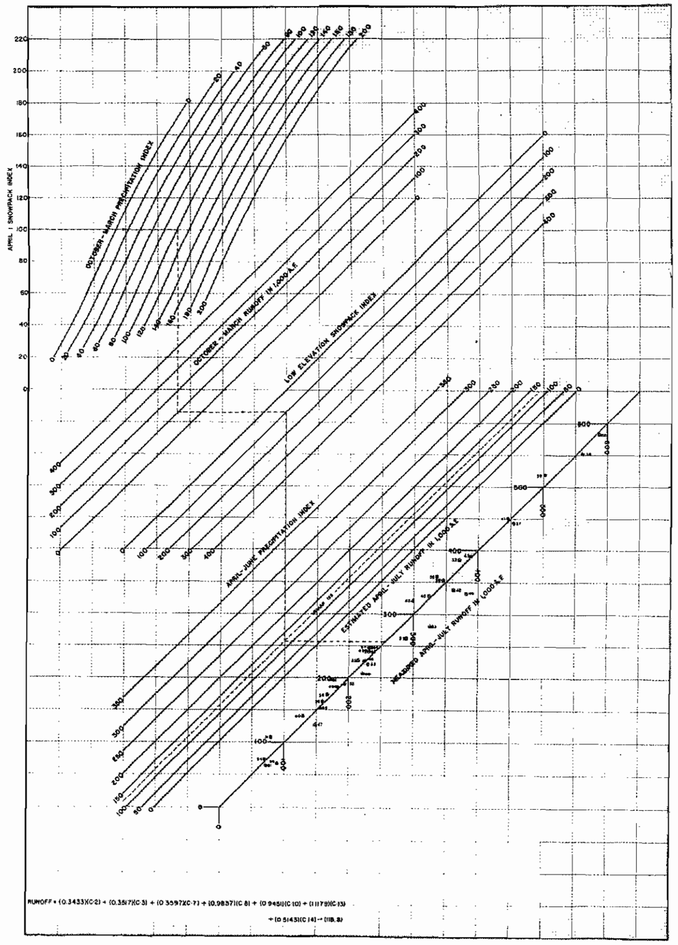
(Values in thousand ac-ft) Sept 1971

Year	Recorded Flow	1 February Forecast	1 February Error	1 March Forecast	1 March Error	1 April Forecast	1 April Error	1 May Forecast	1 May Error
1933	230					276	46		
34									
35									
36	345					335	-10		
37	454					394	-60	394	-60
38	562					400	-162	400	-162
39	159					130	-29	120	-39
1940	323					250	-73	250	-73
41	445					400	-45	440	- 5
42	362					315	-47	350	-12
43	388					320	-68	320	-68
44	235					270	35	270	35
45	381					360	-21	340	-41
46	224					270	46	240	16
47	148					150	2	145	- 3
48	226					120	-106	210	-16
49	181					210	29	170	-11
1950	222					195	-27	200	-22
51	172					65	-107	90	-82
52	588					600	12	600	12
53	213	300	87	200	-13	140	-73	170	-43
54	231	200	-31	220	-11	250	19	230	- 1
55	194	280	86	260	66	170	-24	180	-14
56	336	400	64	350	14	280	-56	300	-36
57	232	200	-32	190	-42	160	-72	170	-62
58	502	265	-237	290	-212	500	- 2	490	-12
59	88	155	67	195	107	105	17	75	-13
1960	129	125	-4	175	45	125	- 4	125	-4
61	77	165	88	80	3	70	- 7	55	-22
62	298	195	-103	310	12	345	47	300	2
63	325	150	-175	125	-200	155	-170	235	-90
64	163	200	37	130	-33	145	-18	140	-23
65	314	350	36	280	-34	250	-64	300	-14
66	149	250	101	215	66	150	1	110	-39
67	610	705	95	665	55	775	165	610	0
68	131	200	69	155	24	140	9	110	-21
69	799	550	-249	700	-99	800	1	800	1
1970	203	220	17	180	-23	170	-33	150	-53
71	196	270	74	220	24	190	- 6	170	-26
Average			-1		-13		-23		-29
Extreme			-249		-212		-170		-162

(1) All forecasts prepared and published by State of California.
(2) Year to year accuracy of forecasts cannot be compared because later forecasts are based on greatly increased data coverages with increasing length of record, as well as development of improved techniques and forecast criteria.
*Beginning 1962-Natural inflow to Terminus Reservoir

FORECAST DIAGRAM
KAWEAH RIVER INFLOW TO TERMINUS
UNIMPAIRED APRIL-JULY RUNOFF

FIGURE 1



FORCAST COMPUTATION INDEXES
FIGURE 2

I APRIL SNOW PACK INDEX — Precipitation Gauge: Giant Forest

Date Measured (1)	Snow Course Index (1)	Snow Course Number (2)	Snow Depth Equivalent (3)	Average April 1 Snow Depth Index (Cal 3)
2,3,4,5	Rowell Meadow	226	12"	27.0
3,4	Farewell Gap	292	10	33.5
2,3,4,5	Panther Meadow	243	11	37.4
3,4	Hockett Meadows	244	0.9	30.8
4	Quinn R.S.	264	0.9	20.8
2,3,4,5	Big Meadows	236	1.1"	26.5
2,3,4,5	Horse Corral Meadows	237	0.6"	18.0

February 1 (Cols 4–8): Date of Fast Measurement; Water Content of Fast Measurement (Inches); Unmeasured Precipitation Correction (Inches); Cal 3 × Cal 4 (Inches again); Cal 3 × Cal 7 (Inches again); Snow Course Index (Cal 6 + Cal 5) × Cal 3

March 1 (Cols 10–14): Date of Fast Measurement; Water Content of Fast Measurement (Inches); Unmeasured Precipitation Correction (Inches); Cal 2 × Cal 12 (Inches again); Cal 11 × Cal 13 (Inches again); Snow Course Index Cal 9 × Cal 3

April 1 (Cols 16–20): Date of Fast Measurement; Water Content of Fast Measurement (Inches); Unmeasured Precipitation Correction (Inches); Cal 2 × Cal 18 (Inches again); Cal 17 × Cal 19 (Inches again); Snow Course Index Cal 20 × 100 × Cal 3

Total February 1 Snow Pack Index
Average February - March Increment: 33
April 1 Snow Pack Index (Estimated as of February 1)

Total March 1 Snow Pack Index
Average March Increment: 6
April 1 Snow Pack Index (Estimated as of March 1)

Total April 1 Snow Pack Index

Low Elevation Snow Pack Index

3,4	Mineral King	243	0.7	20.6
2,3,4,5	Grant Grove	240	0.6*	15.3
3,4	Old Enterprise Mill	248	0.6	18.2
2,3,4,5	Giant Forest	246	0.5	17.4

*Huntington Lake

Total February 1 Snow Pack Index
Average February - March Increment: 17
April 1 Snow Pack Index (Estimated as of February 1)

Total March 1 Snow Pack Index
Average March Increment: -5
April 1 Snow Pack Index (Estimated as of March 1)

Total April 1 Snow Pack Index

OCTOBER - MARCH RUNOFF

PERIOD	FEBRUARY 1	MARCH 1	APRIL 1
October - January Runoff			
February Runoff	17		
March Runoff	31	31	
October - March Runoff			

OCTOBER - MARCH PRECIPITATION — Precipitation Gauge: Giant Forest

Precipitation Station (1)	Snow Index - March Precipitation (Inches) (2)	October Precipitation (Inches) (3)	0.5 × (Col 3) (4)	November Precipitation (Inches) (5)	0.6 × (Col 5) (6)	December Precipitation (Inches) (7)	0.7 × (Col 7) (8)	January Precipitation (Inches) (9)	0.8 × (Col 9) (10)	Total Adjusted Precipitation (11)	Station Index (Col 11 × 100 ÷ Col 2) (12)	February Precipitation (Inches) (13)	0.5 × (Col 13) (14)	Station Index (Col 14 × 100 ÷ Col 2) (15)	March Precipitation (Inches) (16)	Station Index (Col 16 × 100 ÷ Col 2) (17)
Ash Mountain	17.47	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Giant Forest	29.49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Grant Grove	28.40	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Glenville	12.98	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kern River No 3 P H	7.39	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Springville Tule Headworks	25.64	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Three Rivers No 2 PH	14.13	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Total October - January
Total February
Total March

APRIL - JUNE PRECIPITATION

Precipitation Station (18)	April Adjusted Daily Data Precipitation Related (19)	April Precipitation (Inches) (20)	April Station Index (Col 19 × 100 ÷ Col 19) (21)	May Precipitation (Inches) (22)	0.5 × (Col 22) (23)	May Station Index (Col 23 × 100 ÷ Col 19) (24)	June Precipitation (Inches) (25)	0.5 × (Col 25) (26)	June Station Index (Col 26 × 100 ÷ Col 19) (27)
Ash Mountain	3.00								
Giant Forest	4.51								
Grant Grove	3.95								
Glenville	2.09								
Kern River No.3 P.H.	0.71								
Springville Tule Hdw.	3.89								
Three Rivers No 2 PH	2.33								

Total April
Total May
Total June
Basin Index April

PRECIPITATION INDEXES

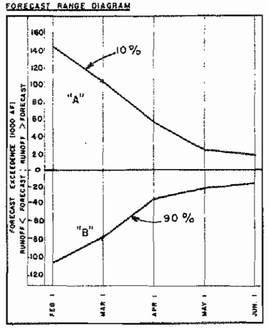
Indexes	February 1	March 1	April 1	May 1	June 1	July 1
October - January						
February	24					
March	18	18				
October - March						
April						
May				29		
June				1	1	
April - June	125	125	125			

APRIL-JULY RUNOFF FORECAST
FIGURE 3

FORECAST SUMMARY

Date of Forecast	April 1 Snow Pack Index	October - March Precipitation Index	Low Elevation Snow Index	April - June Precipitation Index	Miscellaneous	Runoff Forecast (1000 acre-feet)	Percent Range (1000 acre-feet) There is a 10 % probability that forecast will: Exceed	Not exceed
February 1								
March 1								
April 1								
May 1								
June 1								

FORECAST RANGE DIAGRAM



Data furnished by State of California Department of Water Resources.

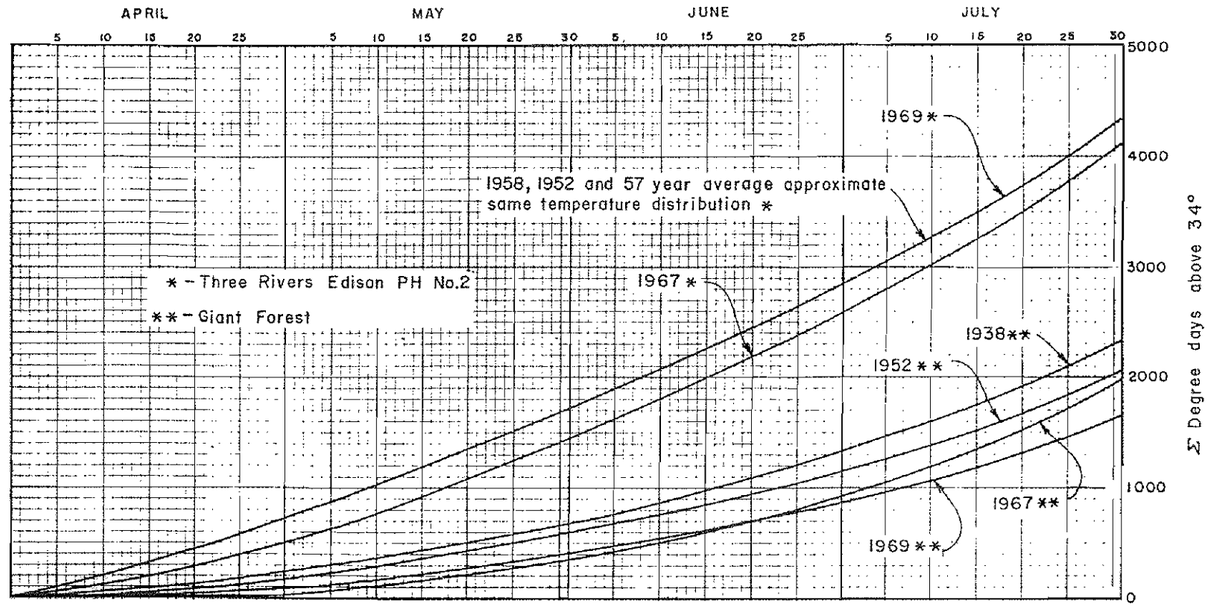
TERMINUS DAM (LAKE KAWEAH)
Kaweah River, California

SNOWMELT FORECAST CRITERIA

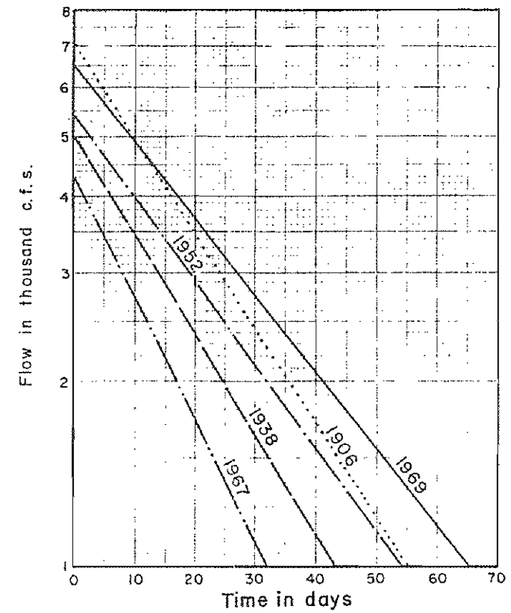
CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA

NOVEMBER 1971

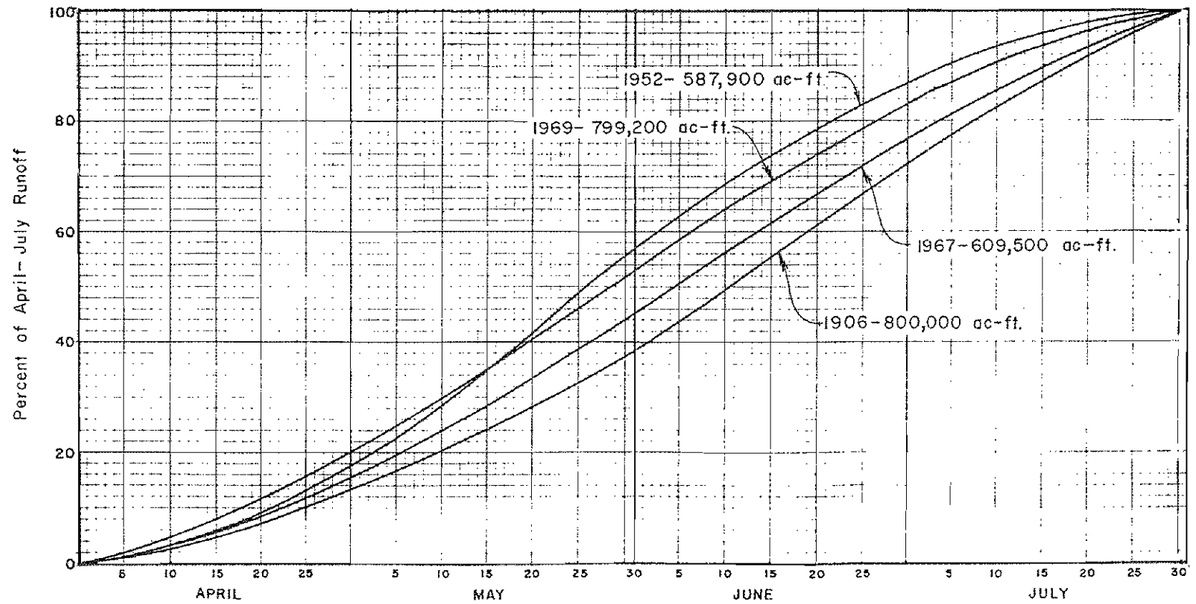
CHART 21



ACCUMULATED DAILY TEMPERATURE IN DEGREE DAYS



TERMINUS RESERVOIR INFLOW RECESSION
(SNOWMELT)



ACCUMULATED NATURAL RUNOFF AT TERMINUS DAM IN PERCENT

TERMINUS DAM, (LAKE KAWEAH)
Kaweah River, California

SUPPLEMENTARY FORECAST CRITERIA
APRIL - JULY RUNOFF
KAWEAH RIVER AT TERMINUS DAM

CORPS OF ENGINEERS	SACRAMENTO, CALIFORNIA
Prepared: C.D.M. Drawn: R.E.Y.	Date: October, 1971

CHART 22

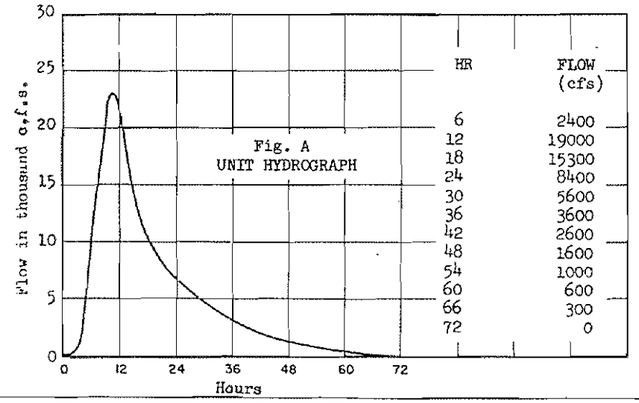


Fig. A
UNIT HYDROGRAPH

HR	FLOW (cfs)
6	2400
12	19000
18	15300
24	8400
30	5600
36	3600
42	2600
48	1600
54	1000
60	600
66	300
72	0

Fig. B SAMPLE COMPUTATION

	Mean Precipitation (inches)			(1) Unit Hydro. Strip	Runoff (thousand cfs)		
	Rain (4) 6-hr	Loss 6-hr	Excess 6-hr		From Rain	Base (2) Flow	Total
Dec 14 - 6	1.90	1.90	0	3.6	0	0.2	0.2
12	3.00	2.00(3)	1.00	5.6	24	0.4	2.8
18	3.87 (5)	2.00	1.87	8.4	23.4	0.6	24.0
24	4.60	2.00	2.60	15.3	57.1	0.8	57.9
Dec 15 - 6	2.15	2.00	.15	19.0	86.8	1.0	87.8
12	1.85	1.85	0	2.4	24.2	1.2	25.4

(1) As unit hydrograph strip is lowered, computed surface runoff for each position of the unit hydrograph strip is equal to the sum of the products of 6-hour excess and unit hydrograph values. This computed runoff corresponds to the time period on the same line as the bottom of the unit hydrograph strip.

(2) For forecasting purposes base flow values are arrived at by taking the inflow at the beginning of the storm and adding 200 cfs to each 6-hour period after an excess has been computed.

(3) Maximum loss for each 5-hour period is assumed to be 2 inches although maximum losses will range from 1.5 to 2.5 inches.

(4) Mean precipitation can be either forecast or computed as described below.

(5) The basin average precipitation is computed by multiplying the sum of the 6-hour precipitation from available reporting stations and the total basin normal annual precipitation, then dividing by the sum of the normal annual precipitation for all reporting stations used.

Station	NAP (inches)	6-Hr Precip (inches)
Atwell	39.6	3.51
Bear Trap Meadow	45.9	4.47
Giant Forest	43.0	4.00
Hockett Meadow	40.9	3.82
Terminus Dam	14.0	2.40
total	183.4	18.20

Kaweah Basin 39.0 inches

$$\text{Basin Mean Precip.} = \frac{(\text{Basin NAP})\ (\Sigma\ \text{station precip})}{(\Sigma\ \text{station NAP})}$$

$$= \frac{(39.0)\ (18.2)}{183.4} = 3.87 \text{ inches}$$

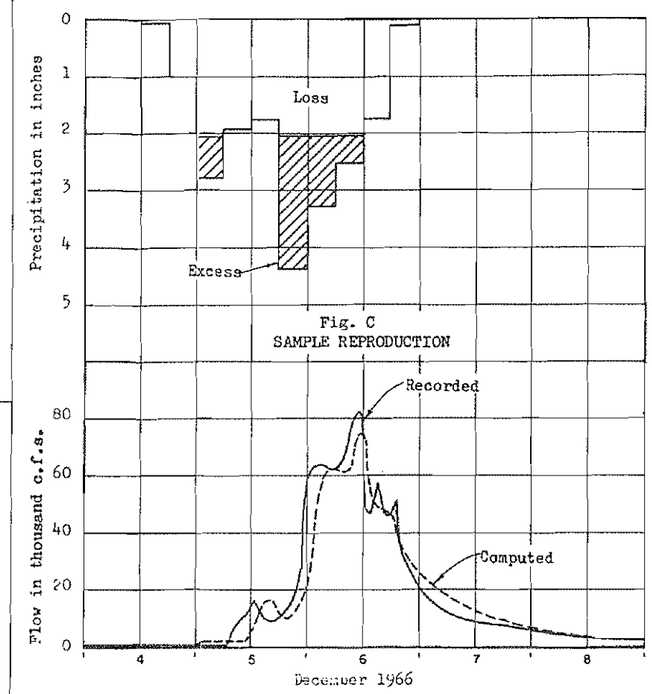


Fig. C
SAMPLE REPRODUCTION

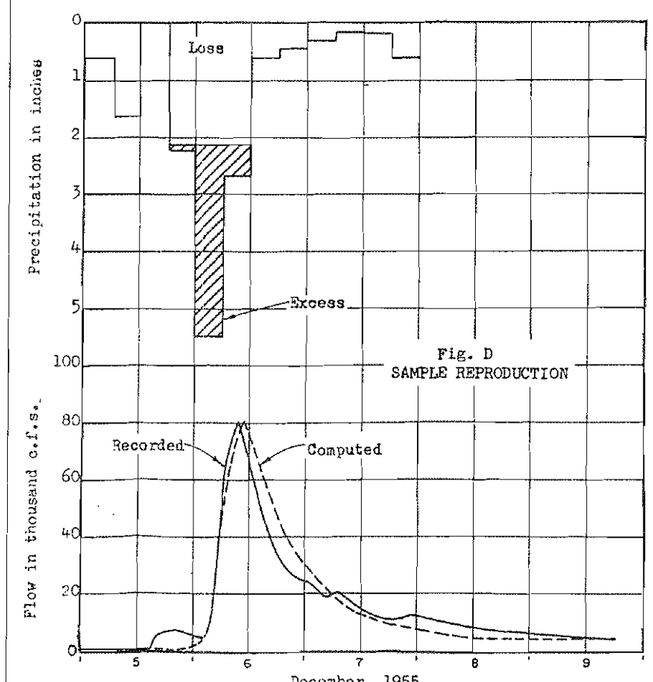


Fig. D
SAMPLE REPRODUCTION

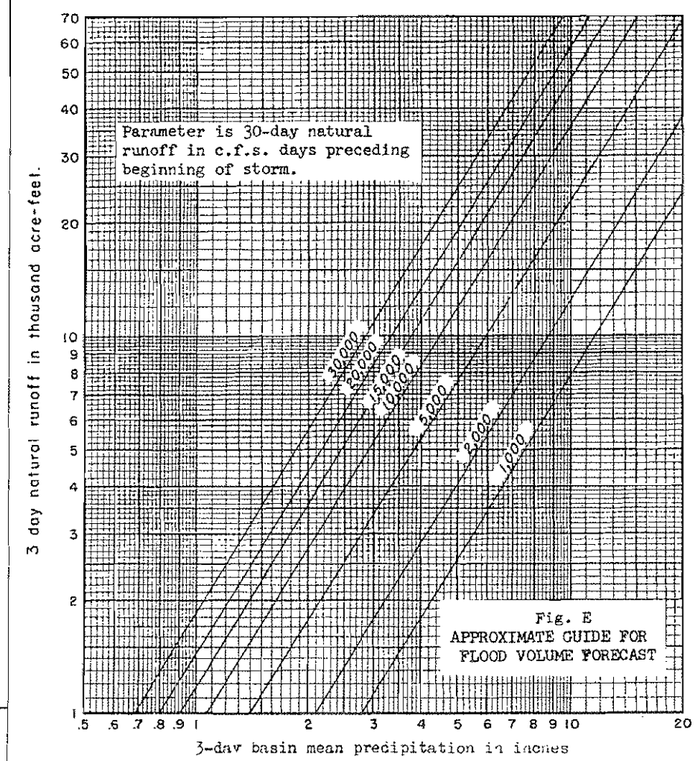


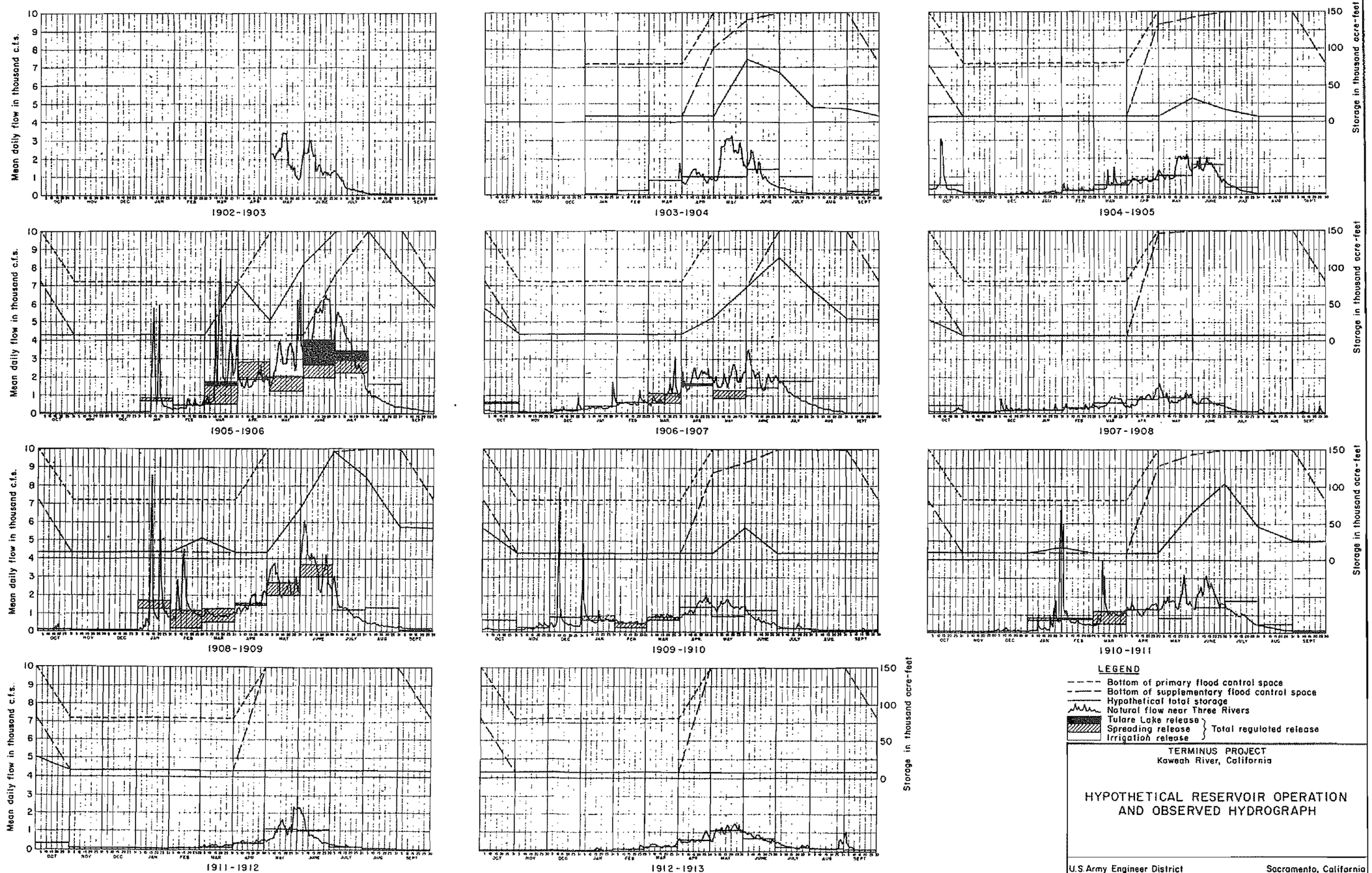
Fig. E
APPROXIMATE GUIDE FOR FLOOD VOLUME FORECAST

