Chapter 3A. Environmental Setting, Impacts, and Mitigation Measures - Hydrology

INTRODUCTION

As described in Chapter 2, alternative amendments to the City of Los Angeles appropriative water rights for diversion of four tributary streams in Mono Basin will have direct hydrologic effects on the four streams downstream of the diversions, the water balance and surface elevations of Mono Lake, and the amount of water exported to the Upper Owens River. The allowable exports from Mono Basin will also have indirect effects on Owens River flows, Lake Crowley reservoir storage, and exports from the Owens Valley to Los Angeles. The relationships between these variables were used to define a set of water rights alternatives using a monthly hydrologic model described in Chapter 2.

Many of the hydrologic conditions in Mono Basin and the Owens River basin will not be altered by the proposed amendments to the city's water rights. The available runoff from the four Mono Lake tributary streams that are diverted by LADWP will not change. The other sources of water flowing into Mono Lake (e.g., rainfall, most groundwater, and other surface streamflow) will not change. The runoff and spring discharges in the Owens Valley will not be affected. As described in Chapter 2, the assumption has been made for this EIR that groundwater pumping in the Owens Valley will not change with amendment of Mono Basin water rights.

The hydrologic records used to analyze the alternative water rights amendments for the four diverted Mono Lake tributaries are for 1940-1989. The LADWP diversions began in 1941 and continued until 1989. Because of large year-to-year variations in the natural hydrology of Sierra Nevada streams, data from a large sequence of years are required to characterize hydrologic patterns accurately. Hydrologic effects caused by each alternative result from different diversions of streamflow for irrigation use or export from Mono Basin, but not from altered runoff patterns. Therefore, these hydrologic records are considered to characterize the prediversion period (before 1941), the historical diversion period (1941-1989), the point-of-reference conditions, and the probable future conditions for this EIR.

The "Prediversion Conditions" section in this chapter describes the basic hydrology of Mono Basin and the Owens River basin. The streamflows in the four diverted Mono Lake tributary streams and the Upper Owens River are described in greatest detail because these are the primary resources being evaluated for amended water rights. The water balance of Mono Lake (Appendix A) is described further because this is the primary tool for determining the relationship between stream releases to Mono Lake and the expected fluctuations of lake surface elevation.

The effects of alternative water rights amendments on Owens River flows and exports to Los Angeles are analyzed with the Los Angeles Aqueduct Monthly Program (LAAMP) operations model. This model is described in Chapter 2, as well as Auxiliary Report 5; model results are given in Auxiliary Report 18.

Results from the aqueduct simulations are used to assess impacts in several topic areas. The hydrologic effects described in this chapter are not themselves classified as environmental impacts, but they may cause impacts as identified in the various resource chapters of this report.

PREDIVERSION CONDITIONS

The general hydrology of Mono Basin and the Owens River basin is described below for the prediversion period, which included LADWP aqueduct facilities in the Owens River basin but none in Mono Basin.

Sources of Information

General Hydrology

Most of the historical hydrologic data was obtained from the LADWP "Totals and Means" database, which contains monthly totals for rainfall stations, streamflow gauges, reservoir storage, and various diversions. Daily records are available in separate LADWP databases for several of these stations. These hydrologic data provide an accurate description of basic hydrologic patterns.

Several detailed investigations of the hydrology of Mono Basin have been made, the most complete being those by Vorster (1985) and LADWP (1987). The U.S. Geological Survey (USGS) has conducted several investigations of the area's surface water and groundwater resources (Hollett et al. 1989, Lee 1912). The extensive measurements by LADWP have contributed to an increasingly accurate understanding of the hydrology of the Owens Valley. Several recent studies have been directly associated with the development of the Inyo County-Los Angeles groundwater management plan (LADWP 1990).

Hydrologic monitoring reports of groundwater and surface water have been prepared by USGS for the Long Valley caldera (Farrar et al. 1989). Streamflow records have been maintained by USGS and LADWP for these streams since before 1940.

Snowpack Measurements

The hydrology of Mono Basin and the Owens River basin is dominated by winter accumulation of snowpack in the upper elevations of the Sierra Nevada and White Mountains, and subsequent snowmelt runoff in the May-July period. Several snowpack depth measurement stations have been maintained by LADWP, the California Department of Water Resources (DWR), and Southern California Edison (SCE) high in the Owens River basin, in Mono Basin, and in adjacent basins on the western crest of the Sierra Nevada.

Use of "Runoff Year"

Because snowpack accumulation is usually complete by early April, the "runoff year" has been used by LADWP for its standard hydrologic record keeping and aqueduct management planning. The runoff year begins on April 1 and ends on March 31. When annual values are reported or discussed in this EIR, the runoff year is the annual period being used, rather than the calendar year.

Rainfall Records

Rainfall is important at low elevations for replenishing soil moisture for vegetation but does not provide a significant portion of the basin runoff. Some rainfall and snowmelt infiltrates into the soil and is lost to evapotranspiration or percolates to groundwater. Several reliable records of monthly rainfall are available from stations within Mono Basin and the Owens River basin, but the amount of evapotranspiration and groundwater recharge can only be estimated.

Streamflow

Several stream gauge stations that have been maintained by USGS and LADWP provide accurate records of streamflow in Mono Basin and the Owens River basin. Monthly runoff volumes have been converted to monthly average flows in cubic feet per second (cfs) for easier interpretation in the assessment of riparian and fisheries impacts. The general conversion factor is 1 cfs per day equals 2 acre-feet (af). Daily flows can be higher than the monthly average values, but only average monthly flows are estimated for this EIR.

During runoff, the stream channels allow a portion of the streamflow to infiltrate into the alluvial aquifers. Simultaneous (or synoptic) flow measurements have been used to evaluate these losses along all four diverted tributary streams (Beak Consultants 1991, 1992; EBASCO Environmental and Water Engineering and Technology 1991b, 1991c). These losses are also described in Chapter 3C, "Vegetation", as they relate directly to riparian habitat conditions.

Mono Basin Hydrology

Mono Basin has a mapped surface drainage area of 695 square miles (Vorster 1985). Mono Basin drains the eastern slope of the Sierra Nevada but is located at the western edge of the Great Basin desert region. Mono Basin is a closed hydrographic basin, so all surface runoff and groundwater flows toward Mono Lake. Water leaves the basin naturally only by evaporation from the surface of Mono Lake and evapotranspiration from the riparian corridors and from vegetation and soils on the remainder of the watershed.

Geology

Mono Basin geology is generally described as a sediment-filled structural depression that was created by faulting and tectonic downwarping (Stine 1987). Mono Basin is surrounded by the granite and metamorphic rocks of the eastern Sierra Nevada escarpment on the west, and highly fractured volcanic rocks and deposits of the Bodie Hills, Anchorite Hills, Cowtrack and Glass Mountains, and Mono Craters on the north, east, and south (Figure 1-1). Glacial debris from multiple periods of glaciation has formed many moraines, ridges, and alluvial cobble deposits that cover a broad piedmont slope at the base of the Sierra Nevada. The major surface streams drain from the melting snowpack and alpine lakes high in the Sierra Nevada down across the glacial deposits to the sedimentary and volcanic layers of material that fill Mono Basin. The geologic history of Mono Basin is reviewed by LaJoie (1968), LADWP (1987), and Stine (1987).

Tributary Streams

Three major streams enter Mono Lake: Mill Creek, Lee Vining Creek, and Rush Creek (Figure 1-2). Mill Creek enters in the northwestern corner of the western embayment of Mono Lake and has not been diverted by LADWP. Lee Vining Creek enters the western embayment of Mono Lake from the southwest. Rush Creek enters Mono Lake from the south. Walker Creek and Parker Creek are tributaries to Rush Creek, but they can be diverted directly into the Lee Vining conduit of the LA Aqueduct system.

Three other small, perennial tributary streams (Wilson, Post Office, and DeChambeau Creeks) enter Mono Lake from the Sierra Nevada. Springs and intermittent streams drain the volcanic and alkaline hills that surround the rest of Mono Lake; their water contributions to Mono Lake are considered as part of the unmeasured local runoff and groundwater inflows. Several geothermal springs exist within Mono Basin, including some within Mono Lake itself; however, flows from these geothermal sources are not considered important relative to the other surface water and groundwater sources (LADWP 1987).

Lee Vining Creek Watershed

Lee Vining Creek has a watershed area of 47 square miles, most of which (40 square miles) is upstream of the LADWP diversion into Lee Vining conduit (Table 3A-1).

Watershed Character. Lee Vining Creek drains the eastern Sierra Nevada crest. Mount Dana, with an elevation of 13,053 feet, is the highest peak in Mono Basin, and several other peaks above 12,000 feet rim the watershed boundary (Figure 1-1). Several small glaciers are present, and a series of alpine lakes provides storage for snowmelt and dampens the peak runoff. Three of these lakes (Saddlebag, Tioga, and Ellery) were enlarged for hydropower storage and regulation in the 1920s.

Lee Vining Creek drops precipitously down the eastern Sierra escarpment from Ellery Lake at elevation 9,500 feet to the Poole Power Plant at elevation 7,825 feet. Warren Fork enters Lee Vining Creek from the north upstream of the Poole Power Plant. Gibbs Creek is a major tributary that joins Lee Vining Creek upstream of the LADWP diversion.

