R E S E R V O I R   R E G U L A T I O N   M A N U A L

FOR

MOJAVE RIVER DAM

MOJAVE RIVER BASIN, CALIF.

AUTHORITY

1. The authority for preparation of this manual is contained in ER 1110-2-240. Detailed instructions pertaining to the contents of the manual are contained in EM 1110-2-3600.

SCOPE

2. This manual contains (a) descriptive information pertaining to the project and its drainage area; (b) a description of the plan of operation; and (c) the basis of design for the project, including the reservoir design and spillway design flood routings.

BASIN INFORMATION

3. PHYSIOGRAPHIC CHRACTERISTICS. The Mojave River basin, which, in its entirety, comprises about 4,700 square miles, lies on the northern side of the rugged and precipitous San Bernardino Mountains (see pl. 1). Ninety-five percent of the entire Mojave River drainage area is desert, consisting primarily of alluvial plains sloping away from scattered, irregular, sharp-crested hills and mountains. The Mojave River Dam's drainage area consists of 215 mountainous square miles. This area is drained by 2 main tributaries, Deep Creek and West Fork Mojave River, which converge at the base of the San Bernardino Mountains to form the Mojave River. Nearly all the surface runoff that reaches the Mojave River is contributed by this relatively small area. The drainage area of Deep Creek comprises about 140 square miles. Elevations in the area range from more than 8,300 feet at Crafts Peak to about 3,000 feet at the mouth, while the average elevation of the area is about 5,800 feet. The main channel flows through a narrow canyon with an average gradient of 185 feet per mile. The drainage area of the West Fork Mojave River comprises about 75 square miles. Elevations in this area range from more than 6,100 feet at Strawberry Peak to about 3,000 feet at the mouth, with an average elevation of about 4,000 feet. The average gradient of the channel is 195 feet per mile. The upper reaches are very steep while the lower reaches are in a broad, relatively flat valley.

a. Geology. The mountainous headwaters of the Mojave River basin are composed, chiefly, of crystalline rock consisting of metamorphic rocks of both igneous and sedimentary origin. The mountain soil mantle is shallow (varying from 2 to 10 feet, with occasional large areas of rock outcrops), low in organic content, and well leached of soluble salts.

b. Vegetation. The vegetal cover of the mountain drainage area is segregated into zones, which are characterized by elevation and the precipitation distribution within the area. The plant associations found in the Mojave River drainage area, in order of increasing elevation are desert shrubs, desert woodland, chaparral and the yellow pine forest.

4. ECONOMIC DEVELOPMENT. The Mojave River Dam provides protection to essentially the entire downstream length of the Mojave River. Plates 2 through 6 identify the 44,200 acre overflow area of the standard project (reservoir design) flood prior to the construction of the dam. The potential value of damage that would be caused by this flood calculated to be $12,310,000 in 1965. Furthermore, the total value of property subject to inundation by this flood was estimated to be $65,800,000 in 1965. Most damage would occur to agricultural, military, and railroad property; however, considerable damage would also occur to highway, residential, business and industrial improvements. Nearly all damage in the overflow area would be prevented by the dam. The remaining damage would be due to downstream tributary inflows. The economic analysis of the project found in the "Design Memorandum No. 2, General Design for Mojave River Forks Reservoir" dated October 1966 indicates that this is a well-justified project with a benefit-cost ratio of 1.3 to 1.

5. EXISTING STRUCTURE AFFECTING RUNOFF. No other flood-control reservoirs are in the drainage area of the Mojave River Dam. Lake Arrowhead and Lake Gregory, with a combined drainage area of only 9.1 square miles, are both used almost exclusively for recreation. The Cedar Springs Dam and its associated Silverwood Lake are part of the California Aqueduct operated by the State of California Department of Water Resources and are used both for water supply and recreation. The drainage area tributary to the reservoir is 34.3 square miles, and the capacity of the reservoir is approximately 200,000 acre-feet at spillway crest. None of these reservoirs make any significant contribution to flood control.