TERMINUS DAM (LAKE KAWEAH)
KAWEAH RIVER, CALIFORNIA

RAIN-FLOOD FORECAST CRITERIA

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: R.F.C.
Drawn: T.G.K.
Date: NOVEMBER 1971



LEGEND

- Bottom of primary flood control space
- Bottom of supplementary flood control space
- Hypothetical total storage
- Natural flow near Three Rivers
- Tulare Lake release
- Spreading release
- Irrigation release
- } Total regulated release

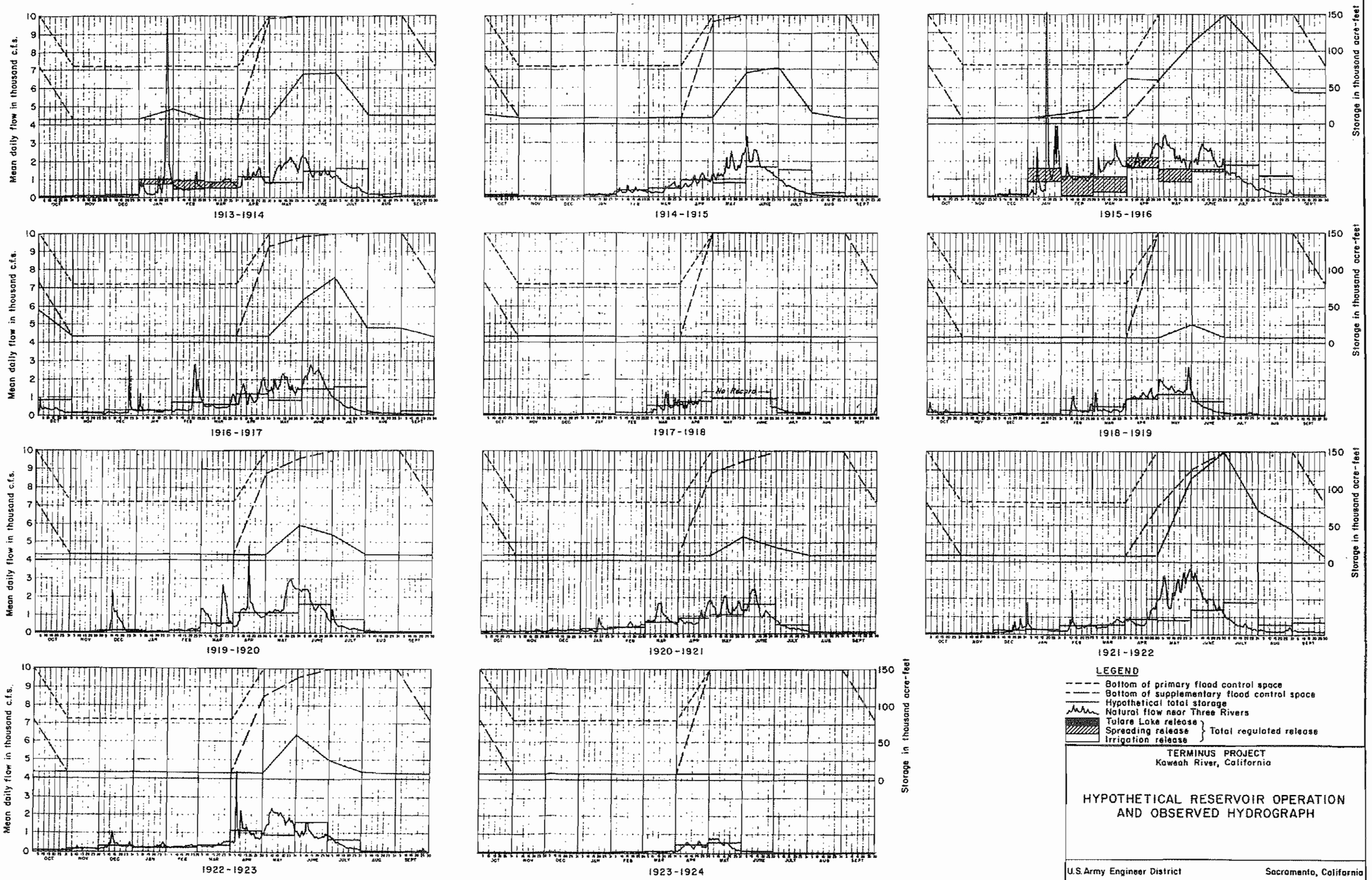
TERMINUS PROJECT
Kaweah River, California

HYPOTHETICAL RESERVOIR OPERATION
AND OBSERVED HYDROGRAPH

U.S. Army Engineer District — Sacramento, California

C.J.A. — June 1962 — File: KT-2-26-249

SHEET 1 CHART 24

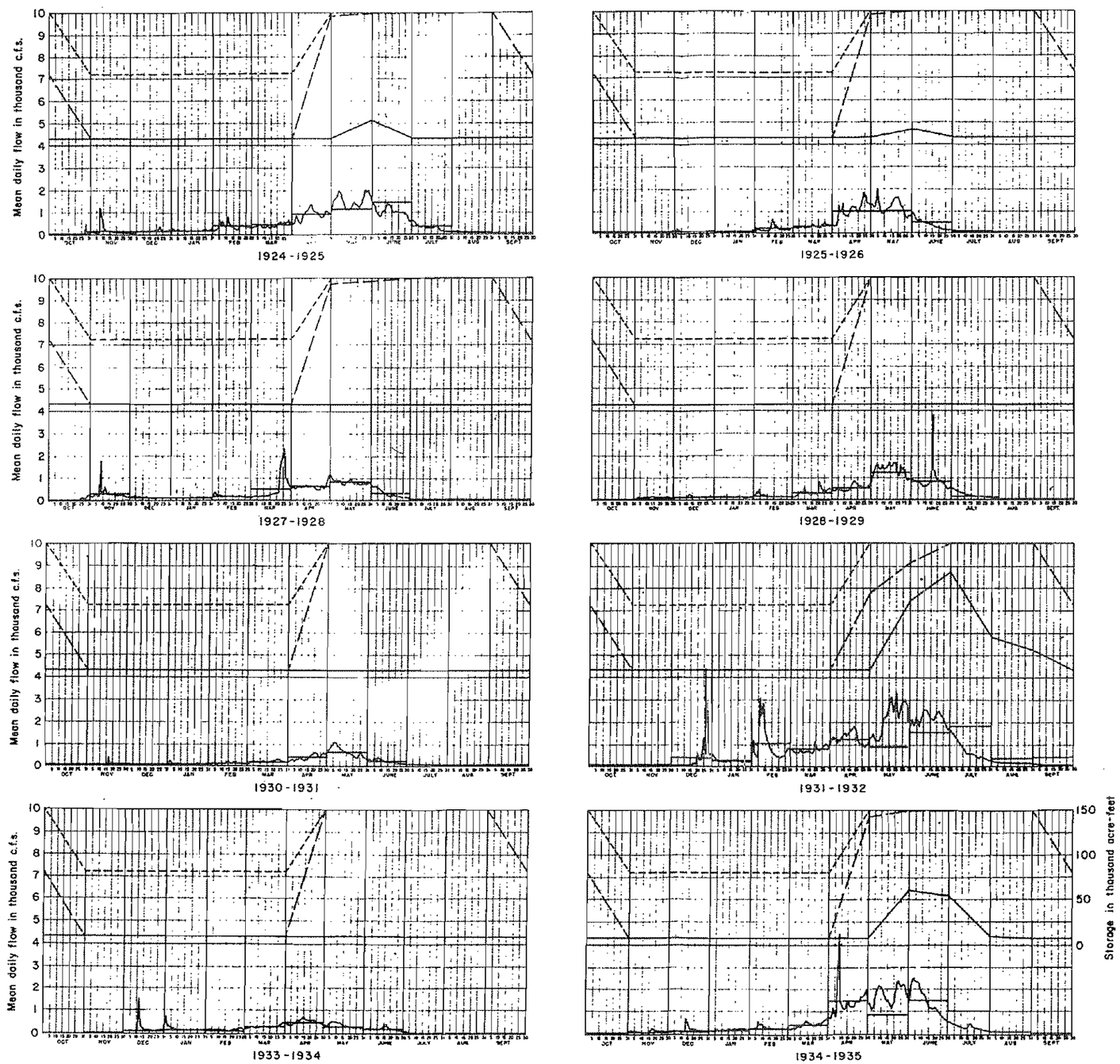


TERMINUS PROJECT
Kaweah River, California

HYPOTHETICAL RESERVOIR OPERATION AND OBSERVED HYDROGRAPH

U.S. Army Engineer District		Sacramento, California
C.J.A.	June 1962	File: KT-2-26-249

SHEET 2 CHART 24



LEGEND

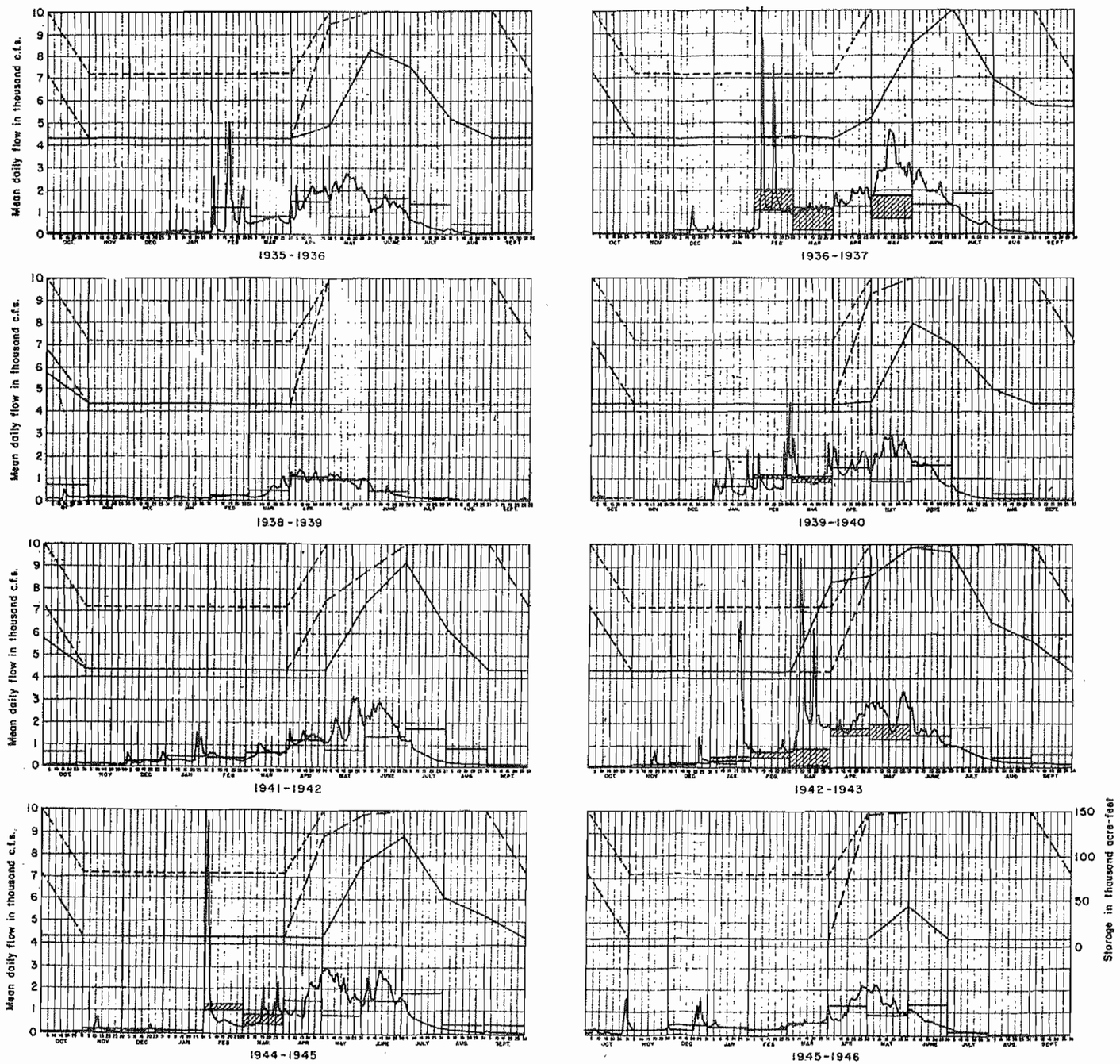
- Bottom of primary flood control space
- Bottom of supplementary flood control space
- Hypothetical total storage
- Natural flow near Three Rivers
- Tulare Lake release
- Spreading release
- Irrigation release

} Total regulated release

TERMINUS PROJECT
Kaweah River, California

HYPOTHETICAL RESERVOIR OPERATION
AND OBSERVED HYDROGRAPH

U.S. Army Engineer District		Sacramento, California
C.J.A.	June 1962	File: KT-2-26-249



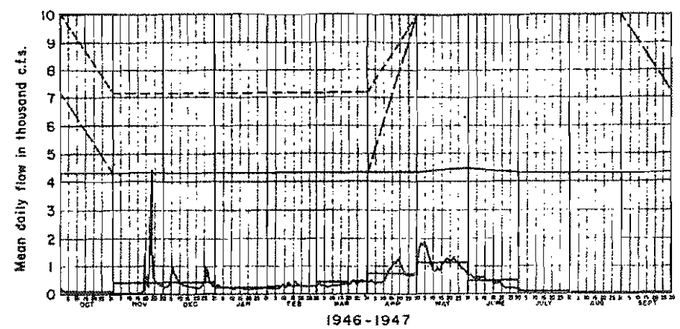
LEGEND

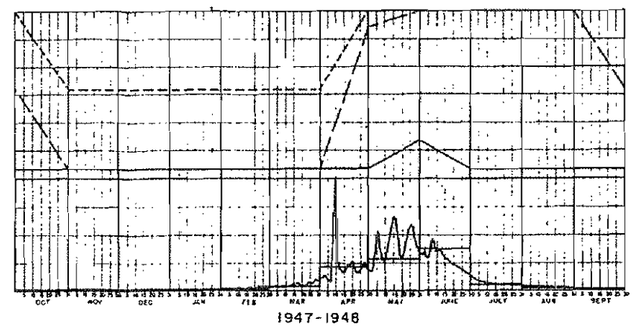
- Bottom of primary flood control space
- Bottom of supplementary flood control space
- Hypothetical total storage
- Natural flow near Three Rivers
- Tulare Lake release
- Spreading release
- Irrigation release
- } Total regulated release

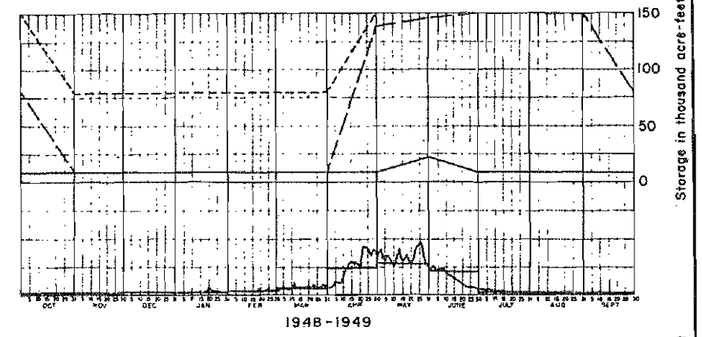
TERMINUS PROJECT
Kaweah River, California

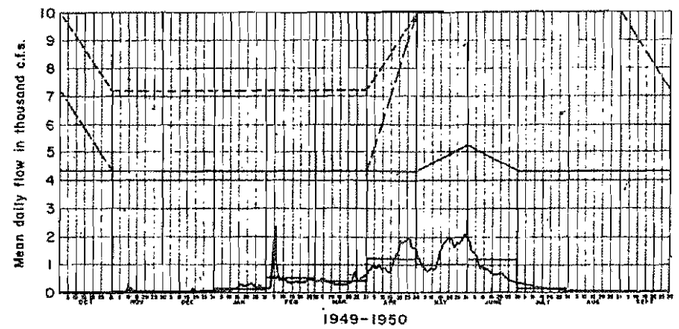
HYPOTHETICAL RESERVOIR OPERATION AND OBSERVED HYDROGRAPH

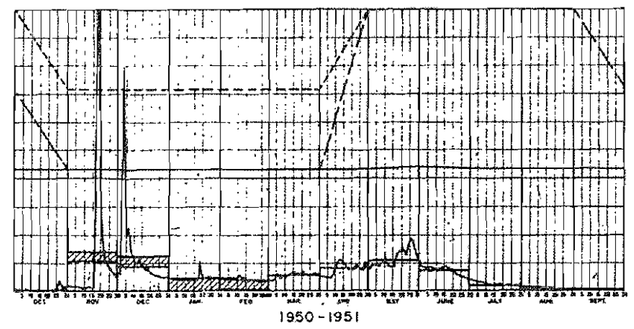
U.S. Army Engineer District		Sacramento, California
C.J.A.	June 1962	File: KT-2-26-249

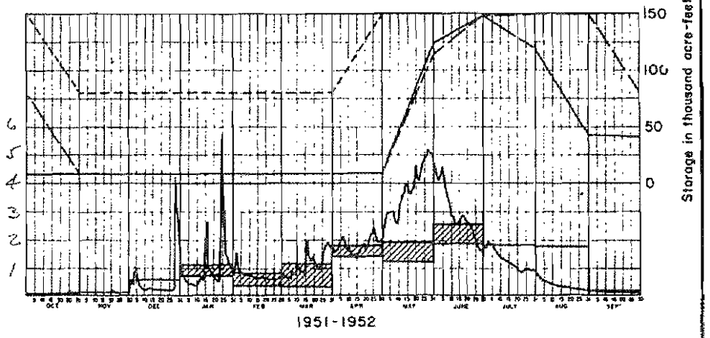


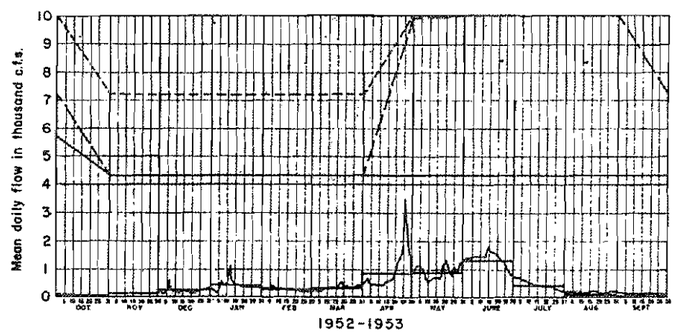


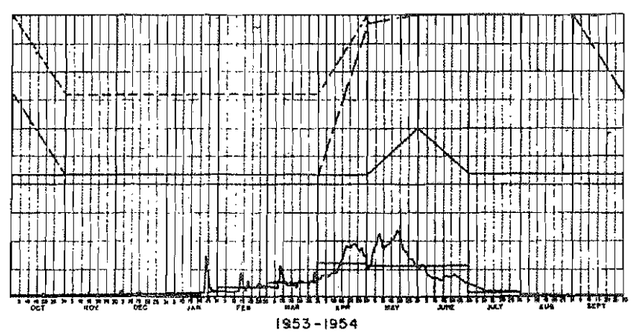


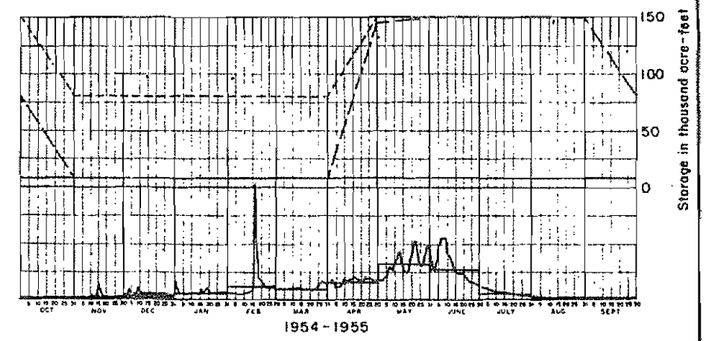


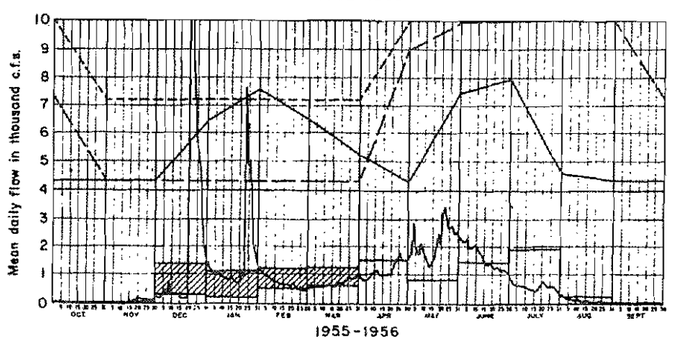


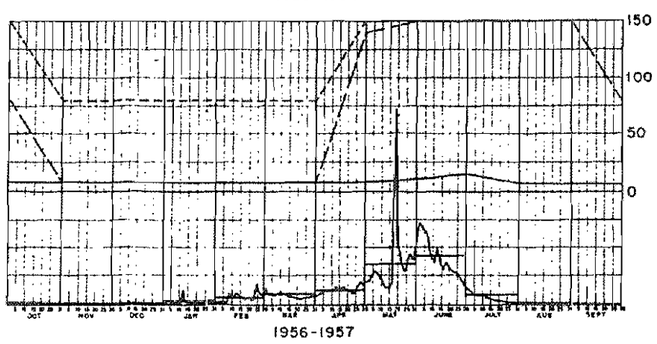












LEGEND

- Bottom of primary flood control space
- Bottom of supplementary flood control space
- Hypothetical total storage
- Natural flow near Three Rivers
- Tulare Lake release
- Spreading release
- Irrigation release

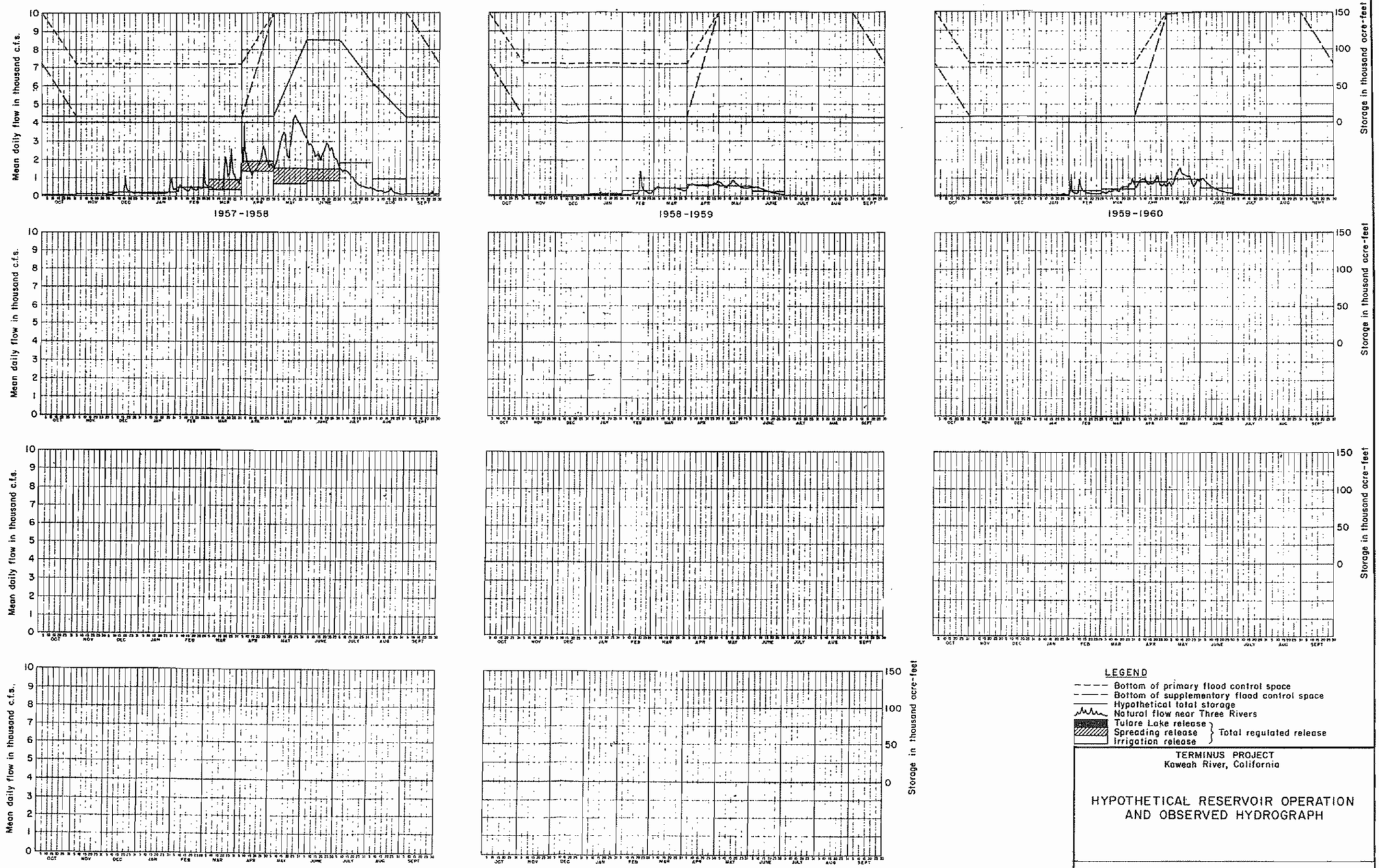
} Total regulated release

TERMINUS PROJECT
Kaweah River, California

HYPOTHETICAL RESERVOIR OPERATION
AND OBSERVED HYDROGRAPH

U.S. Army Engineer District		Sacramento, California
C.J.A.	June 1962	File: KT-2-26-249

