RESERVOIR REGULATION MANUAL

FOR

PAINTED ROCK RESERVOIR
GILA RIVER BASIN, ARIZ. AND N. MEX.

GENERAL INFORMATION

1. Authority.--The authority for the preparation of this manual is contained in paragraph 6, Engineering Regulation 1110-2-240, titled "Engineering and Design, Reservoir Regulation," and dated 8 December 1958. Detailed instructions pertaining to the contents of the manual are contained in chapter 6, Engineering Manual 1110-2-3600, titled "Engineering and Design, Reservoir Regulation," and dated 25 May 1959.

2. Scope.--This manual contains: (a) general descriptive information pertaining to the drainage area and project; and (b) a description of the plan of operation, the district's organization and methods for applying the plan, and examples of its application to various floods.

3. Project history and authorization.--The project consists of Painted Rock dam and reservoir on the Gila River, Ariz. (See pl. 1 for project location). A public hearing was held at Yuma, Ariz., on 11 February 1938, in connection with the preparation of the preliminary examination report dated 9 May 1938, on the Gila River from Gillespie Dam to a point near Wellton, Ariz. Another public hearing was held at Phoenix, Ariz., on 20 October 1938, in connection with the preliminary examination report dated 10 January 1939, on the Gila River and tributaries, Arizona and New Mexico. Local interests indicated at these two meetings that they desired (a) a flood-control and water-conservation dam on the Gila River at the Sentinel damsite (river mile 112), and (b) channel improvements on the Gila River downstream from the damsite. In the publication titled "Interim Report on Survey, Flood Control, Gila River and Tributaries Below Gillespie Dam, Arizona," dated 1 September 1948, various plans of improvement were considered. The plan recommended in that report provided for an earthfill dam to create a flood-control basin at Painted Rock site (river mile 126). Studies indicated that there was a lack of justification for water conservation in the reservoir behind the dam. Furthermore, consideration of the Sentinel site was dropped on the basis of geological investigations. No recommendations pertaining to the downstream channel were made. Although no public hearings

were held subsequent to authorization of the project, public officials and representatives of many local groups appeared before the appropriation committees in support of the project.

4. The construction of Painted Rock Reservoir project (as set forth in H. Doc. 331, 81st Cong., 1st sess.) was authorized by act of Congress of 17 May 1950, Public Law 516, 81st Congress, 2d session.

5. Physiographic characteristics.--Painted Rock Dam is located in the southwest part of Maricopa County in the State of Arizona about 20 miles northwest of the town of Gila Bend (See pl. 1). The dam is on the Gila River, 38 miles downstream from Gillespie Dam. The drainage area above the dam is 50,800 square miles, excluding the Willcox and Animas closed drainages. The Gila River basin, which is an irregular area of 57,950 square miles (excluding the Animas and Willcox closed drainages) extends from the Continental Divide in southwestern New Mexico to the Colorado River at Yuma, Ariz. It includes practically all the southern half of the State of Arizona and constitutes a region of widely varying topographic and climatological characteristics. A topographical map of the basin is shown on plate 2. The river, which is 654 miles long, rises in an area of high mountains and plateaus and flows westward, in a generally central course through the basin, to a point on the Colorado River about 3 miles upstream from Yuma, Ariz.

6. Much of the northern part of the basin is extremely irregular and rugged, the boundary elevations ranging from about 7,000 feet to more than 12,000 feet. This part of the basin is mostly drained by the Salt River, the largest tributary, which joins the Gila River at river mile 198 near Phoenix. The eastern half of the southern part of the basin consists largely of long desert valleys lying between north-south ranges of rugged mountains; here the elevations are generally lower but in places are above 10,000 feet. The southwest third of the basin consists essentially of broad, flat, flow-lying desert valleys and isolated mountains of relatively low relief. Comparatively few localities are more than 4,000 feet in elevation and a large part is below 1,000 feet; the elevation of the river mouth near Yuma is about 130 feet.

7. In general, the mountains in the Gila River basin are of igneous rock, mostly granitic, schistose, or volcanic. The valleys along the Gila River and its tributaries are alluvial fills of varying depth. The soil in the valleys is fertile, and where water without a high saline content is available for irrigation, the crop yields are high. The type, density, and distribution of vegetation in the Gila River basin reflect the differences in

elevation, temperature, and precipitation. The desert vegetation is sparse and composed principally of cacti, creosote bush, and sagebrush. Mesquite, salt cedar, and arrowweed grow in dense thickets in stream bottoms and other areas where the water table is near the surface of the ground. Grasses interspersed with desert and semidesert shrubs grow at elevations ranging from 3,000 to 8,000 feet. Chaparral, oak, pinion, and juniper grow at elevations ranging from 4,000 to 7,000 feet. Aspen and conifers, such as fir, spruce, and pine are common above elevations of 6,000 feet.

8. Existing improvements.--There are numerous dams in the Gila River basin above Painted Rock Reservoir; however, only eight of them influence the regulation of major floods at Painted Rock Reservoir. A tabulation of pertinent data for these eight reservoirs is given in table 1 and their locations are shown on plate 1.

9. Downstream economic development.--With the exception of a few widely dispersed residences, no developments exist along the Gila River from Painted Rock Reservoir to Texas Hill (see pl. 1). From Texas Hill to the Colorado River (see pl. 3), the principal occupations in the Gila River basin are agriculture and related industries. The U. S. Bureau of Reclamation is constructing the Gila project which provides for diverting Colorado River water to 115,000 acres of irrigable land in the lower Gila River basin. According to 1959 figures, the total value of property at that time in the overflow area and outside of the overflow area along the Gila River from Texas Hill to the Gila siphon subject to damage by the occurrence of a standard project flood below Painted Rock Reservoir was $69,000,000. Damage to areas outside of the overflow area would be caused by disruption of irrigation facilities. This property included residential, crops, farmland, irrigation works, highways and roads, drainage works, utilities, and riverbed and wasteland.

10. Below the confluence of the Gila and Colorado Rivers, Painted Rock Reservoir provides flood protection to the city of Yuma and the towns of Gadsden and Somerton in Arizona. Protection is also provided for extensive irrigation facilities, Federal, State, and county highways, and bridges for the Southern Pacific Railroad and San Diego and Arizona Eastern Railroad. Also, residences, irrigation works, highways and railroads in Imperial Valley, Calif., are protected.

