IV - WATERSHED CHARACTERISTICS

4-01 General Characteristics. East Fullerton Creek originates on the southern slopes of the Puente Hills in the northwestern corner of Orange County, California. The stream flows in a southwesterly direction, through Fullerton Dam, to the edge of the City of Fullerton, where it turns westward and joins Coyote Creek. The longest watercourse in Fullerton Dam's drainage area is 5.4 miles, and the overall gradient is 187 feet per mile.

The total drainage area controlled by Fullerton Dam is 5.0 square miles. Natural drainage area above the dam is approximately 3.25 square miles, with an additional area of 1.75 square miles drained through the Loftus Diversion Channel. The entire drainage area is shown on plate 2-05. The upper portion of the drainage area has a light-to-medium cover of chaparral. Native grasses and a variety of small trees exist in the watershed along with residential development in the lower areas. At the time of Fullerton Dam's construction, the watershed contained extensive orange groves and oil fields. The orange groves have been replaced by residential development, but active oil fields remain.

4-02 Topography. Elevations in the watershed vary from 261 ft. NGVD at Fullerton Dam to 1,298 ft. NGVD at the highest point in the Loftus drainage area. The Puente Hills define the northern portion of the watershed and are characterized by rolling hills punctuated with steep narrow canyons. The watershed south of Puente Hills is a mildly sloping plain until it reaches the Coyote Hills where Fullerton Dam is located. Peak elevation of the East Coyote Hills near Fullerton Dam is 534 ft. NGVD. Downstream of the dam, Fullerton Creek moves through a gently sloping coastal plain until it reaches Coyote Creek. The channel profile is depicted on plate 4-01.

4-03 Geology and Soils. The Whittier fault zone is located just north of the East Fullerton Creek drainage area, traversing the Puente Hills in a north 65° west direction. This fault exhibits upward movement of the fault block containing most of the Puente Hills. During this uplift, sediments of this region were subjected to considerable folding, especially in the immediate vicinity of the major fault zone. Older Tertiary sediments are present east of the Whittier fault, while to the west the Pliocene aged Fernando beds are continuous for many miles, dipping deeply beneath the alluvium toward the coastal plain.

The local soils are composed of marine sediments of late Tertiary to Quaternary age. Igneous rocks are absent from the region, and the sediments in the area consist of a variety of sand and clay loams of the Altamont, Diablo, Ramona, and Yola series. These are moderately weathered, medium-textured soils of high agricultural value.

4-04 Sediment. The slope and soils of the Fullerton Dam drainage area are such that appreciable erosion occurs in undeveloped areas. A November 1944 survey of the Fullerton Dam Flood Control Basin indicated that the storage capacity loss rate due to sedimentation was 3.4 AF per year during the first 3 years of operation. A March 1962 survey indicated that the storage capacity loss rate decreased to 2.1 AF per year for the period between November 1944 and March 1962. Although the drainage area and sediment contributing area were increased when the Loftus Diversion Channel was completed in December 1954, an increase in urbanization has probably reduced potential sediment inflow and deposition. The completion of a debris basin in 1984 at the outlet of Loftus Diversion Channel is expected to further reduce sedimentation rates in the flood control basin. In 1970 the reservoir capacity was increased by excavation upstream of the dam to provide material for freeway construction. The June 1970 survey of the reservoir was done by CALTRANS after this excavation.

4-05 Climate. The climate of the drainage area above Fullerton Dam is generally temperate-subtropical and semi-arid, with warm, dry summers and mild, moist winters.

a. Temperature. Average daily minimum/maximum temperatures (degrees Fahrenheit) range from 42/66 in winter to 59/90 in summer. All-time low/high extremes of temperature are about 22/113. The area does not experience significant periods of freezing temperatures.

b. Precipitation. Normal annual precipitation in the drainage area above Fullerton Dam ranges from greater than 13 inches at the dam to about 16 inches at the top of the watershed. Monthly precipitation data are shown on plate 4-02. Plate 4-03 is a listing of historic monthly precipitation and a summary of mean and maximum observed monthly and annual precipitation for Fullerton Dam (Sta. No. 3285). There is a great deal of year-to-year variability in annual, monthly, and daily precipitation.