SHEET 5 CHART 24



TERMINUS PROJECT
Kaweah River, California

HYPOTHETICAL RESERVOIR OPERATION
AND OBSERVED HYDROGRAPH

U.S. Army Engineer District — Sacramento, California

C.J.A. — June 1962 — File: KT-2-26-249

Terminus Project
Kaweah River, California

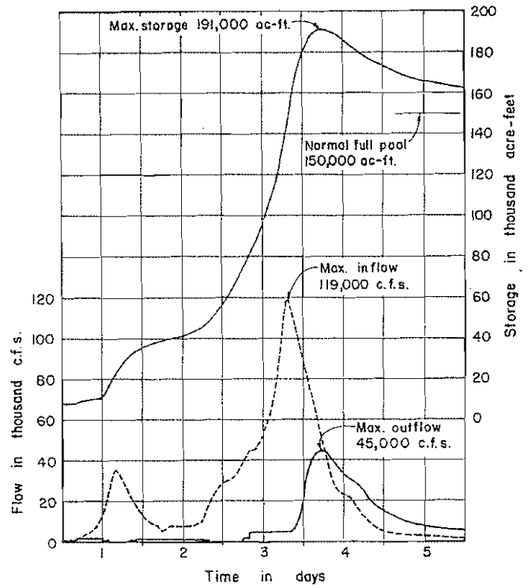
HYPOTHETICAL OPERATION
1904 - 1960

(Quantities in thousand acre-feet)

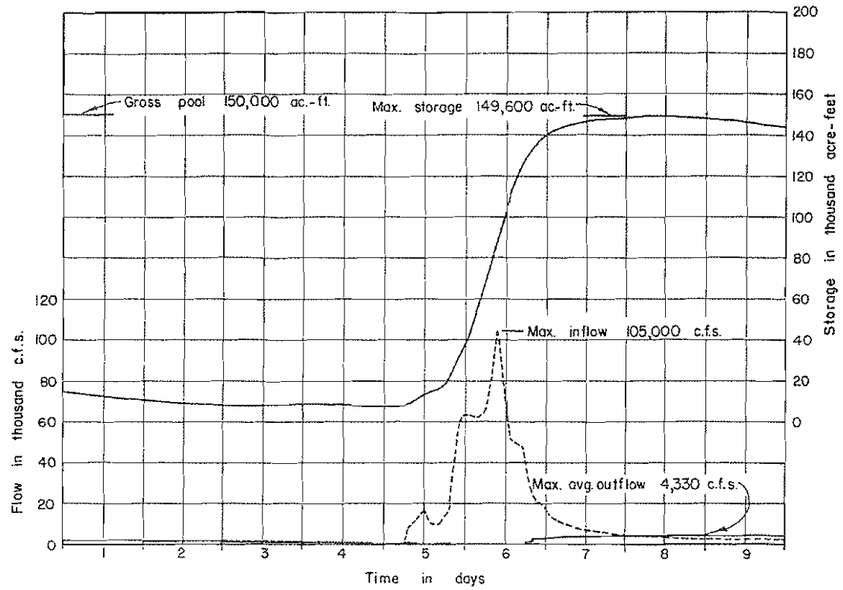
Water Year	Flow		Disposition of Water				Storage 30 Sept. Midnight
	Impaired Inflow	Flow Past Dam	Irrigation	Spreading	Tulare Lake Flood Control	Evaporation Loss	
1904-1905	347.7	347.0	413.6	0	0	0.7	8.0
06	1,148.6	1,106.5	712.5	259.4	123.6	6.1	44.0
07	609.1	619.3	647.3	65.3	0	4.6	29.2
08	257.4	278.4	276.9	0	0	0.2	8.0
09	822.4	783.7	652.0	211.5	0	4.6	42.1
1909-1910	413.9	447.1	459.9	35.2	0	0.9	8.0
11	554.5	534.1	568.2	50.2	0	3.2	25.2
12	207.6	224.6	233.1	0	0	0.2	8.0
13	221.8	221.8	195.5	0	0	0	8.0
14	493.4	486.9	536.5	63.3	0	2.2	12.3
15	373.9	375.9	450.0	0	0	2.3	8.0
16	780.6	739.6	650.4	233.5	0	5.7	43.3
17	477.4	509.8	530.8	0	0	2.9	8.0
18	228.7	228.7	267.8	0	0	0	8.0
19	260.3	260.0	273.9	0	0	0.3	8.0
1919-1920	353.1	351.8	351.6	0	0	1.3	8.0
21	350.9	350.1	416.4	0	0	0.8	8.0
22	468.0	463.5	535.2	0	0	4.5	8.0
23	366.3	365.0	392.8	0	0	1.3	8.0
24	101.5	101.5	92.6	0	0	0	8.0
25	328.3	327.9	332.8	0	0	0.4	8.0
26	219.7	219.5	224.0	0	0	0.2	8.0
27	490.6	488.2	507.7	26.8	0	2.4	8.0
28	203.8	203.8	211.3	0	0	0	8.0
29	223.4	223.4	201.2	0	0	0	8.0
1929-1930	223.2	223.2	201.7	0	0	0	8.0
31	114.2	114.2	100.0	0	0	0	8.0
32	526.5	522.7	549.8	0	0	3.8	8.0
33	285.0	284.8	281.1	0	0	0.2	8.0
34	130.8	130.8	119.4	0	0	0	8.0
35	361.1	359.3	400.6	0	0	1.8	8.0
36	492.9	489.7	532.0	0	0	3.2	8.0
37	689.2	649.1	572.3	168.4	1.2	4.9	43.2
38	893.7	887.5	669.0	232.5	5.2	6.1	43.3
39	248.1	283.1	275.7	0	0	0.3	8.0
1939-1940	519.1	516.5	545.7	16.6	0	2.6	8.0
41	652.6	612.4	656.8	44.8	0	4.8	43.4
42	497.1	528.8	575.4	0	0	3.7	8.0
43	673.9	668.0	595.3	131.2	0	5.9	8.0
44	317.6	316.8	329.5	0	0	0.8	8.0
45	558.4	554.6	571.4	39.5	0	3.8	8.0
46	359.6	358.9	395.7	0	0	0.7	8.0
47	266.6	266.5	255.3	0	0	0.1	8.0
48	262.6	262.1	264.8	0	0	0.5	8.0
49	219.6	219.3	226.6	0	0	0.3	8.0
1949-1950	302.9	302.4	329.1	0	0	0.5	8.0
51	425.6	425.5	353.9	92.3	0	0.1	8.0
52	844.8	805.1	667.6	200.4	0	5.0	42.7
53	310.3	344.7	363.1	0	0	0.3	8.0
54	308.2	307.5	336.5	0	0	0.7	8.0
55	276.0	275.2	376.4	0	0	0.8	8.0
56	738.8	729.6	562.8	169.1	0	1.9	15.3
57	306.4	313.5	309.6	0	0	0.2	8.0
58	665.2	662.0	589.9	154.2	0	3.2	8.0
59	161.0	161.0	163.5	5.7	0	0	8.0
1959-1960	187.5	187.5	170.3	0	0	0	8.0
Total	23,121.4	23,020.4	22,471.8	2,199.9	130.0	101.0	
56 yr avg	412.9	411.1	401.3	39.3	2.3	1.8	

June 1962 File: KT-2-26-243

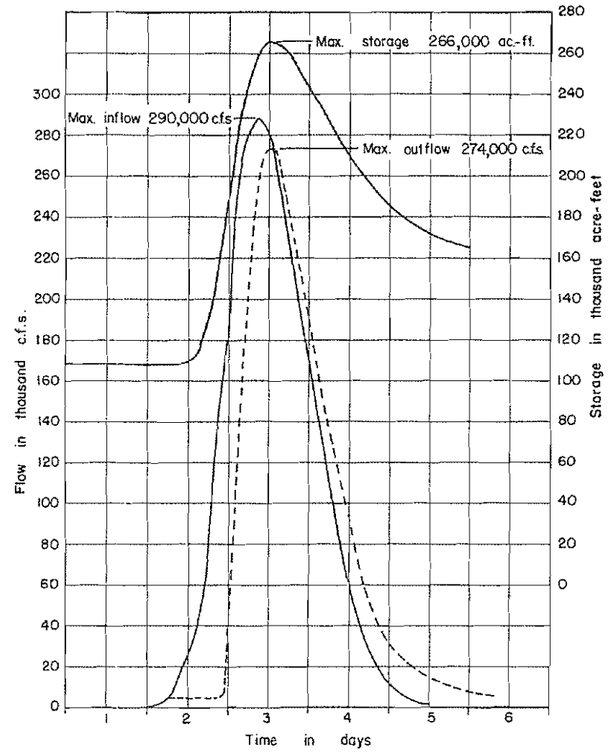
CHART 25



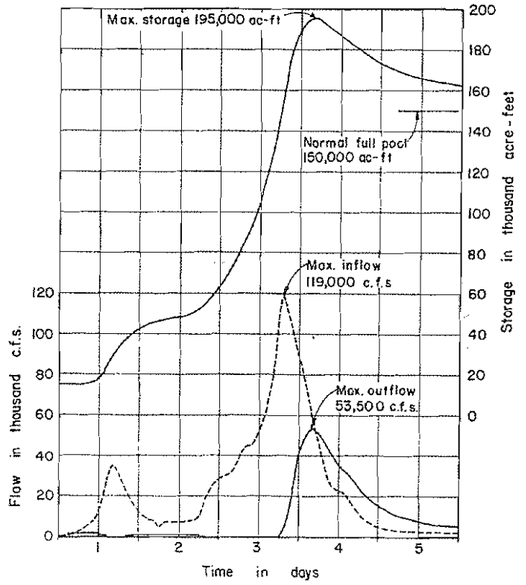
STANDARD PROJECT FLOOD ROUTING NO. 1



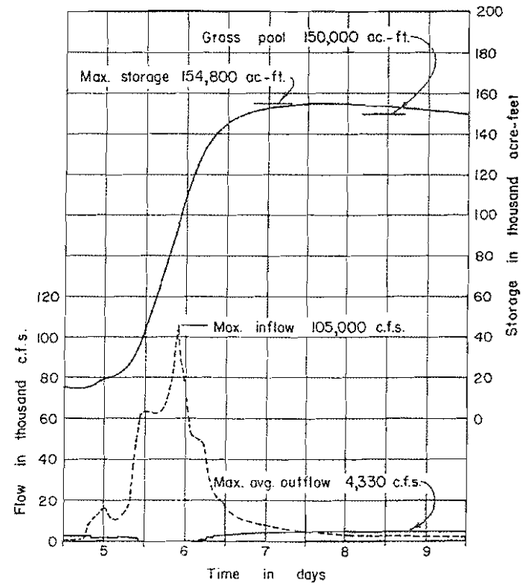
DECEMBER 1966 FLOOD ROUTING NO. 1



SPILLWAY DESIGN FLOOD



STANDARD PROJECT FLOOD ROUTING NO. 2



DECEMBER 1966 FLOOD ROUTING NO. 2

NOTES:

1. Standard Project Flood Routing No. 1 is based on wet ground conditions and 8,000 acre-feet of water in storage at the beginning of the flood. Standard Project Flood Routing No. 2 is based on wet ground conditions and 15,000 acre-feet of water in storage at the beginning of the flood with initial releases, insofar as possible, equal to total capacity of inlet channels to the spreading basins (reduced by 20 percent for operating contingencies).

2. December 1966 Flood Routing No. 1 is based on wet ground conditions and 15,000 acre-feet of water in storage when precipitation index criteria for evacuation of the conditional storage water are exceeded. Initial releases, up to the total capacity of inlet channels to the spreading basins (reduced by 20 percent for operating contingencies) are made as necessary to transfer the conditional storage water to downstream spreading areas in accordance with observed precipitation criteria. December 1966 Flood Routing No. 2 is similar to Routing No. 1 except routing begins 5 days later when increasing inflows prevent evacuation of conditional storage.

3. Standard Project Flood Routing No. 2 and December 1966 Flood Routing No. 2 presuppose an assumed physical inability to evacuate the conditional space as required by precipitation parameters.

4. Standard Project Flood Routings are based on operation as shown on the flood control diagram, Chart A-11 and include reduction of outflow as necessary to accommodate local accretions between Terminus Dam and McKays Point.

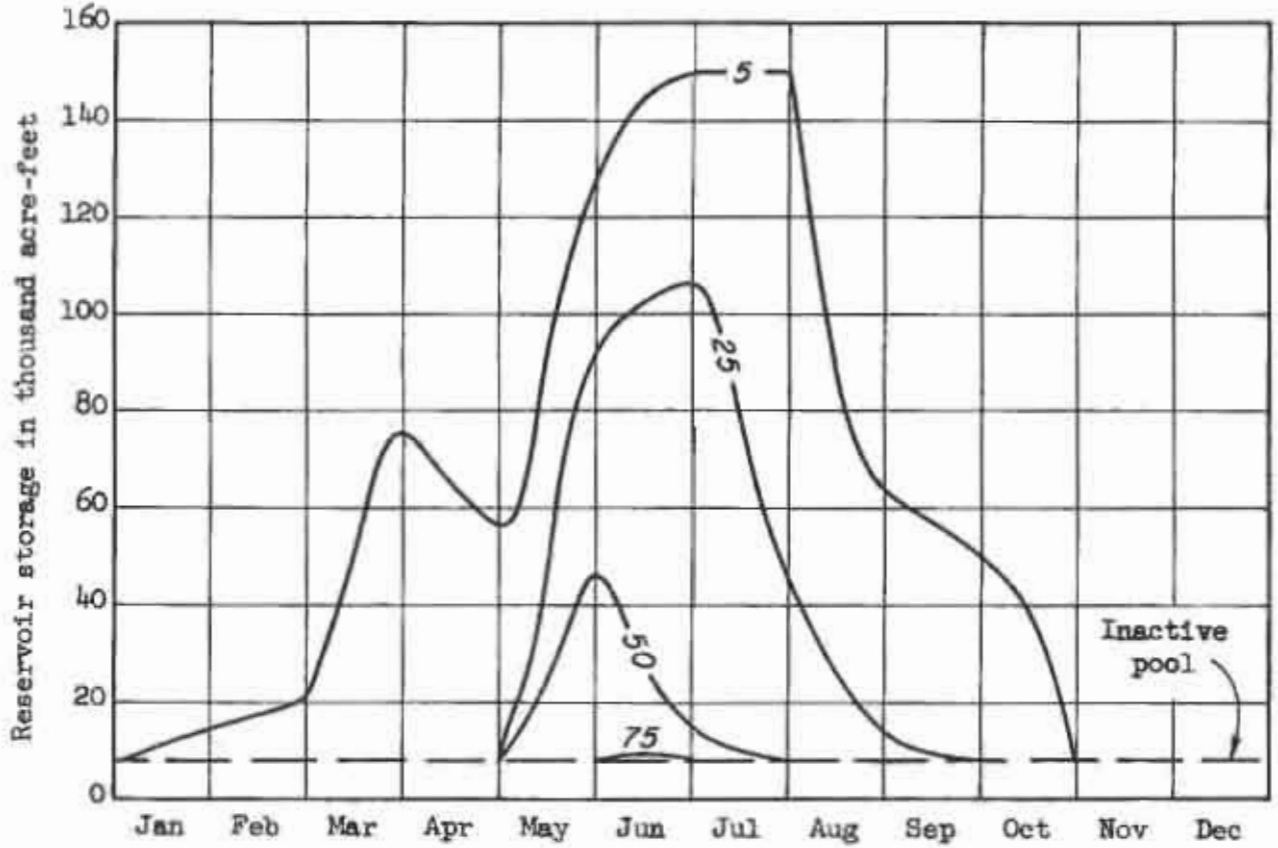
SPF revised and December 1966 Flood Routings added, November 1971

TERMINUS PROJECT
Kaweah River, California

FLOOD ROUTINGS

Corps of Engineers		Sacramento, California
R. E. B.	October 1957	File KT-2-26-193

CHART 26



Notes:

1. Indicated value is percentage of years that storage is equalled or exceeded on given date.
2. Curves based on reservoir operation study assuming an 8,000 acre-feet inactive pool.

TERMINUS PROJECT
Kaweah River, California

SEASONAL VARIATION OF
RESERVOIR STORAGE FREQUENCIES

U S Army Engineer District
Sacramento California
C.J.A. June 1962 File: KT-2-26-260

CHART 27

FLOOD CONTROL PARAMETER COMPUTATION

Basin NAP = 39
Σ NAP = 183.4
39 / 183.4 = 0.213

TERMINUS RESERVOIR
GROSS POOL 150,000 ACRE-FEET

Month May
Year 1969

DATE	PRECIPITATION IN INCHES FOR PERIOD: TERMINUS	BEAR TRAP	ATWELL	HOCKETT	GIANT FOREST	STATION TOTAL	BASIN MEAN PRECIP IN INCHES: FOR PERIOD	30-DAYS EARLIER	Σ 30-DAY		STORAGE	PREPROJECT SITE FLOW: CFS	THOUS AC-FT	Σ THOUS AC-FT	REMAINING FORECASTED RUNOFF	UNADJUSTED ALLOWABLE STORAGE	DEMANDS: NORMAL	ANTICIPATED	DIFFERENCE		ADJUSTMENT		ADJUSTED ALLOWABLE STORAGE	REQUIRED SPACE
NAP	14.0	45.9	39.6	40.9	43.0	183.4					(Taf)				(Taf)	(Taf)	(Thousand ac-ft)				(Taf)		(Thousand ac-ft)	
	Carried Forward													1480	650.0	—	871.2	572.8	141.6		—	—	0	150.0
1											68.8	3039	6.0	154.0	644.0	0	827.5	566.2	138.7		138.7		0	150.0
2											69.0	3084	6.1	160.1	637.9	0	823.8	559.0	135.8		135.8		0	150.0
3											68.4	2723	5.4	165.5	632.5	0	820.1	553.0	132.9		132.9		0	150.0
4											67.5	2544	5.0	170.5	627.5	0	816.4	546.4	130.0		130.0		0	150.0
5											66.3	2392	4.7	175.2	622.8	0	812.7	539.8	127.1		127.1		0	150.0
6											65.8	2742	5.4	180.6	617.4	0	809.0	533.4	124.2		124.2		0	150.0
7																								
8																								
9																								
10																								
11																								
12																								
13																								
14																								
15																								
16																								
17																								
18																								
19																								
20																								
21																								
22																								
23																								
24																								
25																								
26																								
27																								
28																								
29																								
30																								
31																								

SAMPLE
(SNOWMELT COMP.)

SPK Form 441 OCT 71

(Previous editions are obsolete)

SHORT - PERIOD RESERVOIR INFLOW COMPUTATIONS

RESERVOIR *TERMINUS*

MONTH *DEC.*

YEAR *1966*

DAY	PRECIP INCHES	TIME	ELEVATION FEET	STORAGE AC-FT	TOTAL RELEASE INST CFS	TOTAL RELEASE AVE CFS	STORAGE CHANGE AC-FT	STORAGE CHANGE CFS	INFLOW CFS	REMARKS
7	0	1500	692.39	146,482	5109					
	T	1700	692.54	146,771	5109	5109	289	1748	6857	
	.01+.01	1900	692.66	147,003	5109	5109	232	1404	6513	
	.01 0	2100	692.72	147,119	5109	5109	116	702	5811	
	.03+.02	2300	692.76	147,196	5109	5109	77	466	5575	
8	.03 0	0100	692.77	147,215	5109	5109	19	115	5274	
	.03 0	0300	692.76	147,196	5109	5109	-19	-115	4994	
	.03 0	0500	692.73	147,138	5109	5109	-58	-351	4758	
	.03 0	0700	692.67	147,022	5109	5109	-116	-702	4407	
	0	0900	692.59	146,868	5109	5109	-154	-932	4177	
	NR	1100	692.49	146,675	5108	5108	-193	-1168	3940	
	NR	1300	692.39	146,482	5108	5108	-193	-1168	3940	

SAMPLE

SPK FORM 121
2 APR 70

(Previous editions are obsolete)

LOG OF GATE OPERATIONS

_____ PROJECT

MONTH _____

YEAR _____

DAY	TIME	WATER SURFACE ELEVATION	NEW GATE OPENING IN FEET					
			GATE #	GATE #	GATE #	GATE #	GATE #	GATE #

SPK FORM 147
MAR 71

(Previous editions are obsolete)

CHART A-7

LOG OF MESSAGES AND INSTRUCTIONS

_____ PROJECT

MONTH _____

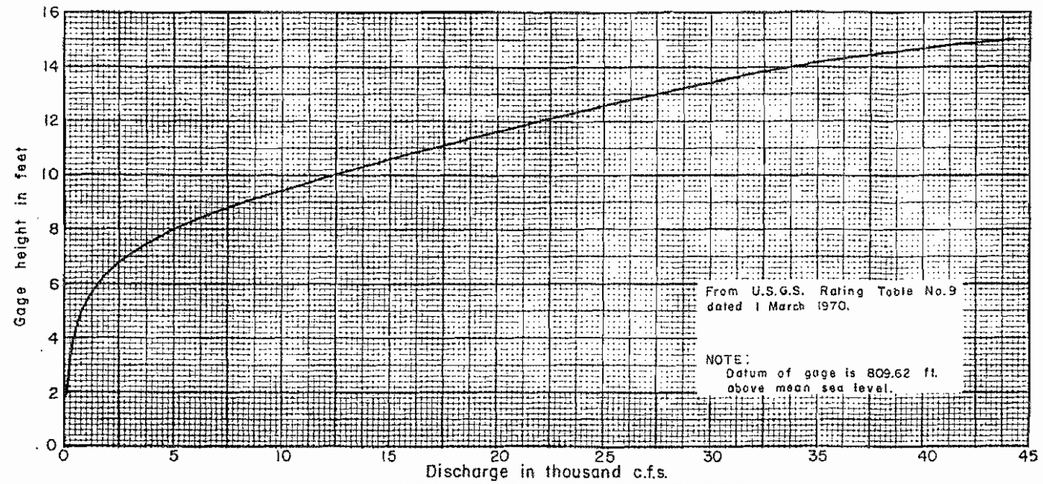
YEAR _____

DATE	TIME	MESSAGE	BY

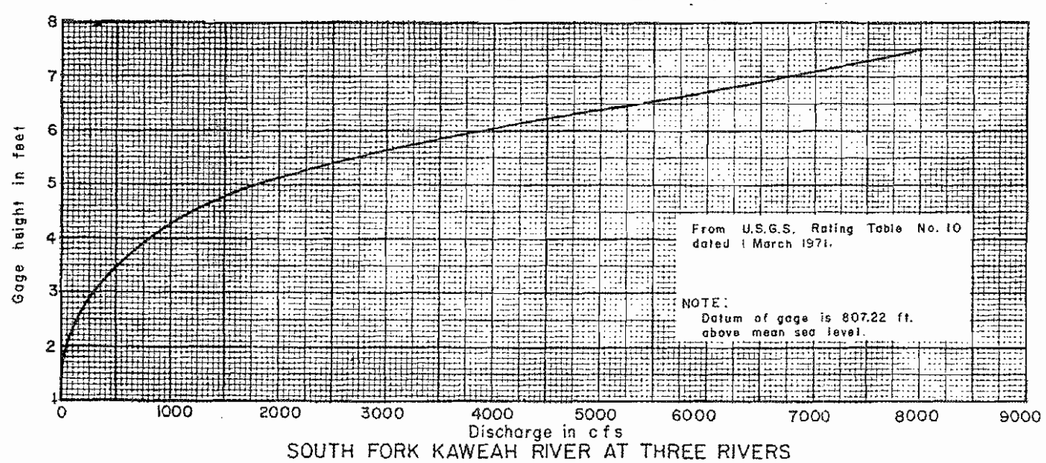
SPK FORM 122
MAR 71

(Previous editions are obsolete)

