VI - HYDROLOGIC FORECASTS

6-01 General.

a. Role of the Corps of Engineers. The LAD does not prepare formal published hydrologic forecasts for Prado Dam. Despite the lack of formal hydrologic forecasts, the LAD does carefully monitor the reservoir including the existing and anticipated hydrometeorologic conditions of the entire Santa Ana River watershed. Other agencies are notified of any significant changes or anticipated changes as described in Section 5-06c.

Quantitative Precipitation Forecasts (QPF) for the Santa Ana River Basin are obtained from a private meteorological firm under contract with the LAD. These are used in determining the potential for significant runoff into Prado Reservoir and other reservoirs within the watershed. The Santa Ana River Real-Time (SARRT) Water Control System integrates the QPF and telemetered precipitation and streamflow data to provide a real-time overview of the entire Santa Ana River basin as well as a runoff forecast for the watershed. The SARRT water control system allows the water control manager to more efficiently regulate Prado Dam as a component of the Santa Ana River flood control system during significant runoff events.

In addition to the SARRT, a simplified QPF/API algorithm and a Recession Limb Inflow Forecast Method have been developed which can be used to respectively determine an estimated inflow volume and a recession limb hydrograph for Prado Dam.

b. Role of Other Agencies. Real-Time weather data and forecasts for the southern California region are received from the NWS. This information is received via a weather satellite display system and DATACAL.

Historical precipitation and stream flow data are available from the OCEMA, NWS, USGS, and OCWD. These data, while not of use in real-time, are important to studies of historical storms and floods that aid in the development and refinement of manual and computerized rainfall-runoff forecast models such as the QPF/API algorithm, the Recession Limb Inflow Forecast Model, and the SARRT water control system.

6-02 Flood Condition Forecasts. The LAD uses three forecasting methods to determine the inflow to Prado Dam. For significant flood events the SARRT Water Control System is used. The QPF/API algorithm is also used to determine flood volume inflows. And finally a Recession Limb Inflow Forecasting model is used to

predict the recession limb of the inflow hydrograph.

The SARRT Water Control System was first completed in 1987 and then revised due to software changes, in 1989. The purpose of the SARRT water control system is to enhance the regulation of the Santa Ana River flood control system by:

1. The acquisition, management, and display of real-time data that reflects the current status of the watershed and water control facilities.

2. The production of runoff forecasts for the entire Santa Ana River Watershed, based on observed or forecasted precipitation.

3. Allowing the water control manager to evaluate several regulation alternatives for the multi-reservoir system, thereby allowing the water control manager to implement a regulation alternative which best controls the forecast flood event.

SARRT was calibrated for significant flood events and is therefore best suited for use during such events. The SARRT is capable of producing forecast hydrographs at several control points in the Santa Ana River Watershed. Plate 6-01 is a schematic of the Santa Ana River Watershed showing the control points at which hydrographs can be generated. SARRT remains largely untested due to the lack of significant storm events since its completion.

The QPF/API algorithm was developed to aid the water control manager during flood events which impact water conservation regulation. Unlike the SARRT, the QPF/API algorithm does not produce a forecast inflow hydrograph for Prado Dam, but rather, it only determines a forecast inflow volume to Prado Dam.

The recession limb inflow forecast model can be used as a secondary check of the SARRT water control system or to improve a forecast based on the QPF/API algorithm. As the name implies, this model can only be used after the inflow hydrograph has peaked. Also if substantial precipitation is still falling the water control manager should expect a possible secondary peak, which would require reiteration of the recession limb inflow forecast model.

a. Requirements.

(1) **Santa Ana River Real-Time (SARRT) Water Control System.** The SARRT was developed by adapting computer software developed by the U.S. Army, Corps of Engineers, Hydrologic Engineering Center (HEC). The SARRT accesses telemetered precipitation, stream flow, and reservoir elevation data as well as current QPF's for the Santa Ana River basin. The water control manager specifies zonal hydrologic parameters for ungaged watersheds and future reservoir release schedules.

With this information stored in the master data base, the water control manager can either view the existing conditions or prepare a forecast for the entire watershed. The SARRT also checks for pre-programmed alarm conditions at the various control points in the watershed. The SARRT uses the computer programs HEC-1F and HEC-5 to generate forecast hydrographs for the various control points.

The LAD Harris-800 minicomputer is dedicated to flood control regulation during significant flooding events. The SARRT software package is one of many programs used during flood control regulation. SARRT is capable of generating a forecast of the entire watershed in minutes. Should the forecast results show undesirable conditions, the water control manager can change the regulation schedule of either San Antonio, Carbon Canyon, or Prado Dam in an effort to obtain a desirable result.