Below the LADWP diversion, Lee Vining Creek flows past the USFS Lee Vining Ranger Station to the mouth of a glacial canyon, above U.S. Highway 395 (U.S. 395) and the town of Lee Vining. Water supply and hydropower diversions were historically located at this point in the stream. The hydropower plant was located downstream in the town of Lee Vining. The creek then flows over alluvial deposits to its delta in Mono Lake.

Precipitation, Runoff, and Diversions. Four snow courses are maintained in and adjacent to the Lee Vining Creek watershed by DWR and SCE. These provide an excellent record of snowpack in the watershed at the 9,600 to 9,900-foot elevation. The average April 1 water depth at the four stations is about 29 inches (Table 3A-2).

Average precipitation is 25.5 inches at Ellery Lake (9,645 feet elevation) and 27.5 inches at Poole Power Plant (7,850 feet), but only 12.8 inches at the Lee Vining Ranger Station (7,175 feet). The rain shadow of the eastern Sierra Nevada is evident in the rain gauges east of the Sierra Nevada crest.

Streamflow has been measured on Lee Vining Creek above Gibbs Creek since 1934 and on Gibbs Creek from 1948 until 1977. The long-term runoff from Gibbs Creek is approximately 2 thousand acre-feet per year (TAF/yr). Irrigation diversions of approximately 1 TAF/yr from Gibbs Creek to Horse Meadow and Farrington Ranch lands were made in the period before LADWP diversion began. Another irrigation diversion (at O-Ditch) of approximately 0.75 TAF/yr was made from Lee Vining Creek onto National Forest meadows above the Lee Vining Ranger Station.

The annual average runoff from Lee Vining Creek has been estimated from the LADWP records to be 49.2 TAF/yr. Annual flow variations of Lee Vining Creek have generally followed the pattern of other diverted streams in the area (Figure 3A-1). Figure 3A-2 shows the monthly cumulative distribution of runoff for Lee Vining Creek, as estimated by LADWP and adjusted to include Gibbs and O-Ditch diversions. The seasonal distribution of flow in Lee Vining Creek is strongly affected by the upstream SCE storage and hydropower operations.

The monthly flows during dry years (lowest 20% of years) are remarkably constant throughout the year (Table 3A-3). In near-normal runoff years, the base flow during the entire year is slightly higher and the peak runoff during the snowmelt period is increased. During wet years (highest 20% of years), most of the additional runoff occurs during the snowmelt period, although elevated summer and fall flows sometimes have occurred.

Above the Poole Power Plant, an average of approximately 6.3 TAF of the annual runoff is stored during the May-July peak period and released during the fall and winter period (Vorster 1985). Following snowmelt, SCE normally releases a fairly constant flow from the upper basin. Observed streamflows as regulated by SCE are used as the undiverted streamflows for determining the effects of alternative LADWP water rights on Lee Vining Creek.

Channel Losses. Infiltration, evapotranspiration, and unknown diversion losses along Lee Vining Creek can be estimated from the 1941-1969 period of record when a streamflow gauge was located near Mono Lake. The apparent losses were about 1-2 TAF per month (17-33 cfs), regardless of the flow rate or month of the year. Recent synoptic streamflow measurements on this portion of Lee Vining Creek have indicated that the actual loss is much less, however, being about 3-8 cfs (Trihey & Associates 1992).

Walker Creek Watershed

Walker Creek is south of Lee Vining Creek and has a watershed of 7.8 square miles (Table 3A-1).

Watershed Character. The watershed extends to the Sierra Nevada crest, with a maximum elevation of 12,800 feet (Mount Gibbs). Walker Creek above Walker Lake (elevation 7,935 feet) drains steep, mountainous terrain mostly above treeline where a soil profile is not well developed. Walker Lake is an alpine lake that was enlarged for irrigation storage and recreation use, with a surface area of about 85 acres and a usable storage of 550 af (Vorster 1985). Below Walker Lake, the creek flows through a narrow moraine-bound canyon and crosses the Lee Vining conduit where it may now be diverted at an elevation of 7,150 feet. Downstream of the conduit, the stream meanders through the Cain Ranch irrigated pasturelands on the alluvial piedmont east of the mountains and then descends in a canyon eroded into former lakebeds to join Rush Creek at an elevation of 6,610 feet. (EBASCO Environmental and Water Engineering and Technology 1991c.)

Streamflow. Streamflow has been measured by LADWP on Walker Creek above the Lee Vining conduit since 1942. The annual average runoff from Walker Creek has been estimated at 5.4 TAF/yr. The annual variations of Walker Creek have generally followed the pattern of other diverted streams in the area (Figure 3A-1). The seasonal distribution of flow in Walker Creek is modified only slightly by storage in Walker Lake. In particular, the flashboards on the dam have normally been removed in November, allowing a pulse of flow that raises the average November streamflows compared to those for October and December. Otherwise, the monthly cumulative distribution of runoff for Walker Creek is very close to runoff patterns typical of eastern Sierra streams (Figure 3A-3, Table 3A-3).

Diversions. Before LADWP diversions began, an unknown fraction of Walker Creek runoff was diverted to irrigate Cain Ranch lands downstream of the Lee Vining conduit. The total irrigated acreage at Cain Ranch is approximately 2,000 acres. LADWP has estimated the average irrigation diversion from Walker Creek during the diversion period to be approximately 2.4 TAF/yr, occurring from April to September, based on Walker Creek flow crossing the conduit and Sand Trap 3, which releases water from the conduit into Walker Creek. (The variability of these monthly releases from year to year suggests that some of the higher flows were spills from the conduit to Walker Creek rather than irrigation diversions.) A streamflow gauge was never established at the mouth of Walker Creek, so an accurate estimate of the irrigation uses along the Walker Creek corridor is not possible.

Parker Creek Watershed

Parker Creek is south of Walker Creek and has a watershed of approximately 12.2 square miles (Table 3A-1).

Watershed Character. The watershed extends to the Sierra Nevada crest, with a maximum elevation of 13,000 feet (Kuna Peak). Parker Creek above Parker Lake (elevation 8,300 feet) is formed by several branches that drain steep, mountainous terrain with permanent snowfields on the north sides of the peaks. Parker Lake is a natural alpine lake. Downstream, the creek flows through a narrow, moraine-bound canyon that broadens in the alluvial deposits just upstream of the conduit at an elevation of about 7,600 feet. Parker Creek crosses the conduit at elevation 7,150 feet, crosses the piedmont pasturelands, and descends in a canyon to Rush Creek at elevation 6,670 feet, just upstream of Walker Creek. (EBASCO Environmental and Water Engineering and Technology 1991b).

Runoff. Streamflow has been measured by LADWP on Parker Creek above the conduit since 1963 and upstream of irrigation diversions above the conduit from 1938 to 1978. The annual average runoff from Parker Creek has been estimated at 9.1 TAF/yr. The annual flow variations of Parker Creek have generally followed the pattern of other diverted streams in the area (Figure 3A-1). The monthly cumulative distribution of runoff for Parker Creek is typical of natural runoff for eastern Sierra streams (Figure 3A-4, Table 3A-3).

Diversions. Before LADWP diversions began, an unknown portion of the Parker Creek runoff was diverted to irrigate Cain Ranch lands both upstream and downstream of the Lee Vining conduit. The total irrigated acreage at Cain Ranch is approximately 2,000 acres. The upstream irrigation diversions have been estimated from the difference between the two streamflow gauges until 1978, and the three separate upstream diversions have been measured by LADWP since 1979. LADWP has estimated its average irrigation diversion from Parker Creek above the conduit to be approximately 1.5 TAF/yr during April-September.

LADWP's total releases downstream of the conduit have been estimated at 2.5 TAF/yr, based on Parker Creek flow crossing the conduit and Sand Trap 4, which releases water from the conduit into Parker Creek. (The variability of these monthly releases from year to year suggests that some of the higher flows were conduit spills to Parker Creek rather than irrigation diversions.) Between 1948 and 1962, many years of no flow were recorded at a streamflow gauge near the Cain Ranch buildings, showing that most of the flow released downstream of the conduit was in fact diverted for irrigation. Measurements of flow crossing the conduit or Sand Trap 4 releases were not made during this period, however. An accurate estimate of the irrigation uses along the Parker Creek corridor is therefore not possible.

Channel Losses. Average channel loss of water during fall and winter was determined by synoptic flow measurements in 1990 and by flow differences between two streamflow gauges at the conduit crossing and near Cain Ranch buildings. A loss of less than 1 cfs was generally measured for this 3.5-mile reach at a flow of approximately 5 cfs.

South and East Parker Creek Watershed

South Parker Creek drains a watershed of approximately 3.8 square miles just south of Parker Creek (Table 3A-1). The larger southern branch extends to near the Sierra Nevada crest at the 12,600-foot elevation (Mount Wood); the smaller branch extends to an elevation of 9,400 feet. The two branches join upstream of the conduit at an elevation of approximately 7,320 feet. The creek descends on the alluvial fan complex, crosses the present conduit location at an elevation of 7,135 feet, and enters Rush Creek at elevation 6,850 feet, just upstream of the U.S. 395 bridge (EBASCO Environmental and Water Engineering and Technology 1991a).

Streamflow has been measured by LADWP for the two branches above the irrigation diversions since 1935, and the combined flow at the conduit has been measured since 1964. LADWP has estimated runoff for South and East Parker Creeks at approximately 1.2 TAF/yr.