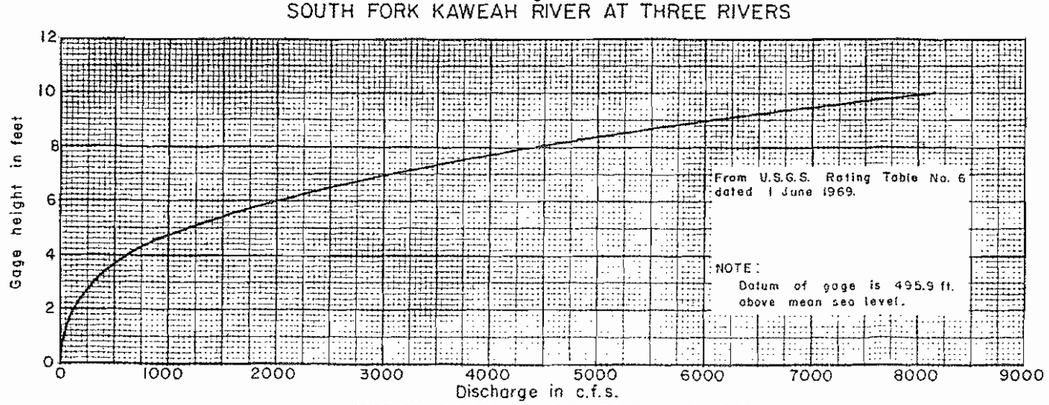
CHART A-8



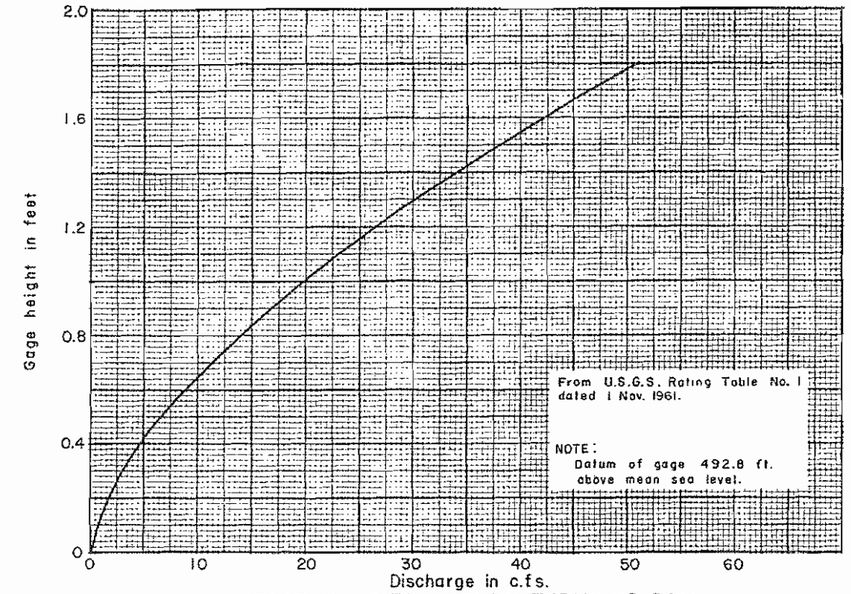
KAWEAH RIVER AT THREE RIVERS



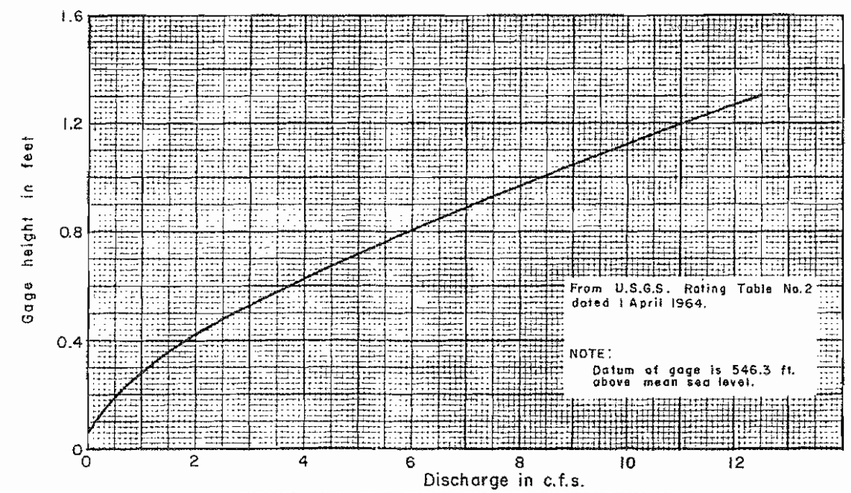
SOUTH FORK KAWEAH RIVER AT THREE RIVERS



KAWEAH RIVER BELOW TERMINUS DAM



FOOTHILL DITCH BELOW TERMINUS DAM



LEMON COVE DITCH BELOW TERMINUS DAM

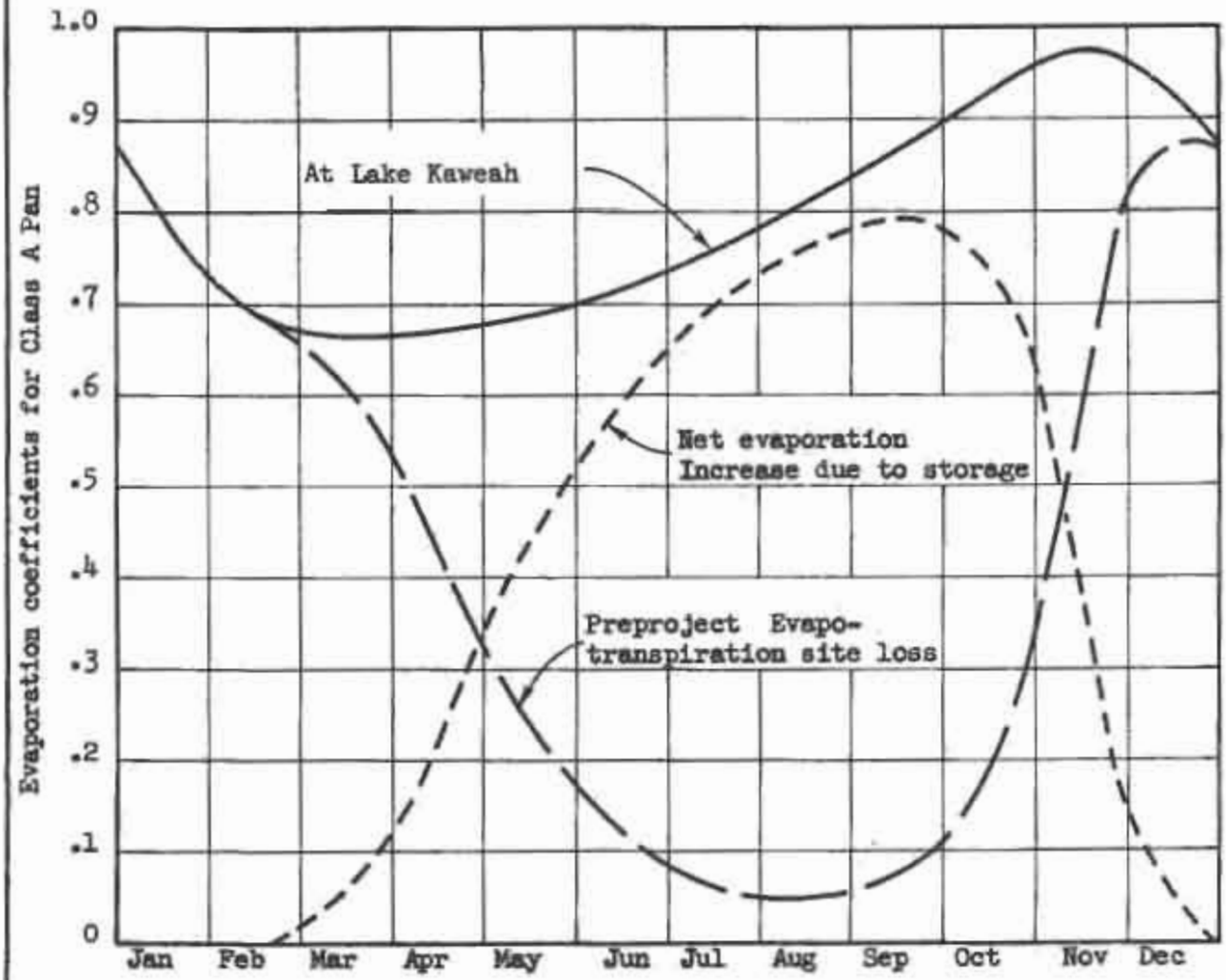
TERMINUS DAM (LAKE KAWEAH)
Kaweah River, California

STAGE-DISCHARGE CURVES

CORPS OF ENGINEERS SACRMENTO, CALIFORNIA

Prepared: H.A.Z.
Drawn: C.D.M. R.E.Y.
Date: November 1971

CHART A-9

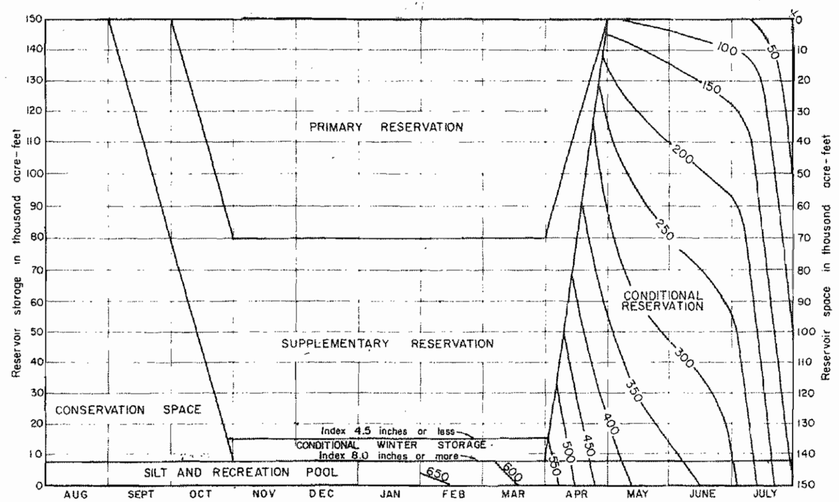


TERMINUS PROJECT
Kaweah River, California

EVAPORATION COEFFICIENTS

U S Army Engineer District
Sacramento California
D.D.D. Oct 1961 File: KT-2-26-263

CHART A-10



USE OF DIAGRAM

1. When storage is in the range of Conservation Space, Schedule I releases shall be made.

2. When storage is in the range of Supplementary Reservation, Schedule II releases shall be made.

3. When storage is in the range of Primary Reservation, Schedule III releases shall be made.

4. The division of space in the conditional winter storage range between 1 November and 1 April is based on watershed ground wetness as measured by the 30-day precipitation index computed on the basis of a basin mean normal annual precipitation of 39 inches. At anytime during the November-April period, when the accumulated basin mean precipitation for the preceding 30 days exceeds 4.5 inches, water stored in the reservoir above the storage level indicated by the precipitation index (interpolated as necessary between 4.5 and 8.0 inches) must be released for transfer to downstream spreading areas at rates corresponding to the channel capacity of inlet channels to the spreading areas. Initial release shall correspond to flows to the spreading areas averaging 5,400 acre-feet per day, and shall be reduced only as the required flood control space becomes available at Terminus Reservoir, or as the capacity of the inlet channels decreases because of filling of the spreading basins as illustrated in the schedule for release of water stored above precipitation index levels shown hereon.

5. After 1 April, the division of space in the conditional reservation range is based on predicted runoff, and the index used is the predicted full natural runoff in thousand acre-feet from the Kaweah River Basin between the given date and 31 July. On any given date after 1 April, space above that indicated by the parameter line (interpolated as necessary) corresponding to the predicted runoff is Supplementary Reservation and releases specified in Schedule II are required. Space below that indicated by the forecast parameter is Conservation Space and when storage is within this range, only such releases as are necessary to meet Schedule I requirements need be made.

6. After 1 May, releases may be increased above Schedule II values when forecasts of snowmelt runoff indicate that spillway releases in excess of channel capacity would otherwise occur.

ADJUSTMENTS

7. Storage of water in the conditional winter storage range is based on availability of alternative storage capacity in downstream spreading areas and on the capability to immediately transfer an amount of water at least equivalent to that stored within the conditional winter storage range to the spreading areas whenever necessary to restore required flood control space at Terminus Reservoir. If prior to 1 April it is determined by the operating agency that the available storage capacity in spreading areas is less than the quantity of water stored into the conditional winter storage range, or that channel capacities are insufficient to permit transfer at rates corresponding to an initial rate of at least 5,400 acre-feet of water per day from Terminus Reservoir to the available downstream spreading areas, the conditional winter storage will be reduced a corresponding amount by immediately initiating Schedule II releases.

8. After 1 April, the supplementary space required within the conditional reservation range is based on irrigation and spreading demands available for disposal of flood water within the downstream service area during the snowmelt season. Assuming an average continuous spreading rate of 42,600 ac-ft per month, if it is determined by the operating agency that actual irrigation and spreading demands will be appreciably different from the normal anticipated values for the snowmelt period as listed hereon, the supplementary flood control reservation shall be adjusted as follows:

> Increase (or decrease) reservation by the amount that the volume of anticipated minimum diversion between given date and 30 June for spreading and irrigation is less (or greater) than the volume determined using the schedule shown hereon.

RECREATIONAL POOL

9. Water supplied by local interests for recreational storage (up to 8,000 acre-feet) shall not be released unless necessary for control of forecasted snowmelt runoff.

RELEASE SCHEDULE

Schedule I	Irrigation Demands	
Schedule II	Irrigation Demands	Spreading Demands
Schedule III	Channel Capacity 5,500 cfs at McKay Point	

SAMPLE RELEASE DETERMINATION

(Volume in thousand ac-ft)

Date	Storage	Forecast	Lower limit of rain-flood reservation		Lower limit of snowmelt-flood reservation			Release Schedule
			Primary	Supple-mentary	Unadjusted Supple-mentary	Adjustment for irrigation and spreading	Adjusted Supple-mentary	
1 Jan	100	(a)	80	8	—	—	—	III
1 Jan	40	(a)	80	8	—	—	—	II
15 Apr	50	400	115	80	61	0	61	I
15 Apr	50	400	115	80	61	−20	41	II
1 Jun	40	300	—	—	47	20	67	I

(a) Available only after 1 February

ESTIMATED IRRIGATION AND SPREADING DEMANDS

(Thousand acre-feet)

MONTH	IRRIGATION	SPREADING DEMANDS (After filling basins)	* NORMAL ANTICIPATED IRRIG. AND SPREADING DURING SNOWMELT PERIOD
January	0-16.2	1st Month 65,000 ac.-ft. 2nd Month 58,000 ac.-ft. 3rd Month 50,000 ac.-ft. 4th Month 40,000 ac.-ft. 5th Month No spreading to recover percolating capacity. Average demand for 5 month period equals 42,600 ac.-ft. per month.	—
February	16.2-29.4		58.8-72.0
March	44.7		87.3
April	105.2		147.8
May	71.0		113.6
June	101.8		144.4
July	130.6		173.2
August	123.4		—
September	76.4		—
October	34.0		—
November	18.2-31.4		—
December	0-16.2		—

* Based on average continuous spreading demand of 42,600 ac.-ft. per month.

SCHEDULE FOR RELEASE OF WATER STORED ABOVE PRECIPITATION INDEX LEVELS

Precip. Index Inches	Storage Ac-Ft.	RELEASE SCHEDULE					
0-4.5	8,000 to 15,000	SCHEDULE I					
0-45	> 15,000	SCHEDULE II					
5.0	> 14,000	Release to equal capacity of inlet channels to spreading areas until required flood control space is restored. Estimated capacities are as follows:					
5.5	> 13,000						
6.0	> 12,000						
6.5	> 11,000						
7.0	> 10,000	1st Day	2nd Day	3rd Day	4th Day	5th Day	Continuous Capacity
7.5	> 9,000	2,700 c.f.s.	2,300 c.f.s.	1,950 c.f.s.	1,650 c.f.s.	1,450 c.f.s.	Schedule II
8.0	> 8,000						
> 8.0	> 8,000						

Revised May 1970

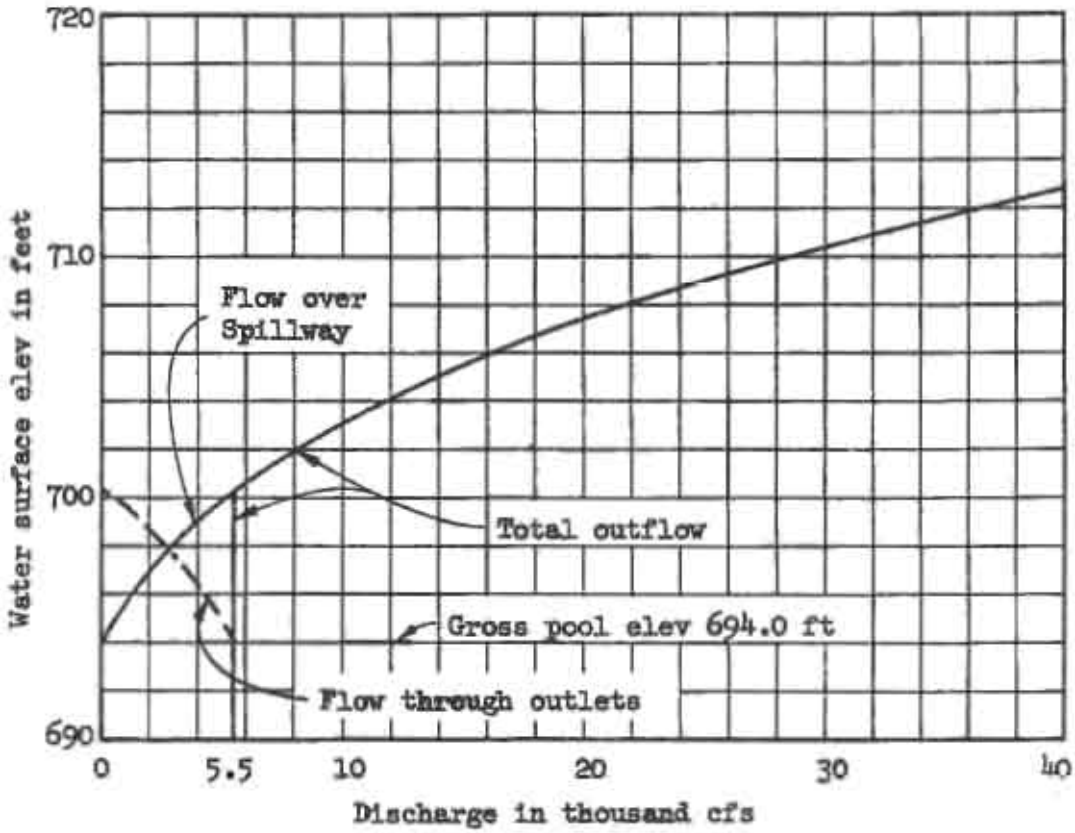
TERMINUS PROJECT
Kaweah River, California

FLOOD CONTROL DIAGRAM

Corps of Engineers — Sacramento, California

D.D.D. October 1957 — File: KT-2-26-192

CHART A-11



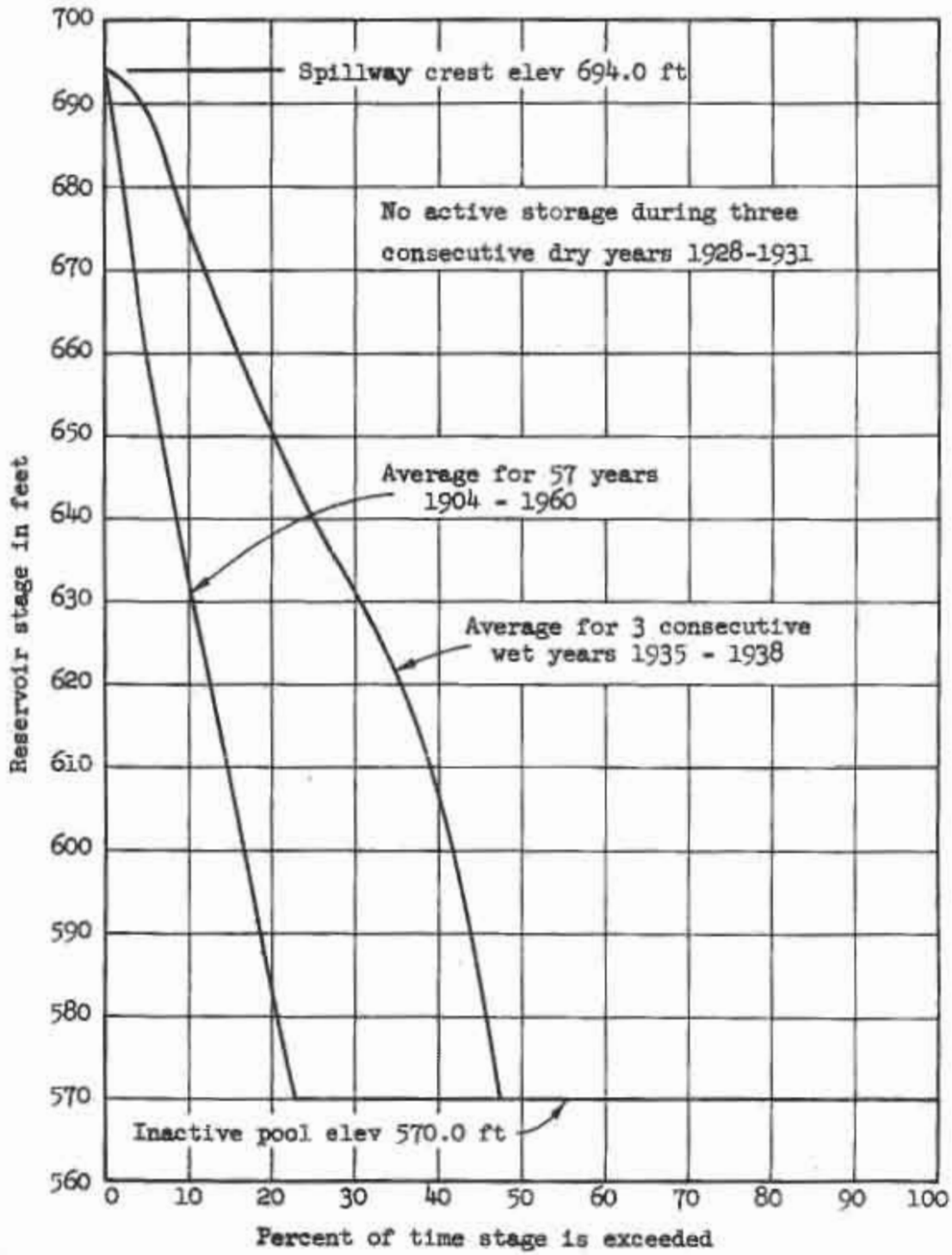
Revised Jan. 1972 to eliminate outlet gate operation during spillway flows above 5,500 c.f.s.

TERMINUS PROJECT
Kaweah River, California

OPERATION OF OUTLET GATES
FOR FLOOD CONTROL

U S Army Engineer District
Sacramento California
R.P.L. June 1962 File: KT-2-26-264

CHART A-12

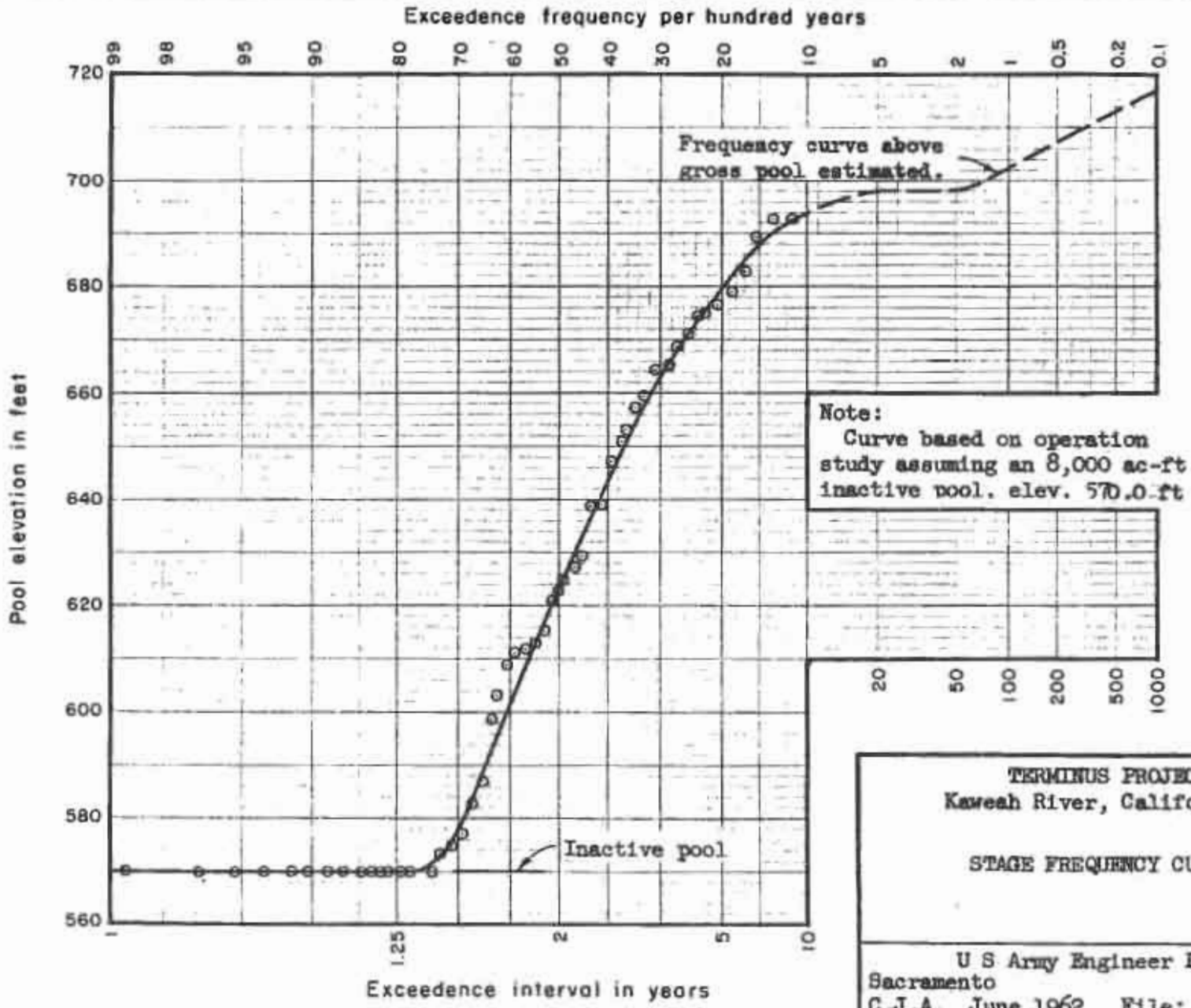


Note: Curves based on reservoir operation studies assuming an 8,000 ac-ft inactive pool.