6. CLIMATOLOGY. Climatic conditions (particularly temperature and precipitation) in the basin generally vary with elevation. Average annual temperatures vary inversely with elevation from 63°F in the desert (with extremes of 12° and 114°) to 51°F in the mountains (with extremes of -7° to 99°). Mean seasonal precipitation, however,

varies directly with elevation ranging from about 12 inches at the damsite to about 55 inches in the vicinity of Strawberry Peak (see pl. 7). Approximately 85 percent of this precipitation occurs during the months of December through March. Snowfall is common during the winter months above 5,000 feet. Here snow accumulates to depths great enough that the melt will slightly increase stream runoff. However, this does not substantially increase the peak flows. Summaries of pertinent data for three selected climatological stations are given in tables 1, 2 and 3. Most precipitation in the drainage area results from general winter storms that are associated with extratropical cyclones of North Pacific origin areas. Such storms commonly result in precipitation over large areas. Major storms that consist of one or more cyclonic disturbances occasionally last 4 days or more. Rainfall intensity and depth are usually greater in the mountains, because there, under most meteorological conditions, the moisture-laden air masses are deflected upwards, causing them to release much of their moisture as rain. Since the major winter storms release the greater part of their moisture in passing over the San Bernardino Mountains, winter rainfall intensities in the desert area are moderate. During major storms rainfall rates of flood-producing magnitude have extended over periods ranging from a few hours to about 2 days. These storms have resulted in the greatest floods of record. Thunderstorms, which may result in intense precipitation over areas of approximately 200 square miles or less occur occasionally, either in association with general storms or independently. Such storms seldom have a period of intense precipitation lasting longer than 2 or 3 hours. During the summer months, rainfall associated with tropical cyclones has occurred in this region, but such occurrences are infrequent and relatively unimportant in the flood history of the drainage area.

7. RUNOFF. Flow in Deep Creek is perennial while flow in the West Fork Mojave River is intermittent. During heavy storms, especially those occurring soon after other storms, the streamflow increases rapidly in response to rainfall. The shallow surface soils, impervious bedrock, fan-shaped collecting system, and steep gradients are also important factors in producing high runoff rates and rapid concentration of floodwaters. Runoff records for Deep Creek and West Fork Mojave River are contained in tables 4 and 5, respectively.

8. FLOODS. The largest floods that have occurred during the period for which runoff records are available (1904 to date), occurred in January 1910, January 1916, December 1921, March 1938, January 1943, January 1969, and February 1969. These floods resulted from storms of the general winter type. Summer floods,

usually caused by local storms of small areal extent, but occasionally by storms covering the whole basin, occur infrequently in the area.

9. FLOOD DAMAGES. The estimated damages from the march 1938 flood, which had a peak discharge of about 73,000 cubic feet per second on the main stream just below the junction of Deep Creek and the West Fork Mojave River, are estimated at $2,184,000. The January 1943 flood of 42,000 cubic feet per second caused damages of $204,000. Theses values have not been converted to present prices.

10. DOWNSTREAM CHANNEL. The San Bernardino County Flood Control District has given assurance to the Corps of Engineers that it will maintain a minimum channel capacity of 23,500 cfs (cubic feet per second) through improved areas downstream from the dam. Therefore, the reservoir design flood peak outflow of 23,500 cfs would not overflow the river in the improved areas. In addition, San Bernardino County is currently (1974) in the process of designating a floodway along the entire length of the Mojave River. The floodway is the natural channel of the river and that part of the adjoining flood plain used to carry a flood flow of 30,000 cfs or less. The floodway design flow is based on the 23,500 cfs release from the dam plus downstream tributary inflow. The floodway boundary is controlled by county zoning ordinances. Development is not permitted to encroach into the floodway. Some undeveloped lowlands adjacent to the floodway are subject to inundation by peak flows. Zoning ordinances require that future development in these areas be protected from the floodway design flow. At present the floodway has been established for the reach extending 63 miles downstream from the Mojave River Dam. Plates 2 through 6 illustrate the established floodway alignment. These plates also identify the area that was expected to be inundated by the reservoir design flood before the dam was constructed. The reach of the Mojave River extending 63 miles downstream from the dam has been studied in two Corps of Engineers flood plain information reports entitled "Mojave River (Vicinity of Barstow) San Bernardino County California, October 1968" and "Mojave River (Vicinity of Victorville) San Bernardino County California, April 1969." Both of these reports consider the effects of the Mojave River Dam related to the potential overflow areas and profiles of the standard project and intermediate regional (100-year-frequency) floods. Table 7 presents travel times for the peak reservoir design flood outflow to reach downstream points of interest.