Plate 4-04 is a precipitation depth-duration-frequency tabulation for Fullerton Dam. In it are listed the computed point-value precipitation depths for durations from 15 minutes to 24 hours, and for return periods from 2 to 200 years. Data for this table were obtained from the State of California Department of Water Resources publication, Rainfall Depth-Duration Frequency for California, revised November 1982. These California Water Resources data are almost the same magnitude as those obtained from the National Oceanic and Atmospheric Administration publication, NOAA Atlas 2, for durations from 15 minutes to 6 hours. At durations of 12 and 24 hours, the NOAA Atlas 2 data are higher than the California data, up to 23 percent higher at 24 hours for the 100-year return period.

(1) General Winter Storms. Most precipitation in southern California coastal basin occurs during the cool season, primarily from November through early April, as mid-latitude cyclones from the north Pacific Ocean move across the west coast of the United States to bring precipitation to southern California. Most of these storms are of the general winter type, with hours of light to moderate steady precipitation, but with occasional heavy showers or thunderstorms. Although these storms frequently produce significant snow above an elevation of 6,000 ft. NGVD snowfall and snowmelt very rarely occur in the Fullerton watershed, with a peak elevation less than 1,300 feet.

(2) Local Thunderstorms. Local thunderstorms can occur in southern California at any time of the year, but are least common and least intense during the late spring. These types of storms occur fairly frequently in the

coastal areas during or just after general winter storms. They can also occur between early July and early October, when desert thunderstorms occasionally drift westward across the mountains into coastal areas, sometimes enhanced by moisture drifting northward from tropical storms off the west coast of Mexico. Local thunderstorms can also occur throughout the fall, as upper-level low-pressure centers trigger residual summer moisture. These local thunderstorms can result in very heavy rain for short periods of time, causing very rapid runoff from small drainage areas. The Fullerton Dam watershed is especially vulnerable to this type of storm.

(3) General Summer Storms. General summer storms in southern California are quite rare. However, a tropical storm from off the west coast of Mexico can occasionally drift far enough northward to bring heavy rain and very heavy thunderstorms to southern California. The season in which these storms are the most likely to significantly affect southern California is mid-August through early October, although there have been some effects in southern California from tropical storms as early as June, and as late as November.

On rare occasions, southern California has received light rain from non-tropical general summer storms, some of which exhibited characteristics of general winter storms.

c. Wind. The prevailing wind in northern Orange County is the sea breeze. This gentle onshore wind is normally strongest during late spring and summer afternoons, with speeds of about 10 to 15 miles per hour (mph) in the Fullerton-Yorba Linda area.

The Santa Ana is a dry desert wind blowing from the northeast, most frequently during late fall and winter. It can be especially strong below the Santa Ana River Canyon (from whence it receives its name), with peak gusts of more than 70 mph. This type of wind, which does not normally occur when water is impounded behind Fullerton Dam, can create very high fire hazards, but can also be instrumental in drying a saturated watershed and reducing the flood potential.

Rainstorm-related winds are the next most common wind type in southern California. Winds from the southeast ahead of an approaching storm average 20-30 mph, with occasional gusts of more than 40 mph. West to northwest winds behind storms can sometimes exceed 35 mph, with higher velocity gusts.

d. Evaporation. Few formal studies of evaporation have been made in Orange County, and evaporation is not a significant consideration at Fullerton Dam. Studies from nearby locations indicate that mean daily evaporation ranges from about one-quarter inch in winter to about one-half inch in summer. On days of very strong, dry Santa Ana winds, evaporation can be considerably greater than one inch.

4-06 Storms and Floods. Most of the major inflow and impoundment events in the history of Fullerton Dam have been the result of general winter storms, but several local thunderstorms have produced significant peak inflows. Plate 4-05 is a summary of peak annual flows affecting Fullerton Reservoir.