TERMINUS PROJECT
Kaweah River, California

STAGE-DURATION CURVES

U S Army Engineer District
Sacramento California
C.J.A. June 1962 File: KT-2-26-261

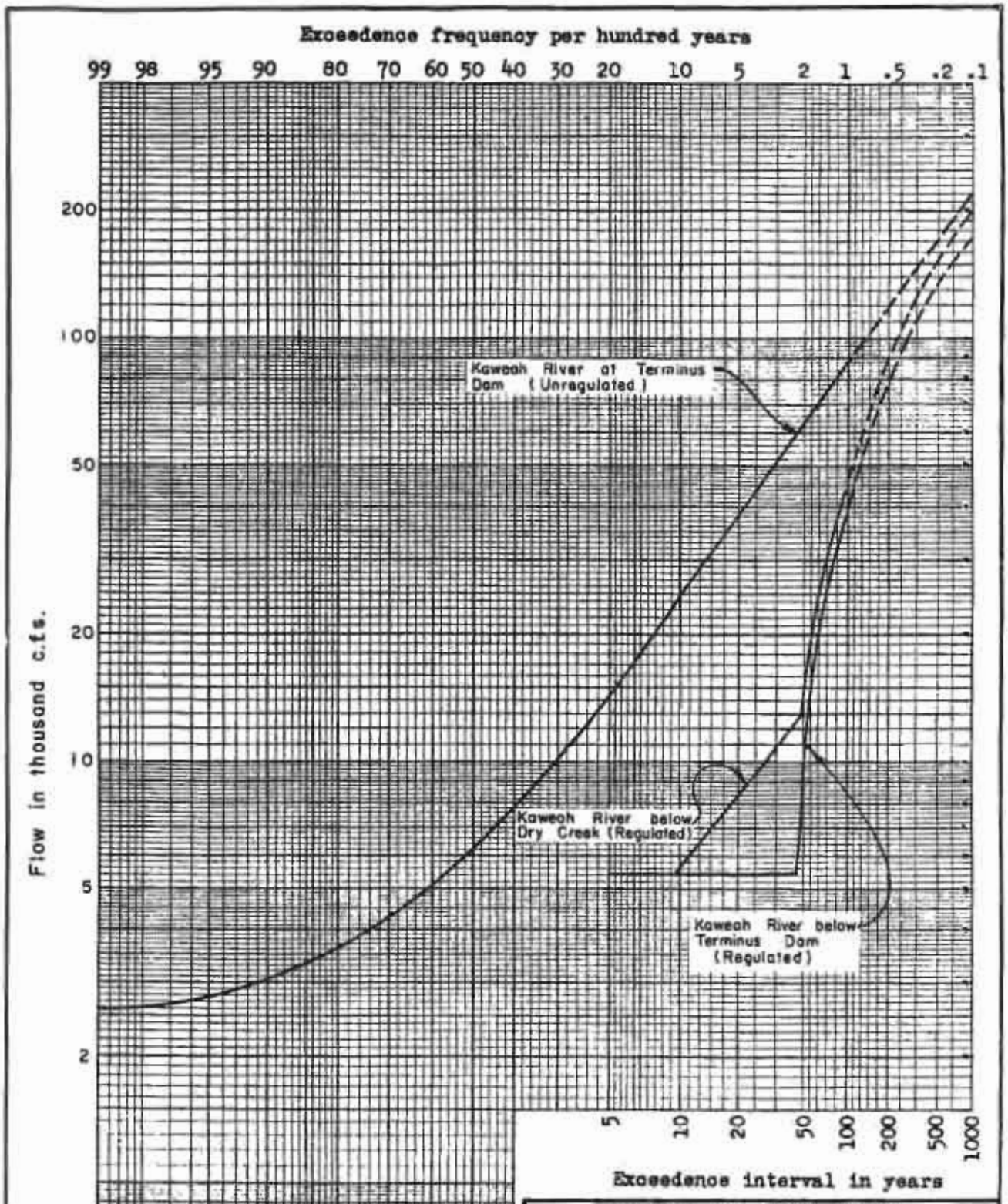


TERMINUS PROJECT
Kaweah River, California

STAGE FREQUENCY CURVE

U S Army Engineer District
Sacramento California
C.J.A. June 1962 File: KT-2-26-262

CHART 29



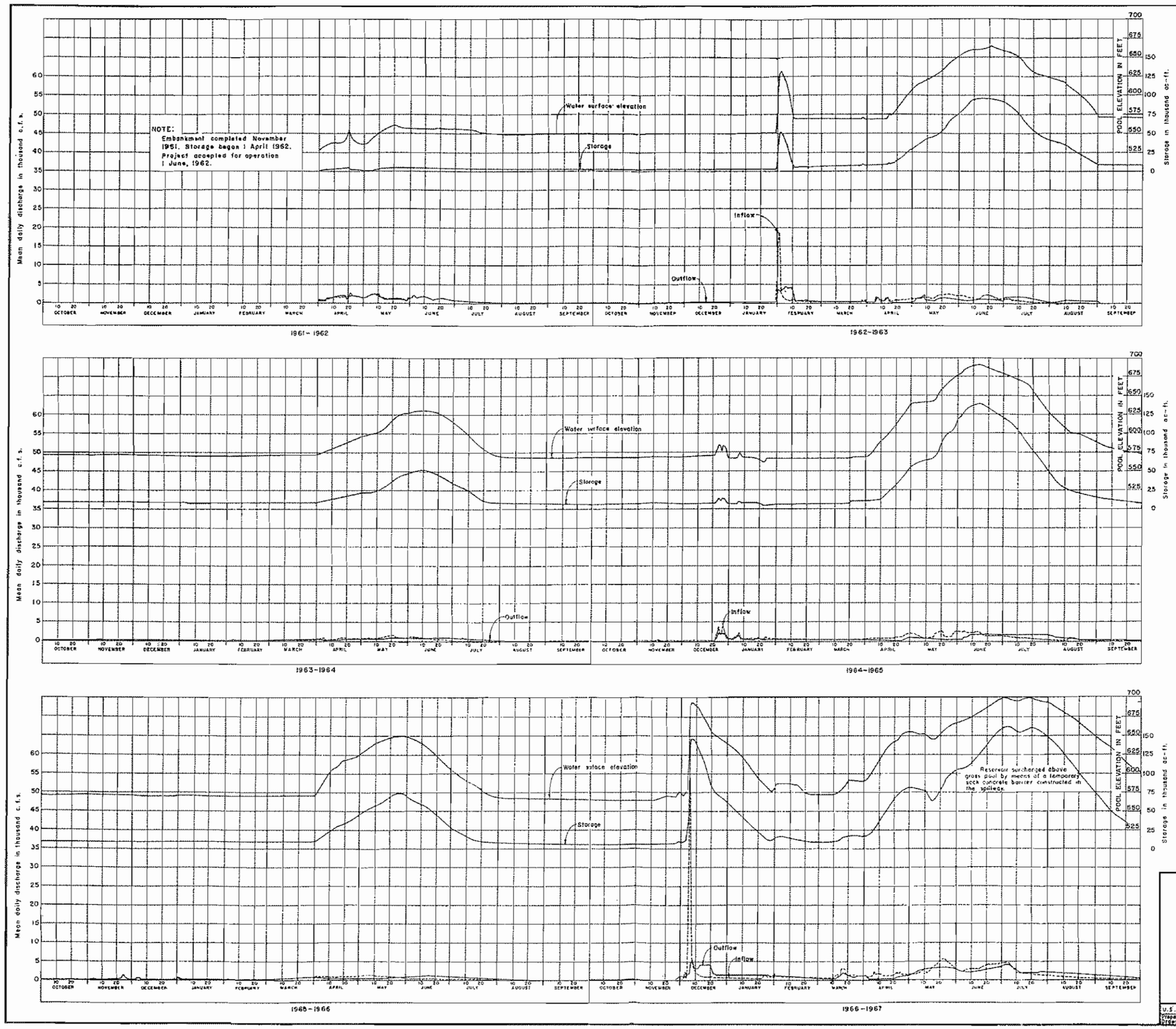
TERMINUS DAM (LAKE KAWEAH)
Kaweah River, California

RAIN-FLOOD
FREQUENCY CURVES

Corps of Engineers, Sacramento, Calif.

Prepared: D.D.D./R.A.N. Date: OCT. 1971

CHART 30

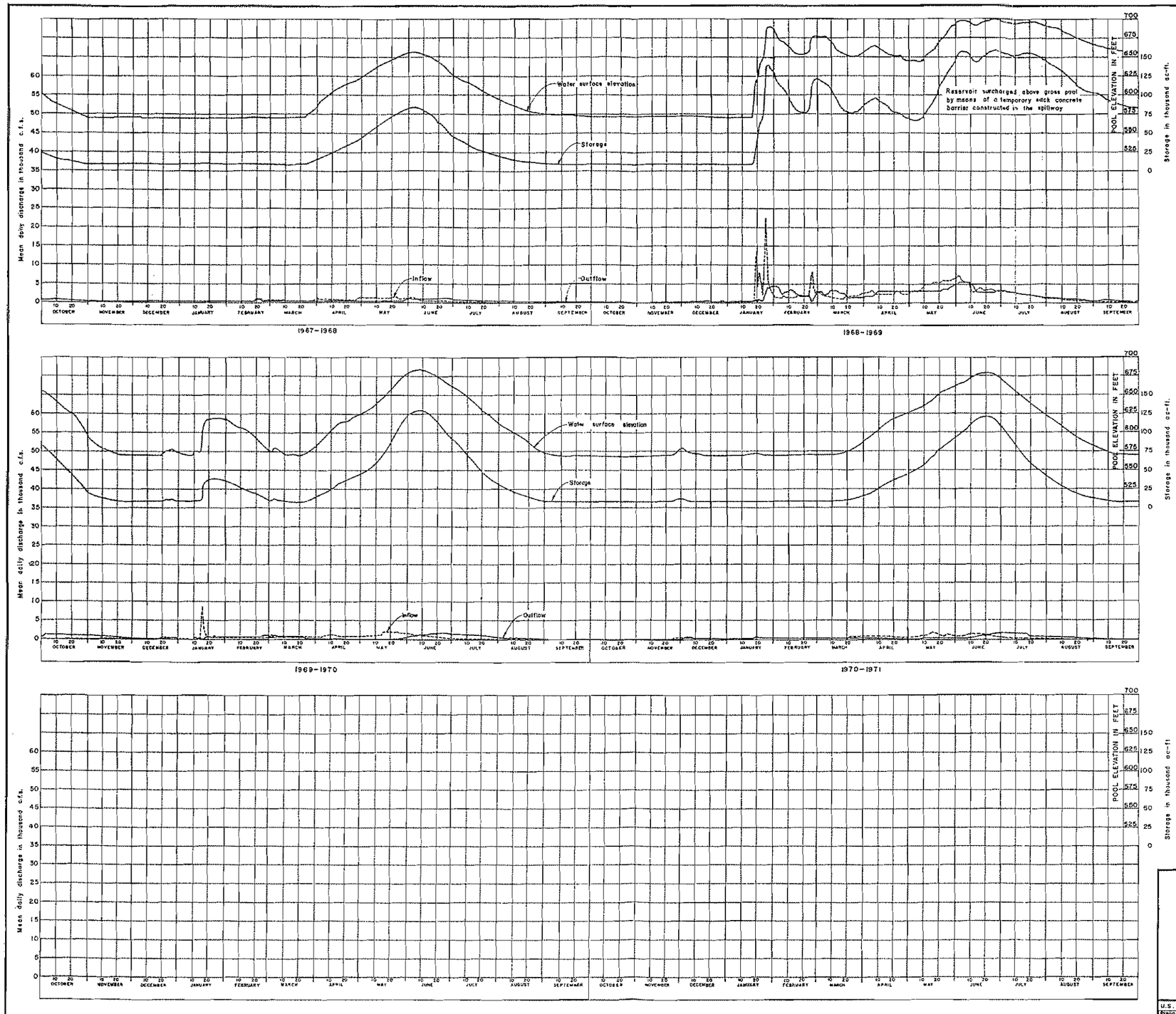


TERMINUS DAM (LAKE KAWEAH)
Kaweah River, California

OPERATION RECORD
TERMINUS RESERVOIR

U.S. Army Engineer District — Sacramento, California
Prepared: H.A.Z.
Drawn: R.E.T. — Date: April 1970

Sheet 1 CHART 31



TERMINUS DAM (LAKE KAWEAH)
Kaweah River, California

OPERATION RECORD
TERMINUS RESERVOIR

U.S. Army Engineer District — Sacramento, California
Prepared: K.A.Z.
Checked: R.E.L.
Date: April, 1970

Sheet 2 CHART 31

RESERVOIR REGULATION MANUAL
TERMINUS DAM (LAKE KAWEAH)
KAWEAH RIVER, CALIFORNIA

NOVEMBER 1971

APPENDIX A
STANDING OPERATING INSTRUCTIONS

U. S. Army Engineer District
Corps of Engineers
Sacramento, California

APPENDIX A

STANDING OPERATING INSTRUCTIONS

1. OPERATING REQUIREMENTS

Operation of Terminus Dam (Lake Kaweah) is accomplished by Corps of Engineers personnel under supervision of the Operations Branch, Construction-Operations Division of the Sacramento District Office, with instructions on all matters covering flood control operation received directly from the Reservoir Regulation Section of the Engineering Division. The reservoir operator is responsible for:

a. Accomplishing the physical operation of the reservoir in accordance with instructions contained in this manual or issued by the Reservoir Regulation Section. During storms, this will often require 24-hour attendance at the dam.

b. Calculating and maintaining a continuous provisional record of inflows, outflows, storage, preproject flows, weather data, and other data specified by the Reservoir Regulation Section. This information should be recorded on forms illustrated on Charts A-1, A-2, A-3, A-4, A-5, A-6, A-7 and A-8; and transmitted to the Reservoir Regulation Section at the end of each month.

c. Reporting by radio (or telephone) to the Reservoir Regulation Section data as outlined in paragraphs 2 and 3, and other data that may be requested from time to time.

d. Obtaining necessary information on scheduled downstream irrigation and spreading activities and keeping local interests continuously advised of the operation of the reservoir.

e. Reporting to the Reservoir Regulation Section any unusual condition in the reservoir or along the downstream channel which might interfere with the planned operation of the reservoir.

f. Maintaining all trash racks clear of trash in order that the outlet gates can be operated systematically and effectively.

g. Maintaining a log of gate operation as illustrated on Chart A-7, containing (a) change in position of gates, (b) date and time, (c) reservoir water level, and (d) the initials of the individual accomplishing the change.

h. Making and recording weekly checks on reservoir and outflow gage readings to assure proper operation of all recording equipment.

i. Obtaining samples for water quality and sedimentation analysis as required.

j. Immediately after the end of each month, transmitting to the Reservoir Regulation Section data specified in paragraph 2.

k. Making emergency operation changes when contact with the District Office is broken and a clearly defined change occurs that warrants immediate action.

l. Maintaining a record of instructions received from the Reservoir Regulation Section, and requests received through the watermaster and from other irrigation interests.

2. OPERATING REPORTS

a. The reservoir operator shall report by radio or telephone to the Reservoir Regulation Section each work day between 7:30 a.m. and 9:00 a.m., data as follows:

(1) Reservoir stage and storage as of midnight.

(2) Reservoir storage increment (ending at midnight).

(3) Pan evaporation.

(4) Lake evaporation

(5) Mean daily flows (ending at midnight) of:

(a) Kaweah River below Terminus Dam.

(b) Foothill Ditch Diversion.

(c) Lemon Cove Ditch Diversion.

(d) Hawkeye Ditch Diversion.

(e) Total outflow.

(f) Total inflow.

(6) Preproject flow.

(7) Maximum temperature at the dam (during snowmelt runoff period, 1 April thru 31 July each year).

(8) Precipitation at the dam as measured and seasonal total to date.

(9) Inches (total and change) of precipitation, or snow, and temperature at 7:00 a.m., reported by radio reporting hydrologic gages.

When conditions do not warrant weekend or holiday reports, complete reports for each day shall be made on the first day following the nonreporting period. More frequent reports of the above information and reports of other Kaweah River data will be made in the same manner when requested by the Reservoir Regulation Section. Forms shown on Charts A-1, A-2, A-3, A-4 should be used to compute the above information.

b. Immediately after the end of each month, the reservoir operator shall dispatch to the Reservoir Regulation Section the charts for that month from the following instruments:

(1) Recording precipitation gage.

(2) Recording hygro-thermograph.

(3) Remote recording gages.

3. SPECIAL WEATHER AND FLOOD REPORTS

During the rainflood season 1 October to 1 May the reservoir operator shall call the Reservoir Regulation Section immediately whenever one of the following occurs:

a. One inch or more of rainfall occurs at the project during any 6-hour period or 1.5 inches of rainfall during any 24-hour period.

b. An increase in flow of 1,000 c.f.s. or more at the Kaweah River inflow gaging station during any 8-hour period. Rating curves for Kaweah River at Three Rivers and South Fork Kaweah River at Three Rivers are shown on Chart A-9.

Any special report based on one of the foregoing criteria should include the latest available data concerning the other. On non-working days or at night, these special reports should be telephoned directly to the Chief of the Reservoir Regulation Section or his designated alternate.

4. COMPUTATION OF HYDROLOGIC DATA

a. The required hydrologic data to be reported, as specified in paragraph 2 above, for use in operation of Lake Kaweah and for official record purposes may be obtained or computed as follows:

(1) Reservoir stage is obtained from the recording pool gage at the dam and storage is obtained from the Lake Kaweah capacity table.

(2) Reservoir storage increment is the algebraic difference between the previous day's recorded midnight storage and the most recent midnight storage.

(3) Pan evaporation is obtained from the class A evaporation land pan located at Terminus Dam.

(4) Lake evaporation in inches is equal to the pan evaporation in inches multiplied by the evaporation coefficient shown on Chart A-10. For this computation, pan evaporation as measured at 7:00 a.m. is used to compute lake evaporation for the previous day.

(a) Gross Evaporation

$$\text{pan evaporation (inches)} \times \frac{\text{gross evaporation coefficient}}{12}$$

x average lake area (acres) = acre-feet
(Round to nearest acre-foot for next computation)

acre-feet x 0.50417* = s.f.d. = mean c.f.s. for 24-hours

(b) Net Evaporation

$$\text{pan evaporation (inches)} \times \frac{\text{net evaporation coefficient}}{12}$$

x average lake area (acres) = acre-feet
(Round to nearest acre-foot for next computation)

acre-feet x 0.50417* = s.f.d.

*Coefficient shown is for 24-hour day. For 23-hour day (last Sunday of April each year) use 0.52609. For 25-hour day (last Sunday of October each year) use 0.48400.

(c) Lake area used when computing evaporation will be the average area for the day; obtained by averaging the midnight areas at the beginning and ending of the period being computed.

(5) Procedures used to compute mean daily flows are detailed in sub-paragraph 4.b. below. Information required in sub-paragraph 2.a.(5) should be obtained as follows:

(a) Kaweah River below Terminus Dam from gage reading.

(b) Foothill Ditch Diversion from gage reading.

(c) Lemon Cove Ditch Diversion from gage reading.

(d) Hawkeye Ditch Diversion from gage reading.

(e) The total outflow is the sum of the outflow through the river outlets, diversions, and over the spillway, and consists of the flows measured at the main outflow gage below the dam and the releases to Foothill, Lemon Cove and Hawkeye Ditch Diversions as measured at the gage on each of the diversions canals. Values for outflow are determined by using computation methods in accordance with U. S. Geological Survey standards. (If streamflow is less than 10 c.f.s., compute to the nearest 0.1 c.f.s. and if the streamflow is more than 10 c.f.s., compute to the nearest c.f.s.) Current rating curves for the streamflow gaging stations are shown on Chart A-9.

(f) Computed mean inflow to the lake will be taken as the algebraic sum of the mean total outflow, change in lake storage, and gross evaporation from the lake water surface and will represent mean inflow to the lake from all sources including rainfall on the lake surface.

Mean daily outflow (c.f.s.) ±
change in lake storage (s.f.d.) +
gross evaporation (s.f.d.) =
mean inflow (c.f.s.)

(6) Computed preproject flow at the lake will be the mean daily inflow minus net evaporation. Net evaporation is defined above.

(7) Temperature and precipitation at the dam is measured at the weather station.

(8) When computed numbers contain more than the required number of significant figures, they shall be rounded to the nearest required unit. If the portion to be eliminated is exactly five (5), the number shall be rounded to the nearest even number. Sample calculations are shown on Charts A-3 and A-4.

b. Mean Daily Flow Computations.

(1) Check chart for errors in gage height and for time. Time is normally corrected to the nearest 10 minutes, gage height to the nearest .01 foot.

(2) Tabulate correct gage height readings at odd hours, starting with 0100 hours. Pen correction, if any, should be noted.

(3) Enter current rating table, using shifts as applicable, determine and list flow at each odd hour.

(4) Total the 12 flow readings so obtained and divide by 12. This is the mean daily flow.

(5) Mean daily flow would be listed to nearest 0.1 c.f.s. for flows up to 10 c.f.s., and to the nearest c.f.s. for flows above 10 c.f.s. Such values will later be rounded to 3 significant figures by the USGS prior to publication.

(6) When calculating discharge for minus shift correction, enter rating table at shift amount <u>less</u> than corrected height, i.e., if corrected gage height is = 4.86 and shift is -.02 enter rating table at 4.84 to obtain discharge. For (+) shift, enter rating table at shift amount <u>above</u> correct gage height.

(7) In order to obtain a desired flow under shift conditions use the following procedures for (-) shifts.

Determine required gage height from rating table for desired discharge.

(a) <u>Add</u> amount of (-) shift to gage height obtained from table. This is the required gage height for desired discharge.

Example: Shift (-.03) desired discharge = 5,000 c.f.s. Rating table shows gage height of 10.20 + = 5,000 c.f.s. Required gage height for 5,000 c.f.s. is 10.20 + (.03) = 10.23.

(b) For (+) shift use same procedure except <u>subtract</u> amount of shift for required gage height.

Example: Shift = (+.06) desired discharge = 5,000 c.f.s. Rating table shows gage height of 10.20 = 5,000 c.f.s. Required gage height = 10.20 - (.06) = 10.14.

(8) Sample calculations are shown on Chart A-3.

5. EMERGENCY FLOOD OPERATION

a. Flood control operations shall be made in accordance with instructions from the Reservoir Regulation Section. During flood periods close contact will be maintained between the project and District personnel on a 24-hour per day basis as required.

b. If communication is broken between the project and the District during a flood emergency the following procedure should be initiated.

(1) Continue releases in accordance with the last instructions received from the District Office.

(2) Make a continuous effort to re-establish contact with the District Office by use of both radio and telephone facilities.

(3) If communication cannot be re-established the outlet works shall be operated in accordance with Chart A-11, and the requirements of Chart A-12 shall be observed if the reservoir level reaches and exceeds elevation 694.0 feet.

RADIO REPORTING HYDROLOGIC GAGES

TERMINUS PROJECT — DEC. 1970

OBSERVER: ✓

NOTE: NR = No Report; RX = Report Unreadable

DAY	TIME	Bear Trap Meadow PRECIPITATION READING	Σ INCHES	Δ INCHES	Atwell Mill PRECIPITATION READING	Σ INCHES	Δ INCHES	Hockett Meadow PRECIPITATION READING	Σ INCHES	Δ INCHES	Giant Forest SNOW W.E. READING	Σ INCHES	Δ INCHES	Giant Forest PRECIPITATION READING	Σ INCHES	Δ INCHES	TEMP °F	REMARKS
1	0700	080	8.8	+.2	081	8.9	+.1	083	9.1	0	010	9.6	0	084	9.2	+.2	—	
1	1000	080	8.8	0	081	8.9	0	086	9.5	+.4	010	9.6	0	084	9.2	0	—	
1	1550	081	8.9	+.1	083	9.1	+.2	086	9.5	0	010	9.6	0	085	9.4	+.2	—	
2	0700	082	9.0	+.1	086	9.5	+.4	086	9.5	0	010	9.6	0	094	10.3	+.9	—	
2	0955	100	11.0	+2.0	090	9.9	+.4	094	10.3	+.8	011	10.6	+1.0	100	11.0	+.7	—	
2	1540	105	11.6	+.6	098	10.1	+.2	095	10.4	+.1	012	11.5	+.9	102	11.2	+.2	—	
3	0700	106	11.7	+.1	092	10.1	0	095	10.4	0	012	11.5	0	102	11.2	0	—	

SAMPLE

CHART A-1

SPK FORM 333

(Previous editions are obsolete)

RECORD OF EVAPORATION AND CLIMATOLOGICAL OBSERVATIONS

STATION *TERMINUS DAM* OBSERVER *—* TIME OF OBSERVATION *0715* MONTH *DEC.*, 19[illegible]

DATE	AIR TEMPERATURE °F				R. H.	WATER TEMP °F		PRECIPITATION		WIND		EVAPORATION			ADDITIONAL DATA - REMARKS
	PRECEDING 24 HRS		AT OBSERVATION		CALC AT OBSN IN %	PRECEDING 24 HOURS		AMOUNT AT OBSN INCHES	SEASONAL TOTAL INCHES	ANEMOMETER READING	24 HR MOVEMENT MILES	AMOUNT ADDED +	AMOUNT REMOVED −	AMOUNT OF EVAP	
	MAX	MIN	DRY	WET		MAX	MIN								
1	60	42	48			50	41	T	4.44	5182	71	.04	—	.04	
2	60	47	53			55	43	0.27	4.71	5236	54	—	.20	.07	
3	57	39	41			55	38	0.31	5.02	5317	81	—	.26	.05	@ 1132 P37 - Dry - 54
4	52	40	45			55	38	0	5.02	5373	56	.06	—	.06	Wet - 48 = RH - 64
5	62	43	43			57	39	0	5.02	5436	63	.09	—	.09	
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															
16															
17															
18															
19															
20															
21															
22															
23															
24															
25															
26															
27															
28															
29															
30															
31															
SUM															
AVG															

SAMPLE

SPK FORM 115 1 FEB 60

REPLACES EDITION OF 27 OCT 53 WHICH IS OBSOLETE.