Upstream of the conduit, streamflow records indicate that approximately 0.5 TAF/yr of the South and East Parker Creek flow has been diverted for irrigation purposes or infiltrated above the conduit during April-September. LADWP does not have appropriative water rights to divert South and East Parker Creeks for export, although a diversion into the conduit was operated until recently.

Rush Creek Watershed

Rush Creek has a total watershed area of approximately 141 square miles (Table 3A-1).

Watershed Character. Rush Creek flows into Mono Lake from the south and drains a rugged watershed in the eastern Sierra Nevada, with several peaks above 12,000 feet, and the June Lake Loop at the foot of the mountains (Figure 1-1). Grant Lake reservoir is an enlarged natural lake used by LADWP to store water for export through the Mono Craters Tunnel. Before exports began in 1941, a smaller Grant Lake reservoir was used to store water for irrigating approximately 1,000 acres in the Pumice Valley along lower Rush Creek (Vorster 1985). Grant Lake reservoir now has a maximum storage capacity of approximately 47,500 af. Average monthly evaporation from the reservoir is shown in Table 3A-4.

Rush Creek above Grant Lake reservoir has a watershed area of approximately 62 square miles, with 52 square miles upstream of the streamflow gauge. A major portion of the watershed (23.2 square miles) is located upstream of Lake Agnew (elevation 8,508 feet) in the Ansel Adams Wilderness area. The other main branch of the Rush Creek watershed includes Gull Lake (elevation 7,602 feet) and June Lake (elevation 7,620 feet) and is drained by Reversed Creek, which joins Rush Creek just downstream of the Rush Creek Power Plant. This portion of the watershed has a maximum elevation of about 9,000 feet.

SCE Hydropower Operations. The upper portion of the watershed includes several alpine lakes, three of which were enlarged during 1916-1925 for hydropower storage. Agnew, Gem (elevation 9,058 feet), and Waugh (elevation 9,442 feet) Lakes provide usable storage of approximately 23,000 af. Waugh Lake is filled (5,000 af) in May and June and remains full until Labor Day. The water is then transferred to Gem Lake in September and October, and Waugh Lake remains nearly empty during the winter (Federal Energy Regulatory Commission 1992). Gem Lake provides the major storage (17,000 af) and is filled with snowmelt runoff between April and July. Agnew Lake provides less than 1,000 af storage.

The Rush Creek Power Plant (operated by SCE) is located just upstream from the mouth of Reversed Creek at an elevation of about 7,300 feet; the plant has penstocks with intakes in Agnew and Gem Lakes. Frequent releases are made from Gem Lake, and the Agnew Lake intake is used only in October. The Rush Creek Power Plant is operated at full capacity during periods of high runoff, and flows are regulated to provide a constant power output for the rest of the year, consistent with available runoff and storage. Releases from Rush Creek Power Plant and streamflow in Rush and Reversed Creeks flow into Silver Lake. Alger Creek flows into Silver Lake from the west. Releases from Silver Lake flow approximately 3 miles to Grant Lake reservoir.

Runoff. Three snow courses are maintained in and adjacent to the Rush Creek watershed by DWR and SCE at elevations of 9,150-10,400 feet (Table 3A-2). The average April 1 water depth is 31 inches. Average precipitation is only 21.8 inches at Gem Lake at 8,790 feet, however (although water depth at a snow course at 7,300 feet averages more than 25.3 inches). At Cain Ranch (6,850 feet), precipitation is only 11.5 inches. Rain shadow effects are again evident.

Streamflow has been measured at the inflow to Grant Lake reservoir since 1934. The annual average runoff from Rush Creek is estimated from the available LADWP records to be 59 TAF/yr. The annual flow variations of Rush Creek have generally followed the pattern of other diverted streams in the area (Figure 3A-1). The seasonal distribution of flow in Rush Creek is strongly affected by the upstream SCE storage and hydropower operations, and resulting streamflows are used as the undiverted streamflows for determining the effects of the alternative LADWP diversions (Figure 3A-5, Table 3A-3).

Diversions. Historically, diversions were made from Rush Creek to irrigate the Pumice Valley area. Diversions were recorded at A-Ditch for 1919-1973 and at B-Ditch for 1919-1968. Because these ditches were also used to spread excess water during high runoff years, irrigation use cannot be estimated accurately. A streamflow gauge was maintained near the mouth of Rush Creek from 1935 to 1939 and from 1952 to 1967. Accurate irrigation losses cannot be determined from these records, however. Springflow in the Rush Creek bottomlands was enhanced by the A-Ditch and B-Ditch irrigation during the prediversion period.

Channel Losses. Infiltration losses from Rush Creek between Grant Lake reservoir and Mono Lake were measured in 1987 (EA Engineering Science and Technology Inc. 1989), with streamflows varying from 15 cfs to 100 cfs, to be approximately 5 cfs in winter and 10 cfs in summer. The 5-cfs difference was assumed to be evapotranspiration from the riparian vegetation.

Mill Creek Watershed and Relationships with Adjacent Watersheds

Mill Creek drains approximately 18 square miles of the eastern Sierra Nevada escarpment. The waters of Mill Creek were diverted before 1941 for hydropower and irrigation of the Conway and DeChambeau Ranches northwest of Mono Lake. The period of record for Mill Creek extends from runoff year 1895 to the present. The average runoff for the 1940-1989 period is about 21 TAF/yr (Table 3A-1).

In the upper watershed of Mill Creek is a series of connected alpine lakes. The lakes store snowmelt and dampen the peak runoff from the upstream portion of the watershed. Lundy Lake, at 7,808 feet in the mouth of Lundy Canyon, was enlarged with a dam constructed by Southern Sierra Power Company in 1911. It has a surface area of 130 acres and provides a seasonal storage volume of about 3,800 af (Vorster 1985).

SCE's Mill Creek Power Plant is located across a ridge north of Lundy Lake at the head of the Wilson Creek drainage. The hydropower diversions from Mill Creek at Lundy Lake are returned to Wilson Creek and then diverted into a series of irrigation ditches in the Conway and DeChambeau Ranch area. Wilson Creek does not have a large watershed area at high elevations and has much smaller natural runoff. Average annual precipitation is only 17-18 inches, as measured at a gauge at Conway Summit (8,150 feet elevation).

Virginia Creek, an adjacent stream north of Wilson Creek in the Walker River watershed, has been diverted to supply irrigation water for the Conway Ranch for many years. Because Conway Ranch also has rights to 13 TAF/yr of Mill Creek water, and less than half of the 6 cfs permitted at the Virginia Creek diversion between March and October has usually been observed, an average annual diversion of less than 1.5 TAF/yr seems likely (Vorster 1985). An unknown portion of this applied irrigation water infiltrates into groundwater and drains toward Mono Lake.

DeChambeau Creek, located just south of Mill Creek, drains a small (2.5-square-mile) but steep watershed. It was historically diverted for irrigation and a small hydropower plant. The average annual runoff is about 900 af/yr. The Mono Lake rainfall gauge (6,450-feet elevation) located in the DeChambeau Creek watershed shows average annual precipitation of 14.2 inches.

The consumptive use of water in the irrigated ranch areas supplied from Mill, Wilson, Virginia, and DeChambeau Creeks can only be estimated from the irrigated acreage on these ranch lands. Although much more water may be diverted from the streams into the irrigation ditches, all but the evapotranspired water will eventually flow to Mono Lake. Vorster (1985) estimated this use of water to be about 2 TAF/yr for the approximately 1,000 acres of irrigated pasture on the Conway and DeChambeau Ranch lands. Net runoff of approximately 21.5 TAF/yr from these northern creeks flows into Mono Lake. The hydropower diversions and irrigation uses have been relatively similar in the prediversion and point-of-reference conditions and would not be changed by amendment of the city's water rights.

Other Mono Basin Streams and Springs

Runoff from about 125 square miles of the Sierra Nevada portion of the Mono Lake watershed is gauged. The 60-square-mile ungauged portion is located below streamflow gauges or is drained by small creeks that are not gauged. Another 440 square miles of the more arid valley floor and hills of Mono Basin are ungauged. Bridgeport and Cottonwood Creeks, draining the Bodie Hills to the north, have been gauged intermittently (Vorster 1985), but Dry Creek and other intermittent creeks to the south and east have not been gauged.

Most of the rainfall on this portion of the watershed is stored in the soils and lost to evapotranspiration. An unknown fraction infiltrates and recharges Mono Lake as groundwater. Vorster (1985) estimated the average net inflow from these ungauged areas at about 35 TAF/yr. A Mono Lake water budget can be used to estimate these unmeasured inflow terms more accurately because a large portion of the inflow infiltrates along the stream corridors and cannot be measured at streamflow gauges.

Mono Lake Hydrology

The hydrology of Mono Lake is described and analyzed by constructing a general water budget that includes inflow, storage, and outflow (Appendix A). Inflows are streamflows and direct rainfall onto the lake surface. Storage is simply the volume of the lake at a particular surface elevation and is determined by Mono Lake bathymetry data. Outflow is the unmeasured evaporation from the lake surface, which is estimated from assumed monthly evaporation rates and monthly lake surface area.