11. In addition to providing flood protection for developed areas in the United States, provisions pertinent to the operation of Painted Rock Reservoir are of interest to the International Boundary and Water Commission because of the Commission's

responsibilities under the 1944 Water Treaty with Mexico. In accordance with Article 13 of that treaty, the International Boundary and Water Commission is charged with investigating and preparing plans for flood control on the lower Colorado River between Imperial Dam and the Gulf of California. The operation of Painted Rock Dam affects the lower Colorado River because a reduction in flood flows on the Gila River reduces flood flows in the lower Colorado River. Also, much Gila River sediment that might otherwise be deposited in the Colorado River is retained in Painted Rock Reservoir. These effects serve to promote river-channel stability. The design of any flood-control structures constructed in the lower Colorado River as a result of the 1944 Water Treaty must take into account the effects of Painted Rock Reservoir. In fact, the design capacity for levees completed in the Yuma area in 1952 is based partly on those effects as indicated in a subsequent paragraph.

12. Hydrometeorological characteristics.--The climate of the Gila River basin as a whole is semiarid but, depending principally upon elevation, ranges from hot to arid in some subareas to cool and humid in others. A summary of climatological data at representative stations in and near the basin is given in tables 2 through 9 and the locations of these stations are shown on plate 4. The average annual precipitation ranges from less than 4 inches in the lower desert to 30 inches or more in the highest mountains. Isohyets of mean seasonal precipitation are shown on plate 5. Most of the precipitation occurs in two distinct seasons, summer (July through September) and winter (December through March), and is about equally divided between them. Little rain falls during spring and autumn. During any season there may be many successive rainless days. In winter, snow may accumulate to considerable depth at elevations above 4,000 feet, but snow practically never falls at elevations below 2,000 feet. Isohyets of mean winter precipitation are shown on plate 6. Three types of storms produce precipitation in the Gila River basin: general winter storms, general summer storms, and local thunderstorms. A brief description of each storm type is given in the following subparagraphs.

(a) General winter storms usually occur during the period from December to March, inclusive. They originate over the Pacific Ocean as a result of the interaction between polar Pacific and tropical Pacific airmasses and move eastward over the basin. These storms, which often last for several days, reflect orographic influences and are accompanied by widespread precipitation in the form of snow or rain.

(b) General summer storms usually occur during the period from July to September, inclusive. They are associated with an influx of tropical maritime air originating over the Gulf of Mexico

or the South Pacific Ocean and entering the area from the southeast or southwest. Usually the influx of tropical air is caused by the circulation about a high pressure area centered in southeastern United States, but occasionally it is caused by the remnants of a tropical hurricane. General summer storms are often accompanied by heavy rainfall over large areas for periods up to 24 hours but showers may continue for as long as 3 days.

(c) Local thunderstorms can occur at any time of the year, either during general storms or as isolated phenomena. However, they are most common during the period from July to September, inclusive, when the basin is frequently covered by moist, unstable air originating over the Gulf of Mexico. These storms cover comparatively small areas and result in high-intensity rainfall of short duration.

13. Runoff.--Runoff from various portions of the drainage area varies considerably. The streams in the desert portion of the southern part of the basin have little flow other than during and immediately after the heavier rains, while the northern and headwater portions of the basin have some flow throughout the year. Prior to the construction of Painted Rock Dam, no stream-gaging station existed at the damsite. However, records of flow below Gillespie Dam located 38 river miles above Painted Rock Dam are available since 1921. Hydrographs of mean daily flows at this location for the period of record are shown on plates 7 and 8. A tabulation of runoff data below Gillespie Dam is given in table 10. The volume of flow at Painted Rock Dam is approximately 75 percent of the flow at Gillespie Dam because of percolation, evaporation, and other losses. Runoff data for the stream-gaging station near Dome, Ariz., located 12 river miles above the confluence with the Colorado River are available since 1903; however, no peak discharges were recorded prior to 1929. A tabulation of peak discharges and maximum mean daily discharges for the Dome gaging station is given in table 11. The locations of this station and the station at Gillespie Dam are shown on plate 4.

14. Floods.--Historical references to floods on the Gila River extend back to 1833 but continuous records of discharge measurements are not available prior to 1903. Historical accounts indicate that general floods occurred in 1833, 1862, 1869, 1880, 1884, 1886, 1889, 1890, 1891, 1893, 1895, and 1903. Records since 1903 show that floods and/or storms occurred in March 1905, November 1905, December 1906, December 1914, January 1915, January 1916, October 1916, November 1919, February 1920, December 1923, September 1926, February 1927, February 1937, March 1938, March 1941, and September 1946. The flood of 1884 was the earliest for which a reasonable estimate of severity can be made. This flood and the flood of 1891, possibly, were comparable to the flood of 14-21 January 1916, the greatest of record.

15. Storms and floods of January 1916.--Two storms occurred over the Gila River basin in January 1916, one from the 14th to the 21st, and another from the 25th to the 30th. The first storm which was of broader coverage than the second, produced the larger flood. Both storms were of the general winter type. The average precipitation over the drainage area above Painted Rock Reservoir site was about 3.5 inches for the first storm and 1.3 inches for the second; in each storm, approximately half of the precipitation occurred in a 24-hour period. Ground conditions were rather severe, owing to the occurrence of light rain on 10-12 January and to the presence of snow cover over much of the area. The estimated peak discharges of the Gila River at the mouth were 230,000 and 155,000 cubic feet per second, respectively, for the two floods. Discharges on many of the tributaries were likewise severe, especially in the northern part of the drainage area. For example, on the Salt River near Roosevelt (drainage area 4,310 sq. miles) the peak discharge of the first flood was estimated at 100,000 cubic feet per second. Pertinent hydrologic data for the two storms and floods are given on plate 9.

16. Storm and flood of September 1946.--The storm and flood of September 1946 illustrates the magnitude of rainfall that sometimes occurs in general summer storms. Beginning as a series of thunderstorms about noon of the 17th, the storm produced practically continuous rain from the afternoon of the 17th until the morning of the 19th. The average depth of rain over the drainage area above Painted Rock Reservoir site was 2.0 inches, more than three-fourths of which fell in a 24-hour period. Because the ground was relatively dry when the storm began, only minor runoff resulted. The peak discharge on the Salt River near Roosevelt was 15,100 cubic feet per second. On the Gila River, the peak discharge below Gillespie Dam was only 4,290 cubic feet per second, and flow at the river mouth was zero.

17. Flood damages.--Floods on the Gila River prior to the construction of Painted Rock Dam caused severe damage to property in the lower Gila Valley, and along the Colorado River below Laguna Dam. Monetary estimates of damage are not available for floods prior to 1890 and are incomplete for floods since that date. In addition to property damage, loss of life has been reported.

18. In connection with this office's "Review Report for Flood Control, Gila River and Tributaries Downstream from Painted Rock Reservoir, Ariz.," dated 1 April 1961, information was compiled on flood damages along the Gila River from Texas Hill to the Gila siphon (see pl. 3 for area subject to overflow). Detailed consideration was not given to the rest of the Gila River below Painted Rock Dam because (a) there are relatively few improvements

in the overflow area between the dam and Texas Hill, and (b) the U. S. Bureau of Reclamation is responsible for flood protection below the Gila siphon.