CHART A-2

BI-HOURLY AND MEAN DAILY FLOW AT LEMON COVE DITCH PROJECT TERMINUS MONTH APRIL YEAR 1971

DATE 22

Hr	Pen Reading	Pen Cor	Correct Gage Ht	Shift Cor	Flow in cfs
1	0.64	0	0.64	-.01	4.0
3					
5					
7	0.64		0.64		4.0
9	0.65		0.65		4.1
11					
13					
15					
17					
19					
21					
23	0.65	0	0.65	-.01	4.1

TOTAL 48.8
MEAN 4.1

DATE 23

Hr	Pen Reading	Pen Cor	Correct Gage Ht	Shift Cor	Flow in cfs
1	0.65	0	0.65	-.01	4.1
3					
5					
7					
9	0.65		0.65		4.1
11	0.73		0.73		5.0
13					
15	0.73		0.73		5.0
17	0.74		0.74		5.1
19					
21					
23	0.74	0	0.74	-.01	5.1

TOTAL 55.9
MEAN 4.7

DATE 24

Hr	Pen Reading	Pen Cor	Correct Gage Ht	Shift Cor	Flow in cfs
1	0.74	0	0.74	-.01	5.1
3					
5					
7					
9					
11					
13					
15					
17					
19					
21					
23	0.74	0	0.74	-.01	5.1

TOTAL 61.2
MEAN 5.1

DATE 25

Hr	Pen Reading	Pen Cor	Correct Gage Ht	Shift Cor	Flow in cfs
1	0.74	0	0.74	-.01	5.1
3					
5					
7					
9					
11					
13					
15					
17					
19					
21					
23	0.74	0	0.74	-.01	5.1

TOTAL 61.2
MEAN 5.1

DATE 26

Hr	Pen Reading	Pen Cor	Correct Gage Ht	Shift Cor	Flow in cfs
1	0.74	0	0.74	-.01	5.1
3					
5					
7	0.74		0.74		5.1
9	0.92		0.92		7.2
11					
13	0.92		0.92		7.2
15	0.99		0.99		8.1
17					
19					
21					
23	0.99	0	0.99	-.01	8.1

TOTAL 82.5
MEAN 6.9

DATE 27

Hr	Pen Reading	Pen Cor	Correct Gage Ht	Shift Cor	Flow in cfs
1	0.99	0	0.99	-.01	8.1
3					
5					
7					
9					
11					
13					
15					
17					
19					
21					
23	0.99	0	0.99	-.01	8.1

TOTAL 97.2
MEAN 8.1

DATE 28

Hr	Pen Reading	Pen Cor	Correct Gage Ht	Shift Cor	Flow in cfs
1	0.99	0	0.99	-.01	8.1
3					
5					
7					
9					
11					
13					
15					
17					
19					
21					
23	0.99	0	0.99	-.01	8.1

TOTAL 97.2
MEAN 8.1

REMARKS

Rating Curve No. 8 Mar. 71

-.01 shift

SAMPLE

SPK FORM 351
12 JAN 66

PACIFIC DAYLIGHT SAVING TIME

CHART A-3

GROSS POOL ELEVATION: 694.00 FT
STORAGE: 150,000 AC-FT

DA Y RESERVOIR COMPUTATIONS

TERMINUS RESERVOIR, KAWEAH RIVER, CALIFORNIA

MONTH: May
YEAR: 1969

DAY	POOL ELEV MDNT (ft)	STORAGE MDNT (ac-ft)	STORAGE INCREMENT (ac-ft)	STORAGE INCREMENT (afd)	MEAN OUTFLOW (cfs) KAWEAH	FOOT-HILL	LEMON COVE	HAWKEYE DITCH	TOTAL	MEAN INFLOW (cfs)	AVERAGE LAKE AREA (ac)	PAN EVAP (in)	GROSS EVAP K	GROSS EVAP LAKE (afd)	NET EVAP K	NET EVAP LAKE (afd)	PRE-PROJECT (afd)	FORE-CAST (1000 ac-ft)	ALLOW STOR (1000 ac-ft)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
1	645.56	68866	+53	+27	2984	16	3.0	2.5	3006	3045	1332	.30	.05467	18	.028167	6	3039	649.0	0
2	645.67	69013	+147	+74	2984	17	3.0	2.5	3006	3088	1333	.20		8	.030000	4	3084	637.9	0
3	645.24	68441	-572	-288	2984	17	3.0	2.5	3006	2727	1330	.24		9	.030000	5	2723	632.5	0
4	644.54	67516	-925	-466	2984	17	3.1	2.5	3007	2547	1322	.15		6	.030833	3	2544	627.5	0
5	643.61	66298	-1218	-614	2978	17	3.8	2.5	3001	2397	1309	.25		10	.030833	5	2392	622.8	0
6	643.20	65765	-533	-269	2980	17	4.8	2.5	3004	2747	1299	.32		18	.031667	7	2742	617.4	0
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			
31																			
SUM																			

SAMPLE

CHART A-4

SPK FORM 153-4 (Replaces SPK Form 266, 18 Sep 68, which is obsolete) PACIFIC DAYLIGHT SAVING TIME

ATTACHMENT 7 – TECHNICAL JUSTIFICATION

APPENDIX C

2005 Terminus Dam and Lake Kaweah Water Control Manual

TERMINUS DAM
AND LAKE KAWEAH
KAWEAH RIVER, CALIFORNIA

WATER CONTROL MANUAL

APPENDIX III TO
MASTER WATER CONTROL MANUAL
TULARE LAKE BASIN, CALIFORNIA

US Army Corps
of Engineers ®
Sacramento District

JUNE 1962
REVISED NOVEMBER 1971
REVISED JULY 2005

I - INTRODUCTION

1-01. Authorization. This Water Control Manual is for the Terminus Dam and Lake Kaweah Project, located on the Kaweah River in California, and is Appendix III to the Tulare Lake Basin Master Water Control Manual. It is prepared in accordance with instructions contained in:

EM 1110-1-1004	Engineering and Design – Geodetic and Control Surveying	1 June 2002
ER 1110-2-240	Engineering and Design – Water Control Management	8 October 1982
ER 1110-2-249	Management of Water Control Data Systems	31 August 1994
EM 1110-2-3600	Management of Water Control Systems	30 November 1987
ER 1110-2-8156	Preparation of Water Control Manuals	31 August 1995
ETL 1110-2-335	Development of Drought Contingency Plans (1944 Flood Control Act)	1 April 1993
CESPD-R-1110-2-8	Guidance on the Preparation of Deviations from Approved Water Control Plans	12 September 2002

All instructions pertain to requirements for reports on reservoir regulation.

1-02. Purpose and Scope. This manual contains descriptive information, a detailed plan for water control management, and a Water Control Diagram for the Terminus Dam and Lake Kaweah Project on the Kaweah River in California. It also assigns responsibilities for water control operation of the project. A description of the overall Tulare Lake Basin plan for flood control is given in the "Master Water Control Manual, Tulare Lake Basin, California."

1-03. Related Manuals and Reports. This manual replaces the "Terminus Dam (Lake Kaweah) Reservoir Regulation Manual" dated June 1962, revised November 1971. The Terminus Dam and Lake Kaweah Water Control Manual is Appendix III to the Tulare Lake Basin Master Water Control Manual. Other related manuals and reports are as follows:

Manuals		Date
Master Water Control Manual Tulare Lake Basin, California		Dec 1953
Appendix I	Pine Flat Lake	Nov 1953 (Rev Sep 79)
Appendix II	Isabella Lake	May 1953 (Rev Jan 78)
Appendix IV	Success Lake	Jun 1961 (Rev Jan 82)
Operation and Maintenance Manual		Jan 1983

Reports	Date
Review of Spillway and Adequacy	Nov 1978
Definitive Project Report	Dec 1949
DM 1 Relocations	1 Jul 1956
Supplement #1	11 Mar 1959
DM 2 Real Estate	22 Oct 1956
Supplement #1	1 Jul 1957
DM 3 Dam and Appurtenances W/App A, B, and C	20 Feb 1957
DM 4 Administrative and Utility Buildings	1 Mar 1957
DM 5 General Design	15 Dec 1957
DM 6 Reservoir Regulation	29 Oct 1957
DM 7 Reservoir Clearing	15 Feb 1959
DM 8 Initial Public-Use Facilities	Apr 1961
DM 9 Master Plan	Aug 1961
DM9B-C1 Recreational Development at Areas 2, 3, 4, 5, and 6	Dec 1964
DM 10 Operators' Quarters	1 Dec 1962
Supplement #1	6 Feb 1963
Kaweah River Basin Investigation, Reconnaissance Report	Jul 1987
Kaweah River Basin Hydrology	Aug 1990
Kaweah River Basin Investigation Feasibility Study, California – Final Feasibility Report	Sep 1996
Kaweah River Basin Investigation Feasibility Study, California – Final Environmental Impact Statement/ Environmental Impact Report	Sep 1996
Terminus Dam at Lake Kaweah, Tulare County, California – Design Memorandum	Aug 1998
Terminus Dam Spillway Enlargement, Initial Filling Plan	Mar 2005

1-04. Project Owner. The Terminus Dam and Lake Kaweah Project is owned by the U.S. Government and represented by the U.S. Army Corps of Engineers, Sacramento District.

1-05. Operating Agency. The U.S. Army Corps of Engineers, Sacramento District, operates the Terminus Dam and Lake Kaweah Project. The Park Manager has the administrative responsibilities for the project and is on duty from 7:45 a.m. to 4:30 p.m., Monday through Friday. Project personnel are normally at the project from 6:45 a.m. to 4:30 p.m. seven days a week and will be on duty during holidays and at other-than-normal working hours, as necessary, for effective project operation. Operational responsibilities are explained in detail in Exhibit A. Business and home phone numbers of the individuals responsible for project operation are given at the beginning of this manual and in Exhibit A.

1-06. Regulating Agencies. The U.S. Army Corps of Engineers, Sacramento District, regulates the Terminus Dam and Lake Kaweah Project. The Corps developed the Water Control Plan for

Lake Kaweah with the objective of obtaining the greatest possible benefits from flood control, irrigation, and recreation. The Kaweah Delta Water Conservation District (KDWCD) directs releases for purposes other than flood control. For more detailed information on KDWCD operational responsibilities, refer to Exhibit A. Personnel responsible for project operation are listed in the front of this manual and in Exhibit A.

(This page intentionally left blank)

II - DESCRIPTION OF PROJECT

2-01. Location. The Terminus Dam and Lake Kaweah Project is located in the southern half of the Central Valley in Tulare County, California, on the Kaweah River, approximately 21 miles (33.8 km) east of the city of Visalia. Lake Kaweah is located entirely within Tulare County and is accessible via State Highway 198. The location of the project is shown on the General Map, Plate 2-1. Its geographic coordinates are:

Latitude:	36° 24' 53" North
Longitude:	119° 00' 07" West

2-02. Purpose

a. The Terminus Dam and Lake Kaweah Project was authorized for the purposes of flood control, irrigation, and recreation. In addition, general congressional acts have authorized fish and wildlife purposes. The capability for hydropower is incidental to these purposes. Details of hydropower construction history and operation are in Paragraph 7-10. The hydropower facilities, however, are not to be considered part of the federally funded facilities.

b. The following Congressional acts apply to Terminus Dam and Lake Kaweah:

(1) PL 85-624 Fish and Wildlife Coordination Act of 1958

(2) PL 93-205 Endangered Species Act of 1973

(3) PL 92-500 Federal Water Pollution Control Act Amendments of 1972 (water quality)

(4) PL 102-240 Clean Air Act of 1990

(5) PL 91-190 National Environmental Policy Act of 1969 (environmental protection)

(6) PL 89-665 National Historic Preservation Act of 1966 (historical and archaeological data preservation)

(7) PL 87-874 Flood Control Act of 1962

(8) PL 101-640 Water Resources Development Act of 1990, Section 310(b)

(9) Water Resources Development Act (WRDA) of 1996

2-03. Physical Components. The Terminus Dam and Lake Kaweah Project includes the following features: two embankments, one dike, outlet works, a fusegate spillway section, and the Terminus Power Project. An Area Map is shown on Plate 2-2. All elevations in this manual are based on the National Geodetic Vertical Datum of 1929 (NGVD29). As directed by EM 1110-1-1004, the datum has been changed to the North American Vertical Datum of 1988 (NAVD88). The elevations in this manual do not reflect the NAVD88. Pertinent data for the project are tabulated at the front of this manual.

a. Reservoir. Lake Kaweah has a shoreline of approximately 30 miles (48.3 km) and is 6 miles (9.7 km) in length. At gross pool, 715.0 feet MSL (217.9 m), the reservoir water surface area is 2,154 acres (871.7 ha) and has a maximum depth of about 215 feet (65.5 m). Lake capacity at gross pool is 185,630 acre-feet (228.9 hm^3), of which a maximum of 173,630 acre-feet (214.1 hm^3) is allocated during the rainflood season. The entire storage capacity of the reservoir may be allocated for snowmelt runoff, if required. Lake Kaweah is shown on the Area Map, Plate 2-2 and Photo 2-1. The Area-Capacity Curves and the Area-Capacity Table for the lake are shown on Plates A-1 and A-2, respectively.

b. Embankments. Terminus Dam (Photos 2-2 and 2-3) and the auxiliary dam are rolled, earthfill structures. The main dam has a maximum height of 250 feet (76.2 m), a crest length of 2,375 feet (723.9 m), and a crest width of 25 feet (7.6 m). The auxiliary dam has a maximum height of 130 feet (39.6 m), a crest length of 870 feet (265.2 m), and a crest width of 20 feet (6.1 m). The elevation at the top of the dams is 750.0 feet MSL (228.6 m), providing 2.88 feet (0.9 m) of freeboard above the Probable Maximum Flood (PMF) pool, used as the Spillway Design Flood, at elevation 747.12 feet MSL (227.7 m). The Plan, Profile, and Sections of Terminus Dam are shown on Plates 2-3 and 2-4.

c. Dike. In 2003, as construction was under way to raise Terminus Dam 21 feet (6.4 m), several alternatives were being considered to protect a private motel at the upstream end of the lake from flood damage during a 1 percent event. With the completion of the dam raise in December 2003 and without mitigation, at approximately gross pool (715 feet (217.9 m)) water would have reached the motel property; at approximately 716.5 feet (218.4 m) it would have reached the buildings. Construction of a dike to protect the motel was begun in October 2004 and completed in April 2005. The dike is a 900-foot-long (274.3 m) earthen embankment designed to protect the adjacent motel from higher lake elevations caused by the raising of the spillway elevation at Terminus Dam. Its crest elevation is 722 feet (220.1 m). The water side slope of the dike is constructed at a 3:1 slope and the land side is constructed at a 2.5:1 slope. Seepage under or through the dike when the lake is full is collected by a toe drain collection pipe on the land side of the dike. Seepage water flows into a pumping station containing three 500-gpm (1.9 kl/m) pumps; when water in the pumping station reaches a pre-set elevation, it is then pumped back into the lake. When the lake is not full, interior drainage of the motel property is accomplished via a 24-inch (61 cm) gravity drain originating at the pump station and exiting on the water side of the dike.

d. Outlet Works. The outlet works are located in the left abutment of the main dam and consist of an inlet with trash rack, control tower, control house, concrete-lined tunnel outlet portal (Photo 2-4) and facilities for Lemoncove Ditch. The control section of the outlet works consist of three 5' 0" x 9' 0" (152 cm x 274 cm) rectangular conduits with appropriate transitions at the upstream end to the intakes and at the downstream end to the 12' 9" (388.6 cm) diameter tunnel.

Releases through the main outlet are controlled by the three 5' 0" x 9' 0" (152 cm x 274 cm) hydraulically operated slide service gates (Photo 2-5). The service gates have been modified to automatically deliver the desired flow in case of a power plant shutdown. The automatic controller operates in parallel with the existing system; isolation valves on the oil lines allow the automated system to be locked out and the slide gate to be operated manually. Three identical hydraulically operated emergency slide gates are placed in tandem with the service gates. The service gates and the emergency gates have a total flow capacity of 4,500 cfs (127.4 m^3/s) at a pool elevation of 570 feet MSL (173.7 m), and 8,900 cfs (252.0 m^3/s) at a pool elevation of 715 feet MSL (217.9 m). An elevation-discharge rating curve for the main conduit outlet works with various gate openings is shown on Plate A-3.

Regulating valves and appurtenances for Lemoncove Ditch are housed in the gate chamber. The outlet for the ditch consists of an inlet, control valves, 36-inch diameter (91.4 cm) concrete-encased steel pipe, bypass, stilling well and outlet, wasteway, Parshall flume, flume over the spillway discharge channel, and an open channel connecting to the existing ditch. From the tower to the downstream portal, the 36-inch diameter (91.4 cm) pipe is located under the invert of the tunnel. This outlet has a total flume capacity of 15 cfs (0.4 m^3/s), by gravity, at a pool elevation of 551 feet MSL (167.9 m), and 10 cfs (0.3 m^3/s), by pumping, at a pool elevation less than 551 feet MSL (167.9 m). Plate A-9 shows the Discharge Rating Curve for Lemoncove Ditch.

Provisions for servicing Hawkeye Ditch from the Lemoncove Ditch stilling well consist of a 12-inch diameter (30.5 cm) pipe connection and Dall flow tube. A 12-inch diameter (30.5 cm) pipeline conveys Hawkeye Ditch Company water, a maximum of 3 cfs (0.1 m^3/s), across government property and is maintained by the Hawkeye Ditch Company. Should the water surface drop below elevation 547.6 feet MSL (166.9 m), gravity delivery from Lemoncove stilling well will become impossible, and pumping will be necessary to deliver water to Lemoncove and Hawkeye ditches. The outlet works plan, sections, and details for Terminus Dam and Lemoncove outlet works are shown on Plates 2-5 and 2-6.

A low concrete ogee-type weir with a step crest and a guide wing levee is located downstream from the dam to act as a control structure for the outflow gaging station and to serve as a diversion dam for the Foothill irrigation ditch. The right end of the wing levee has a crest elevation 2 feet (61.0 cm) lower than the abutments of the control structure so that flows greater than 15,000 cfs (424.8 m^3/s) will cause the levee to be washed out, leaving the main control structure undamaged. Water is conveyed to Foothill Ditch by a steel pipe which discharges directly into the ditch. A Parshall flume measures flow into Foothill Ditch.

A stage-discharge rating curve for the Kaweah River below Terminus Dam is shown on Plate A-7, and the stage-discharge rating curve for Foothill Ditch is shown on Plate A-8.

e. Spillway. The approach channel, fusegate spillway, and exit channel are situated in an excavated natural rock saddle about 800 feet (243.8 m) from the left abutment of the main dam (Photo 2-6). The fusegates will act as plugs that will tip and wash away when needed to pass flood flows that would otherwise potentially top the earthen dam. As each one is washed away, the capacity of the spillway is increased. As the water continues to rise, the next gate will tip and so on. This will continue, as required, until all fusegates have tipped or flow is controlled. To restore operations, lost fusegates need to be replaced with a new structure. During the period between loss and replacement, the gross reservoir pool elevation draws down to and remains at the sill elevation, 693.67 feet MSL (211.4 m), resulting in a loss of storage capacity for that period. The 21.33 feet (6.5 m) standard fusegate was selected because its height was very compatible with the proposed raise in the gross pool elevation. The fusegate height of 21.33 feet (6.5 m) required the sill elevation for the gate to be set at 693.67 feet MSL (211.4 m) in order to achieve a crest elevation of 715.0 feet MSL (217.9 m).

Six fusegates are located in the spillway channel (Photo 2-7). Each fusegate is 21.33 feet (6.5 m) high, 38.4 feet (11.7 m) wide, and 25.6 feet (7.8 m) deep. The six gates are set in a rectangular opening 230.4 feet (70.2 m) by 25.6 feet (7.8 m). The remaining width of the spillway consists of 2 separate broad-crested weirs located at each end of the fusegates. These weirs have a top width of 41.6 feet (12.7 m), depths of 25 feet (7.6 m), and crest elevations of 715.0 feet MSL (217.9 m). The water elevations at which the gates are tipped are 737.17 feet MSL (224.7 m), 737.95 feet MSL (224.9 m), 738.72 feet MSL (225.2 m), 739.47 feet MSL (225.4m), 740.20 feet MSL (225.6 m), and 740.90 feet MSL (225.8 m). Several spillway designs and sizes were studied during the reconnaissance and feasibility studies for enlarging the reservoir capacity. The decision to raise the spillway by using fusegates was based on the costs involved, the required modification of the existing spillway channel, and the ability to pass the Spillway Design Flood with the required freeboard.

The Probable Maximum Flood (PMF) was used to establish the number of gates needed to pass the PMF. The number of gate failures was determined from various flood events. The first gate failure would occur during an approximate 0.01 percent flood. The maximum PMF pool was established as 747.12 feet MSL (227.7 m) and 2.88 feet (0.9 m) of freeboard. The Plan, Profile, and Intake of the spillway are shown on Plate 2-7. The Spillway Rating Curve for Terminus Dam is presented on Plate A-4.

f. Power Plant. The Terminus Power Project consists of an intake, power tunnel, powerhouse, tailrace, and an auxiliary outlet structure (Photo 2-8). The power tunnel is located in the left abutment of the dam, approximately 280 feet (85.3 m) south of the Corps intake tower. The power intake is a reinforced concrete structure equipped with three trash racks and has an invert elevation of 572 feet MSL (174.3 m). A bulkhead gate is included in the intake structure. The

power tunnel has a total length of 1,465 feet (446.5 m): the first 230 feet (70.1 m) are concrete-lined with a circular cross section 12 feet (3.7 m) in diameter, while the remaining 1,235 feet (37.4 m) are steel-lined and 10 feet (3.0 m) in diameter. Upstream of the steel-lined portion of the tunnel is a hydraulically-actuated emergency gate. This sluice gate is designed to permit maintenance of the butterfly valve and the tunnel steel lining. The butterfly valve is just upstream from the turbine and opens and closes automatically at each unit start-up and shutdown. Two hydraulic jacks actuate the butterfly valve. In case of an electric or hydraulic failure, two counterweights close the valve automatically.

The powerhouse and tailrace are located on the south side of the Corps outlet channel. The powerhouse contains one 20 MW Kaplin turbine/generator unit. Two bulkhead gates in the draft tube downstream of the turbine allow for inspection of the turbine runner and draft. Bulkhead handling is performed by truck crane. The tailrace includes a tilting gate installed 40 feet downstream of the powerhouse. The tilting gate is hydraulically actuated and allows the tailrace water level to be varied between 501 feet MSL (152.7 m) and 518 feet MSL (157.9 m), so that the turbine can operate at high reservoir levels. The auxiliary outlet structure is a bypass conduit, capable of discharging 170 cfs (4.8 m^3/s) for reservoir pool level of 600 feet MSL (182.9 m), positioned on the right side of the powerhouse. The auxiliary outlet is equipped with an automatic relief valve and is used to release flow that is just over the turbine maximum flow. The minimum release required to operate the power plant is 400 cfs (11.3 m^3/s). The maximum rated head for the power plant is 191 feet (58.2 m). The plan and profile of Terminus Power Project are shown on Plate 2-8.

2-04. Related Control Facilities. The Terminus Dam and Lake Kaweah Project consists of the dam, reservoir, dike, and appurtenant facilities. Mitigation for the raised spillway's effects on wildlife habitat will occur at four locations.

The riparian mitigation site is located along Dry Creek about 2 miles (3.2 km) from Lake Kaweah. The site consists of about 35 acres (14.2 ha) and is located adjacent to the creek. Cattle have grazed the site in the past. Vegetative communities consist of sycamore alluvial woodland, grassland, and cottonwood/willow riparian scrub. The site has good potential for re-vegetation of riparian forest and scrub habitat.

The endangered species mitigation site is located on Corps property downstream from Terminus Dam adjacent to the pond below the reservoir. The site includes two mitigation areas totaling about 4.2 acres (1.7 ha). Vegetation in the area consists of elderberry plants with associated riparian forest and scrub species.

The oak woodland mitigation area consists of 4,300 acres (1,740.2 ha) located at the Davis Ranch. The ranch is located on the divide between Dry Creek and the north fork of the Kaweah River, about 5 miles (8.0 km) north of Lake Kaweah in Tulare County. The ranch includes three drainages: Mankins Creek, Greasy Creek, and the east fork of Dry Creek. Elevations on the Davis

Ranch range from a low elevation of 1,600 feet (487.7 m) to a high elevation of 3,552 feet (1,082.6 m). The ranch is an operating cattle ranch with little vegetation manipulation since moderate clearing in the 1950's. Most of the property is relatively untouched by humans and is in a near natural condition. Small stock ponds are scattered over the ranch. Vegetation on the ranch includes blue oak woodland, mixed woodland, valley oak woodland, non-native grassland, and chaparral vegetation. Due to the near natural condition, this vegetation provides high value habitat for wildlife.

The mitigation site for flooded agricultural areas in Tulare Lakebed is located in Kings County, north of the city of Corcoran. The mitigation site is located east of State Highway 43, north of Nevada Avenue, west of Sixth Street, and south of Kansas Avenue. The site encompasses 1,289.62 acres (521.9 ha) and includes 11 wells. Cattle grazing occurs year-round depending upon vegetation. There has been no surface irrigation water applied or used on the mitigation site. In the past the site has generally not been farmed. As landowner, Corcoran Irrigation District now owns the fee title to the underlying land encumbered by the easement. Canal levees exist along the west and northern portions of the mitigation site, and an estimated 25-acre pond (10.1 ha) has intermittently formed in a former borrow area on the site. Surface runoff is the source of the water for this pond.

No other improvements outside the reservoir area, except the mitigation areas listed above, were made under the authority of this project; however, local interests have made channel improvements downstream.

2-05. Real Estate Acquisition. Project lands consist of approximately 5,263.5 acres (21.3 km^2) acquired in fee, 635.1 acres (2.6 km^2) under easement, and 0.2 acres (809.4 m^2) under lease or permit. The real estate boundaries are shown on Plate 2-9.

2-06. Public Facilities. Most recreation use at Lake Kaweah occurs in and originates from the developed south and west shores of the lake. Some use occurs in undeveloped areas and the wildlife management area. Recreation at Lake Kaweah includes picnicking, camping, fishing, water skiing, swimming, boating, hiking, and sightseeing. Recreational facilities available at Lake Kaweah are shown on Plate 2-9.