Prior to the construction of the dam, there were a number of major storms and floods on southern California streams, including those of January 1862, February and March 1884, January and February 1914, January 1916, December 1921, February 1927, December 1933-January 1934, October 1934, and February-March 1938. There was also a significant summer tropical storm in September 1939; and shortly before Fullerton Dam began operation, a heavy local thunderstorm struck the watershed in March 1941.

a. Storms of January 1916. Two major series of general winter storms hit southern California during January 16, as intense cold fronts dropped down the coast from the north, then turned inland. The first series occurred 14-20 January and dropped about 6-7 inches over Fullerton and vicinity. Yorba Linda measured 6.38 inches for the storm period, including 3.52 inches on 17 January. The second storm series occurred 24-30 January and was generally somewhat less heavy; but ground conditions, saturated from the first storm, were more favorable for runoff. About 4 inches fell in the vicinity of Fullerton. Yorba Linda measured 3.98 inches, including 3.01 inches on 27 January. No discharge values are available for Fullerton Creek.

b. Storm and Flood of 30 December 1933-1 January 1934. A slow-moving low-latitude North Pacific storm moved directly into southern California at the end of 1933 and dropped very heavy precipitation in Orange County and especially Los Angeles County. Total rainfall in the vicinity of Fullerton ranged between 5 and 6 inches. Yorba Linda measured 5.44 inches. More than half of this rain fell within a 24 hour period of about noon of 31 December to noon of 1 January. The very heaviest rain fell near midnight at the turn of the year. The peak runoff of the 1933-34 season on Fullerton Creek occurred on 1 January, but no time of day or discharge values are available.

c. Storm and Flood of 27 February-3 March 1938. The general winter storm of 27 February-3 March 1938 resulted when high pressure over California and Nevada pushed northward, and allowed a series of low-latitude Pacific storms to move into southern California from the west-southwest. These storms produced an average of about 10 inches of rainfall over the watershed above Fullerton Dam, with roughly 4.5 inches falling on 2 March, the day of the most intense cold front of the storm series. This 2 March rainfall generated a peak flow of 950 cfs at the Fullerton Reservoir site.

d. Storm and Flood of 14 March 1941. On the afternoon of 14 March 1941, during a moderately heavy general winter storm, an intense local thunderstorm occurred in the vicinity of the City of Fullerton, producing more than two inches of rainfall in less than one hour. The peak discharge per square mile from Fullerton Creek exceeded all previous records for drainage areas with similar characteristics. The peak inflow of 3,800 cfs to Fullerton flood control basin, when adjusted to current conditions, would have been 4,000 cfs. Overflow actually occurred at several places along Fullerton Creek and several streets immediately to the north. Although Fullerton Dam was not yet officially complete, gates were operated for flood control, with a maximum water surface elevation of 282.8 ft. NGVD, and a peak outflow of about 140 cfs during the time of greatest inflow. There is no data available on the amount of damage prevented, though it was undoubtedly considerable.

e. Storms and Floods of 19-27 January 1969. In January 1969, a storm track developed from the equatorial zone southeast of Hawaii, all the way to southern California. As a result, four intense storms and several minor rain bands passed through southern California during a nine-day period. About 4.5 inches of rain fell on the Fullerton watershed, producing a peak inflow to the reservoir of greater than 430 cfs (pl. 4-06).

f. Storms and Floods of 21-27 February 1969. In late February 1969 several contiguous storms moved into southern California from the west, with one stalling over Orange County on 25 February. The total of about 6.5 inches of rain over the Fullerton watershed during the 6-day period produced a peak reservoir inflow of about 600 cfs (pl. 4-07).

g. Storms and Floods of 28 February-5 March 1978. In a pattern very similar to that of exactly 40 years earlier, a series of low-latitude Pacific storms moved into southern California at the end of February and beginning of March 1978. There were four major rainfall and inflow peaks during the storm period: 28 February, 1 March, 4 March (greatest volume of rain of the four storms), and 5 March (greatest rainfall intensity). More than 9 inches of rain fell at Fullerton Dam during the storm period, with an estimated 11 inches averaged over the watershed. Close to 3 inches of this fell on 4 March. Plate 4-08 depicts the hydrographs of hourly rainfall at Fullerton Dam (the distribution of which has been partially estimated from that of nearby Brea Dam) and the inflow, outflow, and water surface elevation hydrographs for Fullerton Reservoir during the February-March 1978 storm series. The maximum inflow to the reservoir of approximately 1,500 cfs occurred on 1 March, while the maximum water surface elevation of 280.9 ft. NGVD occurred on 4 March.