19. Although large floods have occurred along the Gila River in the area under consideration, damages have been relatively small because of the small development in the area prior to 1949, when construction was initiated in the Wellton-Mohawk division of the Gila project. No flood has occurred along the main stream of the Gila River downstream from Painted Rock Reservoir since 1949. A flood occurring in August 1955 caused damages estimated at $500,000 along several tributaries of the Gila River, below Painted Rock Reservoir, including Ligurta and Fortuna Washes. Large damages were caused to irrigation facilities including a pumping plant on the Wellton-Mohawk Canal, to agricultural lands, and to highway and power facilities. Flood-control improvements constructed by the U. S. Bureau of Reclamation along Ligurta Wash and widening of the highway bridge across Fortuna Wash by the Arizona State Highway Department have provided control of floodwaters along these two tributaries of the Gila River.

20. Table 12 shows monetary estimates of damages that would result from (a) the occurrences of various size floods between Texas Hill and the Gila siphon, and (b) the various prolonged releases from Painted Rock Reservoir. Developed areas subject to overflow between Texas Hill and the Gila siphon are predominately agricultural. Expensive agricultural lands are serviced by an extensive irrigation distribution system valued at $43,500,000 (including electrical facilities). A major drainage system estimated to cost about $12,500,000 is under construction. Much of these two systems is subject to overflow. About 21,500 cultivated acres would be subject to overflow from the largest scheduled releases from Painted Rock Reservoir. In addition, such releases could seriously damage the Gila main canal and the Wellton-Mohawk canal so that 72,000 acres lying outside of the overflow area would be subject to interruption of irrigation. About 27 miles of major canals, 2 pumping plants, the Gila siphon, 145 miles of concrete-lined laterals, 72 miles of main canal in the drainage system, 33 miles of collector drains, and other drainage facilities such as sumps, wells, and other siphons are in the overflow area. A few residences, some small commercial and industrial properties, several miles of roads and highways, and some utility lines are also in the overflow area. The improvements are in general distributed throughout the overflow area.

21. Upstream regulation.--Although numerous reservoirs exist upstream of Painted Rock Dam, only eight of them (see table 1 for a tabulation of pertinent data for these reservoirs and plate 1 for their locations) exert any appreciable control on floodflows.

These reservoirs were constructed for irrigation or irrigation and power and have a combined usable storage space below effective spillway crests of 3,446,100 acre-feet. They intercept runoff from an area of 26,742 square miles, which is about 53 percent of the total drainage area above Painted Rock Dam.

22. Hydrologic basis of design.--Determination of the spillway crest elevation was made by routing the reservoir design flood through the reservoir assuming net storage available. At the beginning of the routing, it was assumed that the reservoir was empty (elevation 530). Flood-control operation plan B was used. A maximum water-surface elevation of 660.5 feet was reached and, on this basis, the spillway crest elevation was set at 661.0 feet.

23. The reservoir design flood for Painted Rock Reservoir was based on the 14-21 January 1916 storm, the greatest of record in the area. This storm was transposed to effect the most critical amounts of rainfall over the drainage area above Painted Rock Reservoir. A 6-hour period was selected as the smallest time interval for which information on rainfall intensities would be required in developing the standard project flood. Based on rainfall-runoff studies for the area, average effective rainfall percentages ranging from 25 to 35 percent of the total rainfall were used for the various subareas. These percentages were assumed to include adequate allowances for snowmelt and base flow. The reservoir design flood has an inflow peak of 300,000 cubic feet per second and a maximum 8-day volume of 2,490,000 acre-feet.

24. The top of the dam was determined by routing the spillway design flood through the reservoir. At the beginning of the routing, it was assumed that the reservoir water-surface elevation was at spillway crest and the outlets were discharging at full capacity. A maximum water-surface elevation of 696.3 was reached and using the computed freeboard of 8.7 feet (based on possible wind set-up, wave height and ride-up) the top of the dam was set at elevation 705.0.

25. The spillway design flood was based on the U. S. Weather Bureau's estimate of maximum possible precipitation and antecedent snowpack over the drainage area above the dam. In general, rainfall for the storm of 14-21 January 1916, transposed over the drainage area, was increased 34 percent and maximum snow depths of record were used. Snowmelt was computed in conformance with principles and procedures developed under Civil Works Investigation Project CW-171 by the Snow Investigations Unit, North Pacific Division, Portland, Oreg. Loss rates of 0.10 inch per hour or 0.15 inch per hour were used except when the rain and snowmelt for a 6-hour period was less than 0.667 inch and 1.0 inch, respectively;

loss rates equal to 90 percent of the rain plus snowmelt for the period were then used. Base flow for the drainage subareas varied from 0.39 to 4.56 cubic feet per second per square mile and was derived from a study of peak base flows in the Gila River basin and southern California. The spillway design flood has an inflow peak of 620,000 cubic feet per second and a total 18-day volume of 7,680,000 acre-feet.

26. The storage volume alloted for sediment was determined after a study of the drainage area, the mean annual runoff at the site, and silt accumulation rates in existing reservoirs in southwestern United States. From this study, it was estimated that 200,000 acre-feet of sediment would be deposited in the reservoir during a 50-year period. The distribution of the sedimentation deposit was in accordance with a study based on frequency of flooding.

27. Description of the project.--Painted Rock Dam is an earth (rolled-fill) embankment with a crest length of 4,780 feet (excluding saddle dikes and spillway) and a crest width of 20 feet. The top of the dam (elevation 705) is 181 feet above the original streambed at the centerline of the dam. The upstream slope of the embankment is 1 on $2\frac{1}{4}$ to elevation 651 and 1 on 2-3/4 from elevation 651 to 705 (top of dam). The downstream slope is 1 on 2. The general plan of the embankment; and the profile, sections, and details for the embankment are shown on plates 10 and 11, respectively.

28. The reservoir formed by Painted Rock Dam has an area and gross capacity at spillway crest (elevation 661) of 53,200 acres and 2,491,700 acre-feet, respectively; at the top of the dam (elevation 705) the area is 90,100 acres and the capacity is 5,575,000 acre-feet. Area and capacity curves are shown on plate 12 and a tabulation of areas and gross capacities is given in table 13. With the water surface at spillway crest, the reservoir would be approximately 24 miles long with an average width of 3.5 miles.