A 30 minute simulation time interval is used by both the HEC-1F-Stream Flow Forecast Model and the HEC-5 Reservoir System Simulation program. A 24 hour forecast time window is used by the HEC-5 program.

The Santa Ana River watershed drains 2,450 square miles to the Pacific Ocean (2,255 square miles are above Prado Dam). Although the SARRT allows the water control manager to simulate real-time and forecast flows through this large and complex basin, for the SARRT to be an effective tool during an actual flood event, the water control manager must become familiar with the watershed characteristics as well as the complex SARRT water control system before an actual flood event occurs.

A detailed description of the SARRT operation is beyond the scope of this water control manual. The water control manager should refer to reference 22 (as listed on Plate 1-01) for a comprehensive description of the SARRT water control system.

(2) **QPF/API Algorithm**. The QPF/API algorithm only forecasts a flood inflow volume, given a basin average Antecedent Precipitation Index (API) and a Quantitative Precipitation Forecast (QPF) or observed basin average rainfall. The basin average API is generated from the zonal average precipitation values which are available from the REPORT software (See Plate 6-02 for the precipitation zones). Should the REPORT software be down, a "back-up" API can be generated using the precipitation gage at Prado Dam, available from the dam tender via radio. During each flood season, a running record of the basin average API is maintained on both the Harris 800 and on paper for a manual "back-up".

Once the basin average API and QPF are obtained, the forecast inflow volume to Prado Dam can be determined as outlined in Exhibit C.

(3) **Recession Limb Inflow Model**. The recession forecast model is based on a historical analysis of 17 floods. The model employs a graphical procedure to forecast

the recession limb of the inflow hydrograph to Prado Reservoir from the peak to up to seven days into the future.

To prepare a forecast one must determine the total inflow volume to Prado Dam from:

* 1 October to the time of forecast.
* for the past 30 days.

These inflow volumes can be found by using option 6 of the LAD's RESCAL program. Exhibit D outlines the use of this method.

b. Methods.

(1) Santa Ana River Real-Time (SARRT) Water Control System. The primary software used by the SARRT water control system to generate forecasts for the Santa Ana River are "HEC-1F-Stream Flow Forecast" model and "HEC-5-Reservoir System Simulation" program.

Application of HEC-1F to forecast runoff in a multi-sub-basin watershed is generally a two-step process, requiring two separate applications of the program. The first step is to estimate hydrologic parameters (e.g. loss rate, unit hydrograph, and base flow) and discharge hydrographs for gaged headwater sub-basins. An example estimated hydrograph from this process is shown in Plate 6-03. The input file for this step is referred to as the E-model, indicating the parameter Estimation purpose of the model.

The second step of the HEC-1F process accomplishes the following:

1. Sub-basin discharge hydrographs are calculated for all ungaged sub-basins using runoff parameters specified by the water control manager through the MODCON program.

2. Sub-basin hydrographs are routed and combined throughout the basin.

3. Hydrographs are blended at each stream gauge prior to subsequent routing and combining operations. Blending consists of replacing the calculated hydrograph ordinates with observed hydrograph ordinates up to the time of forecast, and providing a smooth transition to the calculated hydrograph over six future time periods following the time of forecast. The blending process is illustrated in Plate 6-04.

The input file for the second step is referred to as the F-model because the end product of this step is a set of Forecasted discharge hydrographs for all the sub-basins and control points.

HEC-5 is used to simulate the sequential operation of the reservoir system. Reservoir releases are determined by HEC-5 in accordance with constraints at downstream control points while keeping the reservoirs of the system "in balance". Reservoir inflow hydrographs and hydrographs of uncontrolled runoff at downstream control points are obtained from previously completed HEC-1F applications via a DSS file. Output from HEC-5 such as hydrographs of discharge, reservoir elevation, and storage are written to a DSS file for subsequent display and analysis. Thus, anticipated runoff from the watershed can be routed through Prado Dam to estimate the maximum water surface elevation, inflow and outflow for a given rainfall event.

(2) QPF/API Algorithm. Exhibit C outlines the QPF/API algorithm and presents an example of its use.

(3) Recession Limb Inflow Model. Exhibit D outlines the recession limb forecast procedure and presents an example of its use.

6-03 Conservation Purpose Forecasts. No forecasts for water conservation are prepared by the LAD. During water conservation regulation, inflows to Prado Dam as well as weather and runoff forecasts are closely monitored to determine if flood control regulation is required (As described in Section 6-02 above).

6-04 Long Range Forecasts. Long-term forecasts of precipitation and runoff (in excess of 1 week) are not normally prepared. In the event of a significant impoundment, long-term forecasts will be made regarding the draw-down time of the impoundment as discussed in Chapter 7.