Historical Lake Levels. The hydrology of Mono Lake can be characterized by the historical pattern of lake-level fluctuation, as shown in Figure 1-7 for the period 1912-1991. Fluctuations in Mono Lake surface elevation were caused by the variability in annual snowpack and runoff that occurs in the eastern Sierra Nevada. Since LADWP diversions and exports began in 1941, the downward trend is explained by the reduced inflows to Mono Lake. High runoff years resulted in periods of rising lake level because LADWP did not divert Mono Basin runoff when Owens Valley runoff was sufficient to meet water demands or fill the aqueduct.

The surface area of Mono Lake has fluctuated between about 57,000 acres in 1919 and 37,000 acres in 1981 (Figure 3A-6). The lake volume has fluctuated between about 4.9 million acre-feet (MAF) in 1919 and about 2.1 MAF in 1981 (Figure 3A-7).

Simulated Lake Levels without LADWP Diversions. The natural behavior of Mono Lake in the 1940-1989 period without any LADWP diversions for irrigation or exports has been simulated with the water balance model (Appendix A) to help characterize prediversion Mono Lake hydrology (Figure 3A-8). Beginning at about 6,418 feet, the lake elevation would have remained relatively constant between 6,419 and 6,425 feet until the high runoff period of 1983-1986, when the simulated natural lake level would have risen to 6,433 feet. The subsequent drought period of 1987-1989 would have lowered the lake elevation to about 6,428 feet. The annual and average terms of the simulated natural water budget are given in Table 3A-5.

Owens River Basin Hydrology

The Owens River basin drains the eastern Sierra Nevada from just north of Mammoth Mountain and the Minarets to south of Mount Whitney. Before diversions for irrigation and export to Los Angeles began, all the runoff from the Owens River basin flowed into Owens Lake. The first barrel of the LA Aqueduct was completed in 1913, and the Owens River intake and other LA Aqueduct facilities were constructed and operated until 1941, when Mono Basin exports began. Long Valley Dam, forming Lake Crowley reservoir, was not constructed until the Mono Craters Tunnel was added to the LA Aqueduct system to allow exports from Mono Basin in 1941. The Owens Gorge hydropower plant were added in the early 1950s, and Pleasant Valley reservoir was constructed to re-regulate the peaking hydropower flows from the gorge (Figure 1-5).

Long Valley Dam separates the Upper Owens River from the Owens River gorge, which has cut through the volcanic tuff tablelands that mark the boundary of the Long Valley caldera. Tinemaha Dam is located on a bedrock outcropping that constricts the Owens Valley groundwater basin just south of Big Pine. The intake to the LA Aqueduct is located downstream of Tinemaha Dam. The lower portion of the Owens River basin contains several creeks that originally flowed directly into Owens Lake but were diverted into the LA Aqueduct between Tinemaha and Haiwee reservoirs.

Estimated runoff for the Owens River basin is shown in Figure 3A-9. (Runoff for Round Valley, located between Long Valley and Bishop, is included with Long Valley runoff.) The average Mono Basin runoff (from the four diverted creeks) is 124 TAF/yr; the average Long Valley and Round Valley runoff is 177 TAF/yr; and the remainder of the Owens River basin runoff is 239 TAF/yr. The total average Mono-Owens runoff is about 540 TAF/yr.

Upper Owens River

The Owens River originates at Big Springs, located downstream of the confluence of Glass and Deadman Creeks and upstream of the East Portal of Mono Craters Tunnel. Below East Portal, the river meanders for several miles across valley-bottom alluvial pasturelands and enters Lake Crowley reservoir. Prediversion streamflows are addressed in detail in Chapter 3C, "Vegetation".

Because of significant geothermal activity, several large hot springs are located in the basin. The largest is Hot Springs, located along Hot Creek. The average annual discharge from Hot Springs (and the cool springs at Hot Creek Hatchery located upstream) of about 30 TAF/yr (41.5 cfs) flows directly into the Owens River just above Lake Crowley reservoir.

Significant diversions are made from the Owens River and Hot Creek for irrigation of LADWP and private grazing pasturelands. LADWP records indicate that an average of 20 TAF/yr are diverted for irrigation of its lands. This represents significantly more than the actual evapotranspiration losses, however. Excess diverted water returns to the Owens River or recharges the groundwater flowing to Lake Crowley reservoir. In the prediversion period, these irrigation withdrawals probably caused virtual dewatering of some reaches of the Upper Owens River during the driest years unless irrigated acreages were reduced, based on an assessment of current irrigation demands. (See "Summary Comparison of Hydrologic Effects of the Alternatives".)

Watersheds Downstream of the Upper Owens River

From Lake Crowley reservoir to the aqueduct intake at Haiwee Reservoir, many watersheds and groundwater withdrawals contribute water to the Owens River and the water export system. Runoff from these watersheds, sustainable groundwater withdrawals in the Bishop area, and basin uses are described in Appendix T.

ENVIRONMENTAL SETTING

The status of the hydrology during the historical Mono Lake tributary diversion period (1941-1989), up to the point of reference for this EIR, is described in the following sections. The additional LA Aqueduct facilities that became operational in both Mono Basin and the Owens River basin during this period are described.

Mono Basin Diversions and Uses during the Diversion Period

Although the Mono Basin runoff hydrology for both the prediversion and point-of-reference conditions are considered to be characterized by the historical 1940-1989 streamflow records, the prediversion and the point-of-reference conditions differ in the amount of diversions for irrigation and export, and the corresponding releases of undiverted water to Mono Lake. The Mono Lake surface elevation also differed because of the effects of the historical diversions between 1941 and 1989 (Figure 1-6). Mono Lake surface elevation was approximately 6,417 feet in 1941, before Mono Basin exports began, and had declined to approximately 6,376 feet by August 1989 (Figure 1-7).

For the 50-year historical period from April 1940 to March 1989, a cumulative total of 3.3 MAF (annual average of 65.4 TAF) of water was exported from Mono Basin, according to LADWP records. This represents an average of 53% of the runoff from the four diverted tributaries. These changes were the direct result of LADWP diversion operations in Mono Basin to supplement Owens River diversions and Owens River groundwater pumping to supply water for the city.

LA Aqueduct Diversion and Storage Facilities in Mono Basin

Mono Craters Tunnel

The Mono Craters Tunnel was constructed near the end of the prediversion period to allow water from Mono Lake tributaries to be exported to the Owens River (Figures 1-1, 1-3, 1-4, and 1-5). The Mono Basin end of the tunnel is called the West Portal, and the Owens River end is called the East Portal. The tunnel has a capacity of approximately 300 cfs, but the amount of water exported is about 285 cfs because of the groundwater inflow along the tunnel (called "tunnel make") that provides a constant flow of about 15 cfs at East Portal. When the East Portal was opened, just before LADWP diversions of the tributary streams began, nearly 11 TAF/yr of groundwater began draining through the tunnel from volcanic uplands making up the divide between Mono Basin and the Owens River basin.

Grant Lake Reservoir and Outlet Facilities

Grant Lake reservoir had been enlarged to provide maximum storage of about 48 TAF as part of the LA Aqueduct extension to Mono Basin. The outlet from the Grant Lake reservoir is a conduit with a capacity of approximately 395 cfs. This outlet supplies the West Portal of the Mono Craters Tunnel and is used to release water through Mono Gate #1 to Rush Creek below Grant Lake reservoir. A canal conveys water from Mono Gate #1 to the original Rush Creek channel. The A-Ditch and B-Ditch irrigation and spreading diversion points are located on the canal just upstream from Rush Creek.

During high runoff periods, excess runoff has been released over the Grant Lake reservoir spillway directly into Rush Creek. A spill ditch near the West Portal has also been used occasionally to release excess water into Pumice Valley. During high runoff periods (e.g., 1967), diversions from Lee Vining Creek to Grant Lake reservoir sometimes continued, causing large spills over the Grant Lake reservoir spillway.

Lee Vining Conduit

The Lee Vining conduit connects the Lee Vining Creek diversion dam to the Grant Lake reservoir. The conduit crosses Walker and Parker Creeks, with diversion structures located on these creeks. Walker and Parker Creek flows are diverted into the conduit, released for irrigation diversions downstream of the conduit, or spilled down their channels during heavy runoff periods.

A small diversion structure was operated at south Parker Creek for many years during the diversion period but was closed recently because LADWP does not have appropriative water rights for this creek. The Lee Vining conduit has a capacity of approximately 300 cfs at Lee Vining Creek, with slightly higher capacity below Walker Creek (325 cfs) and Parker Creek (350 cfs). The Lee Vining conduit ends in Grant Lake reservoir, across from the outlet facility near the dam.

Owens Valley Diversions and Uses during the Diversion Period

Although the Owens River basin runoff hydrology for both the prediversion and point-of-reference conditions are considered to be characterized by the historical 1940-1989 streamflow records, the two reference conditions differ in the amount of diversions for local uses and export to Los Angeles, and in the amount of groundwater pumping. These historical use and export patterns were caused by variable hydrologic conditions and the increasing demands for water supply to the city, as well as modifications to the LA Aqueduct facilities during the period, including the extension of the aqueduct to Mono Basin.

For the 50-year historical period from April 1940 to March 1989, a cumulative total of 18.2 MAF (annual average of 364 TAF) of water was exported from the Owens River basin to Los Angeles, according to LADWP records (Table 3A-6). Pumping was greatly increased following the completion of the second LA Aqueduct barrel from Haiwee to Los Angeles in 1971.