29. The outlet works located in the right abutment consist of an approach channel, a gated intake structure, a transition section joining the intake to an outlet conduit, an outlet conduit, and an exit channel. The approach channel is an unlined trapezoidal section approximately 150 feet in length with a base width of 67 feet. The intake structure consists of three gated passages each 10 feet wide by 18 feet high controlled by hydraulically operated Tainter gates. The Arizona Public Service Company supplies 480-volt power to a $7\frac{1}{2}$ horsepower motor connected to a pump that generates hydraulic pressure for operating the gates. An identical motor and pump serves as a standby unit. In case commercial power fails, a diesel-electric generator is

available. The gates are operated one at a time with a speed of approximately 1 foot per minute. The three gates passages are connected to an outlet conduit by a 123-foot transition. The 25-foot-diameter, reinforced, concrete-lined outlet conduit is 925 feet long. It discharges into an unlined trapezoidal rock channel 330 feet long. The plan and profile of the outlet works are shown on plate 13 and the intake structure is shown on plate 14. Outlet discharge curves are shown on plate 15.

30. A detached broad-crested spillway is located 600 feet beyond the right abutment. It is 610 feet long and its crest elevation is 661.0. It has a trapezoidal cross section with side slopes of 1 vertical on 1/2 horizontal. The invert and side slopes of the spillway are lined with concrete from 25 feet upstream to 60 feet downstream of the crest with a cutoff wall at each end. The side slopes are paved to a height of 47 feet. The spillway channel empties into a small canyon which enters the Gila River about 800 feet below the downstream toe of the embankment. The spillway plan and the profile, sections, and details are shown on plates 16 and 17, respectively. A spillway discharge curve is shown on plate 18.

31. Hydrologic facilities.--Hydrologic facilities at and in the vicinity of the dam consist of (a) a recording rain gage at the dam tender's residence; (b) a glass-tube rain gage at the control house; (c) an outflow-gaging station located about a mile below the dam (see pl. 19 for the rating curve), which is equipped with a battery powered "Telemark" connected to the control house by landline; (d) staff gages to measure water-surface elevations located at the outflow-gaging station, the borrow pit below the dam, and the upstream face of the dam; (e) a reservoir water-surface elevation recorder in the control house; and (f) an automatic recorder and dial indicator, located in the control house, which records and indicates the operation of each gate.

32. Collection of hydrologic data.--In addition to hydrologic data from facilities at and in the vicinity of the dam, locations of other places in the drainage area from which hydrologic information is received are shown on plate 4. A brief description of this information is given in the following subparagraphs.

(a) Gage heights will be received at Painted Rock Dam from the existing stream-gaging stations on the Gila River near Dome and on the Gila River below Gillespie Dam. These stations are equipped with radio "Telemarks" for the transmission of reports. Information on flows in the lower Colorado River will be obtained from the gaging station on the Colorado River below Cibola through the U. S. Bureau of Reclamation, and the station at Yuma, through the U. S. Geological Survey. Pertinent rating curves are shown on

plates 20 through 23. The curves for the Dome, Cibola and Yuma stations are subject to change because of unstable streambed. The curve for the Gillespie Dam station is reasonably firm.

(b) Weather forecasts, severe weather reports, and precipitation reports are collected at the Corps' Arizona office by telephone from the U. S. Weather Bureau office in Phoenix and relayed to Painted Rock Dam by radio. The precipitation reports are for Tucson, Flagstaff, Yuma, Ajo, Phoenix, Show Low, Clifton, Payson, Wickenburg, Prescott, and Jerome, Ariz., and Cliff, N. Mex.

(c) Hydraulic data and precipitation reports for Lake Pleasant Dam are received from Maricopa County Municipal Water Conservation District No. 1 in Beardsley, Ariz., by telephone at the Arizona office and relayed to Painted Rock Dam by radio.

(d) Hydraulic data and precipitation reports for the Salt River system (Roosevelt, Horse Mesa, Mormon Flat, and Stewart Mountain Dams) and the Verde River system (Horseshoe and Bartlett Dams), plus streamflow data for the Salt River near Roosevelt and the Verde River below Tangle Creek are collected from the Salt River Valley Water Users Association in Phoenix by telephone at the Arizona office and relayed to Painted Rock Dam by radio.

(e) Hydraulic data and precipitation reports for Coolidge Dam and Ashurst-Hyden diversion dam are received by radio at the Arizona office from the U. S. Bureau of Indian Affairs, San Carlos project, Coolidge, Ariz. This information is then relayed to Painted Rock Dam by radio.

(f) Hydraulic data and precipitation reports for Parker and Imperial Dams, and discharges for the Bill Williams River near Alamo and the Colorado River below Cibola will be received by radio at Painted Rock Dam from the U. S. Bureau of Reclamation station at Imperial Dam.

(g) Information on snow cover and water equivalent of snow is obtained from publications of the U. S. Soil Conservation Service office in Phoenix, Ariz. If necessary, the Corps' Arizona office can telephone the Soil Conservation Service office and relay pertinent information to Painted Rock Dam by radio. Data for snow courses in and near the Gila River basin are shown in table 14.

(h) Assistance in obtaining special streamflow reports or records of streamflow or reservoir data in the Gila River basin or lower Colorado River basin is obtained by telephone from the U. S. Geological Survey office in Tucson.

33. Communication facilities.--The communication facilities at Painted Rock Reservoir are described in the following subparagraphs.

(a) Commercial telephones are installed in the control house, at the dam tenders' residence, and in the project office.

(b) A 100-watt single sideband AM radio transceiver is installed in the control house. This radio is used for communication with the Los Angeles District Office, the Los Angeles District Maintenance Yard, and the Arizona office.

(c) A 50-watt AM radio transceiver is installed in the project office. This radio is used as a standby for the 100-watt single sideband transceiver. In addition, it will be used to exchange hydrologic data with the U. S. Bureau of Reclamation station at Imperial Dam, Calif.-Ariz.

34. Sedimentation measurements.--An aerial survey of the reservoir area was completed in March 1953. This survey was the basis used in computing the reservoir capacity and area curves. A series of index ranges have been established, consisting of Category A sediment ranges in the reservoir and Category C ranges below the dam as a means of observing channel changes. These ranges are shown on plate 24. They will be resurveyed after every major flood or approximately every 10 years if no major flood has occurred. A resurvey of the reservoir will be made as required based on information obtained from resurveys of the range lines within the reservoir.

35. Diversion structures.--No diversion structures were constructed by the Corps of Engineers in connection with the Painted Rock Reservoir project.

36. Downstream channel.--The Gila River channel from Painted Rock Dam to Texas Hill is, in general, in poor condition because no floodflows have occurred for many years. The streambed is filled with sediment and overgrown with brush, small trees, and other vegetation in many places. In fact, along some sections of the river, no definite channel is evident. Immediately downstream from the dam, a lake formed in the borrow-pit area is used for recreational purposes. Below this lake to Texas Hill, very little development of any kind exists and scheduled reservoir releases would cause little if any damages.