h. Storm and Flood of 5 January 1979. On 5 January 1979 a cold storm dropped rapidly southward from the Gulf of Alaska, spreading general moderate rain over most of southern California. Most of the rain had ended by mid-evening, but an intense post-frontal thunderstorm hit the Fullerton area just before midnight. Fullerton Dam recorded 1.35 inches between 2100 and 2300 hours, and Brea Dam recorded 1.30 inches between 2200 and 2400 hours. The storm totals ending early 6 January were 3.02 and 3.28 inches at the respective dams. This thunderstorm caused a very rapid rise in the inflow rate to Fullerton Reservoir (pl. 4-09), with a peak of 1,490 cfs just before midnight 5 January.

i. Storm and Flood of 30 January-2 February 1979. Near the end of January 1979, a cold low pressure center dropped southward off the coast of California, and picked up moisture over the ocean west of southern California. Locally heavy rain developed during the afternoon of 30 January and became heavy during the early evening. Fullerton Dam recorded 1.61 inches between 1800 and 2100 hours, while Brea Dam recorded 1.70 inches between 1900 and 2200 hours. Brief heavy showers continued on 31 January, with light showers through 2 February. The peak inflow to Fullerton Reservoir of approximately 1,300 cfs occurred on 30 January between 2000 and 2100 hours (pl. 4-10). The peak water surface elevation of 285.6 ft. NGVD, which occurred about 0700 hours on 31 January, is the highest ever recorded at Fullerton Reservoir.

j. Storms and Floods of 13-18 February 1980. From 13 through 21 February 1980 a series of intense, warm Pacific storms moved into southern California from out of the west-southwest, dropping a total of 10-13 inches of rain in the greater Fullerton area over nine days, including about 8 inches during the 5 days 13-17 February. The Yorba Linda station measured 11.69 inches for the period. Of this, 7.83 inches fell 13-17 February, including 2.50 inches from 1800 hours 13 February to 1800 hours 14 February. The heaviest of the series of storms in the greater Fullerton area occurred during the late evening of 13 February, when an sharp occluded cold front moved through and triggered several intense thunderstorms. Although data from several northern Orange County recording rain gauges were not reported for February 1980, the rainfall intensities from stations a few miles away indicate up to 0.6 inch in 1 hour and up to 1.4 inches in 3 hours at or just before midnight of 13 February. The peak inflow to Fullerton Reservoir occurred between 2300 and 2400 hours 13 February, and was 1,700 cfs (pl. 4-11). Additional bursts of heavy rain (up to 1 inch in 3 hours) and significant peak inflows to Fullerton Reservoir occurred late 14 February, 16 February both near mid-day and again late afternoon, and late 17 February into 18 February.

k. Storm and Flood of 28 February-3 March 1983. A low-latitude Pacific storm reminiscent of those of 5 and 45 years earlier moved into southern California at the end of February and first of March 1983, dropping 5-8 inches of rain over portions of Orange County. The heaviest rainfall occurred during the passage of a strong occluded cold front on the morning of 1 March, with peak intensities well in excess of 1 inch per hour. Inflow to Fullerton Reservoir on 1 March consisted of three peaks between 0900 and 1400 hours (pl. 4-12). The first, which occurred between 0900 and 1000 hours, was the heaviest, with an estimated maximum discharge of 1,890 cfs. The maximum water surface elevation of 285.0 ft. NGVD was reached at 1350 hours.

4-07 Runoff Characteristics. Little streamflow occurs in Fullerton Creek except during and shortly after heavy rainfalls. The drainage area characteristics are not conducive to continuous flow, but runoff from the steep slopes in the upper part of the watershed causes streamflow to increase rapidly in response to effective rainfall. These sharp streamflow peaks are followed by rapid recessions in the absence of further rain.