These changes were the direct result of several changes to LA Aqueduct facilities and operations to meet an increasing demand for water in Los Angeles. Determining the portion of these hydrologic changes attributable to the effects of the Mono Basin extension and tributary diversions is difficult.

Modification of LA Aqueduct Facilities in Owens River Basin during the Diversion Period

Lake Crowley Reservoir

Long Valley Dam had been constructed to form Lake Crowley reservoir as part of the LA Aqueduct extension to Mono Basin in 1940. Lake Crowley reservoir has a maximum storage capacity of approximately 183.5 TAF, and the minimum storage for power production is about 40 TAF. Once the Mono Basin diversions began, Lake Crowley reservoir provided storage of Long Valley runoff and Mono Basin exports for later release down the Owens River to Tinemaha Reservoir and the LA Aqueduct intake near Aberdeen. Lake Crowley reservoir is a major LA Aqueduct storage facility that allows upstream runoff to be stored for several months while runoff from Bishop to Haiwee Reservoir is exported to Los Angeles.

Owens River Gorge Hydropower Plants

The Owens River gorge hydropower plants were constructed during the diversion period in 1952-1954. The penstock intake is located just upstream of Long Valley Dam. The power plants are located in the gorge along the Owens River. The penstocks connecting the three hydropower plants have a capacity of approximately 690 cfs. The hydropower plants are usually operated for peaking power generation several hours each day. The downstream plant is located just above the confluence of the Owens River and Rock Creek, at the upstream end of Pleasant Valley Reservoir.

Pleasant Valley Reservoir was constructed when the hydropower plants were built. It serves as a re-regulation reservoir to provide a relatively constant outflow to the Middle Owens River. Releases from Lake Crowley reservoir via the hydropower plants and natural flow from the Owens River gorge, Rock Creek, and Birchim Canyon springs flow into Pleasant Valley Reservoir. A small hydropower plant is located at Pleasant Valley Reservoir Dam.

Rock Creek Diversion Structure

LADWP constructed a diversion from Rock Creek at Toms Place to Crooked Creek and Lake Crowley reservoir in 1964. This allows some of the Rock Creek runoff to be stored in Lake Crowley reservoir and allows hydropower to be generated from the diverted portion of Rock Creek.

Monthly minimum release flow requirements were established below the diversion by California Department of Fish and Game. The average runoff of Rock Creek at the diversion is about 21 TAF. The average annual diversion from Rock Creek into Lake Crowley reservoir has been 7 TAF/yr, with annual values ranging from almost nothing in dry years to almost 25 TAF in 1983.

Second LA Aqueduct Barrel

A major change in LA Aqueduct facilities occurred in 1970, when the second barrel of the LA Aqueduct between Haiwee Reservoir and Los Angeles began operating. The first barrel of the LA Aqueduct had a capacity of 500 cfs, with an annual export capacity of about 360 TAF. The second barrel had a capacity of 300 cfs, increasing the annual export capacity to about 585 TAF (LADWP 1990). This expansion of the LA Aqueduct was planned by LADWP to be supplied with water from three sources: increased surface water diversions from Mono Basin and the Owens River basin, reduced irrigation uses on LADWP-leased lands, and increased groundwater pumping.

As Table 3A-6 indicates, exports to Los Angeles increased after 1970, with corresponding increases in Mono Basin exports and groundwater pumping. The reduction in irrigation use cannot be documented easily.

The increased yield of water from groundwater pumping also is not identified easily, because pumping reduces natural spring flows and reduces the natural groundwater discharges to the Owens River. The effect of groundwater pumping on the Owens Valley is the subject of a separate document (LADWP 1990) and is not analyzed in this EIR. The full capacity of the two LA Aqueduct barrels, as well as a groundwater pumping pattern consistent with the LA-Inyo pumping agreement, is assumed in the analyses of this EIR.

IMPACT ASSESSMENT METHODOLOGY

The basic assessment methodology for hydrologic effects was the LAAMP model of monthly LA Aqueduct system operations, using the 50-year sequence of historical 1940-1989 runoff hydrologic data, and various assumptions and constraints for each alternative. Most of these have already been described in Chapter 2. The details of the model development and testing for application to the EIR alternatives assessment is described in Auxiliary Report 5, "LAAMP Model Documentation" (Luhdorff and Scalmanini 1992). Some additional modeling assumptions are presented here.

Runoff Year-Types

To allow the development of diversion and lake level rules that may vary with runoff, as described in Chapter 2, annual runoff was classified into "wet", "normal", and "dry" categories. Wet and dry year categories were defined as 20% of the runoff years with the lowest and highest runoff, respectively (Table 2-2).

For the diverted Mono Lake tributary creeks, the dry year category represents years with less than 69% of "normal" (average) runoff, and the wet year category represents years with more than 132% of the normal runoff level of about 123,500 af. The dry and wet runoff year categories for the combined Mono Basin and Owens Valley scenario represent years with less than 65% and greater than 125% of the normal runoff of 595,000 af, respectively. Average runoff excluding Mono Basin is approximately 470,000 af.

Use of Measured Runoff as Forecasts from Snowpack Measurements

The LAAMP model assumes that April 1 forecasts of annual runoff are accurate, so that necessary lake level releases, LA Aqueduct export targets, and other aqueduct operating criteria that depend on runoff year classification can be estimated. The LAAMP model uses the cumulative *measured* runoff for each runoff year, whereas future operations must rely on the snowpack accumulation *forecasts* of runoff.

LADWP has developed procedures for forecasting runoff, that are similar to those used by DWR for other river-basin runoff forecasts. These forecasts correlate measured runoff with measured snowpack, base flow, and precipitation. The primary measurements used by LADWP to forecast runoff are snowpack water depth, antecedent (previous) runoff, and precipitation at selected stations.

LADWP forecasts of expected runoff are used to plan aqueduct operations, negotiate allowable groundwater pumping, and estimate supplemental water purchases from the Metropolitan Water District (MWD) that will be necessary. The forecasting generally begins in December and is updated monthly during spring.

Regression equations relating snowpack and precipitation to runoff have been estimated with historical data from 1950 to 1990. All the snow courses have been surveyed consistently since 1971, but data from the early part of that period have additional measurement errors. Estimated runoff values can be compared to the historical runoff measurements to evaluate the accuracy of these runoff forecast equations. This comparison for the combined Mono Basin and Owens River basin indicates that the annual forecasts average within 7% of the actual values (Hasencamp pers. comm.).

This comparison indicates that the April 1 runoff forecasts are sufficiently accurate to allow the historical runoff measurements to be used as though they were forecasts in the LAAMP model. Even with a 7% error in the forecasted runoff volume, the runoff year classification based on the forecasted runoff will almost always be correct.

Use of the Historical Hydrologic Sequence

The use of the historical sequence of hydrologic data for the LAAMP simulation of the alternatives provides a reasonable characterization of the range of aqueduct conditions that are likely to occur under each amended water rights alternative. Although other possible sequences might be generated by rearranging the historical sequence, the historical sequence represents hydrologic conditions adequately. Thus, it is used in the LAAMP aqueduct operations model to simulate lake level fluctuations; diverted creek streamflows; and streamflow, reservoir storage, water supply, and power generation conditions along the aqueduct to Los Angeles.

SUMMARY COMPARISON OF HYDROLOGIC EFFECTS OF THE ALTERNATIVES

Complete results of the LAAMP modeling for each alternative are contained in Auxiliary Report 18, "Summary of Hydrologic Simulation of Mono Basin EIR Alternatives with the LAAMP Aqueduct Operating Model".

Hydrologic effects of the alternatives include direct effects on Mono Lake tributary streamflows, Mono Lake water balance, and exports from Mono Basin and indirect effects on the East Portal flows and delivery to the LA Aqueduct.

Table 3A-7 provides a summary comparison of the LAAMP model simulations of the alternatives. Annual average values are given for most variables. The actual sequence of simulated flows resulted from using the historical 1940-1989 hydrologic patterns in the LAAMP simulations. Future conditions will continue the natural variability of the historical record, but of course will not repeat the historical hydrologic sequence. The normal range of conditions will be similar to that shown in the simulations, but the exact sequence of lake fluctuations, streamflows, or exports will undoubtedly not occur. Effects of extreme drought on Mono Lake level has been characterized separately, as described in Chapter 2 and Appendix H.

Table 3A-8 provides a summary comparison of monthly median flows in the Owens River and indicates the indirect effects of the alternative water rights amendments for the Mono Lake tributaries.

Table 3A-9 provides a summary comparison of simulated monthly flows, estimated irrigation diversions, and the resulting instream flows in the Upper Owens River during normal minimum runoff years. This table indicates that during the lowest runoff years, current irrigation diversions must be limited to provide minimum flow in the Upper Owens River under all alternatives except the No-Restriction Alternative.

HYDROLOGIC EFFECTS OF THE POINT-OF-REFERENCE SCENARIO

As described in Chapter 2, a point-of-reference scenario has been developed for impact assessments that requires minimum streamflows for Rush and Lee Vining Creeks, as imposed by court order by the August 1989 point-of-reference date. For this scenario, minimum flows of 19 cfs for Rush Creek and 5 cfs for Lee Vining Creek are the only requirements placed on Mono Basin export operations. The initial lake elevation for this and all alternative simulations is the August 1989 level of 6,376.3 feet. The simulation shows that the lake surface at that time could not be sustained by continuing those minimum flow requirements.