37. A map of the Gila River channel from Texas Hill to the Colorado River confluence and the Colorado River from Laguna Dam downstream is shown on plate 3. Existing and proposed levees as well as irrigation and drainage facilities are also depicted. The

district engineer in his "Review Report for Flood Control, Gila River and Tributaries Downstream from Painted Rock Reservoir, Ariz.," dated 1 April 1961, has concluded that a serious flood problem exists along the Gila River from Texas Hill to the Gila siphon and has recommended levee and channel improvements to control a 50,000-cubic-foot-per-second flood at Dome, Ariz. The existing nondamaging channel capacity is about 2,500 cubic feet per second. Areas subject to overflow along the reach below Texas Hill are shown on plate 3. The existing capacity of the Colorado River channel from Laguna Dam to Yuma, Ariz., is about 35,000 cubic feet per second. From Yuma, Ariz., to the international boundary, the channel capacity as improved by the U. S. Bureau of Reclamation, is 140,000 cubic feet per second.

38. This 140,000 cubic feet per second design capacity was agreed upon at a meeting held on 24 September 1948, attended by representatives of the Los Angeles District, Corps of Engineers, the U. S. section of the International Boundary and Water Commission, and the U. S. Bureau of Reclamation. Such capacity would be required to carry the peak discharge from a summer storm similar to that of September 1939, critically centered over the tributary area. Under this condition, releases from both Painted Rock Reservoir and the proposed Alamo Reservoir would be curtailed. If necessary, releases from Painted Rock Reservoir could be discontinued completely during a critical Colorado River flood of this kind.

39. The U. S. Bureau of Reclamation has been authorized to construct levees in Yuma Valley as part of the Colorado River front-works system. The Bureau's plan of improvement provides for levees along the left (east) bank of the Colorado River from Yuma, Ariz., to a point near Laguna Dam with tie-back levees along the Gila River from the mouth to the Gila siphon. The capacities of all these different parts of the overall levee system will be mutually consistent.

40. Under existing conditions prolonged releases from Painted Rock Reservoir of about 5,000 cubic feet per second would breach a critical section of the Wellton-Mohawk canal. Large physical damages would occur to the canal and pumping plants and extensive irrigation service interruptions would occur to the entire Wellton-Mohawk diversion and to the Mesa unit of the Gila project, which are dependent upon an uninterrupted source of irrigation water. These damages would total about $960,000.

41. As previously indicated, releases of 22,500 cubic feet per second would inundate 21,500 cultivated acres and would interrupt irrigation deliveries to 72,000 additional acres. About two-thirds of the monetary damage would relate to the irrigation works

(physical damages and interruption of irrigation). Nearly all of the additional monetary damage would relate to agricultural properties and to drainage facilities. The total damage from release of 22,500 cubic feet per second would amount to $11,110,000 (1959 price levels).

42. Changes to authorized plan.--The primary ways in which the final project plan presented in this report differs from the plan approved by Congress are given in the following subparagraphs.

(a) The top of the dam was raised from elevation 698 to 705 and the length increased from 4,710 feet to 4,780 feet. This change increased the storage capacity at the top of the dam from 5,200,000 acre-feet to 5,575,000 acre-feet.

(b) The spillway design was changed from two detached broadcrested spillways, each 525 feet long with crests at elevation 660, to a single detached broadcrested spillway, 610 feet long with crest elevation 661. The storage capacity at spillway crest changed from 2,480,000 acre-feet to 2,491,700 acre-feet.

(c) The outlet design was changed from twelve 6-foot by 9-foot gated outlets with sill at elevation 540 to three 10-foot by 18-foot gated outlets with sill at elevation 530. The original outlet capacity at spillway crest of 33,400 cubic feet per second was reduced to 30,480 cubic feet per second.

43. Construction history.--Construction of Painted Rock Dam began on 25 July 1957, and closure was made 1 April 1959. The structure was officially completed on 18 January 1960, at a cost of $13,670,000 (excluding cost of lands and severence damages).

44. Development of reservoir area.--As of 30 June 1960, the government had acquired or scheduled for acquisition in fee, 5,205 acres of land within the reservoir taking line. Much of this land is leased out for raising crops or for pasture. On the same date, flowage easements had been acquired or scheduled for acquisition on 51,436 acres of land within the reservoir taking line.

45. The Los Angeles District's Design Memorandum No. 8, titled "Master Plan for Administration and Development of Project Land and Water Areas, Painted Rock Reservoir, Gila River, Ariz.," proposes a plan to develop a game-management area above the dam. This area would include sanitary facilities, game-feeding areas, service roads, and parking areas. Downstream from the dam, a lake of about 412 acres exists in the borrow-pit area. The Arizona Game and Fish Department leases the area covered by the lake from the U. S. Bureau of Land Management. The lease is subject to

flood-operation restrictions imposed by the Corps of Engineers. A boat-launching ramp, sanitary facilities, and swimming area buoys have been installed at the lake. Picnicking areas, grading of beaches, tent and trailer camping areas, parking areas, additional boat-launching ramps, and additional service roads are contemplated. A map of the recreational development plan which also indicates the taking line is shown on plate 25.

PLAN OF OPERATION

46. Operational requirements.--Painted Rock Reservoir is operated for flood control to achieve the following objectives insofar as possible: (a) to provide protection from floods for agricultural lands along the Gila River downstream from the dam, along the lower Colorado River in Arizona and California, and in the Imperial Valley of California; and (b) to provide flood protection to residential, commercial and industrial properties in the city of Yuma and towns of Gadsden and Somerton, Ariz.; to extensive irrigation facilities; to transportation facilities; and to important defense installations.

47. Prior operation plans.--The project document (H. Doc. No. 331) for Painted Rock Reservoir presented a general method of operation based on increasing the outflow in steps to a maximum controlled value of 22,500 cubic feet per second.

48. The operation presented in the report titled "Design Memorandum No. 3, General Design for Painted Rock Reservoir," dated March 1955, required the selection of one of two fixed operation plans, A or B. Under plan A, a debris pool would be developed to elevation 550. Then as the reservoir level rose, the outflow would be increased in steps until a value of 22,500 cubic feet per second was reached at elevation 640. This outflow would be maintained as long as possible, using surcharge storage above spillway crest. Under plan B, a debris pool would be developed to elevation 550 as in plan A. Above this elevation, to protect the outlet conduits from debris, the outlet gates would be regulated so that the openings equalled one-fourth of the reservoir water depth. Under this operation plan, a controlled outflow of 22,500 cubic feet per second would be reached at elevation 600 and maintained as long as possible using surcharge storage above spillway crest. The choice of plan depended on available storage space in upstream reservoirs and predicted flow into Painted Rock Reservoir. Plan A would be used to control small floods to relatively nondamaging discharges. If upstream storage space were limited and a major flood was predicted at Painted Rock Reservoir, operation plan B would be used. This plan of operation would control the reservoir design flood below spillway crest.