The drainage area has steadily increased in urbanization since World War II, and the effective impervious cover is currently estimated at about 25 percent, as seen on plate 4-13. As the remaining undeveloped land is primarily in the less easily developed Puente Hills area, the rate of watershed urbanization should gradually decrease.

The Los Angeles region has historically experienced long-term wet and dry periods as seen on plate 4-14. Because of the current generally wet period, it is difficult to establish what percentage of the recent increased flows into Fullerton Reservoir are the result of urbanization, and what percentage increase is attributable to heavier rainfalls. Rainfall records for recent years at Fullerton Dam are not adequate to specifically define the amount of rain that produced the largest peaks because of gaps in the data base.

The inflow frequency curves shown on plate 4-15 are adjusted to 1985 conditions, and represent the instantaneous peak and 24-hour maximum annual inflow frequencies at Fullerton Dam. The curves were derived from the historic record of reservoir regulation and stream gauge records in the vicinity of Fullerton Dam prior to construction. Inflow curves are not affected by the regulation schedule of Fullerton Dam or any upstream facility. Values have been adjusted to establish a homogeneous data set representing current conditions as presented on plates 4-16 and 4-17.

Because of the small size and fast response time of Fullerton watershed (t_c = 30 minutes), antecedent rain need not be present for significant runoff to occur. The pervious area loss rates are generally considered to be a constant 0.20 inches/hour, though in reality the initial loss rate would be greater, and the long-term loss rate may be as low as 0.10 inches/hour.

4-08 Water Quality. Water quality is not affected by the normal operation of Fullerton Dam. The watershed drains unimproved hills, residential areas, oil wells, an oil refinery, and a landfill. Under normal conditions none of these land areas should adversely affect the quality of runoff waters. Impoundment durations at Fullerton Dam are generally less than a day, and should have minimal affect on water quality. There are no ground water recharge facilities available to utilize Fullerton Creek flows, and all inflows ultimately reach the Pacific Ocean.

4-09 Channel and Floodway Characteristics. Downstream of Fullerton Dam the Fullerton Creek channel is unimproved for a distance of approximately 1.2 miles. The remainder of the channel, out to Coyote Creek, is an improved concrete channel built and maintained by OCEMA. The channel's course traverses Orange County's gently sloping coastal plain and goes through the urbanized business districts of Fullerton and Buena Park. Throughout the developed area, storm drains convey urban runoff into Fullerton Creek. The channel is maintained in generally good condition. Plate 4-18 is a schematic diagram of the downstream channel capacities.

a. Unimproved Channel. Immediately downstream of the dam, the channel is a grassy-sloped, irregular trapezoid that is fairly free of obstructive vegetation. Along the approximately 900 foot reach, a wooden pedestrian bridge crosses the channel and allows homeowner access to tennis courts on the east side of the channel. The channel then enters a 12 feet x 8 feet reinforced concrete box (RCB) culvert under Bastanchury Road. Flow from Bastanchury Drain also enters Fullerton Creek on the upstream side of the Bastanchury Road culvert as seen on plate 4-19. This is a critical location for the operation of Fullerton Dam. If Bastanchury Drain flow is great enough, the addition of a large dam release may exceed the Bastanchury Road culvert capacity of approximately 900 cfs. This could result in a backwater effect that might inundate the dam tender's residence, or cause the channel to overflow into Associated Road. Channel observers should be dispatched to this location whenever dam releases of 400 cfs or greater are anticipated. It should be noted that runoff from the Bastanchury Drain watershed of 0.8 square miles could exceed the Associated Road culvert capacity of approximately 600 cfs, and flood Associated Road independently of Fullerton Dam operations.

Downstream from Bastanchury Road, the grassy channel carries flow through the Northcreek Lane RCB culvert and the Almira Road RCB culvert. From Almira Road to State College Boulevard the channel contains scattered trees and a medium density of underbrush. From the dam down to State College Boulevard, the local homeowners associations have responsibility for channel maintenance.