PROJECT INFORMATION

11. AUTHORIZATION. The Mojave River Dam was authorized by act of Congress, Flood Control Act of 1960, Public Law 86-645, 86th Congress, 2d Session, approved 14 July 1960.

12. CONSTRUCTION HISTORY. Construction of Mojave River Dam began in March 1968. Work was completed in May 1971. The cost of the project through FY 71, not including expenditures by the local interests, was $15,667,800.

13. PURPOSE. The purpose of the project is to provide protection against floods to lands and improvements and public-access facilities. The property protected includes cultivated lands; industrial, residential and commercial property; utilities; highways; and railroads. The property protected extends about 125 miles along the Mojave River from the base of the San Bernardino Mountains to Silver Lake near Baker, California.

14. RELATIONSHIP TO COORDINATED PLAN OF DEVELOPMENT FOR THE BASIN. Consideration was given to both initial and ultimate development of public-access areas at the Mojave River Dam. The initial development provides facilities for camping, riding, hiking and picnicking, plus trailers and support facilities. The ultimate phase of public-access development will be provided by the recreation lessee. This will include facilities such as a golf course, shooting ranges, natural areas, and fishing areas.

15. DESCRIPTION. The project consists of Mojave River Dam and Flood-Control Basin on the Mojave River near Hesperia in San Bernardino County, California. A general plan of the project is shown on pl. 8, and a detailed description is contained in the following paragraphs.

16. DAM. The dam is a zoned, rolled-earthfill structure with a crest length of 2,223 feet, and a crest width of 20 feet. The top of the dam is at elevation 3,172. The maximum height above the original streambed is 200 feet. The slope of the upstream side of the embankment is 1 vertical on 2.5 horizontal, and the face is covered with an 18 inch layer of protective stone, while the downstream face has a slope of 1 vertical on 2.2 horizontal with a 12 inch layer of protective stone. Typical embankment sections are shown on pl. 9.

17. SADDLE DIKE. The saddle dike is also a zoned, rolled-earthfill structure with a crest length of 1,255 feet. Its elevation and crest width are the same as those of the dam structure. The slopes of both the upstream and downstream faces of the saddle dike are the same as those of the dam, but the upstream face has a 36 inch layer of protective stone while the layer on the downstream face remains at 12 inches. Typical saddle dike sections are shown on pl. 10.

18. OUTLET WORKS. The outlet works are located in the left abutment of the dam and consist of an approach channel with log rack, an ungated lined tunnel and an outlet channel. The plan, profile, and sections

of the outlet works are shown on pl. 11, and the outlet discharge curve is shown on pl. 12. A general description of the outlet works is contained in the following subparagraphs.

a. Approach Channel. The approach channel is 32 feet wide and about 160 feet long. It consists of about 60 feet of unlined trapezoidal channel, 100 feet of reinforced-concrete trapezoidal channel, and a steel log rack with 9-by-11.83-foot openings.

b. Tunnel. The tunnel is concrete lined and 974 feet long. The tunnel cross-section is 17.75 feet high by 19 feet wide with a semicircular roof of 9.5 foot radius. There is a 2.5 foot radius fillet at each right-angle corner of the cross-section. The invert elevation of the tunnel is 2,988 feet at the inlet portal and 2,967 feet at the outlet portal.

c. Outlet Channel. The outlet channel is 19 feet wide and about 128 feet long. It consists of 28 feet of reinforced-concrete rectangular channel (including flip bucket and cutoff walls at downstream end) and about 100 feet of unlined trapezoidal channel.

19. SPILLWAY. A detached, broad crested spillway (see pl. 13), with a crest elevation of 3,134 feet, and a crest width of 200 feet is located on the right abutment of the dam. The spillway channel is a reinforced concrete rectangular section founded in rock. The spillway discharge curve is shown on pl. 14.

20. RESERVOIR. The reservoir formed by Mojave River Dam has an area and gross capacity at spillway crest (elevation 3,134) of 1,980 acres and 89,700 acre-feet, respectively. At the maximum water surface (elevation 3,165.4) the area is 3,135 acres and the gross capacity is 179,400 acre-feet. There is an 11,000 acre-foot allowance for sediment below spillway crest. Area and capacity curves are shown on pl. 15, and a tabulation of areas and capacities is given in table 6.