49. In the report titled "Design Memorandum No. 6, Dam and Appurtenances for Painted Rock Reservoir," dated November 1956, Painted Rock Reservoir would be operated in accordance with plan B, described in the preceding paragraph. Minor floods would be regulated on a prediction basis so that damage to developments below the dam would be kept to a minimum.

50. Flood-control operation.--The flood-control operation presented in this manual is similar to the operation described in Design Memorandum No. 3. One of two fixed operation plans, A or B, is selected for use depending on available upstream storage and water-surface elevation in Painted Rock Reservoir. Plans A and B are essentially as described under "Prior Operation Plans." The stepped outlet gate operation schedules for these plans are tabulated in tables 15 and 16, respectively.

51. With due regard for any release already in effect, the selection of operation plan A or B is made at the beginning of a flood. Whenever it is not in conflict with conditions resulting from operations for an immediately prior flood, an appropriate operation plan is determined by entering plate 26 with the water-surface elevation in Painted Rock Reservoir and the available storage space in upstream reservoirs. Refer to the note on plate 26 for instructions on the selection of the operation plan. The curves for plans A and B on plate 26 are based on a series of routings through Painted Rock Reservoir. Gross storage was used in these routings and the initial water-surface elevation necessary to control a given flood to spillway crest was calculated. The flood in each case was equal to the reservoir design flood depleted by the storage in upstream reservoirs available to control that flood. A safety factor was integrated into the curves for plans A and B, by assuming 10 percent more storage space would be required in upstream reservoirs than the results of the routings indicated. A form for tabulating the available storage space in upstream reservoirs that can be used to control a reservoir design flood is shown on plate 27. Actual storage and storage capacity of the upstream reservoir system for the period August 1910 through December 1960 are shown on plates 28 and 29.

52. If a flood of reservoir design magnitude should occur, it could be controlled to spillway crest by plan A if the available storage in upstream reservoirs and the water-surface elevation in Painted Rock Reservoir at the beginning of the flood define a point on plate 26 lying to the right of plan A curve. If the point lies between plan A and B curves, plan B can control the flood. If the point lies to the left of plan B curve, the flood cannot be controlled below spillway crest by plan B.

53. If the water surface in Painted Rock Reservoir is at elevation 640.0 feet or lower at the beginning of the spillway design flood, operation plan A or B will control the flood to maximum water-surface elevation 696.3 or lower. However, at a higher initial elevation, the outlets must be fully opened at the time the water surface reaches the elevation shown on plate 30, to control a spillway flood to elevation 696.3. All floods

occurring with initial water-surface elevation at 640.0 or higher will be treated as possible spillway design floods. (This deviation from the fixed operation plan above the spillway crest is required because at the beginning of the spillway design flood routing, it had been assumed that the water surface was at spillway crest, elevation 661.0 and the outlets fully open. The outlet discharge was not transferred above spillway crest as in operation plans A and B.)

54. Operation to reduce flows during downstream floods.--The travel time for releases from Painted Rock Reservoir to the Colorado River is roughly 2 days, which is about equal to the travel time from Parker Dam to the Gila River confluence. Therefore, if floodflows are reported, or are imminent on the Colorado River below Parker Dam, releases from Painted Rock Reservoir can be modified in time to be effective in reducing floods on the Colorado River below the confluence. The criteria for determing whether releases can be reduced, regardless of the time of year, will be determined from plate 26, i.e., it will be permissible to reduce releases if the point on plate 26 defined by available storage in upstream reservoirs and the water-surface elevation in Painted Rock Reservoir lies below the plan B curve. If a flood of reservoir design magnitude should occur above Painted Rock Dam, it would then be controlled to or below spillway crest. In summer, storm conditions may permit reducing the outflow to zero, as indicated in paragraph 68.

55. Conservation operation.--There is no written authority for conservation operation of Painted Rock Reservoir. However, considerable incidental water-conservation benefits result from the flood-control operation of the reservoir. Flood flows are reduced by the stepped operation to releases not exceeding an average discharge of 22,500 cubic feet per second. This operation promotes recharge of the underground basin downstream of the dam.

56. Limitations on storage.--Water cannot legally be stored above the taking line (approx. elevation 661) shown on plate 25. The government has acquired fee title to lands below approximately 585 feet and flowage easements to lands between approximately 585 and 661 feet.

57. Limitation on releases.--Except in floods larger than the reservoir design flood, releases are limited to a maximum average discharge of 22,500 cubic feet per second as shown in the gate operation schedules A and B (tables 15 and 16), which is the rate above which excessive damage occurs.

58. Division of responsibility for operation.--The hydraulic operation of Painted Rock Dam has been delegated through channels

to the Chief, Hydrology and Reservation Regulation Section, Engineering Division. During normal operations, he is assisted by the Reservoir Regulation and Radio Units. The Chief, Reservoir Regulation Unit supervises the Reservoir Regulation and Hydrography Sub Units. The Chief, Reservoir Regulation Sub Unit is responsible for (a) collecting hydraulic data, (b) transmitting operating instructions, (c) investigating and improving operating techniques, (d) keeping the district's "Emergency Flood Control Activities" manual current, (e) preparing reservoir regulation manuals and keeping them current, (f) maintaining prescribed records, and (g) training flood emergency personnel. The Chief, Hydrography Sub Unit is responsible for (a) collecting rainfall and runoff data, (b) maintaining a record of reservoir operation, (c) installing and servicing hydrographic and meteorological instruments, (d) scheduling sedimentation surveys, and (e) preparing reports to higher authority. The Chief, Radio Unit is responsible for (a) maintaining communications and (b) supervising the installation of new radio facilities.

59. During flood emergencies, the normal hydraulic operations organization is greatly expanded and implemented by other district employees who have been trained in their respective flood emergency duties. A Hydraulic Operations Center is established under the supervision of the Chief, Hydrology and Reservoir Regulation Section to supervise the operation of a Control Group, a Hydrography Group, and a Radio Communications Group. The Control Group contains a Flood Prediction Unit for forecasting floodflows and plotting hydraulic and hydrologic data, a Dam Operations Unit to supervise operation of the dams, a Communications Unit to receive data and transmit operating instructions and a River Patrol Unit to observe flow conditions in downstream areas. The Hydrography Group is primarily responsible for obtaining, computing, and recording hydrographic data. The Tucson, Ariz. District Office of the U. S. Geological Survey has agreed to maintain and make necessary stream-gaging measurements for the stations on the Gila River at Gillespie Dam, below Painted Rock Reservoir, and at Dome, Ariz. (records for these stations are published in the U. S. Geological Survey's, "Water Supply Papers"). These measurements are used by the Computing Unit of the Hydrography Group to revise rating curves and tables as required. The Telemark Unit maintains a record of current streamflow reports from the Gila River basin. The Radio Communications Group is responsible for the maintenance and improvement of the district's radio communications system. Reference is made to the district's current "Emergency Flood Control Activities" manual for more detailed information on organization and personnel assignments in the Los Angeles District during flood emergencies.