Visitation records have been kept for Lake Kaweah since 1962. Since that time, visitation has fluctuated considerably, with the highest visitation recorded in 1982 (3,030,000 visitor hours). Annual visitation is shown in Table 2-1 for the years 1962 through 2004.

TABLE 2-1
LAKE KAWEAH ESTIMATED ANNUAL VISITATION
(1,000 Visitor Hours)

Year	Attendance	Year	Attendance
1962	324	1984	1,953
1963	558	1985	2,025
1964	1,029	1986	1,988
1965	1,272	1987	1,997
1966	1,107	1988	2,192
1967	601	1989	1,948
1968	918	1990	2,238
1969	839	1991	2,192
1970	960	1992	2,333
1971	993	1993	2,035
1972	807	1994	1,705
1973	691	1995	1,953
1974	786	1996	1,955
1975	1,048	1997	1,679
1976	915	1998	2,012
1977	864	1999	1,973
1978	1,453	2000	1,864
1979	1,477	2001	2,208
1980	1,417	2002	2,385
1981	1,844	2003	2,811
1982	3,030	2004	2,676
1983	2,483	Average	1,617

Source: U.S. Army Corps of Engineers, Sacramento District, Operations Technical Section

Photo 2-1. Lake Kaweah, looking east.

Photo 2-2. Terminus Dam-Lake Kaweah, looking north.

Photo 2-3. Terminus Dam, looking north from control tower road.

Photo 2-4. Terminus Dam outlet

Photo 2-5. Terminus Dam gates

Photo 2-6. Terminus Dam fusegate intake

Photo 2-7. Terminus Dam fusegate spillway

Photo 2-8. Terminus Power Project powerhouse and tailrace

(This page intentionally left blank)

III - HISTORY OF PROJECT

3-01. Authorization. The Terminus Dam and Lake Kaweah Project was authorized by the Flood Control Act of 1944, approved 22 December 1944. The pertinent portion of the Flood Control Act of 1944 is as follows:

> "The plans for Terminus and Success Reservoirs on the Kaweah and Tule Rivers for flood control and other purposes in the San Joaquin Valley, California, in accordance with the recommendations of the Chief of Engineers in Flood Control Committee Document Number 1, Seventy-Eighth Congress, Second Session, is approved, and there is hereby authorized $4,600,000 for initial and partial accomplishment of the plan."

By joint resolution of the Senate and House of Representatives, Public Law 87-858, Eighty-Seventh Congress, House Joint Resolution 417, 6 August 1962, the reservoir formed by the Terminus Dam was designated as "Lake Kaweah." All document references to "Terminus Reservoir" refer to the reservoir formed by Terminus Dam and designated as "Lake Kaweah" in H.J. Res. 417.

The Water Resources Development Act (WRDA) of 1996 authorized the modifications to the Terminus Dam spillway and expansion of the reservoir pool. Details of the modifications and related documentation can be found in the following reports: "Kaweah River Basin Investigation Feasibility Study, California – Final Feasibility Report," September 1996; Kaweah River Basin Investigation Feasibility Study, California – Final Environmental Impact Statement/ Environmental Impact Report," September 1996, and "Terminus Dam at Lake Kaweah, Tulare County, California – Design Memorandum," August 1998. The Environmental Impact Statement/Environmental Impact Report includes documentation on the affected environment, mitigation measures and environmental requirements pertaining to the WRDA authorization.

3-02. Planning and Design. In Committee Document Number 1, Seventy-Eighth Congress, Second Session, dated 1944, the Chief of Engineers recommended a reservoir capacity of 100,000 acre-feet (123.3 hm^3). In the Comprehensive Report on Sacramento-San Joaquin Basin Streams and the Supplement thereto, published as House Document 367, Eighty-First Congress, First Session, dated 1944, the Chief of Engineers recommended a reservoir capacity of 145,000 acre-feet (178.8 hm^3). No specific reservation for sediment accumulation was defined. The reservoir capacity was increased from 100,000 acre-feet (123.3 hm^3) to the recommended 145,000 acre-feet (178.8 hm^3) by letter from Sacramento District to South Pacific Division dated 28 September 1951, subject "Supplement No. 2, Preliminary Definite Project Report, Terminus Project, Kaweah River, California." By the Sixth Endorsement, dated 3 December 1952, the Chief of Engineers stated that the capacity of 145,00 acre-feet (178.8 hm^3) would be approved for design purposes if the State of California would not actively oppose the increased capacity. Subsequent to that date, the State appeared before the Bureau of the Budget and Appropriations Committees in support of

the project as modified for the 145,000 acre-foot (178.8 hm^3) capacity.

At a 9 May 1956 conference, representatives of the Office, Chief of Engineers, USACE South Pacific Division (SPD), and USACE Sacramento District (SPK) decided to increase the total reservoir capacity to 150,000 acre-feet (184.9 hm^3), including a reservation of 8,000 acre-feet (9.9 hm^3) of that amount for future sedimentation and for other project uses. The 8,000 acre-feet (9.9 hm^3) of inactive storage space could be used for a recreation pool by local interests if they provided the necessary water.

Storage was required to be evacuated to a minimum pool level of 8,000 acre-feet (9.9 hm^3) from 1 November to 31 March, and the entire capacity of 150,000 acre-feet (184.9 hm^3) was reserved when needed for control of forecasted snowmelt runoff. Storage of irrigation water from 1 April was made conditional upon the amount of snowmelt runoff predicted to occur between the given date and 31 July. The latest Water Control Diagram permits conditional carryover storage during the November through March period, based on watershed precipitation.

3-03. Construction. Construction funds were initially appropriated in fiscal year 1957, but relatively little was accomplished until fiscal year 1959, due to the inadequacy of authorized funds. Construction on the main dam and appurtenances was begun during February 1959. Closure of the dam was completed in November 1961, and the project was certified complete and accepted by the government for operation on 1 June 1962. State highway and county roads were relocated.

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 2-03f.

Construction of the Terminus Dam spillway raise and associated projects was initiated in 2002 and was completed in February 2004. Mitigation areas associated with the spillway raise are discussed in Section 2-04.

3-04. Related Projects. The Terminus Dam and Lake Kaweah Project provides flood protection to the Kaweah River, and is also part of a system of reservoirs providing flood protection to the Tulare Lakebed and adjacent areas. Major releases to the Tulare Lakebed may come from Pine Flat Lake on the Kings River, Success Lake on the Tule River, and Isabella Lake on the Kern River.

The Friant-Kern Canal, part of the Bureau of Reclamation's Central Valley Project (CVP), crosses the St. Johns and Kaweah rivers approximately 6 miles (9.7 km) downstream from Terminus Dam. The Friant-Kern Canal delivers irrigation water to the Kaweah River and has the potential to export floodwaters out of the basin. Related mitigation sites are discussed in Section 2-04.

3-05. Modifications to Regulations. Throughout the years, various changes have been made to the Water Control Diagram based on physical changes in the project and on updated hydrology. In 1972, the Water Control Diagram was changed to permit conditional carryover storage of water, up to 7,000 acre-feet (8.6 hm^3) above minimum pool level 8,000 acre-feet (9.9 hm^3), during the November through March period. This conditional carryover is based on the basin watershed precipitation and is discussed in Exhibit A.

Sediment surveys made in 1977 show that the reservoir capacity has decreased from 150,000 acre-feet (184.9 hm^3) to 143,000 acre-feet (176.3 hm^3). The Water Control Diagram was adjusted by decreasing the sediment pool. Sedimentation is discussed in Section 4-04.

The current Water Control Diagram was developed based on historical operation and new hydrology in conjunction with the gross pool of the reservoir being raised 21 feet (6.4 m).

3-06. Principal Regulation Problems. The Terminus Dam and Lake Kaweah Project is operated so that flows will not exceed 5,500 cfs (155.8 m^3/s) on the Kaweah River at McKay Point. Dry Creek and Yokohl Creek are the major uncontrolled tributaries to the Kaweah River below Terminus Dam. These tributaries can produce high magnitude flows that require rapid release changes from the dam. During rain floods, flows on Dry Creek must be considered on a short-term basis. Local flow from Dry Creek must be added to reservoir releases to assure that the desired flow at McKay Point is not exceeded. Yokohl Creek enters the Kaweah River below McKay Point. Downstream channel capacities are discussed in Section 4-09 and shown on Plate A-12.

The Kaweah River is part of the closed Tulare Lakebed basin. Releases above irrigation and spreading demands cause damaging flows to agricultural lands in the lakebed. The irrigation and spreading demands are substantial, but are reduced during periods of heavy rainfall.

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 as required in the Tulare Lakebed operations and maintenance manual.

Although Terminus Dam is operated for flows in the Kaweah River, it is part of a four-reservoir system contributing water to the Tulare Lakebed area. The Tulare Lakebed area has an extensive levee and diversion system designed to manage irrigation flows and minor flood flows from the four projects and the surrounding uncontrolled drainage area. However, flows in the Kaweah River which are less than the design flows and large uncontrolled runoff may cause flooding damage to agricultural areas in the Tulare Lakebed area. The magnitude of flows may exceed the diversion system capacity and damage land protected by the levee system or adjacent areas. Whenever possible, releases from the reservoir should reflect consideration of the conditions in all downstream channels and the operation of the other three projects.

In the winter, due to wet conditions and sedimentation in the reservoir, the Water Control Diagram requires the reservoir to be lowered to a minimal level, causing problems for the marina. Large inflow to Lake Kaweah can cause the lake to rise at a rapid rate. Rapid rises in the pool elevation require that boat docks, portable restrooms, the marina, and other project facilities be quickly moved to higher elevations.

Sedimentation since the project was constructed has been much greater than originally anticipated. Lake Kaweah was constructed with 8,000 acre-feet (9.9 hm^3) of space for sediment accumulation; however, a 1977 survey indicated that 7,000 acre-feet (8.6 hm^3) of sediment had accumulated by that time. Sedimentation is discussed in Section 4-04.

IV - WATERSHED CHARACTERISTICS

4-01. General Characteristics. The Kaweah River Basin is located in Central California, on the western slope of the Sierra Nevada. The Kaweah River flows in a westerly direction through the mountains and foothills, and then across the valley floor to Tulare Lakebed. For descriptive purposes, the project area is divided into the mountainous area above Terminus Dam and the foothill and valley floor below the dam. A map of the area is shown on Plate 4-1.

Above Terminus Dam, the watershed portion of the project is a fan-shaped mountainous area extending 35 miles (56.3 km) upstream into the western slope of the southern Sierra Nevada. Four main forks, flowing from the high eastern border of the basin in a southwesterly or westerly direction to their junction near the foothill line, form the Kaweah River. The slope of the north, middle, east, and south forks averages approximately 350 feet per mile (172 meters per kilometer), while numerous small tributary streams have slopes ranging from 400 to 1,000 feet per mile (196 to 490 meters per kilometer). These streams drain a combined area of 561 square miles (1453.0 km^2) at the dam. Basin features are shown on the General Map, Plate 2-1 and Photos 4-1 and 4-2.

Vegetative cover varies within the basin. Above Terminus Dam, the steep hillsides in the upper basin range from bare rock to coniferous forest. Vegetation on lower elevations consists of deciduous forests, brush, and grasslands. A discontinuous bank of riparian growth stretches through much of the lower basin. The area is sparsely settled and suitable for grazing, lumbering, mining, and recreation. More than half of the basin is within the Sequoia National Park and the Sequoia National Forest. Table 4-1 shows the Land Coverage Distribution on the Kaweah River basin above Terminus Dam.

TABLE 4-1
LAND COVERAGE DISTRIBUTION

DESCRIPTION	ELEVATION (feet)	PERCENT OF BASIN AREA
Grasslands (with scattered brush)	1,000 - 2,000	0.5
Brushlands (chaparral, etc.)	3,000 - 9,000	22.7
Deciduous Forest (with brush, scattered conifers, and grass)	500 - 6,000	26.3
Light Coniferous	5,000 -12,000	30.1
Heavy Coniferous	5,000 - 9,000	6.8
Sub-Alpine Forest	8,000 -10,000	4.3
Bare Rock, Lakes, etc.	9,000 -12,600	9.3
TOTAL		100.0

Source: Kaweah River Basin, California Hydrology Report, August 1990, U.S. Army Corps of Engineers

Dry Creek (Photo 4-3) enters the Kaweah River (Photo 4-4) about 1 mile (1.6 km) below Terminus Dam. Approximately 3 miles (4.8 km) below Terminus Dam at McKay Point weir (Photo 4-5), the flow may be split between the Kaweah (Photo 4-6) and St. Johns rivers. The northerly channel, known as the St. Johns River, flows westerly for about 23 miles (37.0 km), passes the city of Visalia on the north, and joins Cottonwood Creek to form Cross Creek. Cross Creek flows southwesterly about 35 miles (56.3 km) into Tulare Lakebed. The southerly channel, which retains the name Kaweah River, continues south for about 4 miles (2.4 km) and then divides into numerous channels above Visalia. Mill Creek flows in a westerly direction through the city of Visalia before entering Cross Creek. These channels normally transport water for irrigation and spreading. Flows in excess of this demand eventually join the Tule River and then enter the Tulare Lakebed. Tulare Lakebed is a closed basin with no natural drainage to the ocean. Flooding in the Lakebed will continue until excess water is evaporated and/or pumped out of the basin.

The area below Lake Kaweah is predominately agricultural; however, there are numerous towns in the area. Visalia, 12 miles (19.3 km) west, is the largest, with a population of approximately 100,000.

4-02. Topography. The area above the dam is steep mountainous terrain. Below the dam there are foothills which transition into an alluvial fan, and flatlands that gently slope to Tulare Lakebed. Elevations range from about 12,600 feet MSL (3,840.5 m) in the upper basin to 510 feet MSL (155.4 m) at the dam, and 325 feet MSL (99.1 m) at Visalia down to about 175 feet MSL (53.3 m) at Tulare Lakebed. The topographic map is on Plate 4-1. The Area-Elevation Curve and Stream Profiles of principal streams are shown on Plates 4-2 and Plate 4-3, respectively. Table 4-2 shows the elevation distribution of the basin area above Terminus Dam.

TABLE 4-2
ELEVATION DISTRIBUTION

ELEVATION (Feet)	PERCENT OF BASIN AREA ABOVE ELEVATION
510	100
2,000	88
4,000	67
5,000	57
6,000	45
8,000	22
10,000	10
12,000	1

Source: Kaweah River Basin, California Hydrology Report, August 1990, U.S. Army Corps of Engineers

4-03. Geology and Soils. The Kaweah River flows in a westererly direction over a portion of the igneous rock of the southern Sierra Nevada batholith. These igneous rocks vary in mineral composition and color, but are collectively referred to as granite. The Kaweah River is deeply entrenched in its present course and is a degrading stream, having relatively thin alluvial deposits on the valley floor. Most of the regional rock in the Kaweah River is granite, which covers approximately three fourths of the basin. Rocks in this area of the Sierra Nevada and the foothill region can be categorized into one of four groups: (1) Paleozoic metamorphic rock (Calaveras Complex and equivalents), (2) late Paleozoic-Mesozoic metamorphic rock (Kings River ophiolite and Kings-Kaweah suture), (3) Mesozoic metamorphic rock (Mariposa and Logtown Ridge formations), and (4) Mesozoic granitic rock (Sierra Nevada batholith). Rocks in the Calaveras Complex are found as numerous roof pendants with the Jurassic-Cretaceous plutonic rocks of the Sierra Nevada batholith. These rocks had originally extended across much of the Sierra Nevada but have been stripped off by uplift and subsequent erosion. The Lemoncove Schist and Quartzite that underlie Terminus Dam probably belong to this unit. The basic intrusives, meta-volcanic, and meta-sediments form prominent, resistant ridges. These rock types, due to their prominence, appear to be more extensive than they actually are. In general, the rock formations of the Kaweah River region are characteristic of the bedrock complex of the western slope of the Sierra Nevada: generally metamorphosed sediments and volcanics, mostly metamorphosed diorite and gabbro intrusives and granite batholith. The younger sediments of the area include old terrace deposits and recent alluvium.

Several minor faults are located in the area. Regionally, the dam is within 90 miles (144.8 km) of the Garlock and San Andreas fault, 75 miles (120.7 km) of the White Wolf fault, and about 50 miles (80.5 km) of the Sierra Nevada and Pond-Poso faults.

4-04. Sediment. The allocation of sediment space is discussed in Paragraphs 3-02 and 3-05. When Terminus Dam construction was completed in 1962, it was believed that Lake Kaweah had a capacity of 150,000 acre-feet (185.0 hm^3). A 1977 survey showed that Lake Kaweah had a capacity of 143,000 acre-feet (176.3 hm^3). Recent studies on the Kaweah River indicated that the normal rate of sediment accumulation in the reservoir is about 0.21 acre-feet per square mile (1 m^3 per 1 km^2) per year. Since Kaweah River basin above Lake Kaweah is 561 square miles (1,453 km^2), this amounts to 120 acre-feet (0.1 hm^3) of sediment per year. These ranges were not revised with the spillway crest elevation raise.

Twenty-seven monumented sedimentation ranges, as indicated on Plate 4-4, were established before any reservoir operation was initiated. These sedimentation ranges are used to measure sedimentation within the reservoir. Two of these range lines cross the river below the dam, while the remaining range lines are spaced so that no range represents more than 10 percent of the potential sediment accumulation in the reservoir. Each profile is recorded on a permanent drawing to a horizontal scale of 1 inch to 20 feet. Reconnaissance surveys of the sedimentation ranges are made as deemed necessary.

General surveys of the reservoir area were made in 1961 and 1977. The data from these surveys are shown in Table 4-3. Area capacity tables were revised after each survey.

TABLE 4-3 RESERVOIR SEDIMENTATION			
DATE	SURFACE AREA (acres)	CAPACITY (acre-feet)	SEDIMENT (acre-feet below elev. 694.0 ft)
November 1961	1,945	149,600	0
October 1977	1,913	143,000	6,600
Source: U.S. Army Corps of Engineers, Sacramento District, Water Management Section			

There has not been a sediment survey of Lake Kaweah since October 1977. All storage capacities discussed within this Water Control Manual are based on the 1977 storage capacity data.

4-05. Climate

a. General. The climate of the valley area of the Kaweah River Basin is classified as dry and sub-humid, characterized by two well-defined seasons: long, hot, dry summers with very little rain, and moderate, wet winters. At high elevations the summers are cool and the winters severe. The location of climatological stations, normal annual precipitation isohyets, and snow courses are shown on Plate 4-5.

b. Temperature. Temperatures in the basin vary considerably. Temperatures on the valley floor range from lows slightly below freezing during the winter, to highs over 100 degrees Fahrenheit (37.8°C) during the summer. During the winter, the temperatures at 5,000 feet (1.5 km) and higher may remain below freezing for extended periods. The Mean Monthly and Annual Temperatures at Terminus Dam, Grant Grove, Three Rivers Edison Powerhouse 1, and Visalia are shown in Table 4-4.

c. Precipitation. Normal annual precipitation (NAP) varies throughout the Kaweah River drainage area, ranging from 15 inches (38.1 cm) on the valley floor to about 55 inches (139.7 cm) at the headwaters. Normal annual precipitation for the Kaweah River above Terminus Dam is about 33.0 inches (83.8 cm), with approximately 90 percent of the precipitation occurring between November through April. It generally occurs as rain below 5,000 feet (1.5 km) and as snow above that elevation; however, warm weather storms have produced rain up to 11,000 feet (3,353 m), which would cover most of the basin. Snow has occurred on the valley floor below the dam.

Winter precipitation is largely orographic and results from air masses traveling inland from the Pacific Ocean. From November through April, Pacific storms frequently cross the coasts of Northern and Central California. Severe winter storms may involve warm and moist maritime tropical air from the central Pacific. Occasionally, in winter or spring, a large circulation pattern will develop and steer many successive low-pressure systems across the coast, resulting in

prolonged periods of wet weather. Summer precipitation is usually in the form of occasional showers or thunderstorms, and occurs largely above the foothill portion of the basin. Such precipitation may be quite intense for short periods of time, but it is confined to relatively small areas. Although summer precipitation can produce a moderate rise in flow on minor tributaries, it generally does not significantly affect flow on the main streams.

The distribution of Normal Annual Precipitation (NAP) is shown on Plate 4-5. The Mean Monthly and Annual Precipitation at selected stations is given in Table 4-5.

TABLE 4-4
MEAN MONTHLY AND ANNUAL TEMPERATURES (°F)

Month	Terminus Dam (570 feet)	Grant Grove (6,600 feet)	Three Rivers Edison PH 1 (1,140 feet)	Visalia (325 feet)
January	45.8	34.7	47.1	45.8
February	50.1	34.7	50.8	51.4
March	54.2	35.6	54.2	55.9
April	59.0	39.8	59.6	60.9
May	66.8	46.9	67.6	67.8
June	73.9	56.5	75.9	74.7
July	79.8	63.2	82.1	79.5
August	78.6	62.9	81.1	77.9
September	73.8	57.6	75.2	73.1
October	64.6	49.2	65.2	64.9
November	54.9	40.1	53.2	53.0
December	47.4	35.7	46.6	45.2
Average Annual	62.5	46.5	63.3	62.6
Source:	USACE 1965-2004	NOAA 1949-2004	NOAA 1972-2004	NOAA 1952-2004

TABLE 4-5 MEAN MONTHLY AND ANNUAL PRECIPITATION										
Month	Terminus Dam (570 feet)		Atwell (6,480 feet)		Bear Trap Meadow (6,800 feet)		Giant Forest (6,400 feet)		Hockett Meadow (8,500 feet)	
	inches	%	inches	%	Inches	%	inches	%	inches	%
Oct	0.85	5.60	1.64	4.06	1.89	4.02	1.59	3.85	1.51	3.83
Nov	1.75	11.54	4.49	11.11	4.95	10.53	3.60	8.73	3.83	7.18
Dec	2.29	15.10	6.03	14.92	7.44	15.82	6.45	15.64	5.99	15.19
Jan	2.88	18.98	7.31	10.00	8.04	17.10	7.00	16.97	6.80	17.25
Feb	2.51	16.55	6.56	16.23	8.46	17.99	7.80	18.91	7.16	18.16
Mar	2.57	16.94	6.36	15.73	7.33	15.59	6.29	15.25	6.58	16.69
Apr	1.35	8.90	3.44	8.51	3.83	8.14	3.47	8.41	3.68	9.34
May	0.44	2.90	1.78	4.40	2.06	4.38	1.50	3.64	1.62	4.11
Jun	0.17	1.12	0.75	1.86	0.77	1.64	0.74	1.79	0.72	1.83
Jul	0.02	0.13	0.48	1.19	0.53	1.13	0.71	1.72	0.71	1.80
Aug	0.02	0.13	0.48	1.19	0.30	0.64	0.56	1.36	0.54	1.37
Sep	0.32	2.11	1.10	2.72	1.42	3.02	1.54	3.73	1.28	3.25
Average Annual	15.17	100.0	40.42	100.0	47.02	100.0	41.25	100.0	40.76	100.0
Maximum Annual	28.87 (1969)		73.1 (1983)		99.2 (1969)		95.7 (1969)		72.3 (1969)	
Minimum Annual	5.50 (1977)		14.4 (1977)		16.4 (1977)		13.9 (1989)		15.9 (1977)	
Period of Record	1963-2004		1966-2004		1966-2004		1921 -2004		1965-2004	
Source: U.S. Army Corps of Engineers, Sacramento District, Water Management Section										

d. Snowfall. Snow cover below 5,000 feet (1.5 km) is generally transient and may accumulate and melt a number of times during the winter season. Above 5,000 feet (1.5 km), the snow generally accumulates until late March, when the snowmelt season begins. Basin snowpack data for representative snow courses are presented in Table 4-6. Snow surveys are done each year by various agencies. The locations of the snow courses are shown on Plate 4-5. Table 4-7 (Tables Section, Page T4-1) presents the Forecasted and Actual Snowmelt Runoff into Lake Kaweah from 1933 through 2004.

TABLE 4-6 BASIN SNOWPACK								
Snow Course / Elevation	Record Began	Depth in Inches			Water Content in Inches			
		1969 (Wet)	1996 (Avg)	1977 (Dry)	Average 1 Apr *	1983 (Wet)	1996 (Avg)	1977 (Dry)
# 243 Panther Meadow (9,500 feet)	1925	217.5	101.2	30.3	36.7	98.8	44.6	8.8
# 244 Hockett Meadow (8,500 feet)	1930	144.2	73.5	20.3	27.5	71.6	31.4	6.5
# 245 Mineral King (8,000 feet)	1948	138.0	44.8	9.5	20.6	63.8	21.8	2.5
# 246 Giant Forest (6,400 feet)	1930	108.4	25.7	4.4	14.7	49.9	11.8	1.6
# 292 Farewell Gap (9,500 feet)	1952	219.4	93.5	32.2	35.8	99.3	38.6	11.0

*Average for 1951-2000
Source: California Department of Water Resources
http://cdec.water.ca.gov/snow/current/snow/SNOWTAB7.html

e. Evaporation. Historical Mean Monthly and Total Evaporation rates for Lake Kaweah are shown in Table 4-8. The weather station was moved from the Terminus Power Project Substation site to the Park Headquarters in July 1987. The site was again moved to the Corps storage area below the dam in August 1996.

f. Wind. Historical Mean Monthly and Annual Wind movement at Terminus Dam are shown in Table 4-9. The weather station was moved from the Terminus Power Project Substation site to the Park Headquarters in July 1987. The site was again moved to the Corps storage area below the dam in August 1996.

TABLE 4-8 MEAN MONTHLY AND TOTAL EVAPORATION	
MONTH	MEAN EVAPORATION (in)
October	6.78
November	3.01
December	1.52
January	1.42
February	2.07
March	3.28
April	5.10
May	8.20
June	10.63
July	12.77
August	12.17
September	9.77
Annual Total	76.72
Source: U.S. Army Corps of Engineers Water Management Section Period of Record 1963-2004	

TABLE 4-9 MEAN MONTHLY AND ANNUAL WIND MOVEMENT	
MONTH	MEAN WIND (miles)
October	2,434.8
November	1,909.4
December	2,089.7
January	1,917.5
February	1,775.3
March	2,254.7
April	1,749.1
May	1,840.1
June	1,922.4
July	2,150.4
August	2,215.3
September	2,253.5
Annual Total	24,512.2
Source: U.S. Army Corps of Engineers Water Management Section Period of Record 1965-2004	

4-06. Storms and Floods. Floods on the Kaweah River are of two types: winter rainfloods and spring snowmelt floods. Rainfloods are characterized by high sharp peaks and small volumes and are usually of short duration, seldom lasting more than four days. These winter floods normally occur during the period November to March and are caused by intense rains that are sometimes augmented by snowmelt in the lower elevations.