21. BASIS FOR DESIGN. The Mojave River Dam and appurtenances were designed to: control the reservoir design flood, provide storage for sedimentation, and effectively covey the spillway design flood without endangering the dam. The establishment of the spillway crest and top of the dam elevations is described in "General Design Memorandum No. 2 for Mojave River Forks Reservoir" dated 1966. The development of the design floods and sediment volume appear in Appendix 2 of the report. The following subparagraphs briefly describe the design criteria.

a. Reservoir Design Flood. The reservoir design flood is expected to occur from the most severe combination of meteorologic and hydrologic conditions that are reasonably characteristic of the geographical area. The storm of 21-24 January 1943 was used to synthesize this flood. The reservoir design flood was computed using a total precipitation over the drainage area of 23 inches and precipitation-loss rates that are variable with time. The loss rate was assumed to average 0.25 inches per hour with a minimum rate of 0.15 inches per hour. The effective rainfall over the drainage area was 12.2 inches. This rainfall resulted in a flood having a peak discharge of 94,000 cfs and a volume of 154,000 are-feet.

b. Sediment Volume. Part of the reservoir's storage volume was designed to accommodate the total quantity of sediment that would accumulate behind the dam during a 100-year period. Sediment was considered to be contributed by the floods normally expected to occur during this period plus the reservoir design flood. The reservoir was expected to trap 11,000 acre-feet of sediment, which is 60% of the drainage area's total sediment load. The total sediment load was derived on the basis of data collected from other streams and reservoirs in the general area.

c. Spillway Design Flood. The spillway design flood represents a discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The spillway design flood was based on the assumed occurrence of probable maximum precipitation as determined by a method presented in the U.S. Weather Bureau's Hydrometeorological Report No. 36, titled "Interim Report, Probable Maximum Precipitation in California," and dated October 1961. In general, the precipitation-runoff relationships assumed for the reservoir design flood were also assumed applicable for use in developing the spillway design flood, except for precipitation-loss rates and base flow. Ground conditions conducive to maximum runoff were reflected in minimum rainfall-loss rates equal to the minimum rate (0.15" per hour) used for the reservoir design flood. For the spillway design flood, this minimum loss rate was assumed to be constant throughout the storm. The base flow rate during the spillway design flood was assumed constant at the peak rate used for the reservoir design flood, until 12 hours after peak of surface runoff when the same hourly recession factor (0.95) used for the reservoir design flood was applied. The total precipitation over the drainage are was 40.4 inches with an effective precipitation of 29.7 inches. The resultant peak inflow was 186,000 cfs with a total volume of 383,000 acre-feet.

d. Reservoir Design Flood Routing. The spillway crest elevation was determined by routing the reservoir design flood through the reservoir assuming it is dry and contains a 100 years accumulation of sediment at the beginning of the routing. Using set storage, a maximum water-surface elevation 3,133.6 feet was calculated. The peak inflow of 94,000 cfs was reduced to a peak outflow of 23,500 cfs. On this basis, the spillway crest elevation was set a 3,134 feet above mean sea level. See plate 16 for the reservoir design flood routing.

e. Spillway Design Flood Routing. The spillway design flood was routed through the reservoir assuming that the ungated outlet was not blocked by trash. The inflow hydrograph was a combination of the reservoir-design and spillway-design floods with five days between the inflow peaks. A maximum water surface elevation of 3,165.4 feet was calculated. The peak inflow of 186,000 cfs was reduced to a peak outflow of 131,280 cfs. Using a freeboard of 6.6 feet to prevent from overtopping the dam, the elevation of the top of the dam was set at 3,172 feet, NGVD (National Geodetic Vertical Datum). See plate 17 for the spillway design flood routing.

22. RECREATION DEVELOPMENT OF THE RESEROIVR AREA. Initially about 120 acres of land has been used for recreational purposes. This area was designed and constructed by the Corps of Engineers. Ultimate recreational development will include about 2,790 acres. An area used exclusively for flood control operations includes about 460 acres. The initial recreational area is located about one mile upstream of the damsite and above the reservoir area. This area consists of a combined camping and picnic area, trailer camp, equestrian area, administration building and nature interpretation area. San Bernardino County operates and maintains this area under lease arrangement with the Corps of Engineers. The recreation lessee (San Bernardino County) has the added responsibility for future recreational development which is subject to approval by the Corps of Engineers. Plate 18 shows the recreational development plan.