60. Responsibility for the physical operation of Painted Rock Reservoir has been delegated to the Construction Division.

The duties of the Construction Division include: (a) safeguarding the project at all times, (b) maintaining the project in good working condition, (c) performing routine tests of equipment, (d) operating hydrologic and hydraulic equipment, (e) maintaining records as prescribed by the Hydrology and Reservoir Regulation Section, and (f) keeping informed of the information contained in the reservoir regulation manual.

61. Normal organization.--The organization for effecting operation of Painted Rock Reservoir during normal periods is shown on plate 31. The names and telephone numbers of key personnel are shown on plate 32.

62. Flood-emergency organization.--The organization for effecting operation of Painted Rock Reservoir during flood emergencies is shown on plate 33. The names and telephone numbers of key personnel are shown on plate 34.

63. Instruction to dam tenders.--The dam tender at Painted Rock Reservoir is required to (a) be present at the dam when rainfall or runoff is occurring or furnish the Control Group at the District office a telephone number through which he can be reached; (b) see that all equipment at the reservoir such as recorders, indicating gages, gate mechanisms, power units, radios, etc., is in operating condition; (c) operate gates in accordance with instructions from the Control Group; (d) keep the Control Group notified of any unusual developments such as trash accumulation, power failure, mechanical difficulties, etc.; (e) follow the current fixed-gate operation schedule posted in the control house in the absence of communications with the Control Group and in the absence of a representative from that group; (f) assist engineers dispatched by the Control Group during flood emergencies in every way possible; (g) maintain routine records such as water-surface elevations, outflow gage heights, precipitation amounts, gate openings, and a daily log on prescribed forms; (h) notify local authorities and interested agencies of anticipated releases from the reservoir when instructed to do so by the Control Group or if communications are interrupted; and (i) obtain hydrologic and hydraulic data from other agencies upon request of the Control Group.

64. Modification of regulations.--As previously indicated, the reservoir regulation plans given in the fixed operation schedules, tables 15 and 16, serve as guides for personnel operating Painted Rock Dam during flood conditions. These schedules represent the best methods of operation to control a reservoir design flood under given initial conditions of water-surface elevation in Painted Rock Reservoir and storage in upstream reservoirs. Deviation from the fixed operation schedule may be desirable, if

there is high confidence in the prediction of inflow into the reservoir, to prevent or reduce flooding in the following areas: (a) along the Gila River downstream from Painted Rock Dam; (b) along the Colorado River between Laguna Dam and Mexico; and (c) in Imperial Valley, Calif. (flooding possible if the levees in Mexico are breached). Further, if a spillway design flood occurs with the initial reservoir water-surface elevation above 640, it will be necessary to deviate from the fixed operation schedule to control the flood to maximum water-surface elevation 696.3.

65. Deviation from the fixed schedule of operation will normally be made only by responsible persons in the District office. In the event of communications failure, the engineer dispatched from the District office will assume responsibility for deviation from the fixed schedule. Only under extreme emergency, involving imminent levee failure, severe property damage, or possible loss of lives, should the reservoir outflow be throttled or stopped. As soon as the emergency is over, the gates should be slowly opened to agree with the fixed schedule.

66. Other agencies' connection with the operation.--A list of agencies together with a brief explanation of their connection with the operation of Painted Rock Reservoir is given in the following subparagraphs.

(a) U. S. Weather Bureau Airport Station, Phoenix, Ariz.--The Phoenix Weather Bureau office is the River District office for the Colorado River and tributaries from the Colorado River above the mouth of the San Juan River to the Arizona-Mexico border. Flood conditions, weather forecasts, and precipitation reports for the Gila River basin are telephoned to the Corps of Engineers' office in Phoenix. These reports are then relayed by radio to Painted Rock Dam.

(b) U. S. Geological Survey, District Office, Tucson, Ariz.--Current records of streamflow and reservoir storage for the lower Colorado River and Gila River basins are filed in the District office at Tucson, Ariz., and are available to the Los Angeles District.

(c) U. S. Bureau of Reclamation, Region 3, Boulder City, Nev.--Hydraulic and hydrologic data for the lower Colorado River basin are available in the U. S. Bureau of Reclamation's Boulder City office. This information will be relayed by radio to Painted Rock Dam through the Bureau's station at Imperial Dam. The Bureau of Reclamation is responsible for operation of the lower Colorado River system and for flood protective works on the main stem of the river.

(d) U. S. Soil Conservation Service Office, Phoenix, Ariz.--Current data on snow cover in the Gila River basin are available from the Soil Conservation Service office in Phoenix.

(e) U. S. Bureau of Indian Affairs, San Carlos project, Coolidge, Ariz.--Coolidge Dam and Ashurst-Hayden diversion dam are operated by the U. S. Bureau of Indian Affairs. The Corps of Engineers has installed a radio in the Coolidge office so that hydraulic and hydrologic data can be quickly relayed to Painted Rock Dam through the Corps' Arizona office.

(f) U. S. International Boundary and Water Commission, El Paso, Tex.--The International Boundary and Water Commission is interested in the operation of Painted Rock Reservoir because of the Commission's responsibilities relating to the 1944 Water Treaty with Mexico.

(g) Arizona Game and Fish Department, Phoenix, Ariz.--The Arizona Game and Fish Department is interested in maintaining the lake in the borrow pit below Painted Rock Dam as a recreation area. Any operation affecting the level of the lake is of interest to the Department.

(h) Salt River Valley Water Users Association, Phoenix, Ariz.--The Salt River Valley Water Users Association operates the Salt River system consisting of Roosevelt, Horse Mesa, Mormon Flat and Stewart Mountain Dams; and the Verde River system consisting of Horseshoe and Bartlett Dams. Hydraulic and hydrologic data for these reservoirs are available to the Los Angeles District upon request.

(i) Maricopa County Municipal Water Conservation District No. 1, Beardsley, Ariz.--Hydraulic and climatologic data for Carl Pleasant Dam are available from Maricopa County Municipal Water Conservation District No. 1, the agency that operates the dam.

67. Coordination with other projects.--The operation of Painted Rock Reservoir is closely coordinated with the operation of dams on the Colorado River. Furthermore, the choice of operation plans for the reservoir is determined by the available storage space in reservoirs upstream from Painted Rock Reservoir.