Almost unprecedented precipitation in early December 1966 resulted in record-breaking flood runoff on most of the streams in the Tulare Lakebed basin. Continuing storms resulted in flooding in many areas in the Central Valley from December 1966 through March of 1967. Snowpack ultimately reached approximately 2½ times normal, with a abnormal delay in runoff because of continued cool weather through May. Flood damage in the Kaweah River Basin from the December storm totaled $4,750,000. Three lives were lost during the December rainfloods in the Tulare Lakebed basin.

The rainflood of record on the Kaweah River at Terminus Dam was the flood of December 1966, which had an estimated peak flow of 105,000 cfs (2,973.6 m^3/s). The 1966 rainflood produced a 3-day runoff volume of 153,280 acre-feet (189.0 hm^3). Runoff from the upper basin was completely controlled by Lake Kaweah. No releases were made from Terminus Dam until the

flows from the downstream tributaries subsided. However, downstream tributaries produced substantial flows in this flood. A peak of 14,500 cfs (410.6 m^3/s) occurred on Dry Creek. Extensive flooding was prevented in Visalia and other valley floor communities and on thousands of acres of crop and orchard land in the Kaweah River delta and Tulare Lakebed.

During the December 1955 and January 1956 storms, before Terminus Dam was built, the Kaweah River flooded about 126,000 acres (50,992.2 ha) of land. The storm began moderately heavy from 5-9 December, depositing 3 to 7 inches (7.6 to 17.8 cm) of rain along the whole length of the Sierra Nevada. By 15 December, ground conditions in the basin were moderate. Appreciable amounts of rain began to fall on the 18th and substantial quantities of precipitation occurred on the 26th and 27th. The relatively warm moist air, high winds, heavy rains, and the "blanket" afforded by dense clouds melted existing snowpacks at rather rapid rates. In the 4-day period beginning on the 23rd, as much as 2½ feet (.76 m) of snow was observed to melt away. Estimates show that snowmelt water was being added to the flood runoff at daily rates as high as 4.0 inches (10.2 cm) at 5,500 foot (1676.4 m) elevation and 1.7 inches (4.3 cm) at the 7,000 foot (2133.6 m) level. The estimated peak flow of the Kaweah River at the Terminus Dam site was 84,300 cfs (2,387.5 m^3/s). The flooded area extended from the Terminus Dam site on the east to Cross Creek on the west, and from Cottonwood Creek on the north to Elk Bayou on the south. Floodwaters from the Kaweah River and other streams entered Tulare Lakebed and caused damage to that area. Most of the flooded area was along the river and its principal distributaries: St. Johns River, Mill Creek, Cameron Creek, Packwood Creek, Cross Creek, and Elk Bayou.

The December 1955 flood inundated portions of Visalia and portions of the communities of Farmersville, Three Rivers, and Woodlake. In January 1956, much of the same area was flooded again. Damage in Visalia business district and a portion of the residential area was heavy. Water in some homes was about 30 inches (76.2 cm) deep for up to six days. Most of the irrigation diversion structures on the river were also washed out. Water and debris piled up against the Friant-Kern Canal, causing overtopping, which washed away large sections of the canal embankment. Large quantities of debris accumulated against bridges and canal crossings, causing severe damage to most of these structures. Stream bank erosion was severe in many places and great quantities of sand were deposited on farmlands adjacent to the streams. Nearly all roads in the flooded areas were damaged.

The New Year's flood of 1997 was caused by one of the largest storms of the century in Northern California. The storm presented a classic orographic event with warm winds from the southwest blowing over the Sierra Nevada and dropping astounding amounts of rain at middle and high elevations. Even though the majority of the flood damages from this event occurred on the Sacramento, San Joaquin, and coastal river basins, the event produced the 3rd largest peak flow of record, 56,595 cfs (11,602.7 hm^3/s), on the Kaweah River. Terminus Dam was able to control runoff to downstream channel capacities. The volume for 1-day was 35,600 acre-feet (43.9 hm^3) and 3-day was 80,421 acre-feet (99.2 hm^3). Climatologists classify the 1996-97 season as neither El Niño nor La Niña. Statewide, this storm is ranked as second of the 10 most costly California Storms at $1.88 billion.

The largest flows of record for the years 1904-2004 for a variety of durations are shown in Table 4-10.

TABLE 4-10
MAXIMUM UNREGULATED RAINFLOOD FLOWS ON
KAWEAH RIVER AT TERMINUS DAM

DATE (Peak)	PEAK (cfs)	1-DAY (cfs)	3-DAY (cfs)	7-DAY (cfs)	15-DAY (cfs)	30-DAY (cfs)
6 Dec 66	105,000	53,280	25,736	12,461	6,445	3,569
23 Dec 55 *	84,332	44,512	22,918	12,248	6,323	3,693
2 Jan 97	56,595	17,948	13,515	7,478	4,461	3,890
19 Nov 50 *	54,332	16,640	9,741	5,126	2,766	2,395
25 Jan 69	35,200	22,437	13,425	8,519	6,057	3,773
11 Dec 37 *	34,799	11,232	7,720	3,958	2,842	2,258

*Computed from "Kaweah River near Three Rivers" gage flow records
Source: U.S. Army Corps of Engineers, Water Management Section
Period of Record 1904-2004

Snowmelt floods, while not producing as high a peak as rainfloods, have a much larger runoff volume. These floods normally occur during the months of April through July.

The largest snowmelt flood of record on the Kaweah River at the Terminus Dam site was that of 1906. This flood had a maximum mean daily flow of 7,260 cfs (205.6 m^3/s) and a runoff volume during the period April through July of 815,260 acre-feet (1,005.2 hm^3). The snowmelt flood of 1969 approached that of the1906 flood with a total April through July volume of 800,905 acre-feet (987.5 hm^3) and maximum daily flow of 6,824 cfs (193.3 m^3/s). The effects of this flood were greatly reduced by regulation of Lake Kaweah. Flow rates were reduced to a maximum outflow of 5,600 cfs (158.6 m^3/s), which was generally contained in existing channels of the Kaweah and St. Johns rivers. Of the April through July inflow to Lake Kaweah, plus downstream accretions, about 172,000 acre-feet (212.1 hm^3) reached Tulare Lakebed and about 640,000 acre-feet (779.1 hm^3) was diverted and absorbed within the Kaweah Delta service area. With regulation provided by Lake Kaweah, only in years of exceptionally high snow accumulation will snowmelt runoff cause damage downstream along the Kaweah River and distributaries. Serious flooding in the Tulare Lakebed may occur whenever the total annual runoff is in excess of about 120 percent of normal, about 509,000 acre-feet (627.6 hm^3).

The largest snowmelt flows of record for the years 1904-2004 for a variety of durations are shown in Table 4-11.

TABLE 4-11 MAXIMUM UNREGULATED SNOWMELT FLOOD FLOWS ON KAWEAH RIVER AT TERMINUS DAM						
DATE (1-Day)	1-DAY (cfs)	15-DAY (cfs)	30-DAY (cfs)	60-DAY (cfs)	90-DAY (cfs)	120-DAY (cfs)
28 May 06 *	7,260	5,881	5,338	4,553	3,913	3,397
1 Jun 69	6,824	5,985	5,398	4,347	3,752	3,339
29 May 83	6,671	5,393	5,236	4,474	3,606	3,120
16 Jun 98	5,332	4,644	4,376	3,646	3,147	2,797
23 May 67	5,226	4,227	3,532	3,439	2,900	2,546
27 May 52 *	5,170	4,632	4,235	3,406	2,851	2,455

*Computed from "Kaweah River near Three Rivers" gage flow records
Source: U.S. Army Corps of Engineers, Water Management Section
Period of Record 1904-2004

The largest water year of record on the Kaweah River was 1983. Although releases during 1983 did not exceed 5,000 cfs (141.6 m^3/s), close to 500,000 acre-feet (616.5 hm^3) of water was sent to Tulare Lakebed. Table 4-12 (in the Tables Section, Page T4-4) presents the Historical Unregulated Monthly Inflows to Terminus Dam and Lake Kaweah Project from 1904 to 2004.

4-07. Runoff Characteristics. At the beginning of the rainy season the ground is extremely dry. At such times, it may take approximately 3 to 5 inches (7 to 12 cm) of rain to saturate the soil before any significant runoff will occur. Later in the season, when the ground is usually wet, heavy rainfall over the basin can cause large flood runoff.

Approximately 65 percent of the annual runoff into Lake Kaweah occurs during snowmelt season, April through July. The Mean Monthly and Annual Runoff into Lake Kaweah is presented in Table 4-13.

TABLE 4-13 MEAN MONTHLY AND ANNUAL RUNOFF INTO LAKE KAWEAH		
MONTH	AVERAGE INFLOW (1,000 acre-feet)	PERCENT OF ANNUAL STREAM FLOW
January	27.0	6.26
February	32.0	7.42
March	45.8	10.62
April	65.3	15.14
May	103.8	24.07
June	81.5	18.89
July	31.0	7.19
August	8.5	1.97
September	4.6	1.07
October	5.1	1.18
November	9.1	2.11
December	17.6	4.08
Annual Total	431.3	100.00
Period of Record	Water Years 1904-2004	
Source: U.S. Army Corps of Engineers, Sacramento District, Water Management Section		

Annual runoff volumes are subject to wide variation. A graphical presentation of historical operation is shown on Plate 4-6. Recorded runoff data from three upstream gages on the Kaweah River are shown in Table 4-14. The U.S. Army Corps of Engineers maintains the official operation records for Terminus Dam.

TABLE 4-14
RECORDED RUNOFF DATA

	Kaweah River at Three Rivers	South Fork Kaweah River at Three Rivers	Kaweah River near Three Rivers
Period of Record (Water Yrs)	1958-2004	1959-1990	1903-1961
Drainage Area (sq mi)	418	86.7	520
Daily flow (cfs)			
Maximum	37,100 (6 Dec '66)	7,760 (6 Dec '66)	80,700 (23 Dec '55)
Minimum	14 (29 Sep '77)	0 (at times 1960-62)	8.5 (19 Sep '34)
Mean	516	71	554
Daily flow (cfs/sq mi)			
Maximum	88.75	89.50	155.19
Minimum	0.03	0.00	0.02
Mean	1.23	0.82	1.07
Instantaneous flow (cfs)			
Maximum	73,000 (5 Dec '66)	11,600 (6 Dec '66)	80,700 (23 Dec '55)
Minimum	14 (29 Sep 1977)	0 (1962)	8.5 (Sep 34)
Instantaneous flow (cfs/sq mi)			
Maximum	174.64	133.79	155.19
Minimum	0.03	0.00	0.02
Annual flow (ac-ft)			
Maximum	1,176,000 (1983)	183,500 (1983)	1,104,000 (1906)
Minimum	86,360 (1977)	8,050 (1977)	102,000 (1924)
Mean	374,200	51,440	401,100
Annual flow (inches)			
Maximum	52.75	39.68	39.81
Minimum	3.87	1.74	3.68
Mean	16.79	11.12	14.46
April-July flow (ac-ft)			
Maximum	712,300 (1969)	98,170 (1983)	750,000 (1906)
Minimum	56,800 (1977)	5,688 (1977)	75,500 (1924)
Mean	246,630	32,990	287,500
April-July flow (inches)			
Maximum	31.95	21.23	27.04
Minimum	2.55	1.23	2.72
Mean	11.06	7.14	10.37

Source: U.S. Geological Survey and U.S. Army Corps of Engineers, Sacramento District, Water Management Section

4-08. Water Quality. There is no significant agriculture or industry in the basin above Terminus Dam which would affect the water quality of the lake. Tests of inflows and lake storage at Lake Kaweah indicate that the water quality is generally good. The Terminus Dam and Lake Kaweah Project does not operate for water quality purposes.

The chemical, physical, and biological properties of surface water at any given point are the product of a multitude of factors including geography, geology, climatic conditions, discharge, floral and faunal communities, ground water supply, and, of major significance, the effect of man's activities and his domestic animals.

Field data and water samples are collected at Lake Kaweah during April and August of each water year. The field data collected at the time of water sample collection are temperature, electrical conductivity, dissolved oxygen, and pH. The field data are evaluated at various depths within the lake in order to get a better idea of how these characteristics change with depth. The lake Secchi depth for the summer of 2002 was 5.75 feet (1.8 m). The Secchi depth is used as a gage of water clarity in the lake.

Laboratory tests are done on water samples collected in April and August each year at Lake Kaweah. Analysis is done to test for the presence of Methyl Tertiary-Butyl Ether (MTBE), heavy metals, general chemicals, and biological organisms. In 2001, pesticides and herbicides were discontinued as a parameter for testing, since the results from 1995 to 2000 were consistently at non-detectable levels. The results of the field data analysis and the laboratory tests are presented in the Annual Water Quality Report that is published each year. The 2002 water quality report can be found at: <http://www.spk.usace.army.mil/cespk-ed/EnvirProj/AWQM-WY2002/Kaweah_Lake_WY2002.pdf>.

In water year 2002, dissolved heavy metals did not exceed the drinking water standard or the freshwater fishery criteria during either spring or summer, except for dissolved manganese. Table 4-15 provides a summary of water quality data collected in 2002.

TABLE 4-15 WATER QUALITY DATA (2002)				
Constituent or Measurement	Kaweah River at Three Rivers		Lake Kaweah	
	April	August	April	August
Secchi Disk	N/A	N/A	10.85 feet	5.75 feet
Surface Water Temperature	N/A	N/A	61.7°F	77.8°F
Bottom Water Temperature	N/A	N/A	49.3°F	54.5°F
River Water Temperature	61.7°F	68.8°F	N/A	N/A
Surface Dissolved Oxygen	N/A	N/A	12.67 mg/l	4.31 mg/l
Bottom Dissolved Oxygen	N/A	N/A	8.07 mg/l	0.79 mg/l
pH	7.52	7.76	7.74	7.19
Phytoplankton	N/A	N/A	837.43 μg/l	2655.39 μg/l
Dissolved Manganese	N/A	N/A	N/A	85 ppb
Dissolved Mercury	N/A	N/A	.003 ppb	.0043 ppb
MTBE	N/A	N/A	3 ppb	8 ppb

N/A = test not done at this site
Source: U.S. Army Corps of Engineers, Sacramento District, Environmental Engineering Division
http://www.spk.usace.army.mil/cespk-ed/EnvirProj/AWQM-WY2002/Kaweah_Lake_WY2002.pdf

4-09. Channel and Floodway Characteristics. Flooding in the valley floor areas occurs where the stream gradients are fairly flat and the channels do not have sufficient capacity to carry large flood flows. Inadequate drainage facilities, obstruction of natural channels by reeds, brush, and tules, and road and railroad fills across the floodplain also contribute to flooding problems.

The Kaweah River, from Terminus Dam to the Tulare Lakebed, is about 60 miles (96.6 km) long. The channel capacity of the Kaweah River at McKay Point is 5,500 cfs (155.8 m^3/s). At McKay Point, the flow is divided between the St. Johns and the Kaweah rivers. The St. Johns carries flows northwest and the Kaweah River flows southwesterly. Below McKay Point the controlling total capacity of distributary channels is 5,500 cfs (155.8 m^3/s) for short periods (up to a week) and 5,000 cfs (141.6 m^3/s) for long periods (up to 90 days). Such flows would be reduced (by channel losses, irrigation, and spreading) to a flow which, although larger than some within-bank capacities, would not cause significant damage along the channels. Flooding of agricultural areas along the Kaweah River system channels has been observed at flows of 5,500 cfs (155.8 m^3/s) and less. The Kaweah River and its distributaries ultimately terminate in Tulare Lakebed. In most instances, it is expected that the critical reach would be on Cross Creek, southwest of Highway 99.

The channel capacities within the system vary widely, and in many cases are unknown. The estimated non-damaging capacities of various distributary systems and channels throughout the Kaweah River area between Terminus Dam and Tulare Lakebed are shown on Plate A-12.

4-10. Upstream Structures. There are three non-federal powerhouses above Terminus Dam. Southern California Edison owns and operates these small power plants and their regulatory storage is insignificant. None of these projects, or other projects, affects the operation of Lake Kaweah.

4-11. Downstream Structures. At McKay Point, approximately 3 miles (4.8 km) downstream from Terminus Dam, the flow is divided between the St. Johns and the Kaweah rivers. The Friant-Kern Canal part of the Bureau of Reclamation's Central Valley Project (CVP) crosses the St. Johns and Kaweah rivers approximately 2 miles (3.2 km) west of McKay Point. There are turnouts at the canal siphon crossing these rivers. In the valley portion of the watershed are numerous privately constructed flood control levees, irrigation distribution systems, and groundwater recharge areas. The private irrigation diversion systems and recharge areas have both flood control and irrigation purposes. Except during large floods, most releases from Terminus Dam are used to meet irrigation and spreading demands at the McKay Point Diversion structure based on conditions at the time.

4-12. Economic Data. The Kaweah River Basin lies in Tulare and Kings counties. Tulare County, population (2002) of 379,200 and a work force of 170,900, along with Kings County, population (2002) of 133,100 and a work force of 46,110, is dotted with rural farms, ranches, orchards, vineyards, and small communities.

a. Population. The main population center in the Kaweah River Basin is the city of Visalia. Visalia has experienced rapid growth along with the rest of the Kaweah River Basin. The population of Tulare and Kings counties, along with the city of Visalia, are given in Table 4-16.

b. Agriculture. The valley floor below Terminus Dam is a highly developed agricultural area. Agricultural pursuits in the valley include irrigated pasture for beef and dairy cattle, vineyards, extensive orchards, and the production of alfalfa, nursery and greenhouse products, cotton lint, hay, oranges, and vegetables. Untilled portions of the basin support livestock (primarily cattle). Tables 4-17 and 4-18 indicate the value of agricultural activities in the region.

c. Industry. The agricultural industry is the largest employer in the area. Other economic activities in the Kaweah River Basin include governmental agencies, mining, sand and gravel operations, food processing industries, and recreation. Table 4-19 indicates employment and sales in Tulare County by trade category.

TABLE 4-16 POPULATION					
LOCALITY	POPULATION BY YEAR				
	1970	1980	1990	2000	2003
Tulare County	188,403	245,738	311,921	368,021	390,791
Visalia	N/A	N/A	75,600	91,565	98,900
Kings County	64,610	73,738	102,500	129,461	138,564

Source: U.S. Bureau of the Census: http://www.census.gov/population/cencounts/ca190090.txt, http://quickfacts.census.gov/qfd/states/06/06031.html, http://quickfacts.census.gov/qfd/states/06/06107.html
California Employment Development Department (2002): http://www.calmis.ca.gov/file/COsnaps/tularsnap.pdf, http://www.calmis.ca.gov/file/COsnaps/kingssnap.pdf

TABLE 4-17 GROSS VALUE OF COMMODITY GROUP PRODUCTION IN TULARE COUNTY (2003)	
COMMODITY GROUP	GROSS VALUE OF AGRICULTURAL PRODUCTION ($1,000)
Livestock, Poultry, and Products	1,523,506
Fruit and Nut Crops	1,356,387
Field Crops	290,115
Nursery, Flowers, and Foliage	66,775
Apiary Products	34,589
Vegetable Crops	22,212
Timber Products	1,862
Seed Crops	1,076
TOTALS	3,296,522

Source: Summary of County Agricultural Commissioners' Reports, California Agricultural Statistics Service, ftp://www.nass.usda.gov/pub/nass/ca/AgComm/200308cavtb00.pdf

TABLE 4-18 GROSS VALUE OF FIVE MAJOR CROPS GROWN IN TULARE COUNTY (2003)		
CROP	GROSS VALUE ($1,000)	PERCENT STATE TOTAL
Oranges	442,504	46.6 %
Grapes	378,511	12.5 %
Plums	85,500	36.4 %
Alfalfa Hay	84,019	10.2 %
Peaches	70,092	16.8 %
Source: Summary of County Agricultural Commissioners' Reports, California Agricultural Statistics Service, ftp://www.nass.usda.gov/pub/nass/ca/AgComm/200308cavtb00.pdf		

TABLE 4-19 EMPLOYMENT AND TOTAL SALES BY TRADE CATEGORY IN TULARE COUNTY (2002)		
TRADE CATEGORY	TOTAL EMPLOYEES	TOTAL SALES ($1,000)
Manufacturing	11,300	3,167,304
Mining and Construction	5,600	Not Available
Wholesale Trade	21,900	2,527,654
Retail Trade	13,400	2,135,741
Taxable Services	16,228	791,522
Agricultural Workers	33,700	See Table 4-18
Government (All)	29,600	Not Available
Sources: California Employment Development Department (2002), http://www.calmis.ca.gov http://www.calmis.ca.gov/file/COsnaps/tularSNAP.pdf, U.S. Census Bureau, (1997) Economic Census, http://www.census.gov/epcd/ec97/ca/CA107.HTM		

d. Flood Damages. Rainfloods along the Kaweah River, below Terminus Dam, are characterized by comparatively high peaks, small volumes, and short durations, and are damaging to both urban and agricultural areas. These floods also damage channel improvements and adjacent areas. Volumes that exceed irrigation and spreading capabilities continue on to Tulare Lakebed to pond on cropland. Prior to construction of Terminus Dam and Lake Kaweah, rainfloods frequently caused extensive soil erosion, damaged farm equipment and structures, silted in irrigation canals, washed out diversion structures, and washed out reaches of highways. The December 1950 flood, which reached a peak of approximately 54,000 cfs (1529.3 m^3/s) at the Terminus Dam site, extensively damaged agricultural and industrial areas and caused flooding in Visalia. The December 1955 flood, which peaked at approximately 84,000 cfs (2378.9 m^3/s) at the dam site, caused extensive damage to Visalia and its suburbs.

Snowmelt floods have much lower peak flows than rainfloods but larger volumes. Kaweah River snowmelt flood flows, combined with runoff from adjacent basins, flood large areas in Tulare Lakebed for long periods of time. In some cases, inundation can last more than a year.

A number of large floods have occurred since the project was built. The December 1966 flood, with a peak inflow to Lake Kaweah of 105,000 cfs (2973.6 m^3/s), was the largest of record. The estimated damages prevented by Terminus Dam and Lake Kaweah are listed in Table 4-20.

TABLE 4-20 DAMAGES PREVENTED BY TERMINUS DAM AND LAKE KAWEAH (at time of event)	
FLOOD EVENT	DOLLAR VALUE OF DAMAGES PREVENTED IN YEAR OF OCCURRENCE ($1,000)
February 1962	3,100
December 1966	22,200
January-February 1969	10,800
January 1970	1,000
February-March 1978	8,535
January-February 1979	3,000
January-February 1980	26,200
April 1982	26,700
December 1982-March 1983	26,700
November-December 1983	11,300
February-March 1986	8,000
March 1991	8,100
March 1995	800
January 1997	124,165
January-March 1998	7,721
February 2000	1,770
November 2002	20,140
TOTAL	$310,231
Source: U.S. Army Corps of Engineers, Sacramento District, Economics Branch	

Photo 4-1. Kaweah River headwaters

Photo 4-2. Kaweah River at Three Rivers

Photo 4-3. Dry Creek near Lemoncove

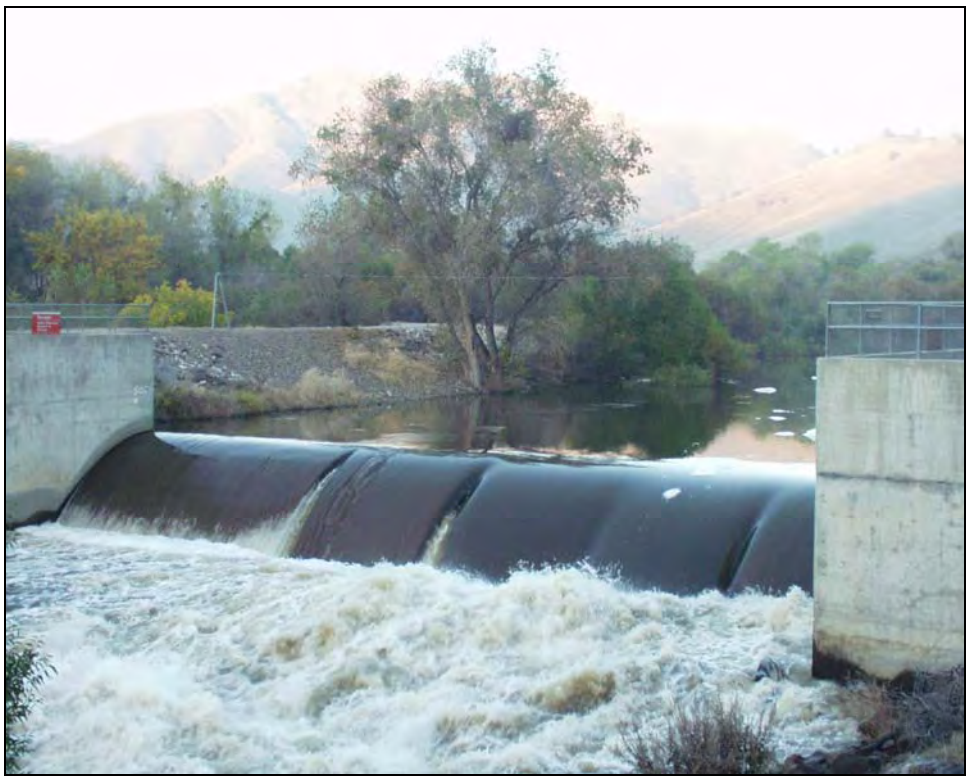


Photo 4-4. Kaweah River below Terminus Dam

Photo 4-5. McKay Point diversion structure

Photo 4-6. Kaweah River below McKay Point diversion structure

(This page intentionally left blank)