Effects on Diverted Tributary Streamflows

The simulated effects on the tributary streamflows are summarized as monthly cumulative flow occurrence, with 10% occurrence intervals, for each tributary (Table 3A-10). Because diversions from Walker and Parker Creeks are not restricted for the point-of-reference case, streamflows are reduced to zero all of the time and flows are always diverted to Grant Lake reservoir. Table 3A-10 indicates that flows in Lee Vining and Rush Creeks are usually held at the specified minimum flows of 5 cfs and 19 cfs, respectively, but that during periods of excess runoff when water is not required for LA Aqueduct operations or cannot be exported from Mono Basin because of physical capacity constraints, water is released down Lee Vining and Rush Creeks to Mono Lake.

Effects on Mono Basin Exports and Releases to Mono Lake

In the point-of-reference scenario, an average of 44.6 TAF/yr would be released to Mono Lake (Table 3A-7). The average export would be 72.7 TAF/yr. An additional 8.9 TAF/yr is assumed to be used for irrigation in Mono Basin under the point-of-reference scenario, reflecting historical practices at Cain Ranch.

Figure 3A-11 shows the expected variation in annual exports, arranged from driest to wettest years. The fraction of the total runoff that is exported is indicated by comparing export to runoff, which is also indicated for the full range of driest to wettest years. Variations from the general trend of the export curve result for carry-over of water in Grant Lake reservoir from one year to the next.

The minimum required streamflows under the point-of-reference scenario would provide a minimum lake release of about 17 TAF/yr. Exports would be less than under the No-Restriction Alternative by an average of only about 12.3 TAF/yr because the minimum flows are often satisfied by excess runoff that is not needed to meet LA Aqueduct export targets.

Effects on Mono Lake Surface Elevations

Under the point-of-reference scenario the lake surface, fluctuating in response to annual variations in runoff, would tend to fall until evaporation losses from the diminishing surface of the lake were balanced by inflows. The transition period would be more than 50 years. Thereafter, a dynamic equilibrium would prevail with a mean lake elevation of about 6,365 feet and normal fluctuations of about 16 feet. The frequency with which the lake surface would be above or below each elevation after the transition period is shown in Figure 3A-10.

Effects on Upper and Middle Owens River Flows

Mono Basin exports increase the Upper Owens River flows between East Portal and Lake Crowley reservoir and increase the releases from Lake Crowley reservoir into the Middle Owens River between Pleasant Valley Reservoir and Tinemaha Reservoir. These effects are summarized in Auxiliary Report 18 (Jones & Stokes Associates 1993).

Effects of the point-of-reference scenario on Owens River flows are given in Table 3A-8 by the median monthly flows (exceeded 50% of the time) at two locations. For dry years, when most Mono Basin runoff is exported under the No-Restriction Alternative, monthly flows are simply reduced by approximately 25 cfs because this is the minimum streamflow required for the Mono Lake tributaries. During years when excess water is already being released to Mono Lake, however, maintaining the minimum streamflows in Rush and Lee Vining Creeks would not require any reduction in Owens River flows.

Monthly flows below East Portal are influenced by the Upper Owens River runoff and Mono Basin exports, which are greatest in early spring and relatively constant the rest of the year. Monthly flows in the

Middle Owens River are influenced by Lake Crowley reservoir operations, minimum and maximum flow constraints, canal diversions for irrigation and spreading, and groundwater pumping, in addition to the direct effects of tributary runoff and indirect effects of Mono Basin exports. Owens River flows are also influenced indirectly by the simulated Haiwee Reservoir export targets, which are set at LA Aqueduct capacity for the first 6 months and reduced in the October-to-March period, depending on runoff year category as described in Chapter 2.

Effects on LA Aqueduct Exports from Haiwee Reservoir to Los Angeles

Under the point-of-reference scenario, exports to Los Angeles would average 438 TAF/yr. This is 8 TAF/yr less than the average export under the No-Restriction Alternative. The Mono Basin export deficit of 12 TAF/yr from the No-Restriction Alternative of maximum export would be reduced by an average 4 TAF/yr decrease in Owens River basin irrigation uses.

HYDROLOGIC EFFECTS OF THE NO-RESTRICTION ALTERNATIVE

Effects on Diverted Tributary Streamflows

Because diversions are not restricted for this alternative, streamflows below the diversion locations are reduced to zero most of the time (Table 3A-11). Only during periods of excess runoff, when water is not required for LA Aqueduct operations or cannot be exported from Mono Basin because of physical capacity constraints, is water released down the tributary channels to Mono Lake. Flows in Walker and Parker Creeks are always diverted to Grant Lake reservoir in Lee Vining Conduit. Only during the highest runoff periods are flows released down Lee Vining Creek or spilled from Grant Lake reservoir to Rush Creek. On average, Rush Creek would experience a spilling flow above 350 cfs once per decade, and Lee Vining Creek would experience a spilling flow above 280 cfs once per decade.

Effects on Mono Basin Exports and Releases to Mono Lake

Figure 3A-13 shows the expected variation in annual exports under this alternative, which results in an average of 32.2 TAF/yr released to Mono Lake. Releases are made only in wet years, when Mono Basin runoff is not needed to meet LA Aqueduct export targets at Haiwee Reservoir. An estimated 8.9

TAF/yr is used for irrigation in Mono Basin under this alternative, reflecting historical practices at Cain Ranch.

Effects on Mono Lake Surface Elevations

The frequency with which the lake surface would be above or below certain elevations is shown in Figure 3A-12.

Effects on Upper and Middle Owens River Flows

Effects of the No-Diversion Alternative on Owens River flows are summarized in Table 3A-8.

Effects on LA Aqueduct Exports from Haiwee Reservoir to Los Angeles

Under the No-Restriction Alternative, exports to Los Angeles would average 446 TAF/yr. This is less than the specified average export target of 475 TAF/yr. The physical aqueduct capacity is approximately 585 TAF/yr, but it is difficult to completely fill the aqueduct throughout the entire year. The No-Restriction Alternative, however, provides the largest export from Mono Basin and the largest export to Los Angeles. The Owens Valley groundwater pumping simulated for the No-Restriction Alternative was used for all other Mono EIR simulations, as described in Chapter 2 and Auxiliary Report 18.

HYDROLOGIC EFFECTS OF THE 6,372-FT ALTERNATIVE

Effects on Diverted Tributary Streamflows

Table 3A-12 indicates that flows in Lee Vining and Rush Creeks would be above the minimum specified values only during the peak runoff months of wet years. On the average, both streams would experience a spilling flow above 120 cfs once per decade. Flows in Walker and Parker Creeks would always be at or above the minimum specified values. During only a few years would the lake level be low enough that additional releases would be required above those resulting from the minimum specified streamflows.

Effects on Mono Basin Exports and Releases to Mono Lake

Figure 3A-15 shows the frequency pattern of runoff and corresponding exports under this alternative, which results in an average of 61.2 TAF/yr released to Mono Lake. Only a small non-LADWP diversion (O-Ditch) of less than 1 TAF/yr from Lee Vining Creek was assumed for the 6,372-Ft Alternative; all Cain Ranch irrigation by LADWP was assumed to be stopped.

The specified minimum monthly streamflows provide a minimum lake release of about 58 TAF/yr, but the average lake release would be 61.2 TAF/yr. The lake release for this alternative is 16.6 TAF/yr more than for the point-of-reference scenario, yet the average export is only 8.4 TAF/yr less than for the point-of-reference scenario because of the gain of 8.2 TAF/yr from reduced use for Cain Ranch irrigation.

Effects on Mono Lake Surface Elevations

The lake level under this alternative would fluctuate much less than under the point-of-reference scenario. The flow target of 300 cfs for the Upper Owens River below East Portal reduces lake level fluctuations during wet years by forcing the export of available Mono Basin runoff in excess of specified streamflows or lake releases. The frequency with which the lake surface would be above or below certain elevations is shown in Figure 3A-14.

Effects on Upper and Middle Owens River Flows

The effects of the 6,372-Ft Alternative on Owens River flows are given in Table 3A-8. During wet years, the minimum specified flow of 300 cfs for the Upper Owens River below East Portal would increase the monthly exports slightly over those under the point-of-reference scenario, shifting the period of greatest median flow from April-June to June-July.

This seasonal effect would be much less apparent in the Middle Owens River at Pleasant Valley because of the regulating operation of Lake Crowley reservoir. Most months would have reduced median flows compared with the point-of-reference scenario.

Effects on LA Aqueduct Exports from Haiwee Reservoir to Los Angeles

Under the 6,372-Ft Alternative, exports to Los Angeles would average 421 TAF/yr. This is 17 TAF/yr less than the average export under the point-of-reference scenario. The Mono Basin export deficit of 8.4 TAF/yr from the point-of-reference scenario would be increased by 8.2 TAF/yr because of increased spreading and spilling in the Owens Valley. The target Upper Owens River flow of 300 cfs would force almost all available water to be exported from Mono Basin, but this water could not always be captured and exported to Los Angeles by the aqueduct system.