Between State College Boulevard and Dorothy Lane, Fullerton Creek is a deep, U-shaped channel with dense vegetation in the flow path. The channel is on the east side of Acacia Park, a flat, turf recreational area that includes Acacia School on the southwestern corner of the park. Crossing the channel in the park is a wooden pedestrian bridge approximately 17 feet above the channel bottom. A drop structure just upstream of Dorothy Lane marks the beginning of the improved concrete channel. The park channel reach is primarily maintained by the City of Fullerton, but the OCEMA also observes and corrects debris problems that may affect their structures.

b. Improved Channel. Fullerton Creek is a concrete channel from Dorothy Avenue all the way to Coyote Creek, as seen on plate 4-18. The channel has been undergoing sectional improvements since the mid-1970's. Some locations of concern are as follows:

(1) Dorothy Lane to Hart Place (extended). The channel capacity here ranges from 1,000-1,700 cfs and is not able to carry the OCEMA Q_{100} (i.e., 100-year discharge) of 3,600 cfs.

(2) Chapman Avenue to Wilshire Avenue. The current box culvert under Wilshire, Raymond, and Chapman Avenues has a capacity of 1,800 cfs and is low compared to the OCEMA Q_{100} of 4,100 cfs. OCEMA finished increasing the channel capacity to 4,100 cfs during August 1988.

(3) Wilshire Avenue to A.T. & S.F. Railway. During the storm of 28 February-1 March 1978 and again in late January 1979, flooding occurred here due to overtopping of the channel reach. In late 1979 the channel was upgraded to its current condition.

(4) Harbor Boulevard to Richmond Avenue. This section was built in 1959, and its capacity of 2,930 cfs is not considered adequate. This reach contains the telemetered stream gauge at Fullerton Creek at Richmond Avenue (FCKR). The ability of Fullerton Dam to control flood events on Fullerton Creek channel downstream of this location is minimal.

(5) Southern Pacific Railroad Bridge d/s of Santa Ana Freeway. Planned improvements on this bridge are currently scheduled by OCEMA to be completed by the Summer of 1989.

4-10 Structures Affecting Fullerton Creek. Upstream of Fullerton Dam, the Loftus Diversion Channel and its debris basin increase the contributing area of runoff into Fullerton Dam. Storm channels draining the developed areas of the watershed feed into Loftus Diversion Channel. No operational facilities exist upstream of the dam.

Downstream from Fullerton Dam, storm channels bring urban runoff into Fullerton Creek. The largest of these drains are the Bastanchury Storm Drain, the Kimberly Storm Drain, and the Melrose Storm Drain, as seen on plate 4-18. No operational or conservation facilities exist on Fullerton Creek. The dam is located within LACDA, but it is not operated as a LACDA water control system element because its influence is strictly local.

4-11 Economic Data.

a. Population. Orange County has been one of the fastest growing areas in the country since the end of World War II. The watershed of Fullerton Dam lies mostly within the City of Brea and an unincorporated area east of the city. Most of the downstream area is located in the heart of the City of Fullerton and further west in the City of Buena Park. The population estimates below are from the State of California, Department of Finance, Population Research Unit, as of January, 1984:

Fullerton	106,900
Brea	31,850
Buena Park	65,100

b. Agriculture. The watershed above and below the dam was once primarily citrus groves. The postwar era has brought increasing urbanization to the area, virtually replacing all agriculture. There is still a large nursery in the watershed.

c. Industry. The explosive growth in population has been accompanied by corresponding growth in industry and commerce. In the watershed there are oil fields and a large refinery. The largest manufacturing facility is a rubber plant. Both the upstream watershed and downstream area have numerous business/industrial parks. Most of the manufacturing is light industry that specializes in highly technical fields, especially aerospace and electronics. The downstream area is heavily residential and supports general office and commercial development. The California State University at Fullerton lies just below the dam.

d. Flood Damages. Since completion of the project, flood damages prevented through fiscal year 1984 are estimated to be $2,200,000. Stage-damage curves for Fullerton Creek are not available.