68. It is particularly important to operate Painted Rock Reservoir for the reduction of flood peaks on the lower Colorado River so that the present capacity of the channel from the Yuma levees to the confluence with the Gila River (35,000 c.f.s.) will not be exceeded. All flood releases are therefore carefully coordinated with releases from reservoirs operated by the U. S. Bureau of Reclamation, the agency responsible for flood protective works on

the main stem of the Colorado River. The U. S. Bureau of Reclamation's Wellton-Mohawk Irrigation project located on the lower Gila River flood plain is subject to floods originating below Painted Rock Reservoir. If such a flood occurs, every effort will be made to reduce or cut off releases from the reservoir to minimize damages. During the occurrence of a summer flood it is possible to withhold releases until the downstream peak has passed because the reservoir design flood was based on a winter storm which is more critical than a summer storm.

69. Additional information relating to coordination of the operation of Painted Rock Reservoir with other projects can be found in this manual under the following subjects: "Upstream Regulation," "Hydrologic Facilities," "Communication Facilities," "Flood-Control Operation," and "Other Agencies' Connection with the Operation."

70. Examples of regulation.--The flood of 14-21 January 1916 (modified to reflect present upstream conditions), the reservoir design (standard project) flood, and the spillway design (maximum probable) flood were routed through Painted Rock Reservoir to test the adequacy of the flood operation plan. These routings are shown on plates 35 through 38, respectively. A tabulation of pertinent data pertaining to the routings is given in table 17. Net storage was assumed available in Painted Rock Reservoir at the beginning of each routing.

71. The flood of 14-21 January 1916, was the largest of record above Painted Rock Reservoir. A routing of this flood, modified to reflect present upstream conditions, is shown on plate 35. Assuming the reservoir empty at the beginning of the routing and using operation plan A, the peak inflow of 195,000 cubic feet per second is reduced to a maximum average outflow of 22,500 cubic feet per second and a maximum water-surface elevation of 657.4 feet is reached.

72. The reservoir design flood routing under operation plan B is shown on plate 36. Assuming the reservoir empty at the beginning of the routing, the peak inflow of 300,000 cubic feet per second is reduced to a maximum average outflow of 22,500 cubic feet per second and a maximum water-surface elevation of 660.5 feet is reached.

73. The spillway design flood routing, assuming the reservoir full to spillway crest and outlet gates fully open at the beginning of the routing, is shown on plate 37. The peak inflow of 620,000 cubic feet per second is reduced to a peak outflow of 436,500 cubic feet per second and a maximum water-surface elevation of 696.3 feet is reached.

74. The spillway design flood routing, assuming the reservoir full to elevation 640 at the beginning of the routing and using fixed operation plan A or B (identical above elevation 640) is shown on plate 38. The peak inflow of 620,000 cubic feet per second is reduced to a peak outflow of 404,000 cubic feet per second and a maximum water-surface elevation of 696.3 is reached.

75. Filling frequency.--A filling frequency curve for Painted Rock Reservoir is shown on plate 39. In deriving this curve, floods of record were routed through the reservoir using stepped operation plan A (table 15) and assuming net capacity available.

76. Operation reports.--The dam tender at Painted Rock Reservoir reports by radio to the Hydrology and Reservoir Regulation Section at 0900 hours Pacific Standard time each workday or as requested. During storms, reports are received more often. The hydraulic data reported for Painted Rock Reservoir is entered by the dam tender on the form shown on plate 40, and the rainfall data on the form on plate 41. The original records are forwarded to the Hydrology and Reservoir Regulation Section immediately following the end of the month. The data reported by radio are tabulated by the Hydrology and Reservoir Regulation Section's Reservoir Regulation Unit on the form shown on plate 42 and hydraulic information is transferred to the form on plate 43 for computation. Information from other locations in the Gila River basin, used in the operation of Painted Rock Reservoir, is recorded on the form shown on plate 44. The locations of dams, stream-gaging stations, precipitation stations, and snowfall courses from which data are obtained are shown on plate 4.

77. Operation record.--The operation record and rainfall records for Painted Rock Reservoir are maintained in the Hydrology and Reservoir Regulation Section files. A record of operation is submitted to the Division Engineer and to the Chief of Engineers each month, using the form on plate 45. This record is submitted by the 15th of each month and contains data for the preceding month.

78. Daily flows at the following selected gaging stations pertinent to the operation of Painted Rock Reservoir are published annually in the "United States Geological Survey Water Supply Papers:" (a) Gila River below Gillespie Dam, (b) Gila River below Painted Rock Dam, and (c) Gila River near Dome. Daily rainfall records for Painted Rock Dam and for other precipitation stations in the Gila River basin are published in the U. S. Weather Bureau's monthly publication titled "Climatological Data."

79. Weather forecasts.--A daily weather forecast for the Gila River basin is received from the U. S. Weather Bureau Forecast

Center at the International Airport in Los Angeles. The forecast, which is especially prepared for flood control use and contains predictions of precipitation amounts, is transmitted over a teletype circuit to the Control Center in the District office. Revised forecasts and special storm warnings are issued when necessary.

80. An automatic weather chart recorder is installed in the Control Center to supplement the service received from the local Weather Bureau office. The following weather information is normally received from Suitland, Md., over the National Weather Facsimile network: (a) current surface chart, (b) prognostic surface chart, (c) winds aloft plot, (d) temperature data, (e) rainfall amounts, and (f) snow cover depth.

81. Additional weather information is obtained from the U. S. Weather Bureau station at Sky Harbor Airport, Phoenix, Ariz. This information is collected over the telephone by the Corps of Engineers' Arizona office and relayed by radio directly to the Los Angeles District office or through Painted Rock Dam.

82. Flood predicition.--At the present time, no very detailed prediction method has been developed for the drainage area above Painted Rock Reservoir. The problem is complicated by the large area involved (50,800 sq. miles), the many flood-control structures in the area, the difficulties in predicting rainfall amounts, and the varying influence of snow cover. However, a good idea of the magnitude and extent of storms in the area can be obtained from weather forecasts and hydrologic data obtained during storm periods (see par. 32). Thus a fair estimate of flood magnitude can be made. Approximate travel times between important points in the Gila River basin for a storm of standard project flood magnitude are given in table 18.

83. Studies in progress or planned.--In order to improve reservoir regulation techniques, this office plans to (a) investigate the affects of snow cover and antecedent rainfall on runoff so that general limitations on the size of a possible flood can be established, and (b) develop methods for using the district's electronic computer in flood routing and flood prediction studies, thereby providing a rapid method of integrating the operation of Painted Rock Reservoir with upstream reservoir systems, and downstream developments.