HYDROLOGIC EFFECTS OF THE 6,377-FT ALTERNATIVE

Effects on Diverted Tributary Streamflows

Specified minimum streamflows would almost always be available except in June. Because the specified minimum June values are median flows, they would be available only 50% of the time. Table 3A-13 indicates that flows in Lee Vining and Rush Creeks would be above the minimum specified values only during the peak runoff months of wet years. Flows in Walker and Parker Creeks would remain at the minimum specified values except during June. Additional lake releases would be required for only a few years.

Under this alternative, Rush and Lee Vining Creeks would experience spilling flows above 230 cfs once per decade on the average.

Effects on Mono Basin Exports and Releases to Mono Lake

Figure 3A-17 shows the expected variation in annual exports under this alternative, which results in an average of 73.8 TAF/yr released to Mono Lake. The simulated average export for the 6,377-Ft Alternative was 51.8 TAF/yr. During many years, the specified minimum flows for June would not be available, so required lake releases would be less than the 70 TAF/yr of specified monthly releases. Only if the operation rules to maintain lake levels required more lake releases would deficits in monthly specified streamflows be released in later months.

The specified minimum monthly streamflows provide a minimum lake release of about 70 TAF/yr, and the average lake release would be slightly higher at 73.8 TAF/yr. The average lake release for this alternative would be 29.2 TAF/yr more than for the point-of-reference scenario, and the average export would be 20.9 TAF/yr less than for the point-of-reference case because of the gain of 8.3 TAF/yr from reduced use of irrigation for Cain Ranch.

Effects on Mono Lake Surface Elevations

The frequency with which the lake surface would be above or below certain elevations is shown in Figure 3A-16.

Effects on Upper and Middle Owens River Flows

The effects of the 6,377-Ft Alternative on Owens River flows are given in Table 3A-8. The median monthly flows of the Upper Owens River below East Portal would generally be less than those under the point-of-reference scenario, although the July flow would be greater.

Seasonal effects are much less apparent in the Middle Owens River at Pleasant Valley because of the regulating operation of Lake Crowley reservoir. All months would have reduced median flows compared with the point-of-reference scenario.

Effects on LA Aqueduct Exports from Haiwee Reservoir to Los Angeles

Under the 6,377-Ft Alternative, exports to Los Angeles would average 412 TAF/yr. This is 26 TAF/yr less than the simulated average export under the point-of-reference scenario. The Mono Basin export deficit of 21 TAF/yr from the point-of-reference scenario would be increased by about 5 TAF/yr because of increased spreading and spilling in the Owens Valley.

HYDROLOGIC EFFECTS OF THE 6,383.5-FT ALTERNATIVE

Effects on Diverted Tributary Streamflows

Table 3A-14 indicates that flows in Lee Vining and Rush Creeks would be above the minimum specified values during the peak runoff months of many years because of the increased lake releases required to achieve and maintain the 6,383.5-foot target minimum lake level. Flows in Walker and Parker Creeks would always remain at or above the minimum specified values except during June, when the median flow would be available only 50% of the time.

Under this alternative, Rush Creek would experience a spilling flow above 290 cfs, and Lee Vining Creek would experience a spilling flow above 260 cfs once per decade, on average.

Effects on Mono Basin Exports and Releases to Mono Lake

Figure 3A-19 shows the expected variation in annual exports under this alternative, which results in an average of 88 TAF/yr released to Mono Lake during the first 50 years of implementation. Once the lake level reached the target minimum level of 6,383.5 feet, less water would be required to maintain that level, and 82.2 TAF/yr would be released during the next 50 years. The average export for the first 50 years would be 37.7 TAF/yr and for the second 50 years would be 43.5 TAF/yr.

Greater releases would be required during the first 20 years to raise the lake elevation to the target level. The average for the first 50 years reflect this increased initial water requirement. The average for the second 50-year period is more indicative of the long-term split of available water between lake releases and exports.

The average lake release for the first 50 years of the 6,383.5-Ft Alternative would be 43.3 TAF/yr more than for the point-of-reference scenario; for the second 50 years, releases would be 37.6 TAF/yr more. The average export during the first 50 years would be 35.0 TAF/yr less than for the point-of-reference case; for the second 50 years, export would be 29.2 TAF/yr less.

Effects on Mono Lake Surface Elevations

The frequency with which the lake surface would be above or below certain elevations after dynamic equilibrium was reached is shown in Figure 3A-18.

Effects on Upper and Middle Owens River Flows

The effects of the 6,383.5-Ft Alternative on Owens River flows are given in Table 3A-8 for the first 50 years of implementation. Values for the second 50 years would be slightly higher because Mono Basin exports would be increased by an average of 6 TAF/yr. Median monthly flows of the Upper Owens

River below East Portal would be less than those of the point-of-reference scenario, especially during the peak runoff period.

Effects of reduced Mono Basin exports for this alternative would be evident in the Middle Owens River at Pleasant Valley, especially during the peak runoff months. All months would have reduced median flows compared with the point-of-reference scenario.

Effects on LA Aqueduct Exports from Haiwee Reservoir to Los Angeles

Under the 6,383.5-Ft Alternative, exports to Los Angeles would average 403 TAF/yr for the first 50 years of simulation and 408 TAF/yr for the second 50 years. This is 35 TAF/yr less than the average export under the point-of-reference scenario for the first 50 years and 30 TAF/yr less for the second 50 years. These figures are identical to the Mono Basin export deficits compared with the point-of-reference scenario. No additional water would be lost to spilling or spreading in the Owens Valley.

HYDROLOGIC EFFECTS OF THE 6,390-FT ALTERNATIVE

Effects on Diverted Tributary Streamflows

Table 3A-15 indicates that flows in Lee Vining and Rush Creeks would be above the minimum specified values during the peak runoff months of most years because of the greatly increased lake releases required to achieve and maintain the 6,390-foot target minimum lake level.

Under this alternative, Rush Creek would experience a spilling flow above 360 cfs, and Lee Vining Creek would experience a spilling flow above 280 cfs once per decade, on average.

Effects on Mono Basin Exports and Releases to Mono Lake

Figure 3A-21 shows the expected variation in annual exports under this alternative, which results in an average of 95.9 TAF/yr released to Mono Lake during the first 50 years of implementation. Once the lake level reached the target minimum level of 6,390 feet, less water would be required to maintain that level, and 88.7 TAF/yr would be released during the next 50 years. The average export would be 29.8 TAF/yr for the first 50 years and 37 TAF/yr for the second 50 years.

Greater releases would be required during the first 40 years to raise the lake elevation above the target level. The average for the first 50 years reflects this increased initial water requirement. The average for the second 50-year period is more indicative of the long-term split of available water between lake releases and exports.

The average lake release for the first 50 years of the 6,390-Ft Alternative would be 51.3 TAF/yr more than for the point-of-reference scenario; for the second 50 years, releases would be 44.1 TAF/yr more. The average export during the first 50 years would be 42.9 TAF/yr less than for the point-of-reference scenario; for the second 50 years, exports would be 35.7 TAF/yr less.

Effects on Mono Lake Surface Elevations

The frequency with which the lake surface would be above or below certain elevations after dynamic equilibrium was reached is shown in Figure 3A-20.

Effects on Upper and Middle Owens River Flows

The effects of the 6,390-Ft Alternative on Owens River flows are given in Table 3A-8 for the first 50 years of implementation. Values for the second 50 years would be slightly higher because Mono Basin exports would be increased by an average of 7 TAF/yr. Median monthly flows of the Upper Owens River below East Portal would be much less than for the point-of-reference case, especially during the peak runoff period.

Effects of reduced Mono Basin exports for this alternative would be evident in the Middle Owens River at Pleasant Valley, especially during the peak runoff months. All months would have less median flow than with the point-of-reference scenario.

Effects on LA Aqueduct Exports from Haiwee Reservoir to Los Angeles

Under the 6,390-Ft Alternative, exports to Los Angeles would average 398.6 TAF/yr for the first 50 years of implementation and 404.3 TAF/yr for the second 50 years. This is 39.2 TAF/yr less than the average export under the point-of-reference scenario for the first 50 years and 33.5 TAF/yr less for the second 50 years. These figures are slightly less than the Mono Basin export deficits of the point-of-reference scenario because of reduced Owens Valley uses when target levels of the Haiwee Reservoir export cannot be satisfied in dry runoff years.

HYDROLOGIC EFFECTS OF THE 6,410-FT ALTERNATIVE

Effects on Diverted Tributary Streamflows

Table 3A-16 indicates that flows in Lee Vining and Rush Creeks would be above the minimum specified values during the peak runoff months of most years because of the greatly increased lake releases required to achieve and maintain the 6,410-foot target minimum lake level.

Under this alternative, Rush Creek would experience a spilling flow above 400 cfs, and Lee Vining Creek would experience a spilling flow above 280 cfs once per decade, on average.

Effects on Mono Basin Exports and Releases to Mono Lake

Figured 3A-23 shows the expected variation in annual exports under this alternative, which results in an average of 114.8 TAF/yr released to Mono Lake during the first 50 years of implementation. Because the lake level would not yet be above the target minimum level of 6,410 feet after 50 years, increased lake releases of 108 TAF/yr would be required during the second 50 years of implementation, and 104 TAF/yr would be released during the third 50 years of implementation. The average export would be 11 TAF/yr for the first 50 years, 17.7 TAF/yr for the second 50 years, and 21.7 TAF/yr for the third 50 years of implementation.