OPERATION

23. RESPONSIBILITY FOR OPERATION. The operation and maintenance of Mojave River Dam is the responsibility of the Los Angles District of the Corps of Engineers. The District Engineer has delegated authority for this function through the Chief, Engineering Division, Chief Hydrology and Hydraulics Branch and Chief, Hydrologic Engineering Section to the chief, Reservoir Regulation Unit. The chain of command for reservoir operations decisions is given on plate 19.

24. FLOOD-CONTROL OPERATION PLAN. Inflows of magnitudes up to and including the reservoir design flood would be controlled by the project, such that peak outflows from the reservoir would be safely carried in the downstream reach of the Mojave River. Inflows would be released from the reservoir through the outlet tunnel. The outlet works do not include any mechanical equipment that would permit adjustment to reservoir outflows.

25. RESERVOIR FILLING FREQUENCY. A filling frequency curve for Mojave Dam is shown on plate 23. In deriving this curve, inflow records for the water years 1938 through 1968 were routed through the reservoir using the gross capacity based on the 1962 survey.

26. REPORTING CRITERIA. A radio telemetry station was installed during FY 1981 in the recording house at the top of the dam. However, the COE District office in downtown Los Angeles has been unable to interrogate this station because of the distance and the mountains between the District Office and the station. During 1986, a GOES (Geostationary Operational Environmental Satellites) Data Collection Platform will be installed to replace this telemetry station. The recording house is also equipped with a strip chart and a punched tape. The strip chart records the water surface elevation continuously. The punched tape reports the precipitation and water surface elevation every 15 minutes from October through March and every hour from April through September.

27. EMERGENCY NOTIFICATION. During the event of heavy rains or high discharges from the Mojave Dam, personnel at the Los Angeles District should be in communication with the San Bernardino County Flood Control District. The San Bernardino County Communications Center (telephone no. (714) 383-3915) and the San Bernardino County Emergency Services (telephone no. (714) 383-2414) are on alert 24 hours a day as the County's central coordinators for disaster control. The Communications and Emergency Services functions in conjunction with the County's flood control district according to an established disaster plan. If anticipated high outflows from the reservoir pose a threat to people along the downstream channel, the Communications and Emergency Services, at their discretion, could direct the operation to warn and, if need be, evacuate people located in hazardous areas.

COLECTION OF HYDROLOGIC DATA

28. HYDROLOGIC FACILITIES. Hydrologic facilities include the following:

a. Reservoir Water-Surface Recorder System. A concrete block instrument house is provided to house the bubbler gage installation used to obtain the water level. The installation consists of a 120-inch mercury servomanometer; water-surface recorder; gas purge system with gas bottle, and three 1/4 inch outside diameter polyethylene lines, one terminating at the invert, one about 10 feet above the invert, and the third about 100 feet above the invert. A telemark that was installed to provide a means of obtaining a reservoir water-surface elevation was removed and replaced with a telemetry station in 1981. Commercial power is required to operate the water-surface recording equipment. This gage was not used until 1974 when the dam's electrical system became operable.

b. Gaging Station. Stream gaging stations (see plate 7 for locations) upstream and downstream of the reservoir are described in the following subparagraphs.

(1) In 1974 the Corps of Engineers installed a stream gaging station on Deep Creek, about 1-1/2 miles above the dam. This station has equipment that continuously record water depths in a natural cross section of Deep Creek. The new station was built to replace the old Deep Creek stream gaging station that was in continuous operation since 1929 (see Table 4 for summary of significant discharges). The old station was located in the dam's reservoir area and was thus inadequate. The U.S. Geological Survey, who operated the old station, also operates the new station. A discharge rating curve for this station is located on plate 26.

(2) The West Fork Mojave River stream gaging station was discontinued from September 1971 to September 1974. This station was located about 1/2 mile upstream of the damsite. In October 1974 a new stage recording station was established further upstream from the site of the discontinued gage. This new recording station will also be discontinued on October 1, 1985. Table 5 is a summary of hydrologic data collected at these gaging stations by the U.S. Geological Survey. A discharge rating curve for this station is located on plate 27.