Greater releases would be required during the first 80 years to raise the lake elevation above the target minimum level. The averages for the first and second 50-year periods reflect this increased water requirement. The averages for the third 50-year period are more indicative of the long-term split of available water between lake releases and exports.

The average lake release for the first 50 years of the 6,410-Ft Alternative would be 70.2 TAF/yr more than for the point-of-reference scenario; for the second 50 years, releases would be 63.4 TAF/yr more; and for the third 50 years, they would be 59.4 TAF/yr more. The average export during the first 50 years would be 61.7 TAF/yr less than for the point-of-reference scenario; for the second 50 years, exports would be 55 TAF/yr less; and for the third 50 years, they would be 51 TAF/yr less.

Effects on Mono Lake Surface Elevations

The frequency with which the lake surface would be above or below certain elevations after dynamic equilibrium was reached is shown in Figure 3A-22.

Effects on Upper and Middle Owens River Flows

The effects of the 6,410-Ft Alternative on Owens River flows are given in Table 3A-8.

Effects on LA Aqueduct Exports from Haiwee Reservoir to Los Angeles

Under the 6,410-Ft Alternative, exports to Los Angeles would average 385.8 TAF/yr for the first 50 years of implementation, 389.5 TAF/yr for the second 50 years, and 393.5 TAF/yr for the third 50 years. This is 52 TAF/yr less than the average export under the point-of-reference scenario for the first 50 years, 48.3 TAF/yr less for the second 50 years, and 44.5 TAF/yr less for the third 50 years. These figures are slightly less than the Mono Basin export deficits of the point-of-reference scenario because of reduced Owens Valley water use, reduced spreading, and reduced aqueduct spilling.

HYDROLOGIC EFFECTS OF THE NO-DIVERSION ALTERNATIVE

The No-Diversion Alternative represents no diversion and export of Mono Basin streamflow, but groundwater inflow would continue to be relatively constant into the Mono Craters Tunnel draining from East Portal into the Upper Owens River.

Effects on Diverted Tributary Streamflows

For each diverted creek, Table 3A-17 shows runoff flows modified by SCE storage and hydropower operations. No hydrologic effects on the diverted creeks were assumed in this alternative. Spilling flows would be similar to those described for the 6,410-Ft Alternative.

Effects on Mono Basin Exports and Releases to Mono Lake

Figure 3A-25 shows no exports for this alternative, with results in all runoff (124.2 TAF/yr on average) being released to Mono Lake. For this alternative, Grant Lake reservoir is assumed to remain full, so evaporative losses are slightly greater than for the point-of-reference scenario. No exports are allowed, implying 72.7 TAF/yr less export than under the point-of-reference scenario.

Effects on Mono Lake Surface Elevations

The frequency with which the lake surface would be above or below certain elevations after dynamic equilibrium was reached is shown in Figure 3A-24.

Effects on Upper and Middle Owens River Flows

The effects of the No-Diversion Alternative on Owens River flows are given in Table 3A-8. Flows in the Upper Owens River below East Portal would be the natural runoff values, supplemented with a nearly constant 17 cfs from "tunnel make".

The effects of eliminating Mono Basin exports would be strongly evident in the Middle Owens River at Pleasant Valley, especially during the peak runoff months. All months would have reduced median flows compared with the point-of-reference scenario. The flows at Pleasant Valley would generally be uniform, with median monthly flows between 200 and 300 cfs, except for July with a median flow of 433 cfs.

Effects on LA Aqueduct Exports from Haiwee Reservoir to Los Angeles

Under the No-Diversion Alternative, exports to Los Angeles would average 373.6 TAF/yr. This is 64.2 TAF/yr less than the average export under the point-of-reference scenario. This figure is slightly less than the Mono Basin export deficit of 72.7 TAF/yr compared to the point-of-reference scenario because of reduced Owens Valley water use, reduced spreading, and reduced aqueduct spilling.

CITATIONS

Printed References

Aquatic Systems Research. 1992. Instream flow requirements for brown trout in Lee Vining Creek, Mono County, California. December. (DFG Stream Evaluation Report No. 92-4, Volume I.) Prepared for California Department of Fish and Game, and Los Angeles Department of Water and Power, Sacramento and Los Angeles, CA.

Beak Consultants, Inc. 1991. Instream flow requirements for brown trout, Rush Creek, Mono County, California and appendices to the technical report. (DFG Stream Evaluation Report 91-2, Volumes I and II.) August and May. Sacramento, CA. Prepared for California Department of Fish and Game and Los Angeles Department of Water and Power, Sacramento and Los Angeles, CA.

Davis, S. N., and R. J. DeWiest. 1966. Hydrology. John Wiley & Sons. New York, NY.

EA Engineering, Science, and Technology, Inc. 1989. Fish populations in lower Lee Vining Creek, 1986-1988. Prepared for City of Los Angeles Department of Water and Power, Los Angeles, CA.

EBASCO Environmental and Water Engineering and Technology, Inc. 1991a. Habitat restoration for South Parker Creek, Mono County, California. (DFG Stream Evaluation Report 91-4.) Sacramento, CA, and Ft. Collins, CO. Prepared for California Department of Fish and Game, and Los Angeles Department of Water and Power, Sacramento and Los Angeles, CA.

___________. [1992] 1991b. Habitat restoration for Parker Creek, Mono County, California. December. (DFG Stream Evaluation Report 91-5.) Sacramento, CA, and Ft. Collins, CO. Prepared for California Department of Fish and Game and Los Angeles Department of Water and Power, Sacramento and Los Angeles, CA.

__________. 1991c. Habitat restoration for Walker Creek, Mono County, California. Draft. December. (DFG Stream Evaluation Report 91-6.) Sacramento, CA, and Ft. Collins, CO. Prepared for California Department of Fish and Game and Los Angeles Department of Water and Power, Sacramento and Los Angeles, CA.

EBASCO Enviromental, Water Engineering and Technology, Inc., and W. Davis and Associates. 1993. Instream flow and habitat restoration investigations for the Upper Owens River, Mono County, California. February. (DFG Draft Stream Evaluation Report, February 1993, Volume 1.) Sacramento, CA, Ft. Collins, CO, and Chandler, AZ. Prepared for California Department of Fish and Game and the City of Los Angeles Department of Water and Power, Sacramento and Los Angeles, CA.

Farrar, C. D., M. L. Sorey, S. A. Rojstager, A. C. Steinemann, and M. D. Clark. 1989. Hydrologic and geochemical monitoring in Long Valley Caldera, Mono County, California, 1986. (U.S. Geological Survey Water-Resources Investigations Report No. 89-4033.) U.S. Geological Survey. Sacramento, CA. Prepared for U.S. Department of the Interior, Washington, DC.

Federal Energy Regulatory Commission. 1992. Environmental assessment for hydropower license, Rush Creek. (FERC Project No. 1389-001.) Office of Hydropower Licensing, Division of Project Review. Washington, DC.

Hollett, K. J., W. R. Danskin, W. F. McCaffrey, and C. L. Walti. 1989. Geology and water resources of Owens Valley, California. (U.S. Geological Survey Open File Report 88-715.) Prepared in cooperation with Inyo County and the Los Angeles Department of Water and Power, Sacramento, CA.

Inyo County and Los Angeles. 1990. Green book for the long-term groundwater management plan for the Owens Valley and Inyo County. Aqueduct Division. Los Angeles, CA.

Jones & Stokes Associates, Inc. 1993. Summary of hydrologic simulations of Mono Basin EIR alternatives with the LAAMP Aqueduct Operations Model. (Mono Basin EIR Auxiliary Report No. 18.) Prepared for California State Water Resources Control Board, Sacramento, CA.

LaJoie, K. R. 1968. Quaternary stratigraphy and geologic history of Mono Basin, Eastern California. MS thesis. University of California. Berkeley, CA.

Lee, C. H. 1912. An intensive study of the water resources of a part of Owens Valley. (Water Supply Paper 294.) U.S. Geological Survey. Washington, DC.

Los Angeles Department of Water and Power. 1987. Mono Basin geology and hydrology. Aqueduct Division, Hydrology Section. Los Angeles, CA.

Luhdorff & Scalmanini Consulting Engineers. 1992. LAAMP (Los Angeles Aqueduct Monthly Program) documentation version 2. Prepared for California State Water Resources Control Board, Woodland, CA.

Mono Basin Ecosystem Study Committee of the National Research Council, National Academy of Sciences. 1987. The Mono Basin ecosystem: effects of changing lake level. National Academy Press. Washington, DC.

NAS. 1987. See Mono Basin Ecosystem Study Committee of the National Research Council, National Academy of Sciences, 1987.

Stine, S. 1987. Geomorphic and geohydrographic aspects of the Mono Lake controversy. Prepared for The Community Organization and Research Institute (CORI), University of California. Santa Barbara, CA.

Trihey and Associates. 1992. Comparison of historic and existing conditions on lower Lee Vining Creek, Mono County, California. Walnut Creek, CA.

Vorster, P. 1985. A water balance forecast model for Mono Lake, California. Masters thesis. California State University. Hayward, CA.

Personal Communications

Hasencamp, William I. Civil engineering associate. Los Angeles Department of Water and Power, Los Angeles, CA. January 14, 1993 - correspondence to Dr. Russ Brown regarding forecasted and actual runoff for the Mono Basin and Owens Valley.