(3) A gaging station located just below the dam's outlet works was also abandoned. Stream flow measurements at this site were discontinued because an unstable riverbed negated accuracy. As a replacement in 1971 the U.S. Geological Survey constructed the Mojave River below Forks Reservoir station, about 1/2 mile downstream of the dam. This station consists of a continuous recording gage and a cableway that is used exclusively to measure large discharges. The recording gage was removed in October 1974 but it was installed again in October 1980. Sufficient data has not yet been collected to establish a discharge rating curve for the cross section.

(4) The California State Department of Water Resources operates the East Fork of the West Fork of the Mojave River above Cedar Springs station. This station is on Miller Canon 2-1/2 miles upstream of Silverwood Lake which is formed by the Cedar Springs Dam. The drainage area above this station is 11-1/2 square miles and the datum elevation for gage height is 3,580.30 feet, NGVD (National Geodetic Vertical Datum). The period of record for this station is from March 1961 to present. A discharge rating curve for the cross section is located on plate 30.

(5) The California State Department of Water Resources also operates the West Fork of the Mojave River above Cedar Springs station. This station is on Cleghorn Canyon just upstream of Silverwood Lake. The drainage area above this station is 3.2 square miles and the datum elevation for gage height is 3,552.3 feet, NGVD (National Geodetic Vertical Datum). The period of record for this station is from February 1961 to present. A discharge rating curve for the cross section is located on plate 31.

(6) The U.S. Geological Survey operates the Mojave River at Lower Narrows, near Victorville Stream gaging station. This stage recording station has been in continuous operation since October 1930

and was also operated between February 1889 and September 1906. The datum elevation for gage height at this station is 2642.97 feet, NGVD. A discharge rating curve for this station is located on plate 24.

(7) The U.S. Geological Survey also operates a stage recording stream gage on the Mojave River at Barstow. Operation of this gage height is 2089.80 feet NGVD. A discharge rating curve for this station is located on plate 25.

(8) The Mojave River near Hodge gaging station is also operated by the U.S. Geological Survey. The drainage area above this station is 1,091 square miles and the present altitude of the gage is 2,260 feet, NGVD (National Geodetic Vertical Datum). The period of record for this station is from October 1930 to September 1932 and from October 1970 to present. A discharge rating curve for the cross section is located on plate 28.

(9) The Mojave River at Afton gaging station is also operated by the U.S. Geological Survey. The drainage area above this station is 2.121 square miles and the present altitude of the gage is 1,398.15 feet NGVD. The period of record for this station is from October 1929 to September 1932 and from October 1952 to present. A discharge rating curve for the cross section is located on plate 29.

(10) In March 1979, three more stream gaging stations were added in the Mojave River Basin operated by the U.S. Geological Survey: The Houston Creek above Lake Gregory (drainage area 0.35 mi^2), the Abondigas Creek above Lake Gregory (drainage area 1.15 mi^2) and the Houston Creek below Lake Gregory (drainage area 2.68 mi^2).

(11) In October 1980, the West Fork Mojave River below Silverwood Lake station was added to the Mojave River Basin. This stream gaging station is also operated b the U.S. Geological Survey. The drainage area of this station is 34 square miles and the gage altitude is 3,160 ft., NGVD (National Geodetic Vertical Datum).

c. Reservoir Staff Gages. A reservoir staff gage system, consisting of 38 adjustable 5-foot sections are installed so that they can be read from the top of the dam.

d. Precipitation Gages. The San Bernardino County Flood Control District, the National Weather Service and the Corps of Engineers, together operate more than 20 precipitation gates, scattered throughout the dam's drainage area. The Corps of Engineers operates a recording station at the dam. A recording station at the community of Summit that was also operated the Corps of Engineers was abandoned in January 1980. Precipitation gage locations are shown on plate 7.

29. SEDIMENTATION. The sedimentation allowance in Mojave River Reservoir of 11,000-acre-feet is based on a 100-year design period. In order to check sedimentation periodically, four category "A" index ranges were established in the reservoir area and four Category "C"

index ranges across the downstream channel. Each index range is a surveyed cross-section. A reconnaissance survey will be made every two years, or after every major storm (whichever comes first) to determine if the index ranges should be resurveyed. A comprehensive survey of Mojave River Reservoir will be made whenever a survey of the Category "A" ranges indicates an appreciable amount of sediment. At least one such survey will be made every ten years. Category "C" ranges will be surveyed at least once every five years. Locations of index ranges are shown on plates 32 and 33.